Work Package 1.1: Barley Genetics

Progress against the required outputs

- **Required Output 1: Tools (genes, markers, bioinformatics, knowledge) which allow the production of improved barley varieties which help Scottish farmers to remain competitive in an enlarged Europe**.

Summary

Malting barley is the dominant Scottish arable crop yet the genetics underlying key aspects of sustainable production and end-use quality is poorly understood and thus hampers progress in developing new varieties that improve the competitiveness of its production. We have therefore developed the ability to DNA fingerprint different barley varieties in considerable detail. In addition, we have developed collections of different barley types that either have been or will be scored for key aspects of barley yield and quality. We are currently using these two types of data to identify specific regions of barley chromosomes that are associated with the genetic control of crucial aspects of barley performance not only on the farm but also in processing. We can then identify specific DNA markers that can be utilised by plant breeders and processors in the identification of varieties for growing and processing. We have already released an example of such a marker to reduce the amount of a pre-cursor of a potentially harmful compound in Scotch Whisky production. The volume of data encompassed by these data sets is considerable and presents challenges in efficient storage and utilisation and we have developed database resources for this specific purpose. These resources are being utilised by other research groups globally, which makes the potential merging of different data sets to meet new problems, e.g. study of a pest that has become important in Scotland, much easier. Future work will concentrate upon extending the range of barley characters for which we can develop DNA. We will attempt to prioritise targets for the DNA marker work through utilising a socio-economic valuation of key plant characteristics by the Scottish Agricultural College (SAC).

- **Required Output 2: Identification of tools (genes, markers, bioinformatics, knowledge) to allow breeders to select crop varieties suitable for future Scottish climates.**

Summary

Genetic tools, such as molecular markers, are of growing importance in modern crop improvement programmes because they permit a detailed genetic characterisation of breeding and related germplasm and, if associated with valuable characteristics, allow plants expressing these characteristics to be

identified indirectly by acting as surrogates. State of the art genetics and genomics tools developed within the Work Package and within the international barley community (including those described in the previous section) have been used to pursue the identity of several genes and processes that, once identified, will allow breeders in to select varieties that are more suited to Scottish (and NW European) agriculture (e.g. markers for heading date / earliness). Ongoing investigations are targeted towards the development of strategies that allow the molecular isolation and validation of important genes and progression towards a deeper understanding of the biological processes that underlie both genetically simple, and in the longer term, more complex plant characters.

- **Required Output 3: Increased emphasis on developing crops with enhanced nutritional quality.**

Summary

The health benefits of the inclusion of beta glucan in the human diet are well documented as inclusion in the diet results in reduced cholesterol, increased antioxidant intake, better gut health, and reduced potential for cancer development. Barley is now recognised as good source of beta glucan, giving a marketable potential health benefit to a foodstuff, provided barley flour is incorporated at a level exceeding 4%. In addition, beta glucan is more evenly distributed in barley grain than it is in oat or wheat grain, where it is concentrated in the outer layers, which are removed in processing. Therefore, barley flour represents a potentially healthier product compared to other cereals. Most contemporary barley varieties have low levels of beta glucan in the grain as it is an undesirable characteristic in malting and so selection has focused on reducing this important nutritional trait. Thus many of the potentially healthy benefits of barley beta glucan may well have been bred out of current varieties. We are therefore examining the natural variation for grain beta glucan content in a range of barley cultivars and landraces to examine the potential for developing varieties with enhanced content. This work is complemented by more detailed genetic analysis, which is expected to identify the key genes controlling this variation and thereby facilitate their utilisation to meet divergent market needs.

- **Required Output 4: Improved understanding of factors contributing towards product quality including the identification of markers for key traits and genes for use by breeders.**

Summary

Genes are being identified that are involved in plant development and stress responses, which ultimately influence the quality of the final product. For example, under stress, not only is grain fill restricted but the content of the seed also varies leading to poor grain quality. Genetic mapping and sequencing of genes involved in different aspects of seed, root and flower development is

underway to identify genes potentially involved in grain size and flowering. Plants respond to different stresses by turning genes on and off and by changing gene expression levels. Genes involved in temperature stress responses have been identified from data accumulated from barley and other species. For example a protein produced in response to cold stress has been isolated and its role in stress tolerance is being evaluated. Additional barley genes induced by temperature stresses will be identified and their roles assessed. We are also examining specific and novel processes that control gene expression. A procedure has been established to monitor such changes and in the coming year responses to different temperature stresses in barley will be carried out.

- **Required Output 5: Explore the potential for extended season (early cropping): science to deliver barley varieties with earlier maturation.**

Summary

Maximising the growing season is the best way to achieve high crop yield. However this concentrates the harvest period into 2-3 weeks of intensive activity and the ability to bring the start of harvest forward by 1-2 weeks would benefit the Scottish farming system. Spring barley is the logical target for incorporating earlier maturity, however in current material this results in a yield penalty. A study of the key dwarfing gene currently used in spring barley, which is associated with later maturity, is underway to search for genes that control earlier maturity but which maximise the period between the beginning of stem extension and flowering to maintain yield potential. More fundamentally, changes in the flowering pattern and patterns of ear development are being studied through a combination of approaches including the use of novel barley mutants. This is expected to produce tools and resources that can be assessed for potential use in Scottish agriculture.