Innovation in crop and livestock breeding

ZONE 1

Beyond the genome: translation to improved crop varieties

Key contacts

Dr Mark Taylor

The James Hutton Institute

Background

Scottish Government funded scientists made major contributions to the elucidation of the barley and potato genome sequences and related resources have been made freely accessible to the scientific community and industry. These resources will accelerate research in barley and its close relative wheat, and in potato and other Solanaceae. Armed with this information breeders and scientists will be much better placed to deal with the challenge of effectively addressing the food security agenda under the constraints of a rapidly changing environment. The technologies are transferable to other important crop plants such as raspberries and blackcurrants that are not researched as intensively on a worldwide scale but have huge potential for the Scottish economy.

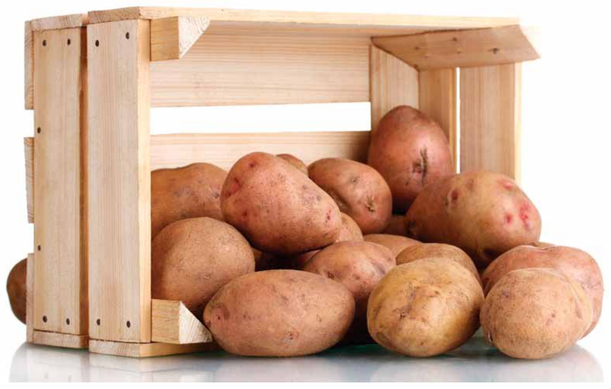
Approaches

Development of exome capture in barley

Barley has an extremely large genome (5.3 Gb) of which 80% is repetitive non-coding sequence and only 20% encodes genes. We have therefore designed a method for identifying variation in the gene coding regions called whole exome capture on the Nimlegen platform. Using this approach, thousands of sequence variants (single nucleotide polymorphisms (SNPs)) identified from cultivated, wild and related species will allow unprecedented analysis of cereal diversity.

New SNP mapping in soft fruit

The development of Genotype by Sequencing protocols for Ribes has led to the generation of very dense genetic maps that can be used to identify the gene regions that control key traits including developmental characters (time of budbreak, flowering etc.) and also fruit quality components (Vitamin C and anthocyanin content). Markers for these gene regions are being used and these will accelerate breeding programmes producing cultivars with improved characteristics



Novel method for identification of key genes in autotetraploid potato

Modern genomic technologies can identify high numbers of gene markers and can be used to work out numbers of gene variants for autotetraploid species such as potato. A dense potato linkage map with 3800 markers has been developed and new candidate genes have been identified for key potato quality traits such as sugar content and tuber dormancy. Association genetics is another powerful approach being developed in potato.

Outcomes and benefits

- Translation of research to new breeding practices is already in progress – for example the introduction by some companies of genomic selection in barley, but there is still more translational work required to fully harness and exploit the advantages of approaches such as marker assisted selection in other crops such as potato

- Using advances in genomics, the genes that impact on agronomic traits can now be identified, characterised and used to improve crops. Through collaboration with the plant breeding industries the contribution of Institute scientists is essential to ensure an enduring pipeline of new cultivars in potato, barley and soft fruit. Via this pipeline we can safeguard food security, mitigate the effects of disease (see Zone 2) and climate change and ensure a vibrant rural economy

Innovation in crop and livestock breeding

ZONE 1

Linking livestock phenotypes and genotypes - improving livestock performance

Key contacts

Dr Eileen Wall

Scotland's Rural College

Background

Scottish research is providing information for livestock industries and policy makers to improve the sustainability and profitability of livestock farming. Research highlights includes the development of new genetic improvement tools and management approaches to improve productivity, product quality and the environmental impact of farm systems.

Approaches

Milk monitoring - understanding the health attributes of livestock products

- Systems for predicting fatty acids from mid infrared (MIR) analysis of milk have been developed and implemented
- The genetics and the diet of the animal have been shown to significantly influence on the fatty acid profile and mineral profile of milk
- The use of milk MIR is being further developed for a wider set of management tools (e.g., feed efficiency, immune performance, methane emissions)

Mothers and babies - exploring aspects of lamb survival

- Factors affecting lamb survival have been studied and showed there was a genetic basis to lamb survival (heritability = 9%)
- Maternal vocal response to lamb handling was shown to be associated with future survival (high vocal response = better survival)
- There are significant breed differences in mothering ability, including offspring recognition. This helps mother's care for their lambs leading to improved survival

Getting genomics going - helping identify best solutions for beef

- Nasal swabs for DNA extraction in cattle was trialled and found to be satisfactory thereby reducing a barrier to uptake of genomic selection
- Multiple data sources can be combined (e.g., individual carcass data from abattoirs) have been used to explore the genetics of meat/carcass quality
- The net returns from investing in combining genotype with abattoir data are predicted to be worth in excess of £50 million to the beef breeding industry

Outcomes and benefits

- Advances have been made in measuring important aspects of farmed livestock and their systems. These tools have been shown to have industry relevance and uptake and will help our livestock industries measure, monitor and manage human health characteristics of livestock products, animal health & welfare and environmental impact
- The advances in genomics are helping us develop tools to deliver more accurate and faster mechanisms to improve our livestock populations for economically, environmentally and socially important traits. For example, current work with the dairy industry is working towards the implementation genetic and genomic tools to improve TB resistance in our national dairy herd
- Scottish Govt funded livestock research has helped us to understand how we can improve efficiency and other benefits stemming from livestock production with aspects of this work are already informing/changing industry practices

Livestock and crop disease

ZONE 2

Late Blight of potato: sustainable crop intensification through integrated pest management

Key contacts

Dr Alison Lees, Dr David Cooke, Dr Peter Skelsey

The James Hutton Institute

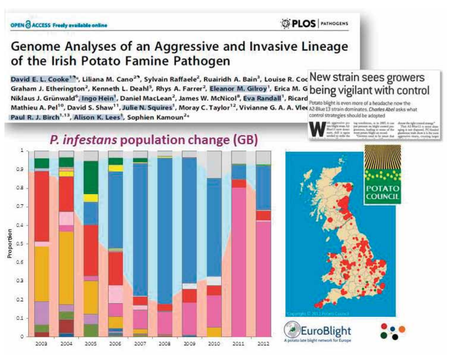
Background

Late Blight of potato caused by *Phytophthora infestans* can cause significant yield loss and is controlled by repeated application of fungicides throughout the growing season. Sustainable intensification through an Integrated Pest Management (IPM) approach aims to increase yield, target resources more efficiently and reduce economic losses.

Novel research contributes to IPM through both genetic improvement of crops and by managing inputs and resources effectively.

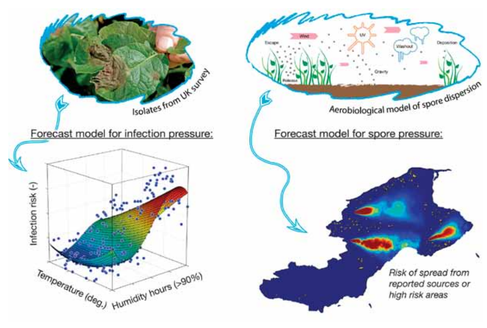
- Genetic improvements to potato can occur through breeding to introduce a range of desirable traits
- Deployment of late blight resistance should be managed carefully to prevent selection of resistance-breaking strains of *P. infestans*
- Decision making tools can be used for disease risk prediction, forecasting, modelling, surveillance and in Decision Support Systems
- Informing use of products e.g. lower risk synthetic pesticides, precision application, alternatives to conventional pesticides

Approaches



Understanding the pathogen population: The identification of lineages of *P.infestans* via genetic fingerprinting and their characterisation for fungicide insensitivity, aggressiveness, temperature response and ability to overcome certain host resistances underpins late blight research.

Identifying host resistance: Germplasm collections, breeding lines and populations are tested in glasshouse and field trials using contemporary isolates of *P.infestans* to inform potato breeding (see Zone 1). Innovative use of pathogen effector and host resistance data is made to identify novel and durable resistance.



Modelling and decision making: Disease forecasting and early warning systems to predict disease risk are being developed to aid management decisions. Epidemiological models have provided insight into the spatial scale at which management interventions are most likely to be successful.

Managing resources: Research aims to extend the durability of late blight control by integrated deployment of host resistance and fungicides. A rational basis for integrated control which constrains pathogen evolution towards fungicide insensitivity and virulence is being sought.

Outcomes and benefits

Informing practice: An understanding of the characteristics of the contemporary *P. infestans* population has directly informed appropriate fungicide use and breeding for late blight resistance in the UK.

Implications of a changing climate: Small differences in the responses of particular *P. infestans* lineages to the environment have been shown to translate into large differences in epidemics at the landscape scale. The potential impact of future wind speeds on spatial spread of pathogens in Scotland has also informed biosecurity preparedness.

Reducing inputs: It has been demonstrated that a substantial reduction in fungicide inputs can be made, without compromising control, when used in combination with resistant varieties, even under severe epidemics.

Decision making: A local early warning system for potato late blight, driven by incoming weather patterns, detailed field elevation and aspect information, and remotely sensed canopy data will improve the accuracy of crop disease forecasts and agrochemical applications and may be extended to other pathosystems.

The UK national forecasting system for late blight will be updated with predictions based on weather forecast data, epidemiological properties of the contemporary pathogen population and risk of inoculum dispersal.

An IPM approach: Collectively, these areas of late blight research contribute to sustainable intensification through effective disease control.

Livestock and crop disease

ZONE 2

Case study – livestock productivity

Key contacts

Dr Colin McInnes

The Moredun Research Institute

Background

Livestock have a role in securing a safe and nutritious food supply for future generations in the UK and for the expanding human population across the world. Disease, however, impacts livestock productivity through mortalities, abortion and morbidity. In the worst case scenario this can make livestock farming uneconomic. Without increasing the number of breeding animals, efficiencies could be gained from controlling disease and ensuring that more lambs and calves are reared successfully.

- Worldwide population growth, urbanisation and individual income growth are all thought to be drivers for increased meat and milk consumption
- Demand for animal food products by 2050 is predicted to remain the same in most OECD countries, but in sub-Saharan Africa it is predicted to double
- Livestock diseases can result in poor conception rates, abortions, still births and neonatal deaths
- Future diseases affecting livestock productivity may be very different due to climate, demographic and technological changes

Objective: To develop sustainable controls for the major production-limiting diseases of livestock

Approaches

Causes of abortion: Although surveillance programmes in the UK have identified some of the most common causes of abortion in sheep and cattle, in both species the majority remain undiagnosed. Prior to 2012, *Chlamydia abortus* and *Toxoplasma gondii* were considered two of the most important causes of abortion in sheep – in 2012 *Schmallenberg virus* (SBV) emerged as the second most common diagnosis behind Chlamydia. SBV was also diagnosed as causing fetal disease in cattle, but *Neospora caninum* is one of the most often diagnosed causes.

Diagnostics and surveillance: Purchase of apparently healthy carrier animals as replacement stock is one of the most common ways of introducing disease into a herd or flock. Moredun scientists are working on better diagnostic tests to identify infections at an early stage before disease is apparent. Using such tests as part of a health scheme would allow replacements to be purchased from accredited flocks/herds. Scanning surveillance can help identify new disease threats as they emerge allowing appropriate control measures to be undertaken.

Vaccines: Although existing vaccines for *Chlamydia abortus* are available the problem persists particularly in the more intensively farmed lowland enterprises. Current efforts are directed at producing a safer, more cost effective vaccine.

There are currently no marketed vaccines for *Neospora caninum* in Europe. Infection is considered an important cause of abortion in cattle, but can also manifest as cases of apparent infertility. Infection is often latent and inducing protection against abortion in such latently-infected animals is seen as the major challenge confronting researchers.

Outcomes and benefits

The overall aim of this research is to increase the efficiency of livestock farming to the benefit of the farmer and ultimately, global food security.

- Current average productivity rates in the UK are approximately 90 calves born for every 100 cows and 1.5 lambs per ewe. Increasing productivity, even slightly, will reduce wastage by ensuring that more of the resources invested by the farmer go on to produce healthy calves and lambs.
- Prevention is better than cure and the development of better diagnostic tests and vaccines will reduce our reliance on antibiotics and other chemical controls.
- Less of the GHG emissions (see Zone 3) associated with livestock farming will be wasted on sick animals

GHG emissions from agriculture

ZONE 3

Methane emissions from beef cattle

Key contacts

Prof Richard Dewhurst
Dr John Rooke

Scotland's Rural College

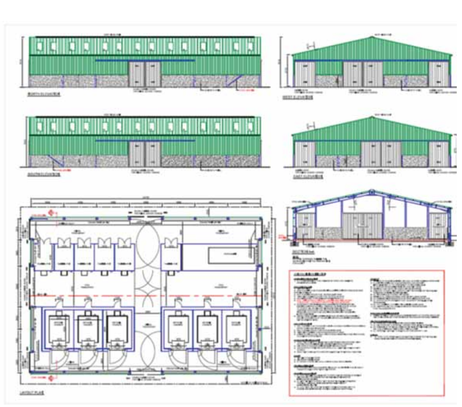
Background

- Major interest in greenhouse gas (GHG) emissions from agriculture – this work focussed on methane production from ruminants
- Methane is a GHG with a global warming potential 25 times that of carbon dioxide. There is a lot of research effort around the world to identify emission factors (EF) for different categories of stock for national GHG inventories, as well as to identify new mitigation options
- The UK has over 5 million beef cattle in a global population of over a billion. Methane output from beef cattle is estimated to be 37% of total emissions from UK livestock
- There are dramatic differences between systems in terms of breeds and their characteristics, performance and feeds - ranging from all year around extensive suckler cows to intensive cereal beef
- Previously, little was known about the extent to which genotype, system and diets influence methane output in beef production

Facilities

Six respiration chambers

Methane detector



Plan of GreenCow facility

HOKO feeders

SRUC has world-class livestock greenhouse gas (GHG) emission research facilities as part of the SRUC Beef Research Centre at the Bush Estate near Edinburgh. The recently-built GreenCow facility has integrated handling and weighing equipment along with:

- Six respiration chambers - these are the 'gold standard' method used to measure methane output from individual cattle
- 44 HOKO feeders - which allow us to record feed intake and meal patterns from over 100 cattle at any time
- A range of proxy techniques for estimation of methane output, including the laser methane detector and breath 'sniffing' equipment integrated into feeders

These facilities have been used for measurements of methane emissions with a wide range of cattle breeds, life stages, diets and supplements designed to reduce methane emissions.

Outcomes and benefits

- Baseline measurements of methane emissions for the main stages of beef production
- Baseline measurements of methane emissions for different breed types - representative of both dairy and specialised beef systems, with a common breed type (Limousin) as a core genotype
- Baseline measurements of methane emissions from cattle pastured on diverse lowland and hill swards - and for housed diets ranging from intensive cereal to forage based typical of UK systems
- Emission factors that cover the range of regional beef production systems in the UK
- Identification of novel mitigation strategies, based on the use of supplements with nitrate salts and oils rich in polyunsaturated fatty acids. These have been evaluated against a baseline of both high-forage and high-cereal diets

GHG emissions from agriculture

ZONE 3

Nitrous oxide emissions from agricultural soils

Key contacts

Dr Bob Rees

Dr Kairsty Topp

Scotland's Rural College

Background

- Major interest in greenhouse gas (GHG) emissions from agriculture - this work focussed on nitrous oxide emissions from agricultural soils
- Nitrous oxide is a GHG with a global warming potential 298 times that of carbon dioxide
- Nitrous oxide contributes around 55% of the GHG emissions from UK agriculture. These emissions are due to the use of synthetic and organic fertilisers
- There is research effort on a world-wide basis to understand the effect of soils and nitrogen sources from soils and crop residues on emissions and emission factors (EF)
- There is high uncertainty in calculating emissions of agricultural nitrous oxide
- The total minimum carbon store for UK peatlands is 3,121Mt C

Approaches

Cereal in East Lothian

Flux tower at Easter Bush

Sampling in East Lothian

Peat erosion on Lewis

- Detailed annual emissions measurements, soil mineral nitrogen and soil water from arable and grassland soils on an annual basis
- Assessment of a range of fertiliser types, and mitigation strategies, including split application and inhibitors
- Exploration of the effects of crop and grazing management on the soil structure and emissions
- Eddy covariance tower measurements on grasslands and peatlands
- Laboratory based experiments assessing the detailed soil microbiology / plant interaction
- Empirical and dynamic and deterministic modelling of the emissions are used to improve our understanding of the factors driving emissions

Outcomes and benefits

- Baseline measurements of nitrous oxide emissions for a range of fertiliser types, and nitrogen sources for arable and grassland soils.
- Baseline emissions for barley varieties and pea / barley mixtures showing the emissions are affected by varietal choice
- An improved understanding of the role of management in greenhouse gas mitigation
- Improved reporting of agricultural greenhouse gas emissions
- Baseline emissions from peatlands
- Emission factors that cover a range of soil types in the UK. This also includes an assessment of the uncertainty in the emissions.
- Carbon footprint with AgRE Calc to enable farmers to monitor their progress in cutting emissions and improving technical efficiency

Nutritionally sensitive agriculture

ZONE 4

The sustainable production of food in Scotland: the link from crops to products

Key contacts

Dr Louise Shepherd
Prof Derek Stewart

The James Hutton Institute

Background

- Sustainability is becoming the central tenet to all economic activities, none more so than in the vital chain that underpins the Scottish food and drink sector
- Primary production of crops has, due to the combined pressures of global financial uncertainty, food security, biodiversity loss and GHG-driven climate change, been challenged to shift towards a more sustainable system and away from the existing "conventional" systems that are underpinned by fossil fuel driven inputs, pesticide, herbicides etc.
- This shift in approach needs to address several questions that we aim to deliver on via The Centre for Sustainable Cropping (CSC) at the James Hutton Institute. The target crops are potato, winter wheat, winter and spring barley, winter oilseed rape and fava bean (Figure 1)
- This centre was established to formulate approaches for sustainable crop production, aiming to minimise the use of valuable natural resources (water, nutrients, soil functionality and resilience) whilst optimising yield, profitability and biodiversity

Questions to be addressed

- What will be the consequences of sustainable practices on crop yield, and will there be deleterious impacts on quality, nutritive value and food safety?
- How will the changes in quality *per se* impact upon food processors and will these be beneficial or deleterious?
- If quality and yield changes are evident, what causes this, and can we select varieties to be used in the short term to offset any negative impacts, with knowledge-based plant breeding driving future improvements?
- Can the possible benefits of long term sustainable input agricultural practices be balanced against economic viability in the food chain?

Figure 1. CSC field layout and the crop rotation layout in 2011 (for further details see hutton.ac.uk/csc). Within each crop, five different varieties are being tested to determine varietal responses to the two contrasting management approaches(Table 1). These are sown in 5x18m wide strips in each half field in the same direction as the split between the two halves.

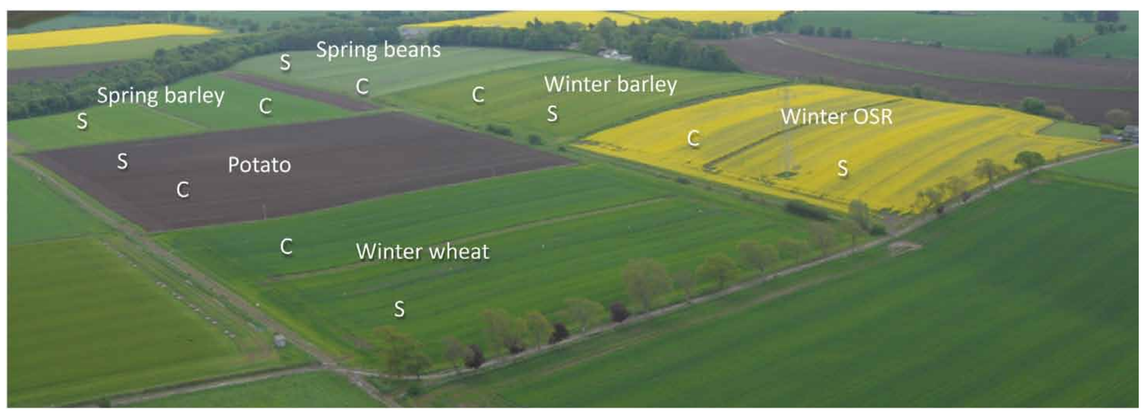


Table 1. CSC management treatments
(for further details see hutton.ac.uk/csc; contact Cathy Hawes)

Conventional:	**Sustainable:**
Current commercial accepted practices	**Reduced pesticide inputs using integrated pest management strategies**
Region accepted application of:	**Reduced inorganic fertiliser (NPK) inputs using:**
▪ Inorganic fertiliser ▪ Herbicide ▪ Pesticide ▪ Fungicide	▪ Compost – increase soil carbon ▪ Legumes – stimulate N-fixing bacteria ▪ Green manures – ploughed in after winter growth to add nutrients and organic matter to the soil ▪ Precision farming – use of GPS ▪ Improve soil structure through reduced tillage and traffic

The cropping systems are planned to have 3 full rotations (3 x 6 years) that will test and demonstrate:

- The optimisation of inputs (nutrients, herbicides and pesticides)
- Yield (quality and quantity)
- Biodiversity (soil, microbes, plants and arthropods)
- Ecosystem processes (photosynthesis, carbon and nutrient transformations and fluxes)
- Assess the effect of the sustainable system on long-term trends in yield and system health

Outcomes and benefits

Although still in the early stages there continues to be a range of outcomes and benefits, and these are accruing over time and with the increasing stakeholder engagement.

To date progress is as planned

- Multiple state of the art analytical approaches are being used to assess the impact of conventional *vs.* sustainable (Table 1)
- Many changes have been noted with, for example, sustainable practices beneficially impacting on oilseed rape oil composition
- The Scottish Cold Pressed Oilseed Rape Interest Group are working with us to look at exploiting these benefits
- All research activities have benefitted from a robust schedule of industrial and stakeholder engagement and site visits

Nutritionally sensitive agriculture

ZONE 4

Sustainable and healthy Scottish food

Key contacts

Dr Wendy Russell

Rowett Institute of Nutrition and Health

Background

It is now important that we rethink the way in which we select, grow, process and prepare the food we eat. With increasing pressures on the food chain, it is essential that our food is healthy and sustainable. To do this effectively, we have to have a clear understanding of the impact of food production in terms of preserving the Scottish environment, growing the Scottish economy and the nutritional benefits to human health. We are striving to understand the complex interplay between diet and health and are working with the 'Food and Drink Industry' to assure overall objectives are achieved. Some of the important food groups we are currently studying include cereals (wheat, barley, oats), legumes (fava bean, pea and lupin), soft fruits (raspberry, strawberry, blueberry), green leafy vegetables (cabbage varieties), rape seed oil and culinary herbs, all of which have potential to be sustainably grown in Scotland.

Approaches

- Our research has shown that many of these foods are good sources of protein, fibre, essential vitamins and minerals. Many also contain high levels of bioactive phytochemicals, which have potential to protect against diet-related disorders such as cardiovascular disease, type 2 diabetes and cancer

- Through a series of human dietary intervention studies we are gaining an understanding of the metabolic effects of both individual foods and whole diets on maintaining human health. This will allow us to improve the Scottish diet by providing advice and encouraging the incorporation of healthier staple food ingredients

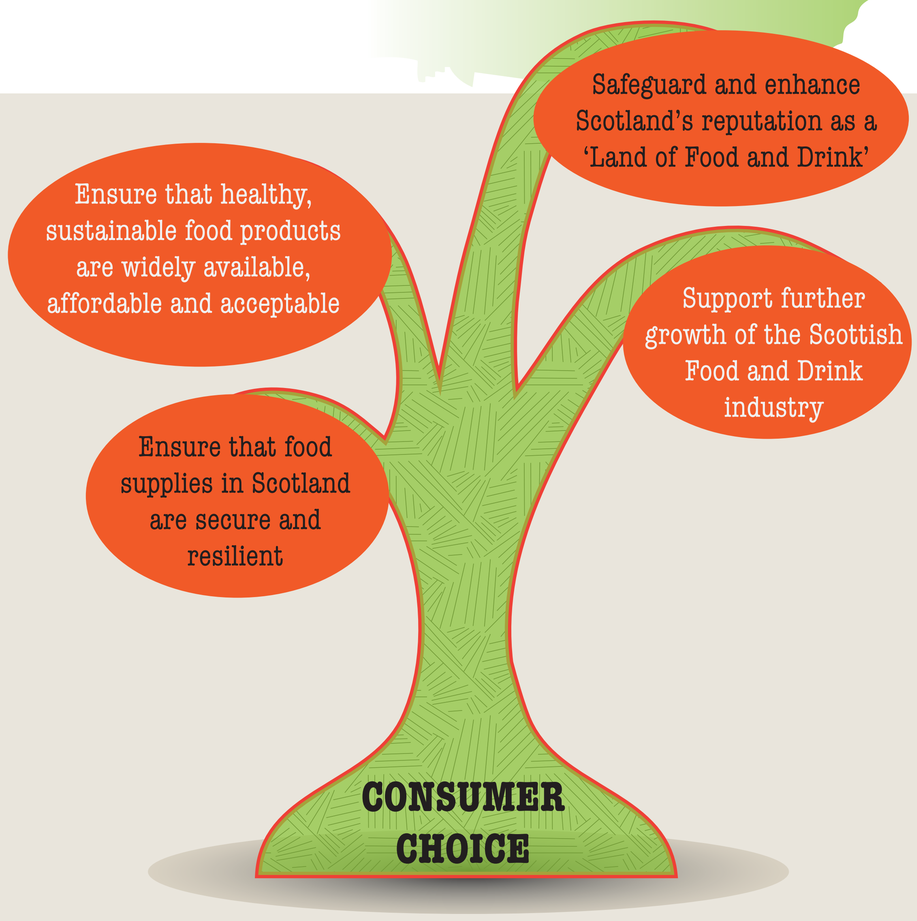
- Working with plant breeders, growers, as well as the food industry we are recognising the impact of food production and processing on important constituents of our diet. This is essential if we are to optimise the nutritional value of our food

- We are also exploring the potential barriers to acceptance and change within both the food supply chain and with consumers for the wider use of these plant-based foods in the Scottish diet

Outcomes and benefits

- Scotland has an extensive larder of nutritionally valuable plant-based foods that can be grown, produced and processed to provide a healthy and sustainable diet

- Our work is providing the necessary evidence to deliver food with improved nutritional qualities, greater resource efficiency, as well as opportunities for growers, producers and the food and drink industry



Improved soil management

ZONE 5

Reducing risks associated with autumn wheeling of combinable crops

Key contacts

Dr Kenneth Loades
Dr Blair McKenzie

The James Hutton Institute

Background

- Tramline wheelings are important for crop management within agriculture but account for ~80% of the runoff and diffuse pollution from winter cereals
- Targeted measures that are practical and cost-effective are needed to keep soil in place and to limit the losses of nutrients to watercourses from high-risk fields
- This research provides practical guidance for farmers on management practices aimed at reducing diffuse pollution resulting from spraying of winter cereals
- Sites were monitored from October to March for 3 consecutive years in Scotland at the Balruddery Centre for Sustainable Cropping (CSC)

Approaches

Spiked harrow unit installed on a sprayer to remove compaction following wheeling

Gutter to collect surface runoff at the foot of a 100 metre long tramline

Field instrumentation to measure runoff and also collect water for chemical analysis

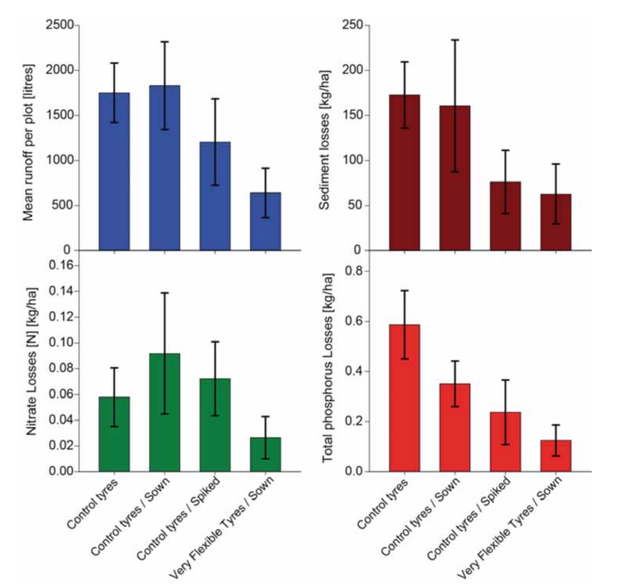
- Multiple tramline treatments were assessed and compared to standard farm practice, treatments included:
  - Sowing tramlines
  - Sprayer installed spiked harrow which removed soil compaction following wheeling
  - The use of Very Flexible tyres, developed by Michelin, and sown tramlines to change tread imprint and minimise soil compaction at the surface
- Data collected following rainfall events included runoff volume and nutrient and sediment concentrations in the runoff

Outcomes and benefits

Environmental Benefits

- Surface runoff and soil erosion were significantly decreased through the use of the Very Flexible tyres
- Significant decreases of phosphorus in runoff water within the sown tramlines using Very Flexible tyres and also in spiked harrow treatments
- Nitrate losses were variable and decreased within the Flexible Tyre treatment on sown tramlines. Such controls on diffuse pollution are key in nitrate vulnerable zones (NVZs)
- Soil erosion was minimised with the use of the spiked harrow and Very Flexible tyres
- Effective reductions in diffuse pollution can be delivered by small changes in tramline management that also help maintain Good Agricultural and Environmental Conditions (GAEC) and satisfy Soil Protection Review (SPR) requirements

Experimental results showing effects of tramline treatments on runoff and diffuse pollution



Key Outcomes

- Correctly-inflated Very Flexible, low ground pressure, tyres minimise compaction, surface runoff and sediment loss from autumn spraying
- Sowing tramlines has no consistent effect on diffuse pollution following autumn spray operations and still cause some compaction

Advice for Practitioners

- Minimise risk - identify high risk fields (Soil Protection Review); increase tramline spacing (≥ 24 m); correctly inflate tyres; use modified low ground pressure tyres, such as Very Flexible tyres in autumn; careful timing of field operations
- Adapt practice - on high risk fields consider targeted change in land use / rotation
- Mitigate losses - remove near-surface soil compaction (e.g. spiked harrow unit)

Improved soil management

ZONE 5

Phosphate fertiliser requirements of Scottish soils

Key contacts

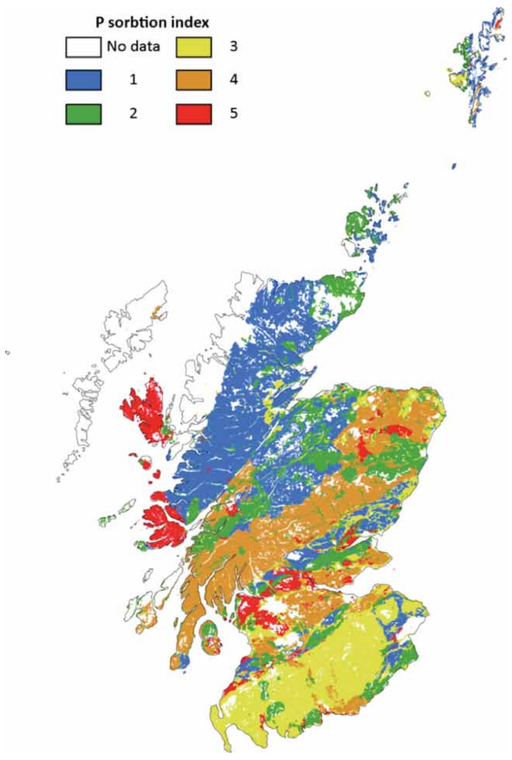
Dr David Lumsdon
Dr Charles Shand
Dr Alex Sinclair (SAC Consulting)

The James Hutton Institute

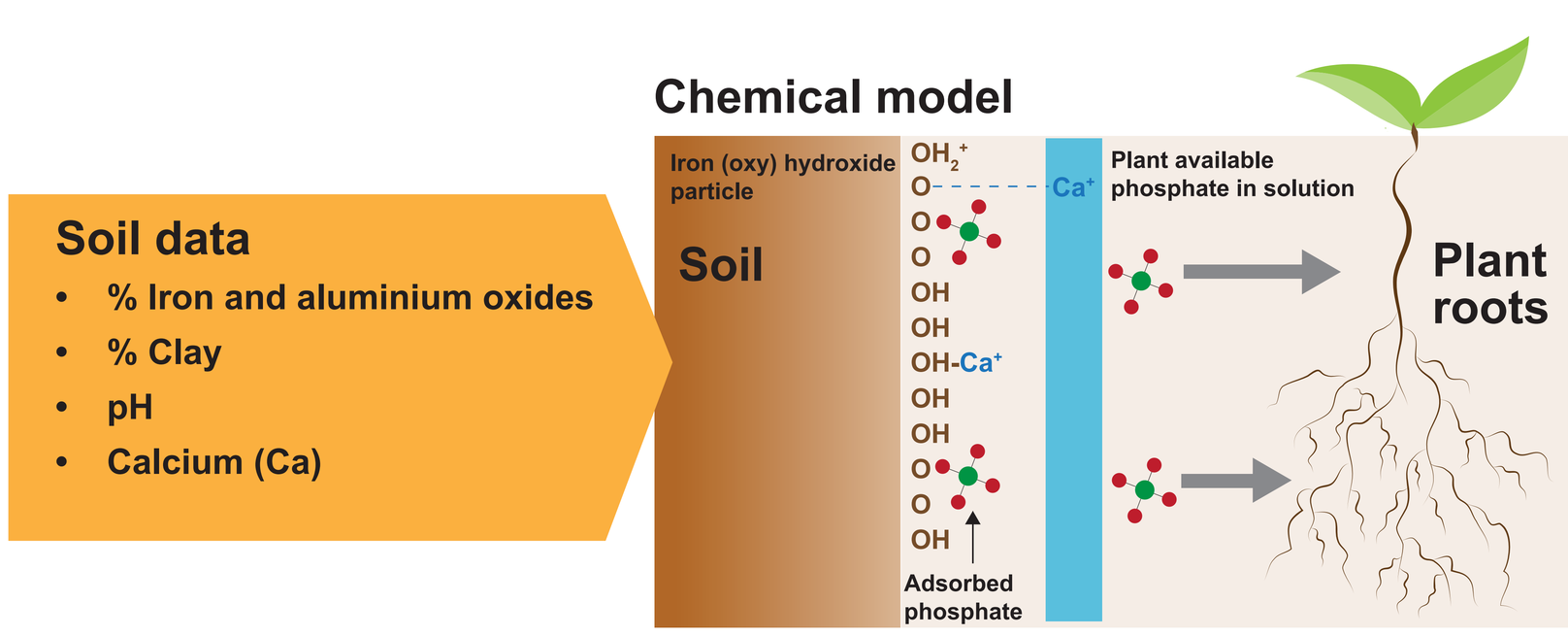
Background

- Modern agriculture relies on phosphate fertiliser additions to maintain high crop productivity
- Phosphate fertilisers are added to soil to build phosphate and maintain a reserve sufficient to meet crop demand
- Over-fertilisation is wasteful and may adversely affects water quality, whereas under-fertilisation may reduce crop yields
- In Scotland, soil testing for phosphate fertiliser requirement usually involves laboratory extraction of the soil with reagents such as solutions of acid ammonium acetate or acetic acid, but the resultant advice usually takes no account of soil type and its individual P sorption capacity. A more refined procedure has been developed

Approaches



Using data from the National Soil Inventory of Scotland (NSIS) and an advanced chemical model we have produced a phosphate sorption map for Scotland



The sorption of phosphate is influenced by soil pH, and calcium which forms inner-and outer- sphere complexes

When phosphate is added to soils a large proportion becomes fixed to reactive surfaces such as iron (oxy)hydroxides

A high phosphate fixing capacity soil means that more phosphate is required compared to those with a low phosphate fixing capacity where less is required

Outcomes and benefits

- By providing rates of application of phosphate fertiliser tuned to intrinsic soil properties there will be a better match to crop demand. Soil with a low P fixing capacity will be less likely to become over-fertilised, whereas soils with a high P fixing capacity will be less likely to be under-fertilised
- The model will help understand the complexities of phosphate loss by leaching and aquatic process involving desorption of phosphate from soil eroded into water bodies
- Additional work is required to complete the picture for the blank areas in the west and to provide information at the field scale

Advice in Practice

Know your soil and its phosphate sorption capacity and apply fertiliser accordingly to increase P use efficiency, reduce losses and maintain yields.

Challenges and opportunities

ZONE 6

Healthy and environmentally sustainable eating patterns

Key contacts

Dr Jennie Macdiarmid

Rowett Institute of Nutrition and Health

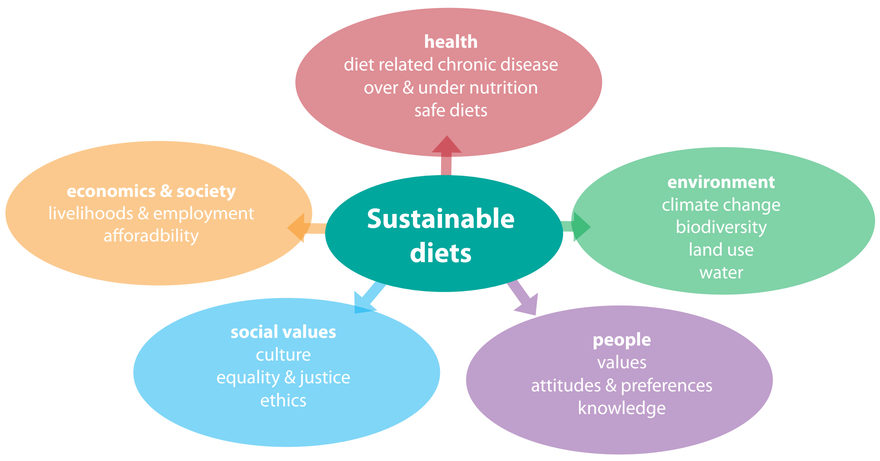
Background

Current dietary patterns in the UK are neither healthy nor environmentally sustainable. They contribute significantly to chronic disease and ill-health health as well as to climate change. Changes are therefore needed across the whole food system, which includes changing our consumption patterns.

- Dietary intakes are high in saturated fat, sugar and salt, and low in fibre
- 64% of adults in Scotland (2012) are overweight or obese (27% are obese)
- 20-30% of greenhouse gas (GHG) emissions come from the food system
- Animal-based products tend to contribute the highest GHG emissions (see Zone 3) in the food system

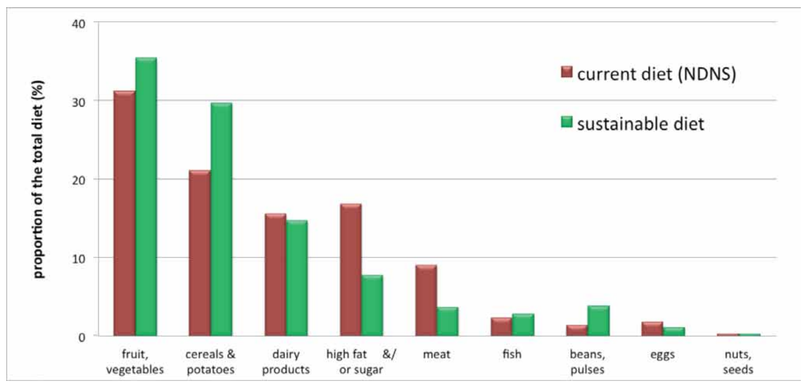
Objective: to understand how dietary requirements for health can complement reducing the environmental impact of our diets.

Approaches

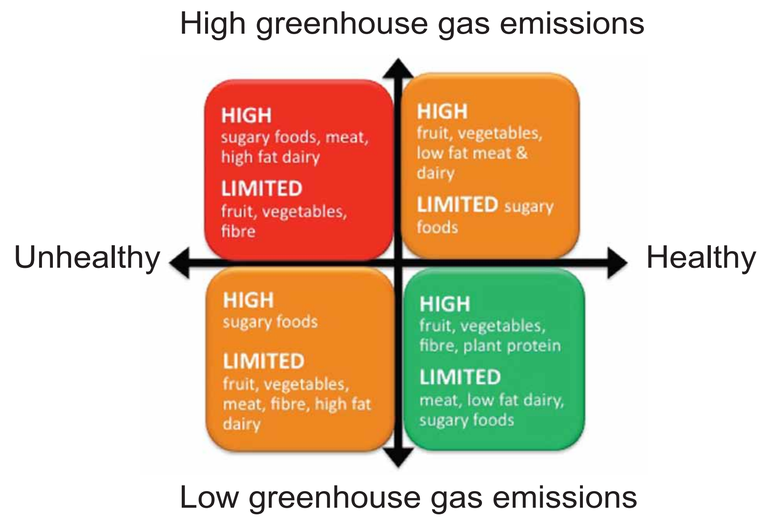


This illustrates how different elements of sustainability can be combined to achieve realistic and acceptable dietary patterns.

The Livewell diet is an example of a 7-day menu that meets dietary requirements for health and achieves a 36% reduction in GHG emissions. This project illustrated how the different elements of sustainability can be combined to achieve realistic and acceptable dietary patterns.



Moving current dietary intakes towards a more sustainable diet (e.g. Livewell) will need changes across all food groups and therefore we should not just target individual foods.



Diets comprise of many different combinations of foods. Modelling different dietary scenarios demonstrates that it *cannot* be assumed a healthy diet will always be lower in GHGE. It is equally possible to have an unhealthy diet that is low in GHG emissions.

Outcomes and benefits

This research is highly relevant to global food security, climate change and health. It brings together natural and social sciences, with practical applications for policy.

- It demonstrates the potential to model dietary scenarios to optimise these different elements of sustainability
- On-going research is examining the impact of other environmental issues such as land use
- We are also exploring the public understanding and perceptions of healthy, environmentally sustainable diets and public willingness to make dietary changes

Challenges and opportunities

ZONE 6

Sustainable intensification within Scottish agriculture

Key contacts

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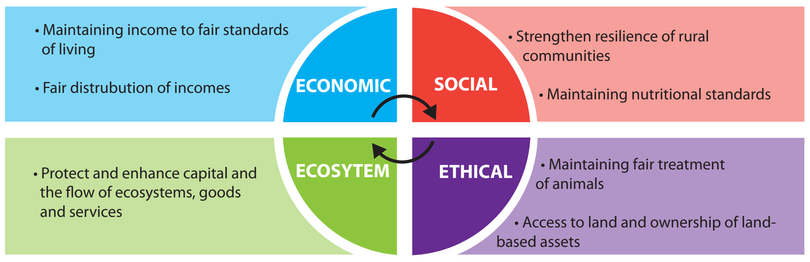
Background

A proposed solution to ensuring food security, managing climate change and biodiversity is sustainable intensification. Generally this means producing more output from the same area but ensuring environmental, social and economic damage is minimised or reduced.

- Scottish agriculture is highly diverse in terms of its efficiency
- Sustainability is crucial to maintaining long-term goals
- Farm level viability is dictated by adoption of sustainable production methods

Research Objective

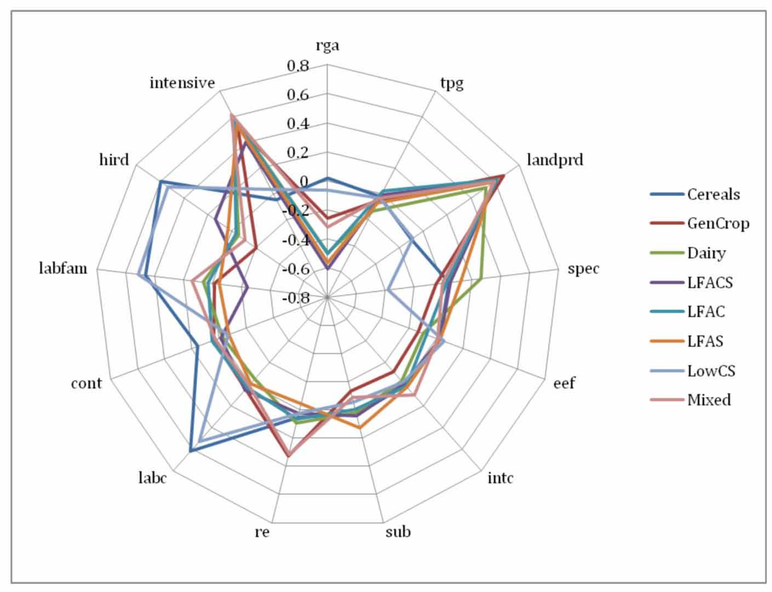
To apply the concept of sustainable intensification to Scottish agriculture

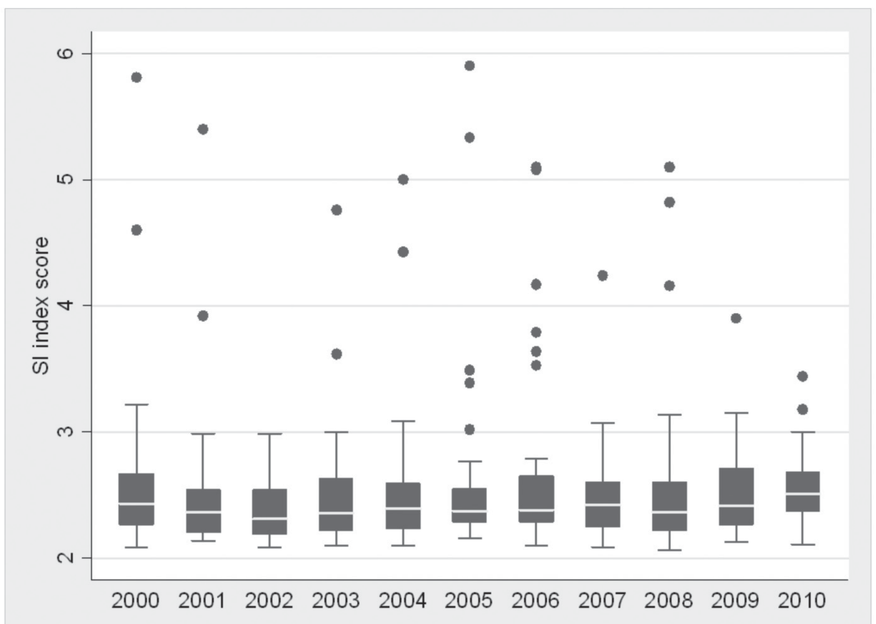


The research applies a theoretical concept for sustainable intensification within the Scottish context, the model proposing that a four dimension requirement be met, namely:

1 It must maintain equity in incomes throughout the supply chain and across producers.
2. It must strengthen the resilience of rural communities and maintain nutritional standards for Scotland's diet.
3. It must maintain or enhance the stock of Scotland's natural capital and the flow of ecosystem services emerging from this stock.
4. It must maintain or enhance the ethical dimension of agricultural production.

We can plot each farm in terms of its economic, environmental and social sustainability by production intensity. On average farms of all types score high on the production aspects, low on the economic aspects and low in terms of environmental aspects.





Sustainble intensification scores for LFA cattle and sheep farms are presented. These weight food production against sustainability and higher scores reflect more value. Clearly there are a small number of farms who perform well in terms of sustainable intensification (the dots on the graph), but on the whole farms have not changed over the last decade.

Outcomes and benefits

This research is highly relevant to global food security, climate change and farm level viability. It demonstrates use of Scottish Government data sets and economic and statistical analysis to provide practical applications for policy-makers.

- It demonstrates the use of a range of indicators for measuring farm level performance and how past interventions have affected development of the industry
- On-going research is examining the perceptions towards sustainable intensification and adoptions of sustainable production technologies and their impact on Scottish agriculture
- Future work takes a whole supply chain view of sustainable intensification to measure and model the drivers of change at the farm level