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Why bother with *Bere*? An investigation into the drivers behind the cultivation of a landrace barley

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Abstract

Why would the farmers in a developed, Western country, dominated by an industrialised agriculture, choose to grow a traditional crop variety? This study aimed to explore this question through an investigation of the reasons why a traditional landrace barley – known as *Bere* – was still grown in the Scottish islands of Orkney and Shetland. Cultivated barley is one of the oldest and most widely grown cereals in the world and plays a significant role in global food security. However, since the beginning of the 20th century the genetic diversity in cultivated barley has been in decline as traditional varieties are replaced with modern cultivars. Traditional varieties, such as landraces, are an important genetic resource, and there is a growing interest in their *in situ* conservation, both in Europe and internationally. The success of such activities would benefit from a proper understanding of the factors that drive farmers' motivations to maintain barley landraces on their farms and this study intended to fill the knowledge gap that existed in this regard in a European context. Interviews were conducted with *Bere* growers and representatives of the food manufacturing industry on the islands to discover why they valued this crop. This was complemented by insights from agricultural calendars, preference ranking tasks and photographic data. Thematic analysis of the data yielded four broad drivers of *Bere* cultivation: market demand, cultural and traditional values, adaptation to conditions, and use as a low-input crop. Preference ranking of these drivers showed their perceived relative importance and the variations in such perceptions between Orkney and Shetland. The paper concludes by discussing the implications of the findings for devising more effective *in situ* conservation strategies for barley landraces in Europe and further afield.

Keywords: Landraces; Crop genetic resources; *In situ* conservation; Drivers of farmer behaviour; *Bere* barley; Sustainable agriculture; Agrobiodiversity; Europe

1 Introduction

Why would the farmers in a developed Western country, dominated by an industrialised agriculture, choose to grow a traditional crop variety, rather than a modern variety (e.g. a hybrid)? This investigation sought to explore this question by uncovering the drivers behind the continued cultivation of a traditional barley landrace – known locally as *Bere* – in the Scottish islands of Orkney and Shetland. Little was known in this regard (Green et al., 2009a,b) and this study aimed to identify the drivers as well as the relative importance of these drivers to the individuals cultivating the crop.

1.1 What is *Bere*?

Bere, a six-row, landrace[1] variety of cultivated barley, is considered to be one of the oldest extant crop varieties in the UK (Scholten et al., 2009). The exact origin of *Bere* is unclear. One body of evidence indicates that it was introduced via waves of Viking invasion from Scandinavia in the 8th century (Martin and Wishart, 2007; Theobald et al., 2006). However, the distinctiveness of the populations of *Bere* in Orkney, Shetland and the Western Isles suggest its cultivation in Scotland may have begun much earlier than this (Glanville and Balfour, 2005). Furthermore, pollen analysis from Shetland suggests that six-row barley has been cultivated in the North of Scotland since Neolithic times (Boyd, 1988). Although whether this is an ancestor of *Bere* or another variety of six-row barley is unknown.

The large number of small, horizontal mills dating from the mid-18th to mid-19th century on Shetland attest to the importance of both *Bere* and native varieties of oats to the population of Northern Scotland (Martin, 2015). Data on the agricultural statistics of

Scotland in the 1850's state that 10% of all barley grown in Scotland was *Bere*, with the majority grown in the North and East of the country (Thorburn, 1855). However, although once common, *Bere* is now only found on Orkney, Shetland and the Scottish Western Isles (Martin et al., 2010). It was estimated that, by the end of the 20th century, as little as 10 ha of *Bere* was grown in Scotland (Martin et al., 2010), with the UK National Inventory of Plant Genetic Resources for Food and Agriculture conducted in 2004 finding no evidence of *Bere* cultivation on mainland Scotland (Scholten et al., 2004). It is also estimated that during the same time period *Bere* cultivation on the Scottish Western Isles had been reduced to as few as between six and twelve farms, with the majority of the crop grown as a mix, along with rye and oats. On the other hand, on Orkney and Shetland it is estimated that as few as only two farmers continued to grow *Bere* (Scholten et al., 2004).

The reasons for the decline of *Bere* in Scotland are not well documented (Martin and Chang, 2008; Hay, 2012). However, it is known that from the 19th century onwards there was a move from the cultivation of traditional, six-row barley varieties – such as *Bere* – to the cultivation of modern, two-row barley varieties, due, in part, to the latter's superior malting qualities (Backes et al., 2003). The decline of *Bere* on Orkney and Shetland meanwhile has been linked to the increase of sheep production. This began in the 19th century, as wool production became an important industry, and continued into the recent past, with EU subsidies encouraging the stocking of sheep at higher densities (Martin, 2015; Science and Advice for Scottish Agriculture, 2015).

Recently, a small, but important market has been developed by a number of local organisations for products containing *Bere*. This is especially the case on Orkney. Barony Mills[2], located in Birsay, Orkney, mills *Bere* grain to produce traditional baked goods, such as bannocks and shortbread. Since 2002, the Agronomy Institute at Orkney College has been researching the potential uses of *Bere*. The institute now manages a supply chain to produce *Bere* grain for malt for distilling. Highland Park distillery, also located in Kirkwall, Orkney, is investigating the use of locally-produced *Bere* in its products by working with a small number of growers on the islands. Shetland, in contrast, has yet to develop a market for *Bere* products or the infrastructure required to process *Bere*, such as distilleries, mills, and malting facilities (Martin et al., 2009; Martin, 2015).

Bere has a number of features which may make it well-suited to the agriculture in Orkney and Shetland. As a crop barley is not well-suited to acidic soils. In contrast, *Bere* is well-adapted to soils of a low pH due to a single gene on chromosome 4, designated as Pht by Stølen and Andersen (1978). However, *Bere* is much taller than modern cultivars of barley (reaching up to 120 cm when mature) and thus is particularly susceptible to lodging, making machine harvesting more difficult when compared with modern cultivars, such as hybrid varieties. This could, potentially, be another reason why its traditional range has been so reduced (Ellis, 2004; Martin et al., 2009; Martin and Chang, 2008). However, in Orkney, and especially in Shetland, the field sizes are much smaller than elsewhere in Britain. This means that they are much less suitable for large-scale machinery, and therefore, issues with machine-harvesting may not be so much of a drawback (Martin, 2015).

Bere traditionally required few inputs when compared with modern cultivars of barley (Theobald et al., 2006). It can produce a good yield in nutrient-poor soils without extra fertilization and the labour required to apply these inputs (Scholten et al., 2009). *Bere* is therefore uniquely suited to “crofting[3],” which requires the farmer to split their time between small-scale agricultural activities and a secondary source of income.

Although poorly frost tolerant and susceptible to mildews and other foliar diseases, *Bere* is able to grow rapidly in the long Summer days experienced at high latitudes (Wright and Dalziel, 2002). Shetland typically has 100 growing days per year only, whereas the Southern UK can have as many as 300 growing days per year. Cultivating a quick growing crop could be advantageous in these regions (Glanville and Balfour, 2005). Furthermore, data from the Scottish Plant Breeding Station produced in the 1970's suggest that the yield potential of *Bere* was greater than contemporary cultivars due to a greater number of ears and a greater number of larger grains per ear (Riggs and Hayter, 1975). A visual comparison between *Bere* and a modern, hybrid cultivar of barley can be made in Fig. 1.

Fig. 1 *Bere* (right), displaying characteristic long straw and awns, and a modern cultivar of barley (left), displaying short straw and less prominent awns (photo source: this research).

In contrast to many modern cultivars of barley, *Bere* has traditionally had multiple uses, many of which are still fulfilled by the crop on Orkney and Shetland (Martin and Chang, 2008). The most common of these include: fodder for livestock, malt for beer and whiskey production, and flour (‘*Bere-meal*’) for use in traditional breads and bannocks (Green et al., 2009a,b; Martin et al., 2009). The crop has also been used as animal bedding and, historically, as a material for thatching and weaving (Glanville and Balfour, 2005). In more agriculturally favourable regions of the UK, other cereals fulfil these roles. However, although these uses and the advantageous features of *Bere* have been discussed in the literature, it is still unknown as to whether these factors influence farmer decision-making in regards to the cultivation of *Bere* on Orkney and Shetland.

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1.2 Why bother with *Bere*?

Whilst, it can be seen from the previous section that *Bere* has certain unique features, the question remains as to why we should be particularly interested in such a crop today. The answers to this question lie in the global significance of barley as a cereal crop and the importance of barley landraces in terms of addressing some of the crucial challenges facing contemporary global agri-food systems.

Cultivated barley, *Hordeum vulgare* L. ssp. *Vulgare*, is one of the oldest and most widely grown cereals in the world. In terms of world production, barley ranks fourth after maize, wheat and rice (Newman and Newman, 2008). It plays a significant role in global food security in terms of direct human consumption and continues to be a major dietary constituent in large parts of Asia (e.g. India and China), North Africa (e.g. Morocco) as well as Europe and the Americas. Other benefits of barley include: the production of alcoholic beverages (especially beer) and use as animal feed. There is a growing recognition that barley has many human health benefits because of its high soluble fibre content, which helps maintain intestinal health, and provides protection against hypertension, stroke, cardiovascular diseases, and type-2 diabetes (see Newman and Newman, 2008).

In addition to the benefits relating to food and feed, barley has the remarkable ability to grow in adverse climatic and edaphic conditions. Newman and Newman (2008) describe barley as a crop that grows on the "frontiers of agriculture" – in regions under stresses, in which only marginal yields can be obtained from other cereals. This ability is due to the underlying genetic diversity of barley (Thiel et al., 2003; Pasam et al., 2014; Ward, 1962), which, many (e.g. Hakala et al., 2012; Himanen et al., 2013; Pasam et al., 2014; Wright and Dalziel, 2002) believe, is crucial for tackling contemporary challenges facing global agriculture, such as the need to grow more food for a growing world population under scarcities of arable land and freshwater and the threat of global climate change (Foresight, 2011; Godfray et al., 2010).

However, since the beginning of the 20th century, the genetic diversity in barley, as in other major cereals, is in decline because of the replacement of traditional barley varieties, such as landraces, with modern, elite, hybrid cultivars (Doebley et al., 2006; Maroof et al., 1994). Landraces are superior in terms of genetic diversity when compared to the modern, genetically uniform, elite cultivars (Pasam et al., 2014). Although modern cultivars provide higher yields under optimal conditions, Yahiaoui et al. (2014) find that landraces can outperform modern cultivars under adverse conditions. Landraces also act as a source of many useful traits and vital information regarding the physiological and genetic mechanisms of stability in stressed conditions (Grando and McGee, 1990). All these features of landraces have already been successfully utilized in crop improvement programmes. Examples include: the introgression of plant height dwarfing alleles derived from the Japanese what landrace "Shiro Daruma", several insect and disease resistance genes in wheat, submergence tolerance in rice, broad spectrum powdery mildew resistance from an Ethiopian barley landrace, as well as boron toxicity tolerance in barley obtained from an Algerian landrace (Pasam et al., 2014).

Considering their importance worldwide, efforts have been undertaken at multiple scales to promote the conservation of landraces, both *ex situ* and *in situ*. At an international scale this includes the implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2003). Within Europe, efforts to preserve landraces have been undertaken by groups of farmers, such as "Rete Semi Rural" in Italy, "le Réseau Semences Paysannes" in France, and "La Red de Semillas" re-sowing and exchange network in Spain (Thomas et al., 2011). At a national scale, these efforts include the Scottish Landrace Protection Scheme, launched by the Scottish Government in 2006 (Green, 2008Please change this to 2009, thank you), and Garden Organic's Heritage Seed Library[4], which first began collecting, and making available, landrace seed in the 1970's. In terms of *ex situ* conservation, barley landraces constitute the largest proportion of germplasm conserved in gene banks (Knüpffer, 2009). However, although *ex situ* conservations are important, they have certain limitations (Wilcox, 1990). First of all, *ex situ* conservation strategies are usually highly costly. Secondly, once a species is removed from the wild it may be more difficult to protect its natural habitat from development pressures, and reintroduction of the species at a later stage may create many challenges. Thirdly, *in situ* conservation has socio-cultural (as well as economic) significance, which *ex situ* conservation cannot provide. Finally, and most importantly, *in situ* conservation preserves the evolutionary dynamic characteristics of genetic resources, allowing gene pools to continue to generate new variants of potential value, whilst *ex situ* methods can adversely affect this (Wilcox, 1990).

In Europe, there has been a growing interest in the *in situ* conservation of landraces, including barleys (C.B.D., 1992 (Please change this to 2016, thank you); Vetelainen et al., 2009). It is recognised that encouraging farmers to cultivate, or continue cultivating, landraces is an important method of conserving these resources in the region they were developed, allowing the process of evolution and crop development to continue (Maxted et al., 1997).

In order to make the *in-situ* conservation of barley landraces successful it is necessary to understand the reasons why farmers may or may not cultivate landraces on their farms, since it is the farmers whose choice ultimately determines the success or failure of on-farm conservation of landraces (Brush and Meng, 1998). However, most studies in this regard are based on developing country contexts and on landraces of maize and wheat varieties. To date, very little is known about the drivers behind the cultivation of barley landraces in Europe. This is despite the fact that Europe shares the largest proportion of area planted by barley in the world and the crop contributes significantly to the food and drink sector in the continent (Newman and Newman, 2008). An exploration of the reasons behind the continued cultivation of *Bere* can therefore contribute towards filing this knowledge gap.

The rest of the paper is structured as follows. In section two, the research methods used in the investigation are described. The results of this research are provided in section three. In section four, the results are discussed in the light of extant knowledge and theories. Finally, in section five the key conclusions and implications of the research are drawn.

2 Methodology

2.1 Analytical framework

According to the norms of case study research (see Yin, 2003) this investigation develops and applies an analytical framework drawing on farmer decision making theories. However, there is no unified theory that explains why farmers do things in the manner they do, since various disciplinary traditions tend to analyse the issue from different angles. Theories of farmer decision making in economics – such as the utility or profit maximisation hypotheses, the portfolio theory, the safety-first model, and the prospect theory – assume farmers to be rational decision makers and therefore often consider private incentives – such as the goals of profit or utility maximisation or risk minimisation – as the underlying motivating factors. Studies applying these theoretical perspectives (e.g. Heisey and Brennan, 1991; Lacy et al., 2006; Lin et al., 1974; Smale et al., 1995) often consider the performance of a variety under different agro-environmental conditions (the so called 'GxE interactions') as the central explanation to farmers' varietal choice. Varietal performance can include a wide range of traits, e.g. yield and yield stability, cycle length, resistance against biotic (e.g. pests and diseases) and abiotic (e.g. drought, soil acidity) stresses, processing and food quality, and seed colour and shape (Lacy et al., 2006). Environmental parameters may include temporal, spatial, and management dimensions, for example, seasons, years, fields, locations within fields, irrigation practices, and labour or fertilizer inputs (Lacy et al., 2006).

Empirical studies on landrace cultivation provide support for the risk minimisation hypothesis, although not necessarily for the profit maximization hypothesis. Studies from countries such as China (Li et al., 2012), Ethiopia (Abay et al., 2009), and El Salvador (Olson et al., 2012) conclude that yield or profit maximisation is not necessarily what drives the maintenance of landraces. Rather, the unique adaptability of landraces to local agro-climatic conditions – such as hardiness against certain pests and diseases, ability to grow in marginal environments, e.g. steep slopes and under irregular rainfall regimes – make them attractive to farmers, since these traits help minimise risks. Sometimes, it is the perceived unsuitability of the modern varieties to cope with local biotic and abiotic stresses that drive farmers to cultivate landraces, as observed by Olson et al. (2012) in El Salvador. Farmers in this context perceived that the cool and wet conditions at high altitudes slowed the growth of modern maize cultivars and favoured certain pests and fungal diseases. Moreover, steep slopes were prone to erosion that contributed to lodging of modern cultivars. In China, Li et al. (2012) found that farmers' perceived utilities of maize landraces included not only yields, but also traits such as particular tastes, household food requirements, and demands from specialised industries like wine-making. Tsegaye and Berg (2007) concluded that household culinary utilities were the vital drivers for the cultivation of durum wheat landraces in central Ethiopia. The study identified as many as 14 dishes and 2 drinks made from the landraces and the valued criteria included e.g. special taste, special aroma, better dough quality compared to modern bread wheat (e.g. bread wheat becomes sticky during cooking), use of roasted wheat as snacks with coffee, brewing local drinks for own consumption and sale, the suitability for brewing high quality malt, and higher shelf life.

Although rational choice explanations are useful, the central assumption of a “rational” decision maker, which underpins rational choice theories, is widely criticised as being narrow, since a farmer's decision to adopt a particular practice may not always be economic in nature. Moreover, the ability to make a fully rational decision requires access to sufficient information which is rarely the case. Alternative theories of farmer decision making, especially those coming from the disciplines of rural sociology and innovation studies (Leeuwis et al., 2004; Roling and Kuiper, 1994; Rogers, 2003), take a much broader approach that consider farmer decisions to be influenced by such factors as: cultural attitudes, beliefs, norms, values as well as social networks.

A cultural choice perspective does not necessarily rule out the importance of farmers' utility but consider such utilities to be social or cultural in nature, rather than being entirely economic. Empirical studies in Scotland and elsewhere tend to support this premise. For instance, Islam et al. (2013) found that the perceived breeding values of a *Tup* (a male sheep) within the landrace *Scottish Blackface* were cultural, rather than economic, in nature. There are many such examples in the crop sector as well. For instance, farmers' decisions to adopt maize landraces in China were influenced by the choices of neighbours and relatives as well as social preferences (Li et al., 2012). In the central Ethiopian study of Tsegaye and Berg (2007) the perceived utilities of the durum wheat landraces included many cultural attributes, including: use in dishes for special occasions (e.g., social gathering, labour exchanges, socialization events, holidays and festivals, the baptism of child, wedding ceremonies, funeral events and memorial ceremonies), a shorter cooking time, and medicinal values.

The cultivation of landraces can also be analysed from the political economy view of agri-food systems, especially the emerging theoretical perspectives of the Alternative Agri-food Network (AAFN). The term AAFN is a broad one, covering the entire networks of actors involved in alternatives to modern, industrialised food production (Murdoch et al., 2000). The growth in AAFNs taps into an emergent interest by consumers in developed countries in the provenance and authenticity of food, the traditions surrounding food, the impact of food on human health (e.g. recent “food scares” – such as bovine spongiform encephalopathy, foot-and-mouth disease, listeria, and salmonella), and an active resistance to the dominance of transnational corporations in global food systems (McMichael, 2009; Murdoch et al., 2000; Renting et al., 2003). This is often framed as a turn away from industrially-produced foods, towards perceived “quality” foods (Goodman, 2004). From the producers' point of view, involvement in AAFNs can be seen in terms of a need to boost farm incomes in situations where increases in production are not feasible, or are undesirable, for example, due to increasing production costs, or the need to meet an increasing number of regulatory standards and market specifications (Renting et al., 2003). This can especially be the case in peripheral regions, such as Orkney and Shetland. In fact, the creation of AAFNs is being promoted by the EU as a tool to drive socio-economic development in marginal regions, an example of which can be the EU-supported “Facilitating Alternative Agri-Food Networks” (FAAN) project[5] (Ilbery and Kneafsey, 2000; LEADER, 2000; Renting et al., 2003).

The influence of AAFN's on farmer decision-making can be seen in the findings emerging from the EU-supported FAAN project (LEADER, 2000). In Cumbria, in the North-West of England, the after-effects of the 2001 Foot and Mouth epidemic caused some farmers to seek alternative methods of generating incomes. From this emerged a number of diversified enterprises, ~~focusing~~ focussing on organic and bio-dynamic practices, and using direct sales, such as “box-schemes,” to interact with consumers (Facilitating Alternative Agri-Food Networks, 2010). In Hungry, “Szövet: Alliance for the living Tisza”, is further example of an AAFN. This network of fruit farmers arose after a series of scandals surrounding the pricing of apples and cherries in supermarkets. These enterprises now organise direct sales, via farmers markets and home deliveries of fruit, rather than interacting with intermediaries (Facilitating Alternative Agri-Food Networks, 2010).

The foregoing discussions indicate that an analysis of the reasons why *Bere* is being cultivated in Scotland would require a multi-dimensional approach, combing economic factors, such as local agro-climatic adaptability, with non-economic factors like cultural preferences and political-institutional influences. However, so far, empirical studies on the drivers to farmers' landrace cultivation, as discussed above, have mostly been on wheat and maize landraces and there is a paucity of knowledge as to what drives farmers' choices in regards to Barley landrace cultivation in a European context.

2.2 Characteristics of the study locations

Orkney and Shetland are two island groups, located in the extreme North-East of the UK. Orkney is located at a mean latitude of 59° ~~degrees~~ North and Shetland at a mean latitude of 60° ~~degrees~~ North (see Fig. 2). The agro-climate of the two regions is strongly influenced by their locations. This results in late, cool Springs and Summers typified by extended sunshine hours. The influence of the sea is also strongly felt in Orkney and Shetland, especially the temperature-moderating effects of the North Atlantic Drift. The mean monthly temperature of the region is approximately 9 °C, falling to an average of 3.5 °C in the Winter and rising to an average of 12.5 °C in the Summer. Average annual rainfall varies from 900 mm/year along the Eastern seaboard of Orkney to 1200 mm/year in the most exposed regions of Shetland (Dry and Robertson, 1982; Dry and Sinclair, 1985).

Fig. 2 The location of Orkney and Shetland in relation to the rest of the UK (modified from Ordnance Survey map data reproduced by permission of Ordnance Survey © Crown copyright 2013.).

Both Orkney and Shetland are sparsely populated. The population density of Orkney (22 people/km^2) and Shetland (16 people/km^2) (Orkney Economic Review, 2012–13) are much lower than the population densities of both the UK and Scotland (263 people/km^2 and 68 people/km (Backes et al., 2003), respectively) (Office of National Statistics, 2013).

The Agriculture, Forestry and Fisheries sector is a significant industry in Orkney. Agriculture on Orkney is focused mainly on livestock (sheep and cattle) production. Of the land given over to arable production, the majority is used for cereal production, with small areas of stock-feeding crops and potatoes (Orkney Economic Review, 2012–13). The Agriculture, Forestry and Fisheries sector is also of importance in Shetland; however, fisheries plays a much more significant role than agriculture. The majority of agricultural land is used for livestock production (mainly sheep and cattle, but with a small number of pigs and poultry) (Shetland in Statistics, 2011). Agricultural census data from Shetland estimates that only 60 ha of land on the islands is used to produce barley, with only 1.0 ha used to cultivate *Bere* (Martin, 2015).

Orkney and Shetland are notable for their lack of large-scale intensive farming, which is indicative of much of the agriculture of the UK (Pakeman et al., 2011). Agriculture in the region is based on small-scale commercial farms and a number of these farms are still practicing “crofting.” Traditionally, the agriculture on crofts was based on subsistence level farming; however, in many cases this has been superseded by small-scale commercial farming (Jones, 2012). Formalised crofting occurs in only seven of the counties of Scotland, with Orkney and Shetland among this number (Doughty, 1999).

The agricultural land on Orkney and Shetland was historically subject to further fragmentation because of ‘*udal*’ rights – a tradition of Norse origin. This involved partible inheritance of land to all children, rather than to the first-born (a system of inheritance more common on the UK mainland) (Vergurnst, 2012). The invocation of *udal* rights by crofters in the Orkney and Shetland Islands continues to this day and can be regarded as a way of maintaining the distinct cultural identities of the islands (Jones, 2012).

2.3 Data collection

As is the case in case study research (Yin, 2003), data for this study were collected using a variety of methods. Although interviews with *Bere* farmers, as well as representatives of the food manufacturing and processing industry, were the primary sources of data; these were complemented by insights from agricultural calendars, preference ranking tasks, and photographic data.

For the purpose of this investigation "farmers" were defined as the person or persons making the agricultural decisions on the farm in question. The participants were chosen because of their residence in Orkney or Shetland and their experience of growing either *Bere* or modern cultivars of barley. Additional data were obtained from interviews with representatives of the food manufacturing and processing industry that used *Bere* and/or modern varieties of barley in their products. The purpose of these additional interviews was mainly to complement the findings emerging from farmer interviews and to uncover the importance of the market for *Bere* in the maintenance of the crop in the study region. As already mentioned in section 1.1, Orkney and Shetland islands are very sparsely populated and the number of farmers continuing to grow *Bere* is estimated to be extremely small. The UK National Inventory of Plant Genetic Resources for Food and Agriculture (Scholten et al., 2004) suggested that at the time of the inventory as few as only two farmers in Orkney and Shetland grew *Bere*, whereas Martin (2015) estimates the number of farmers growing *Bere* on Orkney in 2015 to be at around five. Therefore, the number of interviews in this study was limited. A total of five farmers were interviewed. In addition, one individual who was both a farmer and a food processing representative and one representative from a food processing business were interviewed.

Recruitment of the interviewees was achieved via snowball sampling (Bernard, 2006). This method was chosen as the population of farmers growing *Bere* was very small (Martin, 2015; Scholten et al., 2009), and therefore relatively difficult to find. However, due to the participatory nature of *Bere* cultivation, and information sharing between farmers, participants were able to refer and recommend others from within this small population to interview (Scholten et al., 2010This should be 2004, thank you).

Audio-recorded interviews were conducted face-to-face using a semi-structured questionnaire that contained both close-ended questions as well as more exploratory, open-ended questions. Ranking scales were used to investigate the farmers' and companies' preferences for a range of barley varietal characteristics identified based on a review of the relevant literature on the drivers behind the cultivation of diverse crop species. Participants were asked to rank a total of eight characteristics from 1 (the characteristic the participant considered most important) to 8 (the characteristic the participant considered least important). This activity aimed to investigate the relationship between crop characteristics and the choice of growing and/or using *Bere* or a modern cultivar of barley. Open-ended questions allowed the respondents to express their opinions more freely and reveal information not necessarily covered by the closed questions. These questions probed, but were not limited to, perceived positive and negative attributes of *Bere*, the sowing and harvesting dates used by the farmers, the nature of the demand for *Bere* over the past ten years, the use of *Bere* on-farm or by the company in question, and the participants' opinions regarding the reasons why they continued to cultivate *Bere*.

In addition to interview data, photos of the farm and the surrounding areas were taken. The photographic data were collected in order for comparisons to be made between the growth habit and cultivation practices of *Bere* in Orkney and Shetland and between the growth habit and cultivation practices of *Bere* and modern cultivars of barley. The act of collecting photographic data was often complimented by observation of the lands under cultivation, as suggested by Vogl et al. (2004).

2.4 Data analysis

The interviews were transcribed verbatim and the resultant qualitative data were subject to thematic analysis. Organizing themes developed from the analysis were used to identify the drivers behind the cultivation of *Bere* in Orkney and Shetland. Thematic network illustrations were produced to describe the relationships between, and interrelatedness of, the drivers. The qualitative data were supported by the ranking and photographic data and the information on the agricultural calendar that each farmer followed. Mean values were calculated from the ranking data and were used to construct radar charts. The data pertaining to the agricultural calendar were used to construct a timetable graphic of the sowing and harvesting dates employed by the farmer participants.

3 Results

3.1 Insights from the thematic analysis

The thematic analysis of the qualitative data yielded four organizing themes (Fig. 3): market demand, cultural and traditional values, adaptation to conditions, and use of *Bere* as a low input crop.

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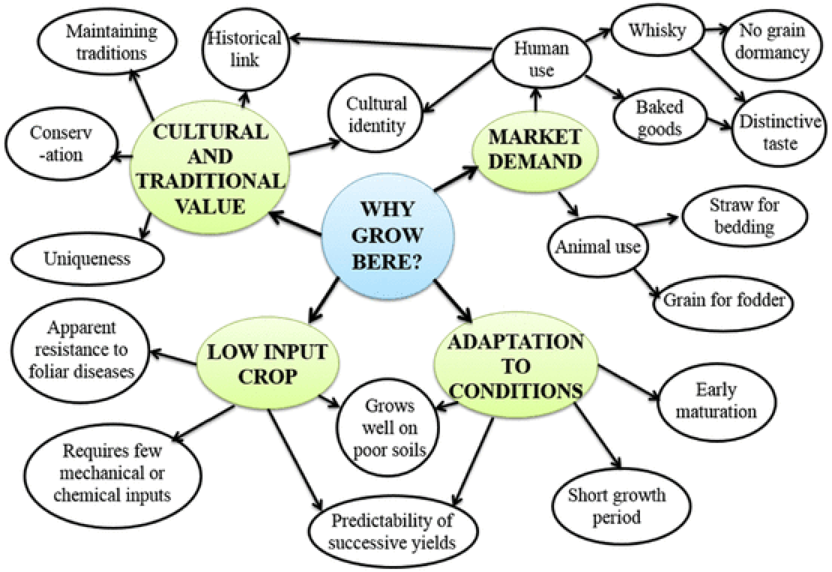

Fig. 3 Theme web developed from the analysis of interview data (source: this research).

3.1.1 Market demand

The interviewees mentioned that the cultivation of *Bere* for human consumption played an important role in providing extra income for Orcadian (someone living in Orkney) farmers. In contrast, the majority of barley cultivated on Orkney from modern cultivars was not sold, rather it was used on-farm as fodder for livestock. *Bere* can therefore be seen as a type of regional cash crop. This was mentioned by a participant from Orkney:

'… the market for *Bere*, although it's only small, is a means of some farmers getting a little bit of cash income for growing cereals.'

In contrast to Orkney, no apparent market for *Bere* produced in Shetland had been developed. The *Bere* produced was used on-farm, since the agriculture of Shetland was focused on the production of sheep for both wool and meat (Shetland Islands Council, 2003). However, unlike the majority of farmers in the region, those that cultivated *Bere* raised cattle and the crop was used mainly for cattle feed and bedding.

3.1.2 Cultural and traditional values

'Cultural and traditional value' is a multi-facetted term, open to multiple interpretations. However, it was found to be of importance to most participants. A number of the participants felt that cultivating *Bere* was a way to maintain the traditional practices of the islands. A participant from Orkney, involved in cultivating the crop for milling into *Bere-meal* commented:

'I just wanted to keep *Bere* available to the public because it's an old, it's a very old, traditional grain.'

Maintaining traditional agricultural practices was of importance to farmers in Shetland, where crofting still occurred on a very small-scale (see Fig. 4). This contrasts with Orkney where the majority of crofts had been amalgamated into large, single income source farms, as was mentioned by a participant in Orkney who cultivated a modern variety of barley:

'It is interesting this difference between Orkney and Shetland. Farms on Orkney are much bigger, crofting isn't, there are a few people I suppose that you would consider to be crofters, but very few. Most of the farms on Orkney are quite large.'

Fig. 4 Traditional *Bere* cultivation as part of a crofting system, Shetland (photo source: this research).

Some participants suggested that *Bere* cultivation was a way of maintaining a link with the past. This could be abstract, relating to Orkney and Shetland's shared Norse and Neolithic histories. It could also be more specific and personal. One participant, a farmer in Shetland, stated:

'Knowledge and information about how to grow *Bere* came from family members.... Cultural reasons were the motivation for starting to grow *Bere*'.

This was especially true in Shetland where a community of farmers, following traditional agricultural practices, kept *Bere* cultivation alive. The communal nature of *Bere* cultivation was important in this context. Communal activities included: group purchasing and sharing of specialized equipment for the cultivation and processing of the crop, and the sharing of seed as a method of reinvigorating the productivity of their crop. Thus, the collective actions of the group allowed each farmer to maintain diverse crop varieties on their farms at a lower cost compared to them working individually. In some cases this allowed for more *Bere* to be cultivated, with one respondent from Shetland commenting:

'12 years ago we started using a new combine, which made it easier to harvest and process *Bere*; therefore, the croft began to grow a little more *Bere*.'

Many participants expressed strong feelings about the uniqueness and authenticity of *Bere*. This appeared to be a point of pride to many participants and an important driver, with one respondent from Orkney stating:

'It's not authentic unless it's grown here.'

Some participants stated that their motivation was as simple as the satisfaction in knowing they were conserving something as old and rare as *Bere*. One respondent in Orkney stated:

'The positive side, it's just an ancient grain that we've kept alive; it was almost extinct fifteen, sixteen years ago... So we sort of saved the *Bere*.'

Many were aware that *Bere* germplasm was stored in gene-banks as part of the Scottish Landrace Protection scheme (Newton et al., 2010), but believed that this was not enough to preserve both the physical crop and the knowledge of how to grow it, with one participant from Orkney mentioning:

'There is a need to maintain it on farm, rather than as a museum piece.'

3.1.3 Adaptation to conditions

The interviewees believed that the suitability and adaptation to conditions was one of the reasons why *Bere* had survived for so long, although it was no longer grown in its historical southerly extremes (Martin and Chang, 2008). In some cases this factor was stated as the specific reason for using *Bere*. One respondent from Orkney mentioned:

'*Bere* has probably survived so long on Orkney because, compared with other varieties, commercially available varieties, *Bere* is very early. It matures very early.'

This was mentioned again by a respondent from Shetland:

'I used it (*Bere*) because it fitted into a growing season of less than 100 days.'

Crop losses, due to heavy wind and rain, were often experienced in the early autumn, with one participant, a conventional farmer from Orkney, mentioning this when discussing harvesting dates:

'I've seen cutting at the end of August, but usually middle of September would be what we aim for anyway. The very last of it might be in in October. But that time of year you're not wanting to be cutting barley, it could end in disaster.'

Data gathered on the dates participants sowed and harvested their barley crop (Fig. 5) confirmed the flexibility that farmers enjoyed in terms of planting and harvesting dates. All participants provided a range of potential dates, as both sowing and harvesting were subject to alteration by other variables (such as weather, labour and machinery availability). In addition, the dates recommended for the sowing and harvesting of spring barley in Scotland obtained from the Home Grown Cereals Association (HGCA, 2006) indicated that *Bere* was sown later than both the modern cultivar and the HGCA recommendation.

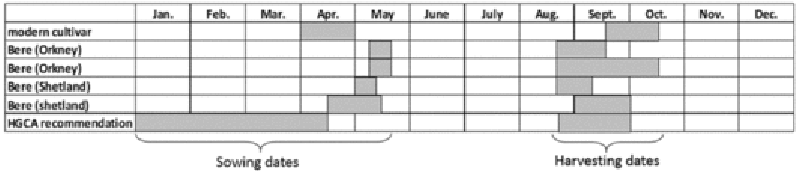

Fig. 5 Sowing and harvesting dates followed by the farmer participants and the recommendations of the Home Grown Cereals Authority (HCGA).

A number of participants mentioned the 10th of May as the traditional sowing date for *Bere* and many of the respondents continued to follow this advice, sowing in a range of dates around this time. In contrast, all harvesting dates given by the participants fell within the HGCA recommendations. However, *Bere* harvesting began earlier in all cases and ended before in most cases than the modern cultivars. The data gathered regarding harvesting dates showed a greater range of potential dates than those for sowing. This could be due to the unpredictability of the weather in late summer/early autumn, or the availability of machinery and contract workers to perform harvesting tasks.

A number of respondents mentioned the ability of *Bere* to grow on the acidic, poorly drained peats soils typical of Shetland, with one respondent from Shetland stating:

'It (*Bere*) grows well on acidic, peaty soils.'

Data showed that the suitability of the variety to the respondents' farm conditions seemed to be a more important consideration in Shetland than in Orkney.

3.1.4 Bere as a low-input crop

While explaining the reasons for *Bere* cultivation, many of the participants referred to a number of economic advantages, including the suitability of *Bere* as a low-input crop, with a participant from Orkney stating:

'I suppose it (*Bere*) has some really positives; one is because of this lodging problem. Lodging can be made worse if you put a lot of fertilizers on, so… (we) don't put much nitrogen fertilizer on. So, the farmer costs in terms of nitrogen are lower.'

It was unclear whether reducing fertilizer use resulted in any observable yield penalty. However, it is likely that any yield penalty was offset by the costs saved in purchasing and applying fertilizers and preventing crop lodging.

Furthermore, *Bere* was seen as a crop well-suited to organic agricultural systems, producing a reliable yield under a low input regime. One participant on Orkney stated:

'It (*Bere*) was suited to the organic system with low inputs on poorer ground.'

The apparent resistance of *Bere* to foliar diseases was also mentioned, with one participant from Orkney commenting:

'It (*Bere*) doesn't seem to get the leaf diseases, there are a couple of leaf diseases, one of them is called Rhynchosporium[6] which does give concern and it doesn't seem to get that.'

3.2 Insights from barley varietal preference ranking

The qualitative data (described in the previous section) provided insights into the range of drivers that the participants considered important in the continued cultivation of *Bere* on Orkney and Shetland. In addition to this, the participants were asked to rank these drivers according to perceived importance. The data obtained from this exercise were tabulated, mean values calculated, and the results plotted on a radar chart (Fig. 6).

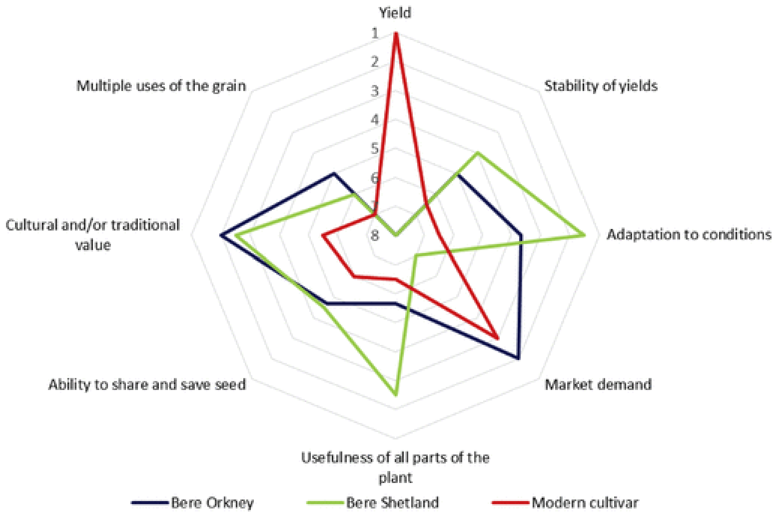

Fig. 6 Barley variety ranking chart, mean results (1 = most important characteristic, 8 = least important characteristic).

In both Orkney and Shetland, 'yield' was perceived to be the least important characteristic of *Bere*. In contrast, for modern cultivars, yield was perceived to be the most important characteristic. However, whilst yield was the most preferred trait for modern cultivars, yield stability was not. On this trait *Bere* was perceived as a better alternative. *Bere* also received higher scores than modern cultivars when considering the 'multiple uses of the grain.'

'Adaptation to conditions' was the most important characteristic for *Bere* growers in Shetland. However, this trait was ascribed a lower value in Orkney. The modern cultivars of barley received the lowest score on this trait.

The value of 'market demand' for *Bere* contrasted markedly between Orkney and Shetland. It was an important consideration in Orkney, but not an important characteristic in Shetland. For modern cultivars, market demand was considered important. However, on Orkney the value of 'market demand' for modern cultivars was valued less than the 'market demand' for *Bere*.

The 'usefulness of all parts of the plant' also contrasted between Orkney and Shetland. In Shetland it was considered an important characteristic; however, in Orkney it was of lesser value for both *Bere* and the modern varieties of barley.

For *Bere*, the 'ability to share and save seed' was valued to a similar degree in both Orkney and Shetland. For the modern cultivars, this characteristic was valued far less.

Finally, the 'cultural and traditional value of the variety' was valued to a similar degree for *Bere* in both Orkney and Shetland, making it one of the most important considerations to the participants. For the modern cultivars, however, this trait was perceived to be far less important.

4 Discussion

Despite an acknowledgement in the literature of the huge significance of barley landraces (Hakala et al., 2012; Himanen et al., 2013; Newman and Newman, 2008; Pasam et al., 2014; Wright and Dalziel, 2002), there is a paucity of work concerning the drivers behind the continued cultivation of barley landraces in a European context. The results obtained from the application of an interdisciplinary analytical framework in the *Bere* case study correspond to many of the drivers for the cultivation of other landraces, as reported in the literature (Abay et al., 2009; Leeuwis et al., 2004; Li et al., 2012; Olson et al., 2012; Roling and Kuiper, 1994; Rogers, 2003; Tsegaye and Berg, 2007).

From an economic perspective and using rational choice explanations, the case of *Bere* confirms both the risk minimisation and profit/utility maximisation considerations, as found in Abay et al. (2009), Li et al. (2012), and Olson et al. (2012). This means that unlike much of the literature cited, which identifies either risk minimisation or profit/utility maximisation, in the context of *Bere* cultivation in Orkney and Shetland, both risk minimisation and profit maximisation were important.

The insights into temporal management decisions suggest that farmers growing *Bere* are similar to other small-scale farmers located within marginal environments who employ variety choice as a risk aversion strategy. This supports studies in both more economically developed contexts, for example, the work of Meert et al. (2005) on farm household survival strategies in Belgium, and in less economically developed contexts, for example, the findings of Lacy et al. (2006) and their investigation into the choice of sorghum varieties by farmers in Mali. Additionally, the adaptation of *Bere* to local conditions was important to participants' decision making. This can be understood both in terms of risk minimisation – reducing the risk of crop losses on acidic soils by selecting a variety that can tolerate these soils, and in terms of maximising farmer profits – growing a crop on land that would have been otherwise unsuited to the cultivation of modern, hybrid cultivars. By the same token, features like the need to use less fertiliser can be considered as an attempt to economise production, that is, an attempt to minimise production costs. Similarly, the responses of farmers to market stimuli (demand) and the importance of *Bere* as a low-input crop can be interpreted as some of the profit maximisation drivers.

Regarding the importance of the market, the finding of this study seems to be in contrast with much of the literature on the factors affecting landrace cultivation in less economically developed countries. This body of literature suggests that farmers choose to abandon traditional crops in order to maximise profits and integrate more closely with mainstream markets (see, for example, Pitt and Sumodiningrat, 1991; Wale, 2012). In contrast, similar to the findings of this study, other authors find the creation of a market for niche goods produced from traditional varieties as an important driver for the continued cultivation of traditional crops in Europe. For example, Ceblla-Cornejo et al. (2007) suggest that the development of specialised markets for traditional varieties of tomatoes in Spain would assure the profitability and therefore conservation, on-farm, of those varieties. Further evidence is supplied by an inventory of landrace crops in the UK undertaken by Scholten et al. (2009) who have shown a relationship between continued landrace cultivation and niche markets for the products made from these crops, a prime example being the cultivation of long-straw wheat and its use in the thatching industry in the south of the UK. This apparent contradiction between developed and developing countries may be because of the lower level of market development in developing counties, especially a weaker capacity of consumers to exercise their choices (because of lower purchasing powers and weaker organising capacity). Indeed, the development of AAFNs (Alternative Agri-Food Networks) in Europe, and other industrialised countries, has been attributed to the beginnings of a shift in consumer preferences, from industrially produced foods to foods that appear to be more authentic, traditional, and with a distinct place of origin (Hinrichs, 2000; Ilbery and Kneafsey, 2000; Goodman, 2003(Please change the date to 2004, thank you); Watts et al., 2005; Higgins et al., 2008). Such an example of consumer power can be rarely noticed in developing countries.

However, these economic explanations do not fully explain all of the drivers behind the continued cultivation of *Bere* in Orkney and Shetland. The farmers were basing their choice to cultivate *Bere* on cultural as well as economic drivers. The cultural value of *Bere* was manifested in the maintenance of the traditions and traditional agricultural and culinary practices unique to the two regions. The use of *Bere* as an ingredient in many traditional foods supports the findings of Li et al. (2012) regarding Chinese farmers' preference for maize varieties. However, especially on Shetland, *Bere* was not just cultivated for its use in human diets. This supports the findings of Tsegaye and Berg (2007) who revealed that the landraces of durum wheat maintained in the East Shewa region of Ethiopia had a range of sociocultural as well as dietary uses. However, unlike the finding of Tsegaye and Berg (2007) the social value of *Bere* had less to do with religious considerations and more to do with both Orkney and Shetland's unique history when compared with the rest of the UK.

The communal nature of *Bere* cultivation on Shetland can be seen as having both economic and a cultural advantages. The choice of farmers to join and remain a part of the community of *Bere* growers allowed farmers to spread the costs of production between members, and in some cases, enabled them to grow more of the crop. This resembles the observations of ~~Seboka and Deressa (2007)~~Please change this to Seboka and Deressa (2000), thank you regarding the importance of local cultural institutions in maintaining the exchange systems of traditional crop varieties in Ethiopia.

As regards the political-economy interpretation, much of the literature on AAFNs states that the growth of such networks reflects a shift in consumer preferences, from industrially produced foods, to those with perceived quality characteristics. This shift is due, in part, to growing distrust in the food industry brought about by recent food safety concerns as well as growing resistance to the corporate dominance of food systems (Goodman, 1999, 2003(Please change the date to 2004, thank you); Ilbery and Kneafsey, 2000; Renting et al., 2003; McMichael, 2009; Bazzani and Canavari, 2013). Although the development of a niche *Bere* market in Orkney and its influence on the *Bere* farmers can be seen as an example of consumer power, the issues of food scare or a drive to counteract corporate dominance in the food system were not mentioned by the interviewees of this study as reasons for the development of the market. Rather than a politically-motivated institution, this market (in Orkney) can be seen as an example of a “Proximate AAFN” (Marsden et al., 2000; Renting et al., 2003), that is, a market that extends beyond face-to-face interactions between the consumer and the producer (direct sales) and is constructed around the idea of “quality” that encompasses associations with the particular region of cultivation, its history and culture, and the uniqueness of the products (Higgins et al., 2008; Ilbery and Kneafsey, 2000). This suggests that although *Bere* is valued on Orkney and Shetland, it would be far less valuable in other regions which do not have these historical and cultural ties to the crop.

Whilst, as discussed above, the reasons behind the continued cultivation of a barley landrace can be many, the preference ranking activity used in this study reveals that some factors can be more important than the others – an important aspect not well-reported in the extant literature. However, the regional differences in the perceived importance of the drivers indicate that it would be difficult to identify traits of universal value. Rather, the extent to which a certain indicator would be valued will be context-specific. For example, as the *Bere* case has shown, whilst risk minimisation was a highly-valued trait in Shetland, this was not necessarily the case in Orkney. This was probably because the crop was generally used on-farm, with very little sold to others. Similarly, market demand was a strong driver in Orkney in comparison to Shetland. A key reason for this could be the fact that *Bere* cultivation on Orkney perhaps was a profit maximisation strategy driven in part due to the presence of a larger number food manufacturing businesses using *Bere* as an ingredient (Green et al., 2009a,b; Martin et al., 2009). In contrast, this has not developed on Shetland (Martin et al., 2009; Martin, 2015). The preference ranking also reinforces the findings in the literature (Abay et al., 2009; Leeuwis et al., 2004; Li et al., 2012; Olson et al., 2012; Roling and Kuiper, 1994; Rogers, 2003; Tsegaye and Berg, 2007) that the criteria based on which modern cultivars are valued are different from the criteria based on which landraces are valued.

5 Conclusions

This investigation sought to explore the reasons why the farmers in a developed Western country would choose to cultivate a barley landrace by investigating the case of the *Bere* in Scotland. Drawing on an interdisciplinary theoretical framework this study concludes that the reasons are multi-faceted, including: economic, cultural, and institutional. However, some of these drivers are more important than the others and such perceived values are context-specific, influenced by the agro-climatic features, cultural values and traditions, and the market infrastructure of the areas where a landrace is grown. The case study also leads us to conclude that the traits based on which a landrace is evaluated are different from those of a modern cultivar. When considered in totality these indicate that the *in situ* conservation efforts of barley landraces would benefit by taking a location-specific and holistic approach, combining economic incentives with cultural preferences and values. This also means that communication campaigns relating to landrace conservation should not only emphasise the way such varieties could minimise farmers' risks and maximise their profits, but also how landraces could contribute towards maintaining and enriching local culture. Furthermore, in the contexts of developed Western countries, such as the UK, encouraging farmers to maintain barley landraces on their farms would greatly benefit from the development of appropriate market infrastructure and networks.

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Footnotes

[1]The term ‘landrace’ has been concisely defined very few times (Love and Spaner, 2007); however, it has been suggested that certain criteria should be applied to a definition. These are that landraces are traditional, domesticated populations of locally adapted genotypes maintained by farmers over generations, rather than subject to formal improvement (Scholten et al., 2010). Negri (2007) goes on to state that landraces can be defined by their association with the traditional knowledge and customs. Indeed, it has been estimated that 15–20% of the world's food supply is produced by small-scale farmers using landraces and heirloom varieties of crops (Veteto, 2008).

[2]Please visit this website for further information: http://www.birsay.org.uk/baronymill.htm.

[3]Crofting is a system of tenured small-holdings, in which employment is a combination of small-scale agriculture supplemented by further, outside employment, and was once common in Orkney and Shetland (Collier, 1958).

[4]Please visit this website for further information: http://www.gardenorganic.org.uk/hsl.

[5]For more information please visit: http://www.faanweb.eu/.

[6]*Rhynchosporium secalis* (barley leaf blotch) is a fungal disease that can be particularly severe in Scotland (HGCA, 2000).

Highlights

- The drivers behind landrace cultivation were investigated.
- The traits based on which a landrace is evaluated are different from those of a modern cultivar.
- The reasons for landrace cultivation include economic, cultural, and institutional considerations.
- *In situ* conservation would benefit from location-specific, holistic approaches.
- In developed countries conservation would benefit from development of market infrastructure and networks.