

AGRONOMY INSTITUTE

- For Northern Temperate Crop Research -

ANNUAL REPORT

2006-2007



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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 2006 to March 2007. The year was a very important one for the Institute as it saw a major expansion of both staff and infrastructure 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). The year also saw the Institute being successfully validated for postgraduate research students by the University of Aberdeen, the launch of Island Bere (the first new commercial product involving the Institute) and commercial scale planting of biomass willow in Orkney. Over the year, the AI also continued its on-going programme of field trials and research projects and 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 is particularly important and over the year the AI actively engaged with the following:

- *Research Organisations:* ADAS, British Nutrition Foundation, Central Science Laboratory (CSL), Inverness College, National Non-Food Crops Centre, Scottish Agricultural College (SAC), Scottish Agricultural Science Agency (SASA), Scottish Natural Heritage (SNH), The Macaulay Institute, University of Reading, University of Aberdeen.
- *Commercial Companies:* Alliance Boots, Alzeim Ltd., Bruichladdich Distillery, Crantit Dairy, JF Groundwater Baker and Greengrocer, Highland Birchwoods, Highland Natural Products Ltd., Isle of Arran Distillers, Orkney Housing Association Ltd., Valhalla Brewery.
- *Growers, Growers' Groups and Trusts:* Birsay Trust, Dunlossit Estate, Orkney Bere farmers, Crofters Commission, Sanday Development Trust, Scottish Crofting Foundation, Shetland Bere and Aets Living Heritage Project, Orkney Renewable Energy Forum (OREF), Scottish Rural Property and Business Association, Tiree Rural Development Ltd., Willow Energy Group for Orkney (WEGO).

The AI held a well attended open day at the College in July 2006 and during the year was visited by a number of visitors and groups including a delegation from the Department of Agriculture, Fisheries & Forestry of the Isle of Man.

In addition, presentations about aspects of the AI research programme were made to the following:

- CIFAL Findhorn sustainable energy study group; Eat Well Orkney delegates; HiLinks seminar invitees; NFU Woodfuel & Farming focus group; Orkney Science Festival; Scottish Crofting Foundation; The Schroder Trust.

AI staff were also invited to present posters or papers at the Biomass for Energy Conference at Bruges in 2006, a meeting on Incorporating The Ecosystem Approach In The Conservation Of Biodiversity at the Royal Botanic Garden Edinburgh and the All-Energy Conference in Aberdeen in 2007.

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 and biomass willows. As a direct result of AI activities, the first commercial planting in Orkney of biomass willows as a renewable wood fuel took place in 2006 and 23 ha of Bere, a barley landrace, is being grown in 2007 for new commercial markets.
- Highlands and Islands SMEs are also starting to benefit 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 has also started with Highland Natural Products while in Orkney, locally grown oats and wheat have been ground into flour by Barony Mills and are



Jim Logan of Dunlossit Estate on Islay inspecting a field of Bere being grown, with assistance from the Agronomy Institute, for Bruichladdich Distillery.



being used in 2007 by local bakery companies. The Institute has also supplied wood chips from willow short rotation coppice to Orkney Housing Association Ltd (OHAL) to test its suitability as a heating fuel and a range of salad and culinary herbs are being produced for sale to a local wholesaler.

- 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), Highland Natural Products (Invernesshire) and Dunlossit Estates (Islay) that the Institute's research activities are benefiting other parts of the Highlands & Islands.

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 having a large impact on the AI. Through ARC, the AI was able to make the following staff appointments in 2006: Dr Geoff Sellers (Research Fellow), Dr Xianmin Chang (Post Doctoral Research Assistant), Mr John Wishart (Technician, 0.5 FTE) and Ms Fay McKenzie (Technician, 0.5 FTE). ARC funding will also support equipment purchases and three PhD bursaries to start in 2007. SRIF funding was used over the year to renovate and equip laboratory and office facilities and to construct a grain and equipment store at Weyland Farm.



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

6 Plant Research Themes And Trials Programme

As a result of annual reviews of the market for novel crops, the AI has identified several research themes on which it is concentrating and within each theme, a list of potential crops for investigation has been drawn up. Since most of these plants have no history of cultivation in Orkney, plant performance is usually first monitored in small observation plots and, subsequently, the most promising species are taken on to larger scale field and on-farm trials. In the following sections, brief descriptions are given of the main plant research themes and the plants within each theme which were grown in observation blocks or trials at Orkney College during 2006/7.

6.1 Specialist Cereals

Under this theme, the Institute is investigating both modern and heritage varieties which are suited to the Highlands and Islands (H&I). They are mainly being considered for specialist bakery and drinks products. Heritage varieties are of 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, advances in plant breeding have produced many modern varieties, some of which may also be suited to the H&I and a few of these are also being grown. The main crops under investigation in this theme during 2006 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 2006, formal replicated trials continued to investigate the effects of inputs like fertiliser, growth regulator and fungicide on yield. In 2007, supply chains for Bere are being developed for supplying the grain for niche beer and whisky markets (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. In 2006, small plots of six spring varieties (*T. aestivum*) were grown for an EU project (see TRACE in Section 7) and about 0.5 ha were grown of each of the varieties Paragon and Anniina. Although the yield of the Finnish variety Anniina was lower than that of Paragon (4.5 t/ha compared with 5.4 t/ha), it had the big advantage of being ready for harvesting about three weeks earlier than Paragon. Flour from Anniina has been produced by Barony Mills and is being tested in 2007 by local bakery companies. Small quantities of Emmer wheat (*T. dicoccoides*) and Spelt (*T. spelta*) are also being grown in 2007.



Spring Wheat. The Finnish variety Anniina (right) and UK variety Paragon (left) in August 2006. Both varieties were sown at the same time but Anniina was ready for harvesting about 3 weeks earlier than Paragon,

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

During 2006, the AI maintained its seed stock of Black oats (*Avena strigosa*) and the old variety Murkle (*A. sativa*). The modern varieties Fiia and Winston were also grown successfully. Although Winston outyielded the Finnish variety Fiia (5.7 t/ha compared with 4.5 t/ha), Fiia had the advantage of being harvested four weeks before Winston.

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 2006, monitoring of existing plots continued (Cranberry, *Vaccinium macrocarpon*; Juneberry, *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. pensylvanicum*) and Half-high hybrids; Elder, *Sambucus nigra* and *S. racemosa*). Additional plots were established of two varieties of Chokeberry (Viking and Nero) and 7 of Saskatoon (*Amelanchier alnifolia*; Lee#3, Lee#8, Nelson, Martin, Smokey, Success and Regent). Amongst the established berry crops, the best production has come from All Fieldberry, Cranberry and Chokeberry.

6.3 Biomass And Biofuel Crops

There is broad 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 renewable fuels like biodiesel and bioethanol to replace fossil transport fuels. Biomass and biofuel crops have the added attraction of providing farmers with a new crop diversification opportunity. In Orkney, there is already a market for biomass since Orkney Housing Association Ltd (OHAL) has installed a wood-fired boiler, supplying heat to its Lynn Road housing scheme.



Building on promising results from small-scale willow trials between 2002 and 2005, the Institute and two local growers contracted Coppice Resources Ltd in May 2006 to plant 10 ha of willow as short rotation coppice (SRC) in Orkney. Of this, 2.5 ha were planted for the Institute to establish a cutting cycle and clone trial at Muddisdale containing 13 new willow clones. The Institute also made a presentation summarising its research results with SRC at the 2006 Orkney Science Festival and this was followed by a discussion session where interested individuals and organisations agreed to form a local stakeholder group to promote the development of SRC in Orkney. The new group is called the Willow Energy Group for Orkney (WEGO) and is chaired by Dr Geoff Sellers from the Institute who now leads the Institute's research on biomass and liquid biofuels. An early success for WEGO was to obtain funding from the Forestry Commission and Highlands & Islands Community Energy Company for an economic study of growing SRC in Orkney which will be carried out by the Scottish Agricultural College. The Institute is also developing international links in willow R&D and is involved in preparing two Northern Peripheries Programme (NPP) project proposals which will benefit the development of willow and other energy crops in Orkney.



Burkart Dieterich, an MSc student with the Institute, standing amongst some of willow planted at Muddisdale at the end of its first growing season.

Since September 2006, Burkart Dieterich has been studying for an MSc by research at the Institute and his work is summarised in Section 8.

Copies of posters describing some of the Institute's research on willows and some of the results from Burkart's studies of a clone trial at Muddisdale are presented on pages 10 and 11.

The AI continued research into biofuels crops by planting 1.0 ha of spring oil seed rape (*Brassica napus* 'Landmark') which yielded 2.2 t/ha. Although winter crops generally suffer badly from wind, salt damage and soil water-logging over an Orkney winter, a 1 ha trial area of winter oil seed rape ("Lioness") planted in August 2005 survived and yielded 2.4 t/ha when harvested in 2006.



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.

6.4 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*) 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.

A new project within this theme, investigating plants as a potential source of skincare products, is described in Section 7.



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. Institute research in this area is being led by Dr Xianmin Chang and is initially concentrating on investigating the production of culinary herbs and salad plants, particularly in identifying the range of species and varieties which can be grown and the potential for extending cropping beyond the main summer months. Interest in these plants has grown as more people become exposed to exotic foods and appreciate the exciting flavours and attractive colours these plants can add to meals. Local production also has the advantage of considerably reducing the carbon footprint of these products. Research into the local market for these crops is being conducted in collaboration with the local wholesaler, James Wilson (Orkney) Ltd.



The Institute started research into growing culinary herbs and salad plants under polythene during 2006.

6.6 On-Farm Protein Crops

With the increasing price of transporting bought-in animal feed, a growing number of farmers in the Highlands and Islands are interested in producing their own protein crops. These are normally leguminous crops which host bacteria in their roots which fix nitrogen. After harvest, the nitrogen is released into the soil, benefiting following crops. In previous years the Institute has grown narrow-leaved lupin (*Lupinus angustifolius*), field beans (*Vicia faba*) and peas (*Pisum sativum*) with varying success. With the development of its research into oil seed rape as a source of biodiesel, the Institute is also considering the use of the rapeseed meal by-product as a high protein feed.

7 Funded Projects

Funded projects are vital to the Institute as a means of generating income to cover costs. During the year, staff were involved in the following funded projects:

Development Of Commercial Products From Bere (Leader+)

This research involves three separate projects funded by the Leader+ programme. Each project involves collaboration between the Agronomy Institute and a Highlands and Islands SME to develop a new commercial product using Bere. The aims of these projects are to develop new commercial products for the SMEs and to increase the demand for Bere so that more farmers can grow the crop. The projects are described briefly below:

- Bere whisky. Bere grown in Orkney was malted by Bairds Malt and this was used for distillation by Isle of Arran Distillers in September 2004. The spirit is now maturing in cask and is reported to be maturing very well.
- Bere beer and malt. A Bere malt was produced by Crisp Malting Group in 2005 and supplied to Valhalla Brewery in Unst, Shetland. A new beer, Island Bere, was launched in May 2006 and is commercially available.



Island Bere, a beer made from Bere malt and developed in collaboration with Valhalla Brewery in Shetland. This was released on the market in 2006.



- Bere water. A lemon-flavoured Bere water is being developed in Orkney by Crantit Dairy which it is intended to release during 2007.

Within the project, research is also being conducted on the heritage aspects of Bere. A copy of a poster produced about Bere and provided to Barony Mills within the project can be seen on page 13. Another output has been a study of historic whisky production in Orkney and copies of a leaflet summarising this were distributed to several of the main tourist centres in Orkney.

Development Of A Supply Chain For Bere Whisky

This is a project involving 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 Bere can be produced on the two islands and supplied to the distillery to make specialist whiskies. For the project Bere will be grown in different locations on both islands and this will provide useful information on the growth of Bere under different soil conditions. The target is to plant 20 ha of Bere on the two islands in 2007 and 40 ha in 2008.



Graham Bichan of Crantit Dairy pouring ingredients into a vat for the production of a flavoured Bere water.

Development Of Skincare Products From Scottish Plants

This is a feasibility study funded by the Hi-Links programme and involving collaboration between the AI, Highland Natural Products Ltd (HNP) and the Boots Company Plc. Within the project, several plant species with a strong Scottish connection and potentially useful chemical profile have been selected and are being grown on a small scale by the AI in Orkney. Fresh material will be provided to the other partners for detailed chemical analysis later in 2007.



Amongst the crops grown in the biodiversity trial, flowers of *Echium plantagineum* (above) were very attractive to bees and bumblebees.

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 have been 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 are being grown in 12 x 30 m plots: *Camelina* (*Camelina sativa*), borage (*Borago officinalis*), *Echium* (*Echium plantagineum*), turnip rape (*Brassica rapa*) and Bere barley (*Hordeum vulgare*). An adjacent area of improved grassland has been selected at each site as a control plot and several indicators of biodiversity are being monitored to compare the alternative crops with the control plots. These include 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.

In the first year of the trial, insect biodiversity was particularly high at both the Orkney College and Sanday site in plots of

turnip rape and borage. The *Echium* and borage were very attractive to bees and bumblebees. Most of the alternative crops supported a more diverse insect life than the grassland. In Sanday, the plots of alternative crops were visited by a range of bird species until late February but the college site was less attractive to birds. The trial is being monitored for a second year during 2007.

TRACE

This is an EU project to develop traceability systems for meats, cereals, honey and mineral water. The AI contributed to this project during 2005 and 2006 by growing different varieties of spring wheat and providing



samples to the project. During the growing season, water and soil samples were also collected. The AI used the wheat which was grown for the project to investigate the possibility of producing a local flour in collaboration with Barony Mills. Bakery products are being made with this flour by the local bakery firms JF Groundwater and Argos.



Arnica trials established by Liz Barron for her PhD studies. The light coloured strips are a mulch of wood shavings.

8 Postgraduate Research

This is a new section for inclusion in the AI's annual report and reflects the growing importance of this area to the Institute. Since 2004, the Institute has been involved in supervising and supporting the field work on Arnica of Elizabeth Barron, a part-time PhD student registered with the Open University. In September 2006, the Institute hosted and provided supervisory support to Burkart Dieterich who is undertaking an MSc by research on biomass willows. An important step in increasing the Institute's postgraduate research capacity was the successful validation of the Institute for postgraduate research degrees by a joint

UHI-University of Aberdeen team during 2007. This is in preparation for the Institute hosting and supervising three full-time PhD students later in 2007. 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 has been doing a part-time PhD with the Institute since 2004 and her 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 have been several attempts to grow *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.* This does not appear to infect *A. chamissonis* which also seems to be agronomically better suited to Orkney conditions. Liz's studies include a detailed comparison of the chemical compounds in the two species of *Arnica*.

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 (see Section 6.3). For his MSc project, Burkart has been investigating the success of the planting and comparing sprouting and biomass production in the different clones in their first year. His project is also developing 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.



Agronomy Institute staff in 2006. From left to right, Xianmin Chang, Fay McKenzie, John Wishart, Geoff Sellers, Arthur Cromarty, Peter Martin and Ronnie Johnson.

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.



SHORT ROTATION COPPICE: A POTENTIAL BIOMASS CROP FOR THE HIGHLANDS AND ISLANDS OF SCOTLAND

Peter Martin, Geoff Sellers and John Wishart

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Orkney's Location in Europe

The Orkney islands are located just off the north coast of Scotland and include the largest island, known as the "Mainland", and 13 other smaller islands. 59°59' North; the islands are at the same latitude as the south of Britain.



Introduction

- The Highlands and Islands are very dependent on fossil fuels, especially oil, for heating and power. With the negative environmental impacts and rapidly increasing costs that this brings, it is vital that the Highlands and Islands diversify and utilise the region's considerable renewable potential, including developing biomass resources.
- Within the region, wood fuel forestry residues and wastes are starting to be used as a heating fuel.
- Orkney Housing Association has installed a wood-chipped heating system for a 40-bedding development.
- Orkney has negligible forest resources, but considerable agricultural land, so Short Rotation Coppice (SRC) was considered a more appropriate option upon which to build a sustainable wood chip supply chain.
- Developing SRC would also assist agricultural diversification and rural employment.
- Research on SRC is well documented for much of the U.K. However, there is little information on growing SRC in challenging environments like Orkney's.
- Since 2002, the Agronomy Institute has investigated the viability of growing SRC on Orkney. However, if SRC is to succeed, a reliable supply chain also has to be established in which growers can be sure of a market and end-users can rely on a consistent supply.

The supply chain involved when Short Rotation Coppice (SRC) is used to produce bio-renewable energy



The Challenge of Growing SRC on Orkney

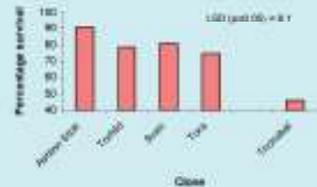
- Soil waterlogging is severe.
- Strong winds often carry wet silt, which can be injurious to plants.
- Equipment for planting and harvesting has to be imported from further afield.
- A working machine (lawnmower with rotavator and water) but diesel, used growing system.

Experimental Objectives and Methodology

- In 2002 a trial to investigate the growth and biomass production of willow and poplar was established.
- Four willow clones included: Autumn Gold, Snow, Tara and Turkel.
- One poplar clone: Trichelid.
- Randomised complete block design consisting of five replicates.
- Plants were cut back in March 2003.
- Biomass production was determined by harvesting two year-old willow and poplar stems in 2005.

Percentage Survival After Cut Back in March 2003

- Percentage survival of Autumn Gold was significantly greater than the other willow clones.
- Percentage survival of the poplar clone, Trichelid was significantly lower than the willow clones.



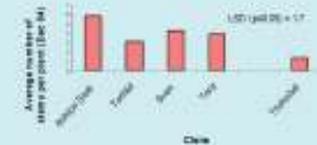
Wind Damage

- In 2003, some wilting, due to the wind, was observed in all clones.
- In the third year of growth, height increase was small in all clones as a result of wind damage.



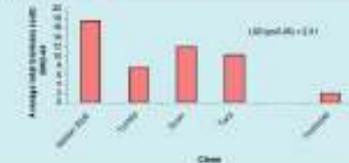
Number of Stems per Plant

- Autumn Gold produced significantly more stems than Trichelid and Tara.
- Trichelid produced significantly fewer stems than the willow clones.



Biomass Production

- Willow biomass production was significantly greater in Autumn Gold than in the other willow clones.
- Amongst the willow clones, Turkel had the lowest biomass yield but this was still significantly greater than that of the poplar clone, Trichelid.



Conclusions

- Willow could form a viable crop for the Highlands and Islands, offering a useful diversification of land use, provided the whole supply chain can be set up, including a range of end-users.
- Autumn Gold produced the best biomass yields.
- These results suggest that poplar is not a suitable biomass crop on Orkney.
- All clones suffered some wind damage, especially in the third year, which suggests that a 3-year cutting cycle may be more suitable than the usual 5.5 year cutting cycle.
- As a result of encouraging results from the trial, the first commercial growers planted willow on Orkney in 2006.
- Now, larger scale research trials were planted in 2006 to investigate growth and biomass production by a larger number of clones (170 to date) in a wider range suited to the Orkney environment. Trials are different lengths of harvesting cycle have also commenced.

Comparison of 13 Willow (*Salix* sp.) Clones for Bioenergy on Orkney

Burkart Dieterich^{1,2}, Peter Martin¹, Geoff Sellers¹, Melanie Smith³, Ken Boyd², Jim Chalmers¹

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2, Environmental Research Institute, North Highland College, Thurso, Scotland.

3, Inverness College, Scotland.

Introduction

The production of biomass from short rotation coppice (SRC) involves fast-growing trees like willows at dense spacing of about 15,000 plants / ha. Coppicing is the practice of cutting back the trees after the first growing season to encourage the development of multiple stems. The aerial biomass can then be harvested regularly, typically every three years for up to 30 years.

In May 2006, the Agronomy Institute established a field trial at Muddsdale, Kirkwall, in order to establish which clones perform best under the demanding maritime conditions on Orkney with high winds and salt spray. The trial consists of 13 different clones replicated four times. Stem cuttings were planted by an Egedal Energy Planter from Denmark.



Location

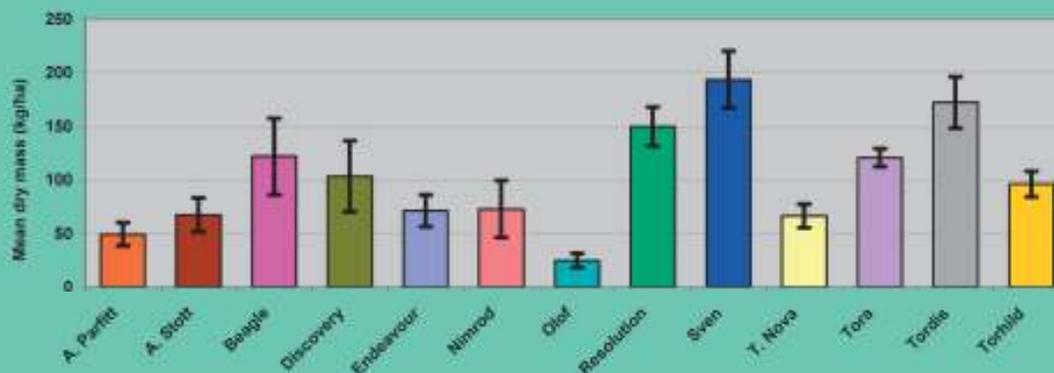
Orkney consists of a group of islands of which around 20 are occupied. The archipelago lies about ten miles off the north coast of Scotland. The largest island is known as the Mainland (in the right-hand picture), where the capital Kirkwall is located.



Materials and methods

- Sample plots encompassing forty planting points were established within the clone plots.
- On four days between 16 February and 2 March 2007 all the plants from the sample plots were cut at about 5 cm above ground.
- The stems were transported to the Agronomy Lab, where a fresh weight was taken for each sample.
- A representative subsample consisting of at least 20% of the fresh weight was dried at 100°C for at least 96 h.
- Dry weights obtained were scaled up based on the assumption of a density of 15,000 plants per ha.
- Data were analysed by ANOVA ($p < 0.05$).

Results



Mean yields varied considerably between clones (22.4 – 183.7 kg/ha). Sven, the highest-yielding clone, produced significantly ($p < 0.05$) more biomass than any other clone except Tordis and Resolution. Bars display standard errors of the mean for each clone.

Conclusions

It remains to be seen whether the observed differences between clones persist over the whole cutting cycle. The poor vitality observed in the field of some of the weaker clones, like Olof, Ashton Parfitt and Ashton Stott, makes it appear doubtful whether they will be able to catch up. However, clonal performance may in part also reflect differences in the quality of the planting stock.



EFFECTS OF ALTERNATIVE CROPS ON BIODIVERSITY IN ORKNEY

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Orkney's Location in Europe

The Orkney Islands are an archipelago of about 50 islands located just off the north coast of Scotland and include the largest island, known as 'Mainland', and 13 other inhabited islands. At 59° North, the islands are at the same latitude as the south of Norway.



Introduction

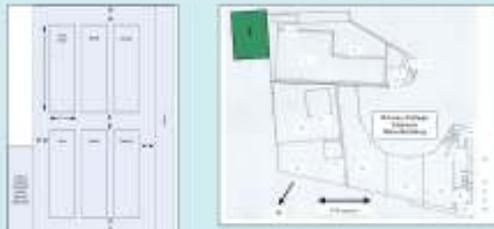
In April 2005, two D6 trial plots were established on Orkney, one at Orkney College on the mainland and one at Nearhouse on the island of Sanday. Nine crop treatments were chosen:

- Bare barley (*Hordeum vulgare*)
- Turnip rape (*Brassica napus*)
- Borage (*Boerhaavia officinalis*)
- Echium (*Echium plantagineum*)
- Carnation (*Caryophyllus*)
- Mix of crop recommended for wild birds: Oats (*Avena sativa*), Keeper kale (*Brassica oleracea* ssp. *capitata*), Mustard (*Sinapis alba*), Linseed (*Linum catharticum*), Phacelia (*Phacelia tanacetifolia*), Quinoa (*Chenopodium quinoa*)
- A winter (*Salix virens*) wind break
- Uncropped heathland surrounding the alternative crops
- Adjacent improved grassland

Biodiversity at each trial site was assessed by gathering information on the following:

- Invertebrates: insects, bumble bees, moths, etc
- Non-crop flowering plants
- Birds and mammals

Map (right) showing location of the Agronomy Institute biodiversity trial (1) and other experimental plots at Orkney College and plot (2) of the biodiversity trial.



Preliminary results

Invertebrates: insects, bumble bees, moths, etc

Investigation found there were 90 species of invertebrates including:

- Great yellow bumblebee (*Bombus distinguendus*)
- Heath garden bee (*Bombus muscorum*)

Crops preferred by these species were:

- Turnip rape (*Brassica napus*)
- Echium (*Echium plantagineum*)
- Borage (*Boerhaavia officinalis*)
- Wild bird crop



Great yellow bumblebee on Echium

This initial study showed that turnip rape, borage and wild bird cover crop ranked highest for biodiversity at both sites while Echium, bare grassland and Carnation ranked lowest at both sites. The other habitats held intermediate positions. The low ranking of the Echium, in spite of its attraction to bees, resulted from the very few insects, which were caught.

Preliminary Results: Plants

At both sites non-crop flowering plants were most diverse on the heathland and amongst the more open broad-leaved crops (especially turnip rape, borage and Echium).

The most common species found were:

- Creeping Buttercup (*Ranunculus repens*)
- Common dock (*Rumex acetosa*)
- Broad-leaf dock (*Rumex obtusifolius*)
- Dandelion (*Taraxacum* spp.)
- Ribwort plantain (*Plantago lanceolata*)

Species of interest included:

- Corn Spurrey (*Spergula arvensis*)
- Purple-ramping lambwort (*Festuca purpurea*)



Purple-ramping lambwort

Red dock list: UK BAP priority species

Most crop plants in the trial flowered in July and August. However, potentially valuable plants for earlier flowering were turnip rape and mustard (in the wild bird mix) while late flowering crop plants included borage, linseed and Phacelia flowering into September and Echium into October.



Biodiversity trial plot and alternative crops at the Agronomy Institute, Kirkwall, Orkney

Preliminary Results: Birds and mammals

Investigation found over 20 species of birds on the plots including:

- Linnets
- Swallows
- Rock doves
- Skylarks

Although birds tended to move freely between the different plots, there was a suggestion from the observations at Nearhouse that borage and Echium were particularly attractive for the following species:

- Chaffinches
- Skylarks
- Linnets
- Redwing

No mammals were recorded on the trials.



Birds feeding in alternative crops at biodiversity trials at Nearhouse, Sanday, Orkney

Initial conclusions

The present study indicates a number of alternative crops can have a marked effect on increasing biodiversity.

- Alternative crops can make a very positive contribution to protecting weed biodiversity compared with improved grassland.
- The more open crops and heathlands also had a more diverse weed flora than improved grassland.
- At the Sanday site, in particular, the unweeded crops, particularly borage and Echium, attracted a range of seed-eating birds through the winter, indicating that some of these could be a useful addition to wild bird cover crop mixes.

Acknowledgements

We thank the Crofters Commission and Scottish Natural Heritage for funding the project and the help and support given to the research by Arthur Connolly, John Crossley, Rod Thorne, Drew Thompson, Sylvia Thorne, Jim Williams, Dick Mathon, Sydney Gault, Roy Hartley and Katy Beaton.





A SHORT HISTORY OF BERE BARLEY IN ORKNEY



Introduction

Bere is a very old type of barley (*Hordeum vulgare*) which was once widely grown in the more northern parts of Britain and which is still grown on a small scale in a few parts of the Highlands and Islands of Scotland, particularly Orkney. Most modern barley is grown for malting or animal feed but Bere is unique amongst barley in the UK in being grown for milling and, in Orkney, Bere meal (flour) is still used in a range of bakery products like bread, biscuits and bannocks. Although the market for Bere is now small, numerous historical accounts show that it once played a major role in the economy of Orkney and probably most of the Highlands and Islands of Scotland.



Bere in Orkney

Uncertain Origins

Barley was one of the earliest crops domesticated in the Near East (c. 8,000 BC) and was probably the first cereal to be grown in Britain (c. 3,000 BC). The origins of Bere are obscure and it is not clear when or where the crop was first grown. Historical accounts often refer to Bere as "Bygge" or "Big" which probably originated from "Bygg", the Old Norse for barley. It has, therefore, been suggested that Bere, or an earlier form of it, may have been introduced to Orkney by the Vikings. A considerably earlier origin is also possible, however, as grains of a similar type of barley were found at Unstan in Orkney dating from about 3,000 BC.



Bere flour and bannocks with capital letters in Bere barley

Different Types

One of the earliest written reference to Bere comes from Fitzherbert writing in 1523 who described it as having "small comes and little flour". Bere was also referred to as "Scots Bere" or simply "corn" and by the end of the 18th century several different types were recognised – "Black Bere", "Victoria Bere", "Buchan Bere" and "Winter White Bere". How these are related to today's Bere, is not known, however.

A Versatile Crop And Strong Orkney Association

Bere has been intimately associated with the Orkney Islands and its agriculture for hundreds, possibly thousands, of years. Bere was a versatile crop which provided meal for baking, malt for brewing and distilling, straw for animal bedding and thatching and was used for paying land rents. It was also a valuable

commodity for an important export trade.

Grown On The Best Land – 17th Century Famines

In Scotland, prior to the enclosure of land and the improvements in farming of the 18th and 19th centuries, the best agricultural land was the fertile area, or infield, closest to settlements. It is a reflection of the importance of Bere that historical Orkney accounts refer to it being grown on the best infield land which was carefully prepared for the coming season's crop. For example, the diaries from 1766 to 1786 of Patrick Fee who farmed at Stove on Sanday indicate that at least 35-40 days a year were set aside for the collection of seaweed and the distribution of it onto the infield land as manure and as many as 28 men and 20-30 horses were employed in the operation. A large labour force was also needed at harvesting time for scything, banding into sheaves and building these into stooks, stacks or srows.



18th Century sheaves of Bere, with the word 'Bere' on the side.

The success of the crop was very dependent on weather and a poor season (approximately, one year in three) could result in serious grain shortages. In some years this meant a lack of the staple food, barley bread, but during the Little Ice Age of the 17th Century, there were several years when crop failure resulted in severe famine and the death of thousands in Orkney.



Orkney landscape with Bere barley in the foreground.

Bere Meal And Malt

While land rents in Orkney were often paid with Bere grain or malt, both also had important domestic uses. Grain was ground into meal which was mainly used for making barley bread, a staple for the poorer people, or bannocks. Milling was either done at home using small hand mills or querns or at larger water mills – there were 28 of these on

mainland Orkney at the start of the 17th century. Malt would have been made into ale and even in the 18th century, visitors to Orkney remarked on the quality of its ale. A tradition of using Bere for making homebrew has survived in a few Orkney households down to the present. Bere malt would also have been used for whisky production which became more common in Scotland from about the 17th century. The first legal, large-scale distilleries in Orkney were built at the start of the 1900s.

Bere Straw

Bere straw was not only used for animal bedding but also for thatching and for making the straw ropes or "simmens" which held the thatch in place. It would probably also have been used for basketry.

An Export Crop

Bere was an important Orkney export crop and was shipped as grain or meal to Shetland, other parts of Scotland, Norway and Germany. It was a profitable but risky trade, however, subject to the vagaries of the size of the Orkney harvest, spoilage or loss during the voyage and competition at the port of sale. Bere exports peaked between about 1790 and 1820.

Decline Of Bere

It is likely that Bere remained the most important cereal crop in much of the Highlands and Islands until the 19th Century. From then, like most old types of cereal, it was gradually displaced by the appearance of higher yielding varieties with short straw which were better suited to mechanised agriculture. In Orkney this coincided with a change in farming from grain production to grass as the beef industry developed from about the middle of the 1800s. By the end of the 20th century, only about 18 ha of Bere were being grown in Orkney, Shetland and Caithness.



The Millstream in Orkney



19th Century Orkney with Bere, showing the typical stone buildings and a small landscape view.

Survival Of Bere

The survival of the crop in cultivation is largely thanks to the dedication of a few interested growers and, in Orkney, to the commercial outlet for Bere meal provided

by Barony Mills. Since 2002, the Agronomy Institute has been doing research into growing Bere under modern farming conditions and is also working with commercial companies to develop new products using the crop so that it will continue to be grown on Orkney farms.

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INSTITUTE

11 Acknowledgements

The Institute has been very fortunate in receiving assistance from a large number of people and organisations in the past year. While it is not possible to acknowledge everyone, we are especially grateful to the following:

Advisory Board Members: Cliff Bichan, Graham Bichan, Richard Constanduros, Jim Foubister, Andy Geddes, Simon Meason, Bill Ross, Peter Scott, Kerr Walker, Alan Younie

Alzeim Ltd. Trevor Walker

Barony Mill & Birsay Trust: Rae Phillips, Johnny Johnston, Keith Johnson

Bere Malt: Crisp Malting Group, Andrew Howard

Bruichladdich Distillery: Mark Reynier

Crantit Dairy: Denis and Graham Bichan

Crofters' Commission: Jane Thomas;

Growers: Dunlossit Estate; John and Jimmy Brown; John Corrigan; Magnus Spence

HIE: Calum Davidson, Laura Dingwall, Stephen Graham, Jeff Howarth, Bob Kass

Highland Natural Products Ltd: Richard Constanduros

Inverness & Nairn Enterprise: Richard Myers

Isle Of Arran Distillers Ltd: Gordon Mitchell

JF Groundwater, Baker & Greengrocer: Paul Groundwater

Macaulay Institute: Barry Thornton

Machinery: David Harper (Avon Engineering)

Meteorological Data: Keith Johnson

National Institute of Agricultural Botany: Bob Jarman

Photographs: Laura Cromarty, John Wishart

Plant Materials: Richard Shearer, Springdale Crops

Orkney Enterprise: Ken Grant, Chessa Llewellyn-White

Orkney Housing Association Ltd: Sally Inkster, Raymond Sutherland

Orkney Islands Council: Shona Croy, Jeremy Baster

Orkney Woodland Development Project: Jenny Taylor

SAC: George Baikie, Elaine Booth, Mike Girvan

SASA: Niall Green

SNH: John Uttley, Gail Churchill

UHI Millennium Institute: Neil Chisholm, Paddy Maher

University of Aberdeen: Paul Mitchell; David Robinson

Valhalla Brewery: Sonny Priest

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