Wheat for distilling and bioethanol: Developments in 2007

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WIGN Stakeholder meeting 29/11/07

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Agenda

- Development in the biofuels market
- Progress understanding variety effects
- Alcohol productivity and N effects
- Summary of projects completed in 2007
- New bioethanol projects
Planned UK bioethanol plants

Existing: Scottish Distillers, 700 kt

Roquette: 300 kt

GSF (1): 350 kt

GSF (2): 700 kt

Losonoco: 360 kt

Ensus: 1000 kt

BP/ABF: 1000 kt

Vireol: 500 kt

Bioethanol Ltd: 325 kt

British Sugar

Requirements for wheat
### Planned UK bioethanol plants

<table>
<thead>
<tr>
<th>Company</th>
<th>Req for wheat (kt)</th>
<th>Predicted EtOH prod (kt)</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSF (1)</td>
<td>350</td>
<td>105</td>
<td>Late 2008</td>
</tr>
<tr>
<td>GSF (2)</td>
<td>700</td>
<td>210</td>
<td>Late 2009</td>
</tr>
<tr>
<td>Roquette</td>
<td>300</td>
<td>100</td>
<td>Late 2008</td>
</tr>
<tr>
<td>Bioethanol Ltd</td>
<td>325</td>
<td>100</td>
<td>2008 ??</td>
</tr>
<tr>
<td>Vireol</td>
<td>500</td>
<td>150</td>
<td>2008</td>
</tr>
<tr>
<td>Losonoco</td>
<td>360</td>
<td>110</td>
<td>2008</td>
</tr>
<tr>
<td>Ensus</td>
<td>1,000</td>
<td>325</td>
<td>Late 2008</td>
</tr>
<tr>
<td>BP/ABF</td>
<td>1,000</td>
<td>330</td>
<td>Late 2009</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,535</strong></td>
<td><strong>1,430</strong></td>
<td></td>
</tr>
</tbody>
</table>

| British Sugar  | -                  | 55                       | Late 2007  |
Spain - Abengoa

- Plans next year for purchase of 250,000 tonnes of UK wheat under contract

- An existing market which justifies understanding the quality of wheat for bioethanol
Will premia be paid for high AY?

US - Monsanto/FOSS
- Significant developments in 2007

UK - Centaur
Sweden – Agroetanol
Spain - Abengoa
Sweden – Agroetanol

Protein: 9-11%
Moisture: below 15% at harvest (or 14.5% post harvest) no correction
Specific weight: over 750 g/l no correction
Starch: up to 71.0% = base price
  - From 71.1% added payment of 1.5% per % starch
  - 71.1-71.5% starch = +0.75%
  - 71.6-72.0% starch = +1.5% etc
UK Centaur bioethanol contract

Starch premium
  - Basic starch content 60% (no premium)
  - Premium £0.25 per 0.5% starch (up to max of 70% starch)

... assume these are on an ‘as is’ basis (85%DM)
Previous WIGN meeting 2006

- What drives alcohol yield?
- Measuring and Predicting alcohol yield
- Effects of Variety
- Environmental influences
Wheat: benchmark analysis

- Starch: 69.0%
- Protein: 11.5%
- NSP: 11.0%
- Lignin: 1.0%
- Oil: 2.5%
- Ash: 2.0%
- Sugar: 3.0%
Varieties and starch vs protein

Source: Moss et al. (1999) HGCA report 182
Varietal effects on alcohol-protein relationship

We assume the alcohol yield:protein relationship is the same for all varieties

[Data: SWRI, 2005; analysis DK]
Variety effects

- Why do some varieties consistently outperform in terms of alcohol yield?
Assessing wheat varieties for alcohol yield

Objective 1
- compare varieties at same grain N content

Objective 2
- compare varieties across N rates

<table>
<thead>
<tr>
<th>Grain Protein (%)</th>
<th>Alcohol yield (l/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 10 11 12 13 14</td>
<td>460 450 440 430 420 410</td>
</tr>
</tbody>
</table>

- Variety 1
- Variety 2
- Variety 3
- Variety 4
- Variety 5
- Variety 6
- Variety 7
- Variety 8
- Variety 9
- Variety 10
Why is Riband a good distilling wheat?

Riband – good, traditional soft distilling variety

Why is Riband a good distilling wheat?

Riband – 3% higher starch content at a given level of protein

### Summary of variety effects

<table>
<thead>
<tr>
<th></th>
<th>Option</th>
<th>Riband</th>
<th>sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol yield (L/t)</td>
<td>445</td>
<td>454</td>
<td>(*** )</td>
</tr>
<tr>
<td>Starch (g/100g)</td>
<td>69.9</td>
<td>73.0</td>
<td>(*** )</td>
</tr>
<tr>
<td>Total protein (g/100g)</td>
<td>9.93</td>
<td>9.63</td>
<td>(*)</td>
</tr>
<tr>
<td>TGW (g)</td>
<td>44.8</td>
<td>50.0</td>
<td>(*** )</td>
</tr>
<tr>
<td>Grain width (mm)</td>
<td>3.9</td>
<td>4.2</td>
<td>(*** )</td>
</tr>
<tr>
<td>Grain l:w ratio</td>
<td>1.72</td>
<td>1.62</td>
<td>(*** )</td>
</tr>
<tr>
<td>Vitreous grains (%)</td>
<td>16.3</td>
<td>12.2</td>
<td>(ns)</td>
</tr>
<tr>
<td>Alcohol/starch (L/10kg)</td>
<td>6.37</td>
<td>6.23</td>
<td>(*)</td>
</tr>
<tr>
<td>Gliadin (%)</td>
<td>42.5</td>
<td>40.9</td>
<td>(*)</td>
</tr>
</tbody>
</table>
Conclusions: Riband

- High alcohol yield in Riband associated with:
  - More starch at a given level of protein
  - Large well filled grains
  - Small grain l:w ratio

- No interactions between variety and N for any trait

but...

Glasgow (good distilling wheat) does not have large grains
Variety effects

- More work required to understand variety effects……
Sustainable biofuel production

- Alcohol yield per tonne, or per hectare?
Alcohol yield/ha driven by grain yield

Sustainable biofuel production

- Fertiliser very important for GHG emissions (manufacture & in-field GHG emissions)

- Optimum N rates to maximise GHG savings substantially lower than to optimise yield

- Increasing productivity (e.g. by breeding) will be very important in reducing GHG intensities per t of grain, and getting maximum production off limited land area

- Displacement of agricultural activity onto virgin lands (e.g. forest or grassland) gives enormous CO2 releases
Recently completed ADAS projects on biofuels

HGCA project report No. 417
- Optimising nitrogen applications for wheat grown for the biofuels market

HGCA review No. 61
- Wheat as a feedstock for alcohol production

HGCA review No. 66
- Opportunities and implications of using the co-products from biofuel production as feeds for livestock

Levy funded
Ongoing: GREEN grain Project
Genetic Reduction of Energy use and Emissions of Nitrogen through cereal production

\[ y = -5.3979x + 504.03 \]
\[ R^2 = 0.8898 \]
Ongoing: Grain size and shape

- PhD studentship, University of Manchester
- ‘Understanding and predicting the determination of alcohol yield from wheat’

Mabille & Abecassis model (2003) \(\rightarrow\) volume & surface area

\[\text{... can such models be adapted to predict alcohol yield}\]
New ADAS projects on bioethanol

RD-2005-3176
- Maximising the yield of high value components from wheat by fractionation

RD-2006-3314
- Maximising bioethanol yield of UK wheat: Effect of non starch polysaccharides in grain

RD-2007-3348
- Triticale – opportunities as a low input cereal for bioethanol production
Conclusions

- UK wheat shows potential for high alcohol yields (ca. 480 L/tonne) – competitive with US maize
- NIR calibration for alcohol yield well advanced
- Agronomy key to maximising benefits of biofuels by min. GHG emissions
- Breeding for yield important for max alcohol production per hectare (and min GHG/t of grain)
- Breeding for starch content key to producing high quality feed stock
Thank you

Green Grain analytical group, 2007

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