Growing wheat for alcohol/bioethanol production

Bioethanol: A growing market for UK wheat

From 2010 wheat will become a major UK biofuel crop. In addition to the current 800,000 tonnes used by distillers for alcohol production, a potential market of some 2.5 million tonnes per year could be created through UK and EU initiatives to expand biofuel production. The first wheat biofuel plant opened in 2010 on Teeside (Ensus) and this will be followed by the second in Hull (Vivergo) in 2011 and a third to follow near Grimsby (Vireol). This represents a major market opportunity for UK growers but it will depend on the delivery of sustainability requirements, including reduction of greenhouse gas emissions (GHG), as required under European legislation. Bioliquids used for transport or energy are legally required to meet GHG emissions targets and, in the future, it is possible that drivers to reduce carbon footprints may lead to closer scrutiny of potable alcohol production methods also. Therefore, these guidelines are relevant for both industries.

Managing wheat for alcohol production

To maximise GHG savings and profitability, crops grown for alcohol production should generally be managed as for feed wheat to maximise yield. Variety choice and nitrogen (N) rates are the most critical decisions. The bioethanol producer will look for high starch/low protein grain. Starch formation is best in northern UK, but grain will be needed from across the UK. The best growing conditions are where high yields are expected, for example after a break crop on moisture retentive soils. Avoid drought-prone fields and areas with a high risk of take-all.

Choosing varieties

The variety Beluga is predicted to produce the most alcohol.

Predicted differences between current varieties are mostly due to grain yields.

Soft wheats are currently favoured for distilling as they combine high alcohol yields with few processing problems. The Scotch Whisky Research Institute (SWRI) does not currently test hard wheats but HGCA-funded work is investigating their potential as new biofuel plants may accept them.

The HGCA Recommended List indicates varieties suitable for distilling. The best varieties are likely to combine high alcohol yields with good disease resistance and agronomic features. Until further data are available, conclusions from Figure 1 should be considered tentative. This applies especially to Beluga, Invicta and Warrior for which data are more limited (2009 data only).

Comparative alcohol production per hectare (%)

Beluga 90% 80% 100% 110%
Viscount
Zebedee
(Invicta)
Glasgow
Cassius
Robigus
Istabraq
Alchemy
Claire
Scout
(Warrior)

Comparative alcohol production per hectare (l/ha)

Beluga 420 440 450 460 480 470
Viscount
Zebedee
(Invicta)
Glasgow
Cassius
Robigus
Istabraq
Alchemy
Claire
Scout
(Warrior)

Figure 1. Alcohol processing yield (purple) and comparative alcohol production (green) of wheat varieties.

Control alcohol production = 4098 l/ha.
Potential alcohol yield was calculated by combining actual processing yield (SWRI 2006-2009) and mean grain yields (HGCA Recommended List).
Nitrogen
Avoiding overuse of N is vital as its production and use accounts for about 70% of GHG costs of growing wheat. There may be benefits from reducing N, but this has implications for alcohol yield (Figure 2). Any grain quality (e.g., high starch content) premiums may justify adjusting N rates.

Figure 2. N response of alcohol production and processing yield
Predicted by NIR (near infra-red reflectance) using a calibration developed in the GREEN Grain project (2005–2010).
Variety: Alchemy grown at ADAS Terrington in 2009.

Potential GHG savings
GHG savings from wheat cultivation and processing can be estimated, as CO₂ equivalents (CO₂e), using tools such as the HGCA Biofuel GHG Calculator (Figure 3; www.hgca.com/biofuelcalc). Savings are calculated by subtracting the total GHG costs of growing and processing wheat into alcohol, from the total GHG savings from using ethanol as a petrol substitute. Co-product credits are allowed within the savings. These reflect the value of DDGS (distiller dried grains and solubles) and sales of excess electricity to the grid when used to displace more GHG intensive sources of livestock feed and electricity. In future, credits could also be applied for CO₂ capture from fermentation.

Figure 3. Typical GHG costs of growing wheat for ethanol in 2010
HGCA’s biofuels calculator gave a net GHG saving of 36.7% relative to petrol from the following scenario:
- Wheat yield = 75t/ha,
- N application = 200kg/ha,
- Processed by a modern biorefinery with natural gas boiler and steam turbine, credit for exporting excess electricity to the grid, ‘co-product credit’ for DDGS based on the value of substituting for US soya estimated from production and transport costs of imported soya. Under the RED a different calculation method will be used (on an energy allocation basis) which may increase the co-product credit, leading to greater net GHG savings.

Policy drivers
- Under the Renewable Transport Fuel Obligation (RTFO) a target of 5% by volume by 2010 was set. After the Gallagher Review, the 5% target was extended to 2013/14.
- By 2011, the RTFO will be superseded by the EU Renewable Energy Directive (RED) which sets minimum GHG saving targets of 36% for transport biofuels using to 50% by 2017 for existing refineries and 60% for new refineries.
- The RED biofuel target is 10% inclusion (dry energy content) of road transport fuel by 2020.
- A separate Fuel Quality Directive (FQD) implemented by 2011, will aim for an overall GHG reduction of 6% for road transport by 2020.
- The RED methodology will be adopted for the calculation of GHG emissions for year 3 of the RED starting in April 2010 and these are the figures that everyone will relate to.
Towards 2020

To meet increasing RED biofuel targets for GHG savings and to reduce the carbon footprint of traditional potable alcohol production, suitable ways will be sought to reduce GHG emissions at all stages of alcohol production. Opportunities for processors include generating power from burning biomass rather than fossil fuel. Future policy may favour certain technologies through larger credits for fuel manufacturers to use non-food crops and waste materials. Ultimately, this could provide additional markets for UK growers to supply crop residues and other biomass.

Changes in wheat production could include higher yielding varieties with improved N-use efficiency. This work was initiated under the GREEN Grain LINK project. Further changes could include adopting low input cereals such as triticale, especially if grown after another cereal, due to its greater take-all resistance and lower N requirement compared to wheat. In future, a greater proportion of N fertiliser will be manufactured using abatement technology thus reducing N₂O emissions during production. Other HGCA-funded work through the Min-NO LINK project aims to better understand soil N₂O emissions and eventually develop mitigation strategies. Table 1 shows possible developments in bioethanol production which could bring GHG savings to over 60%. For growers this highlights the importance of increasing yields, whilst reducing N inputs.

Table 1. Growing and processing for bioethanol production from wheat and projected GHG savings

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2017</th>
<th>2020</th>
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<tbody>
<tr>
<td><strong>Growing</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Average yield (t/ha)</td>
<td>75</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Nitrogen yield (%)</td>
<td>30%</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>Proportion of N accounted for by abatement technology (%)</td>
<td>0</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td></td>
<td></td>
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<tr>
<td>Heat and power source</td>
<td>Natural gas turbine, steam generation and steam turbine</td>
<td>Biomass boiler and steam</td>
<td></td>
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<tr>
<td>Credit for co-products</td>
<td>DDGS</td>
<td>DDGS</td>
<td>DDGS</td>
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<tr>
<td>GHG Savings (% relative to petrol)</td>
<td>37%</td>
<td>56%</td>
<td>86%</td>
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Data estimated using the HGCA Biofuel GHG calculator (www.hgca.com/biofuelcalc). Subject to development of legislation under the Renewable Heating Obligation and the RED

Indirect effects on land-use

There has been concern that European biofuel cropping may result in grasslands and forests around the world being converted to crop land as demand increases, so-called 'indirect land-use change'. The amount of carbon released from soils and vegetation through ploughing such lands could be large enough to negate any GHG savings. The Gallagher Review in the UK was carried out to begin to explore some of the potential indirect effects and UK targets for inclusion of biofuels were moderated as a precaution. The UK Department for Transport and the EU Commission are conducting further research to quantify GHG emissions from indirect land-use change.

Indirect effects on land-use will reduce GHG emissions by over 60%. For growers this highlights the importance of increasing yields, whilst reducing N inputs.

Carbon accounting

In future, biofuels may be rewarded according to how much carbon is saved. The Renewable Energy Association, together with the Low Carbon Vehicle Partnership, have examined the feasibility of linking reward to carbon saved (so-called carbon linkage). While delivery mechanisms are not yet in place, if carbon rewards are passed to growers, this will incentivise the development of on-farm carbon reporting methodologies and production of low carbon feedstock.

Further details on possible approaches to carbon linkage are expected in the government’s Action Plan for implementation of the renewable transport elements of the RED and FGD, 2010. Ultimately, these developments may also lead to lower carbon production across the food sector.
Acknowledgements
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HGCA publications

Green fuel you can trust – developing accreditation for bioethanol in the UK. NF1105 HGCA (2006).

Making sense of biofuels. FACTS01 HGCA (2007).


Opportunities and implications of using the co-products from biofuel production as feeds for livestock by B Cottrill, ADAS (and others). Research Review 66. HGCA (2007).


Arable farming and the changing climate: what will it mean, what can I do? CC01 HGCA (2008).

The potential of triticale as a low input cereal for bioethanol production by H Davis-Knight and RM Weightman, ADAS. Project Report 434. HGCA (2008).


Ongoing HGCA projects

Minimising nitrous oxide emissions (Min-NO) LINK. HGCA RD 3474 (LINK 9128) July 2009 to July 2014.

Production of bioalcohols from lignocellulosic waste materials produced in the agri-food chain (‘HOOC’) LINK. HGCA RD 3400 (LINK 0848).

Other reports
Growing wheat for alcohol and bioethanol production in the north east by S Clarke, ADAS and others (2008). Report for NEPIC as part of the regional strategy for transport biofuels.

Nitrogen timings to wheat crops to optimise bioethanol production in the north east by DR Kindred, ADAS and others (2009). Report for NEPIC as part of the regional strategy for transport biofuels.


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