University of the Highlands and Islands Orkney College

AGRONOMY INSTITUTE

AGRONOMY INSTITUTE

- For Northern Temperate Crop Research -

ANNUAL REPORT

(April 2021 to March 2022)

Tea (*Camellia sinensis*) plants growing in the Agronomy Institute's polythene tunnel in 2022

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Oilthigh na Gàidhealtachd agus nan Eilean

Contents

1 Introduction

The Agronomy Institute (AI) is a plant-based research centre at Orkney College UHI which is an academic partner in the University of the Highlands and Islands (UHI). This report covers the year from April 2021 to March 2022. During this period, AI research activities were concentrated on a Scottish Government funded heritage barley project in collaboration with the James Hutton Institute (JHI). Collaborations also continued with other researchers at the Universities of Copenhagen, Sheffield, St Andrews and Trinity College Dublin on Bere barley. On the commercial side, the AI continued to manage a Bere barley supply chain to provide grain for malting to Bruichladdich Distillery and other end users, and collaboration continued with Raasay and Borders (R&B) Distillers to help it source high provenance malting barley for use by its new distillery on the Isle of Raasay. Projects on growing tea and producing Orkney-fruit flavoured kombuchas with Norse Pilgrim Ltd and Orkney Craft Vinegar, respectively, were completed in 2021 while a new project helping North Uist Distillery develop a local supply chain for growing Bere for whisky production started in 2022. A proposal for an Orkney Vertical Farm, based at the Institute, has been included in the Islands Growth Deal and an Outline Business Case for this was completed in March 2022.

2 Background

The AI was opened at Orkney College UHI in June 2002. Its mission statement is “to establish an internationally recognised centre for the research, development and promotion of northern temperate plants and their products which contributes significantly to the sustainable economic, social and environmental well-being of the Highlands and Islands of Scotland”. This is being achieved by a research and development programme which is focused on:

- Identifying and screening crops and plants with potential for commercialisation in the Highlands and Islands, taking into account their potential impact on the environment and biodiversity.
- Collaborating with growers and end-users to develop *Best Practices* and supply chains for these crops.
- Stimulating the market for crops grown in the Highlands and Islands by collaborating with end users to develop new products.
- Developing collaborations with other research organisations to bring economic and research benefits to the Highlands and Islands.

The AI's development aims are delivered through a combination of field trials, research projects and commercial linkages which are outlined below.

FoodCult project leader, Dr Susan Flavin, interviewing John Wishart from the AI about bere for a film produced as part of the project.

3 Links With Other Organisations And Profile Raising Activities

As an emerging research centre in the north of Scotland, the development of collaborative links with other organisations is very important and over this reporting period the AI actively engaged with individuals in the following organisations:

- *Research Organisations:* The James Hutton Institute (International Barley Hub; Advanced Plant Growth Centre; Centre for Sustainable Cropping); Stockholm University; Swansea University; Trinity College Dublin (FoodCult project); the Universities of Birmingham, Copenhagen, Manchester, Sheffield and St Andrews.

- *Commercial Companies:* Bairds Malt; Bruichladdich Distillery; Crisp Malt; Intelligent Growth Solutions; Norse Pilgrim Ltd; North Uist Distillery Ltd; Orkney Distilling Ltd; Orkney Craft Vinegar; Orkney Wine Company; R&B Distillers Ltd; Swannay Brewery; Warminster Maltings Ltd.

- *Growers, Grower and End-User Groups and Trusts:* Agriculture and Horticulture Development Board; Balfour Castle Estate; Birsay Heritage Trust; Orkney Bere supply chain; Orkney Food and Drink.

AI staff participated in the 2022 UHI Tourism Forum and presented an outline of the Institute's collaboration with the Shapinsay company, Norse Pilgrim, to help it develop a small-scale tea growing enterprise.

4 Impact Of The Agronomy Institute

The Institute continues to make an impact at several levels:

- Growers have benefited from the new markets for crops and supply chains which the AI has developed as well as its knowledge exchange activities, particularly with cereals. In 2021, for the fifteenth successive year, Orkney growers working with the Institute planted about 30 ha of Bere for specialist whisky and beer markets which the AI has developed and supplies. The success of this market has created a demand for Bere from other end users which has also allowed Birsay Heritage Trust to expand its Bere supply chain to a similar scale.

  Since 2017, the Institute has been helping growers on Raasay and in other locations produce high provenance malting barley for whisky production by

Growers of Orkney bere, Sydney Gauld (left) and Erik Stout (right). Sydney retired from growing bere for the AI's supply chain in 2021 and was replaced by Erik, a neighbouring farmer.

R&B Distillers' new distillery on the Isle of Raasay in the Inner Hebrides. Small scale production of fruit (by Orkney Wine Company) for wines and liqueurs, and botanicals (by Orkney Distilling Ltd) for gin, has been made possible through help provided to these companies to establish their own crop production areas. Since 2019, the Institute has been helping the Shapinsay company, Norse Pilgrim, develop its tea growing enterprise.

A range of Bere whiskies produced by Bruichladdich Distillery using bere supplied by the Agronomy Institute since 2005.

- Commercial companies have also benefited as crops have been made available for the development of new products. Thus, in 2012 and 2014, Isle of Arran Distillers produced two limited edition Bere whiskies; since 2014, Bruichladdich Distillery has released the first seven of a series of Bere whiskies, and Valhalla Brewery in Shetland and Swannay Brewery in Orkney have both produced beers using Bere malt supplied by the AI. Since 2012, collaboration between the AI and Orkney Wine Company has resulted in the release of three new wines and a liqueur, and both the Orkney Wine Company and Swannay Brewery developed successful cask-matured products using Bere whisky casks supplied by the Institute. In 2016, Orkney Distilling Ltd released its first product, *Kirkjuvagr* gin, which contains Orkney botanicals supplied by the Institute and in 2017 Orkney Craft Vinegar was helped to produce a cask-matured Bere malt vinegar. On the Inner Hebridean island of Raasay, barley produced on the island in trials run by the AI was distilled at the Isle of Raasay Distillery in both 2018 and 2019.

- As a research centre within UHI, it is particularly appropriate that the benefits of AI activities are spread over the Highlands and Islands. In addition to the Institute's strong Orkney links, collaborations with commercial organisations in Shetland (Shetland Livestock Marketing Group and Valhalla Brewery), Islay (Bruichladdich Distillery), Arran (Isle of Arran Distillers), Raasay (R&B Distillers Ltd) and North Uist (North Uist Distillery) demonstrate that the Institute's activities impact on diverse parts of the region. Collaborations between the AI and other research centres (e.g. the James Hutton Institute, the Rowett Institute and Forestry Commission Scotland) have helped these organisations deliver research projects benefiting remoter parts of the Highlands and Islands.

A test sample of tea made from leaf supplied by several Tea Scotland growers including Norse Pilgrim on Shapinsay which has been helped by the AI to grow tea since 2019.

- With an aspiration for both national and international recognition, it is crucial, not only that the AI has international links (see Section 3) and collaborations (e.g. through the Northern Periphery and Arctic Programme), but also that its research outputs are of a high quality and contribute significantly to UHI. In recent years, AI staff have made important contributions to scientific publications on cereals, willow and natural products and the Institute was part of UHI's submission to the 2021 Research Excellence Framework (REF).

Bere barley being cut for whole crop silage on the most northerly Orkney island of North Ronaldsay. Here, the crop is grown for feed on an organic farm and is valued because of its tolerance to the farm's manganese deficient soils.

5 Plant Research Themes

As a result of reviews of potential markets for local crops in the Highlands and Islands, the AI has identified several research themes on which it is concentrating. Within each theme, a number of potential crops have been tested and subsequent research has focused on those crops and themes for which funding or commercial opportunities have been available. The main current research themes are reviewed below:

5.1 Early-Maturing Cereal Varieties

Under this theme, the Institute is investigating both modern and heritage cereal varieties which are early-maturing and therefore suited to growing in the Highlands and Islands' short, cool growing season. They are mainly being considered for food and drink products and have included varieties of barley, wheat and oats. Early-maturing varieties from Northern Europe are thought to be very suitable for the north of Scotland, and Icelandic, Finnish, Swedish and Norwegian varieties have been grown successfully in Orkney; some have also been tested on Shetland and Raasay. AI research and commercialisation activities have focused particularly on the ancient Scottish barley landrace, Bere, which is very early-maturing and has a long association with Orkney. A diverse range of UK and Scandinavian heritage barley types have been grown by the Institute between 2016 and 2022 as part of a collaborative project with the James Hutton Institute funded by the Scottish Government. This research has also included trials of populations of crosses between Bere and two modern varieties and have also recently included landraces of rye (*Secale cereale*) and black oats (*Avena strigosa*) from Scotland's Western Isles.

Plots of rye (centre left) and black oats (centre right) in a trial on a nutrient-poor soil at Burray. Like some types of bere, these landraces are tolerant to the deficiency of trace minerals at the trial site and grew much better than the modern barley varieties in the trial.

5.2 Woody Biomass Crops

Initial AI research into biomass crops focused on willow (*Salix* spp) grown as short rotation coppice (SRC) which was investigated as a possible source of local renewable heating fuel to help reduce dependence on fossil fuels. This resulted in the establishment of several trials between 2002 and 2007. Between 2011 and 2018, the AI collaborated with Forestry Commission Scotland and Orkney stakeholders to investigate the potential for short rotation forestry (SRF) in Orkney. The AI continues to manage small areas of SRC and SRF at Muddisdale on the edge of Kirkwall.

Norse Pilgrim's raised bed of tea in August 2022, two years after planting. The first small crop of shoots were plucked from these plants during 2022, providing sufficient leaf for test processing.

5.3 Plants For Natural Products

Plants in this theme could have a wide range of end uses, but most of those investigated have been grown for pharmaceutical and cosmetic products, or flavourings. These include sweet gale (*Myrica gale*), the source of a high-value cosmetic oil and *Narcissus* cultivars as a source of galanthamine for treating Alzheimer's disease. Others, like angelica (*Angelica archangelica*), marshmallow (*Althaea officinalis*) and meadowsweet (*Filipendula ulmaria*) have been grown as flavourings. Most recently, the Institute has started to investigate the local cultivation of tea (*Camellia sinensis*) with a grower on the Orkney island of Shapinsay.

Several northern berry crops have the potential for supplying high-value extracts for the nutraceuticals / health food supplements sector as well as products for the food and drink industry. Species being grown by the AI include cranberry (*Vaccinium macrocarpon*), sea buckthorn (*Hippophae rhamnoides*), aronia (*Aronia melanocarpa*), Saskatoon (*Amelanchier alnifolia*), low-bush blueberries (*Vaccinium angustifolium*), salal (*Gaultheria shallon*) and elder (*Sambucus nigra*).

6 Projects And Commercial Activities

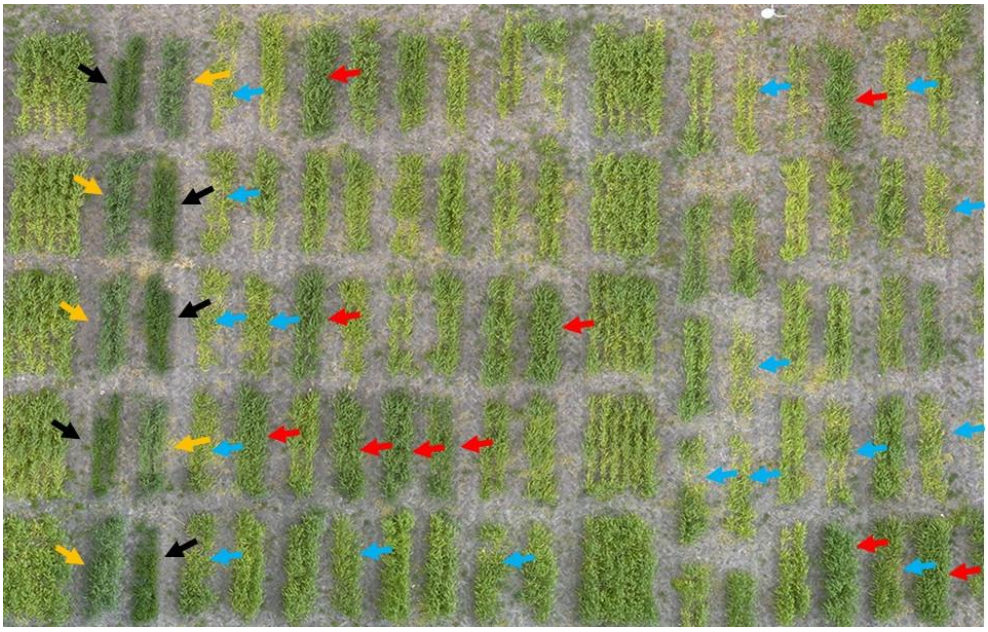
Income from research projects and commercial activities are vital for ensuring the financial sustainability of the AI. In 2021/22 the AI was involved in the projects and commercial activities outlined in the following sections:

Sam Britten of Orkney Craft Vinegar providing samples of kombucha for consumer testing. These were flavoured with Orkney-grown fruit sourced by the Agronomy Institute.

6.1 Cereals

Bere Barley Adaptation To Scottish Island Low Input Agriculture

This project started in 2016 and is funded through the Scottish Government's Rural and Environmental Science and Analytical Services (RESAS) Division. As part of a wider research programme supported by RESAS on Biodiversity and Ecosystem Function, the Institute is collaborating with researchers at the James Hutton Institute (JHI) to investigate genetic diversity and local adaptation in Scottish barley landraces. Through the project, the partners aim to help preserve and utilise novel genetic diversity which exists in landraces (especially Bere) to improve the sustainability of the Scottish barley crop which is nationally important for the high value distilling and brewing industries and also for animal feed. Since many of the Bere accessions originate from the Northern or Western Isles, the Institute's northern maritime trial sites and research facilities are an important resource for the project.



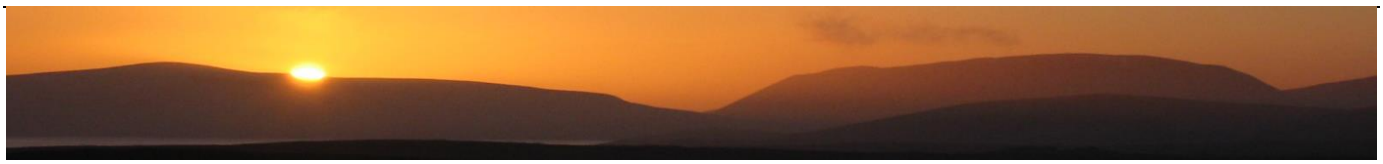
Drone photograph taken in June 2021 of the RESAS barley trial on a manganese defeicient soil at Burray.The photo shows the much poorer establishment (poor leaf development and light green canopies) of modern varieties (light blue arrows) compared with landraces of black oats, rye and bere (black, yellow and red arrows, respectively).

The 2021 Orkney research programme included a 432-plot trial containing different accessions of bere (41) and other old types of barley from Scotland (7), other parts of Britain (39) and Scandinavia (15) together with modern barley varieties (39) and traditional rye (*Secale cereale*) and black oats (*Avena strigosa*) from the Western Isles). This was the first time that such a wide range of barley material from the Hutton's barley collection had been screened on a site with marginal, manganese-deficient soil. The trial confirmed the unique ability of some types of bere to tolerate the soil conditions at the Burray site but also demonstrated that this trait was present in the landraces of rye and black oats.

R&B Distillers (Isle of Raasay Distillery)

Raasay and Borders (R&B) Distillers opened a new distillery on the Hebridean island of Raasay, near Skye, in September 2017. The company was keen to source some of the barley used by the distillery locally but, since the crop had not been grown there for a long time, it approached the Institute to help it investigate the feasibility of doing this. The Institute selected very early maturing barley varieties from northern Europe for testing in on-farm variety trials which were established on Raasay between 2017 and 2019. In all three years, early maturing varieties were successfully grown and harvested and the barley has been malted and used by the distillery for

Wort, made from mashing bere malt, being drained from the mash tun during brewing trials with bere as part of the FoodCult project.



whisky production. Further assistance to the company was provided in 2020 and 2021 to help it source high provenance barley from other Scottish locations for distilling.

During 2021, Swannay Brewery released three new canned bere beers made from bere supplied by the Agronomy Institute.

Researching The Origins Of Bere

This is an initiative which is being pursued by the Agronomy Institute in collaboration with the Archaeology Institute at Orkney College and other archaeologists and biomolecular archaeologists at the Universities of Manchester and Sheffield. Methods under investigation include geometric modern morphometric (GMM) analysis of grains of Bere and other 6-row hulled barleys (University of Sheffield) and genotyping by sequencing of Bere and other barley cultivars (University of Manchester). So far, although it has not been possible to totally dismiss an earlier suggestion that bere was introduced to Scotland by Norse settlers, there is accumulating evidence suggesting that it was probably introduced much earlier than this – possibly in the Bronze Age or even in the Neolithic (see Section 8, Drosou *et al*. 2022).

FoodCult Project (https://foodcult.eu/)

This project brings together history, archaeology, science and information technology to explore the diet and foodways of diverse communities in early modern Ireland. The Institute is collaborating with experimental archaeologists on the project investigating brewing in the 16th century, and especially the nutritional value of beers of this period, which often included oats. Since Bere was grown in Ireland at this time, an important contribution of the Institute to the project was to supply the bere for brewing and information about the crop. The bere was malted by Warminster Maltings and the beer was made in a specially constructed brewhouse in a Tudor farmhouse at the Weald and Downlands Living Museum in West Sussex.

Supply Chain For Bere

For the fifteenth year, the AI ran a Bere supply chain with local growers and, following a good harvest, was able to supply 100 t of Orkney-grown grain to Bruichladdich Distillery for whisky production. Bruichladdich uses Bere to produce high provenance *Bere Barley* whiskies which are released as annual vintages. In 2021, *Bere Barley 2011* was released which was distilled in 2011 from the 2010 Orkney Bere crop. Bere from the supply chain is also made into specialist products by other companies. These include Swannay Brewery and Orkney Craft Vinegar; it has also been supplied to a few other companies for product development work.

Peas (left) growing at Orkney College. Nitrogen fixing bacteria grow in nodules (right) on the roots of peas and other legumes and can fix most of the nitrogen required by the crop. Residues supply significant amounts of nitrogen to following crops.

North Uist Distillery
With funding from the Scottish Food and Drink net zero challenge fund, the AI and partners at the Environmental Research Institute started a feasibility study in 2022 to help North Uist Distillery (NUD) set up a sustainable local bere barley supply chain for whisky production.

Centre for Sustainable Cropping
From 2014 to 2018, the Institute rotated a crop mixture of barley and peas (*Pisum sativum* cv. Magnus) amongst its bere fields and collected samples of peas, weeds and soil for a project being run by the Centre for Sustainable Cropping (CSC) at the James Hutton Institute on biological nitrogen fixation (BNF). The results have now been published (Section 8; Maluk *et al*., 2022) and indicated that the peas in Orkney were able to obtain almost 80% of their nitrogen requirement from BNF. Trials at the CSC indicated that, with suitable management, Faba bean and pea crops can leave a residue of 50-110 kg N ha^{-1} yr^{-1}. These results are currently of particular relevance to farmers because of the large increases in mineral fertiliser prices in 2021 and 2022.

6.2 Plants For Natural Products

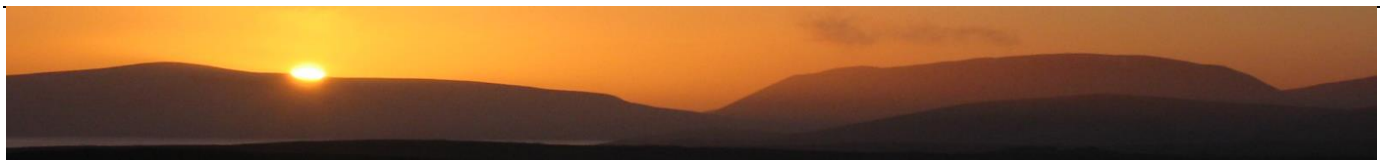
Orkney Botanicals For Flavouring Gin
Orkney Distilling Ltd (ODL) was established in 2016 and since then the company has opened a new distillery and visitor centre at a site on the Kirkwall waterfront. Using a selection of locally grown botanicals produced by the Institute, the company developed its first product, *Kirkjuvagr* gin, later in the year. In 2017, the AI helped ODL establish a botanicals garden from where it sources some of its own botanicals. The Institute continues to provide samples of some of the species it grows to the distillery for testing in its gins.

Orkney Fruit Kombucha
Building on earlier links between the Institute and Orkney Craft Vinegar which helped the company develop its Bere Malt vinegar, the partners worked together in 2021 to develop novel fruit kombuchas. In line with the company's ethos, the fruit supplied by the Institute were all Orkney-grown.

Northern Fruit Species For Orkney Wine
Orkney Wine Company (OWC) produces a range of fruit wines and liqueurs using non-grape ingredients. Since 2012, the AI has been helping the company source unusual, locally grown ingredients to produce unique wines with a high content of local fruit. Several of the species have been in Institute research trials since 2004. The collaboration has been assisted by chemical analyses of the fruit species and wines, carried out by the James Hutton Institute. During 2015, the AI helped the company establish its own fruit garden so that it can expand production of wines made from local fruit. Commercial products which have resulted from this collaboration include the wines *Orkney White, Orkney Rosé* and *Viking Red*, and the liqueur *Kvasir.* These products contain fruits of cranberry, aronia, elder and salal and flowers of elder, supplied by the Institute.

Growing Tea On Shapinsay
Although tea (*Camellia sinensis*) is more suited to being grown in warmer climates, there is increasing interest in growing it in Scotland for a high value market for high provenance teas with special flavours. While tea grown outside in Scotland will never produce the leaf yields obtained from more traditional areas, it is thought that the challenging growing conditions combined with long summer daylength could result in the production of uniquely flavoured teas which can be sold on the high value specialist tea market. With funding support from Interface and from UHI's Tourism

An outside area of tea planted by Norse Pilgrim Ltd in Shapinsay in June 2021 with help from the Agronomy Institute. This will complement a raised bed of tea which the Institute helped the company to establish in its polycrub in 2019.



Challenge Fund, the AI helped the Shapinsay company, Norse Pilgrim Ltd, establish a small area of tea in a polycrub in 2019 and produced plants for the company which were planted in a small test area outside in 2021. The Institute is also helping the company develop appropriate growing practices for young tea under north of Scotland conditions.

7 Staff

The following people contributed to the work of the AI over the period:

Dr Peter Martin - Director
Mr John Wishart – Field, laboratory and technical support; supply chain management

8 Publications

AI staff contributed to the following peer reviewed publications:

Drosou K, Craig H, Palmer K, Kennedy SL, **Wishart J**, Oliveira HR, Civáň P, **Martin P**, Brown TA (2022). The evolutionary relationship between bere barley and other types of cultivated barley. *Genetic Resources and Crop Evolution.* https://doi.org/10.1007/s10722-022-01377-8

Maluk M, Ferrando-Molina F, Lopez del Egido L, Langarica-Fuentes A, Gebre Yohannes G, Young MW, **Martin P**, Gantlett R, Kenicer G, Hawes C, Begg GS, Quilliam RS, Squire GR, Young JPW, Iannetta PPM, James EK. (2022). Fields with no recent legume cultivation have sufficient nitrogen-fixing rhizobia for crops of faba bean (*Vicia faba* L.). *Plant Soil* **472,** 345–368. https://doi.org/10.1007/s11104-021-05246-8

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