Understanding carbon footprinting for cereals and oilseeds

HGCA

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

Introduction

The need to measure and reduce carbon footprints

Governments around the world have committed to finding ways to reduce greenhouse gas emissions. In the UK, emissions from industry remain a significant proportion of the total carbon footprint. Emissions from agriculture accounted for almost 9% of UK greenhouse gas emissions in 2010.

The UK Government Climate Change Act 2008 has set out clear targets for reducing UK greenhouse gas emissions by 80% (from 1990 levels) by 2050. The agricultural industry has signed up to a Greenhouse Gas Action Plan that commits it to reducing the carbon footprint of English agriculture by 3 million tonnes CO_2e (CO_2 equivalent) by 2020.

Carbon management is good for business

Low carbon footprints are often associated with high technical efficiency, above average yields and better margins.

The demand for information on carbon footprints by end markets and policy makers is set to increase, so it makes good business sense to understand them and take action in areas where a difference can be made now to reduce environmental impact.

Government targets

UK greenhouse gas emissions: ⬇80% by 2050
from 1990 levels; UK Government Climate Change Act (2008)

Agriculture in England:
⬇3 $MtCO_2e$ by 2020
from 2008 levels

Agriculture in Wales:
⬇0.6 $MtCO_2e$ by 2020
from 2008 levels

Agriculture in Scotland:
⬇1.3 $MtCO_2e$ by 2020
from 2008 levels

Agriculture in N. Ireland:
⬇0.276 $MtCO_2e$ by 2020
from 2008 levels

Understanding carbon footprints

1. Collect information
and calculate the carbon footprint
(see pages 8-9)

2. Interpret results
and identify areas for improvement
(see pages 10-11)

3. Take action
to reduce emissions
(see pages 12-13)

4. Understand the impact
of actions taken on the carbon footprint and profits

Glossary

Greenhouse gas emissions:

The release of gases whose molecules trap heat (infrared radiation) emitted by the earth and reflect some of it back, preventing the energy being lost to space.

Climate change:

The process by which the climate is changing over periods of many years; for example, rainfall patterns may change in terms of both amount and seasonality. Climate is distinct from weather, which is the natural variability which we experience day-to-day.

Global warming potential (GWP):

Describes how much energy the gas will trap over 100 years compared to carbon dioxide. Each greenhouse gas has a different potential to trap energy in the atmosphere and some gases remain in the atmosphere for longer than others.

Carbon footprint:

A way of estimating the impact that a production process has on climate change. It is calculated by adding up the impact of the emissions from all the greenhouse gases emitted during production.

CO_2 equivalent (CO_2e):

A standard measurement unit that enables the impacts of greenhouse gases with different global warming potentials to be compared and/or combined.

Adaptation:

Changes made to activities in response to climate change.

Mitigation:

The process of finding ways to reduce the greenhouse gas emissions created by human activities.

Carbon sequestration:

Locking up carbon for the long-term in the natural environment (for example, woodland) or manufactured products (for example, hemp fibre used in buildings). As plants grow, they capture carbon dioxide from the atmosphere to produce biomass via photosynthesis.

Renewable energy:

Energy generated from naturally replenished resources such as sunlight, wind, water and biomass.

Contents

Carbon footprinting is not just about carbon dioxide (CO_2) emissions

For global agriculture, other greenhouse gases are as – or more – important than CO_2.

Methane (CH_4)

- Around 23 times as powerful as CO_2
- Particularly relevant to livestock (enteric fermentation and manure management) and paddy rice systems

Nitrous oxide (N_2O)

- Around 300 times as powerful as CO_2
- Occurs in fertiliser manufacture and the breakdown of fertilisers and other organic matter in the soil

HGCA carbon footprinting decision support tool

HGCA has developed a tool to help increase growers' understanding of the process of calculating a carbon footprint.

The tool offers a straightforward and transparent way to calculate the carbon footprint of a particular crop and to test different scenarios to identify areas in which efficiency gains can be made.

It considers each combinable crop separately and produces a carbon footprint of the crop both per tonne and per hectare.

Visit **www.hgca.com/tools** to use the tool and see how different cropping situations affect the carbon footprint.

Climate change and greenho

– Carbon footprints measure the impact that different products can be expected to have on climate change
– Agriculture is a significant contributor to greenhouse gas emissions
– Any process of activity that adds nitrate to the soil increases the risk of nitrous oxide emissions
– In the crop sector, the main sources of emissions tend to be nitrogen fertilisers and the production of inorganic fertiliser

Climate change and greenhouse gases

Greenhouse gases are those which "trap" the heat energy emitted by the earth (Figure 1). When these molecules re-emit the energy they trap, some of it is redirected back towards the earth, providing the heating (or greenhouse gas) effect. A range of natural greenhouse gases and particles, including water vapour, carbon dioxide and dust, help to keep the planet warm – without these, the earth's surface would be too cold to be habitable.

Global temperature and greenhouse gas concentrations are linked and follow a natural cycle. However, since the industrial revolution, human activity, particularly the burning of fossil fuels, has increased the concentration of greenhouse gases in the atmosphere substantially above the historical extremes. This recent spike in CO_2 levels leads the vast majority of the scientific community to conclude that we are beginning a period of unprecedented global warming.

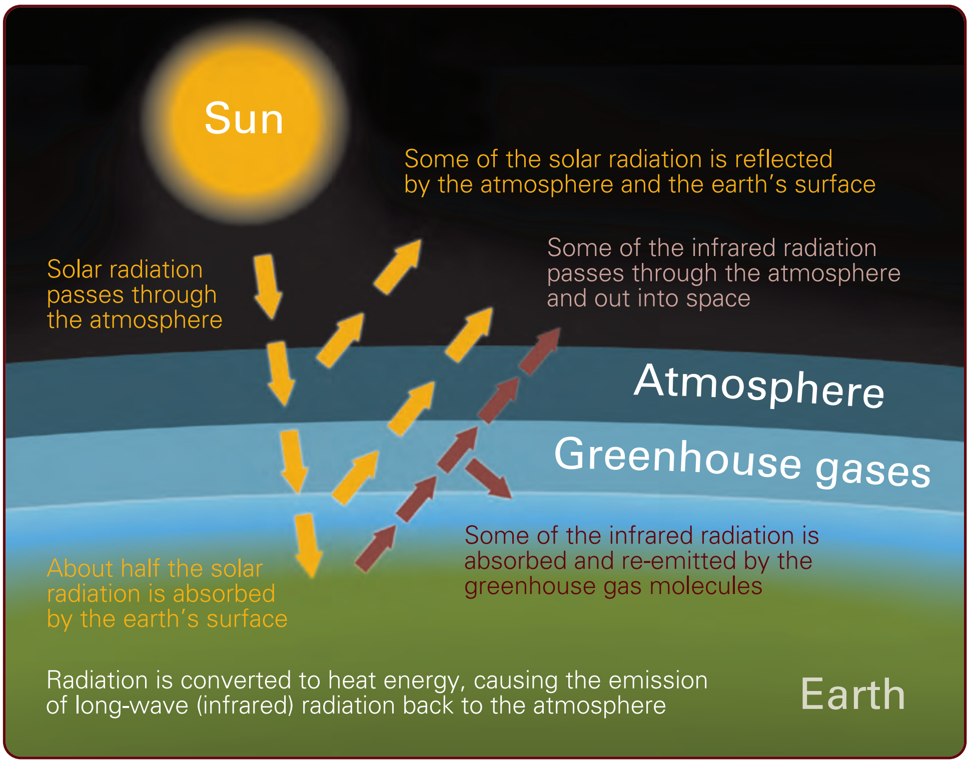


Figure 1. The greenhouse gas effect.

What is a carbon footprint?

A carbon footprint is a way of estimating the impact that a production process has on climate change.

Each gas emitted by the production process is rated on its 'global warming potential' (GWP). Carbon dioxide (CO_2) is given a rating of one unit and other gases, such as methane or nitrous oxide, have a higher GWP depending on the amount of energy the gas will trap over 100 years relative to carbon dioxide. The GWP of different gases varies so much because of differences in how each gas traps energy and how long they persist in the atmosphere.

Methane (CH_4)
– Around 23 times the GWP of CO_2
– Particularly relevant to livestock (enteric fermentation and manure mangement) and paddy rice systems

Nitrous oxide (N_2O)
– Around 300 times the GWP of CO_2
– Occurs in fertiliser manufacture and the breakdown of fertilisers and other organic matter in the soil

Adding up the emissions from all gases emitted gives a greenhouse gas emissions figure, which is usually expressed as kilograms of CO_2 equivalent (CO_2e) per tonne of product.

use gases

Legislation

Given the concern about climate change and the costs this may impose on society, governments around the world have committed to finding ways to reduce carbon emissions.

In the UK, emissions from industry remain a significant proportion of the total carbon footprint and, working with other sectors, the agricultural industry has signed up to a Greenhouse Gas Action Plan which commits it to reducing the carbon footprint of English agriculture by 3 million tonnes CO_2e by 2020. There are similar (by percentage) reduction targets for Scotland (1.3 $MtCO_2e$), Wales (0.6 $MtCO_2e$) and Northern Ireland (0.276 $MtCO_2e$).

As with the Voluntary Initiative and the Campaign for the Farmed Environment (CFE), voluntary action by the industry now on carbon footprinting will help to reduce the risk of future legislation or taxation.

Greenhouse gas emissions from agriculture

Globally, agriculture is a significant contributor to greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) fourth assessment report[1] estimates that agriculture is directly responsible for 13.5% of global greenhouse gas emissions (Figure 2), with a further 17.4% coming from land use change (mainly deforestation in the developing world to clear land to grow more food or for grazing).

The two biggest sources of greenhouse gases from agriculture are the release of nitrous oxide from agricultural soils and methane from livestock and manures, each of which represents more than 5% of total global greenhouse gas emissions. While energy use in agriculture (for example, diesel for cultivation) is important, its contribution to greenhouse gas emissions is much lower – less than 1.5% of total emissions.

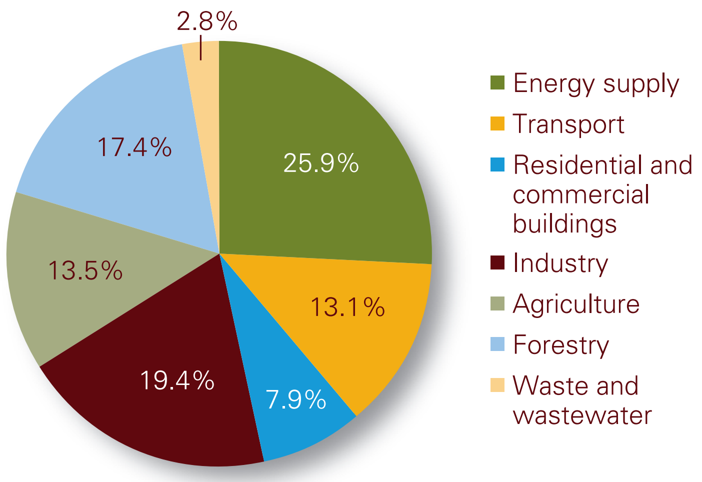


Figure 2. Global greenhouse gas emissions. Adapted from Olivier *et al.*, 2005[2], 2006[3].

Greenhouse gas emissions from cereals and oilseeds production

For conventional cereal crops, nitrogen fertilisers are the most important component of the carbon footprint (Figure 3).

These emissions from fertiliser are split into two parts, with emissions from fertiliser manufacture and the emission of nitrous oxides from the soil of roughly equal importance.

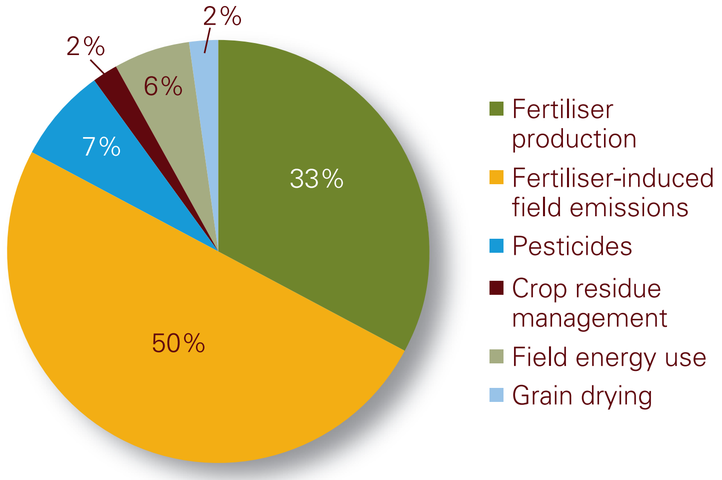


Figure 3. Typical emissions from conventional cereals and oilseeds. Data derived from three case studies (HGCA Project Report 506).

Sequestration

Crop production produces greenhouse gases but also captures atmospheric CO_2 to produce plant material. Where this material is then stored long-term, for example, as thatch or timber in buildings, crops can reduce society's carbon footprint.

Renewable energy

Agriculture (including forestry) is arguably the only industrial sector which can claim to capture large amounts of carbon and this is why governments have been keen to support the development of biofuels to replace fossil fuels.

[1] www.ipcc.ch
[2] Olivier *et al.* (2005) Environmental Science, 2(2-3): 81-99
[3] Olivier *et al.* (2006) In *CO_2 emissions from fuel combustion 1971-2004*, 2006 Edition, ISBN 92-64-10891-2 (paper) 92-64-02766-1 (CD ROM) (2006)

Profitability and carbon efficie

- Small carbon footprints per tonne are associated with efficient crop production systems that are effective at turning crop inputs into yield
- High performance crops tend to be good in terms of both their carbon footprint and profitability
- Care needs to be taken that small savings (eg by reducing pesticide usage) do not cost more in lost yield than the saving made

The link between profitability and carbon management

Arable farming has seen an increase in the value of the crops it sells in recent years but the cost of inputs such as fertiliser and fuel have risen at an even faster rate.

High-yielding crops are now constrained in many areas by restrictions on nitrogen use introduced as part of the Nitrate Vulnerable Zone (NVZ) legislation; future yield growth is, therefore, dependent on using nutrients more efficiently.

On-farm efficiency is key to both profitability and the carbon footprint of cereals and oilseeds production. The target should be to find ways (through technology, the timeliness of operations, attention to detail and the targeted use of inputs) to maintain yield while reducing fertiliser, pesticides and fuel use per hectare. If yield can be at least maintained while input use is reduced, this will:

- Save money on input costs and increase profitability per hectare and per tonne
- Reduce the carbon emissions per hectare, leading to a reduced carbon footprint per tonne of crop

In contrast, choosing low input crop production systems in an attempt to reduce the carbon footprint is potentially much more difficult to achieve and can also lead to lower profits. A reduction in inputs usually leads to a reduction in yield and can lead to a reduced profit if the value of crop produced falls more than the reduction in growing costs. Low output systems also often cause the carbon footprint per tonne to rise because, while carbon emissions per hectare may fall (due to lower input use), it is very easy for the reduction in yield to be greater in percentage terms.

Adopting techniques to reduce the carbon footprint of cereals and oilseeds can help achieve optimum yields while minimising production costs, leading to improved margins and farm profitability.

Techniques such as improved targeting of nutrients, using GPS yield maps or N-sensing can help to increase the yield response from fertiliser while also reducing fuel use.

Reviewing policies on cultivations can improve soil structure, leading to healthier plants which use a deeper soil profile and produce higher yields, while at the same time optimising energy use.

ADAS and Firbank Ecosystems were commissioned by the Countryside Council for Wales, on behalf of the Land Use Policy Group (LUPG) to test the concept of sustainable intensification using case study farms. The case study on the following page is reproduced with their permission. For more information, see **aplus.adas.co.uk/Services/sustainability/Testing-the-concept-of-sustainable-intensification.aspx**

Case study: Cargill Farms, Gimingham, Norwich

- 494ha owned arable unit
- Main crops: winter wheat, potatoes and sugar beet
- Free draining soils, largely medium textured (90%)
- Low rainfall area

The approach

"We are trying to develop a sustainable agricultural model based on margin over fixed costs, on a multi-year contract basis, which gives us the ability to invest in the environment as well as reinvest in infrastructure."

Land sparing

- The farm has put unproductive land into permanent grassland and created grass buffers, hedgerows and woodland

Use of technology to improve energy and resource use efficiency, including:

- GPS
- Humidification and adiabatic cooling (where energy is neither added or removed) of potato stores
- Modernised irrigation system
- New tractors
- Nutrient recommendations from an independent agronomist tailored specifically on a field-by-field basis

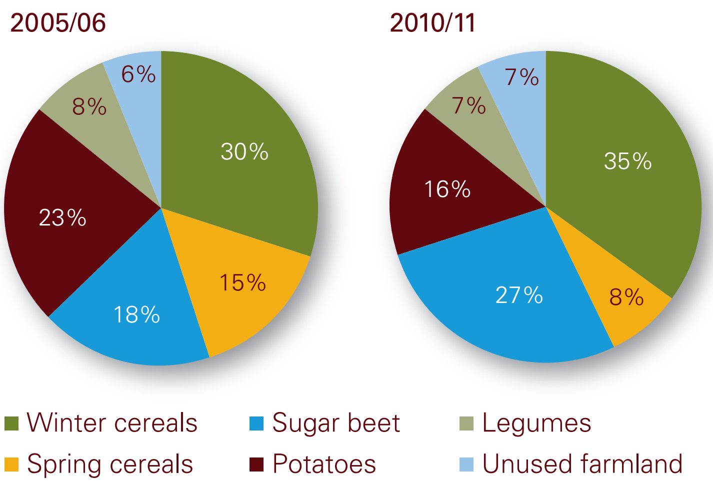
"The ability to invest in new, improved technologies is reliant on economies of scale and, therefore, this has only been possible due to the contract farming enterprise."

Monitoring of performance

The farm uses software for:

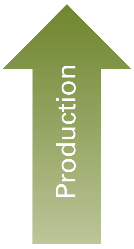
- Farm records
- Nutrient management planning
- Forward business planning
- Group benchmarking

Figure 4. Changes in cropping from 2005/06 to 2010/11.



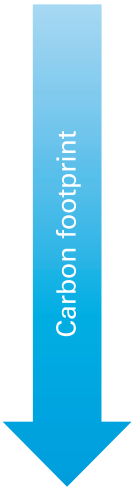
Farm performance

Indicator	2006	2011	Change
Food production (GJ/ha)	128	171	33%
Carbon footprint per unit food ($kgCO_2e$/GJ food)	29.3	21.6	-26%
Carbon footprint per unit land ($kgCO_2e$/ha)	3,754	3,694	-2%
Nitrate loss to water (kg/ha)	44	38	-13%
Ammonia loss to air (kg/ha)	11	8	-30%



33% increase in absolute food production (expressed in gross energy per unit of land area)

- Significant increase in potato yield based on variety change
- Reduced losses from stores because of improved storage



26% decrease in carbon footprint per unit food

- 6% decrease in nitrous oxide emissions per hectare due to increased nitrogen use efficiency
- The increase (9%) in carbon dioxide emissions per hectare was limited by:
  - Changing to more fuel-efficient machinery
  - Investing in machinery that can perform multiple tasks simultaneously
  - Mapping out the most direct routes between fields and stores
  - Updating stores with extra insulation
  - Fitting invertors to fans

The farm has shown an overall reduction in pollutant pressure

- More efficient application of resources
- More marginal land and land adjacent to water courses taken out of arable production

"Attention to detail in variety selection, cultivation techniques, crop husbandry, storage practices and agronomic management have all been key."

Collecting the information

- The information required to calculate a carbon footprint can be taken from farm records
- Standard 'default' values can be used for areas where farm records are not available
- The HGCA carbon footprinting decision support tool is designed to increase understanding of how different factors affect the carbon footprint

Tools from HGCA

HGCA carbon footprinting decision support tool

This tool was developed to help increase understanding of the process of calculating a carbon footprint, to highlight the emissions 'hotspots' and to stimulate discussion around improvements in efficiency.

The tool offers a straightforward and transparent way to calculate the carbon footprint of a particular crop and to test different scenarios to identify areas in which efficiency gains can be made.

The assumption in the tool is that in most cases you will want to calculate the carbon footprint of each crop grown for the whole farm. The tool, therefore, allows you to look at each crop separately because the carbon footprint of each crop will be different. Data is therefore needed for each crop separately.

Visit **www.hgca.com/tools** to use the tool to see how different cropping situations affect the carbon footprint.

HGCA biofuel greenhouse gas calculator

This calculator was designed to provide the basis for a credible calculation of the greenhouse gas emissions arising from UK-derived biofuels using specific agricultural and conversion processes. The calculator can be used for wheat to ethanol, oilseed rape to biodiesel and, provisionally, for straw to ethanol. The development of this HGCA calculator has led directly to the development of biofuel and bioenergy calculators for the Renewable Fuels Agency (RFA), Department for Transport (DfT) and the Department of Energy and Climate Change (DECC).

The calculator (in the form of an MS Excel spreadsheet) is available upon request. Please contact **research@hgca.ahdb.org.uk**

What information is needed?

The figures used in the calculation can be either:

– Actual figures from farm records

Where your own records allow accurate farm-level data entry, tools allow you to enter this and produce a more reliable result for your farm than using default values

– Default values

Where data is not readily available on farm, tools use estimates based on industry averages

The factors listed in the table on page 9 all affect the carbon footprint of a crop and are all included in the HGCA carbon footprinting decision support tool. The list can be used to identify areas where it may be helpful to collect additional farm data in the future.

Organic systems

The tools used to calculate carbon footprints are focused on annual crop inputs and yields. In organic cereal and oilseed systems, this annual focus is not appropriate because organic arable systems are typically based on two phases, which occur over rotations of 4-6 years:

- A fertility-building phase, when the land is dedicated to nitrogen-fixing crops and leys or used by livestock to build up soil nutrient levels
- A fertility-using phase, when crops that demand more nutrients (eg cereals and oilseeds) are grown, with these crops utilising soil fertility and nutrients built up in the other part of the rotation

While it is commonly asserted that organic sources of nitrogen, for example, from livestock manures or nitrogen fixing crops, tend to have lower carbon footprints than inorganic (manufactured) nitrogen, they can still have a significant impact from the breakdown of nitrogen in the soil and, in the case of animal manures, from methane emissions.

With nitrogen use making up most of the carbon footprint of cereals and oilseeds, it is essential to calculate the carbon footprint of organic systems over the whole rotation and not focused on a single crop. Currently, no existing carbon footprint tool is able to handle the extra complexity that this produces.

Factor	Why it is included	Data needed in the HGCA tool
Crop type	Including the crop type enables the crop to be clearly identified and to allow comparison with other similar crops.	Crop type (eg nabim wheat group) *and* whether winter- or spring-planted
Yield and moisture content	Yield and moisture content are needed for each crop to calculate the carbon footprint per hectare and per tonne of crop. Moisture content is included because the crop yield needs to be for a standard moisture content and the calculator will work out how much fuel is used to dry the crop.	Crop yield (tonnes per hectare) *and* the average moisture percentage of the crop when harvested The standard dry moisture percentages used are 14.5% for cereals and 9% for oilseeds.
Soil type	The soil type on which the crop was grown will affect the greenhouse gas emissions associated with production (eg cultivations).	The percentage of the crop grown on each of light, medium and heavy soils
Mineral fertiliser	Fertiliser is often the biggest single source of greenhouse gas emissions so it is important to detail the quantity of mineral fertiliser that has been used per hectare. The emissions come from both manufacturing and the release of nitrous oxide from the soil.	Amount of each fertiliser used as an average across the crop area (kg per hectare)
Organic manures, composts and biosolids	These can both substitute for inorganic fertilisers and have their own emissions because they emit greenhouse gases in the soil.	Amount of each product applied (tonnes per hectare) *and* the percentage of the crop area receiving each material
Nitrogen-fixing crops	Previous leguminous crops can leave nitrogen in the soil which benefits a subsequent crop. They can substitute for inorganic fertiliser.	The percentage of the crop area on which nitrogen-fixing crops were grown in the previous year
Pesticides	The accepted way to account for emissions due to pesticides is to use an average figure (emissions per hectare) for one pesticide application and multiply this by the number of pesticides used.	Whether the crop had a low, standard or high intensity spraying regime used to maintain crop health
Crop residue management	For cereals and oilseeds, this is primarily straw. How these residues are managed can impact on the carbon footprint.	How the crop residues across the majority of the crop area were dealt with after harvest
Field operations and fuel use	Fossil fuels are used in field operations.	Field operations carried out on the crop *or* if known, the fuel usage for each operation per hectare
Energy used in drying	Energy is used in drying systems.	Whether the crop was dried or not (the tool will then calculate the energy used based on the harvest moisture percentage) *or* if known, the actual energy used to dry the crop (kWh per tonne)
Transport to point of first storage	Most grains and oilseeds have to be stored before use. Including this factor enables greenhouse gas emissions associated with transporting them to the first store (whether on farm or central storage).	Transport distance to point of first storage *or* if known, fuel use

Interpreting the results

– There is no 'ideal' carbon footprint and there are few published standard figures for carbon footprints per tonne of crop
– As long as the same reliable method is used to measure the carbon footprint each time, comparisons can be made and the impact of changes made can be assessed
– The HGCA carbon footprinting decision support tool enables the impact of different production decisions on the size of the carbon footprint to be tested

Interpreting the results

While some carbon calculators are focused on per hectare emissions, feedback from the industry has suggested that it is better to focus on a carbon footprint per tonne of crop produced. This has the advantage of focusing on how grain and oilseed buyers will wish to see the carbon footprint presented to them and makes it easier to work out the average footprint from a consignment of grain from multiple farms. It also avoids penalising high-output efficient production systems, which may have a higher carbon footprint per hectare of crop grown but a footprint per tonne that is often similar to or lower than that from low-output systems.

Carbon footprints are expressed as 'kilograms of carbon dioxide equivalent' ($kgCO_2e$). The amount of energy that each gas emitted by the production process will trap over 100 years is compared to the amount trapped by CO_2, which is given a rating of one unit (see pages 4-5). By converting the impacts of the different greenhouse gases to this single unit of measurement, the impacts can be added together to give a total carbon footprint for the process.

Comparing carbon footprints

The average carbon footprint of each crop type is different because of differences in yield and the inputs used. Even for the same crop type, the carbon footprint will vary between fields and between farms depending on husbandry and production decisions and natural factors, such as weather and soil type.

There is no 'ideal' figure: some soil types or locations will always have a larger carbon footprint than others. The challenge for the industry is for growers in all areas to reduce their carbon footprint per tonne by adopting best practices.

Different calculators will also make different assumptions, so the footprints generated by different calculators for the same production process may differ slightly. As long as the same reliable method is used to measure the carbon footprint each time, comparisons can be made and the impact of changes made can be assessed.

Scenario testing

The HGCA tool was developed to increase understanding of the process of calculating a carbon footprint and to enable growers to test the impact of different production decisions on the size of the carbon footprint of their crop.

Visit **www.hgca.com/tools** to use the tool.

Carbon footprints from HGCA case studies

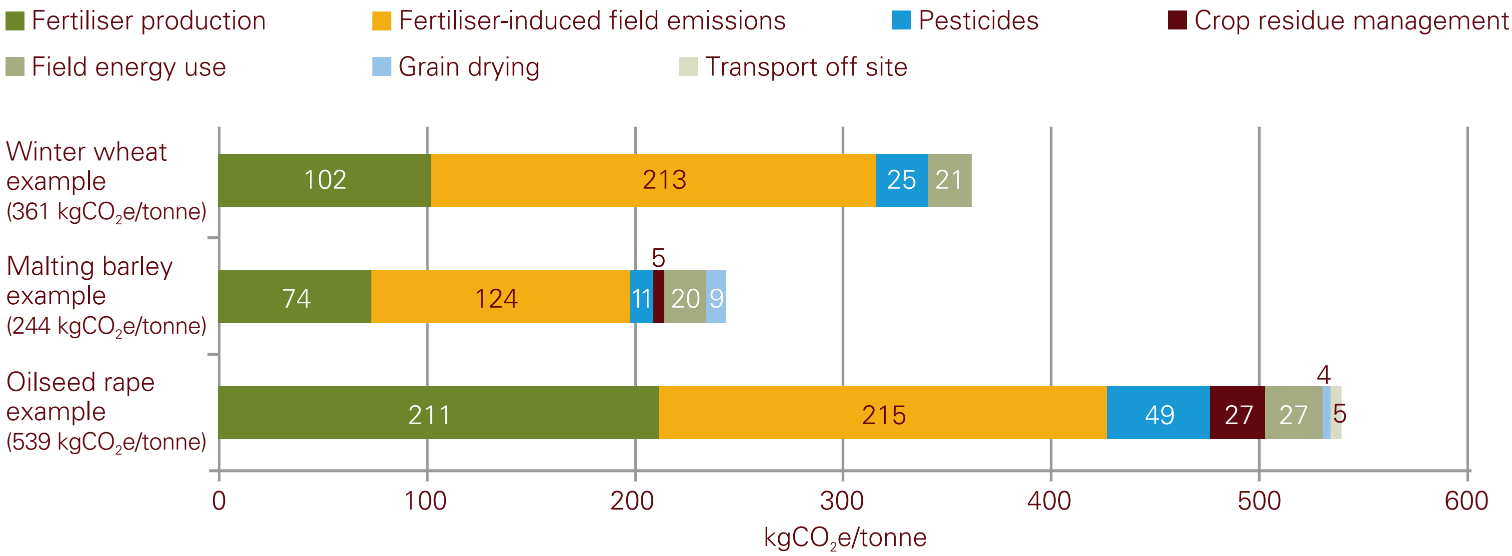
As the science of carbon footprints is still evolving, there are few published standard figures for carbon footprints per tonne of crop. As part of the research project that developed this guide and the associated tool, HGCA looked at some case study farms. Some example carbon footprints from those farms are presented on page 11. The examples have been chosen to illustrate a number of points:

– The majority of the greenhouse gas emissions are due to fertiliser, both its production and fertiliser-induced field emissions
– Oilseed crops have much larger carbon footprints per tonne because their yields are lower but key inputs, particularly nitrogen use, are similar to those of cereals
– The carbon footprints per tonne for the two cereal crops are similar because, although the winter wheat crop received more nitrogen, this was compensated for by the higher yield

Uncertainty

In agriculture, carbon footprints contain some uncertainty due to limited scientific understanding and practical limitations on the data available on farm to quantify emissions, eg greenhouse gas emissions from soil. Although, over time, the uncertainty will reduce as our understanding improves, it will never be zero because of natural variation. For example, the climate varies in time and geographically and the nature of the land varies locally and regionally.

Example carbon footprints from HGCA case studies



Crop type	Winter wheat (nabim Group 2)	Malting barley (winter)	Winter oilseed rape
Emissions per hectare ($kgCO_2e/ha$)	2,963	1,756	2,693
Emissions per tonne ($kgCO_2e/tonne$)	361	244	539
Total nitrogen applied (kg)	261	130	177
Total fuel used (litres)	64	54	51
Yield	8.2 t/ha fresh weight	7 t/ha dried weight	5 t/ha fresh weight
Moisture content	14.5% mc	17% mc	10% mc
Soil type	Medium	50:50 light:medium	60:30:10 light:medium:heavy
Fertilisers	492 l/ha urea ammonium nitrate 17 t/ha compost	406 l/ha urea ammonium nitrate	290 kg/ha ammonium nitrate 300 kg/ha ammonium sulphate nitrate 140 kg/ha triple super phosphate 20 kg/ha muriate of potash
Pesticides	Standard	Very low	Standard
Residues	Baled and sold	33% incorporated	92% incorporated
Field operations	Min-till cultivator Rolling Conventional drill 3 distributions of solid fertiliser 7 spray applications Combining Baling (Heston type)	Min-till cultivator Power harrow drill 1 application of liquid fertiliser Combining	Discing Conventional drill 4 distributions of solid fertiliser 8 spray applications Combining Straw chopping
Grain drying	None (already at 14.5%)	Dried to 14.5% on site	Dried to 9% (15 miles away)

Reducing the carbon footprint

- The biggest impact on a cereal or oilseed carbon footprint will come from maximising the efficiency with which nitrogen is converted into seeds or grain that can be sold
- Low carbon footprints are often associated with high technical efficiency, above average yields and higher margins

Which areas will make the most impact?

The science of carbon footprinting is still comparatively new and a lot of research is being done to determine which crop production systems are the most efficient in terms of their carbon footprint. As with other new areas of research, some of the issues are not obvious and it is important to look carefully at every aspect of how crops are grown, dried and transported.

It might be expected that the very visual use of cultivation equipment, combine harvesters and lorries must constitute a major part of a crop's carbon footprint. All the evidence, however, suggests that emissions associated with machinery are small (less than 10% of the crop carbon footprint) compared to those related to the breakdown of fertilisers in the soil (around 40%).

The most important relationship is the amount of fertiliser applied per tonne of crop produced. Reducing the carbon footprint of the crop must, therefore, focus on the efficiency with which inputs, particularly nitrogen, are used and converted to grain or oilseed.

Reducing fuel or pesticide usage too much may increase the carbon footprint per tonne if it reduces the efficiency with which the crop converts nutrients into yield.

Choice of inputs

Use the best genetics

Crops that use resources efficiently to produce marketable yield can have smaller carbon footprints

- Choose varieties with the ability to cope with stress so that yield is maintained even in poor conditions
- Choose varieties with a higher proportion of the crop's biomass in the harvested grain or seed
- Longer-term, the industry should encourage the development of new varieties with high nitrogen use efficiency

Use lower carbon inputs

New technology is being developed to reduce the carbon footprint of crop inputs

Ask your agronomist or supplier about:

- New 'abated' nitrogen fertilisers that have lower carbon footprints
- Selecting nutrient sources with higher potential nitrogen use efficiencies
- Nitrification/urease inhibitors, or polymer-coated fertilisers that have the potential to reduce nitrous oxide emissions from the soil

HGCA Recommended Lists

The HGCA Recommended Lists compare new and existing varieties in terms of their yield, quality, agronomic features and disease resistance.

RECOMMENDED HGCA

See **www.hgca.com/varieties** for more information.

How do these compare to traditional inputs?

Use the HGCA carbon footprinting decision support tool to see the difference made to the carbon footprint by using lower carbon inputs.

Visit **www.hgca.com/tools** to use the tool.

Production efficiency through technical efficiency

Practise good husbandry

Healthy plants use inputs more efficiently, leading to higher yields and smaller carbon footprints

Maintain a healthy, efficient crop through:

- Timeliness of crop operations so crops fulfil their potential
- Plant health to optimise yield
- Weed control to reduce resource competition
- Plant nutrition targeted at crop needs
- Soil structure to optimise water and nutrient availability to the plant
- Considering adopting precision farming techniques

HGCA resources

Each year, HGCA runs a comprehensive programme of events and produces a range of publications focusing on improving technical efficiency.

See **www.hgca.com** for more information.

Optimise machinery efficiency

Using machinery and equipment efficiently will reduce fuel use and greenhouse gas emissions

Efficiency can be increased through:

- Technology and machinery choice to reduce energy used per hectare
- Using precision technology to reduce overlaps in the field and to target nutrient use
- Matching tractors and machines
- Good maintenance
- Driver training

Be PRECISE

HGCA's precision farming initiative, Be PRECISE, aims to provide growers with the information and knowledge to make informed decisions about whether precision farming techniques are appropriate for their farm system.

See **www.hgca.com/beprecise** for more information.

Post-harvest options

Help optimise the supply chain

Consider the options available for drying, storing and transporting grain or oilseeds

For the supply chain, working together is essential to reduce emissions by co-ordinating transport, reducing rejections and storing and maintaining grain quality efficiently.

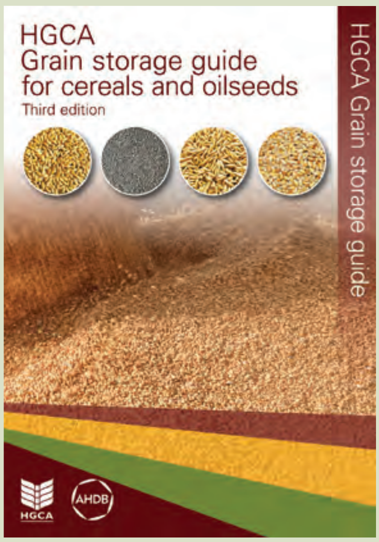
On-farm drying and storage can reduce transport emissions but can be less energy-efficient than larger central stores. Differences in efficiency need to be offset against the potential extra transport involved in moving the crop more times before it is used.

Moving crops directly to the end user will be more efficient than crops that are handled many times.

Best practice grain storage

For more information on best practice grain storage, see HGCA's Grain storage guide for cereals and oilseeds.

See **www.hgca.com/grainstorage** for more information.



Further information

HGCA publications and details of HGCA-funded projects are all available on the HGCA website – **www.hgca.com**

Varieties

www.hgca.com/varieties

HGCA Recommended Lists for cereals and oilseeds (annual)

RL *Plus* – **www.hgca.com/varieties/rl-plus**

Precision farming

www.hgca.com/BePRECISE

PF_Gls09	Precision farming glossary (2009)
Case Study 1	Soil management: variable rate application
Case Study 2	Nutrient management: variable rate application
Case Study 3	Input costs: variable rate nitrogen application
Case Study 4	Variable soil types: yield mapping
Case Study 5	Field operation efficiencies: autosteer
Case Study 6	Nutrient variability: yield mapping and variable rate application
Case Study 7	Soil management: controlled traffic farming
Case Study 8	In-field accuracy: autosteer
Case Study 9	Crop variability: N-sensor to vary nitrogen rate
Case Study 10	Variable soils: nutrient and yield mapping

Soil and nutrient management

IS14	No-till: opportunities and challenges for cereal and oilseed growers (2012)
TS115	Estimating Soil Nitrogen Supply (SNS) (2012)
AHDB-IS01	Improved analysis of solid manures and slurries (2011)
G48	Nitrogen for winter wheat – management guidelines (2009)

Disease and weed management

G54 Wheat disease management guide (2012)

G53 Barley disease management guide (2012)

G50 Managing weeds in arable rotations – a guide (2010)

P05 Nozzle selection chart (2010)

Grain storage

G52 Grain storage guide, 3rd edition (2011)

HGCA carbon footprinting decision support tool

HGCA has developed a tool that offers a transparent way to calculate the carbon footprint of a particular crop and to test different scenarios to identify areas in which efficiency gains can be made.

www.hgca.com/tools

Growing for the future: an environmental roadmap for UK cereals and oilseeds industry

This roadmap is a plan of action for HGCA to assist the UK cereals and oilseeds industry to meet its contribution to greenhouse gas emission reductions and environmental improvement targets by providing relevant information and tools.

www.hgca.com/roadmap

Greenhouse Gas Action Plan

The Agriculture and Horticulture Development Board (AHDB) is a partner in the Greenhouse Gas Action Plan, which sets out how the agriculture industry in England is delivering on its commitment to reduce greenhouse gas emissions by 3 $MtCO_2e$ by 2020.

www.ahdb.org.uk/projects/GreenhouseGasActionPlan.aspx

HGCA Project Reports

PR506 Development of a carbon footprint protocol for the UK cereal and oilseed sectors

PR496 Adapting wheat to global warming (ERYCC)

PR494 Optimum N rate and timing for semi-dwarf oilseed rape (2012)

PR490 Establishing best practice for estimation of Soil N Supply (2012)

PR479 Breeding oilseed rape with a low requirement for nitrogen fertiliser (2011)

PR471 Proof of concept of automated mapping of weeds in arable fields (2010)

PR468 Genetic reduction of energy use and emissions of nitrogen through cereal production: GREEN grain (2010)

PR435 Facilitating carbon (GHG) accreditation schemes for biofuels feedstock production (2008)

PR438 Optimising fertiliser nitrogen for modern wheat and barley crops (2008)

PR435 Understanding and managing uncertainties to improve biofuel GHG emission calculations (2008)

PR417 Optimising nitrogen applications for wheat grown for the biofuels market (2007)

HGCA Research Reviews

RR71 An up-to-date cost:benefit analysis of precision farming techniques to guide growers of cereals and oilseeds (2009)

RR68 Better estimation of soil nitrogen use efficiency by cereals and oilseed rape (2008)

RR62 Spatially variable herbicide application technology; opportunities for herbicide minimisation and protection of beneficial weeds (2007)

RR59 'Controlled traffic' farming: literature review and appraisal of potential use in the UK (2006)

Current HGCA-funded projects

RD-2007-3458 Improving resource use efficiency in barley, through protecting sink capacity

RD-2007-3409 Sustainability of UK-grown wheat for breadmaking

RD-2009-3624 Exploiting resource use efficiency and resilience in ancient wheat species

RD-2012-3772 Agricultural biomass supply chain GHG reporting

RD-2007-3356 Reducing the carbon footprint of the lubricants industry by the substitution of mineral oil with rapeseed oil

RD-2008-3474 Minimising nitrous oxide intensities of arable crop products (MIN-NO)

RD-2009-3659 A breeder's toolkit to improve Hagberg Falling Number for the economic and environmental sustainability of UK wheat

RD-2008-3543 Exploiting novel genes to improve resource use efficiency in wheat

RD-2008-3575 New wheat root ideotypes for improved resource use efficiency and yield performance in reduced input agriculture

RD-2008-3530 Automating nitrogen fertiliser management for winter cereals

RD-2007-3454 Improving the sustainability of phosphorus use in arable farming

RD-2009-3699 Modern triticale crops for increased yields, reduced inputs, increased profitability and reduced greenhouse gas emissions from UK cereal production

Websites

Centre of Excellence for UK Farming: **www.ceukf.org**

Farming Futures: **www.farmingfutures.org.uk**

Greenhouse Gas Action Plan: **www.ahdb.org.uk/projects/GreenhouseGasActionPlan.aspx**

Nitrous Oxide Focus Group: **www.nitrousoxide.org**

The Carbon Labelling Project: **www.co2star.eu**

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