Producing low protein malting barley

Richie Hackett
Oak Park
Outline

• The dilution effect – key to low protein
• Management effects on protein
• Nitrogen effects on protein
• Summary
Low protein malting barley

- % protein ≤ 8.8%
- Referred to as distilling barley
- Very little produced in 2016
- Significant requirement
- Achieving low protein requires large dilution effect
  - Protein must be diluted by grain yield
- Crop requires different management to ‘normal’ malting barley
Dilution of grain protein content

Protein Yield (t/ha) = Grain yield \times \% \text{ Protein}

- Protein yield = tonnes of protein produced per hectare
- \% \text{ protein} = \%N \times 6.25 \text{ (for barley)}
- Protein yield mirrors nitrogen yield
More fertiliser N/hectare = more protein yield/hectare

![Graph showing the relationship between N rate (kg N/ha) and protein yield (t/ha). The graph includes a line for 'After grass' and indicates an 'Extra N from soil.' The x-axis represents N rate (kg N/ha) ranging from 0 to 250, and the y-axis represents protein yield (t/ha) ranging from 0 to 0.8.]
More fertiliser N/hectare = more protein yield/hectare

![Graph showing the relationship between N rate (kg N/ha) and protein yield (t/ha). The graph illustrates a positive correlation with increasing N rate leading to higher protein yield.]
Yield and % protein response to fertiliser N

Yield (t/ha) vs N rate (kg N/ha)

High Dilution

Low Dilution

Protein (%)

protein

Protein (%)
Dilute the protein as much as possible with yield
Protein Yield

Protein Yield (t/ha) = Grain yield × % Protein

% Protein = Protein Yield
            Grain Yield
What influences protein yield

Protein yield = Nitrogen yield

INFLUENCING FACTORS

N inputs

• Fertiliser N rate
• N in manures/slurries

Protein yield

• High organic matter
  - Near grass
  - Repeated manure/slurry inputs
• Very heavy soils
• Previous crop

Soil N

• High organic matter
  - Near grass
  - Repeated manure/slurry inputs
• Very heavy soils
• Previous crop
Survey - Effect of years in tillage on protein

![Bar chart showing the effect of years in tillage on protein content. The chart indicates that protein content decreases with an increase in years of tillage, with the highest protein content observed in the 1-5 years category.](image-url)
Survey – Effects of previous organic manure applications on protein

![Bar graph showing the relationship between organic manure applications in the past 3 years and protein percentage.](image-url)
Management effects on % protein

\[
\text{Protein Yield} \quad = \quad \% \text{ protein} \\
\text{Grain Yield}
\]
Yield limiting factors increase % protein – Phosphorus example

**Protein Yield**

![Graph showing Protein Yield vs P rate (kg P/ha)]

**Grain yield**

![Graph showing Grain yield vs P rate (kg P/ha)]

**% Protein**

![Graph showing % Protein vs P rate (kg P/ha)]

P Index 1 site
Yield limiting factors increase % protein – Sulphur example

![Graphs showing Protein Yield, Grain yield, and % Protein against S rate (kg S/ha)]

The Irish Agriculture and Food Development Authority
Good disease control will help reduce protein

**Protein Yield**

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Protein yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fungicide</td>
<td>0.8</td>
</tr>
<tr>
<td>Low fungicide</td>
<td>0.9</td>
</tr>
<tr>
<td>High fungicide</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Grain yield**

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Grain yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fungicide</td>
<td>8.5</td>
</tr>
<tr>
<td>Low fungicide</td>
<td>9.0</td>
</tr>
<tr>
<td>High fungicide</td>
<td>9.5</td>
</tr>
</tbody>
</table>

**% Protein**

<table>
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<tr>
<th>Fungicide</th>
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<tbody>
<tr>
<td>No fungicide</td>
<td>11.5</td>
</tr>
<tr>
<td>Low fungicide</td>
<td>11.0</td>
</tr>
<tr>
<td>High fungicide</td>
<td>10.5</td>
</tr>
</tbody>
</table>
Non leguminous cover crops small effect on % protein

### Protein Yield

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>Protein yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>phacelia</td>
<td>0.3</td>
</tr>
<tr>
<td>mustard</td>
<td>0.3</td>
</tr>
<tr>
<td>natural regeneration</td>
<td>0.3</td>
</tr>
</tbody>
</table>

### Grain yield

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### % Protein

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<td>9.5</td>
</tr>
<tr>
<td>natural regeneration</td>
<td>9.5</td>
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</table>

No fertiliser N applied
Cover crop management can have small effects on % protein

**Protein Yield**

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<thead>
<tr>
<th>Cover crop management</th>
<th>Protein yield (t/ha)</th>
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</thead>
<tbody>
<tr>
<td>early ploughing + early glyphosate</td>
<td>0.3</td>
</tr>
<tr>
<td>early glyphosate</td>
<td>0.2</td>
</tr>
<tr>
<td>normal ploughing</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Grain yield**

<table>
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<th>Cover crop management</th>
<th>Grain yield (t/ha)</th>
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</thead>
<tbody>
<tr>
<td>early ploughing + early glyphosate</td>
<td>4</td>
</tr>
<tr>
<td>early glyphosate</td>
<td>3</td>
</tr>
<tr>
<td>normal ploughing</td>
<td>2</td>
</tr>
</tbody>
</table>

**% Protein**

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<th>% Protein</th>
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<td>early ploughing + early glyphosate</td>
<td>8</td>
</tr>
<tr>
<td>early glyphosate</td>
<td>7</td>
</tr>
<tr>
<td>normal ploughing</td>
<td>6</td>
</tr>
</tbody>
</table>
% Protein – influencing factors

- Agronomic management (excluding N) can have modest effects on % protein
- Nitrogen inputs have a more consistent effect on protein
  - More nitrogen = Higher % protein
- Factors that give the crop more N will tend to give increased protein
  - Fertiliser N
  - Slurries/manures
  - High soil organic matter/heavy soils
  - Leguminous cover crops
Leguminous cover crops can increase % protein

Must have lots of legume to get effect
Fertiliser N trials

- Range of fertiliser N rates (0-240 kg N/ha)
- Range of sites
  - Low N index sites
- Some N in seedbed (30-40 kg N/ha)
- Remainder at mid tillering (split second split for very high rates)
- Measured yield and protein
- Used data to examine how different N rates affected yield and protein
Little effect of delayed split on yield; small positive effect on protein.

Note: Applications at GS61 can lead to immature (green) tillers at harvest.
Effect of N rate on grain yield and Nopt over sites and seasons (Low N index sites)
A given fertiliser rate can give a range of protein %

![Graph showing the relationship between N rate and protein content (7.7% and 13.2%).]
Chances of meeting distilling standard decrease as fertiliser N increases

8.8% protein
Chances of meeting distilling standard decrease as fertiliser N increases

% crops ≤ 8.8 % protein
Protein increases by 0.2% for every 10 kg N/ha

\[ y = 0.021x + 6.635 \]
Nitrogen rate questions

- What was the economic N rate?
- What protein does the economic optimum N rate give?
- What was the average N rate that gave distilling spec barley?
- How does this rate compare with the economic optimum rate?
- Was there a yield penalty incurred in producing distilling spec barley?
### Fertiliser N rates for yield and protein
### Summary of 22 sites (2011-2016)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic optimum N rate ((N_{\text{opt}}))</td>
<td>kg N/ha</td>
<td>177</td>
<td>120</td>
<td>241</td>
</tr>
<tr>
<td>Yield at (N_{\text{opt}})</td>
<td>(t/ha)</td>
<td>7.7</td>
<td>5.4</td>
<td>9.0</td>
</tr>
<tr>
<td>% protein at (N_{\text{opt}})</td>
<td>%</td>
<td>10.2</td>
<td>8.7</td>
<td>13.0</td>
</tr>
<tr>
<td>N rate that gives 8.8% protein ((N_{8.8}))</td>
<td>kg N/ha</td>
<td>123*</td>
<td>22</td>
<td>221</td>
</tr>
<tr>
<td>Yield at (N_{8.8})</td>
<td>(t/ha)</td>
<td>7.0*</td>
<td>4.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Yield loss between (N_{\text{opt}}) and (N_{8.8})</td>
<td>(t/ha)</td>
<td>0.85*</td>
<td>0.03</td>
<td>2.76</td>
</tr>
</tbody>
</table>

* Data are mean of 20 sites - 2 sites did not produce grain at 8.8% protein.
Scenario analysis

- **Scenario 1**
  - Manage for distilling low protein
  - Use average N rate that gave <8.8% protein (120 kg N/ha)

- **Scenario 2**
  - Manage for yield – hope for distilling
  - Use average optimum N rate (175 kg N/ha)

- **Scenario 3**
  - Manage for yield only (feed barley)
  - Use average optimum N rate (175 kg N/ha)
Methodology

For each of 22 individual sites
• Yield at 120 kg N/ha and 175 kg N/ha
• Determined if protein was below 8.8%
• Calculated value of yield = Yield x grain price
• If protein <8.8% malting premium added to grain price, else feed price used
  • Assumed sufficient brewing barley already produced
• Calculated cost of fertiliser N = fertiliser N rate x Fertiliser N cost
• Margin over fertiliser cost = grain value – fertiliser value
  • No account taken of other costs (seed, transport etc)
• Got average margin for all 22 sites
### Scenario analysis – either distilling or feed

<table>
<thead>
<tr>
<th>N rate</th>
<th>Target</th>
<th>Distilling success</th>
<th>Malting premium</th>
<th>MOFC (€/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>€20</td>
<td>€40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 kg N/ha</td>
<td>Distilling</td>
<td>9/22 (41%)</td>
<td>938</td>
<td>998</td>
</tr>
<tr>
<td>175 kg N/ha</td>
<td>Distilling</td>
<td>4/22 (18%)</td>
<td>959</td>
<td>990</td>
</tr>
<tr>
<td>175 kg N/ha</td>
<td>Feed</td>
<td>-</td>
<td>927</td>
<td>927</td>
</tr>
</tbody>
</table>
Methodology

For each of 22 individual sites
- Yield at 120 kg N/ha and 175 kg N/ha
- Determined if protein was below 10.8%
- Calculated value of yield = Yield x grain price
- If protein <10.8% malting premium added to grain price, else feed price used
- Calculated cost of fertiliser N = fertiliser N rate x Fertiliser N cost
- Margin over fertiliser cost = grain value – fertiliser value
  - No account taken of other costs (seed, transport etc)
- Got average margin for all 22 sites
Scenario analysis – either malting (brewing or distilling) or feed

<table>
<thead>
<tr>
<th>N rate</th>
<th>Target</th>
<th>Malting success</th>
<th>Malting premium €20</th>
<th>Malting premium €40</th>
<th>Malting premium €60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MOFC (€/ha)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 kg N/ha</td>
<td>Distilling</td>
<td>20/22 (90%)</td>
<td>1012</td>
<td>1148</td>
<td>1283</td>
</tr>
<tr>
<td>175 kg N/ha</td>
<td>Distilling</td>
<td>17/22 (77%)</td>
<td>1056</td>
<td>1182</td>
<td>1310</td>
</tr>
<tr>
<td>175 kg N/ha</td>
<td>Feed</td>
<td>-</td>
<td>927</td>
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MOFC = grain value – fertiliser cost
Summary

• Choose long term tillage site (but one with good yield potential)
• Avoid sites with history of manure/slurry application
• Ideally choose site with history of low protein
• For low protein manage crop for maximum yield with minimum fertiliser N input (to maximise dilution effect)
  • Sow early but in good conditions
  • Ensure adequate lime, P, K and other nutrients
  • Ensure good weed, disease and pest control
• Ideally not more than ~120 kg N/ha to maximise chances of low protein
  • Use previous protein from field to help guage fertiliser N inputs
  • Protein reduces by ~ 0.2% per 10 kg N/ha
• Timing of N inputs not very critical