Addressing the Yield Gap in Winter Wheat: Issues for the Milling Industry

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SRUC – Scotland’s Rural College

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- Crop Protection
- Soil Science
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**Crop & Soil Systems**
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- Crop Protection
- Soil Science
- Applied Practice Team
What are the main factors affecting yield trends in wheat?

• Genetic yield potential
• Climate / weather
• Agronomy
  – Economics (prices) & policies … maximise profit not yield
  – Structural change: fewer and larger farms, less labour
  – Technical change … key to improvement
  – New threats: pests & diseases, resistance, loss of pesticides
Progress in world average yields

Source: FAO Statistics
UK wheat yields
Evidence for a yield plateau in UK wheat

Source: Cereal Production Surveys (Defra)
### Wheat yields plateauing across Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>1989</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1990</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1993</td>
</tr>
<tr>
<td>Italy</td>
<td>1994</td>
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<tr>
<td>Denmark</td>
<td>1995</td>
</tr>
<tr>
<td>France</td>
<td>1996</td>
</tr>
<tr>
<td>UK</td>
<td>1996</td>
</tr>
<tr>
<td>Germany</td>
<td>1999</td>
</tr>
</tbody>
</table>

Brisson *et al.* 2010
Current Understanding

UK  Spink et al 2009

- Cost / price squeeze
- Agricultural policies discouraging production
- Restrictions to available chemistry, loss of actives, use limitations

France  Brisson et al. 2010

- Variety contribution to yield increase is 0.10-0.12 t/ha per year
- Climate change responsible for yield decline of 0.02-0.05 t/ha per year
- Tighter rotations and static N fertiliser use responsible for yield decline of 0.05 t/ha per year
Current understanding

Finland  Peltonen-Sainio et al. 2009
- Environmental programme aimed at increasing sustainability of agriculture by reducing environmental load it represents
- Decreased economic incentives to produce intensively as cereal prices decreased and input prices were unchanged

Denmark  Petersen et al. 2010
- Factors considered to have negative yield impact:
  - reduction in N fertiliser use
  - trend towards higher proportion of wheat in rotation
  - increase in use of reduced tillage systems
  - reduction in fungicide use (outweighing increased efficacy)
- Low grain prices from 1990-2006 reduced farm inputs
Long term improvement in yields from variety trials

Study by Ian MacKay et al. (NIAB TAG) into trends in UK variety trials, 1948 to 2007

Long term progress of 0.06 t/ha per year increase in yield potential through genetic improvement
Wheat genetic yield gain by nabim Group

\[ y = 0.064x + 9.162 \quad R^2 = 0.669 \]
\[ y = 0.053x + 9.585 \quad R^2 = 0.929 \]
\[ y = 0.039x + 9.996 \quad R^2 = 0.874 \]
\[ y = 0.097x + 9.249 \quad R^2 = 0.909 \]

Source: NIAB Classified List
Wheat yield and N fertiliser applications, 1983 - 2010

Source: Cereal Production Surveys (Defra) and British Survey of Fertiliser Practice
Average wheat grain nitrogen content (GB)

Overall effect: A small yield penalty due to N supply limiting yield

Source: Cereal Production Surveys (Defra) and HGCA Cereal Quality Survey
Effect of nitrogen fertilizer and crop nitrogen uptake on yield

Influence of N fertilizer application on grain yield and total N taken up by the crop (WGIN trials, Rothamsted)

Source: Hawkesford (2014)
For milling wheat a major challenge is to maintain grain protein as yield improves.

Grain protein deviation, based on grain N content and yield for 47 wheat cultivars (WGIN trials, Rothamsted)

Source: Hawkesford (2014)
Crop protection and the yield plateau

Average number of active ingredients applied to wheat crops in GB has increased

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<tbody>
<tr>
<td>Group</td>
<td>Number of active ingredients applied to wheat</td>
<td></td>
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<td></td>
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<tr>
<td>Insecticides</td>
<td>1.2</td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Fungicides</td>
<td>6.4</td>
<td>6.4</td>
<td>5.9</td>
<td>7.5</td>
<td>7.5</td>
<td>9.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Herbicides</td>
<td>4.6</td>
<td>4.8</td>
<td>5.3</td>
<td>6.2</td>
<td>5.8</td>
<td>6.0</td>
<td>5.8</td>
</tr>
<tr>
<td>PGRs</td>
<td>2.2</td>
<td>2.1</td>
<td>2.3</td>
<td>2.2</td>
<td>2.5</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Molluscicides</td>
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<td>0.4</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
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<tr>
<td>All pesticides</td>
<td>14.5</td>
<td>14.7</td>
<td>15.1</td>
<td>17.6</td>
<td>17.5</td>
<td>20.4</td>
<td>19.0</td>
</tr>
</tbody>
</table>

Source: Pesticide Usage Survey
Percentage of wheat crops receiving fungicides 1990-2010

Source: Cereal Production Surveys (DEFRA) and CropMonitor (FERA)
Soil cultivation and wheat yield

Source: Cereal Production Surveys (Defra) and CropMonitor (Fera)

Estimated a small yield decline per year from 1996 to 2010 due to a rise in reduced tillage.
Wheat yield trends by farm yield quartile

Farms categorised by their average yield: from upper to bottom quartile

Yield limitation is less evident in farms within the upper yield quartile

Source: Farm Business Survey
Climate or weather effects on yield, since 1980 (UK)

- Increase in mean spring and summer temperatures
- Increase in mean autumn temperature
- Increase in summer sunshine (in England), but highly variable across seasons
- Net effect of recent weather patterns on UK wheat yield has most likely been negative, with increased water stress and a reduced grain filling period
- In some regions, summer/autumn rainfall and prolonged harvest periods (highly variable between seasons) may predominate over general UK effects
Summary of factors contributing to trends in wheat yields

• Genetic improvement ✓
• Sowing date ✓
• Crop rotation ✓
• Establishment method ✓
• Disease control ✓
• Nitrogen nutrition ✓
• Other nutrition e.g. P, K, S ✓
• Climate plus other soil and/or operational factors ✓
What is needed to help the arable sector deliver better wheat for milling?

- Information to guide variety selection for specific situations
- Benchmark farm yields and health-check farming systems
- Survey the extent and severity of deep soil compaction
- Verify yield impacts of transition to non-inversion tillage
- Need advice on coping with delayed sowing
- Opportunities to improve nitrogen use efficiency with agronomy
- Update information on crop area at risk of nutrient deficiencies
- Tackle threats posed by resistance and loss of pesticides
How might improvements in wheat productivity help the milling industry?

• Provision of wheat varieties to suit specific situations

• It is essential to have a better understanding of how yield improvement will impact on grain quality and yield stability

• Wheat varieties with improved nitrogen and nutrient utilisation to maintain or improve grain quality

• Wheat improvement must be developed alongside new technologies or methods for early ‘value for use’ e.g. processability traits that are difficult to measure until National List stage

• Yield improvement from research and variety trials translated in a more integrated way e.g. through monitor farms and processing
Acknowledgements

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• Desk study to evaluate causes of the current “yield plateau” in wheat and oilseed rape