

AGRONOMY INSTITUTE

- For Northern Temperate Crop Research -

ANNUAL REPORT



Planting sweet gale (*Myrica gale*) near Elgin

2007-2008

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1 Introduction

The Agronomy Institute (AI) is a research centre at Orkney College UHI which is an academic partner in UHI Millenium Institute, the project to bring a university to the Highlands and Islands of Scotland. This annual report covers the period from April 2007 to March 2008. The year saw the continuation of considerable investment into the AI in the form of staff and equipment as a result of two major funding packages obtained through UHI - ARC (Addressing Research Capacity in the Highlands and Islands) and SRIF (Science Research Infrastructure Fund). During the year, major achievements of the AI were to win major funding for a project to investigate the agronomy of sweet gale (*Myrica gale*), to successfully tender for implementing research in Orkney on energy crops for pelleting (PelleTime project) and to supply substantial quantities of Bere barley to Bruichladdich distillery for the development of a niche market whisky. In addition, the research capacity of the AI was further strengthened by the arrival of two PhD students who started research projects on willow and Bere. Over the year, the AI also continued its on-going programme of field trials and research projects. All these developments are described in the following sections.

2 Background

The AI was opened at Orkney College in June 2002. Its mission statement is “to establish an internationally recognised centre for the research, development and promotion of 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 programme which is focused on:

- Identifying and screening crops and plants with potential for commercialisation in the Highlands & Islands, taking into account their potential impact on the environment and biodiversity.
- Collaborating with growers and end-users to develop Best Practice Guidelines and supply chains for crops and plants.
- Stimulating the market for crops and plants by collaborating with end-users to develop new products.

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



3 Links With Other Organisations And Profile Raising Activities

As an emerging research centre, the development of collaborative links with other organisations and individuals is very important and over the year the AI actively engaged with the following:

- *Research Organisations:* ADAS, British Nutrition Foundation, Central Science Laboratory (CSL), Forestry Commission, Inverness College, National Non-Food Crops Centre, Rothamsted Research, Scottish Agricultural College (SAC), Science and Advice for Scottish Agriculture (SASA), Scottish Crops Research Institute (SCRI), Scottish Natural Heritage (SNH), The Macaulay Institute, University of Reading, University of Aberdeen.
- *Commercial Companies and Individuals:* Alzeim Ltd., Argo's Bakery, The Boots Company Plc, Liz Ashworth (Food Product Development Consultant), Bruichladdich Distillery, Crantit Dairy, Essentially Scottish Botanicals Ltd (formerly Highland Natural Products Ltd), JF Groundwater Baker and Greengrocer, Highland Birchwoods, Isle of Arran Distillers, Orkney Housing Association Ltd, Valhalla Brewery.
- *Growers, Growers' Groups and Trusts:* Birsay Trust, Dunlossit Estate, Orkney Bere farmers, Crofters Commission, Scottish Crofting Foundation, Shetland Bere and Aets Living Heritage Project, Orkney Renewable Energy Forum (OREF), Tiriee Rural Development Ltd., Willow Energy Group for Orkney (WEGO).

The AI held a well attended open day at the College in July 2007 and during the year was visited by a number of other visitors and groups including advisers from SAC's North Group Farm Business Service, members of Tiriee Rural Development Ltd, the HIE board, Richard Lochhead MSP and potential research collaborators from Iceland, Finland and Sweden.

In addition, AI staff also presented posters or papers at the All-Energy Conference (Aberdeen), a HI Links GI (glycaemic index) and Health seminar (Inverness) and the 5th International Symposium on New and Underutilised Crops (Southampton).

4 Impact of the Agronomy Institute

The AI has continued to make an impact at several levels:

- Growers have benefited from the knowledge transfer activities of AI staff, particularly on cereal crops. In 2008, as a result of new markets developed by the AI, 10 ha of the barley landrace, Bere, are being grown in Islay and 28 ha in Orkney. There has also been considerable interest from local farmers in early-maturing Finnish cereal varieties, particularly of oats and wheat, which the AI has grown for several years.
- Highlands and Islands SMEs are also benefiting as crops are being made available for the development of new products. With Bere, for example, supply chains have been established so that Bruichladdich Distillery can produce a specialist Bere whisky and Valhalla Brewery can produce a Bere beer. Collaborative work on plants for skincare products and research into developing sweet gale (*Myrica gale*) as a plantation crop has also started with Essentially Scottish Botanicals Ltd and The Boots Company Plc and this work will benefit growers throughout the Highlands and Islands area as well as other parts of the supply chain. In Orkney, oats and wheat grown by the AI have been milled by Barony Mills and have been used in new commercial products by local bakery companies since 2007.



Jim McEwan, Production Director at Bruichladdich distillery, tasting the 2008 new-make Bere spirit.



- As a research centre within UHI Millenium Institute, it is particularly important that the activities of the AI are spread over the Highlands and Islands. In addition to the AI's strong Orkney links, it is clear from its collaboration with Bruichladdich Distillery (Islay), Valhalla Brewery (Shetland), Essentially Scottish Botanicals Ltd (Invernesshire), Dunlossit Estates (Islay) and from its contribution to sweet gale research (6 trials sites on mainland Scotland) and the PelleTime project (one trial in Shetland and one in Orkney) that the Institute's activities are benefiting several other parts of the Highlands & Islands.
- The AI makes a valuable contribution to the research capacity of UHI and in 2007 the Institute produced one of eight submissions from UHI to the Research Assessment Exercise (RAE) 2008.

5 ARC and SRIF Funding Support For The Agronomy Institute

ARC (Addressing Research Capacity in the Highlands and Islands) and SRIF (Science Research Infrastructure Fund) funding to the AI through UHI Millenium Institute is contributing significantly to strengthening the AI. Through ARC, the AI has been able to fund two additional research posts, one technical position and two PhD studentships. SRIF funding has been used to build a grain store and SRIF and ARC funds have been used to purchase a wide range of equipment for the laboratory, field, office and grain store.



Agronomy Institute grain and equipment store built at Weyland farm in 2006 with funding from SRIF.

6 Plant Research Themes And Trials Programme

In its first years after opening, the AI reviewed the market for novel crops in Orkney and identified several research themes on which it concentrated. Within each theme, a list of potential crops for investigation was drawn up and many of these were tested on a small scale in observation blocks. Subsequently, research has focused on those crops and themes for which funding or commercial opportunities have been available. In the following sections, brief descriptions are given of the main plant research themes and the plants within each theme which were grown at Orkney College during 2007/8.

6.1 Cereals

Under this theme, the Institute is investigating both modern and heritage cereal varieties which are suited to the Highlands and Islands (H&I). They are mainly being considered for bakery and drinks products. Local heritage varieties are of particular interest because they are suited to low-input agricultural systems and often have distinctive quality characteristics, some of which have been lost in modern varieties. However, there are also modern varieties which are well-suited to the H&I and a few of these are also being grown. The main crops under investigation in this theme during 2007 were the following:



Bere Barley (*Hordeum vulgare*)

Bere is a 6-row barley landrace, the ancestry of which may go back to the 8th century or earlier. In recent years, its cultivation on any scale has been restricted to Orkney, although it was much more widely grown in Scotland in the past. Within the UK, Bere is unique in being the only barley grown commercially for milling although in the past it was also commonly used for malting. Bere flour is used traditionally in Orkney for making bannocks and is also used locally in bread and biscuits. During 2007, formal replicated trials continued to investigate the effects of inputs like fertiliser, growth regulator and fungicide on yield

Black oats are a traditional Orkney crop which were often grown on marginal land where other varieties failed.



and to compare the growth of Bere with modern varieties. Since 2007, supply chains for Bere have been developed for supplying the grain for the niche whisky market (see Section 7).

Wheat (*Triticum spp*)

Wheat is not normally grown in Orkney, but surveys of food companies within the H&I indicated an interest in obtaining local supplies and since 2007 there have been major increases in the costs of flour and of transporting it to Orkney. Since 2006, the Institute has grown several different varieties of spring wheat (*T. aestivum*) but has identified the Finnish variety 'Anniina' as the most suited to Orkney because it has the big advantage of being ready for harvesting about three weeks earlier than UK varieties. Flour from 'Anniina' has been produced by Barony Mills and has been used commercially by local bakery companies since 2007. Small quantities of Emmer wheat (*T. dicoccoides*), Spelt (*T. spelta*) and Einkorn (*T. monococcum*) are also being grown.

Oats (*Avena strigosa* and *A. sativa*).

The AI has grown the Finnish oat variety 'Fiia' for several years. Although it yields less than UK varieties, it is several weeks earlier maturing. Since 2007 the AI has supplied grain of this variety to Barony Mills for the production of oat meal, the quality of which is considered particularly good by local bakers. A small area of the traditional crop, black oats (*A. strigosa*), is also grown.

6.2 Northern Berry Crops

These make an important contribution to the rural economy of other countries at a similar latitude (e.g. Scandinavia and North America) and are therefore thought to have considerable potential for the H&I area. They are an attractive option because they can be used in a number of ways to produce a range of "added value" products (e.g. jams and drinks). There are very well-documented health benefits from eating fruits and berries and this has resulted in the recent promotion of their role in a healthy diet. A number of these crops have also attracted attention as sources of high-value extracts for the nutraceuticals / health food supplements sector.

In 2007, monitoring of existing plots continued (cranberry, *Vaccinium macrocarpon*; junberry, *Amelanchier canadensis*; sea buckthorn, *Hippophae rhamnoides*; black chokeberry, *Aronia melanocarpa*; all-fieldberry, *Rubus arcticus* Ssp. x *stellarcticus*; blueberries - high bush (*Vaccinium corymbosum*), low bush (*V. angustifolium*, *V. pennsylvanicum*) and half-high hybrids; elder (*Sambucus nigra* and *S. racemosa*). Fruit production has been disappointing, apart from all-fieldberry, cranberry and chokeberry.

6.3 Biomass And Biofuel Crops

There is considerable global acceptance that climate change is real, accelerating and that it is attributable to increasing levels of greenhouse gas emissions as a result of human activities. Most developed countries, including the UK, are now committed to reducing their greenhouse gas emissions, of which CO₂ is one of the most important. This is being done in a number of ways including increasing the use of renewable energy resources (wind, wave, tide, solar, hydro and biomass) for producing electricity and heat and by promoting liquid biofuels (biodiesel and bioethanol) to replace fossil transport fuels. There is, however, growing concern about the CO₂ emissions savings of some biofuels and of the effects of taking land out of food production for biofuels. Biomass crops like willow, which would be grown on more marginal land for crops are less controversial and provide higher energy savings than most liquid biofuels. In Orkney, there has been a small potential market for biomass since 2003 when Orkney Housing Association Ltd (OHAL) installed a wood-fired boiler, supplying heat to its Lynn Road housing scheme.

As a result of promising results from a small-scale willow (*Salix spp*) trial at Orkney College between 2002 and 2005, the Institute established 2.5 ha of short rotation coppice (SRC) willow at Muddisdale in 2006 and 2 ha at Papdale in 2007. Both areas include clone trials and a total of 13 different clones are being grown. The Institute is promoting its activities with willow through a local stakeholder group, the Willow Energy Group for Orkney (WEGO) which is chaired by Dr Geoff Sellers from the Institute. With funding from the Forestry Commission and Highlands & Islands Community Energy Company, WEGO commissioned an economic study of growing SRC in Orkney by



the Scottish Agricultural College (SAC). This study has shown that the enterprise margin for willow is very dependent on yield and wood chip price. The recent clone trials established by the AI will, therefore, make an important contribution to identifying the viability of biomass willows in Orkney and monitoring of these trials is being done by postgraduate students (see Section 8).



Bundled willow stems in a drying trial as part of Fay McKenzie's PhD programme.

In 2008, the Institute will be contracted to carry out research for a 3-year Northern Peripheries Programme project (Pelletime, see Section 7) to investigate the potential of a number of crop species as a source of material for producing pelleted fuel.

Amongst the species to be investigated are the biomass crops, willow and reed canary grass (*Phalaris arundinacea*).

Over the year, the AI has abandoned its interest in small scale biodiesel production from spring oil seed rape (*Brassica napus*) and is now considering the crop's potential in Orkney as a source of virgin cooking oil.

6.4 Plants For Extracts And Flavourings

Plants in this theme could have a wide range of end-uses, but those currently being investigated are for pharmaceutical and cosmetic end-uses.

Research on the medicinal plant arnica (*Arnica montana* and *Arnica chamissonis*) forms the basis of a PhD which is being undertaken by Elizabeth Barron and this is described in Section 8.

Collaborative links were developed in 2006 with Alzeim Ltd as a result of which the Institute has planted an observation block containing several different *Narcissus* cultivars. These are of interest as a potential source of the chemical Galanthamine which is used to treat patients suffering from Alzheimer's disease.



Two funded project with plants in this theme are described in Section 7. One is investigating a range of Scottish plants as potential sources of skincare products and the other is to develop the agronomy of sweet gale (*Myrica gale*) from which a high-value pharmaceutical oil is obtained from the leaves.

Daffodils. A range of different varieties of daffodil are being grown by the Institute in collaboration with Alzeim Ltd to investigate their potential as a source of Galanthamine which is used to treat Alzheimer's disease.



6.5 Culinary Herbs And Salad Plants

Within the Highlands & Islands, wind and the cool growing season are often major constraints limiting the range of plants which can be grown outside. Protected cropping using polythene tunnels provides a relatively cheap way of dramatically improving the microclimate, allowing the production of a number of high-value crops. Local production also has the advantage of considerably reducing the carbon footprint of these products. In 2007, research in this area was led by Dr Xianmin Chang and initially concentrated on investigating production methods and the range of culinary herbs and salad plants which could be grown and the potential for extending cropping beyond the main summer months. Research into the local market for these crops was conducted in collaboration with the local wholesaler James Wilson (Orkney) Ltd and the retailer William Shearer.



Some of the culinary herbs and salad plants grown by the Institute under polythene during 2007.

7 Funded Projects

Since the Institute receives no core funding, funded projects are vital for providing the main source of income for the Institute. During the year, staff were involved in the following funded projects:

Development Of A Supply Chain For Bere Whisky

This project involves the AI, Bruichladdich Distillery and Dunlossit Estate on Islay and is funded by the HI Links programme. Within the project, the AI is providing Bere to growers on Orkney and Islay so that the crop can be produced on the two islands and grain supplied to the distillery to make specialist whiskies. In 2007, 19 ha of Bere were grown in Orkney and 10 ha in Islay and a total of 77 t of Bere were sent to Bairds Malt in Inverness for malting. A slightly larger area has been planted in 2008. The new-make spirit from the 2007 Bere has been described as “exceptionally good” by Bruichladdich distillery.



Bere grains from the 2007 crop sprouting during malt production at the Inverness plant of Bairds Malt.

Orkney Flours Feasibility Study

This project is funded by HI Links and involves the AI, JF Groundwater (Baker & Greengrocer) and Liz Ashworth (food product development consultant). Within the project, wheat, Bere and oats are being grown by the AI to produce different types of flour milled by Barony Mills. These are then being used by JF Groundwater to develop a range of specialist biscuits in collaboration with Liz Ashworth. Over the year, the crops were successfully grown and harvested, flours were milled and test batches of different biscuits have been made. The most promising ones are being taken forward for consumer testing.



Tasting of some of the biscuits being developed by JF Groundwater, using wheat, oat and Bere flour produced by Barony Mills from locally grown crops.



Development Of Skincare Products From Scottish Plants

This feasibility study was funded by the HI Links programme and involved collaboration between the AI, Essentially Scottish Botanicals Ltd and The Boots Company Plc. Within the project, three plant species with a strong Scottish connection and potentially useful chemical profile were selected and grown by the AI. Plant materials were then provided to the other partners for detailed chemical analysis. The project finished in April 2008 and some of the plants have been selected for further research.

Effects Of Selected Alternative Crops On Biodiversity

This project is part-funded by the Crofters Commission and Scottish Natural Heritage and its aim is to investigate some of the effects of alternative crops on biodiversity in comparison with improved grassland. For the project, trial plots were established at Orkney College and on Sanday. At each site, a strip of four double rows of biomass willows was planted down one edge of the plot in April 2005 and the following crops were grown in 12 x 30 m plots in 2005 and 2007: camelina (*Camelina sativa*), borage (*Borago officinalis*), echium (*Echium plantagineum*), turnip rape (*Brassica rapa*) and Bere barley (*Hordeum vulgare*). An adjacent area of improved grassland was selected at each site as a control plot and several indicators of biodiversity were monitored to compare the crops with the control plots. These included the collection of insects during the summer in pitfall and water traps, recordings of bee, wasp and bird activity and enumeration of the weed flora.



Fay McKenzie and Burkart Dieterich monitoring plants growing at the Orkney College biodiversity trial site.

The results from 2007 have shown that insect biodiversity was particularly high at both the Orkney College and Sanday site in the plots of turnip rape, borage and echium and most of the alternative crops supported a more diverse insect life than the grassland. A wider range of bird species visited the Sanday plots than the Orkney College plots. The project finished in April 2008.

Sweet Gale Research Project

This project started in December 2007 and is funded jointly by the AI, The Boots Company Plc, Essentially Scottish Botanicals Ltd and HIE. Sweet gale, or bog myrtle (*Myrica gale*), is a shrub which is native to the UK and is particularly common in high rainfall areas like north-west and north Scotland where it can be found from sea-level up to about 500 m. It has a tradition of use in many countries but recently, the plant has attracted attention as the source of an oil (obtained from the leaves) which is being used for cosmetic products by Boots. Currently, most sweet gale oil is obtained by harvesting leaf from wild stands, but to increase production to meet growing demand for the oil, interest is focusing on developing sweet gale as a planted crop. Since very little is known about the growth of sweet gale under cultivated conditions, this project has been developed to investigate the crop and develop Best Practice Guidelines for growing it.



Agronomy Institute sweet gale trial site at the Hill and Mountain Research Centre, SAC Kirkton. Within the deer fenced area, there are two plots, each containing 500 plants, investigating different establishment methods.

As a first step in providing information about the growth and oil yield from newly planted sweet gale, small trials containing about 1,000 plants are being established at several different locations in the Highlands during 2008. These will be monitored over the 3 years of the project to provide information on site-to-site variation in growth, leaf yield and leaf oil content. Soil and



climatic data will also be collected from these sites to see whether plant growth and leaf and oil production can be related to these environmental factors.

Other topics to be investigated within the project include the use of different types of planting material, the effects of different planting densities and fertiliser, the development of weed control strategies and the incidence of pests and diseases.

PelleTime Project

There has been considerable expansion in the market for pelleted wood fuel in the UK over the last few years because it is a clean, convenient renewable fuel for small scale users. However, increased demand for pulverised wood fuel, particularly for co-firing in power stations, can sometimes result in shortages of raw materials for pellet production and there is a need to explore the possibility of obtaining the raw material for pellets from a range of sources, including agricultural crops. In peripheral locations, like Orkney, where the costs of importing pellets are high, there would be major sustainability advantages in encouraging the development of local, small scale pelleting using a mixture of raw materials.



Preparation of the PelleTime project trial site at Sandwick in Shetland.

The PelleTime project is a three-year Northern Periphery Programme (NPP) project involving Scotland, Finland, Sweden and Iceland which aims to address shortfalls in pellet production by expanding the raw material supply and increasing productive capacity by encouraging SME participation in this market. The AI will be involved in the project from May 2008 and will be conducting growing and pelleting trials on a range of biomass energy crops to assess yields, technical properties, economic feasibility and impacts on biodiversity and landscape. Trials and knowledge transfer activities will be run in both Orkney and Shetland.

8 Postgraduate Research

As a developing research centre within UHI Millenium Institute, hosting postgraduates is an important part of the AI's work and, at the same time, postgraduates make a valuable contribution to the AI research output. Since 2004, the Institute has been involved in supervising and supporting the field work on Arnica of Elizabeth Barron, a part-time PhD student. In September 2006, the Institute hosted and provided supervisory support to Burkart Dieterich who undertook an MSc by research on biomass willows. In November 2007, two full-time PhD students (Fay McKenzie and Syed Shah) started studentships with the AI. Progress over the year with the current postgraduate projects is described briefly below.

Quantitative analysis of active compounds found in Arnica in relation to varied environmental, agronomic and genetic factors (Elizabeth Barron). Liz's research focuses on the plants *Arnica montana* and *A. chamissonis*, the main sources of the herbal medicine, Arnica. The increasing popularity of this medicine has led to over-harvesting of *Arnica montana* in the wild so that it has become an endangered species in many parts of Europe. As a result, there is considerable interest in growing *A. montana* and the closely related *A. chamissonis* under cultivation. Liz's research has shown that, in Orkney, *A. montana* is very prone to a fungal crown rot disease associated with *Phytophthora* and *Pythium spp* but this does not appear to infect *A. chamissonis* which also seems to be agronomically better suited to Orkney conditions. Liz completed her field trials programme in 2007 and over the year has concentrated on the chemical analysis of flower extracts from these trials and writing her thesis.

Establishment of willow (Salix spp.) for renewable fuel in Orkney. (Burkart Dieterich). With increasing interest in willow as a potential renewable wood fuel in Orkney, a willow clone trial was planted by the Institute at Muddisdale in 2006. For his MSc project, Burkart investigated the success of the planting and compared sprouting and



biomass production in the different clones in their first year. He also developed a Geographical Information Systems (GIS) model for determining the suitability of sites for planting with willow, using the island of Rousay as a case study. Burkart successfully defended his thesis in February 2008.

Investigating the potential of willow short rotation coppice as a biomass crop for the Northern Isles of Scotland (Fay McKenzie). Fay's PhD covers a wide range of topics but it has initially focused on collecting baseline survival and yield data from willow clone trials established in previous years at Orkney College, Muddisdale and Papdale. In addition, she has established a trial at Papdale investigating the need for first year cutting back and will use harvested stems from the college trial to investigate outside drying of willow rods. At Muddisdale, a new trial is being established on two-year-old stools to compare the biomass production of four different clones (Ashton Stott, Sven, Tora and Resolution) under different fertiliser regimes – none, mineral fertiliser and slurry.



Application of slurry to Fay McKenzie's willow fertiliser trial at Muddisdale.

The effects of soil types and agricultural inputs on yield, grain quality and economic returns of Bere barley in Orkney (Syed Shah). Syed's research will initially investigate the effects of selected agricultural inputs (fertiliser, growth regulator and fungicide) on growth, yield and grain quality of Bere and compare this with a modern barley variety. He will also investigate the effects of different types of growth regulator and the stage at which they are applied on the lodging and yield of Bere. Field trials to investigate these factors have been planted in 2008.

9 Staff

The following staff worked at the AI over the year:

Dr Xianmin Chang - Post Doctoral Research Assistant
 Mr Arthur Cromarty - Field Trials Officer
 Mr Ronnie Johnson - Development Officer
 Dr Peter Martin - Director
 Ms Fay McKenzie – Technician
 Dr Geoffrey Sellers - Research Fellow
 Mr John Wishart - Technician.



Agronomy Institute staff and students in 2007/8. From left to right, Syed Shah, Ronnie Johnson, Geoff Sellers Peter Martin, John Wishart, Fay McKenzie, Arthur Cromarty and Xianmin Chang.



10 Posters Produced By Agronomy Institute Staff And Students



Developing New Markets and Supply Chains for Bere

Peter Martin, John Wishart, Arthur Cromarty, Xianmin Chang and Syed Shah
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Introduction

Bere is a barley (*Hordeum vulgare* L.) landrace, possibly introduced to Britain by Norse settlers in the 9th century, and is the only British cereal landrace which has remained in commercial cultivation down to present times. It is well-adapted to growing in the north of Britain because of its rapid spring growth, short growing season and tolerance to acidic soils. In the past, Bere was an important multi-use crop in Scotland's Highlands and Islands area, providing grain for both milling and malting and straw for animal bedding and thatching. It was also exported to Northern Europe. Although several historical sources mention the importance of Bere to the early whisky industry, a major disadvantage was its low alcohol yield and most distilleries had probably ceased using it by the early part of the 20th century. By the start of the 21st century, only about 10 ha were being grown a year – mostly on Orkney, Shetland, the Outer Hebrides and Caithness. In Orkney, Bere has continued in cultivation to supply Barony Mills, a 19th century watermill, which purchases the grain and produces flour (Bere meal) for local use in bread, biscuits and bannocks (a type of scone).



Orkney Bere meal and a traditional Bere bannock



Barony Mill in Orkney



Bere (right), showing its long straw compared with that of a modern variety (Riviera, left)

The Plant

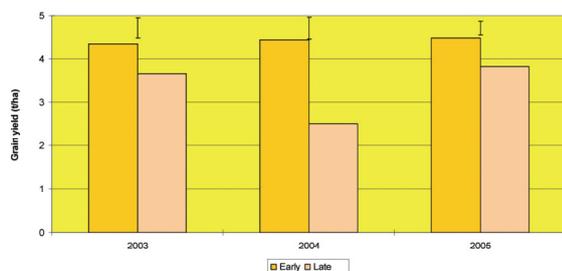
In spite of Bere's long history of cultivation, there has been very little research on it. It is a 6-row barley which was traditionally planted late in the spring and, although one of the last crops sown, it was usually the first to be harvested. As a result of its rapid growth, it has been described as a 90-day variety. Although tolerant of acidic soils, it also grows on more alkaline manganese-deficient sandy coastal soils (machair). Bere is susceptible to both powdery mildew disease (*Blumeria graminis* DC. Speer f. sp. *hordei* Marchal) and leaf stripe (*Pyrenophora graminea* Ito et Kuribayashi) and has long, weak straw making it very susceptible to lodging.

Agronomy Research And New Markets

Since 2002, the Agronomy Institute at Orkney College UHI has been researching the agronomy of Bere to improve yields and make the crop easier to grow. Simultaneously, it has also been developing new markets for the crop so that it can continue to be grown commercially in the north of Scotland.

Agronomy Research

In 2003, a survey of farmers who had grown Bere in Orkney since the 1980s showed that most had planted it at the traditional time in mid-May, used few inputs and considered the main constraints of the crop to be its low yield (2.8 to 3.8 t ha⁻¹) and susceptibility to lodging. Three years of trials in Orkney between 2003 and 2005 showed that very significant increases in grain yield (17-76%) and thousand grain weight resulted from planting Bere earlier, in the second half of April. Yields showed smaller, but often significant, increases (5-11%) from applying mineral fertiliser, growth regulator or fungicide, while combinations of growth regulator and fungicide increased yields from 10-22%. Of the treatments investigated, early planting gave the highest net profit. In spite of usually increasing grain yield, growth regulator did not always control lodging of Bere.



Grain yields of Bere from 2003 to 2005, showing the yield advantage of early planting. Bars indicate the least significant difference (P<0.05) between planting date means in each year.

New Markets

In collaboration with Highlands and Islands companies, several new markets for Bere have been developed since 2005.

Beer

To produce a beer, Bere was grown in Orkney in 2005, malted by Crisp Malt and used for product development by Valhalla Brewery in Unst, Shetland – Britain's most northerly brewery. The commercial product, "Island Bere" was launched in 2006 and has an alcohol content of 4.2%.



Island Bere – a new beer produced in Shetland using Bere from Orkney

Whisky

The Institute has collaborated with two distilleries in the Highlands and Islands which are using Bere to produce specialist whiskies. The first project was with Isle of Arran Distillers, for which Bere was grown in Orkney in 2004, malted by Bairds Malt and distilled at Lochranza in Arran in 2005. More recently, in 2007, the Institute and farmers in Orkney and Islay supplied almost 80 t of Bere to Bruichladdich distillery in Islay and will supply more in 2008. Although the production cost of Bere spirit is about twice that of spirit from modern barley varieties, Bruichladdich distillery has reported the new-make spirit to be of exceptional quality and is convinced it will mature into a unique, very high quality whisky.



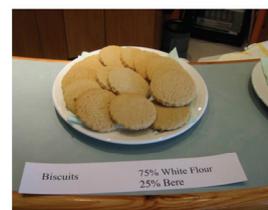
A cask of Bere spirit maturing at Lochranza distillery in Islay



Jim McEwan, Bruichladdich Distillery Production Director, tasting new-make Bere spirit in February 2008

Meal & Biscuits

Analyses carried out for the Institute by Direct Laboratories, RHM Technology and other UKAS-accredited laboratories provided the first detailed nutritional analysis of Bere meal (Theobald *et al.*, 2006). These showed that a number of minerals (particularly iodine, iron, magnesium and phosphorus) are present in significant quantities in both wholemeal and white Bere flours while a significant quantity of Zinc is present in wholemeal flour. A range of vitamins are also present in Bere flours, notably the B vitamins, thiamin, pantothenic acid and folate. High levels of fibre were also found. These results are being used to help develop new markets for Bere meal and, in Orkney, the Institute is working with the bakery company JF Groundwater to develop a range of specialist biscuits using local flours, including Bere.



Biscuits using Bere flour from Orkney

Conclusion

Although Bere is unlikely to be grown again on the scale seen in the 18th and 19th centuries, the market for Bere meal and the recent interest in the crop for specialist whisky and beer production shows that there is still a demand for it in today's world. Expansion of these markets is enabling this important landrace to continue to be grown commercially in those parts of Scotland with which it has traditionally been associated.

Reference

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SHORT ROTATION WILLOW COPPICE AS A BIOMASS ENERGY CROP IN ORKNEY

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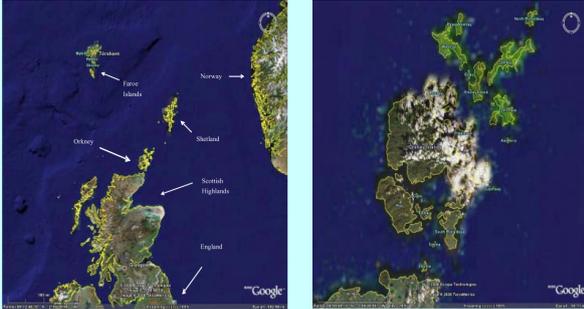
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Orkney's Location in Europe

Orkney is an archipelago of about 80 islands located off the north coast of Scotland. At 59° North, the islands are at the same latitude as southern Norway. They have a rich resource of agricultural land within a mosaic of locally, nationally and internationally designated areas for their valuable wildlife, archaeology and other interests.



Left image: Location of Orkney in the context of UK and Norway. Right image: Orkney

Short Rotation Coppice (SRC)

Coppicing is the oldest form of management for forest and woodlands dating back to 5,000 BC. It involves cutting the main stem so that the coppiced plant develops a multiple number of straight stems which have many uses. Traditional coppicing manages trees in a rotation of between 2-8 years. To produce biomass for energy, a shorter 2-5 year rotation cutting cycle is used in commercial production.



Willow planting in Orkney 2007



Two year old Willow SRC plantation

Willow SRC in Scotland

Willow clones specially bred for biomass energy have been successfully grown commercially elsewhere in the UK. However, little is known about the suitability of these clones for growth in the climatic conditions of the north of Scotland.

SRC in Orkney 2002 - 2006

In 2002, four Willow clones and one Poplar clone were selected by the Agronomy Institute, for a field trial programme on Orkney. Initial results in 2005 suggested willow could be a viable biomass crop in Orkney, but that poplar was unsuitable because of poor survival and low biomass production. In 2006, the programme was expanded to investigate 13 willow clones, the largest trial of its kind in the north of Scotland.

Willow PhD programme: 2007 onwards

The main objective is to produce a comprehensive strategy for the environmentally and economically sustainable production and use of willow woodchips in Orkney's sensitive and culturally diverse environment. Specific objectives are:

- Identify suitable areas of land on which to grow willow
- Identification of the most appropriate planting and harvesting techniques for Orkney
- Economic evaluation of biomass production in Orkney
- Identifying potential markets for wood fuel in Orkney and barriers to further expansion
- Investigation into the environmental impact of willow on Orkney



Orkney's Neolithic landscape, the standing stones of Stenness within the World Heritage Site

Willow in the Orkney environment

Many parts of Orkney are treeless due to adverse environmental conditions, particularly frequent strong to gale force salt laden winds. Other factors which limit tree growth in Orkney are:

- Low spring temperatures
- High annual rainfall (900-1000 mm)
- Waterlogged soils
- Short cool growing season

In spite of these conditions, willows are among the most common of Orkney's native trees.



Shaggy Inkcaps in Orkney grown Willow SRC crop



Grey willow Hobbister, Orkney

The potential for Willow SRC in Orkney

Despite the challenges, Willow SRC has the potential to provide Orkney with reliable, renewable heating fuel. Development of willow as a biomass crop may assist agricultural diversification, rural employment and the potential to increase farmland biodiversity. In areas of such high environmental and cultural importance, conservation, farming, tourism and wider economy are intertwined. Therefore, a holistic strategy is needed to sustain willow SRC as a biomass crop in Orkney.





RECENT DEVELOPMENTS WITH BERE IN ORKNEY



Agronomy Institute Research On Bere

Bere is a very old type of barley which has been grown in the north of Britain for hundreds, or possibly thousands, of years. It has long been associated with Orkney which is one of the last places where it is still grown commercially. Unlike modern barley varieties which are grown for malting or animal feed, Bere has traditionally been milled into a flour which is still used in Orkney to produce a number of specialist bakery products. Since opening in 2002, the Agronomy Institute (AI) at Orkney College has given a high priority to reviving interest in this unique crop and has developed a research programme focusing on two areas:

- Improving knowledge about growing it (agronomy research).
- Investigating the quality characteristics of Bere and identifying new commercial opportunities for the crop (commercial research).

Characteristics Of Bere

Bere has the following characteristics:

- It is a landrace which has resulted from farmers growing, harvesting and selecting the best seed from the crop over hundreds or thousands of years.
- It is a 6-row barley which means that the grains are arranged in 6 rows down the ear – in most modern barleys the grains are arranged in only two rows down the ear.
- It is a spring barley - it is sown and planted in the same year.
- It tolerates acidic soils which are unsuitable for most modern barley varieties
- It grows very rapidly in the late spring / early summer, making it particularly well-suited to the short growing season of northern areas.
- Its yields are low - about half that of modern varieties - but it does not require as many inputs (e.g. fertiliser).
- It has long but weak straw so that it often lodges (falls over) close to harvest.



Ears of barley showing the difference between a modern two-row barley (2r) and Bere (6r). (Courtesy of R Jarman, NIAB)



Modern barley varieties (left) have short straw. Bere (right) has long straw, typical of most varieties grown before the 20th century.

Agronomy Research

When the AI started research on Bere in 2002, there was very little information available about the response of the crop to modern agricultural practices as very little scientific research had ever been done on Bere.

As a first step in learning more about the crop, the AI interviewed a number of people in Orkney who had grown it in recent years. This showed that:

- The traditional sowing date for the crop was mid-May.
- The seed rate used was between 140 and 190 kg/ha.
- Apart from herbicide, very few agro-chemicals were used and only low levels of fertiliser.
- Low grain yields of about 2.5-3.5 t/ha were usually obtained.
- The main problems in growing the crop were low yields, lodging and the awns ("skegs") which made the crop unpleasant to handle.



Lodging of Bere (foreground). The dark, rectangular area in the middle is a plot where the Bere has not lodged due to the application of a growth regulator.

The research programme developed by the AI since 2002 has sought to address these problems and to identify other factors which might be restricting Bere yields. In particular, the effects on yield of the following are being investigated:

- Different planting dates.
- Growth regulators to prevent lodging
- Fungicides to control leaf diseases
- Different levels of fertiliser

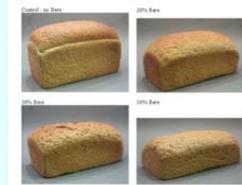


Planting date has a marked effect on the development of Bere. The plot on the left was planted mid-May while that on the right was planted in mid-April.

Commercial Research – Nutritional & Baking Properties

With funding from the Highlands & Islands Enterprise Research Challenge Fund, the AI has investigated the nutritional and baking properties of Bere flour in collaboration with RHM and the British Nutrition Foundation. This has shown that Bere flour is high in fibre and contains significant quantities of several minerals (e.g. iodine, iron, magnesium, zinc and phosphorus) and a range of vitamins (particularly the B vitamins, thiamine, pantothenic acid and folate).

Studies of the bread-making properties of Bere flour showed that loaf height and volume decreased as the proportion of Bere increased and that 10-20% Bere flour gave the most acceptable loaves for texture, crumb colour, taste and smell.



The above picture shows the effect on loaf height of using different proportions of Bere and wheat flour.

The above information on the nutritional and baking properties of Bere flour will be important in developing new markets for it.

Commercial Research – New Products

New commercial products containing Bere are being investigated with funding from the Leader+ programme in collaboration with Highlands and Islands companies. The first of these products, Island Bere, a beer which has been developed with Valhalla brewery in Shetland is now on sale. Other products being developed include a flavoured Bere water and a whisky.



Cask of Bere whisky maturing in a Distillery warehouse.



Island Bere – a new beer produced in Shetland using Bere from Orkney

Outlook

Although Bere is unlikely to return again to mainstream agriculture, the recent development of new commercial products will help to increase demand for the crop and provide an incentive for dedicated farmers in the north of Scotland to continue to grow it. In this way, Bere will continue to be a living component in our agricultural landscape – a reminder of our debt to the hard work and skills of previous generations of farmers.

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11 Acknowledgements

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