Work Package 1.2: Potato Genetics

- **Required Output 1: Characterisation and evaluation of germplasm collections which focuses on plant health improvement, improvement of the environment, sustainable agriculture and market needs including the needs of relevant markets.**

Summary

The Commonwealth Potato Collection (CPC) and derived germplasm is recognised as a source of genetic diversity not available within cultivar collections of the European potato. Hence maintenance, characterisation and evaluation of this germplasm are of immense value for potato breeding and research.

The CPC is maintained by rejuvenation of a proportion of the collection every year to ensure that true seed is available to researchers and breeders under agreements consistent with the provisions of the Convention on Biodiversity and the International Undertaking on Plant Genetic Resources for Food and Agriculture. This rejuvenation is carried out by true seed multiplication in isolation from other *Solanum* material. During 2005 and 2006, 200 new accessions were added to the collection, making a total of 1500. In 2008 a more informative CPC Website was made publicly available and will be updated at frequent intervals. Analysis of DNA data from the collection clarified the origin of the cultivated potato and will inform better utilisation of the collection. To aid evaluation and utilisation of the cultivated potatoes in the CPC, a long day adapted population was produced from Andean material during the 1960s and 1970s. As this material is valuable as a biodiverse population for research and utilisation, it was re-established from true-seed during 2006 and 2007 and maintained at a high grade seed site. New glasshouse screenings of the CPC for resistance to potato disease such as late blight and cyst nematodes were initiated because they still pose serious problems for growers in Great Britain and there is still a shortage of good resistance genes for use in breeding. Initial results were encouraging enough for more detailed assessments in 2008 before undertaking genetic analysis and breeding. Genetic analysis of resistance to the white potato cyst nematode (*G. pallida*) was carried out using two potato populations involving wild species and genetic analysis of yield, agronomic and quality traits was performed on the progeny of a cross between a processing potato and a table cultivar. Both analyses gave results which have informed potato breeding strategies.

The CPC will continue to be maintained, characterised, evaluated, documented and distributed upon request to breeders and researchers. Germplasm derived from the CPC will also be maintained, characterised and evaluated for biologically and economically important traits, particularly those likely to be important during a period of climate change.

- **Required Output 2: New resources (improved germplasm, markers, genes, knowledge) which deliver potato products capable of capturing and maintaining market share.**

Summary

Important combinations of traits are lacking in European potato cultivars. In particular there is an urgent need for cultivars combining high levels of durable resistance to late blight and potato cyst nematodes with acceptable yields and either cooking or processing quality, and preferably with some virus resistance. Furthermore, supermarkets want to offer consumers a wider choice of potato and there is particular interest in ones with novel flavour and texture. Improved parental material, molecular tools (e.g. markers) and genetic knowledge are required to allow breeders to achieve these goals more efficiently and effectively.

Material derived from the CPC was taken to a fifth cycle of crosses using breeding lines selected for improved yield and fry colour as well as resistance to potato cyst nematodes and to late blight, and the potato lines produced from these crosses were assessed for these traits. New parents with this combination of traits were also selected from these potato lines for use by commercial breeders and in SCRI's commercially funded breeding programmes. SCRI's "Phureja" potatoes attracted wide press coverage for their novelty, flavour and texture, following the launch in 2006 of cultivar Mayan Gold by commercial collaborators Greenvale AP. As a result, specific lines of Phureja potatoes were selected in 2007 for improved appearance and longer dormancy, traits which are a relative weakness of Phureja. One DNA based marker has been identified that may be used to track a gene for late blight resistance in breeding programmes and two for resistance to cyst nematodes. Furthermore a DNA resource has been developed to assist with the identification of the gene underlying blight resistance. Advances were also made in providing genetic knowledge for more efficient breeding for field resistance to late blight and resistance to *Potato virus Y.* Genetic analysis of the potato has been made easier by the release of new Windows-based computer software (TetraploidMap for Windows). Extensive DNA marker development is anticipated from potato and tomato genome sequences and will allow accurate marker design for key traits.

- **Required Output 3: Identification of tools (genes, markers, bioinformatics, knowledge) to allow breeders to select crop varieties suitable for future climates in Scotland and elsewhere.**

Summary

Water and fertiliser use efficiency are seen as major political and environmental issues facing potato growers in Britain at a time of climate change, which is

predicted to result in higher winter but lower summer rainfall. Most potato growing is in nitrate vulnerable zones and potatoes need large inputs of phosphate fertiliser and irrigation to maintain crop yields and quality. Climate change is likely to result in increased competition for water resources between agricultural, industrial and domestic users. Preliminary experiments in 2007 on the mineral content of potatoes revealed regions of the potato chromosomes which affect phosphorus use efficiency (higher yield with reduced phosphate inputs). Preliminary experiments were also performed on root mass and structure and revealed significant differences in root length among commercial cultivars and longer roots in Phureja potatoes. This might be exploited to help plants capture more soil resources effectively. A potato geneticist has been appointed from May 2008 to develop a joint programme with WP 1.7 on the genetics of water and fertiliser use efficiency. Initial research will build on the 2007 preliminary experiments with field trials in 2008 on a wider range of potato material. The research will be extended to improving the nutritional value of potatoes by enhancing the levels of specific inorganic elements.

- **Required Output 4: Increased emphasis on developing crops with enhanced nutritional quality.**

Summary

The potato is highly nutritious as it is a rich source of energy in the form of carbohydrate (starch) and provides significant amounts of good quality protein, as well as vitamins, minerals, micronutrients, dietary fibre and antioxidants, with yellow-fleshed potatoes rich in carotenoids. However, cooked potatoes can have a high glycaemic index (GI) and roast and fried potatoes contain acrylamide. The Scottish Government is concerned about poor diet contributing to high obesity levels and resultant chronic diseases such as type II diabetes, and has made tackling obesity a priority ("Choosing the Right Ingredients. The Future for Food in Scotland Discussion Paper"). Potatoes with a lower glycaemic index (GI) may benefit diabetics and hence potatoes known to differ in tuber starch content or starch composition are being examined for differences in GI. The Food Standards Agency and international food organisations wish to minimise the amount of acrylamide present in roasted and fried products because its presence may harm people's health. For this reason we are determining the genetic variation present in potato for acrylamide production. Finally, there is interest in carotenoids in potato as yellow-fleshed Phureja potatoes are known to have high contents. Carotenoids help to protect against sight deterioration in the aged.

Variation in GI potential has been demonstrated within our potato collection and relationships to starch chemical makeup are currently being examined**.** Variation in tuber fry colour and acrylamide production after cold storage of potatoes has been found within lines derived from a cross between a processing potato and a table variety. Low sugar content and low levels of a specific amino acid are both needed to obtain the lowest levels of acrylamide in processed products. The

conclusion is that breeding for lower acrylamide production needs to be targeted to crosses between parents with a light fry colour after storage at 4°C.

- **Required Output 5: Improved understanding of factors contributing towards product quality including the identification of markers for key traits and genes of use to breeders.**

Summary

Potato processors and supermarkets want improvements in potato product quality and novel products in order to remain economically competitive. As the main potato users at the end of a long supply chain, it is important for that chain to provide more saleable product at less cost of production. The key to this is to understand the factors that contribute to the flavour and texture of potatoes, to provide markers for key traits and to identify genes of use to breeders who are the start of the supply chain. In addition, we are examining the possibility that biochemical markers exist that could be applied to growing and stored potatoes crops to help us predict potato processing quality during the storage phase. This would help potato-store managers in delivering high quality raw materials for processing.

We have compared different varieties of potato and determined important differences in specific quality traits. Some material, such as the Phurejas take less time to cook, have higher dry matter contents, different starch properties, novel texture and greater flavour intensities. We have shown, using modern analytical methods, that Phureja has higher levels of specific compounds important to flavour, including so called ‘umami’ compounds found within the tuber flesh but also volatile flavour compounds released during cooking. A gene has been isolated which regulates one of the most abundant volatile flavour components of cooked Phureja tubers. Other genes have been isolated that could account for the differences in texture between Phureja and other tubers.

The roles of the flavour and texture genes are being assessed using transgenic potato lines in which the genes are turned off or expressed at higher levels. DNA markers for these genes that will be of use to breeders are being developed.