Today’s talk

• GHG emissions explained
• How to calculate GHG emissions
• Indirect land use change (ILUC)
• Cost of disease on GHG emissions
Main sources of direct GHG emissions

Segregated the C footprint into 8 categories

Emissions originate from three divisions:

1. Embedded emissions
   - Seed
   - Ag-chemical manufacture
   - Nitrogen fertiliser manufacture
   - Non-N fertiliser manufacture

2. Energy
   - Operations

3. Direct and indirect $N_2O$ emissions
   - Nitrogen fertiliser application
   - Manure application
   - Crop residue decay

C footprint of YEN Zero 2021 and 2022 winter wheat (feed and seed) crops n=157

17 October 2023
Calculating GHG emissions

**Activity × Emission Factor = Greenhouse gas emissions**

**Greenhouse gas emissions × Global Warming Potential = kg CO₂eq**

- Rate of ag-chemicals based on kg of active substance applied per ha
- Emission factors for ag-chemicals sourced from Green et al. (1987)
YEN Zero Crop C footprints, per hectare

1000
500
0

C footprint (kgCO2e/ha)

Peas-combining
Winter field beans
Winter barley-malting
Winter Rye
Spring Oats
Spring barley-feed or seed
Spring wheat
Winter Oats
Winter barley-malting
Winter wheat-feed or seed
Winter wheat Triticale
Maize - forage or seed
Winter wheat-milling
Winter oilseed rape

No. entries

0
20
40
60
80
100
120
140
160
180

Low N input cereals

N fixing crops

High N input crops
Analysis of GHG intensities for past Cereal YEN crops N fertiliser and N$_2$O dominant

Can we better understand what’s driving this variation?

17 October 2023
Factors associated with low C intensity (Feed wheat)

**Higher yield** associated with lower C intensity
Extra 1 t/ha ≈ reducing C intensity by 15 kg CO₂/t

**Lower N rate** associated with lower C intensity
Reducing by 30 kg N/ha ≈ reducing C intensity by 18 kg CO₂/t
Crops with low GHG emissions

• High yields
• Low rate of synthetic N fertiliser, greater use of fertiliser efficiency products
• Wheat more often following non-cereal break crops
• Less intensive cultivations, less grain drying (wheat)
• Less manures and P, K fertiliser
  • but these may be applied elsewhere in rotation
Effect of Land use change (LUC)

17 October 2023
### Effect of Land use change (LUC)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Forest</td>
<td>553-824</td>
<td>604-824</td>
</tr>
<tr>
<td>Temperate forest</td>
<td>297-627</td>
<td>688-770</td>
</tr>
<tr>
<td>Tropical grassland and savannah</td>
<td>189-214</td>
<td>75-305</td>
</tr>
<tr>
<td>Temperate grasslands</td>
<td>139-242</td>
<td>111-200</td>
</tr>
<tr>
<td>Wetlands</td>
<td>748</td>
<td>1146</td>
</tr>
</tbody>
</table>

Figures are calculated over a 30 year period.
Many scenarios possible
Large variation in GHG emissions associated with LUC

**LUC scenario**
- Calculate yield foregone at crop management intensity below that required for economically optimum yield
- Calculate additional land area required to produce foregone yield
- Extra land is converted from another land use type
  - E.g. temperate grassland or tropical forest
  - Grassland conversion emits 6000 kg CO$_2$ e/ha per year
Impact of LUC using N fertiliser as an example

Kindred et al. (2008) Aspects of Applied Biol. 88
Impact of LUC using N fertiliser as an example

Kindred et al. (2008) Aspects of Applied Biol. 88
Impact of LUC using N fertiliser as an example

Kindred et al. (2008) Aspects of Applied Biol. 88
Quantifying the effects of fungicides and disease resistance on greenhouse gas emissions associated with wheat production

P. M. Berry\textsuperscript{a*}, D. R. Kindred\textsuperscript{b} and N. D. Paveley\textsuperscript{a}

\textsuperscript{a}ADAS High Mowthorpe, Druggleby, Malton, North Yorkshire YO17 8BP; and \textsuperscript{b}ADAS Boxworth, Battlegate Road, Boxworth, Cambridgeshire CB3 8NN, UK
Land use (UK wheat scenario)

- Fungicides increase UK wheat yield by 21%
- Reduce wheat area to produce 15Mt by 0.5M ha
Disease and its effect on GHG emissions (in 2008)

Reduction in wheat growing area means less GHG emissions to produce 15 Mt grain

<table>
<thead>
<tr>
<th>Scenario</th>
<th>GHG emissions (Mt CO$_2$ eq. per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease free</td>
<td>4.70</td>
</tr>
<tr>
<td>Fungicide treated</td>
<td>4.91</td>
</tr>
<tr>
<td>Untreated (2008 cultivars)</td>
<td>5.84</td>
</tr>
<tr>
<td>Untreated (2008 cultivars with Septoria leaf blotch resistance increased by one point)</td>
<td>5.59</td>
</tr>
<tr>
<td>Controlling wheat disease completely can save up to</td>
<td>1.14</td>
</tr>
</tbody>
</table>
Different yields and GHG emissions

Berry et al. (2008) Plant Pathology 57, 1000-1009
Varietal resistance

- Reduction in fungicide input
- Lower GHG emissions when ILUC taken into account

Each unit increase in resistance rating (1–9 scale) to Septoria leaf blotch reduced disease-induced yield loss by $0.31 \text{ t ha}^{-1}$. 
Main findings

• Approximately 70% of total GHG emissions in wheat production are associated with N fertiliser
• Disease interferes with green area and thus with yield
• Less grain produced means more land is needed for the same amount of grain

• On average disease reduces yield from 10.20 t/ha to 8.42 t/ha

  Increasing the net GHG emissions 59 kg CO$_2$eq./t

  A need to convert land elsewhere to obtain the same yields would result in an increase in GHG emissions of 277 kg CO$_2$eq./t
Thank you