YEN ZERO

CROP C FOOTPRINT ANALYSIS

2023

YEN User ID	
Entrant name	
Farm name	
Location	
Crop type(s)	Maize (forage), S. Barley (malting), W. Wheat (feed), W. Oilseed rape
Harvest year(s)	2023, 2022, 2021, 2020, 2019, 2018
Sponsor/supporter	
Sponsor/supporter email	

INTRODUCTION

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

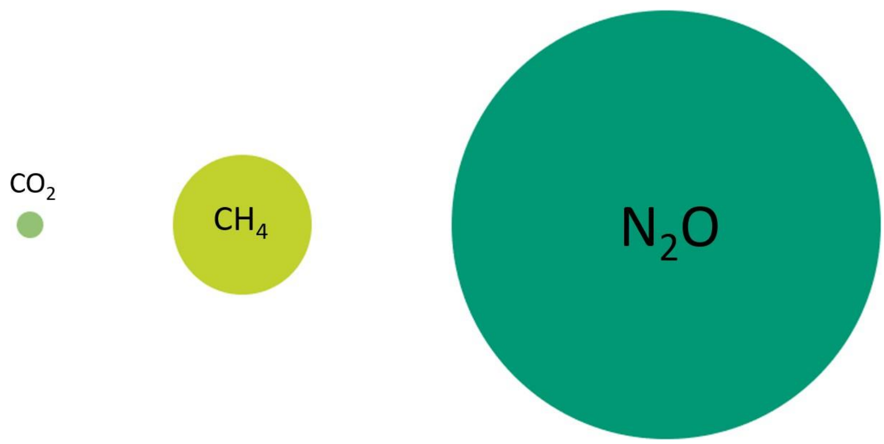
This report provides a detailed assessment of the greenhouse gas (GHG) emissions, and subsequent carbon footprint, associated with your farming operations. It aims to highlight where the emission hotspots lie in your system and provides an indication of which mitigation strategies may be suitable in 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 carbon 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 carbon dioxide (CO_2) = 1 kg CO_2e
- 1 kg methane (CH_4) = 27.2 kg CO_2e
- 1 kg nitrous oxide (N_2O) = 273 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

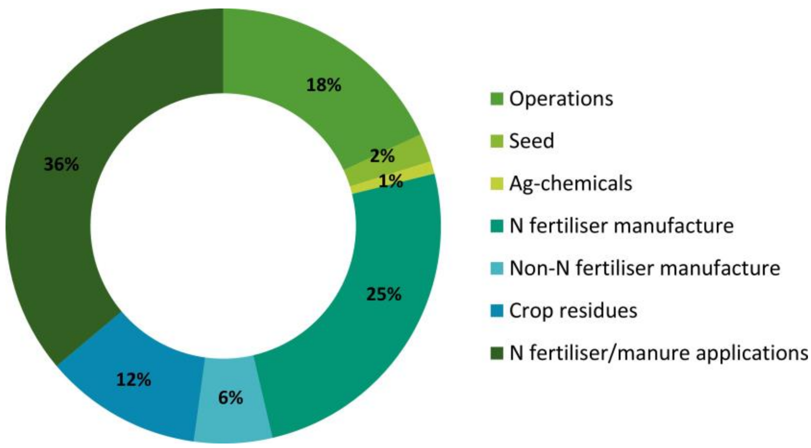
Greenhouse gas (GHG) emissions are generated from on-farm activities.

GHG emissions in this report are separated into seven main categories associated with crop production: embedded emissions of (1) seed, (2) operations, (3) non-N fertiliser manufacture, (4) ag-chemical manufacture, and (5) N fertiliser manufacture, and nitrous oxide (N_2O) emissions associated with (6) N fertiliser and manure 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 i.e., embedded emissions such as ag-chemicals and non-N fertilisers uses energy and produces carbon dioxide. The manufacture of N fertilisers produces nitrous oxide (N_2O) 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 nitrous oxide (N_2O) emissions as bacteria in the soil mineralise the nitrogen, which is exacerbated in wet conditions.

The crop management strategies will determine the extent of emissions per hectare. The emissions per tonne will be further determined by the crop yield. Examples of the impacts of management strategies include: 1) if more intensive soil cultivation strategies were used, then this proportion will be greater in the carbon footprint; 2) if the crop was harvested at a high moisture, grain drying can contribute a significant amount to the carbon footprint; 3) manure can account for a large proportion of a crop carbon footprint due to high total N contents in the material, but these emissions can be reduced by incorporating the manure quickly to reduce volatilisation (although ammonia is not a GHG, it can be converted to N2O after deposition) and improve the quantity of nutrients reaching the crop.

Typical breakdown of GHG emissions by source for a winter wheat feed crop, derived from YEN Zero data.

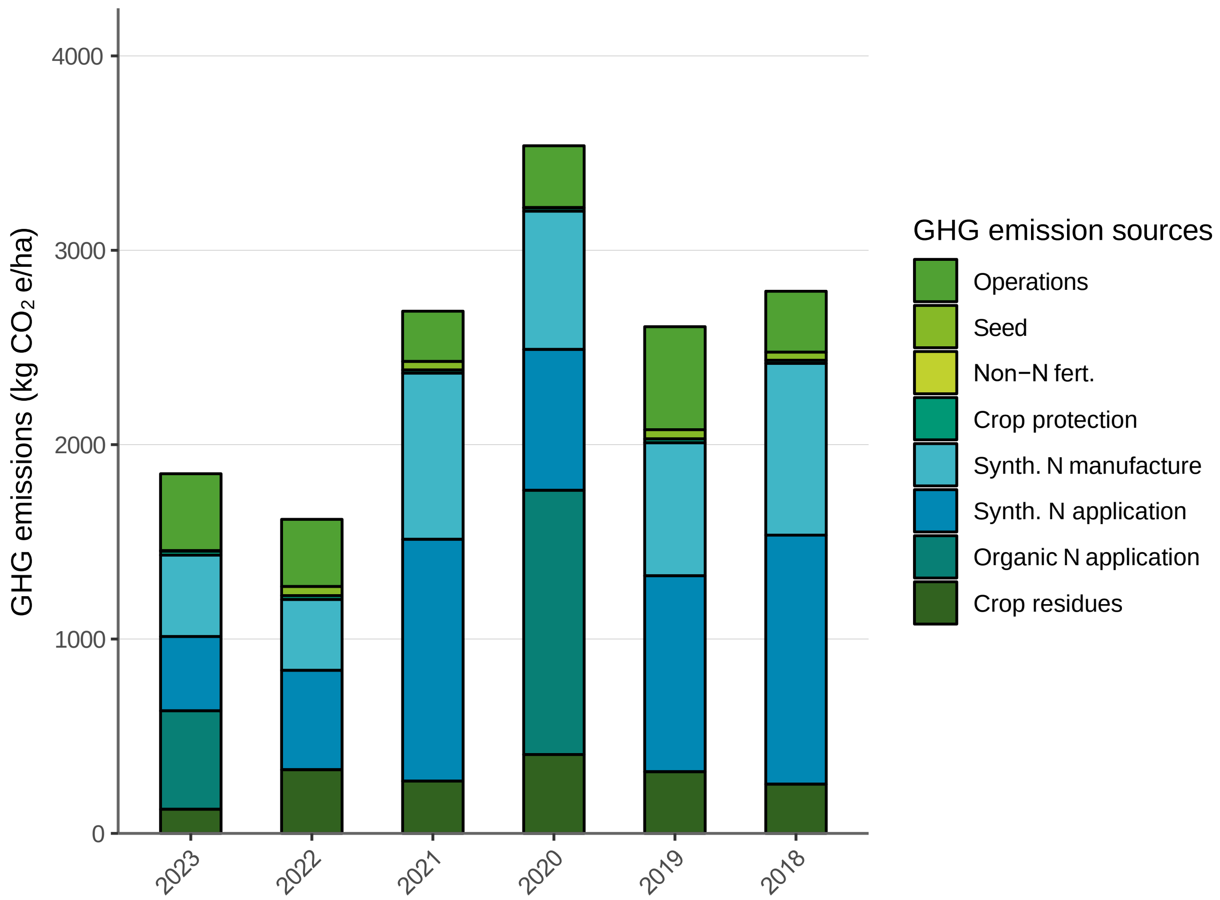


YOUR GHG EMISSIONS

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.

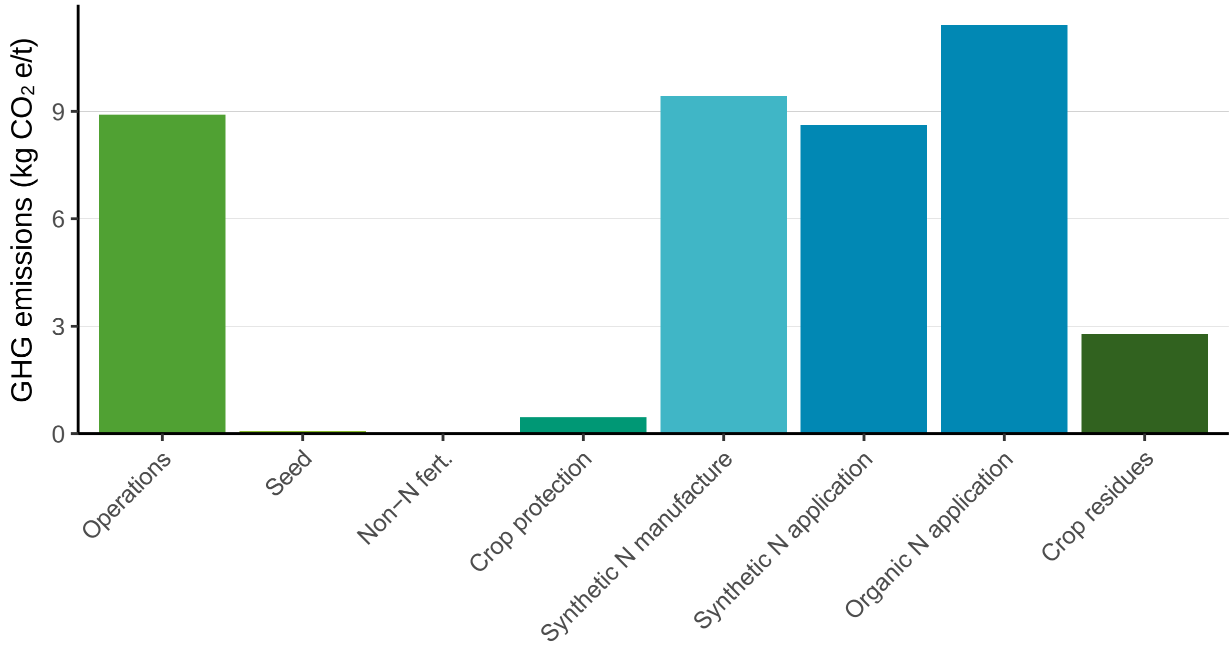
Entry	Field name	Year	Crop type	Variety	Yield	GHG emissions	
					t/ha	kg CO2e/t	kg CO2e/ha
1	Field 1	2023	Maize (forage)	Pioneer 7326.0	44.4	42	1850
2	Field 1	2022	S. Barley (malting)	RGT Planet	8	205	1616
3	Field 1	2021	W. Wheat (feed)	LG Spotlight	8.1	333	2687
4	Field 1	2020	W. Oilseed rape	Phoenix CL	2.3	1545	3538
5	Field 1	2019	S. Barley (malting)	Propino	7.7	342	2607
6	Field 1	2018	W. Wheat (feed)	LG Motown	7.4	368	2789

The graph below shows the total GHG emissions, on a per ha area basis, for each of your entries, broken down into the main emission sources.

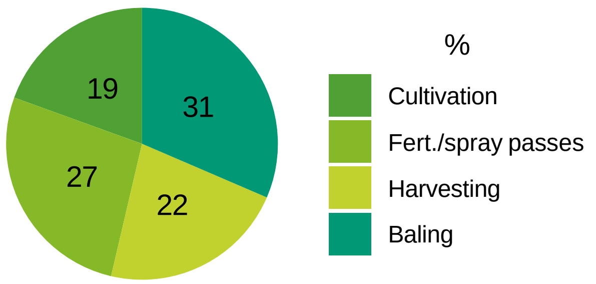


The following charts describe the emission sources within your crop production system, on a per tonne of output basis, for each field entered into YEN Zero.

2023 - Maize (forage)



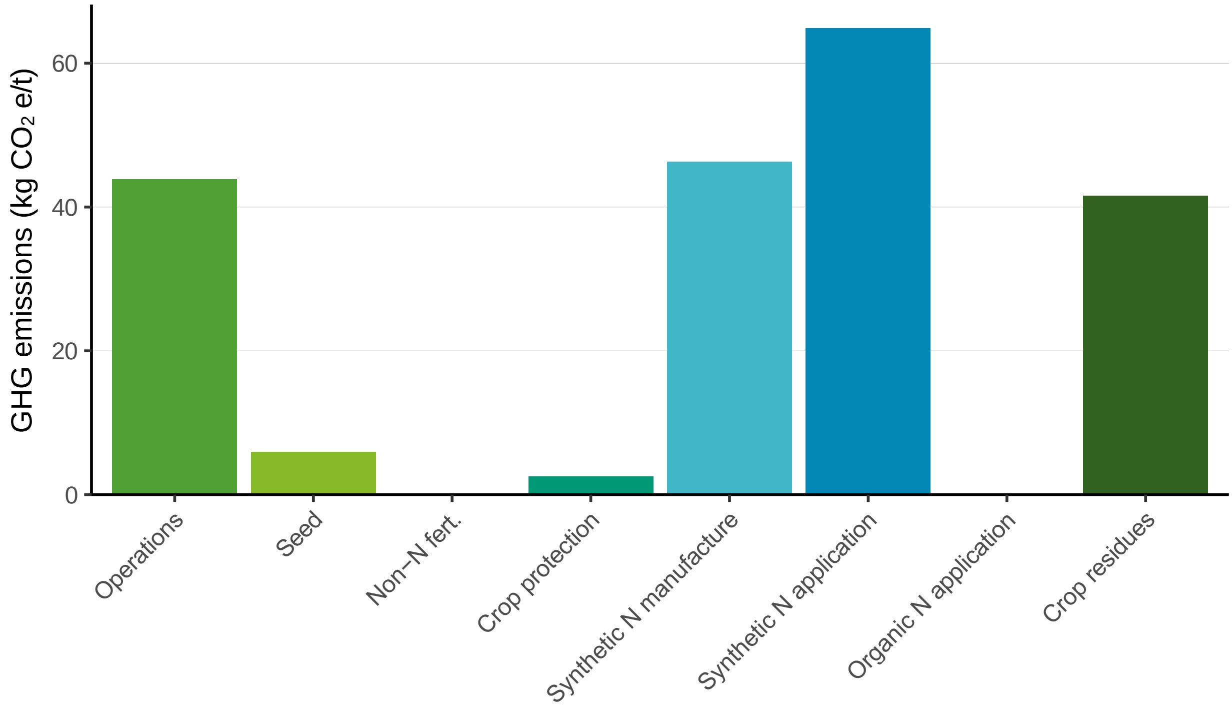
Operations



Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion	104	NULL	NULL	NULL	25	Cattle FYM	5	0	Not chopped

2022 - S. Barley (malting)



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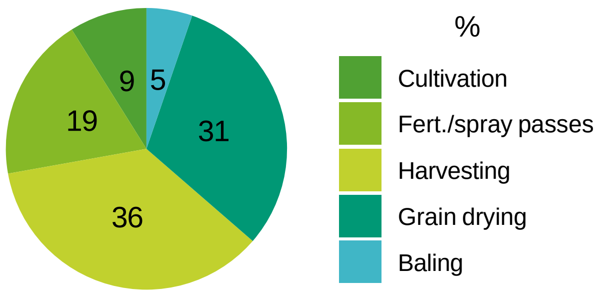
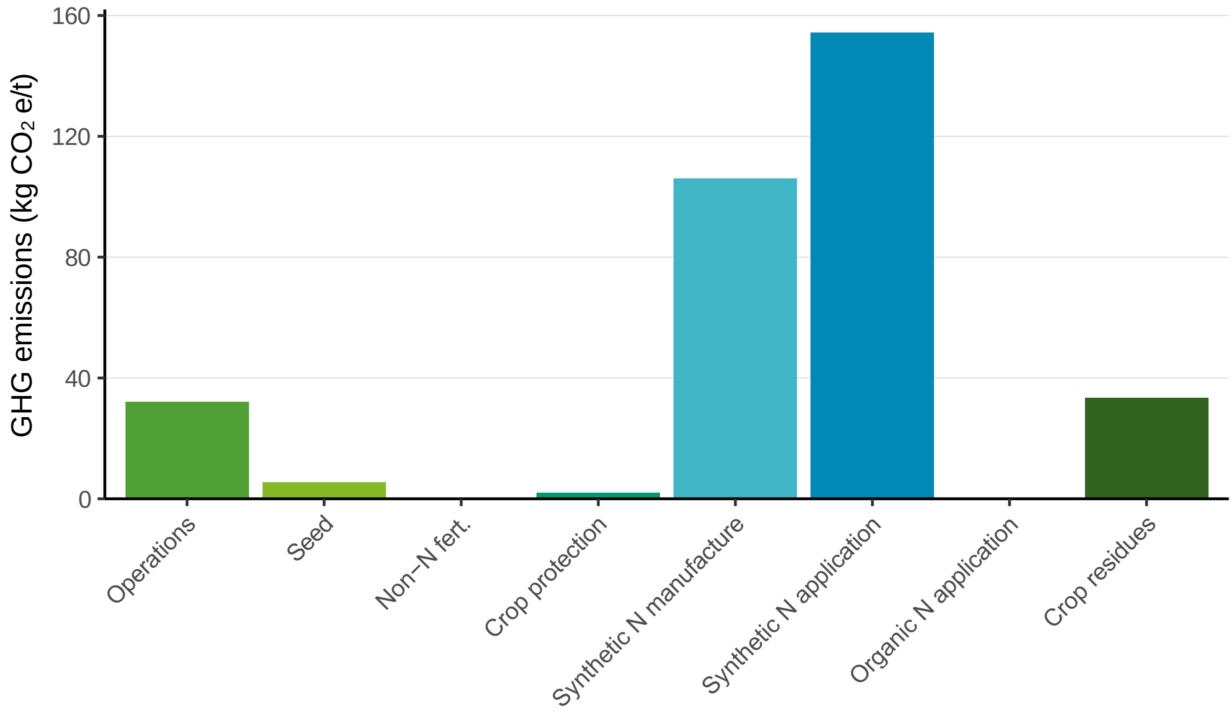


Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Direct drill	97	NULL	NULL	NULL	NULL		6	1.3	Not chopped

2021 - W. Wheat (feed)



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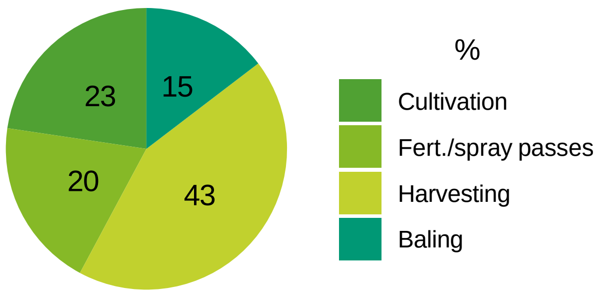
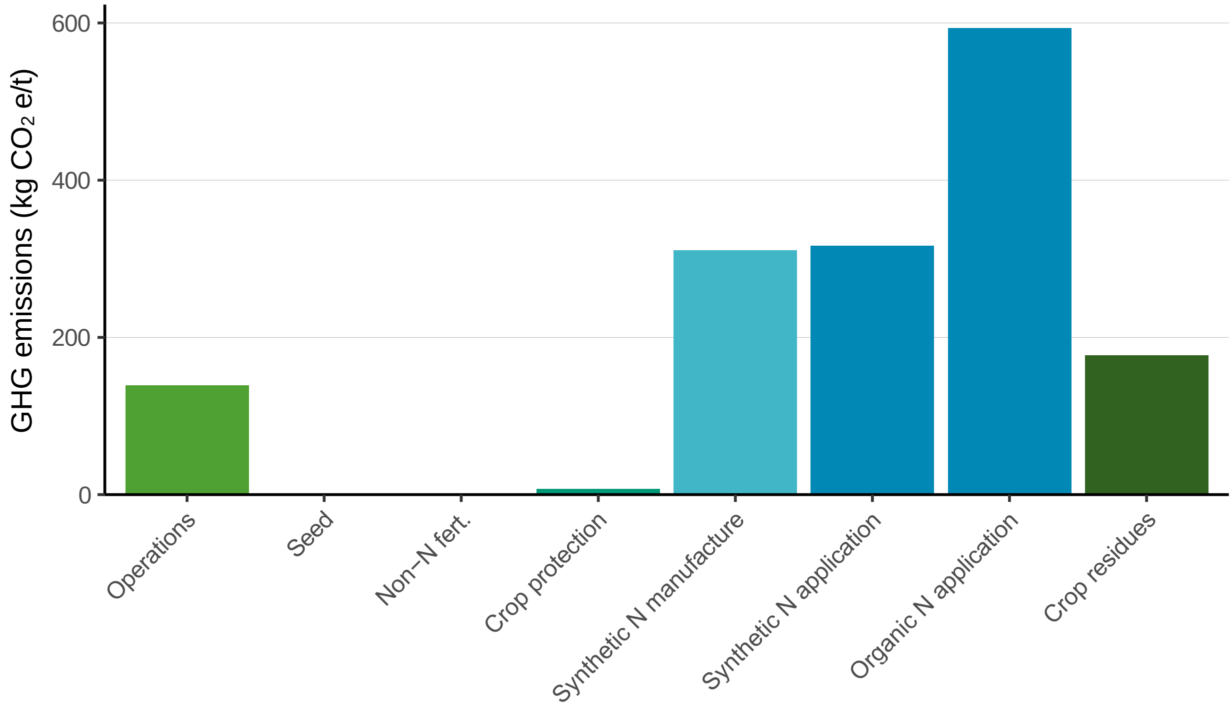


Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Minimum shallow tillage	202	NULL	NULL	NULL	NULL		5	0	Not chopped

2020 - W. Oilseed rape



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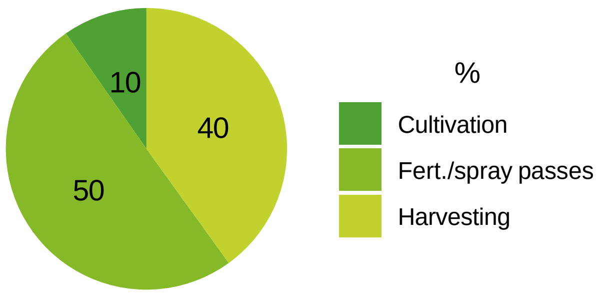
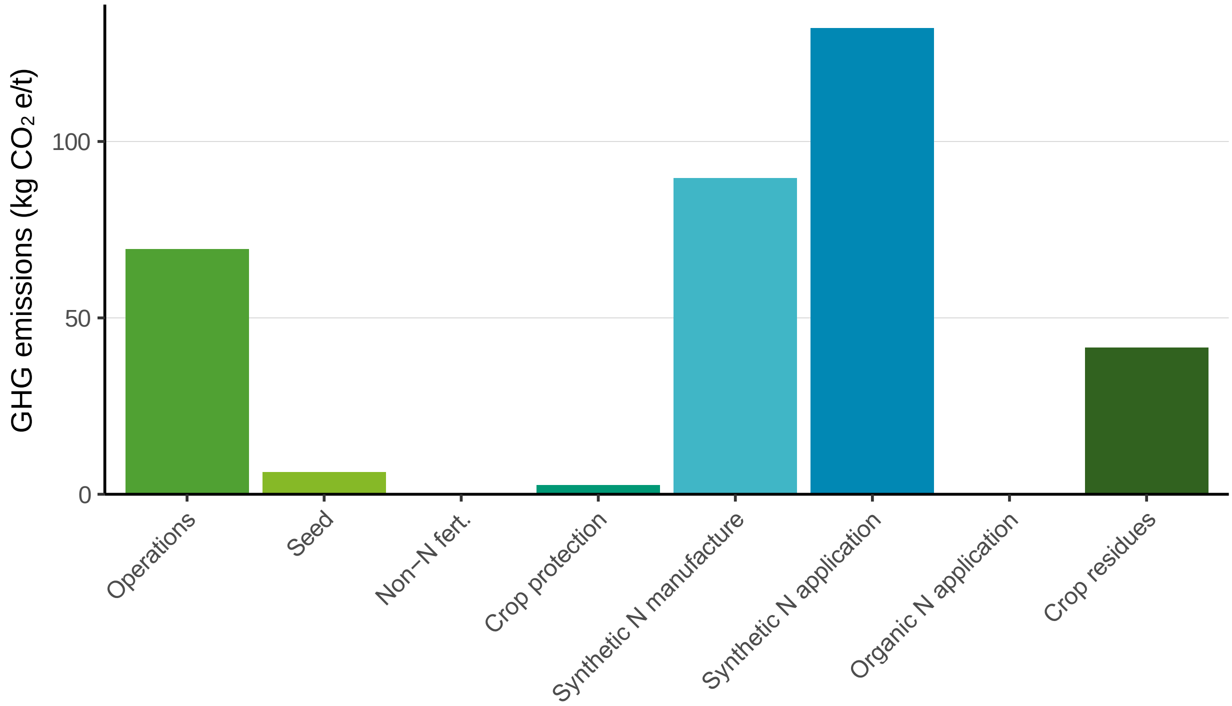


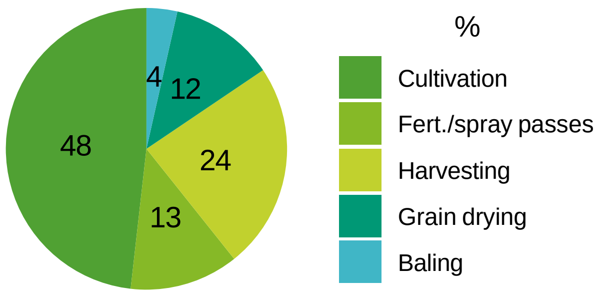
Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Direct drill	185	NULL	NULL	NULL	17	Biosolid - digested cake	6	0	Chopped

2019 - S. Barley (malting)

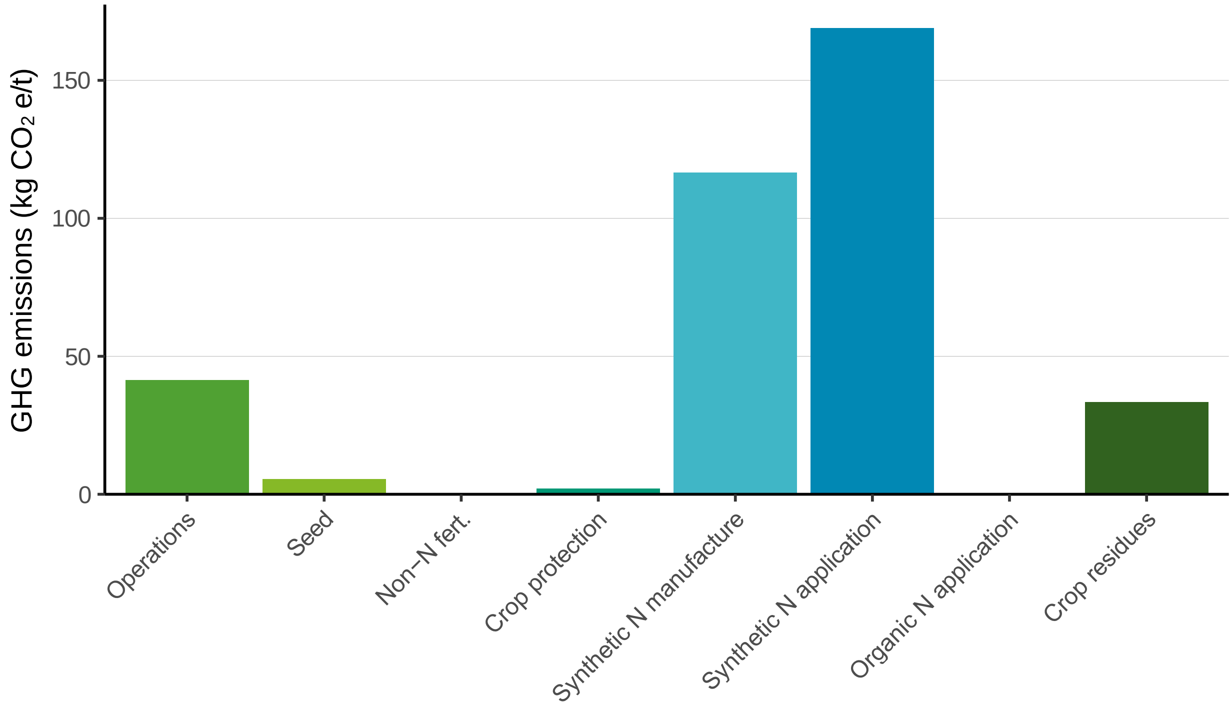


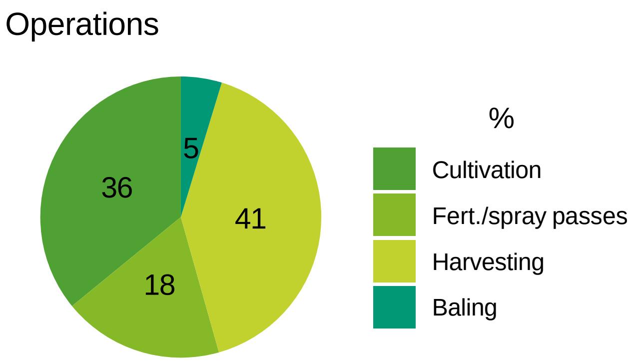
Operations



Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Plough based	150	NULL	NULL	NULL	NULL		6	0.8	Not chopped



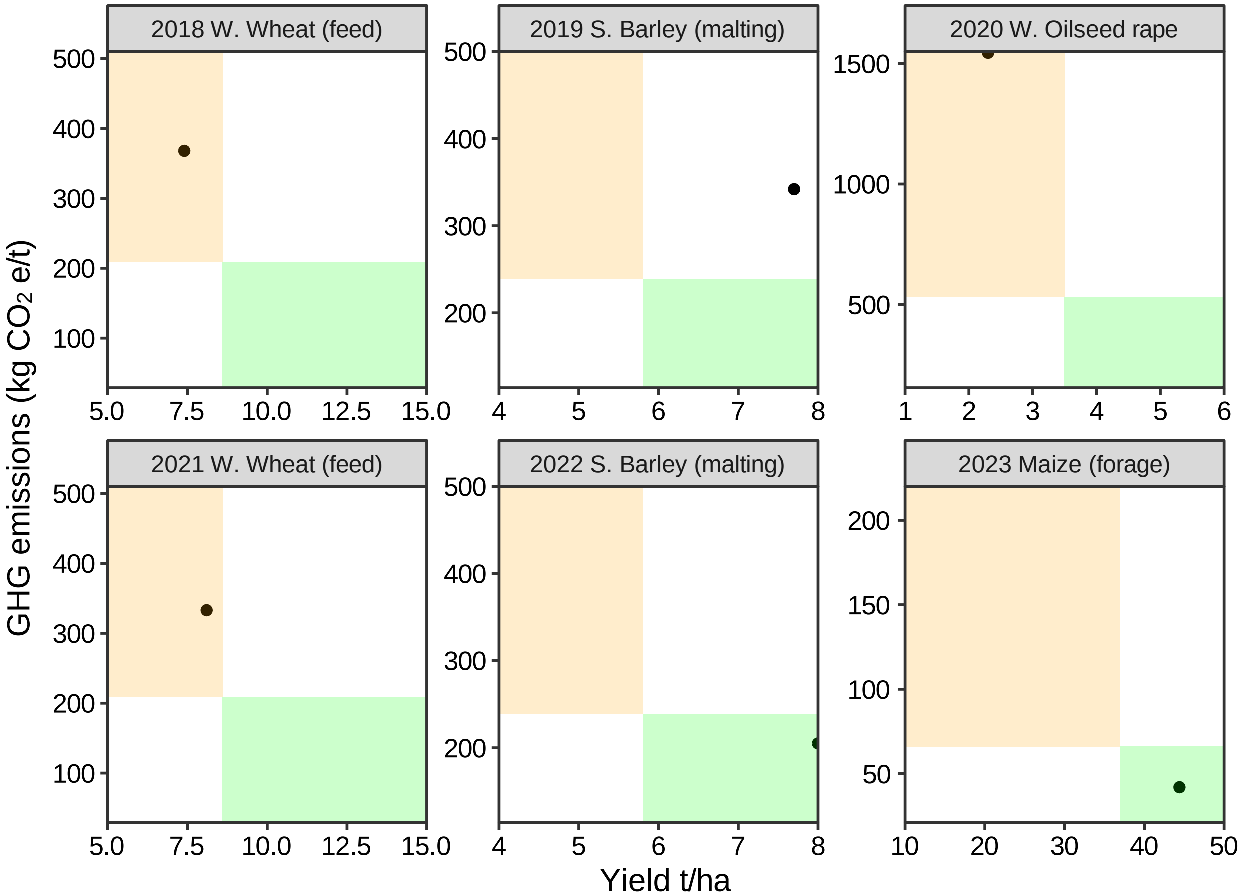


Non−N fert. manufacture

Cultivation type	Synth. N applied (kg/ha)	P applied (kg/ha)	K applied (kg/ha)	Lime applied (kg/ha)	Manure applied (t/ha)	Main manure type	Number ag-chem applications	Grain drying (%)	Straw fate
Deep non-inversion	194	NULL	NULL	NULL	NULL		5	0	Not chopped

PRODUCTIVITY

To minimise GHG emissions and maximise profitability, it is key to improve productivity on-farm by producing more output with fewer inputs. The graph below shows the yield of each of your crops against its GHG emissions per unit of productive output (the Carbon Intensity). This is the carbon emissions footprint of your crop per hectare divided by the yield, giving a Carbon Intensity value per tonne of yield. More efficient systems fall into the green shaded box, where yield is high and carbon is low.



ROTATIONAL EMISSIONS

If you have selected a single field and provided historical rotational data then this information is presented here.

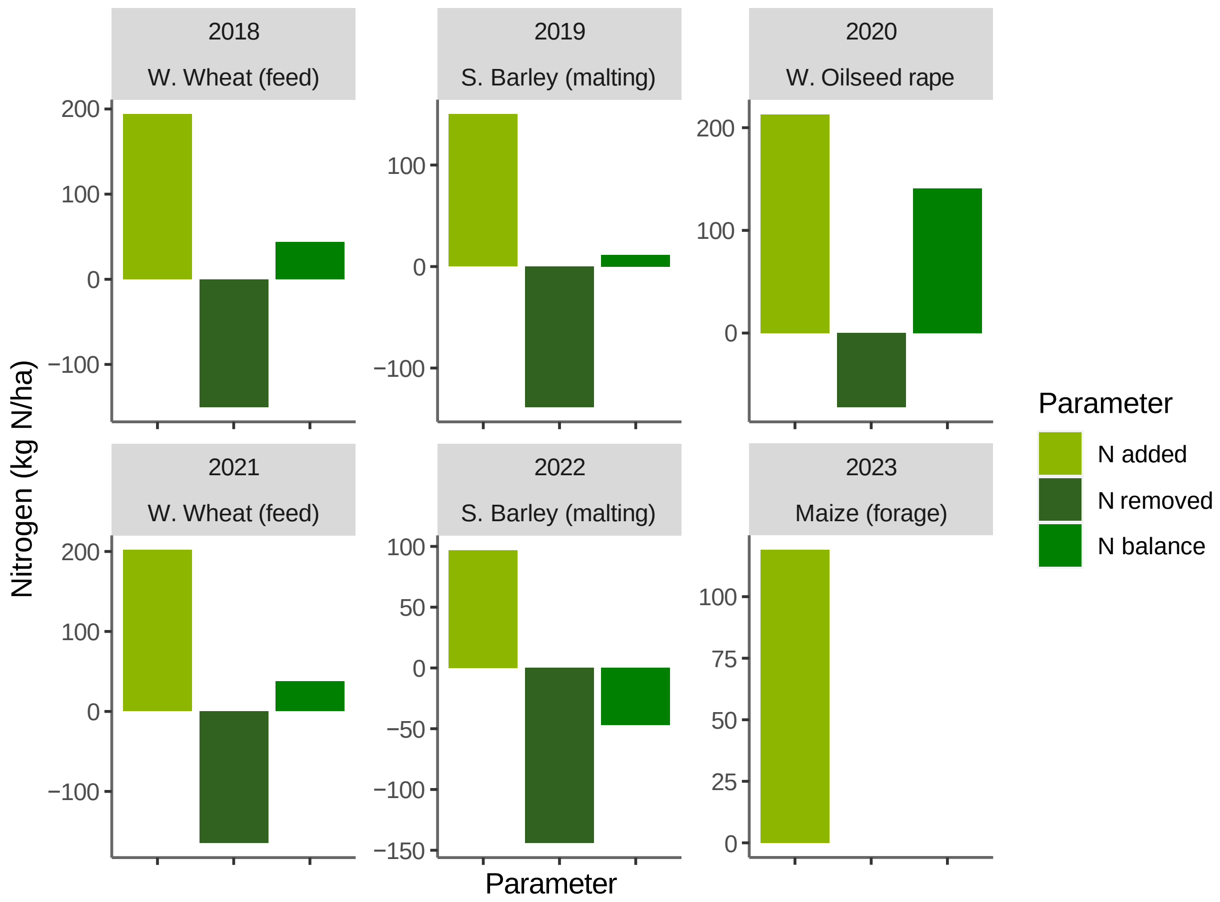
To calculate the rotational footprint, the emissions from lime and manure inputs are expressed on an annual basis across the whole period of the rotation as they are less likely to be applied every year.

Parameter	2018	2019	2020	2021	2022	2023	Mean
Rotation	W. Wheat (feed)	S. Barley (malting)	W. Oilseed rape	W. Wheat (feed)	S. Barley (malting)	Maize (forage)	
Yield (t/ha)	7	8	2	8	8	44	
Lime manufacuture and organic amendments (kg CO2e/t)	41	41	136	39	39	7	50
Other crop emissions (kg CO2e/t)	368	342	951	333	205	30	372
Rotational GHG emissions/t (kg CO2e/t)	409	383	1087	372	245	37	422
GHG emissions/t (kg CO2e/t)	368	342	1545	333	205	42	472
Rotational GHG emissions/ha (kg CO2e/ha)	3100	2918	2489	2998	1927	1655	2514
GHG emissions/ha (kg CO2e/ha)	2789	2607	3538	2687	1616	1850	2514

NITROGEN BALANCE

In a typical crop carbon footprint, more than two thirds of the emissions are associated with the use of N fertiliser. Therefore, understanding the nitrogen (N) use efficiency of the field (i.e., how much N is added against how much is removed from the field) can help identify where there are opportunities to improve N efficiency and reduce GHGs. Large positive N balances generally indicate areas where N efficiency can be improved. A N balance has been calculated using the yield corrected amount of N in the crop grain removed from the field (Nitrogen Removed) subtracted by the amount of N in the manufactured N fertiliser applied and the amount of N in any organic manures, slurries or other organic materials (Nitrogen Added). Default grain N proportions have been taken from YEN Nutrition data. The calculation for estimating the N balance is as follows:

Manufactured fertiliser N (kg N/ha) + Organic N (kg N/ha) – Yield (t/ha) x Grain N (%)

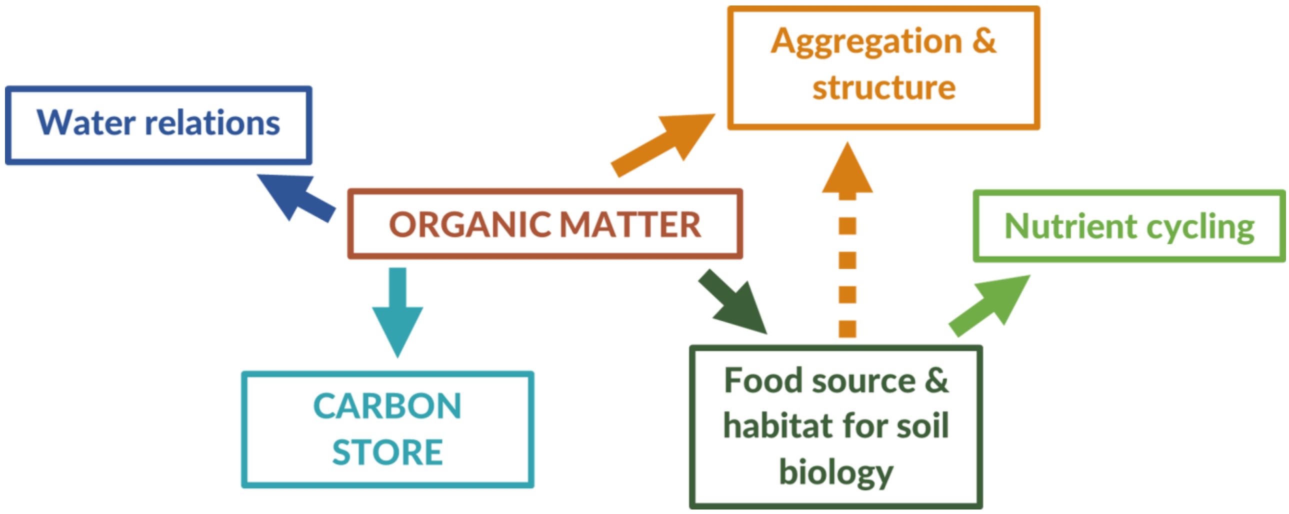


Peas and Beans will biologically fix N at a rate of between 150 and 250 kg N/ha. No data for maize is currently available to estimate N removal, but we hope to be able to provide this in future reports.

SOIL ORGANIC MATTER

In YEN Zero crop carbon footprint analysis, carbon sequestration in soils is not considered because our current understanding does not allow for accurate quantification of soil carbon sequestration, without measurement of soil carbon stocks, which is time intensive and costly. The Sustainable Soils Alliance is currently working to establish a set of scientifically valid minimum standards for soil carbon sequestration in our agricultural soils. The British Standards Institute (BSI) are developing a UK-wide standards framework for nature with 'high integrity markets' to guide private investment in commodities such as soil carbon.

YEN Zero is using soil organic matter (SOM) as a proxy to understand the amount of soil carbon 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 carbon 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, and nutrient retention, 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 carbon inputs in the form of crop roots and residues equal carbon outputs such as CO2 produced during the breakdown of these materials by soil microbes. 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 carbon.

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 (2022), which gives a range of 'typical' SOM contents according to clay content, rainfall, and cropping (grass vs. arable). Soils with a large percentage of clay in areas with high rainfall can store more SOM than lighter soils in dry regions. The upper values in the table below are what is at least potentially achievable on your soil type, and anything you achieve higher than these typical SOM values is considered excellent for arable soils. However, 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.

We assume that the current SOM values you entered have been calculated through robust soil sampling and analysis methods. If you haven't entered current SOM data, then you will only see the potential SOM for your climate and soil type.

Entry	Field name	Year	Clay classification	Long term annual rainfall (mm)	Current SOM level (%)	Typical upper SOM range (%)	Soil health status
1	Field 1	2023	Medium	916.0	NULL	5.1 - 7.6	NULL
2	Field 1	2022	Medium	916.0	NULL	5.1 - 7.6	NULL
3	Field 1	2021	Medium	916.0	NULL	5.1 - 7.6	NULL
4	Field 1	2020	Medium	916.0	9.4	5.1 - 7.6	High
5	Field 1	2019	Medium	916.0	NULL	5.1 - 7.6	NULL
6	Field 1	2018	Medium	916.0	NULL	5.1 - 7.6	NULL

Potential SOM levels based on the AHDB/BBRO (2022) Soil Health Scorecard 'typical' benchmarks for cropped soils, these should be what is at least possible for your soil type but can be higher. Light soils are defined as <18% clay, medium 18-35%, and heavy >35% clay. Low rainfall is defined as <650 mm/year, medium 650-800 mm/year, and high 800-1100 mm/year of rainfall.

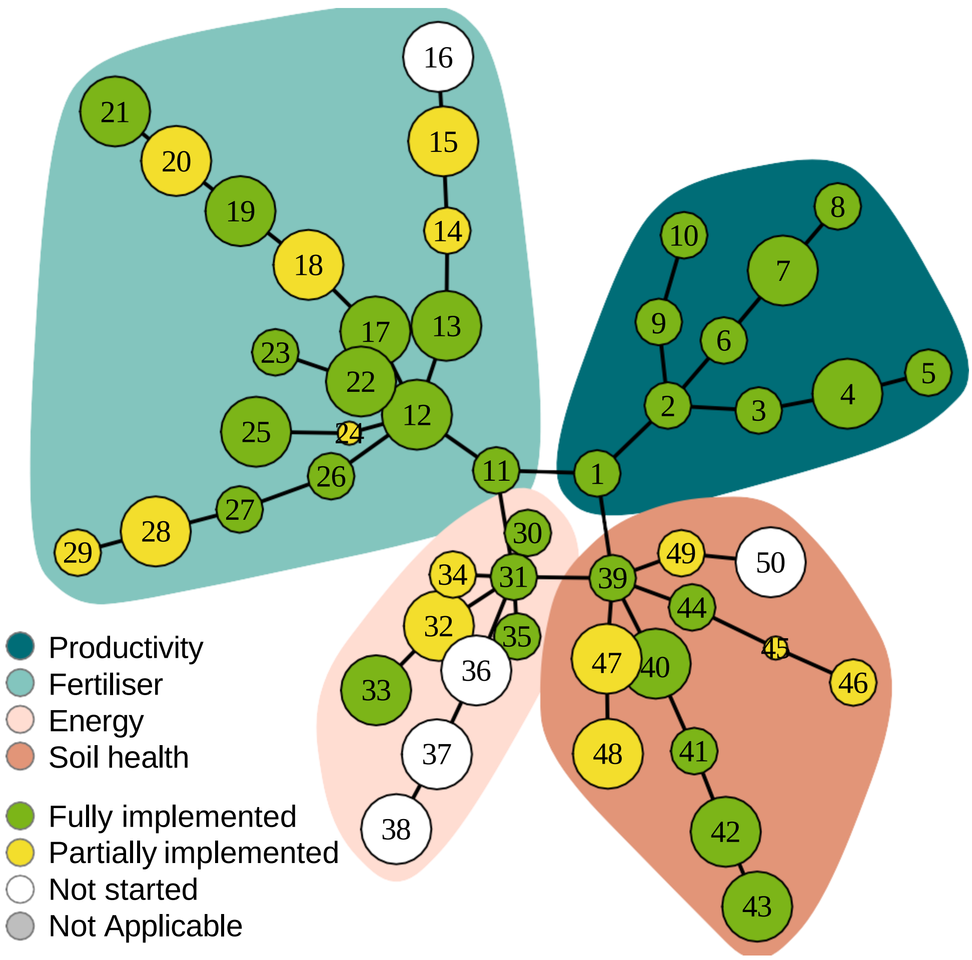
Traffic light	Meaning
Investigate	SOM is very low for the climate and soil type. Add more organic materials to improve SOM.
Review	Lower than the average SOM for the climate and soil type. Add more organic materials to improve SOM.
Monitor - typical	Typical SOM for the climate and soil type. Maintain practices that are building SOM.
Monitor - high	Above average SOM for the climate and soil type. Maintain practices that are building SOM.

REDUCING GHG EMISSIONS

The schematic below provides a summary of some of the main strategies which can be implemented on your farm to reduce GHG emissions.

Each circle represents a GHG mitigation practice (there is a full list on the next page). The size of the circle 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 they 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, with white showing those that are not yet implemented.

This diagram can 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 them.



ID	Practice	Link
1	Soil nutrient and pH sampling (ensure nutrients are not limiting)	Click here for more information
2	Optimise soil pH	Click here for more information
3	Create crop health plan	Click here for more information
4	Choose disease-resistant varieties	Click here for more information
5	Use integrated pest management	Click here for more information
6	Optimise seed rate	Click here for more information
7	Review crop rotation, consider crops and varieties with a low N requirement	Click here for more information
8	Measure yield and protein to assess offtake success	Click here for more information
9	Improve soil conditions to encourage root growth	Click here for more information
10	Monitor crop nutrition to prevent deficiencies	Click here for more information
11	Measure soil mineral N (plus crop N). Base N rate on realistic yield and quality expectations	Click here for more information
12	Use nutrient management planning	Click here for more information
13	Purchased fertiliser from abated sources	Click here for more information
14	Use variable rate fertiliser application	Click here for more information
15	Use urease inhibitors	Click here for more information
16	Use nitrification inhibitors	Click here for more information
17	Calibrate fertiliser spreader	Click here for more information
18	Consider method and timing of organic material applications to minimise NH_3 losses & leaching (rapidly incorporate)	Click here for more information
19	Measure nutrient content of manures to fully account for inputs	Click here for more information
20	Don't apply in warm, wet conditions	Click here for more information
21	Ensure good field drainage	Click here for more information
22	Use legumes in the rotation	Click here for more information
23	Grow cover crops before spring crops and catch crops after high N crops such as vining peas to minimise N losses	Click here for more information
24	Use N-efficient varieties	Click here for more information
25	Adjust N rate according to SMN and fertiliser recovery (consider soil type and N form)	Click here for more information
26	Adjust N rate based on break-even ratio	Click here for more information
27	Adjust N rate based on crop growth across season	Click here for more information
28	Conduct an on-farm trial to optimise N rate for crop and field	Click here for more information
29	Record success of fertiliser strategy by analysing the grain and calculating offtake	Click here for more information
30	Create vehicle maintenance plan	Click here for more information
31	Plan on-farm operations	Click here for more information
32	Harvest grain at correct moisture to reduce drying	Click here for more information
33	Reduce tillage frequency/intensity	Click here for more information
34	Minimise number of passes by combining sprays	Click here for more information
35	Record fuel use	Click here for more information
36	Install Ground Source Heat Pumps for grain drying	Click here for more information
37	Install renewable energy sources such as solar and wind	Click here for more information
38	Switch to EV/alternative fuel vehicles	Click here for more information
39	SOM sampling and monitoring	Click here for more information
40	Reduce tillage frequency/intensity	Click here for more information
41	Use cover crops	Click here for more information
42	Ensure adequate drainage with drainage systems & ditches properly maintained	Click here for more information
43	Avoid compaction in the soil profile	Click here for more information
44	Apply organic materials	Click here for more information
45	Incorporate straw	Click here for more information
46	Store organic materials on concrete pads to reduce leaching	Click here for more information
47	Extend field margins	Click here for more information
48	Expand hedgerows (or fill gaps in existing)	Click here for more information
49	Introduce/extend grass/herbal leys in rotation	Click here for more information
50	Plant agroforestry	Click here for more information

YEN ZERO SPONSORS

We are most grateful to all our sponsors. They not only provide funding, but they are fundamentally involved in managing 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, 20th March 11:00-12:30

A virtual Results Meeting where ADAS will summarise this year's YEN Zero, 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.

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.