YEN ZERO

CROP C FOOTPRINT ANALYSIS

2022

YEN User ID	YZ1000
Entrant name	John Smith
Farm name	Example Farm
Location	Cambridge
Crop type(s)	W. Beans, S. Wheat, W. Wheat (milling), S. Barley (malting)
Harvest year(s)	2021
Sponsor/supporter	Engager
Sponsor/supporter email	engager@email.com

INTRODUCTION

We would like to thank you for submitting your crop entries into YEN Zero.

This report provides a detailed assessment of the greenhouse gas (GHG) emissions, and subsequent carbon (C) footprint, associated with your farming operations. It highlights where the emission hotspots lie in your system and provides an indication of which mitigation strategies may be suitable in reducing your crop GHG emissions. This report is the first of two YEN Zero provides with the second providing a benchmark analysis of your data alongside the range of figures submitted into the YEN Zero network, to allow for comparison.

GHG EMISSIONS ASSESSMENT

A GHG emissions assessment, or C footprint, is a way of estimating the total amount of GHGs emitted from a given activity; reported as the total emissions associated with the production of a product on a per unit area basis (emissions per hectare; kg CO_2e/ha), or on a per unit output basis (emissions per tonne; kg CO_2e/t).

To enable comparison between different greenhouse gases, all emissions are converted into carbon dioxide equivalents (CO_2e), the equivalent amount of CO_2 that would be required to achieve the same amount of global warming, as determined by the IPCC. The standard conversion factors used in this analysis are:

- 1 kg CO_2 = 1 kg CO_2e
- 1 kg CH_4 = 25 kg CO_2e
- 1 kg N_2O = 298 kg CO_2e

THE THREE MOST COMMON ON-FARM GHG EMISSIONS

CARBON DIOXIDE (CO_2)
Produced from combustion of fossil fuels e.g. fuel use

NITROUS OXIDE (N_2O)
Produced during the breakdown of nitrogen compounds e.g. fertiliser and organic residues

METHANE (CH_4)
Produced from livestock and manures

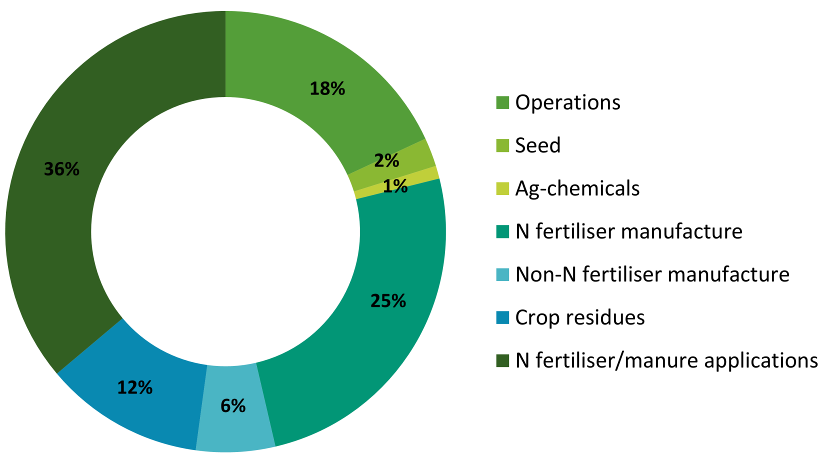
UNDERSTANDING YOUR GHG EMISSIONS

Greenhouse gas (GHG) emissions are generated from on-farm activities.

GHG emissions in this report are separated into seven main categories associated with crop production: (1) operations, (2) embedded emissions from seed, (3) non-nitrogen fertiliser, (4) ag-chemicals, (5) nitrogen (N) fertiliser manufacture, (6) nitrous oxide (N_2O) emissions associated with N fertiliser application and (7) crop residue decomposition.

Farm operations include the combustion of fossil fuels and electricity used in crop production, e.g., for cultivations and grain drying. The manufacture of inputs such as ag-chemicals and non-N fertilisers uses energy and produces carbon dioxide. The manufacture of N fertilisers produces nitrous oxide through the conversion of ammonia to nitric acid. The application of N fertiliser sources (either organic or synthetic), and crop residues left in the field, produce N_2O emissions as bacteria in the soil mineralises the nitrogen, which is exacerbated in wet conditions. The pie chart below is a typical breakdown of GHG emissions by source for a winter wheat feed crop, derived from YEN Zero data.

The contribution of different operation practices will change based on crop management strategies. If more intensive soil cultivation strategies were used then this proportion will be greater in the C footprint. Alternatvely, if the crop was harvested at a high moisture, grain drying can contribute a significant amount to the C footprint. Phosphorus (P) and Potassium (K) fertilisers can be associated with a high manufacture C footprint if multi-nutrient fertilisers which include nitrogen (N) are applied. Manure can account for a large proportion of a crop C footprint due to high total N contents in the material. These emissions can be reduced by incorporating the manure quickly to reduce volatilisation and improve the quantity of nutrients reaching the crop.

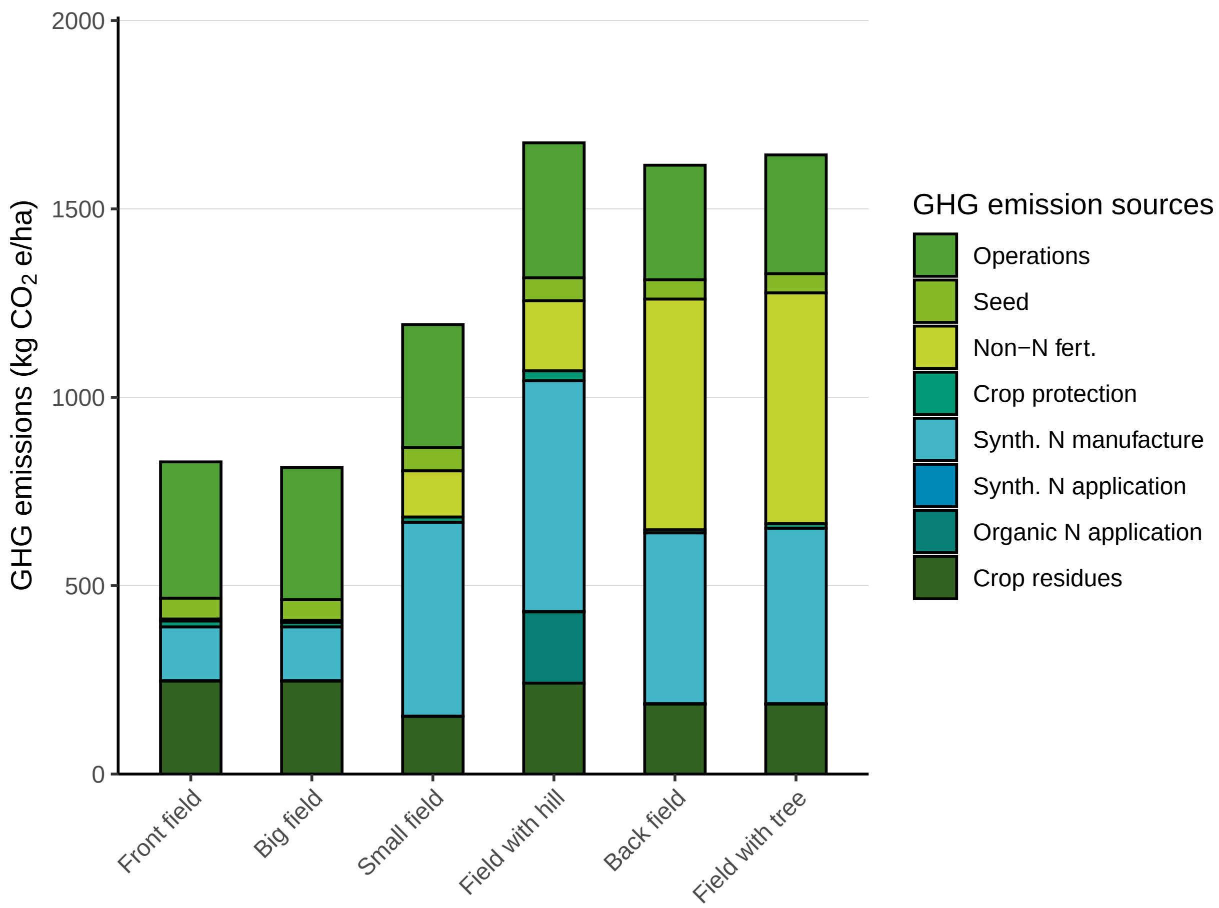


YOUR GHG EMISSIONS

This section provides detailed analysis of the GHG emissions from your farming operations. The table below shows the overall GHG emissions associated with each of your entries.

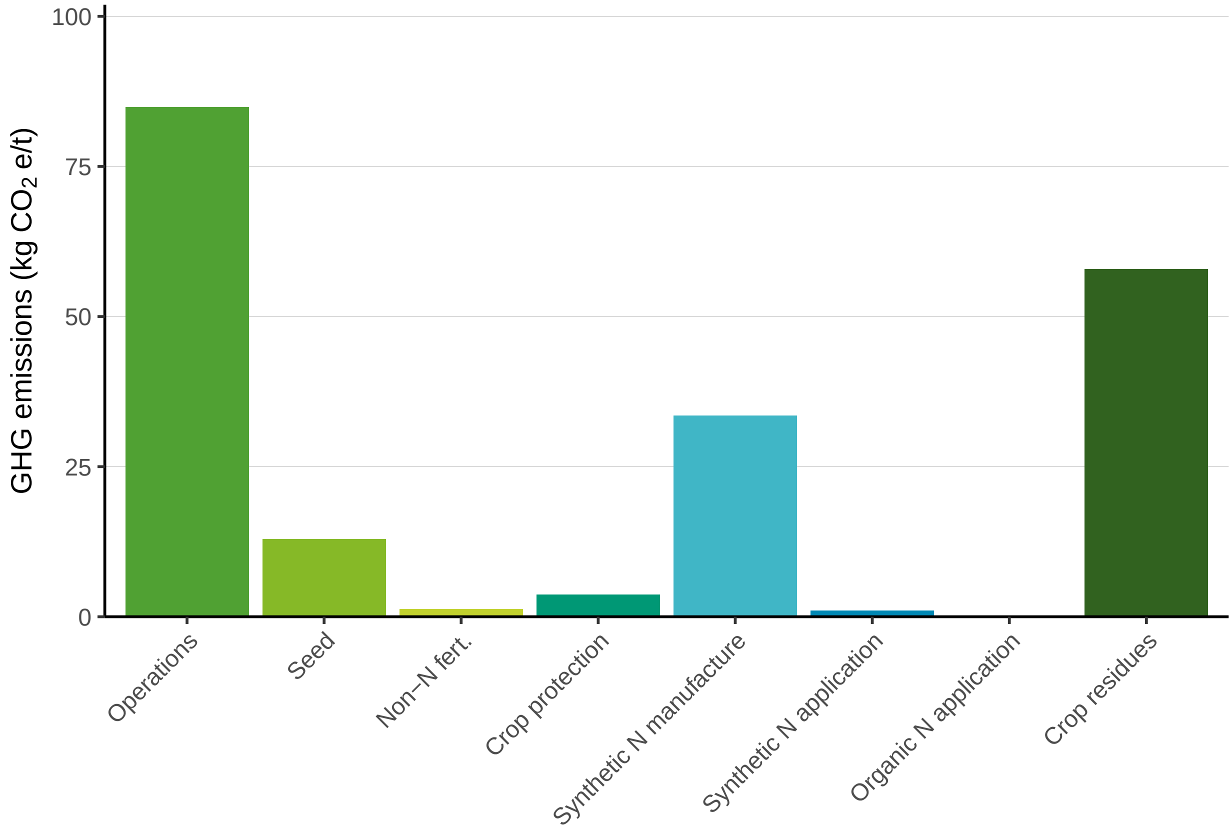
Entry	Field name	Crop type	Variety	Yield	GHG emissions	
				t/ha	kg CO2e/t	kg CO2e/ha
1	Front field	W. Beans	Tundra	4.3	703	958
2	Big field	W. Beans	Tundra	4.3	700	943
3	Small field	S. Wheat	Chilham	5.3	281	1485
4	Field with hill	W. Wheat (milling)	Skyfall	8.3	256	2140
5	Back field	S. Barley (malting)	LG Diablo	5.2	358	1848
6	Field with tree	S. Barley (malting)	LG Diablo	5.2	366	1887

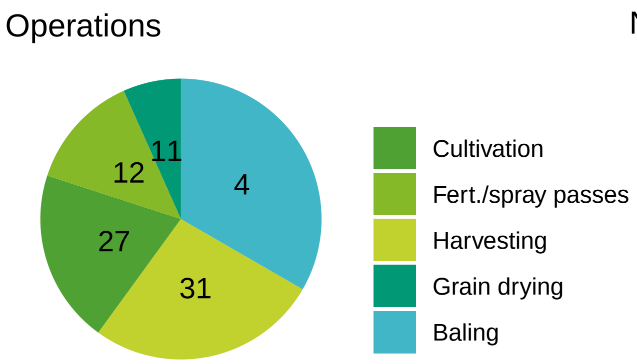
The graph below shows the total GHG emissions (per ha) for each of your entries, broken down into the main emission sources.

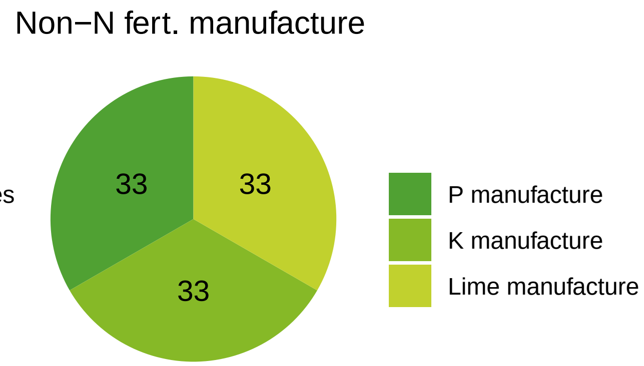


The following charts describe the emission sources within your crop production system, on a per tonne of output basis, for each field entered into YEN Zero.

Front field - W. Beans

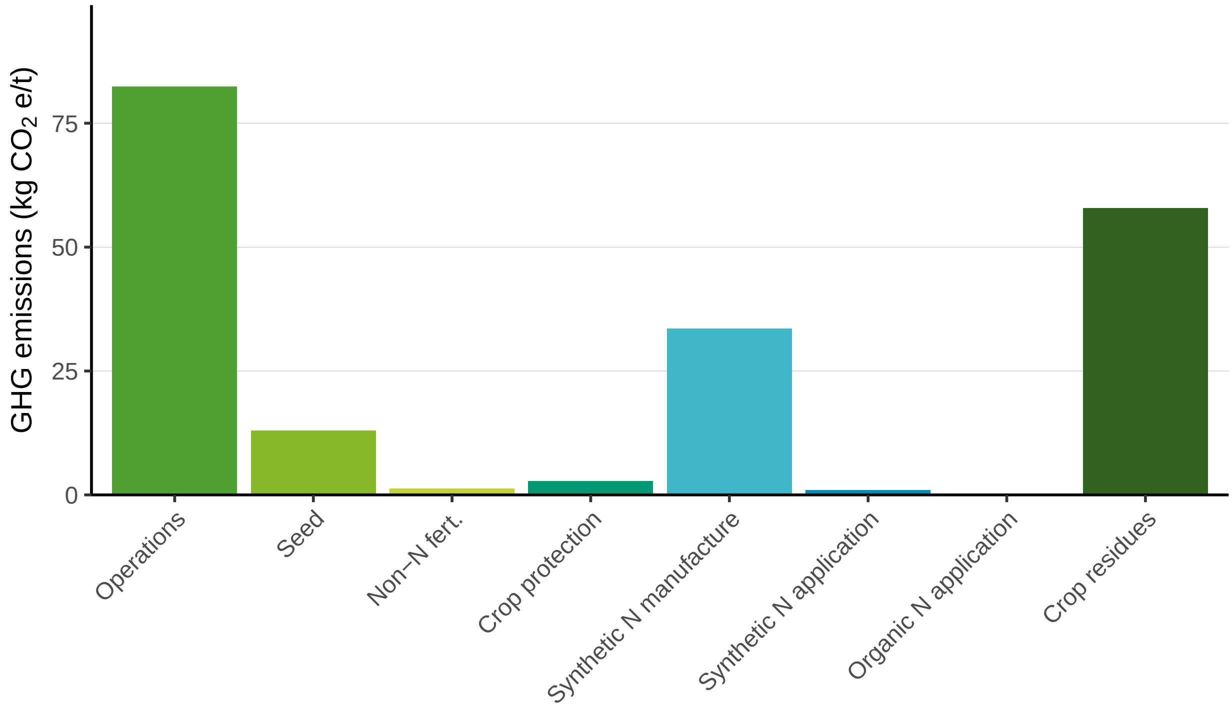


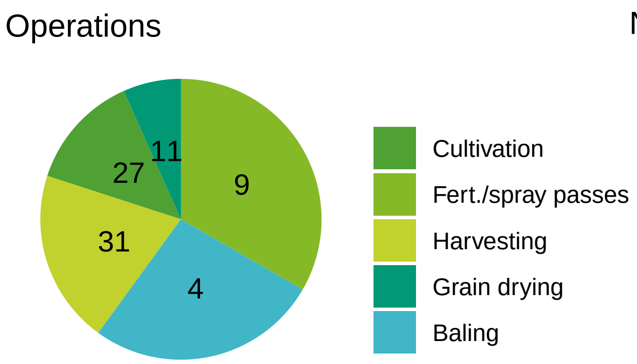


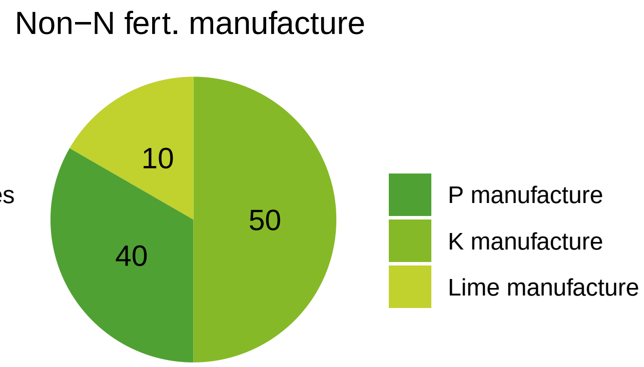


Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	39.4	0	0	77	0	none	5	1	Removed

Big field - W. Beans

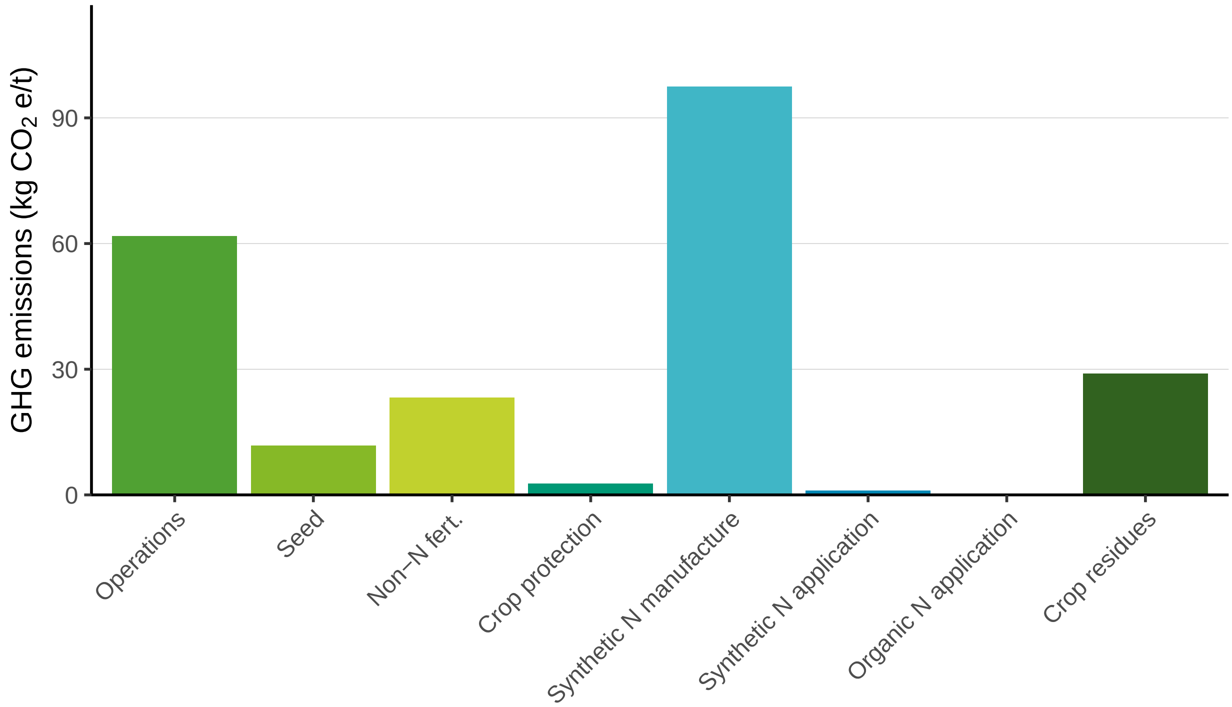


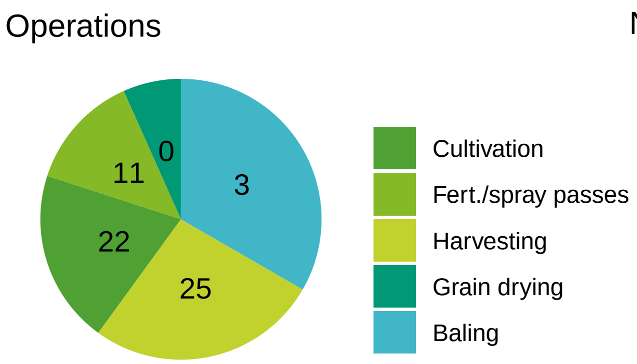


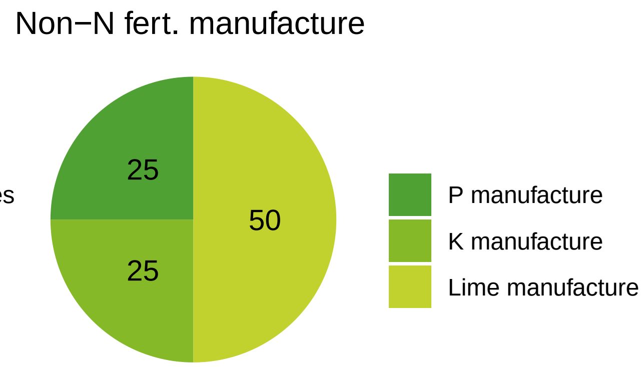


Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	39.4	0	0	77	0	none	4	1	Removed

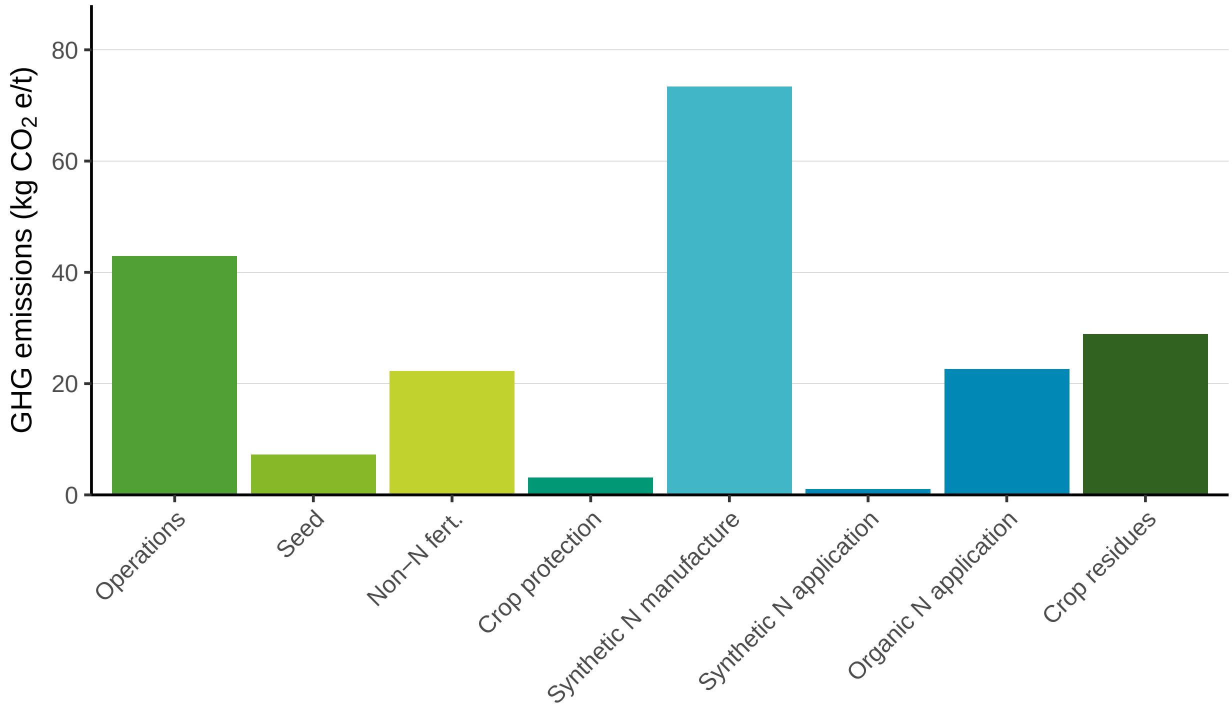
Small field - S. Wheat



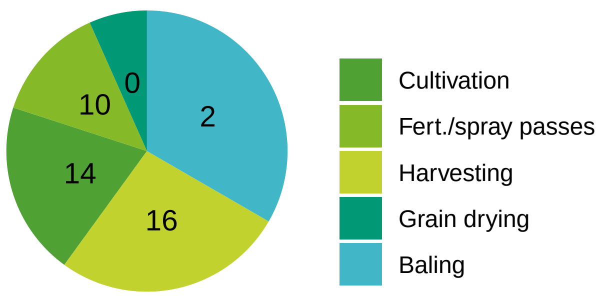




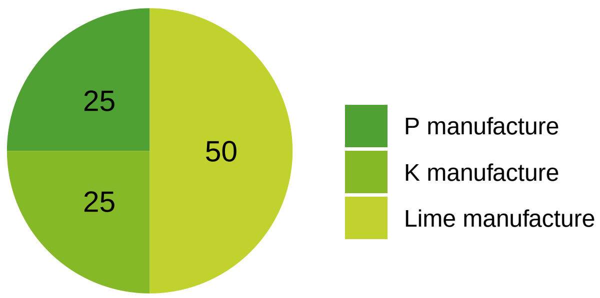
Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	147	0.85	0	1750	6120	none	4	0	Removed



Operations

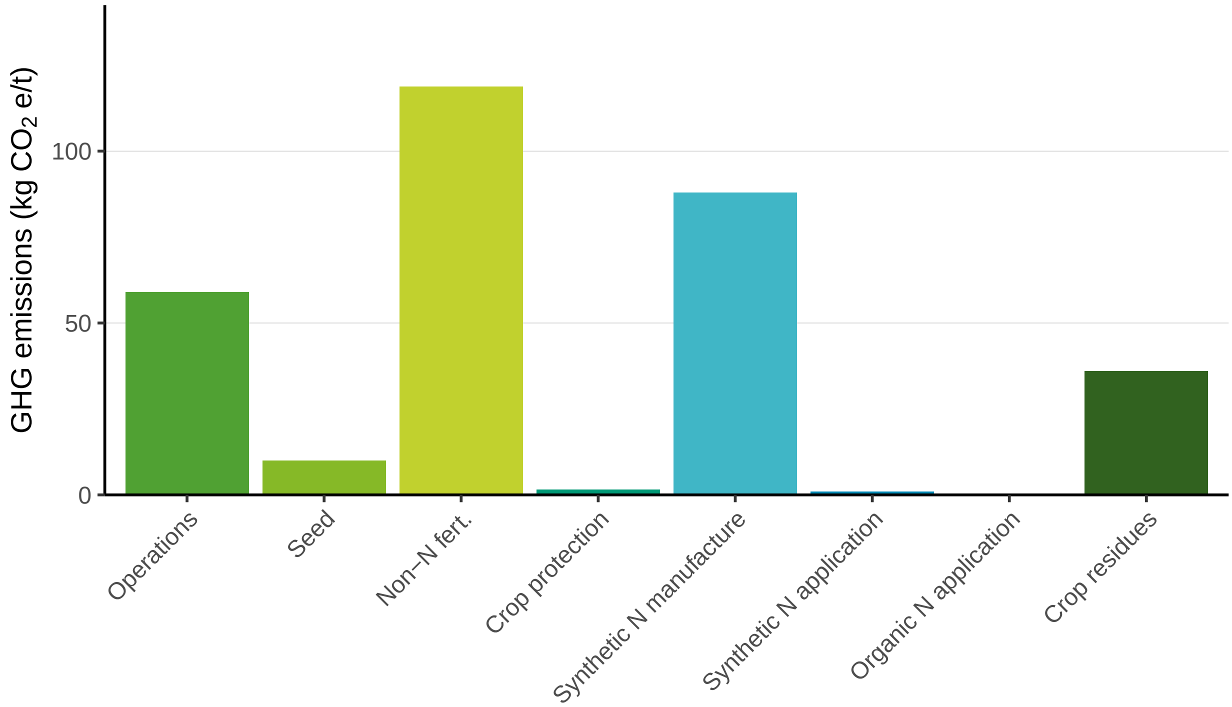


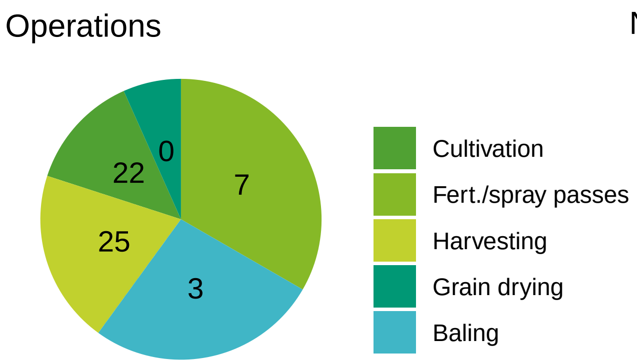
Non−N fert. manufacture

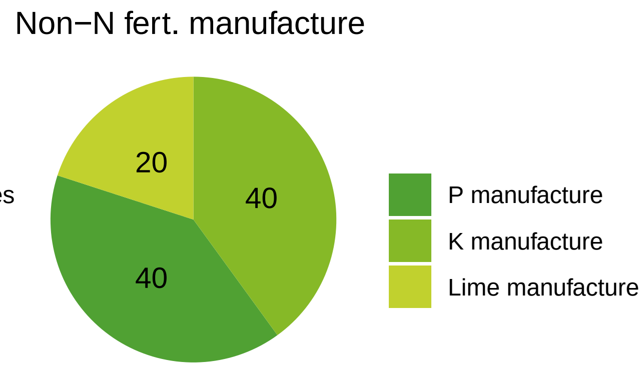


Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	182.2	1.7	0	2623	12	Cattle FYM	6	0	Removed

Back field - S. Barley (malting)

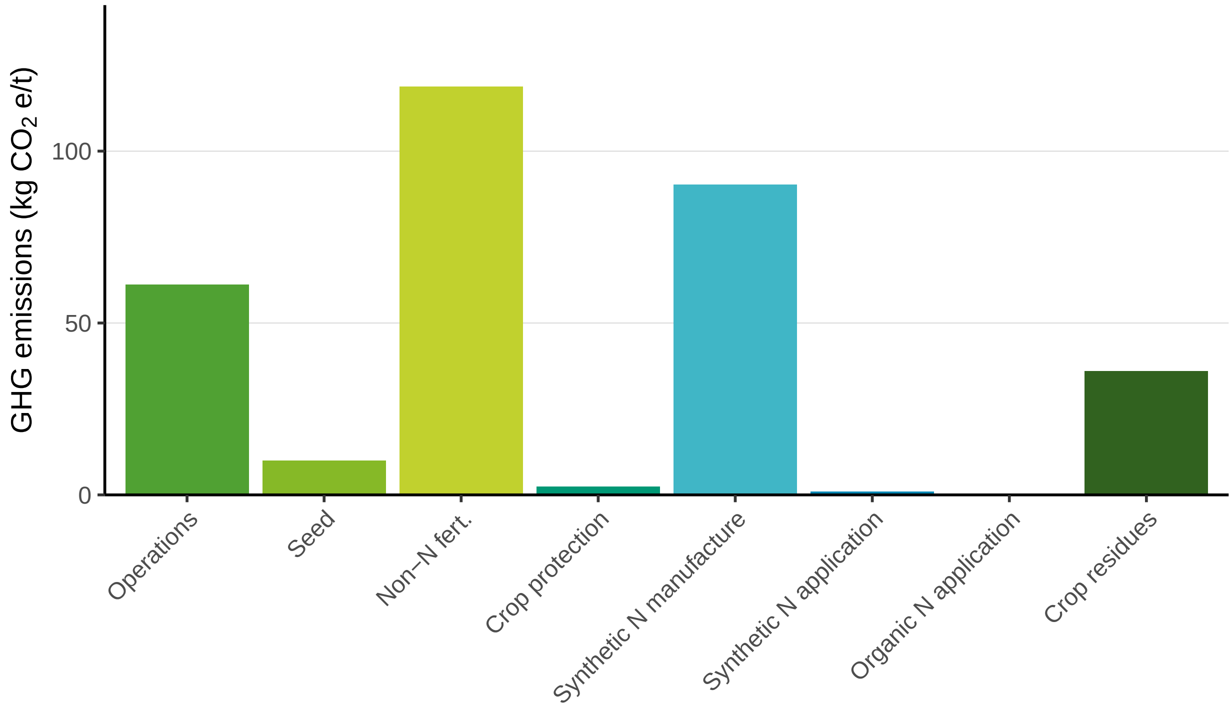


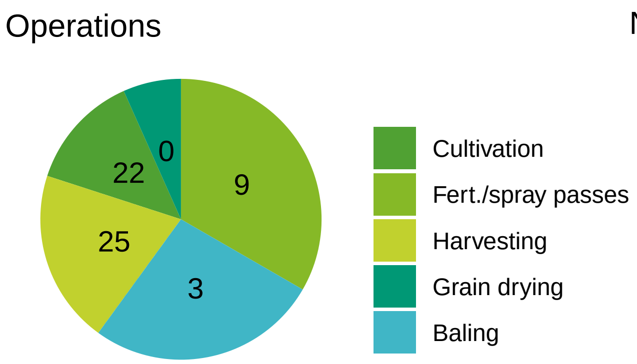


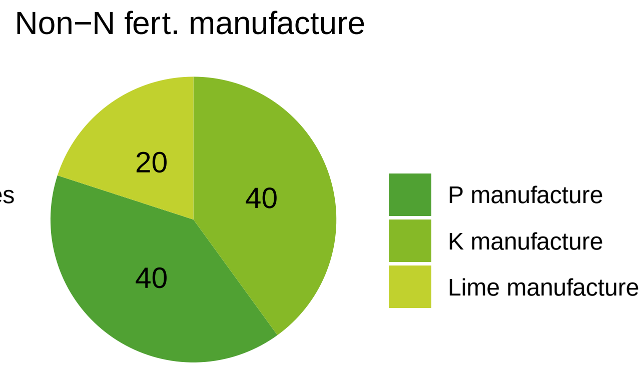


Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	129.5	20	0	8750	0	none	2	0	Removed

Field with tree - S. Barley (malting)





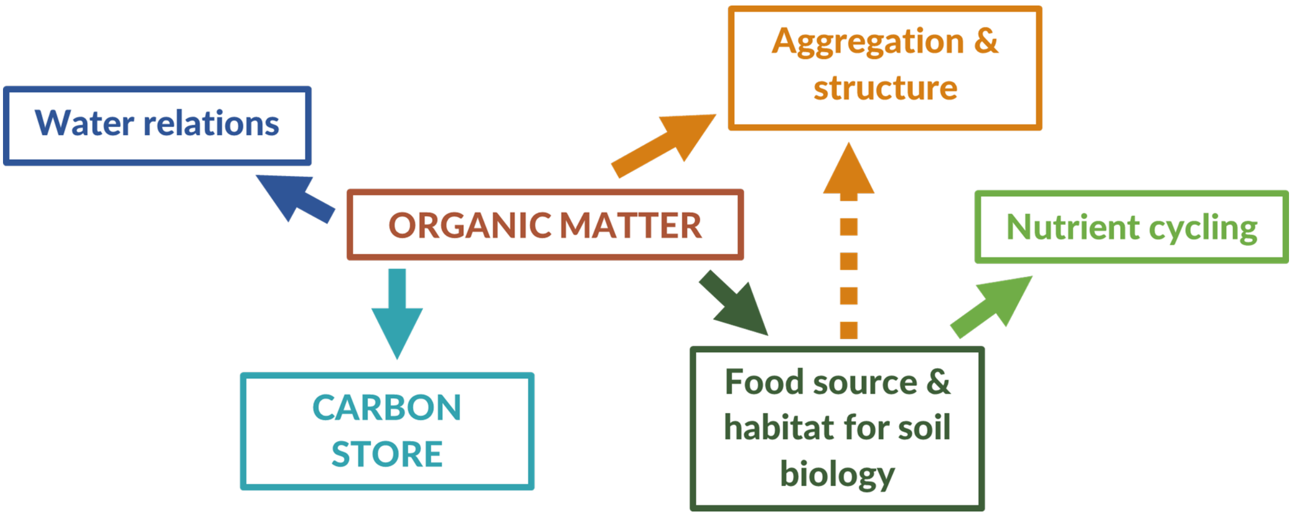


Cultivation type	Total N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	No. ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion (>6 cm)	133	20	0	8750	0	none	3	0	Removed

SOIL ORGANIC MATTER

In YEN Zero crop C footprint analysis, C sequestration in soils is not considered because our current understanding does not allow for accurate quantification of soil C sequestration, without measurement of soil C stocks, which is time intensive and costly. The Sustainable Soils Alliance is currently working to establish a UK Farm and Soil Carbon Code which aims to provide scientifically valid minimum standards for quantification of soil C sequestration in our agricultural soils, bringing consistency to the industry.

Prior to the release of the Soil Carbon Code, YEN Zero is using soil organic matter (SOM) as a proxy to understand the amount of soil C in a YEN Zero field. SOM is an easier characteristic to measure in soils, and an increasingly common assessment undertaken by growers in the determination of soil health. Carbon is a major component of SOM, comprising approximately 58%, and therefore a good indication of soil C levels. It is also an important characteristic to monitor and endeavour to improve, as it provides important benefits such as increased water holding capacity, improved soil structure and workability, nutrient retention, and turnover, which can all contribute to more efficient crop management and nutrient use that is associated with lower GHG emissions.



Organic matter does not accumulate in soils indefinitely, and if management remains unchanged, it reaches an equilibrium where inputs in the form of crop roots and residues equal outputs such as CO_2 from soil respiration produced during the breakdown of these materials. The final equilibrium will differ depending on soil type (particularly clay content), climate conditions (particularly rainfall) and land use (e.g., grass vs arable). Therefore, it is important to know what the potential is for our soils to build up levels of SOM, to understand where the ceiling is. Soils with a high proportion of clay in wet regions of the UK can store higher amounts of soil C.

YOUR SOIL ORGANIC MATTER

YEN Zero has determined the potential level of SOM your soil can achieve, using the AHDB/BBRO Soil Health Scorecard benchmarking guidance (Griffiths et al., 2018), which gives a range of 'typical' SOM contents according to clay content, rainfall region and cropping (grass vs. arable). The upper values in this guidance are considered to be what is potentially achievable on your soil type with a significant and sustained change in practice, although factors such as land use/management history, drainage class, soil pH and position in the landscape will also affect the final equilibrium value. It is important to note that any achieved increases in organic matter can be rapidly reversed unless the change in practice is maintained.

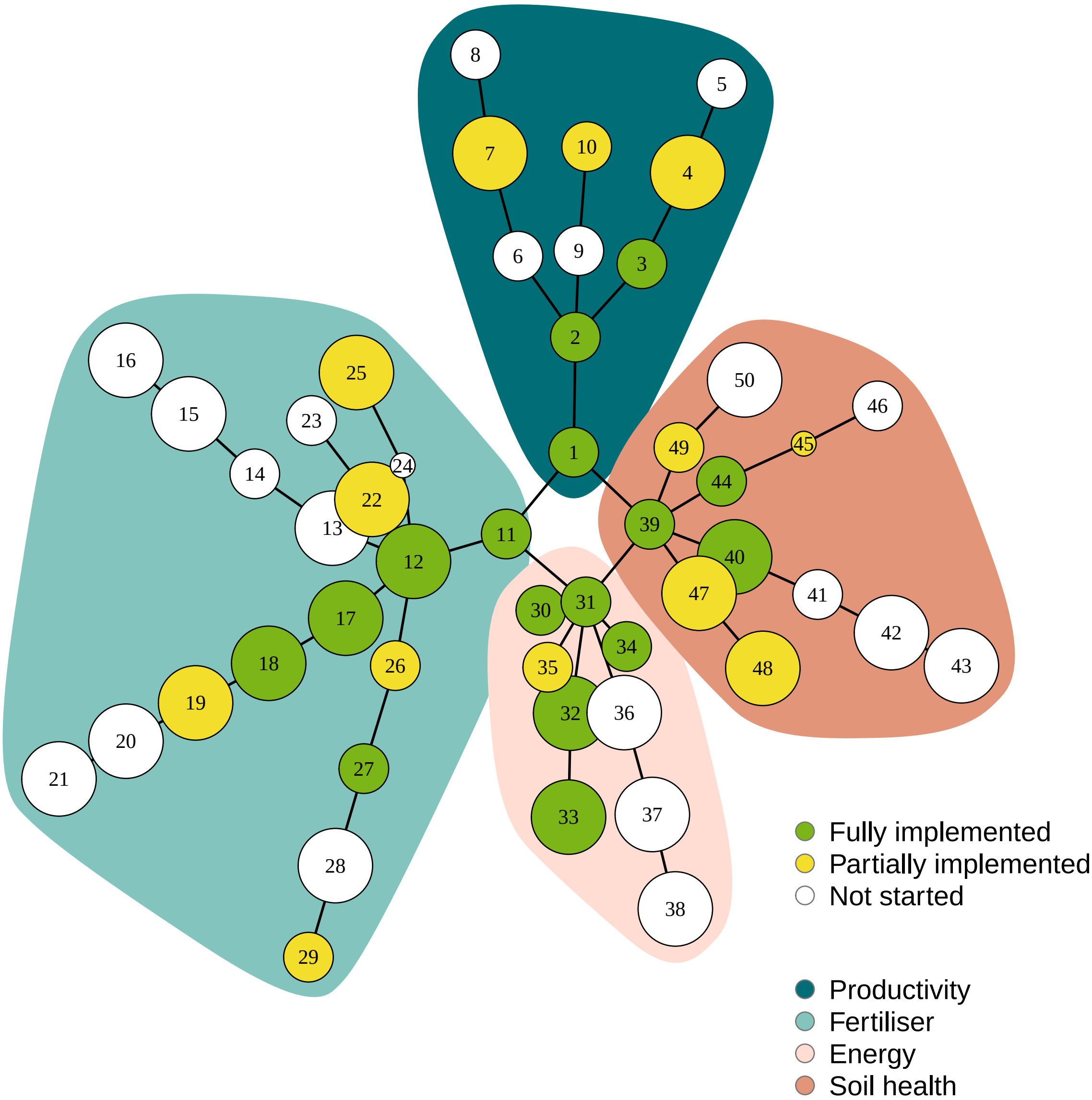
Entry	Field name	Proportion of clay in soil (%)	Long term annual rainfall (mm)	Current SOM level (%)	potential SOM level (%)
1	Front field	Medium	717		4.1 - 6.1
2	Big field	Medium	717		4.1 - 6.1
3	Small field	Medium	717		4.1 - 6.1
4	Field with hill	Heavy	717		5.3 - 7.7
5	Back field	Heavy	717		5.3 - 7.7
6	Field with tree	Heavy	717		5.3 - 7.7

REDUCING GHG EMISSIONS

The schematic below provides a summary of some of the main strategies which can be implemented on-farm to reduce emissions associated with your crop production system.

Each bubble represents a GHG mitigation practice (there is a full list on the next page). The size of the bubble indicates the relative impact on reducing GHG emissions (larger = greater impact). Practices are grouped into four main categories, although some have benefits across multiple categories. Each category has a "core" practice at the centre, which is foundational to the others and should be implemented first. In general, as practices radiate outwards, they become more difficult and/or costly to implement - although often have greater emission reduction potential. If you provided information on what practices you have implemented already, then this will be shown with green (fully implemented) and yellow (partially) bubbles.

This diagram is intended to help you identify and prioritise practices that will have the greatest impact for the least cost. To use it, follow each branch of the tree from the centre to the outside until you find practices that you haven't already implemented. Note down all of these potential practices and then refer to the key on the next page. Of these, consider what is most practical within your production system and seek further information on how best to implement.



ID	Practice
1	Soil nutrient and pH sampling (ensure nutrients are not limiting)
2	Optimise soil pH
3	Create crop health plan
4	Choose disease-resistant varieties
5	Use integrated pest management
6	Optimise seed rate
7	Review crop rotation, consider crops & varieties with a low N requirement
8	Measure yield and protein to assess offtake success
9	Improve soil conditons to encourage root growth
10	Monitor crop nutrition to prevent deficiencies
11	Measure soil mineral N (plus crop N). Base N rate on realistic yield and quality expectations
12	Use nutrient management planning
13	Purchased fertiliser from abated sources
14	Use variable rate fertiliser application
15	Use urease inhibitors
16	Use nitrifcation nhibitors
17	Calibrate fertiliser spreader
18	Consider method & timing of organic material applications to minimise NH3 losses & leaching (rapdily incorporate)
19	Measure nutrient content of manures to fully account for inputs
20	Don't apply in warm, wet conditions
21	Ensure good field drainage
22	Use legumes in the rotation
23	Grow cover crops before spring crops & catch crops after high N crops such as vining peas to minimise N losses
24	Use N-efficient varieties
25	Adjust N rate according to SMN and fertiliser recovery (consider soil type and N form)
26	Adjust N rate based on break-even ratio
27	Adjust N rate based on crop growth across season
28	Conduct an on-farm trial to optimise N rate for crop and field
29	Record success of fertiliser strategy by analysing the grain and calculating offtake
30	Create vehicle maintenance plan
31	Plan on-farm operations
32	Harvest grain at correct moisture to reduce drying
33	Reduce tillage frequency/intensity
34	Minimise number of passes by combining sprays
35	Record fuel use
36	Install GSHP for grain drying
37	Install renewable energy sources such as solar and wind
38	Switch to EV/alternative fuel vehicles
39	SOM sampling and monitoring
40	Reduce tillage frequency/intensity
41	Use cover crops
42	Ensure adequate drainage with drainage systems & ditches properly maintained
43	Avoid compaction in the soil profile
44	Apply organic materials
45	Incorporate straw
46	Store organic materials on concrete pads to reduce leaching
47	Extend field margins
48	Expand hedgerows (or fill gaps in existing)
49	Introduce/extend grass/herbal leys in rotation
50	Plant agroforestry

YEN ZERO SPONSORS

We are most grateful to all our sponsors. They not only provide funding, but they are fundamentally involved in management of YEN Zero and in supporting individual farms in making their entries. YEN Zero would not exist without them!

Upcoming YEN Zero Events

1. YEN Zero Results Meeting, 18th March 09.00-10.30 am

A virtual Results Meeting where ADAS will summarise the YEN Zero Pilot Year, the methodology behind calculating crop C footprints, and present an analysis of the YEN Zero dataset to better understand what is driving the variation in crop C footprints.

Please register for this meeting here.

2. 3rd YEN Zero Pilot Year Discussion Workshop, 5th April 09.00-11.00 am

Our final virtual Discussion Workshop of the Pilot Year will focus on mitigation strategies and provide an opportunity for participants to discuss their results, this will include:

a. What strategies have the most potential to reduce emissions?
b. What strategies are already being successfully used on farm by YEN Zero growers?
c. The practicalities around introducing new mitigation strategies on farm e.g., logistics, cost.

A meeting link to this event will be sent to YEN Zero members very soon.

This report is prepared using standard IPCC and UK National GHG Inventory methodologies for assessment of greenhouse gas (GHG) emissions. Full details of the methodologies used can be found at www.yen.adas.co.uk/projects/yen-zero. For any queries about your report, please contact yenzero@adas.co.uk.