REVIEW OF CEREAL GROWING IN SHETLAND

Bere Growing At Bigton Farm In Shetland

By

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Contents

Executive Summary

- With funding from the Mains of Loirston Charitable Trust, and in collaboration with Shetland Livestock Marketing Group (SLMG) and SAC Consulting, the Agronomy Institute at Orkney College (UHI) implemented a project on Shetland cereals between January 2014 and March 2015. The main tasks within the project were to:
    - Collect and summarise information on the growing of cereals in Shetland, including aspects like current practices, end-uses and constraints. This part of the study was carried out by a combination of stakeholder interviews and a desk study.
    - Establish a trial on a farm in Shetland using a selection of early maturing cereal varieties and collect information on growth and the production of grain and straw.
    - Develop guidelines for growing cereals in Shetland
    - Produce a report on the study and disseminate results.
- As Shetland's weather greatly influences the success of cereal cultivation in the islands, the study included an analysis of weather data for Lerwick from 1989 to 2012. The main results from this are:
    - A comparison of monthly temperatures over the crop growing season (May to September, inclusive) from 1989-2000 and from 2001-2012 showed that the average temperatures were 10.4 and 11.1^{o}C for the earlier and later periods, respectively.
    - Growing season temperature data were also analysed as growing degree days (GDD) with a base temperature of 0^{o}C. For the period 1 May to 30 September the average number of GDD for 1989-2000 and 2001-2012, respectively, were 1598 and 1684 GDD. A plot of these data by year showed that there have been several years since 2002 with markedly higher GDD than occurred between 1989 and 2001.
    - Average monthly rainfall data were also analysed over the same periods and suggested that in recent years there has been lower rainfall in the spring (February to April), but slightly higher rainfall in July and August.
    - There were no marked differences in sunshine hours for the two periods.
- From the above weather data, it was concluded that temperatures have become more favourable for cereal growing in Shetland in recent years but rainfall still presents a major challenge, particularly in the period leading up to and during the harvest.
- In 1982, a Macaulay Institute soil survey of Shetland estimated that only about 3% (4,300 ha) of the land area was considered suitable for arable cropping. Most of this occurs close to coastal areas where calcareous sands are available for raising the pH,

and also in sheltered limestone valleys (e.g. Tingwall) or on localised drifts from ultrabasic rocks.

- It is important to appreciate that Shetland has a long tradition of agriculture and growing cereals. While agricultural production has seldom been sufficient to sustain the Shetland population, agriculture has always been an important element in the economy and cereals have played a significant role in this. For this reason, the study briefly reviewed historical aspects of both and the following are some of the important changes in agriculture and cereal production in Shetland up to the start of the 20th century:
    - Barley grains have been found at some of the earliest sites in Shetland where there is evidence agriculture (e.g. the Scord of Brouster, dated to about 3400 cal BC). Grains, querns for grinding grain, and ard points for ploughing have frequently been found at other Neolithic and Bronze Age archaeological sites.
    - The onset of wet conditions in the late Neolithic resulted in widespread development of blanket peat and by the late Bronze Age/Early Iron Age (c. 500 cal BC) cereal growing had moved away from upper hill to middle hill and coastal sites, similar to those used for arable agriculture today.
    - During the Iron Age, soil enrichment and the appearance of oats (both *Avena sativa* and *A. strigosa*) provide evidence of agricultural intensification. Rotary querns mark the introduction of more efficent processing methods.
    - The Norse period started in the 9th century AD and was accompanied by a milder climate during which homesteads and farms were established with barns, byres and corn-drying kilns. Common grazing divisions were established in this period.
    - Coinciding with the transfer of Shetland to Scottish rule in the 15th century, the climate again started to deteriorate and the economy became increasingly dependent on fishing.
    - The Shetland population doubled from about 15,000 to 31,000 between 1755 and 1850, resulting in considerable pressure on the land and an increase in land under arable agriculture. Evidence for the importance of Bere and oats for milling during this period comes from the large numbers of sites of small, horizontal mills.
    - With the development of an important wool industry in the 18th and 19th centuries, sheep farming became increasingly profitable and resulted in the eviction of many crofter tenants in the 19th century.
    - Greater security of tenure was given to tenants by the 1886 Crofters Holding (Scotland) Act, tenants and by the 1900s, Shetland farming had evolved from a subsistence to a livestock economy.
- The 20th century was marked by major changes in agriculture and cereal cultivation:

- There were large increases in sheep numbers (from ca. 150,000 to 400,000) and a decline in both cattle and horses.
- Amongst crops, the area of rotational grass increased markedly (from ca. 600 to 2,500 ha) but the areas of all other crops have declined, especially oats (from ca. 3,000 to 30 ha).
- There were many reasons for these changes, but in recent years the most important were:
  - EU subsidies encouraged high stocking rates of sheep.
  - Greater opportunities for crofters to earn salaries elsewhere, resulted in less time for working on the croft (especially managing cattle).
  - Since sheep needed less winter fodder than cattle, arable cropping could be reduced, especially as relatively cheap imported animal feeds became available.
  - Cereal cropping became less attractive as modern machinery became too large for many of the small fields owned by crofters.

- Based on recent agricultural census data and interviews with growers, contractors and staff of SAC Consulting, the following is a summary of the current situation of cereal growing in Shetland:
  - Compared with about 4,300 ha of land estimated to be suitable for arable cropping (Macaulay soil survey, 1982), the 2012 census showed 269 ha under crops and fallow and 1,028 ha under grass below 5 years old.
  - About 60 ha of barley and 25 ha of oats are grown for grain, with perhaps about another 70 ha grown for arable silage.
  - The amount of grain and straw produced is insufficient for demand and in most years this is supplemented by imports from Orkney and Aberdeen for very high prices – ca. £40-50 for round bales and £180/t for grain.
    - In 2013 and 2014, respectively, 1572 and 1953 t of straw were brought to Lerwick by Serco NorthLink Ferries.
    - Although differences in the size and weight of bales, makes it difficult to convert this to a monetary value, the above figures are roughly equivalent to 7,860 and 9,770 round bales (1.22 x 1.22 m) in 2013 and 2014, respectively, which would have cost growers ca. £314,000 and £390,000 in each year at a price of £40 per bale.
  - The most common barley variety grown is Waggon with smaller areas of Tyne and Westminster also grown. Most of this is treated with propcorn and produced in south mainland on the larger farms where mechanisation is most advanced.

- The most widely grown oat is Canyon and this is mainly grown for arable silage.
- There is major concern about the very small area which is grown of the landraces Bere and Shetland aets (oats). In total, this is now less than 1.0 ha for each crop and with very small quantities of seed being held, there is a serious risk that these landraces could be lost from cultivation in Shetland.
- Apart from a negligible quantity of Bere which is milled on a domestic scale, there is no use of Shetland cereals for food and drink purposes.

- In discussions with growers, the main constraints on cereal cropping in Shetland were considered to be:
  - Rain and wind in August and September which can cause crop lodging and grain stripping. Wet weather at this time also limits the windows of opportunity for harvesting and can create soil trafficking problems for machinery.
  - The difficulty of accessing machinery when appropriate windows of opportunity occur (e.g. at planting and harvesting).
  - The lack of machinery to purchase of a suitable size for Shetland conditions. In particular, there is a need for smaller, lighter-weight combines which could be used on crofting land where field size is particularly small.
  - Damage from geese (trampling of the crop) and stripping of grain by birds like sparrows. This was reported to be a growing problem, especially where cereals are being harvested for dry grain (e.g. Bere).
- If the machinery constraints can be overcome, there is potential for increased cereal production in Shetland:
  - The greatest potential is for expanding the use of early harvesting methods (e.g. crimping and propcorning) to produce more animal feed and straw for overwintering livestock. With the current prices of imported straw bales and grain, this is actually a high-value market! Early maturing varieties could help facilitate this by spreading the harvest over a longer period, allowing more harvesting windows to be exploited.
  - With significant numbers of tourists, and a growing interest in high-provenance food and drink products, there could also be potential for growing cereals for these markets. In Orkney, successful products have been developed from Bere (e.g. Beremeal, whisky and beer) and this could be a way of helping to conserve Bere in Shetland while at the same time providing local companies with unique ingredients/products. Currently, one of the factors limiting the scale of what could be done in this area is the lack of a grain dryer able to deal with several tonnes of grain.
  - Shetland Museum has an annual requirement for straw of Shetland aets which is more durable for thatching than modern oats. Although a small market, this could

help to conserve this landrace and might also encourage the development of a straw market which could stimulate an expansion in the production of specialised craft items like Shetland chairs and baskets (kishies).

- A replicated trial which included 5 early-maturing varieties of barley and one of oats was established and monitored at Bigton Farm in the south of mainland during 2014. The main results from this trial were:
    - Two varieties of barley (Iskria from Iceland and Vilde from Norway) were very promising, combining reasonable grain yield (ca. 4.5 t/ha at 15% moisture content) and straw yield (ca. 4.5 t/ha dry weight) with earliness (about 2-3 weeks earlier than Waggon).
    - The oat variety Haga had a very high straw yield (ca. 5.5 t/ha dry weight). Although grain was not harvested from this variety because of damage by birds, data from Orkney indicate it has a similar grain yield to the barley, Vilde. It also has good resistance to lodging.
- Provisional guidelines were prepared for growing cereals in Shetland and will be finalised with local stakeholders when more results from the NORA project become available.
- Apart from this report, which will be distributed to key Shetland stakeholders, results from this study have been summarised and disseminated by the following means:
    - A demonstration event and interview with Radio Shetland was held at the Bigton cereal trial on 15 August 2014.
    - Results from the Bigton trial were summarised for SAC Consulting in Shetland and distributed to growers in their January 2015 newsletter.
    - A presentation of results was made to Shetland stakeholders on 25 March 2015 and was followed up by an interview with Radio Shetland and an article in the Shetland Times.
    - The guidelines for growing cereals will be disseminated through SAC Consulting and SLMG when they have been finalised.

1 Introduction

Since opening in 2002, cereals have been a prominent part of the research programme of the Agronomy Institute (AI) at Orkney College (UHI). This has included work on both modern varieties and traditional Scottish landraces. There have been some notable commercial outcomes from this research including increased growing of the barley landrace Bere for producing whiskies and beer, the development of a supply chain growing modern malting barley in Orkney for Highland Park Distillery and the expansion of milling at Orkney's Barony Mill to include wheat flour and oatmeal. The Institute has also developed valuable cereal research collaborations including links with The James Hutton Institute, The Rowett Institute and a consortium of researchers in Norway, the Faroes, Iceland and Newfoundland.

Although only a small area of cereals is grown in Shetland, a recent project (Northern Cereals – New Opportunities) involving the Institute and partners in other North European countries is aimed at encouraging cereal production within the region as a response to greater consumer demand for northern products and to the perception that growing conditions are becoming more favourable in the region. The Institute made a successful application for funding to the Mains of Loirston Charitable Trust to allow it to carry out cereal development activities in Shetland as part of the Northern Cereals project aimed at transferring the knowledge and experience obtained by the Institute to Shetland growers in collaboration with Shetland Livestock Marketing Group (SLMG) and SAC Consulting. The activities undertaken by the Institute were grouped in 4 work packages (WP) which are outlined below.

WP1. Analysis of the current cereal situation in Shetland.

This included an analysis of cereal production on Shetland and the collection of information about the main uses of locally produced cereals. It was done by telephone interviews with stakeholders (both growers and end-users) and also included literature/internet-based research into important limiting factors like soil, climate and topography. Results related to WP 1 are presented in Chapter 2,

WP2. Research trial and demonstration of early maturing cereal varieties.

During 2014, a trial was established on a Shetland farm investigating the growth and production of grain and straw by 6 different early-maturing cereal varieties including Bere from Shetland and two varieties which the AI had grown successfully for several years in Orkney. A demonstration event was held at the trial site in August 2014. Chapter 3 provides the results of WP3.

WP3. Guidelines for cereal growing In Shetland.

Results from the study, including the variety trial, were used to develop guidelines for growing cereals in Shetland, including recommendations tailored to specific niche market end uses identified during the project. Preliminary guidelines for growing cereals in Shetland are presented in Appendix 3 and will be finalised when more information is available from other partners in the NORA project.

WP4. Reporting and dissemination.

An open event at the Shetland field trial was held in August 2014 at Bigton Farm (Photograph 9, p. 35) and included an interview with Radio Shetland. Results from the trial were summarised and distributed to growers in a newsletter sent out by SAC Consulting in January 2015. A presentation, summarising the results of the project, was made to stakeholders in Shetland on 25 March 2015 and an interview with the author and Ronnie Eunson (Chairman, SLMG) about the project was broadcast on Radio Shetland on 27 March 2015. An electronic version of this presentation was made available to SLMG for distribution to their members. This project report will also be distributed to key Shetland stakeholders.

2 Cereal Growing In Shetland

2.1 Location

The Shetland Isles are located at 60^{o}N and are the most northerly archipelago in Britain, being about 180 km northeast of mainland Scotland and 90 km northeast of Orkney. The island group extends from south to north for about 112 km and consist of over 100 islands of which 16 are inhabited, including Foula and Fair Isle. As a result of their North Atlantic location and the moderating influence of the North Atlantic drift they have a hyper oceanic climate (Crawford, 2000) which results in much less temperature variation throughout the year than in continental areas at the same latitude. Dominant aspects of the climate are late springs, cool summers, mild and wet winters and exposure to strong winds. These conditions and their effects on soils can present major challenges for plant growth and agricultural cropping. Since the first human settlement of the islands, relatively small changes in climate, probably interacting with human influences, have had major effects on both vegetation and agriculture.

2.2 Recent Weather

Weather data (1989 to 2012) for Lerwick (60.14, -1.18; 84 m above sea level) in Shetland were obtained from the Meteorological Office web site (http://www.metoffice.gov.uk/climate/uk/stationdata/lerwickdata.txt) and consisted of monthly averages of maximum and minimum temperatures and total rainfall and sunshine hours. Data for the period 1989 to 2000 have been compared with those for 2001 to 2012 to see whether there are any recent changes in weather patterns which might be expected to affect cereal cultivation in Shetland.

2.2.1 Temperature

For crop growth in northern areas, temperature is a very important factor since it determines the rate of plant growth, development and maturation. Fig 1 compares monthly temperatures at Lerwick for 1989-2000 and 2001-2012. The monthly trend in temperature is the same for both periods, with the lowest temperature being for February and the highest for July and August. For all months, except January, the average temperature was higher for the period 2001-2012 and, over the year, the average temperatures were 7.4 and 7.8^{o}C for the earlier

and more recent periods, respectively. Over the crop growing season (approximately May to September, inclusive), the average temperatures were 10.4 and 11.1°C for the earlier and later periods, respectively. There is therefore an indication that temperatures have been warmer, especially during the crop growing season, in recent years.

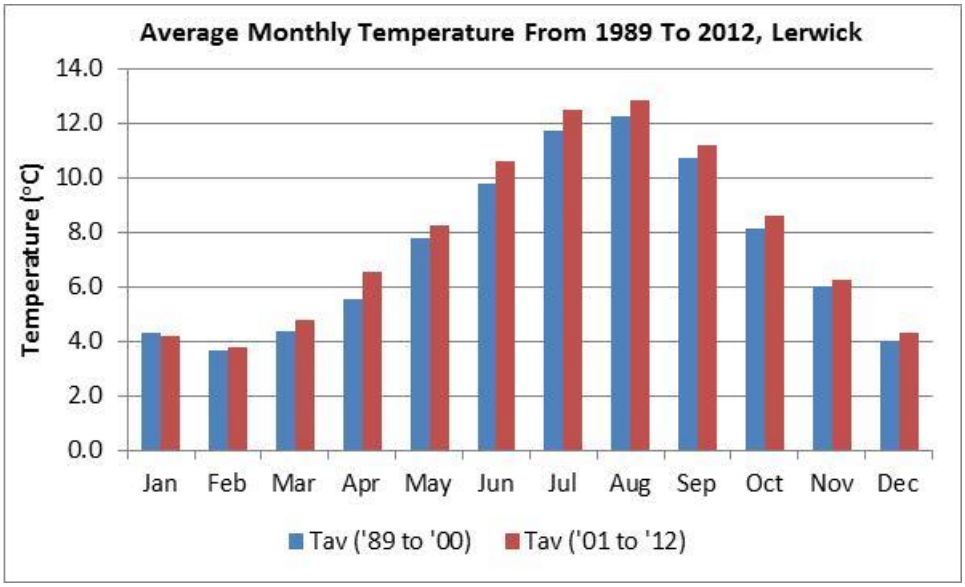

Fig. 1. *Average monthly temperatures at Lerwick for the periods 1989-2000 and 2001-2012.*

2.2.2 Growing Degree Days

In northern areas, one very useful derived temperature variable is growing degree days (GDD) because crop development can often be related to this and, for different locations, the length of the growing season can be defined in terms of degree days. Usually, a base temperature of 0°C is adopted for calculating this and, in this case, the number of GDD in a growing season is the sum of the average daily temperatures from the day of planting to the day of harvesting. This was calculated from the Lerwick weather data making the following assumptions:

- The dates of planting and harvesting, respectively, were approximated by 1 May and 30 September (allowing GDD for the growing season to be calculated from monthly temperature data for May to September)
- Average monthly daily temperature is calculated as half of the sum of the average monthly maximum and minimum temperatures.

Fig. 2 shows the GDD from 1 May to 30 September from 1989 to 2012 for Lerwick. Over this period the average GDD was 1646, but it is conspicuous from Fig. 2 that there have been several years since 2002 with markedly higher GDD than occurred between 1989 and 2001.

The average number of GDD for 1989-2000 and 2001-2012, respectively, were 1598 and 1684 GDD.

Crop requirements for GDD from planting to harvest vary with cereal crop (usually wheat>oats>barley) and also between varieties of each crop. Over several years, the Agronomy Institute (AI) has collected data on this from variety trials at Orkney College with barley, oats and wheat. In these trials, several North European barley varieties have been found which are at least as early as Bere in reaching harvest. Varieties of oats have also been found which are about two weeks earlier than standard UK varieties. Fig. 2 also shows the average number of GDD required by early North European varieties of barley and oats in Orkney trials harvested for dry grain (at about 22% moisture content). The following should be noted from Fig. 2:

- For most years, the cropping season GDD is about the same or more (especially since 2002) than that required by early barley varieties harvested for grain. This indicates that North European varieties similar to Bere for earliness should be suitable for Shetland. In part, this is confirmed by the survival and continued growing of Bere in Shetland.
- Although the GDD requirement of the earliest varieties of oats was met only once from 1989 to 2012, these varieties might still be useful in Shetland for feed if the grain is harvested at a higher moisture content and treated with a preservative. Also, it is sometimes possible to plant in April or harvest in October which would increase the GDD in some years.

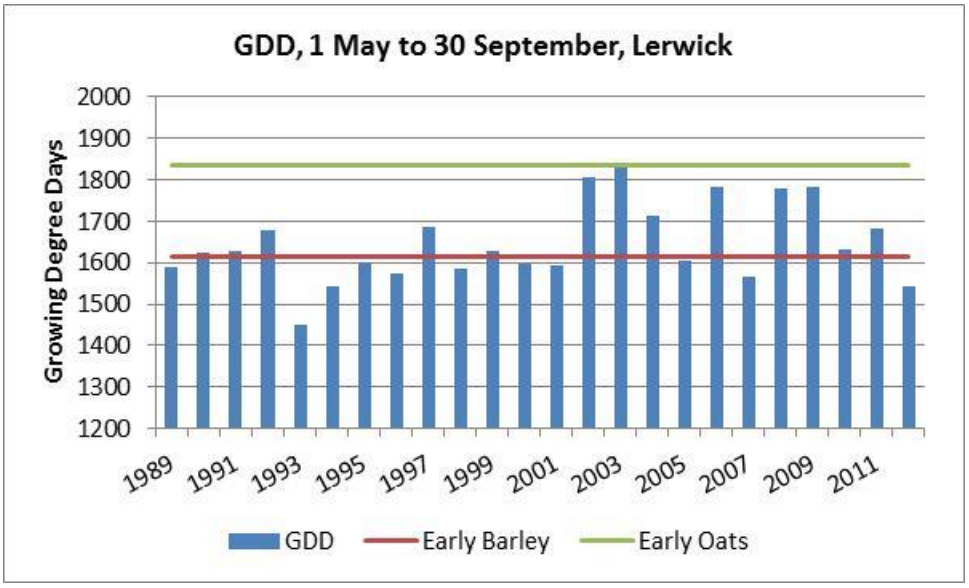

Fig. 2. *The number of Growing Degree Days (GDD) at Lerwick between 1 May and 30 September from 1989 to 2012.*

2.2.3 Rainfall

Fig. 3 shows average monthly rainfall in Lerwick for the periods 1989-2000 and 2001-2012. Total annual rainfall for the earlier period (1296 mm) was slightly higher than that for 2001-2012 (1224 mm). Although the rainfall pattern for both periods is similar, with the highest monthly rainfall from October to March and least from May to August, there is a suggestion of lower rainfall from February to April in recent years (an average of 282 mm compared with 373 mm). This has also been seen in an analysis of data for Orkney over the same period. Apart from making it easier for cereal growers to complete their cultivations and plant earlier than formerly, this would also help to extend the growing season which would result in an increase in GDD. In contrast, however, rainfall in July and August has been higher in recent years. The increase in August rainfall is particularly concerning because this is the main month for grain filling and is at a time when crop susceptibility to lodging, because of rain and wind, is increasing.

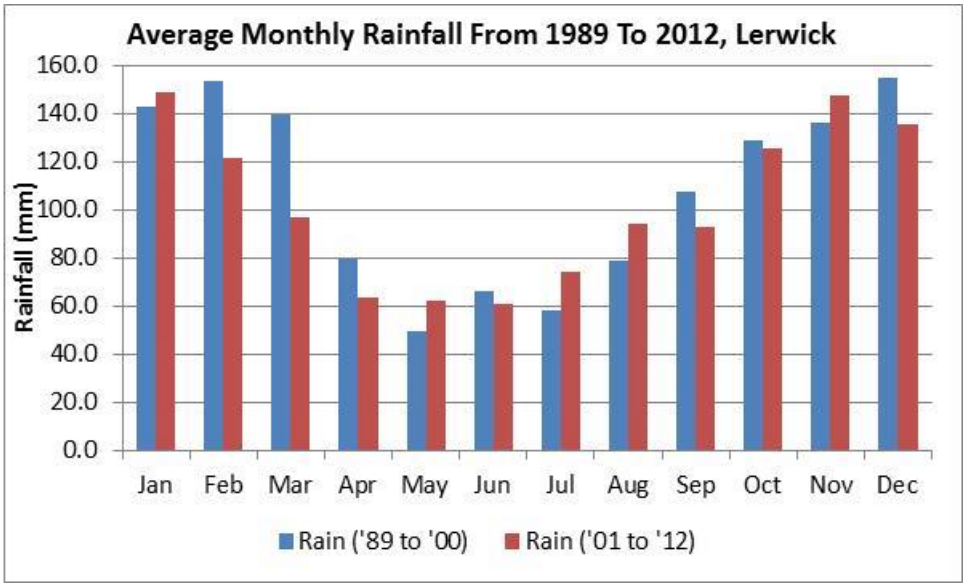

Fig. 3. *Average monthly rainfall at Lerwick from 1989-2000 and 2001-2012.*

One factor affecting the ease of harvesting a crop is the number of dry days during the harvesting period. Fig. 4 shows the number of dry days from 1 September to 15 October (the approximate harvest period) from 1989 to 2012 in Lerwick and Kirkwall. Surprisingly, averaged over all years, there are more dry days in this period in Lerwick (13.7 days) than Kirkwall (12.0 days). In recent years this difference has become more marked – 14.2 days and 8.9 days, respectively, for Lerwick and Kirkwall for 2001-2012, compared with 13.2 and 11.4 days, respectively, for the two sites in the earlier period. This does not necessarily indicate easier harvesting in Shetland than Orkney, however, as rainfall is higher in Lerwick and this may indicate a higher intensity of rainfall which may increase the risk of crop lodging and could also create trafficking problems for harvesting machinery.

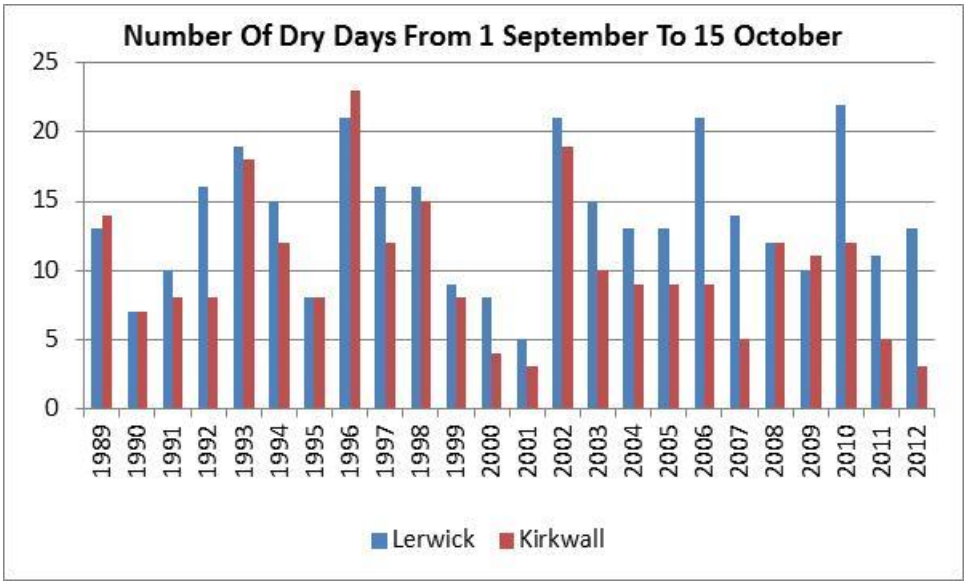

Fig. 4. *Number of dry days from 1 September to 15 October in Lerwick and Kirkwall from 1989 to 2012.*

2.2.4 Sunshine

Fig. 5 compares average monthly sunshine hours at Lerwick for the periods 1989-2000 and 2001-2012. There are no major differences between the two periods, although possibly there has been a tendency for more sunshine from December to March in 2001-2012. In both periods, peak sunshine is in May; sunshine is often reduced from June to August by sea mist.

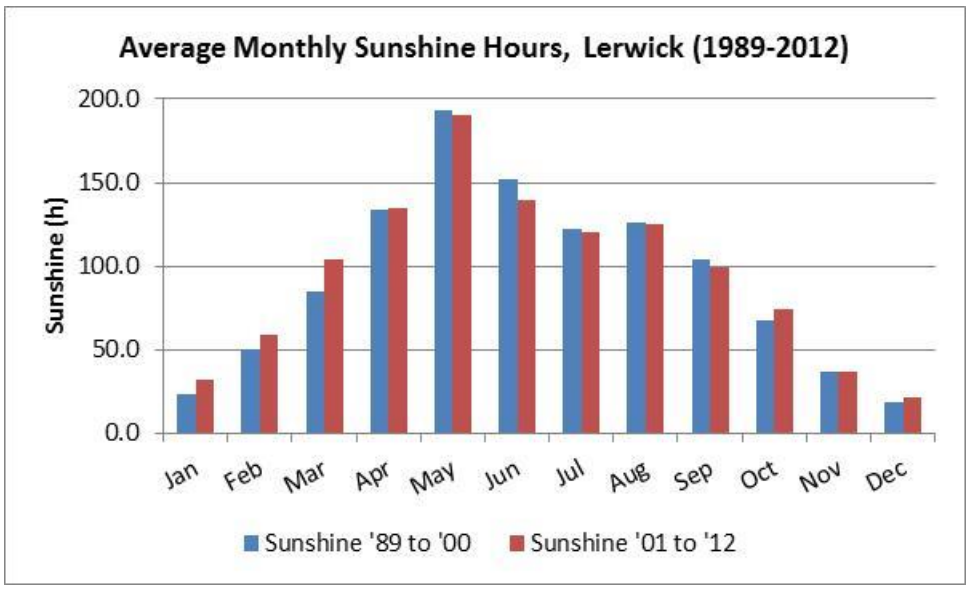

Fig. 5. *Comparison of average monthly sunshine hours at Lerwick from 1989-2000 and 2001-2012.*

2.3 Geology And Soil

The geology of Shetland is complex (Dry and Robertson, 1982), consisting both of ancient sedimentary rocks which were metamorphosed and intruded by igneous rocks during the Caledonian Orogeny and sedimentary rocks of Old Red Sandstone age (about 350 million years ago). A major north-south fault, the Walls Boundary Fault, divides Shetland into geologically distinct East and West halves. The west is more rugged and varied and includes several large masses of granite and diorite and highly folded sandstone and lava from the Old Sandstone era. Less strongly undulating land occurs along the south east coastal strip of Mainland and on the western edge of Walls and Esha Ness peninsulas and these areas are formed by more gently inclined sandstones, flagstones and conglomerates of Old Red Sandstone age.

Shetland soils derive mainly from glacial till resulting from erosion of local rocks during the last glaciation (from about 25,000 to 12,000 years ago). This was caused by a local ice cap which flowed outwards (west and east) from a central spine down the long axis of the islands. With the melting of the ice, the till was mostly deposited on low land near the coast. Since most of the rock from which the till was formed is acidic, this has mostly developed into acidic soils. With Shetland's high rainfall and cool temperature, this has resulted in waterlogged soils which have allowed the widespread development of blanket peat, covering about 40% of the islands. Peat is also a major component of several of Shetland's soil complexes. Only about 3% (4,300 ha) of Shetland's land area is classified as suitable for arable cropping (Dry et al., 1982) and this is all Class 4, Division 2 land (primarily grassland with limited potential for other crops). Cultivated ground is usually in the coastal fringes, particularly on those soils which are close to sources of shell-sand for amelioration and also in sheltered limestone valleys (e.g. Tingwall) or on localised drifts from ultrabasic rocks (the Leslie Association in Unst and Fetlar). On areas of windblown sand the soils are mainly brown calcareous soils, calcareous gleys and regosols.

2.4 Historical Review Of Agriculture And Cereal Growing In Shetland

Although agriculture has been important throughout the thousands of years that Shetland has been settled by people, it has always been a challenge to produce sufficient food because of its climate and soils. Consequently, there has always been a need to supplement agricultural production with food from elsewhere. Very often this has come from the coast (sea birds, seals and shellfish) and especially from fishing in coastal waters or further afield. As trade developed, money earned from exports (especially fish and wool) was used to purchase and import food and animal feed. For example, there is a long-established tradition of importing grain from Orkney which survives down to the present day.

The earliest evidence for farming in Shetland comes from the Scord of Brouster, a site in West Mainland which has been dated to about 3400 cal BC (Dickson and Dickson, 2000) in the Late Neolithic. Here, hulled 6-row barley and naked barley grains were both found. In a relatively short time scale, archaeological evidence suggests tree clearance started, field systems were established and extensive stone dykes built, probably for the separation of grazing land. Gradually, however, the climate became wetter and cooler resulting in a transformation of hill land from woodland and shrub into grassland, heathland and finally blanket peat by the late Bronze Age/Early Iron Age (c. 500 cal BC). At Catta Ness (in

Lunnasting), analysis of sediments suggests large scale tree clearance, probably as a result of burning to provide grazing, occurred later, around 1100 cal BC (Bennett et al., 1992). As a result of the spread of peatland, there was a movement of settlement away from the upper hill to the middle hill and the shore where settlements already existed. From early times, therefore, the pattern on Shetland was for hill land to be used for grazing (especially by cattle and sheep) and for arable agriculture to be concentrated on the better soils, mostly around the coast. Evidence for arable agriculture during the Neolithic and Bronze Ages include cereal grains (mostly naked and hulled barley), saddle- and trough-querns (Photograph 1, p. 31) for grinding grain, stone ard points used for ploughing, ard marks in the soil, and soils mixed with midden waste (including ash) indicating enrichment of soils.

Many of the shoreline settlements in the Iron Age were associated with brochs where barley, especially hulled barley, dominated the cereal finds. Evidence from Scatness (Bond *et al.*, 2004) suggests more intensive cultivation of soils during the Iron Age, including enrichment with animal manure and peat which had been used as animal bedding (a plaggen system). The presence of grains of oats (*Avena strigosa* and *A. sativa*) indicates that this was introduced to Shetland during the first millennium AD, before the Norse settlement. The introduction of oats is thought to be significant because of its ability to produce a crop on poorer land than barley, with fewer inputs. This may have allowed poorer land to have been brought into cultivation, providing extra fodder for animals. Rotary querns were first adopted during the Iron Age and were used for grinding grain (especially barley) or malt. They continued to be used in Shetland for small-scale domestic milling until the 20th century (Fenton, 1978).

The Norse settlement of Shetland started about the beginning of the 9th century AD and evidence for its associated agriculture comes mainly from Old Scatness and Jarlshof in the south of the island. The settlement occurred at the start of a period with a milder climate which lasted until about 1500 and this probably allowed an expansion of agriculture, resulting in the establishment of homesteads and farms with barns, byres and corn-drying kilns. Flax also appears to have been introduced as a crop, probably for making into sail cloth. During this period the *scattalds* or common grazing divisions were established.

In 1469, Shetland was transferred from Norwegian to Scottish rule but the deteriorating climate resulted in a reduction in agriculture and a growing economic dependence on fishing. This developed from the commercial fishing of cod and ling in coastal waters which had started in the 12th century and grew into trade, initially with the Hanseatic League, and later with German merchants who came to Lerwick. Following the union of Scotland and England, taxes were imposed to discourage foreign traders operating in Britain and the trade was taken over by local landowners. This led to a land-holding and fishing system called “Truck” which tied tenant farmers to the land without security and forced them to sell their fishing catch to the landowner who then exported the fish to Europe (Laughton, 1998). The system required frequent, perilous trips to the open ocean to catch, cod, ling and saithe. To maximise their profits from the system, landowners encouraged population expansion so that they could subdivide the land. Between 1755 and 1850, the population doubled from about 15,000 to 31,000, placing considerable pressure on land and resulting in erosion of hill land, over-exploitation of peat banks and loss of arable soils. There was also an increase in land (the *innadaek*) used for arable crops – especially for hay, potatoes, kale, turnips, oats

and bere. The fertility of this land was maintained by returning animal bedding to the land in the spring and supplementing this with peat and soil from hill land and seaweed from the shore. With many men away from home fishing, much of the agricultural work had to be done by women. Shetland's hilly terrain was not very suitable for vertical water mills and the majority of mills were horizontal (Photographs 2 and 3, pages 31 and 32). It is not known when these were introduced but there were large numbers in the 18th and 19th centuries. For example, in Papa Stour (6 square miles), 24 mill sites have been found (Fenton, 1978). A few vertical mills, for example at Quendale and Kergord, were built in the 19th century. By early in the 20th century, most mills had been abandoned as cheap wheat flour, imported from North America, became readily available.

Sheep have always been an important component of Shetland agriculture because they are hardy and can be left to graze unherded on the hills, nesses and holms. They were a source of meat and wool for both domestic use and for the payment of land rent. The original sheep which were introduced were similar to Soay sheep and a special feature of them was that their wool could be plucked by hand (rooed) which allowed the fine wool to be separated from coarser hair. Larger scale production, and export of woollen goods, started in the 17th and 18th centuries and by 1790 the trade had become an organised cottage industry producing prestige items. This was assisted by the development of better transportation links with the islands. Since then, the skill of Shetland knitters and the quality of the wool has resulted in a high value market for Shetland woollen goods which has persisted to the present. A result of this in the 18th and 19th centuries, however, was that sheep farming became increasingly profitable and, between about 1830 and 1886, many landowners evicted crofter tenants from their land and replaced them with sheep. New breeds of sheep were also introduced. As a result, sheep numbers rose from about 81,000 in 1870 to 110,000 in 1900 and 168,000 in 1936. Another result of the "clearances" was a loss of population as many tenants emigrated to mainland Scotland or overseas.

Security of tenure for crofters was provided by the 1886 Crofters Holdings (Scotland) Act and this provided tenants with much more incentive to take care of, and invest in their land. By the 1900s, Shetland farming had changed from subsistence to a livestock economy supported by the cultivation of fodder crops. This, however, resulted in a decline in the importance of arable production which is reflected in the decline in crop production from 1890 to 1930 shown in Table 1 (data extracted from O'Dell, 1935). During the 20th century, the improvement of arable land, by drainage and liming, which landowners had started in the previous century, continued.

Table 1. *Changes in crop production on Shetland from 1890 to 1930 (after O'Dell, 1935).*

Crop	1890	1930
Barley/bere (bushels, t in brackets) [1]	63,547 (1,418)	16,431 (367)
Oats (bushels, t in brackets) [2]	195,677 (3,320)	142,160 (2,412)
Turnips and Swedes (t)	21,625	5,136
Potatoes (t)	11,107	4,906

[1] Production of barley and bere has been converted to tonnes by assuming a bushel weight of 50 lbs

[2] Production of oats has been converted to tonnes by assuming a bushel weight of 38 lbs

An interesting picture of the geographical production of cereals in Shetland in the 1930's is provided in O'Dell (1935) and is reproduced in Table 2. This clearly shows that the southern end of mainland (Dunrossness) was the most important area for the production of bere and barley. While, Dunrosness also produced a high proportion of oats, this crop was better represented in the other areas than bere/barley.

Table 2. *Production of bere/barley and oats in Shetland parishes in 1936 (after O'Dell, 1935).*

Area	Bere / Barley (Bushels)	% Of Bere & Barley Total	Oats (Bushels)	% Of Oats Total
Dunrossness	12,588	73.9	40,597	19.8
Lerwick	878	5.2	11,412	5.6
Bressay	-		6,562	3.2
Tingwall	184	1.1	19,328	9.4
Sandsting and Aithsting	202	1.2	20,547	10.0
Delting	244	1.4	9,495	4.6
Nesting	52	0.3	6,232	3.0
Lunnasting	21	0.1	5,408	2.6
Whalsay and Skerries	78	0.5	10,168	5.0
Northmavine	264	1.6	18,256	8.9
Sandness	512	3.0	5,462	2.7
Papa Stour	863	5.1	601	0.3
Walls	119	0.7	9,378	4.6
Foula	718	4.2	1,139	0.6
Fetlar	117	0.7	4,870	2.4
Unst	54	0.3	15,810	7.7
Yell	135	0.8	19,557	9.5
Shetland Total	17,029		204,822	

The 20th century was characterised by a large increase in the number of sheep (see Fig. 6) and a decline in cattle. This reflects the greater profitability and convenience of farming sheep for sale compared with arable cropping as part of a mixed agriculture aimed at home consumption. As a result in-bye land became increasingly used for sheep pasture. The marked changes in the area under the most common agricultural crops during the 20th century is shown in Fig. 7. There has been a particularly large decline in the area under oats.

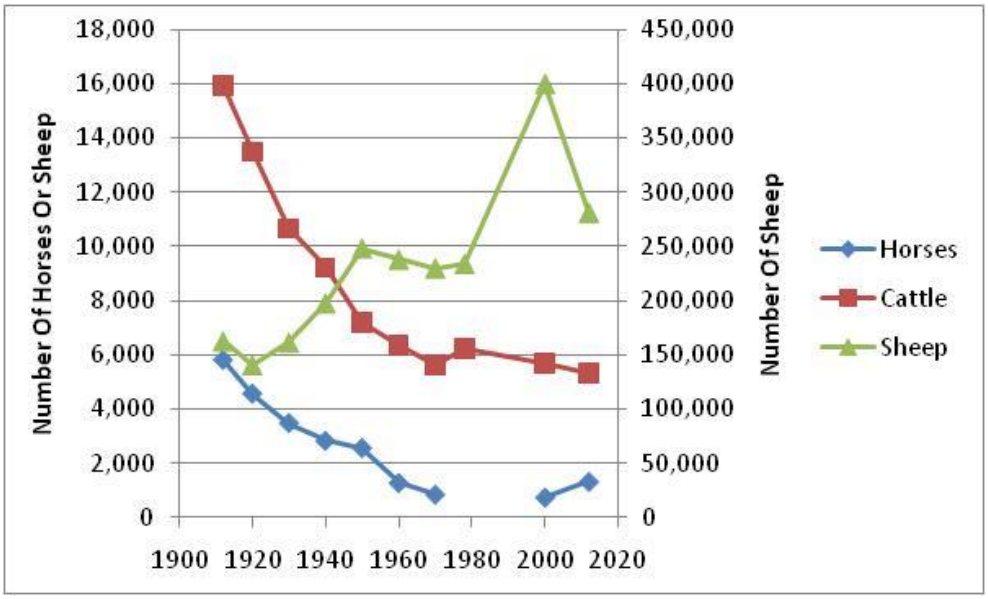

Fig. 6. *Changes in the number of horses, cattle and sheep on Shetland during the 20th century. Note that the numbers of sheep are indicated on the secondary vertical axis. (Data extracted from Government statistics and census reports for Scotland).*

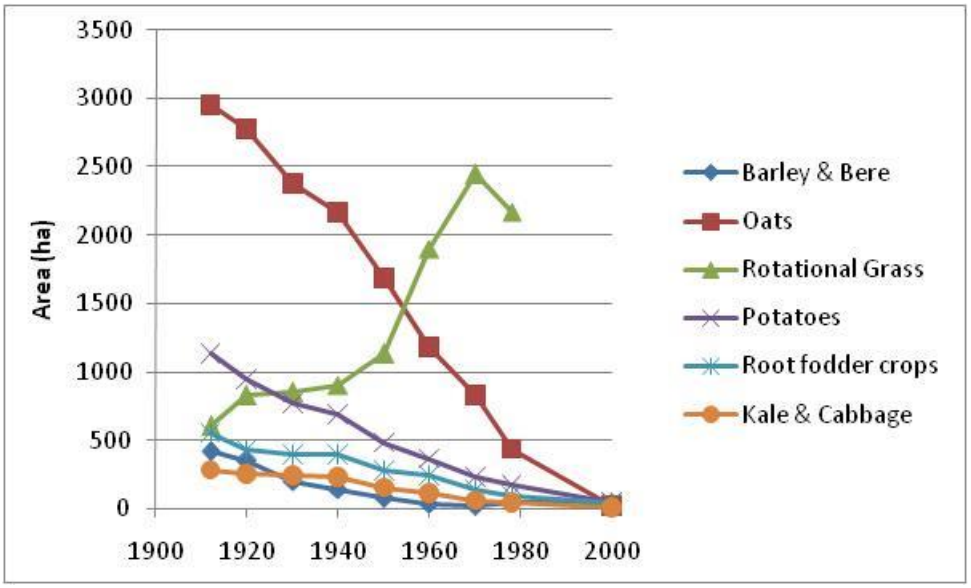

Fig. 7. *Changes in the area of selected crops in Shetland (Data extracted from Government statistics and census reports for Scotland).*

The total arable area in 1910 was approximately 6,200 ha. For comparison, Dry et al., (1982), estimated that there were 4,300 ha of land in the land suitability division 4.2 in

Shetland. This is the best category of land in Shetland for agriculture (but the poorest in the classification scheme for arable cropping). After this, the next best land in Shetland is division 5.2 (25,300 ha) and so it is clear that some of this less suitable land was being used for arable cropping at the start of the 20th century.

Clearly there were major changes in agriculture in Shetland during the 20th century and some of the most important factors influencing this in the latter part of the 20th century (http://www.livingshetland.org.uk/documents/AgriBAPBiodiversityFINAL.pdf) are thought to have been:

- Subsidies from the European Union's Common Agricultural Policy (CAP), based on stocking density, encouraged high stocking levels of sheep.
- Greater opportunities for crofters to earn salaries in jobs away from the croft meant less time was available for crofting activities, especially cattle management.
- There was a reduction in arable cropping, partly because sheep needed less winter fodder than cattle but also because of increased importation of cheaper animal feed. Another factor is that large modern machinery, which would reduce the labour input for cereals, is often not suitable for use on small crofts.

Since the start of the 21st century, there has been a very significant drop in sheep numbers which has resulted from a change from a headage-based subsidy system to area-based payments. Other factors were disease control measures and support for stock disposal under the Environmentally Sensitive Area scheme.

One of the main results of these factors for arable cropping is that it is now mostly done by a few larger scale farmers with access to suitable land and machinery, mostly in the south and centre of mainland.

2.5 Current Situation

2.5.1 Introduction

Information for this section of the report has been obtained from various sources, but particularly:

- Scottish Agricultural Census data
- Interviews with stakeholders (especially growers, seed merchants and staff of SAC consulting in Shetland)

2.5.2 Area Of Cereals Grown

A summary of data from the 2000, 2008 and 2012 Scottish Agricultural Census in Table 3 shows the change in agricultural land use in Shetland in recent years. It demonstrates the continued decline in the area under crops (especially since 2008), and suggests that young grassland (less than 5 years old) is being converted to older grassland (over 5 years old).

Table 3. *Area (ha) of land in different agricultural use in Shetland in 2000 and 2012 (Data extracted from Scottish Agricultural Census Summary Sheets).*

	2000	2008	2012
Crops and fallow	369	377	269
Grass under 5 years	2,306	1,992	1,028
Grass over 5 years/sole & common right grazing	144,670	144,613	147,020
Woodland	34	55	37
Other land	433	591	1,358
Total agricultural area	147,379	147,037	148,354

Information about the area of cereal crops grown is sometimes difficult to extract from the census data because the data may be withheld, where a crop is grown by only a small number of farmers, to prevent disclosures of individual holdings. The areas and numbers of holdings growing barley, oats and other major crops in 2000, 2008 and 2012 are shown in Table 4.

Table 4. *Number of holdings with barley and oats and the areas (ha, in brackets) of these crops grown in Shetland in 2000, 2008 and 2012 (Data extracted from Scottish Agricultural Census Summary Sheets).*

Crop	2000	2008	2012
Barley	12 (49)[1]	17 (62)	*
Oats	44 (23)	32 (23)	24 (25)
Potatoes	214 (50)*	117 (28)	62 (18)
Turnips, swedes and fodder beet	127 (46)	71 (26)	36 (12)
Cabbage, kale, rape and other fodder crops	(84)	(75)	(73)

[1] excludes winter barley

* Census data completely or partially withheld

Table 4 indicates a continued trend over the past 12 years for a reduction in the number of growers and areas of potatoes, “turnips and swedes” and a very slight reduction in the area

of “cabbage, kale rape and other fodder crops”. In contrast, the area under cereals appears to have remained about static. Although the data are incomplete for barley, farmer interviews suggest that at least 60 ha were grown in 2013 so that the area of barley grown seems to have stabilised at about 60 ha while that of oats has also been stable at about 25 ha.

2.5.3 Varieties Grown

Currently, the most common variety of barley grown is Waggon, with small areas of Tyne and Westminster also grown. Although Tyne is an old variety (released in 1986) it is still liked by some growers because of its earliness. The main barley growing area of Shetland is in the south of South Mainland and here much of the barley is grown for treatment with propcorn; elsewhere it is often grown for silage. A very small area (probably less than 1.0 ha in total) of Bere continues to be grown by a few growers for their own use (feed or domestic milling).

Canyon is the most popular variety of oat and is mainly grown for silage. A very small area (probably less than 1.0 ha in total) of Shetland aets (oats) (*Avena strigosa*) continues to be grown by a few growers, mainly for its straw.

A few growers of both barley and oats have experimented with a small number of north European cereal varieties in recent years (e.g. Philippa barley and Fiia and Belinda oats). While these were generally successful, they were not persevered with because of difficulties in obtaining seed.

Apart from very small quantities of Bere and Shetland aets, the majority of the seed used in Shetland is imported. Part of the reason for this is the difficulty of taking grain to maturity but another major reason is the lack of grain drying facilities. The only fully-functioning grain dryer on Shetland is a small one owned by the Shetland Organic Producers Group (SOPG) which has a drying capacity of about 0.5 t and is mainly use for drying seed of Bere and Shetland aets. A second grain dryer is thought only to be drying with ambient air.

Bere and Shetland aets are landraces which have a long association with Shetland. Apart from being an important part of Shetland’s agricultural heritage, they are also an important Scottish genetic resource which have potential value to plant breeders because of attributes like tolerance to manganese deficient soils and an ability to produce a crop with few inputs. While both crops are grown in other parts of Scotland, it has been confirmed by the James Hutton Institute that there are genetic differences between Bere grown in Shetland, Orkney and the Western Isles. It is likely that the same is the case for Shetland aets which is also grown in Orkney and the Western Isles, where it is called black oats. Continued growing of these crops on-farm is important for their conservation, but is only likely if they continue to be useful to farmers or if markets can be found for them. There is now so little of these crops grown that there is a real risk that a couple of poor harvests could so severely deplete seed stocks that the crops could be lost. For general agricultural purposes, both crops have been long out-classed by modern varieties and continued growing of them will depend on the development of specialist markets. Such markets have been successfully developed in Orkney for Bere (see 2.5.6.3).

2.5.4 Constraints On Cereal Cultivation

Although damage from geese and birds appears to be an increasing problem, most informants reported weather conditions as being the main problem for growing cereals in Shetland. Wet and windy weather from about August often causes lodging and grain stripping and heavy rain can create trafficking problems for harvesting machinery. These difficulties are most likely to affect late crops and it is recognised that early planting is important for ensuring an earlier harvest. In addition, however, most stakeholders felt that early maturing varieties would help to reduce the likelihood of harvest damage although it is important that they should also have other desirable traits like disease resistance, good standing ability and resistance to wind-induced grain stripping and ear loss. Planting can usually be done earlier on sandy land than on the heavier land and so this is one of the reasons why most cereal production is in the south of Mainland.

With unreliable weather both for planting in the spring and harvesting in the autumn, growers are most likely to be able to exploit windows of opportunities if they have ready access to machinery. This requires growers either to have their own machinery or to be close to a contractor or to share machinery with a small group of local growers.

Apart from a few of the largest farms, field size in Shetland is mostly small and is not suited to the large machinery used elsewhere in Britain. Wet ground conditions in both the spring and autumn favour lighter machinery or machinery which causes little compaction and trafficking damage. Most Shetland farm machinery is sourced second-hand from elsewhere in Britain and concern was expressed that, with the trend for larger machinery on British farms, it could soon become very difficult to find machinery suitable for Shetland conditions – especially combines.

2.5.5 Current Use Of Local Cereals

Most cereals are grown in Shetland for animal feed with probably about 10-15 ha of oats and 60-80 ha of barley being harvested as grain for treatment with propcorn and about 75-80 ha of cereals grown for arable silage. Straw is an important by-product of the harvested grain. There are also a few growers producing straw for specialist purposes like weaving, producing straw-backed chairs or thatching.

Apart from very small quantities of Bere and Shetland aets, there appears to be hardly any drying of grain for use as seed or for food and drink products.

2.5.6 Potential For Increased Growing Of Cereals In Shetland

2.5.6.1 Animal Feed

Interviews with farmers indicated that, over recent winters, there have been significant imports of straw and/or grain for feed from Aberdeen or Orkney. This is very costly, and it was reported that round straw bales had been sold for £40-50 per bale and grain for about £180/t – comparable prices in Orkney would be about £14/bale and £120/t for grain. The scale of the shortfall is shown by data for straw imports to Lerwick supplied by Serco NorthLink Ferries. In 2013 and 2014, respectively, 97 and 112 trailers of straw arrived in Lerwick, carrying 1572 and 1953 t of straw in each year. Monthly imports for the two years are shown in Fig. 8. With straw bales being of very variable size, it is difficult to put a cost on

these imports, but round bales (1.22 m diameter x 1.22 m wide) usually weigh about 200 kg and at a cost of £40/bale, the annual straw imports would be equivalent to about 7,860 and 9,770 round bales in 2013 and 2014, respectively which would have cost growers ca. £314,000 and £390,000 in each year. With an average production of about 22 round bales/ha, straw imports represent the production from ca. 357 and 444 ha in 2013 and 2014, respectively.

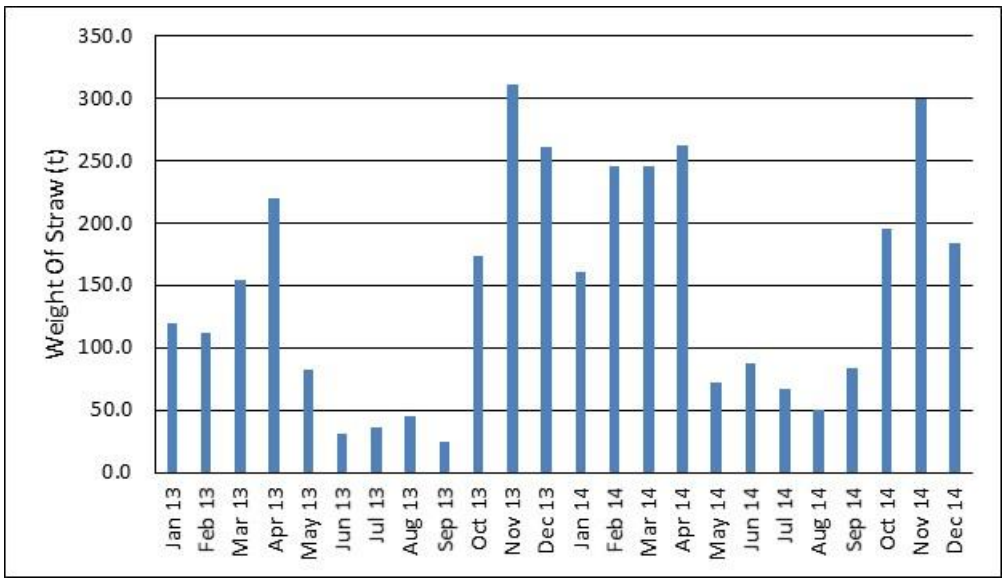

Fig. 8. *Weight of straw transported to Lerwick each month by Serco NorthLink Ferries in 2013 and 2014.*

In 2014, 96 t of grain were also imported by Serco NorthLink Ferries (between March and November).

With such high prices for straw, and with such large amounts being imported, increased cereal production could be an important way of reducing farm costs in Shetland. Without grain dryers, increased production of straw would require increased amounts of cereals being grown for crimping or treating with propcorn. For this purpose, the wider use of early maturing varieties (e.g. from Northern Europe) would have the advantage of allowing growers to spread their harvest over a longer period, reducing the demands on machinery, and would also help to spread risk.

2.5.6.2 Seed

With seed prices at about £400/t, the use of farm-saved seed can be an important way of reducing crop production costs. This option is not available to most farmers in Shetland, however, as they do not have access to a grain dryer. The 0.6 t dryer owned by SOPG would be too small for significant seed production.

2.5.6.3 Food And Drink Markets

Although northern areas like Orkney and Shetland, are a long way from mainland markets, large numbers of visitors, especially during the summer, significantly increase the domestic

market. Visitor numbers to Shetland have recently been estimated at ca. 65,000 with an average length of stay of 10 nights (Shetland Visitor Survey, 2012/13). This excludes visitors on cruise liners. For most tourists, consuming local food and drink products is an important aspect of the tourist experience. On a global scale, there is an expanding market for regionally distinct food and drink products, especially if these are made from locally produced ingredients. There is also a market for unique, high-value craft products which may sometimes include cereal materials – e.g. Orkney and Shetland chairs. Cereals can provide many opportunities for developing such products as is demonstrated by the markets which exist in Orkney for local cereals:

- Barony Mill produces Beremeal, wheat flour and oatmeal from locally grown cereals which are sold to both the public and local bakeries for making specialist products.
- Highland Park distillery supports a local supply chain of 5 growers which produces about 50 t of malting barley annually for the distillery. This is then malted at Highland Park and is being used for the production of an “all-Orkney” whisky.
- The Agronomy Institute manages a supply chain which produces about 50 t of Bere annually for Bruichladdich distillery for the production of Bere whisky.
- Locally grown Bere has also recently been used by the Highland Brewing Company for producing a new beer (Scapa Bere).
- Straw from locally grown oats is used by several manufacturers of Orkney chairs.

Shetland currently has two micro-breweries and a distillery under development which are potential markets for local barley/malt. It also has several bakeries and restaurants/hotels which are potential users of local flours (Bere or other types of barley are the most likely). Undoubtedly, the infrastructure and machinery needed to utilise cereals is much poorer in Shetland than in Orkney and this is a serious constraint in using them for food and drink markets. In particular, the following can be highlighted:

- Wet weather at harvest in the Northern Isles can make the harvesting of cereals difficult, and it is important that growers are able to take maximum advantage of suitable windows of opportunity when these occur. Under these conditions, producing grain for malting or milling is most likely if growers have their own combine or have ready access to a contractor who is able to harvest at short notice. The number of farmers in this situation is limited as there are probably only about 8 combine harvesters in Shetland.
- Grain for malting or milling also requires drying very soon after harvest to prevent deterioration in quality and to allow safe storage. There is only one small grain dryer in Shetland and this is only capable of drying about 0.6 t of grain in one batch.
- Orkney benefits from having a functioning mill which has a tradition of producing Beremeal. There are no comparable functioning large mills in Shetland but there are a few “almost operational” horizontal or click mills (e.g. at the Shetland Croft Museum at Voe).
- In order to use locally grown barley for making beer or whisky, it must first be malted. In Orkney, Barony Mill is testing the use of traditional “sweet heap” malting of Bere in batches of approximately 0.5 t. This would also be possible in Shetland, but it is not yet clear whether this will produce commercially acceptable malt. An alternative to

this would be to send grain away for malting. Unfortunately, there are no commercial maltings in Scotland capable of malting small quantities (e.g. 1-3 t) and the Agronomy Institute has sometimes had to send Bere down to the south of England for malting. This adds considerably to the cost of using local grain for brewing.

In spite of the above challenges, if a strong partnership could be developed between a few growers and end-users, the feasibility of using local cereals for food and drink purposes could be investigated. If this is successful, it could provide the justification for expansion and the investment in equipment and machinery this would require.

Initially, because of its traditional association with the islands, and the different markets it can supply, Bere would probably be the most suitable cereal to use, although its low yield will mean that growers will require a high premium for grain. The development of a food and drink market for Bere would also provide a mechanism for conserving Bere in Shetland. The two markets which could be investigated are for milling and malting and possible approaches are outlined below:

- Growing Bere. A crucial aspect in developing markets for Bere will be to identify one or two enthusiastic growers who are keen to participate. They should also have ready access to a combine harvester and also to the SOPG grain dryer to ensure maximum likelihood of good quality grain being produced. It would also be important to collect data on the production costs of Bere and the output of grain (at a specific moisture content) and straw so that a realistic price for grain can be calculated. About 1.5-2.0 ha would be required
- Milling. With a milling out-turn of about 75-80%, initially about 300 kg of grain would provide sufficient beremeal for testing. The easiest option for producing this would be to do this in collaboration with one of the owners of a functioning horizontal mill (Photograph 3, p. 32). It would be necessary to discuss this first, however, with SIC's Department of Environmental Health to ascertain that milling could be done in such a way that this would meet food hygiene standards. If this is not possible, then it may be necessary to acquire a set of millstones and set these up with an alternative power source in a location where it would be easier to meet hygiene standards. Testing of the acceptability of the locally produced Beremeal should be done in collaboration with local restaurants, bakeries, cafés and retail outlets (e.g. Scoop). Once a good local product has been produced, its profile could be raised by holding cooking demonstrations/events which could also provide information about Beremeal, milling in Shetland and Bere the crop. These might also involve links with schools, Shetland College, history societies and Quendale mill.
- Malting. Bere malt could provide the basis for unique product development by Shetland's two breweries and its developing distillery. In fact, Valhalla brewery already uses Bere from Orkney in its beer, Island Bere. It might also be possible to find a brewery or distillery outside Shetland which would be interested in using Shetland Bere. Initially, collaboration with just one of these companies would be sufficient to investigate the potential for developing malt from Shetland Bere. The grain would need to be sent to England for malting and about 1.5 t would probably be needed to produce about 1.0 t of malt (depending on how much screening was done to the grain). This would be sufficient for breweries to make several test batches of

beer, depending on the proportion of Bere malt used. In the 2014 trial at Bigton, the Thousand Grain Weight of Shetland Bere was very low (25.7 g compared with 36.0 g for Bere grown in Orkney), showing that the grains are very small. Plump grains tend to produce malt which gives a higher alcohol yield and so, if this cannot be improved, the small size of Bere from Shetland might be an added disadvantage. This aspect would need further investigation in the feasibility project.

2.5.6.4 Straw

Apart from the use of straw for animal bedding, it can be a valuable commodity when used for thatching, making into backs for Shetland chair or for weaving into traditional objects like baskets (kishies). The straw traditionally used in Shetland for these purposes was from Shetland aets and small quantities are still grown for chairs (on Fair Isle) and basketry. Shetland Museum has responsibility for thatching a number of historic buildings (e.g. South Voe horizontal mill, Photograph 2, p. 31) and estimates that it has an annual requirement for about 200-300 sheaves (c. 0.5 ha). Harvesting of straw for these purposes is time-consuming because it has to be cut by scythe, sickle or reaper binder (combine harvesters break the straw) and tied into sheaves which are then stooked and stacked. After threshing, the straw needs to be cleaned. In Orkney, there are about 5 people making Orkney chairs professionally and several who do this part-time. Mostly, they are using straw from modern oats and, therefore, the use of Shetland oats for Shetland chairs could be a way of giving Shetland chairs a unique selling point.

The development of greater use for Shetland aets straw would be an attractive way of helping to conserve the crop and could involve running courses for schools or at Shetland College as well as historical/cultural exhibitions for tourists. The development of this area would benefit greatly from interacting with the few people who are still actively using straw (e.g. Ewan Balfour who makes kishies and Stewart Thomson who makes chairs in Fair Isle).

3 Trial Of Early Maturing Cereal Varieties

3.1 Introduction

For several years, the Agronomy Institute (AI) of the University of the Highlands and Islands (UHI) has been testing early maturing north European cereal varieties in Orkney. Since some of these varieties had performed well in Orkney for several years, they were considered particularly suitable for Shetland. Inclusion of the Institute in a cereals project with other north European partners, together with funding from the Mains of Loirston Charitable Trust, provided an opportunity to test some of these varieties in Shetland in 2014. SLMG identified a grower, Bryden Budge at Bigton Farm in the south of mainland, who was keen to host the trial.

3.2 Results And Discussion

The trial (Photographs 4 to 6, pages 32 and 33) was planted on 30 April 2014 and consisted of 5 barley varieties (Shetland Bere, Tiril, Saana, Iskria and Vilde) and one oat (Haga). The Norwegian varieties Vilde and Haga have been grown successfully in Orkney for 2-4 years

by the Institute while Tiril, Saana and Iskria were early varieties provided by other partners in the European cereals project. Iskria is from Iceland, Tiril is favoured in Northern Norway and Saana is a malting variety from Finland. The trial contained 3 replicate plots of each variety and was treated with herbicide on 28 May. Farmyard manure was applied to the trial area before planting and a further 120 kg/ha of 16:16:16 at planting. No fungicide was applied to the trial so that the susceptibility of the varieties to disease could be assessed.

The variety which developed most rapidly was Tiril but this was also highly susceptible to mildew (*Blumeria graminis*) (Photograph 7, p. 34). To a lesser extent, Iskria, Saana and Bere were also affected by mildew. Bere was the worst variety for lodging which started in late July/August; closer to harvest, Saana also lodged badly. Although it was originally hoped to harvest the plots by combine, it was difficult to find an opportunity for doing this and so yields were estimated from samples harvested by hand from a 0.6 m^2 area in each plot when each variety reached maturity. The data are summarised in Table 5. Amongst the barley, Vilde (Photograph 8, p. 34) and Iskria were the most promising varieties, combining both reasonable grain yield (4.55 and 4.48 t/ha at 15% mc) and straw yield (4.61 and 4.55 t/ha) with earliness (121-125 days from planting to harvest). Saana was slightly lower yielding than these varieties while Bere and Tiril were both much lower yielding. Birds ate most of the grains of the oat variety Haga before it could be harvested but the straw yield of Haga (5.48 t/ha) was the highest of all varieties.

For comparison with the above, the same sampling system was used to estimate yield for an adjacent field of Waggon barley which was planted almost 2 weeks earlier than the trial and which received a fungicide spray. Waggon was harvested at 149 days after planting and had grain and straw yields of 5.27 t/ha (at 15% mc) and 4.33 t/ha (dry weight), respectively, and a thousand grain weight of 34.9 g. Although Vilde and Iskria had about a 14% lower grain yield than Waggon, their straw yields were slightly higher than those of Waggon. Grain size, reflected in thousand grain weight, was lower in the northern varieties than in Waggon; this was especially the case for Vilde because it is a 6-row barley. It is likely that the yield advantage of Waggon would have been less if the northern varieties had also received a fungicide spray.

The trial demonstrated that the north European barley varieties Vilde and Iskria are promising early maturing varieties for growing in Shetland but that, compared with a variety like Waggon, growers can expect a grain yield penalty of about 10-15% as a result of earliness. Straw yield, however, appears to be similar. The trial also indicated that the oat variety Haga was very promising for Shetland, having a very high straw yield and showing good resistance to lodging. The suitability of Haga for Shetland is also indicated by results from another small area of Haga grown further north in Shetland in 2014 which performed well and was reported to have better resistance to lodging than an adjacent area of the variety Canyon. Although grain yield data were not available for Haga in Shetland, it yielded 5.62 t/ha (at 15% mc) in Orkney which was about 9% less than that of the slightly later maturing Canyon. In two previous years, Haga out-yielded Canyon in Orkney.

Table 5. *Summary of harvest data from the Bigton Farm cereal trial.*

Variety	Date of harvest	Days from planting to harvest	Grain yield (t/ha @ 15% mc[1])	Thousand grain weight (g)	Straw yield (t/ha (dry weight))[1]	Straw length (cm) [1]
Iskria	28 Aug 14	121	4.48 a	32.8 a	4.55 ab	75.2 d
Saana	14 Sep 14	137	4.01 a	32.3 a	4.13 b	73.5 d
Shetland Bere	14 Sep 14	137	2.59 b	25.7 b	3.79 b	94.3 a
Tiril	29 Aug 14	122	1.96 b	19.6 c	4.09 b	86.9 b
Vilde	2 Sep 14	125	4.55 a	27.8 b	4.61 b	83.0 c
Haga	1 Oct 14	149	-	-	5.48 a	94.6 a

[1] Means followed by the same letter are not significantly different (at P<0.05).

4 Provisional Guidelines For Shetland Cereals

4.1 Introduction

Based on the information generated by the project, a broad set of guidelines for growing cereals in Shetland have been developed in collaboration with SLMG and SAC Consulting in Lerwick. As detailed information on several specific aspects of cereal growing have already been produced for UK or Scottish growers by the Home Grown Cereals Authority (HGCA) or SAC/SRUC, the guidelines refer readers to the relevant publications and concentrate on providing information about practices which have to be carried out differently in Shetland because of local conditions. Since it is anticipated that extra information, resulting from the NORA project, may be included in the guidelines, they are only presented as provisional guidelines at this stage and are included in Appendix 3.

Acknowledgements

The author is especially grateful to Ronnie Eunson, Chairman of Shetland Livestock Marketing Group, and Graham Fraser, Senior Consultant with SAC Consulting in Lerwick, for their support and assistance throughout this project. He is also very appreciative of the assistance provided by the late Bryden Budge and his family in managing and collecting data from the Bigton cereal trial. Finally, he would like to thank all the others who have contributed information to this report (see Appendix 1) and to the Mains of Loirston Charitable Trust for the funding which allowed the project to be undertaken.

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Appendix 1. List Of People Consulted

Ronnie Eunson, Chairman Shetland Livestock Marketing Group

Graham Fraser, Senior Consultant SAC Consulting

Bryden Budge, grower

John Alex Cromarty, grower/contractor

Tommy Isbister, grower

Stuart Balfour, grower

John Flaws, grower

Peter Dodge, grower

Ben Wilcock, grower

Marty Hay, Orkney grower

Pete Glanville, Shetland Organic Producers Group

Stewart Thomson, grower and maker of chairs

Ian Smith, owner of Troswick horizontal mill

Joyce Henderson, South Mainland Community History Group

George Black, South Mainland Community History Group

Ann Johnson, Scoop Wholefoods

Sonny Priest, Valhalla Brewery

Rhanna Turberville, Lerwick Brewery

Stuart Nickerson, The Shetland Distillery

Richard Shearer, William Shearer (agricultural seeds and general merchant)

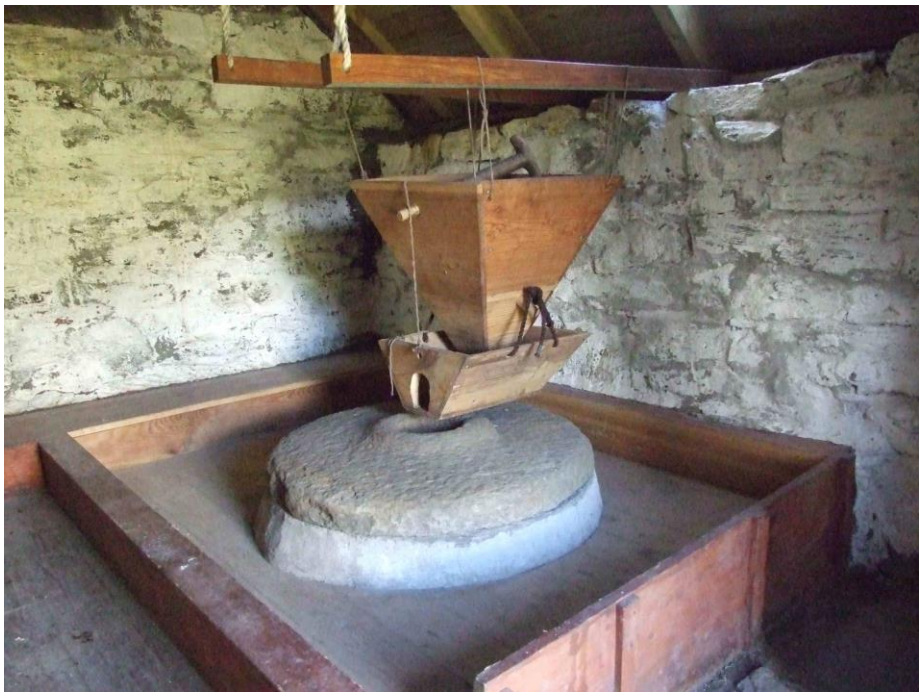
Dr Ian Tait, Curator of Collections Shetland Museum

Kristopher Bevan, Freight Manager, Serco NorthLink Ferries

Appendix 2. Photographs

Photograph 1. *Iron Age trough querns at Jarlshoff. Querns for grinding grain are common at many Shetland archaeological sites, providing evidence for the historical importance of cereals in Shetland.*

Photograph 2. *Horizontal mill at South Voe Crofting Museum. This dates from the 18th century when the majority of flour in Shetland was produced from locally grown grain. This is one of the buildings for which Shetland Museum requires thatching material.*



Photograph 3. *Mill stone and grain hopper inside Tommy Isbister's restored horizontal mill at Burland Croft Trail, Trondra.*

Photograph 4. *Cereal variety trial at Bigton Farm on 2 June 2014. Photograph supplied by Bryden Budge.*

Photograph 5. *The Norwegian oat variety Haga (left) and Icelandic barley Iskria (right) in the Bigton Farm variety trial on 6 July 2014. Photograph supplied by Bryden Budge.*

Photograph 6. *The Norwegian and Finnsh barley varieties Tiril (left) and Saana (right) in the Bigton Farm variety trial on 6 July 2014. Photograph supplied by Bryden Budge.*

Photograph 7. *The Norwegian barley variety Tiril on 17 July 2014. No fungicide was applied to the trial so that varieties could be assessed for disease susceptibility. Although Tiril was the earliest variety in the trial, it was very badly affected by powdery mildew as can be seen from the photograph (supplied by Graham Fraser).*

Photograph 8. *The Norwegian barley varieties Vilde (left) and Tiril (right) on 14 August 2014.*

Photograph 9. *Some of those who attended the cereal open event at Bigton Farm on 15 August 2014.*

Appendix 3. Provisional Guidelines For Growing Cereals In Shetland

By Peter Martin, Graham Fraser and Ronnie Eunson

Introduction

Growing cereals in Shetland is a challenge, principally because of the weather, but also because of other factors like potential damage from birds (especially geese) and a lack of readily-available, appropriately-sized machinery. The guidelines below have been drawn up to summarise some of the most important considerations to be taken into account. As detailed information on several aspects of cereal growing have already been produced for UK or Scottish growers by the Home Grown Cereals Authority (HGCA) or SAC/SRUC, the guidelines direct readers to these publications and concentrate on providing information about practices which have to be carried out differently in Shetland because of local conditions. Although several species of grain-producing crop are covered by the term "cereals", the present guidelines only cover barley and oats as these are the ones most suited to conditions in Shetland. The format of these guidelines is to first present general considerations which are then followed by more specific ones for different crops and end-uses.

Location and weather

Shetland is the most northerly area where cereals are grown in Britain and its maritime climate and northern location (60^{o}N) create special growing conditions which require modifications to the agricultural practices commonly used in more southerly areas. The weather-related factors of particular significance for cereals in Shetland are its late spring, low growing season temperatures, high rainfall and frequent strong winds. In spite of the challenges in growing cereals in Shetland, there have been several recent years with markedly warmer growing seasons than occurred in the last decades of the 20th century and, if these trends continue, they may make cereal growing easier in these islands.

Soils

With large areas of acidic, peaty soils in the interior of Shetland, the best areas for cereals are in some of the more fertile valleys (e.g. the Tingwall valley) and in coastal locations where lighter, sandy soils occur. Much of this is in the south of mainland, but parts of Unst are also suitable. The advantage of lighter soils is that they are free-draining and can be cultivated and planted earlier in the spring and are less likely to present trafficking problems

at harvest. Crops also mature earlier on these soils and they are less likely to present trafficking problems during wet harvests. One disadvantage of coastal, sandy soils is that they are derived from beach sands and have a high pH which can result in manganese deficiency – but, this can be remedied by a foliar spray of manganese. Shetland's traditional landraces, Bere and Shetland oats, are thought to be more tolerant to soils with a low manganese content than modern varieties.

It is important to regularly analyse (every 4-5 years) the soil nutrient content and pH of fields where cereals are being grown and to use these and a field's cropping history as a basis for determining how much fertiliser to apply (Fertiliser Manual (RB209), DEFRA 2010). Where mineral fertilisers are used, the application rate should take into account any organic manures which are also applied. It is normally found that field fertility is highest in the first year that a field is brought into arable cropping and gradually declines in subsequent years. Soil pH should be above 6.0 for good cereal growth.

Varieties

Shetland winters are characterised by frequent gales, high rainfall and prolonged periods of waterlogging – conditions which are unfavourable for the survival of winter cereals. Consequently, only spring varieties are used. To some extent, the most important attributes of a variety will depend on the end-use for which it is being grown, but generally the following are of particular importance in Shetland: strong straw to prevent lodging, earliness, good grain and straw yields and disease resistance. Each year a list of cereal varieties, recommended for use in Scotland, is released by SRUC and the list for 2015 can be found at http://www.sruc.ac.uk/recommendedcereals . This is a good source of information about newly released varieties. Modern varieties which are known to perform well in Shetland include Waggon (barley) and Canyon (oats), although some growers still use older varieties like Tyne which is favoured for its earliness. A few north European varieties like Vilde (a 6-row barley) and Haga (oats) are also thought suitable, but have not been extensively tested. Comparing barley and oats, barley is usually earlier to mature than oats but the latter are often considered to be less demanding in inputs. Oats are probably best used for whole crop silage because they are late maturing.

Cultivations

Before sowing, the land must be ploughed and power harrowed, operations which are very weather dependent. Power harrowing may be done at the time of sowing in a one-pass

operation. To achieve good germination and a fairly even plant stand, the seed bed should be firm and fairly fine.

Sowing

Sowing date depends very much on when weather conditions allow cultivations to be completed, but ideally this should be in April. But, on heavier land it may not be possible to do this until early-May while, on lighter land, planting in late-March is sometimes possible. The advantage of early planting is that it will allow the crop to make the best use of long summer days and usually results in higher yields. It also usually results in an earlier harvest which often means harvesting in dryer conditions.

The seed rate at planting should be adjusted to produce a seedling population of about 320 plants/m^2. This requires a knowledge of the seed's Thousand Grain Weight and germination percentage. Excessively high plant populations can result in tall plants which are more susceptible to lodging.

After sowing, roll the ground as this will help establishment.

Use Of Herbicide And Fungicide

Where land is not under organic management, it may often be considered necessary to apply herbicide to control weeds and fungicide, to control fungal diseases. Good control of weeds and disease usually results in higher grain or whole-crop yields. To be most effective, crop protection chemicals need to be applied close to specific stages of weed growth or crop development (growth stages, GS), but also need to take into account the types of weed or diseases which are present. For example, herbicide should be applied while weeds are young (preferably when they have 2-4 leaves) to reduce weed competition with the developing crop while fungicide is usually applied to spring barley at GS25-30 (T1) to reduce early disease outbreak and at GS39-49 (T2) to provide maximum protection to the flag-leaf and ear which provide much of the nutrients for grain filling. In the Northern Isles, where there is less disease pressure, many farmers only apply a T2 spray. Since the use of crop protection chemicals increasingly relies upon specialist knowledge and machinery, and misuse can have serious environmental consequences, it has become increasingly common for farmers to use advisors and contractors to provide advice about the chemicals to be used and to apply them. In this case, it is important to arrange for crop inspections to be done at an appropriate time, bearing in mind that unsuitable weather often delays spraying in Shetland.

Harvesting

If cereals are being used for animal feed, there are several different ways in which they can be harvested. The main differences in harvesting methods are the stage of crop development when this occurs and, consequently, the moisture content of the grain at harvest. The main options for harvesting cereals for feed are briefly outlined below:

Whole Crop Cereal (WCC) Silage. This is made from crops which are in the early stages of grain development (soft dough to hard cheddar stage) when grain moisture is above 45%. In appearance, the crop is between having green ears and stems to only having some green in the stem and has an overall dry matter content of 40-45%. Harvesting is carried out by cutting the whole crop with a direct-cut precision chop harvester. Yield and feeding value are affected by the height at which the stubble is cut. Crops cut with low stubble have higher yields, but lower feeding value. A short chop length (c. 2.5 cm) and use of a narrow pit will help to reduce aerobic deterioration. The silage should be well-compacted, double-sheeted (to prevent aerobic fermentation) and weighed down. Use of baits around the pits is often necessary to control rodents.

Crimping. A crop is suitable for crimping when grain moisture content is at about 35%, which is about 3 weeks before it would be ready for harvesting as dry grain. After harvesting grain with a combine, the grain is crimped (crushed with rollers) and an additive mixed in. This is an organic acid which reduces pH and aids preservation. The grain is then put in a pit, well-rolled and sheeted. Alternatively, with the appropriate equipment, it may also be stored in bags.

Propionic Acid Treatment (Propcorn). This can be used for grain which is harvested with a moisture content up to 25%. Often the propcorn is applied by a pump at the base of an auger as the grain is put into store. Treated grain should not be stored directly on concrete as the acid will attack it. The floor can be protected by using a barrier paint or plastic sheet. The grain will need to be rolled or milled before it is fed and a vitamin E supplement may be necessary as this can decline in storage.

Harvesting Cereals For Dry Grain. Drying of grain for animal feed is not often done in Shetland because of the lack of grain drying facilities and because the previous options are easier considering the region’s high rainfall. Dry grain is required, however, if it is going to be used for milling, malting or seed. For all of these purposes, grain needs to be dried down to about 13% moisture content for stable storage. This will be easiest if the cereal crop is

combined at a fairly low grain moisture (<22%) which is most likely to be achieved with early-maturing varieties.

For malting and seed, a high germination percentage is required and, for this, the grain drying temperature should not exceed 38ºC. In addition, low levels of grain nitrogen/protein are usually expected in grain which is being purchased for malting because high levels can reduce alcohol yields and produce problems of haze. The most desirable level of grain nitrogen/protein depends on whether the grain is being used for brewing or distilling; lower levels are normally required for distilling. To achieve low grain nitrogen/protein, growers need to pay careful attention to the amount of fertiliser applied to barley and it is often best to use fields which have been in arable cropping for several years. Sometimes, where an end-user is primarily concerned with obtaining grain with unique provenance (e.g. “grown in Shetland”), grain nitrogen/protein content may not be considered so important. This needs to be ascertained, however, before the crop is grown.

Special Considerations Related To Landraces

Shetland is one of the last locations in Scotland where two traditional cereal landraces are still grown. These are Bere, a 6-row barley (*Hordeum vulgare*), and Shetland aets (*Avena strigosa*). Cultivation of both these species is now on a small scale, by only a few growers, and there is a real risk that, in the near future, these landraces may cease to be grown. Although Bere is also grown in both Orkney and the Western Isles, research at the James Hutton Institute has shown that there are genetic differences between the types of Bere grown in each area. It is likely that there are similar differences between the *Avena strigosa* which is grown and for this reason it is important to conserve both crops in cultivation in Shetland.

Both landraces have long straw and are susceptible to lodging which can make harvesting difficult. In a wet year, heads can be slow to dry out and this may result in grains germinating in the head. In the past, these crops were often grown on nutrient-poor soils and they should not be grown on very fertile land as this will result in tall, lush growth which usually results in serious lodging. For the same reason, if mineral fertiliser is used, only small amounts should be applied. Lodging of both species can also be aggravated if too close a spacing is used at planting. This can happen if the seed is broadcast manually by someone with little experience. The most satisfactory results will be obtained by drilling both crops and in Orkney, with seed of a high germination %, a seed rate of 160 kg/ha is used for Bere and 95 kg/ha for *A. strigosa.*

In recent years, considerable damage to small areas of both crops has been caused by birds – not only geese, but also sparrows and pigeons. Attempts to protect these areas have often not worked well and it has been suggested that growing of small plots should not be encouraged - unless excellent bird-protection measures are used. A minimum area of about 0.1 ha (0.25 ac) is thought to be appropriate.

Bere is one of the very few cereals in Shetland which is usually grown for dry grain and very small quantities are still occasionally used for grinding into Beremeal. When grown in a large area, Bere can be harvested by combine. To maintain the purity of Bere, it may be necessary to rogue out other volunteer cereal plants, especially other types of barley, but also Shetland aets. After drying the grain, seed for the following year should be kept in a cool, dry vermin-proof environment. Shetland Organic Producers Group (SOPG) purchased a small electric grain dryer specifically for drying Bere and Aets. This is suitable for drying up to about 0.5 t of grain. Access to the grain dryer can be obtained through SOPG.

Aets is normally grown as a source of straw - for weaving into baskets or kishies or for making into strawback chairs. To obtain straw of a suitable quality the crop has to be cut by sickle, scythe or binder and the straw is tied into sheaves which are usually left in the field for initial drying before being put into a stack or put under cover. After threshing, the grain should be dried and stored safely, like Bere.

As an insurance against losing Bere or Aets as a result of crop failure, it is a wise precaution for each grower to hold a reserve of their own seed which should be stored safely and replaced annually. Extra security can be obtained by using SASA's Landrace Protection Scheme (http://www.scottishlandraces.org.uk/scottish_landrace_protection_scheme.htm). Seed deposited with SASA will be cleaned and kept safely in cold-storage. Some of it can be later reclaimed by the grower, if this is necessary.

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Acknowledgements

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