Data driven decisions in potatoes

Final Report

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1. PROJECT TITLE

1.1 Title

Data driven decisions in potatoes – improving financial and environmental performance (phase 2)

1.2 Lead Organisation

SAOS
SAOS delivered the project on behalf of the Scottish Potato Co-op (SPC).

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.

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.

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.

For further details see www.saos.coop

2. EXECUTIVE SUMMARY

The project's primary aim is to improve the productivity and competitiveness of Scottish ware growers through a combination of benchmarking their financial and environmental performance and improving information flows. All to support potato growers to become more productive and sustainable, reducing their impact on the environment /biodiversity.

Scotland is famous for the quality of potatoes it produces, but the continued success of the Scottish potato sector depends on its ability to adapt to an ever changing operating environment. In particular, reducing the carbon footprint and improving the sustainability of potato production.

Agriculture has typically lagged behind other industries in utilizing data to enhance productivity and competitiveness, when it comes to advances in data capture, storage and analytics allowing powerful insights and improved decision making. There is a low level of awareness among many Scottish farmers as to the real value of farm data, therefore a risk that growers loose out in the data revolution. Growers are foregoing the insights and opportunities afforded by effective data management and analysis.

What have we learned:

- Although the benefits of benchmarking are well proven, there is a real challenge to get more farmers involved in business benchmarking.
- Even with good training and support, it takes time for participating farmers to produce accurate data for benchmarking. Experience shows it probably takes individuals 3 years before they are producing accurate robust data.
- The sharing of information and experiences amongst a closed trusting group has huge potential to drive performance improvements.
- Growing ware potatoes is expensive, an average of £7,532 /ha (before rent and interest), margins are being squeezed, therefore growers need to constantly strive to improve their enterprise performance, practicably marketable yield.
- The average carbon footprint of ware production is circa 90kg CO2e per tonne, across a range of 60 -120kg CO2e. This is a wide variation so further work is required to explore the reasons for the variation between growers.
- The three main sources of GHG emission from ware production is; inorganic fertilisers 67%, fuel 22% and electricity 11%. This clearly shows where the focus on reducing emissions associated with potato production should be.
- There is only two years of data. Consistent and repeated GHG emissions measurement (accurate) is required to build a true picture over different seasons.
- The challenge of improving the data flow back to grower members for a produce group is not easy. We now have a clearer understanding of what information growers would like to improve their decision making. This will require SPC to invest resources to make this happen.

Whilst the project has encountered challenges, the co-op and participating farmers all agreed real progress has been made. There is real commitment to continue the project, as it is widely recognised that the need for this type of work will only grow in the future.

3. PROJECT DESCRIPTOR

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

What was the project setting out to achieve?

Although in its second year, the project's primary aim remains unchanged, it is to improve the productivity and competitiveness of Scottish ware growers through a combination of benchmarking and improved information flows. All to support potato growers to become more productive and sustainable, reducing their impact on the environment /biodiversity. The project also looked to support Scotland's ware potato growers following the demise of AHDB Potatoes. This was phase 2 in a multi-year project.

Why - the need?

Scotland is famous for the quality and high health status of potatoes it produces, but the continued success of the Scottish potato sector depends on its ability to adapt to changing circumstances. In particular, reducing the carbon footprint and improving the sustainability of potato production. Due to the associated high level of inputs required, potatoes are a crop with a considerable impact on the environment and associated GHG emissions. The challenge is to improve the productivity of the potato sector, reducing its GHG emissions and impact on the natural environment through improved decision making.

Agriculture has typically lagged behind other industries in utilizing data to enhance productivity and competitiveness, when it comes to advances in data capture, storage and analytics allowing powerful insights and improved decision making. We are now seeing advances in the technologies (precision farming, smart sensors, etc) used to collect data across agriculture and the supply chain, meaning there is an urgent need to harness the power of this information in order to benefit farm practices and lower carbon emissions. There is a low level of awareness among many Scottish farmers as to the real value of farm data, therefore a risk of growers loose out in the data revolution.

When – Timescale

The project took place from May 2023 – 31 March 2024. This allowed sufficient time for the linked activities to be properly planned and implemented to ensure successful outcomes.

How the project was delivered

The project was delivered by working closely with 10 potato growers who are looking to improve their business performance. It involved facilitating a benchmarking group, holding regular group meetings, conducting farm carbon audits, calculating the nitrogen use efficiency (NUE) for participating farms, and exploring how to improve the data provision provided by the Scottish Potato Co-op (SPC) to their grower members.

Who

This is a bottom-up approach, growers themselves taking responsibility for action through their co-op. The project was led by SAOS on behalf of the Scottish Potato Co-op (SPC) and wider Scottish potato ware producers. SPC is a ware marketing co-op involving 24 large professional growers, producing 90,000t of potatoes.

Where

The project was undertaken by potato growers from across Angus, east Perthshire and Fife. These are the main growing regions of potatoes in Scotland.

4. FINANCE

4.1 Grant Award

To deliver the project a KTIF grant award of £25,575 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 £34,100, with a grant award at 75% of £25,575. The table below shows actual project expenditure across various elements of the project. It shows the actual eligible expenditure incurred was £32,814.17 – the total of the two claims. This was £1,285.83 less than the project budgeted cost. The net effect is that the project received a grant of £24,610.63, slightly less than the grant award of £25,575.

Item Description		Claim 1	Claim 2	Overal Claim	Grant Budget	Grant awarded KT @ 75%
A) Project development costs		£ 4,340.04	£ 5,556.69	**£ 9,896.73**	£ 8,575.00	£ 6,431.25
B) Project management costs		£ 2,080.08	£ 3,380.13	**£ 5,460.21**	£ 5,075.00	£ 3,806.25
C) Fees for speakers/facilitators		£ 3,123.39	£ 3,330.04	**£ 6,453.43**	£ 6,600.00	£ 4,950.00
D) T&S for speakers/ facilitators		£ 499.20	£ 442.90	**£ 942.10**	£ 900.00	£ 675.00
E) Event venue costs		£ 72.45	£ 883.86	**£ 956.31**	£ 700.00	£ 525.00
F) Materials costs		£ -	£ -	**£ -**	£ -	
G) Publicity		£ 780.03	£ 693.36	**£ 1,473.39**	£ 3,250.00	£ 2,437.50
H) Other approved external costs		£ -	£ 7,632.00	**£ 7,632.00**	£ 9,000.00	£ 6,750.00
	Totals	**£10,895.19**	**£ 21,918.98**	**£ 32,814.17**	**£ 34,100.00**	**£ 25,575.00**

4.3 Reasons for variation from budget.

Although actual costs were close to those budgeted in the application, the main discrepancies were:

- The planned webinar was not delivered due to the delay in getting the Agrecalc farm carbon audit results. This resulted in a saving of £1,776.61 in "Publicity /Comms".
- 'Other' was underspent by £1,368. This was due to 8 farm carbon audits being completed rather than the budgeted 10.
- There was an overspend of £1,321.73 in "Project Development".

The net impact was an underspend of **£964.37 from the grant awarded.**

5. PROJECT OBJECTIVES

The project's overall objective is to improve the productivity and competitiveness of Scottish ware production. This will be achieved through a combination of benchmarking and improved information flows, all of which to improve the decision making of ware growers. As a result, growers should become more efficient in their use of inputs, reduce their waste, which will all contribute towards a reduction in the environmental impact of potato production.

Anecdotal experience suggests, that for a variety of reasons, Scottish potato growers are failing to make use of the data generated on-farm and from the supply chain. Growers are foregoing the insights and opportunities afforded by effective data management and analysis. The project will focus on tackling this through the improved use of data; leading to an improved awareness of the carbon footprint, inefficiency, and importantly a lower impact on the environment.

Benchmarking is a widely adopted approach to improve the performance of a business. It is the process of measuring and evaluating the performance of an enterprise, to identify areas that need to be improved. By comparing the physical and financial performance of a group of similar potato growers, individual members can see how they compare with others; what they are good at but more importantly, identify areas of weakness that need to be tackled.

We know from experience many farmers don't really understand their production costs, enterprise performance, breakeven cost, and what to focus their efforts on. By the process of measuring the key performance indicators (KPIs) and the carbon footprint of their enterprise, growers will develop a better understanding of their potato enterprise, be more able to ask the right questions and identify what needs to be improved.

In life and in business, we tend to make decisions subjectively. Benchmarking helps train individuals to make, evidence-based objective decisions. Investing in skills development – human capital – is widely regarded to be the most effective use of limited resources. Interest in benchmarking and data usually comes from younger members in the farm business, so it is a good route to support the "next generation".

Specific Objectives

1. To determine the cost to produce a tonne of potatoes, across a range of different Scottish farm systems, soil types and management practices. This will be across different categories of ware potatoes (Whites, Maris Piper, and processing potatoes)
2. To determine the carbon footprint associated with producing ware potatoes (per ha and tonne) and the variation in GHG emissions across different farm systems, soil types and management practices.
3. To improve the data information flow between the co-op (producer group) and individual growers
4. To engage with supply chain customers to demonstrate the value and benefit of adopting a more collaborative supply chain approach through the improved sharing of information.
5. To deliver an effective communications strategy to share the project learning throughout the Scottish potato sector. This will involve the delivery of an open online webinar, the farming press, articles and social media.

6. PROJECT OUTCOMES

6.1 Project Outcomes

The approach used to deliver 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 described below.

1. Ensure continued Grower engagement

- Two new growers have been recruited to the Benchmarking Group, which now comprises of 10 growers.
- All participating growers continue to receive support to use AHDB's Farm Bench. The information is inputted online by each participating grower and covers their whole farm, not just the potato enterprise.

2. Benchmarking Group meetings

- The Benchmarking Group is facilitated by an experienced independent consultant. The group met three times over the year.
- The first meeting was a 'technical' meeting, held on 8th June involving on-farm visits to two members farms followed by an open discussion.
- The second meeting was held on the 15th Dec in a hotel, near Perth. This was the main benchmarking results meeting exploring the 2023 harvest figures. Prior to the meeting, growers submitted their individual physical and financial whole farm performance online using AHDB's Farmbench. Individual support was provided as required. The meeting focused on analysing the results and discussing what it all means.
- The third meeting was a 'management' focused meeting, held on-farm at two growers farms in East Lothian. In addition, the management topic was building personal and business resilience. The output from the discussion, produced by the group, was a list of potential routes to build personal and business resilience. An action that came from the discussion was the need to explore how to produce a farm 'Risk Register' in more detail. This will be done at a future meeting.
- Although benchmarking is at the heart of the project it is much more than that. The project focused on real practical issues, which included comparisons of growing systems, variety performance, the efficient use of inputs, soil management, disease control, irrigation management, etc. This is the reason why on-farm visits are so powerful.

3. Conducting carbon footprints on each Farm

- All the group members had a whole farm carbon audit completed in March 2024 based on the 2023 harvest. It was important to use the same carbon calculator for consistency so Agrecalc V2 was used. There was 8 farm carbon audits completed. It is important to build up a body of evidence not solely based on one year but from a variety of seasons.
- Agrecalc has recently undergone some major improvements so the farm audits and results produced should be more accurate.
- The growers involved now have more experience of carbon audits and how to provide more accurate information. We know carbon audits are only an estimate and are heavily dependent on the quality and accuracy of the information inputted into the calculation. It is important farmers understand the limitations of carbon calculators. Use was made of the Benchmarking figures to make it less onerous on individual members to complete the carbon audits.

4. Calculating Nitrogen use efficiency (NUE)

- This was a new activity, estimating the NUE for each farm. This provided invaluable information on how well each farm is using nitrogen. The project showed from the previous year that one of the main sources of GHG emissions in growing potatoes comes from inorganic fertiliser use. Nitrous oxide has 300 times the global warming potential of carbon dioxide. Therefore, there is a need to examine how well farms use the nitrogen applied.
- Establishing a baseline NUE for each farm for the potatoes and combinable crops harvest in 2023. It involves estimating the tonnes of potatoes and grain crops produced, the nitrogen(N) content of each crop, and the total tonnes of N applied from inorganic fertiliser plus any organic manures, FYM or digestate applied to each crop.
- The results of the NUE calculation are shown in appendix 1 for the range of crops grown on the participating farms. It should be noted only 5 growers estimated their NUE. Clearly more work is required here.
- The results show that nitrogen is not used well in potatoes compared to combinable crops. The average NUE for M. Piper was 83% and 78% for White varieties. There was considerable variation in the results across the farms, ranging from 46% to 87%. This is an area that needs further work.

5. Improving Data /Information flows

- Following the Initial data scoping work carried out in phase 1, further work was carried out over the year.
- An open SPC grower meeting was held on the morning of 13th Dec in Dundee to discuss what information / data SPC members would like to receive from their co-op. 15 members attended that meeting.
- A short presentation, by Fraser Malcolm (SPC's Marketing Agent) demonstrated the range of potential information which could presented back to members. Members were then divided into smaller sub-groups to explore what additional information would they like to receive from the co-op.
- A consensus was agreed around a two stage approach. Stage 1 would be to produce individual annual summary reports, followed by stage 2, which would be more detailed benchmarking figures comparing individuals against the average for the membership.

6. Open meeting with the whole co-op members

- This stage of the project was about sharing the project's aims, results and learning to date amongst all SPC's members.
- This was done on the afternoon of 15th Dec 2023 at Dundee, which was also SPC's AGM. This ensured as many members were present as possible.
- There was considerable interest and questions from the wider membership on the project's activities and learning to date.

7. Delivery of an open webinar to share project results with wider farming audience

- This activity was not completed due to the delay in getting the Agrecalc farm carbon audits completed. We couldn't continue without the results being available from one of the main activities.

8. Produce final report

- A project report has been produced. The materials are ready to be shared with the FAS website and will also be available on the project partners websites.

6.2 Milestones

Activity	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Operational Group Meetings											
Training on AHDB's Farm Bench											
Benchmarking Group meetings (3)											
Carbon Footprints											
Reviewing data provision and growers needs											
Supply Chain Engagement											
Deliver online webinar											
Open Grower Meeting - project summary											
Project evaluation & Final Report											

Note, the planned online webinar was not delivered.

7. LESSONS LEARNED

7.1 Issues /Challenges

The main issues associated with achieving the objectives set are:

1. Although the benefits of benchmarking are well proven, there is still a challenge to get more farmers involved in business benchmarking. Some farmers, for a variety of potential reasons, simply don't want to be part of benchmarking group. The number of potato growers who know their actual production costs is unknown, however, it is considered to be low, circa 10-15%. Part of good professional management for any business is understanding your production costs and key performance indicators. This is a potential weakness of Scottish agriculture.

2. **Providing accurate data for benchmarking.** Even with good training and support, it takes time for participating growers to produce accurate data for benchmarking. Experience shows it probably takes individuals 3 years before they are producing accurate robust data. This is part of the learning process. Farming is a complex business, involving multiple enterprises (e.g. cereals, potatoes, vegetables, soft fruit, cattle, sheep, etc.) Allocating costs such as labour, machinery, fuel, etc which are shared across multiple enterprises is not easy.

   The solution is to develop initial simple allocation rules (e.g. 25% of the labour cost is spent on potatoes), then over time and experience, to consider how to make the allocations more accurate. This is the reason why it is so important that the farmer themselves are involved in the process – they know the farm and its operations better than anyone else.

3. **Conducting Carbon Audits**. Experience from last year highlighted the importance of accurately entering the data into the carbon calculator. The accuracy of the audit results was dependent on the grower who provided the data and the consultant who completed the carbon audit. The growers involved now all have more experience of carbon audits and how to provide more accurate information. This year, one dedicated adviser inputted all the data for the participating 8 farms. As a result, everyone involved agreed the results generated was more accurate compared to last year. This was a significant improvement from the previous year.

   There is a close relationship between the information required for benchmarking and for a carbon audit. It should therefore be easier for participating farmers to provide the necessary data for completing a carbon audit. In the future, the intention is to link the benchmarking data with the carbon emissions data to demonstrate how the two sets of figures are closely dependent on each other. Again, this is part of the learning process for participants.

4. **Provision of data to Members**. This was another key task that provided lots of learning. The aim was to review the current data information provided to member growers' by SPC, identifying areas how the information could be improved to support growers decision-making. SPC had invested in a bespoke software whose function is the real time stock control of members potatoes,

and importantly it is linked with their financial accounts package (Zero). This has turned out to be a great asset and worthwhile investment, however, there is considerable scope to improve the information flow back to members. A review of the current data system was successfully completed.

7.2 Impacts and anything that could be done differently?

For a variety of reasons, the Agrecalc farm audits were not completed until the end of March 2024. The project team were unable to validate the collated results to ensure any potential errors were corrected before circulating the results back to the participating farmers. This pushed all subsequent activities for time to meet the project deadline of 31st March.

One of the knock-on effects of the project results being late was there was no time to deliver the planned open online webinar. The agreed solution is to deliver the planned online webinar later in the summer, once all the field work and potato planting was complete. This has been one of the wettest winters /springs for many decades, resulting in a very late spring. The co-op, SPC, will cover the cost of organising and delivering the webinar themselves.

The project team and participating ware growers have all learned a great deal during the two years of the project. We are now gaining real traction and more able to deliver value to the group, to help them improve their business performance.

In designing the project, we intentionally wanted to ensure that it would adopt a bottom-up approach, with farmers taking the lead role in finding solutions. Consequently, it is unrealistic to expect that all the project's objectives would be met in two years.

8. COMMUNICATIONS AND ENGAGEMENT

As a means of highlighting the "Data driven decisions in potatoes" project to the wider agricultural community a variety of communications channels were planned. This used the immediate and extended networks of the project partnership.

Press & PR

A seminar was delivered by Jim Booth at the new "Future Farming Event", which was held at the Aberdeen Exhibition Centre on 10th & 11th Oct 2023. The seminar was held on day 1, 10th October. The project's objectives, activities, results and learning to date were all covered in the presentation. A lively Q&A session followed the presentation. A total of 27 people attended the seminar.

As previously mentioned, an open meeting was held on 15 January 2023 at the Landmark Hotel, Dundee, attended by 23 people. This was a great opportunity to share the project's objectives and to discuss the results and learning amongst the wider SPC members. There is a real interest amongst the membership in the project, as its widely recognised that this is something that will impact on all growers. Having 10 fellow members actively involved in the project gives the project real creditability.

The final project report will be available to share on the "*Farm Advisory Service"* (FAS).

Webinar

A key project activity planned was the online webinar, as explained previously, this was not delivered. We did request permission to deliver it in April, but advised any work beyond the 31st March was not permitted.

In recognition that the comms plan of the project hasn't been successfully delivered, we still plan to deliver a webinar later this summer, at a time which is convenient to potato growers. This will not form part of the project delivery or claim but is in recognition of the need to share the results and learning amongst the wider potato community and supply chain.

9. KEY FINDINGS AND RECOMMENDATIONS

To discuss the project's key findings , the following provides a reminder of the specific study objectives and the project's achievements

Specific Project Objectives

1. To continue to engage with 8-12 ware growers representing a variety of farm systems.

This was achieved. There are now 10 farm businesses involved in the Benchmarking Group (the previous year involved 8 growers). It is pleasing to note this also included three younger family members. The success of the group is spreading, more growers are interested in benchmarking and measuring their carbon footprint.

2. To determine the cost to produce a tonne of ware potatoes, the different elements of the main costs, the key performance indicators, all across a range of potato growers and farm systems.

The production cost of growing ware potatoes in 2023 was achieved. Appendix 1 provides the group average benchmarking figures for Maris Piper and White potatoes (plus other cereal crops).

For Maris Piper. The average area of Piper grown was 46 ha, the average yield was 51.8 t/ha with a range of 44.7 – 58.9t/ha. The average price £253/t, with a range of £223 - £270/t. Average total sales came to £13,104 per ha – with a range from £10,953 to £14,275.

It is interesting to note some significant differences between growers, for example: irrigation passes (ranged from 1 – 6); nitrogen applied (ranged from 176 – 220 Kg/ha); purchased seed (ranged from £240 - £750 /ha); seed treatment (ranged 0 - £75 /ha); crop protection (ranged £468 - £823 /ha). These are significant variations and reflect the differences in land, production systems and management practices applied to growing ware potatoes. Clearly there is no one 'blueprint' for growing ware potatoes.

Appendix 2 shows the production costs per tonne. It is important to stress this is **before rent and finance.** These are omitted as they are commercially sensitive to individual growers. The average production costs for M. Piper is £146/t, with an average net margin is £107/t – all before deductions for rent and interest.

For Whites. There are a range of varieties (Cultra, Manitou, Saxon, etc) grown under this category. The average area of Whites grown was 22 ha, the average yield was 52.8 t/ha with a range of 49.2 – 60.3t/ha. The average price £213/t, with a range of £193 - £247/t. Average total sales came to £11,268 per ha – with a range from £19,520 - £14,504.

Again, it is interesting to note some significant differences between growers, for example: irrigation passes (range 0 – 5); nitrogen applied (range 163 – 220 Kg/ha); purchased seed (range £400 - £1,020 /ha); seed treatment (range 0 - £100 /ha); crop protection (range £380 - £797 /ha). Again, these are significant variations and again reflect the differences in land, production systems and management practices applied to growing ware potatoes.

Appendix 2 shows the production costs per tonne. It is important to stress this is **before rent and finance,** As highlighted earlier, these are omitted as they are commercially sensitive to individual growers. The average production cost for Whites is £122/t, with an average net margin is £91/t.

3. To estimate the average carbon footprint for ware potatoes, the range across various farm systems and the sources of GHG emissions.

The carbon footprint was calculated using Agricalc v2 with 8 growers completing their farm audits. This was up from only 4 last year. Appendix 3 provides the group average carbon audits for ware potatoes plus the main combinable crops for the 2023 harvest.

The figures show that the carbon footprint for potatoes was 4,639kg CO2e per ha. On an area basis this is significantly higher than the corresponding emissions for combinable cereals. Turning to examine emissions on an output bases (per tonne), then potatoes due to their high yield (54.6 t/ha), have a lower carbon footprint per kg. The total emissions based on output are 0.09 CO2e /kg potatoes.

For potatoes there are only three sources of GHG emissions, namely; inorganic fertilisers 67%, fuel 22% and electricity 11%. This clearly shows that the focus on reducing emissions associated with potato growing should focus on using fertiliser, fuel and electricity as efficiently as possible.

Appendix 4 shows the average carbon footprint comparison between the 2023 and 2022 harvest years. We know that the 2022 harvest was a record one for combinable crop yields, which makes a significant impact on emissions per output. It is interesting to note the carbon footprint of potatoes have increased by 4% in 2023 compared to the previous year. This is attributed to a combination of lower average yields and higher fertiliser use.

It is worth reflecting that the estimate of carbon footprints per ha or per tonne for potatoes still have little meaning for most people. What is important, and increasingly what customers and consumers will demand, is evidence of actions taken to reduce GHG emissions. Potato growers need to start thinking about that now. This is the start of the journey to decarbon potato production and to better understand the sources of GHG emissions. The key factors are saleable yield, fertiliser and energy use (tractor fuel and electricity to operate cold stores).

4. To improve the data information flow between the co-op (producer group) and individual growers

Some progress has been made in improving the data flow back to members but more needs to be done. Although the co-op has a bespoke data management system, there is still a lot of data entered manually. This is both time consuming plus prone to human error in data entry. There is a need to invest in additional software to make this as automated as possible.

The bespoke data management system provides real time stock control for all the potatoes grown by members, which is the basis for all the marketing conducted by the co-op. The starting point is the information provided by members at planting on the area planted and the varieties grown. Members also provide key harvest data on the crop yield (number of boxes), across the different varieties, fields and which store they go into. Ensuring the information provided by members is accurate is always a concern, but is improving with experience and support.

Members have access to their individual figures through an online secure portal. Its use by members has steadily increased and now the majority use this depository of information on a regular basis.

At present, the portal provides a historical list of all the sales completed by; the date, number of boxes despatched, the customer, final paid yield and total price. What members requested is Stage 1: a summary annual report for the whole season containing the following information:

- The total tonnes sold and the average price paid
- A breakdown of the harvest yield and saleable yield per variety
- The average price paid per variety
- Breakdown of the tonnage sold to different customers
- Movement of potatoes (tonnes) per month

This would be the basic information required for a summary report. Stage 2, would be further analysis to explore how individual members compared with the average for the whole membership. This could be undertaken across key metrics – e.g. harvest yield per variety, saleable yield per variety, average price per variety, averages across different customers, and yields per field.

5. To engage with supply chain customers to demonstrate the value and benefit of adopting a more collaborative supply chain approach through the improved sharing of information.

Ensuring customers receive the potatoes that meet their specification, on the day requested, with the correct tonnage is the basic of service delivery. Building trust with the co-op's customers is an ongoing activity. The co-op strives to ensure good quality potatoes and superior service as a route to compete in the market, building a reputation for excellence. This has borne benefits. Although SPC is only in its 5th year, the number of members, tonnage marketed and customers served has steadily grown over the time.

SPC now supply 10 different customers, from all the major Scottish ware packers to a range of processing companies down in England. There is a range of audit and quality assurance requirements for the different customers. The only way this can work effectively is by collaborating with each customer. The requirement to provide information to ensure individual audit requirements is steadily increasing. For example, all grower members have to complete SEDOX online, some need to be Leaf accredited, and increasingly carbon audits are also required. Admittedly this is more about compliance at present, but having developed a strong relationship, there is scope to improve information sharing to save duplication, reduce cost and improve efficiency for mutual benefit.

6. To deliver an effective communications strategy to share the information and learning from the project widely throughout the Scottish potato sector.

As already highlighted this is an area that wasn't successfully achieved. The planned online webinar was not delivered. In recognition of this, SPC plans to deliver a webinar later this summer, at a time which is convenient to potato growers. This will not form part of the project delivery or claim but is in recognition of the need to share the results and learning amongst the wider potato community and supply chain.

10. CONCLUSIONS

In conclusion, some of the key learning from the project:

- The project has made great strides as evidenced by the progress in terms of the improved understanding of the challenge of improving the productivity and competitiveness of ware production.
- A good benchmarking group has been established of progressive growers who are open to change and the sharing of information.
- That said, it is only year 2, the robustness and accuracy of the data generated by the group will only improve with experience.
- Although benchmarking is at the heart of the project it is about much more than that. The project focused on real practical issues, which included comparisons of growing systems, variety performance, disease control, irrigation management, machinery replacement policy, storage design, ventilation systems, managing people, risk management, cold store management, amongst other things. These are critical issues for the successful operation of a potato enterprise.
- The sharing of information and experiences amongst a closed trusting group has huge potential to drive performance improvements.
- Growing ware potatoes is expensive, an average of £7,532 /ha (before rent and interest), margins are being squeezed, therefore growers need to constantly strive to improve their performance and marketable yield (potato quality).
- The project has provided SPC with more accurate production costs data allowing it to negotiate future contracts with customers more effectively. This has already paid dividends to the co-op.
- The average carbon footprint of ware production is circa 90kg CO_2e per tonne, across a range of 60 -120kg CO_2e. This is a wide variation so further work is required to explore the reasons for the variation between growers.
- The three main sources of GHG emission from ware production is; inorganic fertilisers 67%, fuel 22% and electricity 11%. This clearly shows where the focus on reducing emissions associated with potato production should be.
- That said, saleable yield and production efficiency will play a crucial role to lower carbon emissions in ware production.
- There is only two years of data. Consistent and repeated GHG emissions measurement (accurate) is required to build a true picture over different seasons.
- As previously mentioned, the challenge of improving the data flow back to grower members is complex and hard to achieve. This is still at an early stage.
- We know that there is an issue in general with information overload and farmers becoming increasingly time constrained.
- We now have a clear demand from growers for individual annual summary reports as the first stage of improving the data flow. Further stages would include benchmarking individual results across the whole membership. This will require SPC to invest resources to make this happen.

The benefits for the wider agricultural community include:

- The project showcases to the wider farming community what can be achieved by farmers themselves taking proactive ownership and action.
- It demonstrates the value and benefits of farmers working co-operatively together. Since producer members own their co-operative, it innately self-empowers producers to coalesce around a tangible delivery model, to take

the initiative, and unlock ambition. More confidence can be taken in shared commitment to projects that would not be feasible by an individual business.

- Increased awareness and understanding amongst farmers and their supply chains, of the role and importance of collaborative data sharing.
- Producer co-ops improve industry engagement, support delivery, manage resulting data for greater scheme efficiency, and to unlock value-add opportunities for producers and their supply chains.

The role and contribution of the 10 farmers was unquestionably integral to the project's success. There is a commitment to continue the project, as it is widely recognised that the need for this type of work will only grow in the future. The aim is to build on this foundation and to progress into Year 3.

APPENDIX 1

Production costs per hectare (excluding rent and interest), Harvest 2023

SAOS/SPC Benchmarking Group - Harvest 2023 - Group Averages by Crop

Per hectare	Winter Wheat	Winter Barley	Spring Barley	Oats	Potatoes (Piper)	Potatoes (Whites)
Technical Performance						
Total area grown (ha)	123	63	109	63	46	22
Total production (t)	1,230	548	774	484	2,500	1,181
Yield (t/ha)	9.9	8.5	7.1	8.1	51.8	52.8
Price (£/t)	210	204	228	203	253	213
Inorganic nitrogen (N) (kg/ha)	208	176	134	138	171	164
Inorganic phosphate (P) (kg/ha)	58	69	43	69	85	78
Inorganic potash (K) (kg/ha)	73	98	87	56	313	269
Inorganic sulphur (S) (kg/ha)	53	53	41	56	239	172
Total N applied (kg/ha)	**213**	**162**	**134**	**160**	**215**	**200**
Nitrogen Use Efficiency (%)	**91**	**89**	**87**	**126**	**83**	**76**
Income						
Crop sales	2,080	1,726	1,597	1,620	13,103	11,118
Total income	**2,169**	**1,783**	**1,670**	**1,644**	**13,104**	**11,268**
Variable costs						
Total seed costs	**100**	**92**	**99**	**73**	**518**	**713**
Total fertilisers	**601**	**506**	**372**	**353**	**822**	**780**
Total crop protection	**228**	**147**	**118**	**106**	**680**	**598**
Total other variable costs	**5**	**6**	**6**	**5**	**126**	**174**
Total variable costs	**931**	**749**	**593**	**536**	**2,104**	**2,170**
Gross Margin	**1,197**	**1,034**	**1,077**	**1,108**	**10,999**	**7,150**
Overheads						
Total labour	**169**	**154**	**163**	**141**	**1,221**	**825**
Total machinery and equipment	**451**	**435**	**431**	**468**	**2,523**	**2,125**
Total property and energy costs	**106**	**63**	**97**	**68**	**1,418**	**975**
Total administration costs	**44**	**50**	**47**	**34**	**265**	**290**
Total overheads excl. rent & finance	**770**	**701**	**739**	**711**	**5,428**	**4,215**
Cost of production and margins Excluding rent & finance						
Cost of Production / hectare	**1,701**	**1,450**	**1,332**	**1,247**	**7,532**	**6,385**
Net Margin / hectare	**427**	**333**	**338**	**397**	**5,572**	**4,883**

APPENDIX 2

Production costs per tonne (excluding rent and interest), Harvest 2023

SAOS/SPC Benchmarking Group - Harvest 2023 - Group Averages by Crop						
Per tonne	**Winter Wheat**	**Winter Barley**	**Spring Barley**	**Oats**	**Potatoes (Piper)**	**Potatoes (Whites)**
Total seed costs	10	11	14	9	10	13
Total fertilisers	63	63	53	43	16	15
Total crop protection	23	18	17	13	13	11
Total other variable costs	1	1	1	1	2	3
Total variable costs	96	93	84	66	41	41
Gross margin	**119**	**117**	**152**	**141**	**212**	**172**
Total labour	17	19	24	16	24	16
Total machinery and equipment	45	51	60	62	49	41
Total property and energy costs	10	8	13	8	27	18
Total administration costs	5	6	7	4	5	6
Total overheads excl. rent & finance	77	84	104	91	105	81
Cost of production and margins Excluding rent & finance						
Cost of Production / tonne	**174**	**177**	**188**	**157**	**146**	**122**
Net Margin / tonne	**42**	**33**	**47**	**50**	**107**	**91**

APPENDIX 3

SPC Carbon Audits Harvest 2023

Grp averages by Crop

	Spring Barley	Winter Barley	Winter Wheat	W OSR	Oats	Ware Pots	Seed Pots	"Farm" Average
Crop Area (ha)	110	63	123	67	55	110	11	**77**
Inorganic N applied (kg/ha)	134	176	206	215	127	172		**172**
Total N applied (kg/ha)	134	162	213	252	174	134		**178**
Nitrogen Use Efficiency (%)	**87**	**89**	**91**	**50**	**82**	**87**		**81**
Enterprise Resource Use & Emissions								
Physical Performance								
Yield (t/ha)	7.1	8.5	10.0	4.4	7.5	54.6	32.3	**18**
Electricity use (kWh/t grain)	7.8	15.1	19.2	38.9	24.3	37.7	47.6	**27**
Diesel use (lt/t grain)	14.8	19.7	15.6	35.1	14.8	6.1	10.3	**17**
Diesel use (lt/ha)	105	162	154	150	112	333	378	**199**
Enterprise Emissions (kg CO2e/kg grain)								
Manures & Fertilisers	0.23	0.28	0.26	0.68	0.22	0.06	0.05	**0.25**
Lime	0.03	0.01	0.02	0.10	0.04	0.00	0.00	**0.03**
Fuel	0.05	0.06	0.05	0.10	0.05	0.02	0.03	**0.05**
Electricity use	0.00	0.00	0.00	0.01	0.00	0.01	0.01	**0.00**
Crop Residues	0.03	0.03	0.03	0.03	0.02	0.00	0.00	**0.02**
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Total Emissions / kg of Output (kg CO2e/kg grain)	**0.34**	**0.39**	**0.37**	**0.91**	**0.33**	**0.09**	**0.09**	0.36
Total Emissions / Hectare (kg CO2e/ha)	**2,350**	**3,164**	**3,663**	**3,766**	**2,475**	**4,639**	**2,791**	3,264
Whole Farm Sustainability Indicators								
Nitrogen use (kg/ha)	161	162	157	164	157	161	174	**162**
Phosphate use (kg/ha)	51	58	45	44	52	51	53	**51**
Potash use (kg/ha)	124	137	94	86	82	124	154	**115**
Waste (kg)	3,463	4,400	3,086	3,725	4,350	3,463	3,000	**3,641**
Water use (lt)	6,496,697	10,340,000	281,939	443,600	28,022	6,496,697	12,943,600	**5,290,079**
Stocking density (LU/ha)	0.03	0.05	0.04	0.00	0.03	0.03	0.00	**0**
Sequestration (t CO2e)	140	200	153	242	259	140	45	**168**
Renewable energy used (kWh)	110,398	129,140	33,926	26,921	16,225	110,398	188,346	**87,908**

APPENDIX 4

SPC Carbon Audits Harvest 2023

Grp averages by Crop	Spring Barley		Winter Wheat		Maincrop Potatoes	
Harvest 2022 vs Harvest 2023	**Harvest 22**	**Harvest 23**	**Harvest 22**	**Harvest 23**	**Harvest 22**	**Harvest 23**
Crop Area (ha)	102	110	194	123	78	110
Inorganic N applied (kg/ha)		134		206		172
Total N applied (kg/ha)		134		213		134
Nitrogen Use Efficiency (%)		**87**		**91**		**87**
Enterprise Resource Use & Emissions						
Physical Performance						
Yield (t/ha)	8.0	7.1	9.5	10.0	56.5	54.6
Electricity use (kWh/t grain)	1.0	7.8	11.5	19.2	30.2	37.7
Diesel use (lt/t grain)	17.0	14.8	15.4	15.6	6.6	6.1
Diesel use (lt/ha)	130	105	153	154	372	333
Enterprise Emissions (kg CO2e/kg grain)						
Manures & Fertilisers	0.21	0.23	0.28	0.26	0.06	0.06
Lime	0.05	0.03	0.04	0.02	0.00	0.00
Fuel	0.05	0.05	0.05	0.05	0.02	0.02
Electricity use	0.00	0.00	0.00	0.00	0.01	0.01
Crop Residues	0.03	0.03	0.03	0.03	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Total Emissions / kg of Output (kg CO2e/kg grain)	**0.34**	**0.34**	**0.41**	**0.37**	**0.08**	**0.09**
Total Emissions / Hectare (kg CO2e/ha)	**2,624**	**2,350**	**3,882**	**3,663**	**4,457**	**4,639**
Whole Farm Sustainability Indicators						
Nitrogen use (kg/ha)	121	161	146	157	121	161
Phosphate use (kg/ha)	34	51	45	45	34	51
Potash use (kg/ha)	81	124	104	94	81	124
Waste (kg)	2,575	3,463	1,400	3,086	2,575	3,463
Water use (lt)	12,943,750	6,496,697	591,667	281,939	12,943,750	6,496,697
Stocking density (LU/ha)	0	0.03	0.00	0.04	0.00	0.03
Sequestration (t CO2e)	61	140	67	153	61	140
Renewable energy used (kWh)	161,425	110,398	0	33,926	161,425	110,398