Decarbonising Scottish Malting Barley

Final Report

KTIF Reference No: KTIF/010/2022

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Scottish Government
Riaghaltas na h-Alba
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1. PROJECT TITLE

1.1 Title

Decarbonising Scottish Malting Barley

1.2 Lead Organisation

SAOS

SAOS delivered the project on behalf of East of Scotland Farmers and Highland Grain farmer members.

SAOS is Scotland's expert on farmer co-operation and supply chain collaboration. It provides a range of specialist information, development, and consultancy services. Our work allows Scotland's farming, food, and drink businesses to benefit from the commercial advantages that can be achieved by working together more effectively, enabling them to contribute to the success of Scotland's food and drink industry and its rural economy.

SAOS is itself a co-operative founded in 1905 and owned by sixty agricultural co-ops who have a combined turnover of over £1.6bn and 24,600 members. Its work spans agriculture, aquaculture, forestry, and their marketing chains with the aim of increasing competitiveness and responsiveness through 'smart' solutions and innovation. SAOS employs a team of eighteen specialist project managers qualified, experienced, and trained in co-op and collaborative development, delivering a range of strategic national projects as well as specialist co-op advice

SAOS's work today includes thought leadership on more complex challenges than ever before, identifying and supporting the development of innovative solutions for farming and food production on topics such as climate change, carbon sequestration, technology and the use and translation of data.

The purpose of SAOS is to ensure that Scotland's farming, food and drink businesses and supply chains benefit from the commercial advantages that are achieved through co-operation and collaboration, enabling them to contribute sustainably to the success of Scotland's food and drink industry.

For further details see www.saos.coop

2. EXECUTIVE SUMMARY

The project's primary aim was to raise the awareness and understanding amongst farmer producers of the greenhouse gas (GHG) emissions associated with producing malting barley, supporting arable growers on their journey to transition to lower carbon production systems for malting barley to meet the expectations of both Scottish Government and the Scotch Whisky Industry.

The Scotch Whisky sector has created a roadmap to achieve net zero by 2040 (SWA Net-Zero Report June 2020). This study showed that 37% of the GHG emissions attributed to malt whisky comes from the production of barley on-farm. To achieve the ambitious targets set by the Scotch Whisky industry, will require farmers to play their part and drastically cut their emissions associated with barley production. The first step is to better understand the current carbon footprint of malting barley and the main sources of emission.

We adopted a bottom-up approach, with farmers taking responsibility for action through their grain co-ops. The two grain co-ops involved were East of Scotland Farmers and Highland Grain. The project delivery involved sixteen malting barley producers representing a variety of farm systems across two regions, namely the arable Highlands and Angus /Perthshire. It involved facilitated farmer workshops, conducting farm carbon audits, detailed soil analysis, technical experts, and importantly discovery and practical problem solving by the growers involved.

What we have learned:

- The task of reducing emissions per tonne of output, to a meaningful extent, is going to be a huge challenge
- The main sources of GHG emissions in malting barley is fertiliser (particularly nitrogen) and energy to power machinery and dry grain – both account for some 83% of GHG emissions in malting barley production
- That said, the single most important factor in determining the carbon footprint of malting barley is crop yield
- The main message is optimised yield is the key for both profitability and delivering 'low carbon' produce into the supply chain
- Based on one year's experience, there was no correlation between different farm systems and GHG emission levels. The impact on emissions of a specific production system is less than the impact of a farmers' ability to manage that system efficiently
- The results from the carbon audits highlighted the importance of accurately inputting the data into the calculator. There needed to be improved validation of the inputted data to ensure greater accuracy
- Business efficiency - using less inputs without reducing output - is the key. It is believed there is currently scope for growers to reduce their GHG emissions to the order of 5-15% by improving their efficiency and reducing waste
- There is a belief among many farmers that they have been unjustifiably blamed for contributing to the climate crisis and should bear the main responsibility for action
- The lack of clarity from Government policy on how to tackle GHG emissions and who will pay for it, makes it particularly challenging to identify a direction in which to guide the project outcomes

The project has been a resounding success evidenced by the progress that has been made in terms of the improved understanding of the issues and challenges of reducing GHG emissions from malting barley production.

3. PROJECT DESCRIPTOR

This section in the report aims to provide an overview and context for the project.

What did the project set out to achieve?
The project's primary aim was to raise the awareness and understanding amongst farmer producers of the greenhouse gas (GHG) emissions associated with producing malting barley, supporting arable growers on their journey to transition to lower carbon production systems for malting barley to meet the expectations of both Scottish Government and the Scotch Whisky Industry.

Why - the need?
Agriculture contributes around a quarter of Scotland's total greenhouse gas emissions, making it a significant contributor to the climate crisis. For Scotland to meet the ambitious targets contained within the Scottish Government Climate Change Plan, agriculture will have to play its part. Now is the time for the farmers to demonstrate the most effective route to action.

The Scotch Whisky sector have created a roadmap to achieve net zero by 2040 (SWA Net-Zero Report June 2020). The whisky industry has already started the journey to reduce GHG emissions by focusing on Scope 1 and 2 emissions associated with the sector's own operations. Increasingly, the industry will turn to Scope 3 emissions, which are those associated with its suppliers of inputs in its supply chain e.g., farm production. Arable farmers need to start preparing now.

The SWA study showed that 37% of the GHG emissions attributed to malt whisky come from the production of barley on-farm. Achieving the ambitious targets set by the Scotch Whisky industry, will require farmers to play their part and drastically cut their emissions associated with barley production. The question is how can this be achieved? The first step is to better understand the current carbon footprint of malting barley and the main sources of emission.

When – timescale?
The project took place during the period 1 May 2022 – 31 March 2023. This allowed sufficient time for the linked activities to be meticulously planned and implemented to ensure successful outcomes.

How the project was delivered
The project was delivered by working closely with sixteen malting barley producers representing a variety of farm systems across two regions: the arable Highlands and Angus /Perthshire. It involved facilitated farmer workshops, conducting farm carbon audits, detailed soil analysis, technical experts, and importantly discovery and practical problem solving by the growers involved. This is phase 1 in potentially a multi-year project.

Who?
The project focus was on a bottom-up approach and saw the farmers take responsibility for action through their grain co-ops. The two grain co-ops involved (East of Scotland Farmers and Highland Grain) aspire to take the lead role on behalf of all (c 4,000) Scottish barley producers. The co-ops involved have strong relationships with a range of maltsters and distillers in the supply chain and wider farming community, allowing them to communicate the learning and outcomes across the industry.

Where?
The project was undertaken across sixteen focus farmers: eight from the arable regions of Easter Ross and Black Isles, and a further eight growers from Angus /Perthshire /Fife.

4. FINANCE

4.1 Grant Award

To deliver the project a KTIF grant award of £37,287.75 was successfully secured, under the Knowledge transfer and skills development element (grant rate of 75%).

4.2 Project Expenditure

The project was budgeted to cost £49,718, with a grant award at 75% of £37,289. The table below shows actual expenditure and claims across various elements of the project. It shows the actual eligible expenditure incurred was £45, 661.15 – the total of the two claims. This was £4,056.85 less than the budgeted cost.

Item Description	Claim 1	Claim 2	Overal Claim	Grant Budget	Difference
A) Project development costs	£ 2,166.75	£10,180.00	**£ 12,346.75**	£ 12,000.00	-£ 346.75
B) Project management costs	£ 1,386.72	£ 7,007.48	**£ 8,394.20**	£ 8,050.00	-£ 344.20
C) Fees for speakers/facilitators	£ 8,983.00	£ 5,511.00	**£ 14,494.00**	£ 14,350.00	-£ 144.00
D) T&S for speakers/ facilitators	£ 967.75	£ 540.45	**£ 1,508.20**	£ 1,306.00	-£ 202.20
E) Event venue costs	£ -	£ 1,000.00	**£ 1,000.00**	£ 1,384.00	£ 384.00
F) Materials costs	£ -	£ -	**£ -**	£ -	
G) Publicity	£ -	£ 1,420.00	**£ 1,420.00**	£ 1,300.00	-£ 120.00
H) Other approved external costs	£ 3,378.00	£ 3,120.00	**£ 6,498.00**	£ 11,328.00	£ 4,830.00
Totals	**£16,882.22**	**£28,778.93**	**£ 45,661.15**	**£ 49,718.00**	**£ 4,056.85**

4.3 Reasons for variation from budget.

The actual project costs were close to those budgeted in the application.

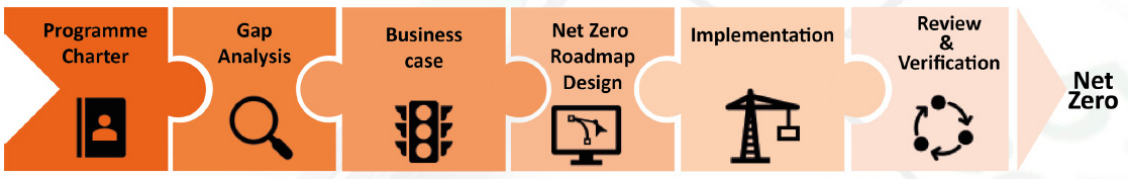
"Project development" had a slight overspend of £347
"Project Man" had a slight overspend of £344
"Facilitators" had an overspend of £144
"T&S" slight overspend of £202
"Venue and catering" – an underspend of £384 (the Co-ops paid for four of the meeting venues)
"Comms" had an overspend by £120
"Other" had an underspend of £4,830. There was a saving in soil sampling and testing of £1,600, plus a saving in carbon audits of £3,230.

The total project claim was £45,661.15 against a grant award of £49,718.
The net impact was an underspend of **£4,056.85**

5. PROJECT OBJECTIVES

The overall project objective was to raise the awareness and understanding amongst Scottish farmers of the GHG emissions associated with producing malting barley and to support arable growers on their journey to transition to lower carbon production systems for malting barley, to meet the expectations of the Scotch Whisky industry and Scottish Government's own legal targets.

Note: it is acknowledged that getting to net zero for malting barley production is 15-20 years' away at present. The logical step approach to address the challenge to get to net zero is shown below:



This is phase 1 in a multi-year project, which increasingly will look at the practical steps producers can take now to reduce GHG emissions, improve soil health and management, make better use of inputs, and reduce waste, developing more resilient and sustainable arable systems.

Specific Objectives

1. To determine the current carbon footprint for Scottish malting barley, the variation in the carbon required to produce a tonne of malting barley represented across a range of different farm systems and soil types
2. To recruit and engage with sixteen farms representing a variety of farm systems across two regions: the east arable Highlands and Angus /Perthshire
3. To examine the soil analysis, organic matter levels and soil health of the sixteen focus farms, to show how they influence the carbon footprint of the malting barley produced
4. To research the potential actions producers can take to reduce the GHG emissions in malting barley production. What actions are currently economically and technically possible for farmers to pursue?
5. To conduct three KTE events (farmer workshops and meetings) involving specialist speakers
6. To deliver an effective communications strategy to share the information and learning from the project widely across the Scottish arable farming sector including the delivery of an open online webinar, press articles, and social media activity

6. PROJECT OUTCOMES

6.1 Project Outcomes

The approach in delivering the project involved a series of linked activities, each of which contributed to the overall project aims and objectives. Key project activities and outcomes achieved are shown in the following table.

ACTIVITY	OUTCOME
1. Recruitment of sixteen focus farmers across both co-ops and conduct baseline descriptions of each farm	• An open invitation went out to all members of both co-ops (385 farmers). Sixteen farmers were selected to be focus farmers • They were selected across a range of soil types, farm sizes and cropping systems (regenerative farming, min till, all arable farms, mixed farms with livestock /grass, imported FYM /hen pen, chopped straw, etc) • Each participating Focus Farm had its farm system and history scoped and described
2. Conduct carbon footprints on each focus farm	• The carbon footprint was calculated (post-harvest) using SRUC's Agrecalc • For consistency, two SAC Advisers were commissioned to conduct the audits • Having established the whole farm's carbon footprint, an estimate was calculated per tonne of malting barley produced for each farm
3. Soil sampling of focus farms	• Representative soil samples were taken from two spring barley fields (post-harvest) for each focus farm • Comprehensive detailed analysis was undertaken including trace elements, organic matter levels, total nitrogen, and a soil health assessment • Many farms in the project had a history of previous soil tests which helped build a fuller picture of the trends with respect to nutrient levels and soil health over a ten- year period
4. First focus farmers meetings	• The first focus farmer meetings were held in Nov to fully explain the project's objectives and to share the results of the baseline benchmarking and soil test /health results • Two meetings were held locally involving the eight focus farms in each region • Working with a smaller group of committed and engaged growers we believe is more effective than simply holding open meetings. There is more shared learning on what works and what does not. The focus farmers are the progressive, leading growers across each region and will have a positive impact on the more traditional family farms.

5. Potential actions to reduce arable GHG emissions	• Brief desk research was conducted (two-days) to identify the range of potential actions arable growers can take to reduce their GHG emissions • It is acknowledged there is a considerable body of information on how to reduce GHG emissions e.g., FAS, "Farming for a better climate," AHDB and DEFRA, amongst others, however, growers are not proactively sourcing this information • The project made it easier through signposting and highlighting key actions, making existing guidance more accessible. An information sheet was prepared with reference and links to existing information on reducing GHG emissions on arable farms • Although carbon footprints are calculated, it is important farmers understand the limitations of carbon calculators. The focus should be on the whole farm carbon position and not just emissions
6. Joint focus farmer meeting to discuss results	• Following analysis and benchmarking of the carbon footprints, soil analysis and scoping exercise, a joint meeting was held with both groups (18 Jan 2023, Pitlochry) to discuss the results • The results of the desk research on how to reduce GHG emissions on arable farms was also presented • Key staff from Agrecalc provided a presentation on conducting carbon footprints, the limitations and potential mitigation strategies followed by a Q&A session • All focus farmers were actively engaged and committed to the project's aims
7. Open meetings with the whole co-op members	• This stage of the project was about sharing the project's aims, the approach used, the results and learning amongst each participating co-op's wider membership • Two distinct local open member meetings were held, one for each grain co-op in the project • The meetings were held in the afternoon with three speakers presenting– the co-op manager, the facilitator on the project's results and a local adviser on carbon footprints
8. Delivery of an open webinar to share project results with wider farming audience	• A webinar was successfully delivered in March 2023. Effective promotion of the webinar was achieved through the co-operation of wider stakeholders, including Scottish Quality Crops (SQC), NFUS, AHDB, all grain co-ops and Scottish Association of Young Farmers amongst others • The webinar had 157 registrations with ninety-eight attending on the night • The webinar was recorded and openly available to view

	https://us02web.zoom.us/rec/share/5wSODlX-l-eynQr3-hnXvOpmeSzuQmEi8YJFp4vVS4hv-OD27pCzRZuANHpx4sZG.ZujDqNSXEbL7B8ak Passcode: +^Ox0cu*
9. Produce final report	A project report has been produced
10. Place materials on the FAS and project partners websites	The materials are ready to be shared with the FAS website and will also be available on the project partners websites

6.2 Project Milestones

Activity	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
Operational Group Meetings										
Recruitment Farmer Growers (16)										
Baseline farm description										
Carbon Footprints										
1st Focus Farm Workshop - two mtgs										
Soil sampling										
Desk research - how to reduce GHG emissions										
2nd Focus Farm Workshop										
Analysis of data										
Communications										
2 Open grower Workshop - project summary										
Open online Webinar (23/03/23)										
Project evaluation & Final Report										

7. LESSONS LEARNED

7.1 Issues /Challenges

There were four main challenges associated with the project and achieving the objectives set, namely:

1. The results from the carbon audits demonstrated the importance of accurately entering the data into the calculator. Numerous errors were found in the individual farm results, which needed to be corrected. The validity of the results was dependent on both the consultant who conducted the carbon audit and the farmer who provided the data - particularly, allocating the inputs across the various enterprises. It becomes more apparent that these errors exist when the data is benchmarked across all sixteen farms in the focus group.

2. It has proved difficult to establish any correlations and trends between the different farm systems so far. The results of the study do not yet indicate a clear conclusion. It is important to note that this is only one year's worth of data. Several regenerative farms are included in the group, including two that have stopped ploughing for several years and use direct drilling, cover crops, green manuring, and other methods that are considered to be more environmentally friendly. Even though their GHG emissions per hectare were among the lowest, when converted to carbon footprint of malting barley per tonne, they were above average. The reason for this is due to lower yields.

3. It was also difficult to convince participating farmers that the carbon audits were fair and accurate. There was an unrealistic expectation that carbon auditing tools would accurately record the true carbon emissions of individual farms. In carbon calculators, the modelling is complex, and IPPC standard data is often used to simplify the process. The farmers found these limitations difficult to accept and felt that they were being unfairly targeted and treated. Farmers have often been identified as one of the major contributors to the climate crisis in the wider press and media. As one grower commented "*I am fed up with farmers being constantly lambasted and accused of being the main cause of the climate crisis!"*

4. As Government policy is unclear as to how to address GHG emissions and on who will pay, it is difficult to identify a direction in which to guide the project outcomes. That said, it is still possible for farmers to improve their use of inputs to improve efficiency, reduce waste, and reduce emissions. However, it will take a combination of new technologies and a financial commitment to cover the additional costs associated with reducing emissions to make considerable progress towards this end. At present, the market does not appear to be willing to pay a premium for low carbon malting barley, and there is no current policy intervention to assist farmers in reducing their GHG emissions.

7.2 Impacts and anything that could be done differently?

The Operational Group and participating farmers have learned a great deal during the first year of the project. We have always considered this year as the baseline year. There is now a greater understanding of the challenges of reducing GHG emissions and decarbonising malting barley production. A clearer understanding of the issues and challenges has now been achieved. All of this is part of the learning and discovery process. In designing the project, we intentionally ensured that it would adopt a bottom-up approach, with farmers taking the lead role in finding solutions. Consequently, it is unrealistic to expect that clarity on how best to decarbonise malting barley will be achieved after only one year. This was always viewed as

the beginning of a journey that would take a minimum of ten years to develop a viable roadmap and solution.

In hindsight, it would have been better to involve Agrecalc and its key technical staff from the beginning of the project. It was necessary to spend more time preparing the focus farmers for the carbon audits, as well as providing them with the information they required and why. It is important for growers to understand the importance of the data and how it is related to carbon calculations. A greater level of involvement from Agrecalc staff would have helped resolve the errors and anomalies associated with the carbon audit results. There are still some errors that need to be corrected.

This has been recognised and Agrecalc staff have now joined the Operational Group in the application for the next round of KTIF to continue the project.

8. COMMUNICATIONS AND ENGAGEMENT

As a means of highlighting the Decarbonising Scottish Malting Barley Project to the wider agricultural community a comprehensive communications programme was undertaken. This extended across several platforms and used the immediate and extended networks of the project partnership.

Webinar
A key delivery activity of the project was the '" Decarbonising Scottish Malting Barley" webinar. Effective promotion of the webinar was achieved through the co-operation of wider stakeholders, including Scottish Quality Crops (SQC), NFUS, AHDB, all grain co-ops and Scottish Association of Young Farmers amongst others.

The event involved three speakers, namely:

1. Robin Barron, General Manager, East of Scotland Farmers Ltd (EoSF). Robin presented the need for the project and why EoSF and Highland Grain became involved and outlined what malting barley customers will be looking for in the future.

2. Gavin Dick, Independent Farm and Rural Business Consultant. Gavin shared the results from the carbon audits benchmarking exercise on the sixteen focus farms, soil health results, the learning to date and future project plans.

3. Kaia Waxenberg, Agricultural Systems Modeller, Agrecalc Ltd. Kaia explained the benefits of measuring a carbon audit, described the methodology of how it is calculated, sources of GHG emissions in farming, the limitations of an audit, mitigation measures, and the new updated Agrecalc v2.

The event was recorded and openly available for viewing on the following link:

https://us02web.zoom.us/rec/share/5wSODlX-l-eynQr3-hnXvOpmeSzuQmEi8YJFp4vVS4hv-OD27pCzRZuANHpx4sZG.ZujDqNSXEbL7B8ak

Passcode: +^Ox0cu*

Press & PR
Several newsletter/press articles were produced, appearing as follows:

Article in the SAOS Update Newsletter, Autumn 2022. *"Grain co-ops co-operate to reduce carbon footprint".* The Newsletter is distributed to 670 Co-op farmer directors, co-op managers and wider stakeholders, plus openly available on the SAOS website.

Article in the SAOS Update Newsletter, summer 2023. "Decarbonising malting barley project update". Discussing the results and learning from year 1 of the project. The Newsletter is distributed to 670 Co-op farmer directors, co-op managers and wider stakeholders, plus openly available on the SAOS website.

The Dundee Courier (18 March 2023), *"Grain sector aims to join net-zero bid".*

http://digitaledition.thecourier.co.uk/html5/reader/get_clipping.aspx?edid=bc7e8cd1-9e84-4ab5-9a36-9a75d48fbe8f&pnum=66&timestamp=20230320160623353

Farmers Guardian (19 May 2023), *"How Scotland is seeking a path to low emissions barley"* by Emma Penny. Two-page spread.

In addition, now the project has been completed, the intention is to write a summary of the project results and learning for all quality assured (QA) malting barley growers (3,800) through the Scottish Quality Crop (SQC) E-Newsletter. An article will be produced to explain the need for action and will include the project's learnings. This is a highly effective route to ensure all malting barley producers are aware of the issues and challenges.

A press release will also be produced for all Scottish agricultural press at the conclusion of the project, to share the project's lessons and findings amongst the wider farming community. This will reinforce the need for farmers to be proactive in acting with respect to the climate crisis and meeting market expectations.

This final project report is available to share with the "*Farm Advisory Service"* (FAS) and the "*Farming for a better climate*" websites.

9. KEY FINDINGS AND RECOMMENDATIONS

The project has identified several key findings.

9.1 Analysis and Discussion of Results

The summary results from the sixteen focus farms involved in the project are provided in Appendix 1. Average results are provided for both groups of growers from each region, plus the range across all the key factors for the combined data. While providing averages for all sixteen farms is useful, it is worth noting the variation between all the farms is substantial.

The crop yield of spring barley across the farms varied from 6.2 – 8.6t/ha with an average of 7.4t/ha. It is noted, the 2022 harvest produced a record cereal crop with above average yields, which also required little drying. Plant breeding over the last decade has resulted in higher yielding malting barley varieties.

The average GHG emissions for a hectare of spring barley in the project was 2,731 Kg CO2e, with a range from 1,942 – 3,922 Kg CO2e. Converted to output at 1 tonne of spring barley, this equates to 369kg CO2e. The range per tonne varied from 290 – 530kg CO2e. The estimate of carbon footprints per ha or per tonne are meaningless at present, as most people do not think in terms of Kg CO2e and are unfamiliar with emission values for other products. In time this will change as quoting GHG emissions figures will increasingly become more common.

The single most principal factor in determining the carbon footprint of malting barley was crop yield. It was worthwhile, growers should optimise their use of fertiliser and other inputs to allow the crop to reach its full economic potential. Cutting back on fertiliser and other inputs does reduce the GHG emissions per ha but not when converted to a unit of output.

Another learning from the project is that the impact on emissions of a specific production system is less than the impact of a farmers' ability to manage that system efficiently. When benchmarking different farm systems, the one factor that is often overlooked is the ability of the farmer. The ability of the individual, their experience, diligence, technical knowledge, ambition, etc has a major bearing on the performance of the farm. This is a key factor. An early observation is that to make regenerative systems work, a higher degree of management compared to alternative conventional systems is required. The second most crucial factor and main source of GHG emission for malting barley was fertiliser, in particular nitrogen use. Across the farms, 68% of emissions in growing malting barley came from manures and fertiliser. We know that nitrous oxide has three hundred times more globally warming potential compared to carbon dioxide.

Therefore, there needs to be a focus on using nitrogen more effectively and in the longer term looking for alternatives to the current inorganic nitrogen products. It is worth noting that simply cutting back on nitrogen rates is not the solution and will only result in a loss in yield. That said, unlike winter cereals, the nitrogen rates applied to spring barley production are modest (typically 70-110kg N/ha) to meet the maltsters quality specification criteria of below 1.65% N.

The other main source of emissions involved in growing malting barley was energy /fuel use, which accounts for 15% of emissions in the focus farms. Other sources of emissions such as lime and crop residues were of less importance.

Learning also included adopting a whole farm approach. Initially, the project's focus was solely on spring barley for malting barley, we now recognise this was an oversight. One cannot look

at spring barley production in isolation, you must consider the whole farm, the rotation, other crops /enterprises, the farm system, and management practices.

As noted earlier, the lack of clarity, guidance, and forward direction at farm level both from a policy perspective and research output into reducing emissions was seen as a barrier by farmers. Increasingly we are seeing scope three emissions being passed down the supply chain from distiller to maltster to farmer. Focus farmers noted that the process needs to continue to the businesses supplying the inputs to farms, especially fertiliser manufacturers.

Finally, the active engagement and involvement of farmer growers is essential for future success. The discovery phase and peer-peer learning are crucial to achieve grower buy-in and commitment to act. This is one of the best routes to achieve effective knowledge transfer exchange (KTE).

Importance of Soil Health

It is accepted that a healthy soil will use inorganic nutrients more efficiently and store more carbon than an unhealthy soil, as well as producing higher yielding crops – all of which will contribute to lowering emissions.

We wanted to include this factor as a third element in our benchmarking exercise where we were already comparing production systems and emissions, so that we could start to create a best practice model for malting barley production which takes in to account emission levels, soil health and production system / yields.

To ensure we were comparing like for like, we used the NRM Soil Health Suite, which takes the three key criteria in soil health (physical structure, chemical composition, and microbial activity) and combines the results to deliver an individual Soil Health Index number for each farm. Whilst a single year's result from the benchmarking exercise is not sufficient data to give us conclusive directions regarding best practice, the soil results gave us some interesting results when comparing across the farms.

- The equal healthiest soil (highest index) is the farm conducting direct drilling, within a mix of cereal and livestock enterprises
- There was an identical score from an all-arable farm growing potatoes, carrots, and cereal crops where everything is ploughed and intensively cultivated – however, a green manure is grown as part of the rotation (as opposed to cover crops which all the farms grow)
- The lowest soil index came from two farms where straw was removed from the farm (sold) without replacing via green manures or imported FYM

The incorporation of organic material either through green manures or FYM would seem to have a positive impact on soil health, although the use of the latter products impacts negatively on GHG emission levels.

One of the conclusions to be drawn from a single year of data is that it is not necessarily the production system which has the greatest impact on soil health, production, and GHG emissions but the attention to detail in the management of the farm's chosen production system. Reduced tillage is possibly not the answer, just one of the options.

Green manures, as an integral part of the rotation, should also be actively supported as opposed to cover crops.

9.2 Implications for Wider Industry

At present business efficiency - using less inputs (fertiliser, fuel, etc) without reducing output - is critical. It is believed there is currently scope for growers to reduce their GHG emissions by 5-15% through improved efficiency and reduced waste. However, more significant reductions in emissions, will require new technical solutions. For example, developing new sources of low carbon fertiliser, new energy sources to replace fossil fuel to drive machines and dry grain, the adoption of gene editing to develop new varieties, amongst other new innovations.

Farmers must take the initiative and ensure they know their baseline emissions, preferably on an annual basis over a number of years, so that they can start to put in place changes to their management practices / production systems which will begin to reduce their emissions whilst maintaining their productivity – and be able to demonstrate that trend. The alternative is likely to be imposed by policy which will result in emissions being managed at a national level, but which may have a negative impact on productivity at a farm level.

That said, growers need to be aware that carbon audits in themselves are not a game changer or silver bullet. It is a tool to help quantify and identify potential mitigation actions to help ensure the business is efficient and sustainable.

Addressing the challenge of decarbonising malting barley, will require Government interventions to incentivise both the research required to find new technological solutions and farmers to adopt them. This may include incentives for the inclusion of pulses and legumes as part of a mixed rotation to reduce inorganic fertiliser use, support for the use of nitrogen inhibitors/ slow-release fertiliser, greater use of precision farming technology and vari-rate application of fertiliser and sprays amongst other things. These measures will help improve production and farm profits, and are more climate friendly.

The relationship between Scottish Government policy and farm production is crucial to future success. The new Agricultural Policy must function as an enabler, empowering industry to identify and act upon their own priorities.

If farmers are going to be held to account for reducing their emissions, there needs to be a single methodology (carbon calculator) for that to be accepted by all. A scheme similar to Scottish Quality Crops (SQC) Assurance is the accepted means of assuring Scottish product quality.

The two grain co-ops involved identified that growers need to be careful not to become ‘busy fools,’ by taking part in green-washing exercises instigated by others purely to be seen to be doing something. There is a risk that such an approach is unlikely to deliver much change and will simply only add cost, involving more administration and paperwork.

10. CONCLUSIONS

In terms of the need for action to tackle the climate crisis, we were given a stark reminder only a few weeks ago (20 March 2023) with the latest UN Report from the world's leading scientists on the Intergovernmental Panel on Climate Change (IPCC). https://unsdg.un.org/latest/stories/new-un-report-offers-survival-guide-humanity-face-climate-change

The impacts of planet-warming pollution are already more severe than expected and we are hurtling towards increasingly dangerous and irreversible consequences. The report stated there is a rapidly closing window of opportunity to secure a liveable and sustainable future for all. We know the Scottish Government's Climate Change Plan update (Dec 2020) requires the equivalent of a 31% reduction in agricultural emissions by 2032 from 2018 levels. Between 1990-2019 Scottish agriculture's emissions decreased by only 13%, showing the scale of the challenge and the need for action.

In conclusion, the science around climate change and carbon is challenging for everyone and the current science with carbon measurement tools is often too blunt to be useful and the suggested interventions often do not have sensible or positive outcomes.

The project's benefits to date:

- Provision of real farm data, showing the current carbon footprint for producing a tonne of malting barley under a range of different production systems
- Improved understanding of the sources of GHG emissions and how they can be mitigated
- Signposting for readily available materials for arable growers on how to reduce their GHG emissions
- Appreciation of the importance of soil health and the benefits of building soil carbon
- Recognition of the importance of the new agricultural policy on future farm production. The new Agricultural Policy must function as an enabler, empowering industry to identify and act upon its own priorities
- Promoting the benefits of increased farmer co-operation, farmers working together to find practical solutions

What have we learned:

- That the task of reducing emissions per tonne of output, to a meaningful extent, is going to be a huge challenge
- The main sources of GHG emissions in malting barley is fertiliser use (particularly nitrogen) and energy use to power machinery and dry grain – both account for some 83% of GHG emissions in malting barley production
- The single most crucial factor in determining the carbon footprint of malting barley is crop yield
- The main message is optimised yield is the key for both profitability and to deliver 'low carbon' produce into the supply chain
- Based on one year's experience, there was no correlation between different farm systems and GHG emission levels. The impact on emissions of a specific production system is less than the impact of a farmer's ability to manage that system efficiently
- The results from the carbon audits highlighted the importance of accurately inputting the data into the calculator. There needed to be improved validation of the inputted data to ensure greater accuracy

- Business efficiency - using less inputs without reducing output - is crtical. It is believed there is currently scope for growers to reduce their GHG emissions by ~5-15% by improving their efficiency and reducing waste
- There is a belief among many farmers that they have been unjustifiably blamed for contributing to the climate crisis and therefore should bear the main responsibility for action
- The lack of clarity from Government policy on how to tackle GHG emissions and who will pay, makes it particularly challenging to identify a direction in which to guide the project outcomes.

It is worth noting, the focus of the project has solely been on carbon and GHG emissions. It must be acknowledged that carbon is not the only critical factor. “Sustainability” in its broadest sense including farm profitability, biodiversity loss, natural habitat, land use and rural communities are all important factors to be considered.

The study has highlighted the challenge for mainstream family farms when it comes to tackling the climate crisis. For individual farmers it is difficult to know where to start and what should they do now. This highlights the important role farm co-ops can play, by providing the leadership and resources to help their famer members take action and making things happen. Action to deliver both economic and environmental gains will become progressively more difficult as the industry advances through easy wins and lower cost solutions, thus the need for increased co-operation will only increase. Co-operation is one of the best ways to ensure there is a just transition for all involved in agriculture.

Finally, the project has been a resounding success evidenced by the progress that has been made in terms of the improved understanding of the issues and challenges of reducing GHG emissions from malting barley production. The role and contribution of the sixteen focus farmers was unquestionably integral to the project’s success. We want to build on this foundation and progress into Year 2.

APPENDIX 1

Malting Barley Combined data from 16 farms	EoSF Group Averages	HG Group Averages	Range
Farm Details			
Total farm area (ha)	372	345	129 - 890
Arable area (ha)	295	243	86 - 840
Spring malting barley area (ha)	112	139	25 - 275
Enterprise Resource Use & Emissions (spr malting barley)			
Physical Performance			
Yield (t/ha)	7.3	7.5	6.2 - 8.6
Straw yield (t/ha)	2.4	3.2	0 - 6
Fertiliser use (kg/ha)	609	669	390 - 800
Fertiliser use (kg/t grain)	83	91	60 - 100
Fuel use (lt/ha)	97	103	25 - 150
Fuel use (lt/t grain)	13	13	
Electricity use (kWh/t grain)	6.63	2.60	0 - 7.42
Enterprise Emissions (kg CO2e/kg grain)			
Manures & Fertilisers	0.23	0.27	0.18 - 0.42
Lime	0.02	0.05	0 - 0.13
Fuel	0.04	0.04	0.01 - 0.06
Crop Residues	0.06	0.03	0.03 - 0.09
Total Emissions / kg of Output (kg CO2e/kg grain)	0.35	0.39	0.29 - 0.53
Total Emissions / Hectare (kg CO2e/ha)	2,582	2,881	1,942 - 3,922
Soil			
Soil pH (av of 2 samples)	6	6	5.6 - 6.5
Organic Matter	6	5	3.6 - 8
Microbial activity	1xmed; 7xlow	low	
Soil Health Index	4.4	3.7	3.1 - 4.8

APPENDIX 2

Reducing GHG Emissions in Arable Farms

Materials researched

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- AHDB
- DEFRA
- Scot Gov