BARIToNE Project A - The role of agricultural co-ops in driving change supporting the climate challenge

Principal Industrial Supervisor – Jim Booth, SAOS Ltd

Principal Academic Supervisors – Dr. Morris Altman, University of Dundee

This project will be based at the School of Business, University of Dundee, the appointed student will registered at the University of Dundee as the degree awarding institution.

The focus of this project is researching the role agricultural co-ops (member-owned organizations) play in driving change in their networks with a focus on helping their farmer members address the climate challenge. Education and effective knowledge transfer are a key pillar and one of the seven principles of co-operation in co-op enterprises.

SAOS believe addressing the climate emergency is too large a challenge for any one business to tackle alone, especially SMEs. And that Scotland's strong agricultural co-ops can be an effective solution to coordinating meaningful change whilst remaining competitive via highly effective co-op farmer member networks.

The co-op model presents a huge opportunity to support farmers address barriers such as limited time and capital, technical change, and information asymmetries. Action to deliver both economic and environmental gains become progressively more difficult as the industry advances through 'easy wins' and lower cost solutions. This highlights the value of a more collaborative approach between farmers, to support for example, the adoption and development of new technology or commitment to more capital-intensive investments. Arguably one of the key roles co-ops provide is the leadership to facilitate and actualize change. For example, the investment by Aberdeen Grain in large-scale biomass driers to decarbon the drying of malting barley grain.

That said, the co-op business model is not well understood in Scotland or the wider UK, despite their long history as a business model, founded in the principles of mutual support, democracy and shared economic benefits. Apart from the commercial returns from being a member, co-ops seek to build social capital and enhance skills that can be vital in building resilience and strengthening rural communities, whilst remaining competitive.

If you would like to discuss this project in more detail, please contact Jim Booth (jim.booth@saos.coop) for more information.

BARIToNE Project B - Data driven resource optimisation in the barley supply chain

Principal Industrial Supervisor – Emma Hanby, Campden BRI

Principal Academic Supervisors – Dr. Nicholas Watson, University of Nottingham

Additional Supervisors – Prof. David Cook, University of Nottingham

This project will be based at the Faculty of Engineering, University of Nottingham and the appointed student will registered at the University of Nottingham as the degree awarding institution.

The brewing industry needs to lower its carbon footprint with a specific focus on the resources (e.g. energy and water) used to process barley across the supply chain and methods to re-use waste streams from the brewing process.

Data and digital technologies including sensors, machine learning and the internet of things have the potential to address these challenges due to their ability to monitor and optimise processes and generate actionable information. However, there is often a lack of understanding of the most useful data and appropriate technologies for a given application. In addition individual supply chain actors generally focus on optimising their own resource utilisation without considering the impact on the entire chain or understanding how components in their waste streams could be utilised by others. An example is manufacturers providing strict ingredient/feedstock specifications resulting in increased waste for producers and organisations up stream.

This PhD project will explore the use of data and digital technologies to monitor and optimise resource use in barley production and brewing and identify the opportunities for waste stream reuse. The project will focus on determining what data should be collected, how the data should be collected (manually or with autonomous sensing), how the data should be analysed to generate actionable information and how the data can be shared between industry partners whilst ensuring privacy of commercially sensitive information.

Campden BRI is a membership based organisation with over 2500 companies in membership from the food and drink sector. They will sponsor this PhD project and provide technical supervision, access to their members and host a placement.

We are looking for applicants with the appetite and potential to address environmental sustainability challenges facing the brewing industry with a degree in either Engineering, Physical Sciences or Data/Computer Science.

Information enquires can be directed towards Nicholas Watson, University of Nottingham (nicholas.watson@nottingham.ac.uk)

BARIToNE Project C - Identifying novel traits and molecular markers for improved N-use efficiency in malting barley

Principal Industrial Supervisor – Dr. Alex Park, AB InBev

Principal Academic Supervisors – Dr. John Foulkes, University of Nottingham

Additional Supervisors – Dr. Guillermina Mendiondo, University of Nottingham

This project will be based at the School of Biosciences, University of Nottingham and the appointed student will registered at the University of Nottingham as the degree awarding institution.

Developing cultivars with high yields and malting quality whilst minimising N inputs is a key target for the production of sustainable barley crops. High N applications are uneconomic and pose a potential threat of nitrate pollution of ground water as well as emissions of GHGs due to the release of N_2O. To develop N-efficient cultivars will require improved understanding of the genetic and physiological bases of both N uptake and utilization. The project will identify novel genotypes expressing high N-uptake efficiency and N-utilization efficiency, understand the mechanisms underlying the improved N efficiency and investigate the genetic bases of these traits. The plant material phenotyped will include elite UK and European malting barley cultivars and landraces in the public domain and an elite GWAS panel from the ABI breeding programme. In years 1 and 2, a panel of ten elite cultivars and landraces will be phenotyped at a field site at Nottingham University at four fertilizer N rates ranging from sub-optimal to a supra-optimal N rates. Physiological analysis will be carried out to understand how the high N-use efficiency genotypes are explained by the different physiological components of: (i) root activity, (ii) leaf/canopy photosynthetic rate and (iii) optimized N remobilization determining the stay green trait. The field studies will utilise shovelomics or electrophysiological or penetrometer methods for quantifying root traits. Photosynthetic traits will be quantified through analysis of multi and hyperspectral reflectance indices. In addition, biomass and N uptake and dry matter and N partitioning will be quantified at critical development stages through the growing season. Malting quality of grain samples will be assessed through analysis of grain N%, germination performance, texture and micro-malting tests (alpha amylase, moisture, protein, beta glucan, DP, FAN, extract, s/t, soluble protein, turbidity, and wort color). From these data, we will understand the bases of the improved for N-efficiency for malting barley genotypes and identify target traits for improved NUE for further genetic analysis. In year 3, a Genome Wide Association Study (GWAS) study will be carried out phenotyping target traits in a field experiment on an ABI GWAS malting barley panel utilizing a 40,000 SNP array to identify mark-trait associations. The most promising Marker Trait Associations will then be used to search for candidate genes, for which molecular markers will be established for the NUE traits for deployment in the ABI malting barley breeding program.

If you would like to discuss this project in more detail, please contact Dr. John Foulkes (john.foulkes@nottingham.ac.uk) for more information

BARIToNE Project D - Strategies for Control of Head disease and associated mycotoxin risk in Spring Barley production and utilisation

Principal Industrial Supervisor – Dr. Julian South, MAGB

Principal Academic Supervisors – Dr. Edgar Huitema, University of Dundee

Additional Supervisors – Dr Neil Havis, Dr. Kairsty Topp, Dr. Henry Creissen & Dr. Steve Hoad, Scotland's Rural College

This project will be based at SRUC, Edinburgh, and the appointed student will registered at the University of Dundee as the degree awarding institution.

Across the cereals sector, there is renewed interest in grain health and concern about presence of toxic chemicals such as mycotoxins. This concern has been widespread in barley for malting, in wheat destined for milling and feed, and in oats for milling and processing. A project on barley head diseases would attract broad cereal sector interest and would have wide application.

This BARIToNE PhD project builds on previous and ongoing research by considering how crop management and barley cultivar influence the occurrence of major barley head diseases, including blight and ergot. The project relates strongly to the climate resilience theme, but also considers reduced and more efficient inputs. Experimental approaches will combine pathology, agronomy and physiology along with chemical analytical approaches and methods in the following main strands:

1. Agronomic management. To provide gap filling in our current knowledge and include field experiments on the impact of changing agronomic systems on ergot survival and proliferation. We know that ergot infection of adjacent grass swards and margins in getting into grain samples and that previous cropping and cultivation can affect fusarium infection. This aspect will be developed within a suite of agronomic management and risk factors to identify future threats to production. This part of the study will also include novel control measures for ergot and fusarium, such as biological control of plant disease which is a growing area of interest in more integrated approaches to crop protection. In addition, the impact of environmental conditions which favour the germination of ergot sclerotia and the expression of toxin production genes will be examined.

2. Monitoring the presence of mycotoxins. To understand the presence of soil and trash borne inoculum and ergot sclerotia and their contribution to mycotoxin and alkaloid concentrations. The monitoring of the presence of mycotoxins and alkaloids will be undertaken with wider project collaboration, including methods for their minimisation through the supply chain and subsequent processing. We also consider that any changes in agronomy that control ergot must not be to the detriment of Fusarium derived mycotoxins, of which T2/HT2 are important in barley.

Throughout the research programme, the student will have opportunity to engage with broader strategic research on crop health and improvement.

If you would like to discuss this project in more detail, please contact Dr Neil Havis (neil.havis@sruc.ac.uk) for more information

BARIToNE Project E - Towards climate-Positive baRley: developing mOdel-based approaches to idenTify pathways and EvidenCe benefiTs (PROTECT)

Principal Industrial Supervisor – Gillian MacDonald, Glenmorangie

Principal Academic Supervisors – Dr. Pietro Iannetta, James Hutton Institute

Additional Supervisors – Prof. Graeme Walker & Prof. Daniel Gilmour, Abertay University

This project will be based at the James Hutton Institute, Invergowrie and the appointed student will registered at Abertay University as the degree awarding institution.

This four-year PhD studentship is fully funded by the BARIToNE Collaborative Training Partnership and offered (from Oct. 2022) by Abertay University, Glenmorangie Distillers, and the James Hutton Institute.

The project aims to identify approaches to reduce the carbon (C) footprint of cereal (barley) production in-line with net-zero targets. Agriculture is a significant contributor to UK and global greenhouse gas (GHG) emissions, and Scotland has committed to reach net-zero C-emissions by 2045. While crop research trials have identified potential approaches to reduce barley C-footprint for distilling, these have not been critically examined.

The studentship will therefore analyse value chain data to identify and account environmental impact indicators that assess the sustainability of barley production methods, and downstream value-chain segments, using life-cycle analysis (LCA). The approach will identify synergistic 'wins' in overall emissions reductions, minimising negative trade-offs in other impact-categories.

An initial literature review and expert stakeholder consultation will identify innovations to reduce the C-footprint of barley production. In parallel, a bespoke 'grain-to-glass' LCA model will be developed to characterise barley production and processing at Glenmorangie in terms of C-footprint and other environmental impacts. LCA-scenarios will be considered to identify best-case approaches for net-zero barley production and distilling. The approach will draw-upon: Hutton's extensive datasets of integrated cropping practices; Abertay's expertise in applied-science of processing for distilling; and, includes industry placements with Glenmorangie.

The project presents an excellent opportunity for training in multi-disciplinary skills and techniques including stakeholder elicitation, LCA modelling, data management, and statistical analysis. The project will suit candidates with a data science background who are keen to apply their skills to solve agri-environmental and value-chain challenges using quantitative tools for sustainable development. Partnering with Glenmorangie also offers invaluable experience in translating research for practical application - since LCA-based tools which have emerged as critical to inform sustainable development and research priorities of the business, and the industry more broadly.

Candidates should have a high-class Honours degree (equivalent to 2:1 or above) and/or an excellent postgraduate qualification in a relevant subject. The project benefits from a highly experienced supervisory team, including: Profs Graeme Walker and Daniel Gilmour, Abertay University; Gillian Macdonald and Peter Nelson, Glenmorangie; and, Drs Pietro Iannetta and Colm Duffy, James Hutton Institute. Before applying, we recommend contacting pete.iannetta@hutton.ac.uk , or g.walker@abertay.ac.uk , providing a CV and explaining why this project is of interest to you.

BARIToNE Project F - Moving to net zero barley production

Principal Industrial Supervisor – Gillian MacDonald, Glenmorangie

Principal Academic Supervisors – Dr. Roy Neilson, James Hutton Institute (JHI)

Additional Supervisors – Dr. Eric Paterson, JHI & Dr. Davide Bulgarelli, University of Dundee

This project will be based at the James Hutton Institute, Invergowrie and the appointed student will registered at the University of Dundee as the degree awarding institution.

The Climate Emergency demands that innovative and effective mitigations are urgently developed to achieve a just transition to Net Zero. There is an increasing focus on how this can be tackled in the agricultural sector, while still maintaining production for a growing global population. This project, co-developed by academic and industry partners, will explore the potential for reducing the environmental impact of barley cultivation for the whisky industry.

Whisky is the single most valuable Food and Drink product in the UK (£5.5Bn in 2020), but the barley cultivation stage contributes approximately 50% of the carbon footprint associated with each bottle produced. In large part, this is a consequence of chemical fertiliser use (both energy costs of manufacture and GHG fluxes from soil following application). Therefore, strategies to reduce use of chemical fertilisers, while maintaining sustainable grain production are urgently needed.

The use of distillery wastes for energy production (biogas) through anaerobic digestion (AD) is already an established means of off-setting carbon costs of whisky manufacture. However, AD itself generates wastes with high-nutrient content (digestates) that have potentially deleterious environmental impacts (e.g. effluent discharges affecting water quality). Therefore, the specific aim of this project is to examine the potential value of AD wastes for use as fertiliser replacements, exploiting their high-nutrient value in barley cultivation and supporting circular economy principles through diversion from waste streams. The research will involve controlled environment and field trials to assess the fertiliser equivalence of AD wastes, quantifying growth and grain quality of malting barley, relative to chemical fertilisers. It is essential that impacts of AD wastes on soil health are neutral or positive, and the project will quantify effects of their application on soil biological diversity and functions. This will include isotopic approaches to quantify carbon and nutrient cycling processes in soils (including GHG fluxes and nutrient leaching), combined with molecular characterisation of microbial /faunal communities to determine associated impacts of AD waste application. Based on results obtained, formulations (e.g., AD effluent in combination with biochar generated from solid waste fractions) will be explored to optimise barley production and to foster long-term sustainability of soil ecosystem services in malting barley production systems.

The project provides a motivated candidate with an exceptional opportunity to contribute to a highly topical research area, and to gain invaluable experience of working in both academic and industry settings, generating research-specific and transferable skills from collaboration with each partner organisation.

If you would like to discuss this project in more detail, please contact Roy Neilson (roy.neilson@hutton.ac.uk) for more information.