SCRI Group
Science and Operational Strategy
2009-2013

How scientists are battling to make sure that we don't run out of juice

By **Kurt Bayer**

SCOTS experts are racing against the clock to save the country's blackcurrants from extinction as a result of climate change.

Scientists and growers fear the fruit, famed for its healthy properties, will disappear within 15 years due to increasingly mild winters.

Blackcurrants are rich in vitamin C and contain more antioxidants than most other fruit and vegetables. They have been grown in Britain for 500 years, but require a long, cold winter period to enable the buds to grow properly in the spring.

Farmers say warmer weather conditions have resulted in disastrous consequences for their £10 million-a-year crop.

The Met Office has now warned farmers that, at the current rate of climate change, they will not be able to grow current blackcurrant varieties in 15 years – but it can take up to 20 years to develop new varieties.

Researchers at the Scottish Crop Research Institute (SCRI) at Invergowrie, outside Dundee, are now facing a race against time to produce 'environment-adaptable' varieties of blackcurrant.

Last night, Dr Rex Brennan of SCRI's Fruit Breeding Group confirmed the dangers facing the blackcurrant crop, most of which is used to produce Ribena, one of the world's most popular soft drinks.

He said: 'The future of the blackcurrant is uncertain. We are taking climactic changes very seriously.

'There are currently nine or ten varieties in production and it is unlikely we will ever get a variety that is suitable for all growing conditions. But we are working on a new variety that has low chilling requirements and will survive the changing conditions.

'It is very much a long-term operation and we need to be taking action now to deal with the predicted future trends.

'There is no quick fix. But we are speeding up our breeding process and I am confident we can deal with these problems. We don't have the end of the story yet but we need to find a way.'

The most popular variety of blackcurrant for the last 35 years has been Ben Lomond – all of SCRI's varieties are named after Scottish mountains. But it has high chilling requirements, needing a minimum of 2,000 chill hours before it will ripen.

New varieties that SCRI scientists are working on will survive on a fraction of that amount of chill time, but will also be tough enough to resist occasional cold snaps in early spring.

The blackcurrant growers' main customer is GlaxoSmithKline, which buys 95 per cent of the crop to produce Ribena, which is worth £192 million a year.

The group has provided £1.2 million to aid SCRI's breeding programme.

DISASTER: Currant crops cou…

Bid to sell Scots spuds to China

THEY GAVE us chop suey, sweet and sour chicken and prawn crackers — now we hope to give them tatties!

A Perthshire potato farmer is off to China to check out opportunities for Scots in the country that is the world's biggest potato grower.

Peter Grewar sees huge potential for Scotland's growers to ship seed to China, once trade barriers are removed.

Scholarship

His visit is part of the Nuffield farming scholarship that he won last year.

Mr Grewar, of East Ardler, Meigle, and his family farm 1600 acres of potatoes in Perthshire and the Black Isle. They expect to grow 300 acres of seed, 200 acres of organic and 1100 acres of ware, largely for an Airdrie-based processor, this year.

Now the Scottish Government, the Scottish Agricultural Science Agency, Scottish Crop Research Institute and other breeders hope to get the necessary protocols agreed to put Scottish potatoes into China.

"I chose China because they're the world's biggest producer of potatoes at 74 million tonnes," said Mr Grewar

"We are allowed to export mini-tubers, but not actual seed. I want to use the visit to see what they're doing and get a better handle for the opportunities for seed exports."

His visit in July is likely to take in Tibet as well as the north and north-east provinces, where the bulk of potatoes are grown and where the likes of McCain and Pepsico have opened huge processing operations.

Mr Grewar spent two weeks in the country last year as part of a Nuffield-organised visit to see its general farming industry.

Science on show at SCRI

People across Tayside are getting the chance to have fun with science as top scientists let their hair down at Invergowrie's crop research institute, SCRI.

Open days were being held today, for schools, and tomorrow, for the general public, offering a bewildering variety of displays and activities.

Six hundred pupils and teachers attended today from Tayside and Fife, and more than 1000 people are expected tomorrow.

The programme includes tractor tours and computer animations, and there's an opportunity to see the fabled North Lilies — rare and beautiful flowers.

Visitors at the weekend will get hands-on experience of SCRI's science by extracting DNA, looking at how genes work and visiting the robot used in our research.

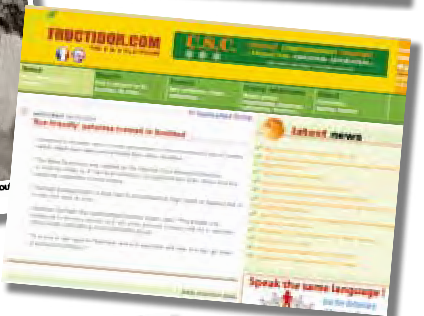
Gruelling

Yet another attraction, fitting for Dundee, will be a presentation by Professor David Hopkins, who has just returned from a gruelling research expedition to Antarctica.

Admission to tomorrow's open day is free of charge and parking at the SCRI headquarters will be available.

There will also be catering on site.

…nstrates an experiment to kids from Dundee's … School.



New variety of rasp unveiled

A NEW raspberry variety was unveiled yesterday at the annual SCRI fruit walk.

Glen Fyne has been hailed by its breeders as a dual purpose variety.

Primarily it is expected to be grown for the fresh market, mostly in polytunnels, but it is also very suitable for machine harvesting for processing.

This latter market has been in decline for years and only a limited acreage is now grown by a handful of growers specifically for processing.

However, prices for raspberry pulp have almost doubled in recent months, which may make machine harvesting an economically viable proposition.

The development of Glen Fyne, which was first crossed at Mylnefield in 1990, was funded jointly by EU grants with Scottish Executive support until 2001 and then by the cross-industry Raspberry Breeding Consortium, again with government support.

In 2006 another variety, Glen Doll, was released and more new varieties are in what is inevitably a rather long pipeline.

All of the raspberry varieties produced at SCRI's Invergowrie site are named after Scottish glens.

The industry standard variety Glen Ample is named after a glen near the top of Loch Earn but it also happened to be a very ample fruit producer.

Dr Nigel Kerby, of SCRI's commercial wing Mylnefield Research Services (MRS), said yesterday, "We just had to call the new variety Glen Fyne because it tastes so goddam fine!"

He might be right. The fruit is claimed to have a sweet and aromatic raspberry flavour with a bright red colour and with a good shelf life, at least as good as Glen Ample.

The berries are round rather than conical and slacken their grip on the husk as they ripen, making them easy to pick by hand or machine.

Unfortunately for the many growers dogged with the soil-borne fungus raspberry root rot, Glen Fyne has no resistance or tolerance to the devastating disease.

However, raspberry breeder Nikki Jennings, who has supervised the development of the new variety, confirmed that there should be a new variety ready for release within a year or two which does have root rot resistance, although its flavour is unlikely to find favour in the fresh market.

"We also have an older selection which has stood up well in an outdoor trial site which has root rot and has survived for seven years when others around it have failed. We are now trialling that variety in polytunnels," she said.

The blackcurrant is our home-grown superfruit

AS the bikini season approaches superfruits will be included in smoothies and diets nationwide in a bid to get so many of us into shape, but how can you be sure what a superfruit actually is and what it is capable of, or even which is best for you?

Latest findings show that the superfruit leading the way with its health benefits is none other than a fruit indigenous to the British Isles — the humble British blackcurrant.

Celebrities and superfruit followers alike have for years been extolling the virtues of blueberries and exotic goji berries, but in actual fact should be looking closer to home for the fruit that is packed with outstanding health benefits and numerous vitamins and minerals.

According to recent research the British blackcurrant is the fruit you should look to this summer when you want to give yourself an optimum health boost, as it can lay greater claim to the term 'superfruit' than any other.

The research has been conducted by Dr Derek Stewart and his group at the Scottish Crop Research Institute (SCRI). The motivation for the research stemmed from the huge media interest and publicity surrounding superfruits, coupled with the lack of consumer knowledge and understanding of what a superfruit is or what a fruit must contain to be one.

The research group has spent time studying reputable food compositional databases and scientific publications, both of which detail actual and potential health benefits, of twenty popular fruits.

Dr Stewart said: "Out of the research we have analysed, we have comparatively assessed various health claims/benefits and nutritional compositions of a number of 'superfruits'.

"From this model it is clear from a quick overview that those with a purple/red colour perform particularly well — the darker the fruit the higher the anthocyanin/antioxidant content. Blackcurrants are very dark purple in colour and in line with these indicators, comes out top in the majority of the categories."

The quintessentially British blackcurrant has high levels of antioxidants, known as anthocyanins. Research from the last three years has found that these anthocyanins, along with other components, can help to prevent Alzheimer's, heart disease, eye strain, MRSA and urinary tract infections. These latest findings certainly show blackcurrants leading the way with their nutritional and health benefits.

"Over the last few years the SCRI has continued to report on new findings in relation to the health benefits of British blackcurrants," said Jo Hilditch, Chairwoman of the Blackcurrant Foundation. "This latest research just proves how eating blackcurrants and drinking blackcurrant juice can help to provide you with a wealth of health benefits."

In line with this research the Blackcurrant Foundation has created a Superfruit 'wheel' to allow consumers to select the fruit they are interested in and to view its health benefits versus other fruits listed on the wheel. For more information or to obtain a superfruit wheel, readers should visit www.superfruits.org

'Super fruits' are trounced on health

Berry special award for Scots scientist

A SCOTTISH scientist has won an accolade from the Royal Horticultural Society for her work on breeding disease-resistant raspberries. Dr Julie Graham, senior researcher at the Scottish Crop Research Institute in Blairgowrie, will today be presented with the Jones-Bateman Cup.

Superfood for future – the Scottish spud

By **Ben Borland**

WITH food prices spiralling at home and hunger riots in developing countries, Scottish Government advisers have come up with a home-grown solution – the humble spud.

Officials at Holyrood have said the potato could play a major role in defeating starvation and poverty around the world, as well as helping to offset the weekly hikes in the cost of groceries here in the UK.

The predicted boom in potatoes, which are nutritious, will grow virtually anywhere and produce a greater yield than wheat or rice, will also bring a multi-million pound boost to Scottish farmers.

Potato exports contributed more than £100million to the Scottish economy in 2006, and experts say that figure looks set to increase as they become more and more popular in countries such as China.

Meanwhile, with the cost of the average UK supermarket shopping basket forecast to rise by as much as 50 per cent by 2018, Scots may have to consider eating more potatoes – despite derision from some quarters for its contribution to expanding waistlines.

A briefing paper, prepared by Alasdair Reid and Leeny Roth from the Scottish Parliamentary Information Centre, states: "It is thought that there is enough arable land to provide for Scotland's population, however the national diet and farming regimes would have to change significantly.

"Bread and potatoes would become staples, and more focus would be made on fish and shellfish, which currently make up the largest proportion of total food exports."

They add: "2008 has been designated the International Year of the Potato. The UN General Assembly is seeking to focus world attention on the role the potato can play in defeating hunger and poverty."

The advice comes as Rural Affairs minister Richard Lochhead this week announced the first steps towards a National Food and Drink Policy, including a 'cooking bus' to teach kitchen skills across Scotland and an inquiry into affordable food.

'We produce good quality seed potatoes, the best in the world'

And the increasingly important role of the potato will be discussed at a major conference in Dundee in August, featuring Dr Pamela Anderson, director of the International Potato Centre in Peru, and Dr Mike Storey, head of research and development, at the British Potato Council.

Mark Prentice, from the British Potato Council, said: "In terms of potatoes feeding the world, we are in an excellent position in Scotland in that we can produce good quality seed potatoes, among the best in the world, and we are a major player in the market.

"We have seen demand for seed potatoes in Scotland increasing in recent years and this is our biggest year yet in terms of tonnage."

However, Finlay Dale, from the Scottish Crop Research Institute, said that no matter what the advice from Holyrood, potatoes have always figured prominently in the Scottish diet.

He said: "Only the Irish and some Eastern European countries have higher consumption per capita than us. We export seed potatoes throughout the Mediterranean and even into China, as well as supplying something like 80 per cent of the seed crop down south."

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Director's Introduction

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Our science continues to deliver new knowledge, products and services in response to the questions asked by our customers and society more generally. Our links internationally and with universities and other research organisations nationally are strong and enable us to undertake research of international quality and to transfer our results to multiple potential users.

As a result of the Scottish Government First Minister's announcement in January 2008, SCRI is actively involved in discussions with the Macaulay Land Use Research Institute about the formation of a "New Institute" for plant and land research. This, together with a new research strategy from the Rural and Environmental Research and Analysis Directorate (RERAD) of the Scottish Government expected during 2009, will clearly have profound effects on the development of SCRI's research over the course of this Plan especially in its latter years. However, since discussions of these prospective developments are continuing and will necessarily take some time to resolve, this Plan focuses on the continued scientific development of the SCRI Group.

I hope that you will enjoy reading this plan and invite you to visit our website (www.scri.ac.uk) for up to date information.

Peter Gregory
Chief Executive and Institute Director

Executive Summary

The SCRI Group aims to undertake excellent research in plant and environmental services that delivers knowledge, products and services to the public

Delivery of our research will be directed to the following: responding and adapting to environmental change; creating wealth and health via innovative plant products; valuing biodiversity; using natural resources sustainably for food and societal wellbeing; and communicating our science responsibly to specific audiences

During the planning period we shall invest in state of the art technology platforms, quantitative biology and new experimental platforms especially at Balruddery Farm.

We shall continue our work to develop strategic alliances with the Scottish Agricultural College and other European and international institutions, and work energetically towards the development of a new institute in partnership with the Macaulay Land Use Research Institute

Independent economic analysis shows that our research delivers a 14-fold return on public spending plus other uncosted environmental, health and social benefits; we shall work with business and government to further enhance this record

Background

The SCRI Group includes SCRI, Mylnefield Research Services Ltd (MRS) and Biomathematics and Statistics Scotland (BioSS) and is located at Invergowrie, Dundee. The University of Dundee Division of Plant Sciences is also located at Invergowrie. BioSS operates at multiple sites.

The aim of the Scottish Government is to create a more successful Scotland with opportunities for all to flourish through increasing sustainable economic development. This will be achieved through a smarter, safer and stronger, wealthier and fairer, greener and healthier Scotland. Our science will continue to deliver new knowledge, products and services in response to the Government's objectives and the questions asked by our customers and society more generally. Our links with universities and other research organisations nationally and internationally are strong and enable us to undertake research of international quality and to transfer our results to multiple potential users.

A long-term strength of SCRI, compared to many research providers, is that there is a "pipeline" of technology transfer that links scientific innovation to commercially useful products ensuring that intellectual property is properly exploited. Independent assessment in 2007 showed that this pipeline has led to considerable financial return to the UK economy (estimated at £160 million per annum and a 14-fold return on public funding).

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SCRI Mission and Vision

We are Scotland's leading institute for research on plants and their interactions with the environment particularly in managed ecosystems. Our research and products are internationally recognised.

Our mission is to conduct excellent research in plant and environmental sciences.

Our vision is to deliver innovative knowledge, products and services that enrich the life of the community and address the public goods of sustainability and high quality and healthy food.

We will achieve our vision by developing a culture that promotes and supports scientific curiosity and celebrates the contribution of all staff and students.

High-level Research Themes

Much of the research undertaken within the SCRI Group requires interdisciplinary and multidisciplinary working because the questions and issues raised by research funders are becoming more complex. While basic and strategic research are still required, the effective delivery of our vision increasingly requires academic disciplines to combine to deliver the resulting knowledge and information in appropriate forms.

During this planning period, particular attention will be directed to the delivery of our outputs under the following themes:

- Responding and adapting to environmental change – environmental change is a major societal concern and research to understand impacts, mitigate effects and adapt to consequences will be a major theme.
- Creating wealth and health via innovative plant products – the development of biofuels and novel plant products, the economic viability of rural communities, and the health of the human population are major areas of policy development.
- Valuing and utilising biodiversity – utilising the existing diversity of crop plants to overcome pest and pathogen problems and to develop novel plant-based products has been a long-standing interest of SCRI. This research provides a platform to bring modern genomics approaches to plant, microbial and ecological research.
- Using natural resources sustainably for food and societal wellbeing – the interacting demands for food, energy and water security globally, coupled with the need to reduce greenhouse gas emissions to the atmosphere and other pollutants to water courses and the sea mean that there will be increased emphasis on improving the efficiency with which agriculture uses all resources.
- Communicating our science responsibly to specific audiences – our research has to be communicated in different ways to different audiences. We will use all available channels, especially web-based platforms, to reach new audiences.

To sustain our mission for research excellence, we shall continue to organise ourselves in four science programmes, with delivery of knowledge to the themes advanced through cross-programme working and the RERAD cross-cutting themes (see next page for details):

	Environmental Change	Wealthier & Healthier
Genetics	Genetics of water and nutrient use effciency Gene expression responses to environment change Adapted cultivars Germplasm collections Breeding for environmental change	Gene mapping and markers Industrial partnerships Cultivars to meet market needs Breeding for improved nutrition
Plant Pathology	Genome sequencing of pathogens and comparative genomics Effects of abiotic stress on host resistance Pest and pathogen epidemiology and population dynamics Biochemical and functional data	New cultivars with disease resistance Pest and pathogen management Plants as sources of high value proteins
Plant Products & Food Quality	Impact on fruit quality Biochemical consequences of climate change	Metabolomics, biochemical and molecular biological techniques Work on bioactives Phytochemicals Food processing Plant products Tasting panels
Environment Plant Interactions	Efficient resource use Reduced greenhouse gas emissions Improved rooting for problem soils New crops and cropping systems Plant ecophysiology and adaptation Preservation of fragile ecosystems Carbon sequestration in soils	Sustainable soil management Efficient use of resources Recycling of urban wastes Micronutrient fertilisers for mineral biofortification EnPrint® environmental monitoring Diagnostic testing

Biodiversity	Sustainability	Communications
Evolution and biodiversity of crop genomes Research and exploitation of germplasm collections Molecular tools for the characterisation and monitoring of biodiversity Diversity of native species	Mapping and markers for reduced inputs Reductions in the environmental footprint of production Genetics of new cropping systems Genetic responses to environmental stress Genetics of durable disease resistance	Crop Open Days Explaining Biodiversity UK and World Crop Networks Industry partnerships and briefings Scientific and popular publications
Development of disease resistant crops to decrease pesticide inputs	Development of sustainable crop production systems Pest and pathogen epidemiology and population dynamics Integrated pest and disease management Sustainable crop production methods	Women in Science Technology Engineering and Maths Potatoes in Practice Cereals in Practice Communicating science through art Fruit for the future LEAF Open Farm Sunday International partnerships
Assessment and utilisation of biodiverse germplasm High throughput phenotyping Crop diversification	Agricultural regimes and quality impacts Whole crop utilisation Food chain nutrient loss	Integrating food and health Cereals in Practice Fruit for the Future Potatoes in Practice Royal Highland Show Advanced Higher days
Assessments of plant biodiversity Biodiversity and ecosystem function Soil biology, structure and function Impacts of crop management on biodiversity Molecular ecology of wild plants	Agroecological impact assessments Soil and water quality indicators Soil restoration and slope stabilisation New crops and cropping systems LEAF/Balruddery platforms Resource use efficiency	Living Field Royal Highland Show LEAF/Balruddery Open Days Potatoes in Practice Teaching (schools, universities & industry) Decision Support tools

External Strategic Drivers

Nearly all of Scotland's land is managed for the dual benefits agriculture and environmental services. Food supply has recently re-emerged as a major political and social issue because of the relative fragility of world food supply, pressure for alternative land uses for plant biomass in biofuel production, the sensitivity of food supply to environmental factors, and the demands for healthy, locally-produced food. In Scotland, the Scottish Government's food policy seeks to promote healthy eating and lifestyles as a means of improving the nation's health.

Global environmental change is now firmly established as a significant challenge to humanity and the planet. Land-use modelling studies indicate an increase in agricultural production in Scotland in future because of the possibility of using marginal land and a gentle amelioration of environmental conditions. However, the appearance of pests and pathogens not previously seen in Scotland and disruptions to local biogeochemical cycles may negate these potential benefits.

The questions that SCRI is being asked to address increasingly span traditional scientific boundaries and also require us to operate as multidisciplinary teams. This requires both acceptance and understanding of the vocabulary, methods and approaches in other disciplines. During the period of this plan, we will actively encourage greater interaction between SCRI scientists with those from outside the natural sciences so as to increase the social and political relevance and applicability of our research.

Our principal customer, RERAD, has indicated that future funding for research is likely to be tight. We shall respond to this by building on our increasing competitiveness in applications for external research funding and by broadening the funding base of research grants and contracts.

The ongoing vertical integration of the food chain, and the changing terms of trade that favour retailers and possessors over producers, mean that the primary focus of SCRI's technology transfer (via Mylnefield Research Services Ltd) will continue to be through contracts with industrial partners that facilitate the development of commercial products from SCRI research, rather than direct interactions with individual producers. Over the course of this plan, greater priority will be given to developing new partnerships with businesses beyond SCRI's traditional strengths in the food chain in area such as environmental monitoring and sustainable energy.

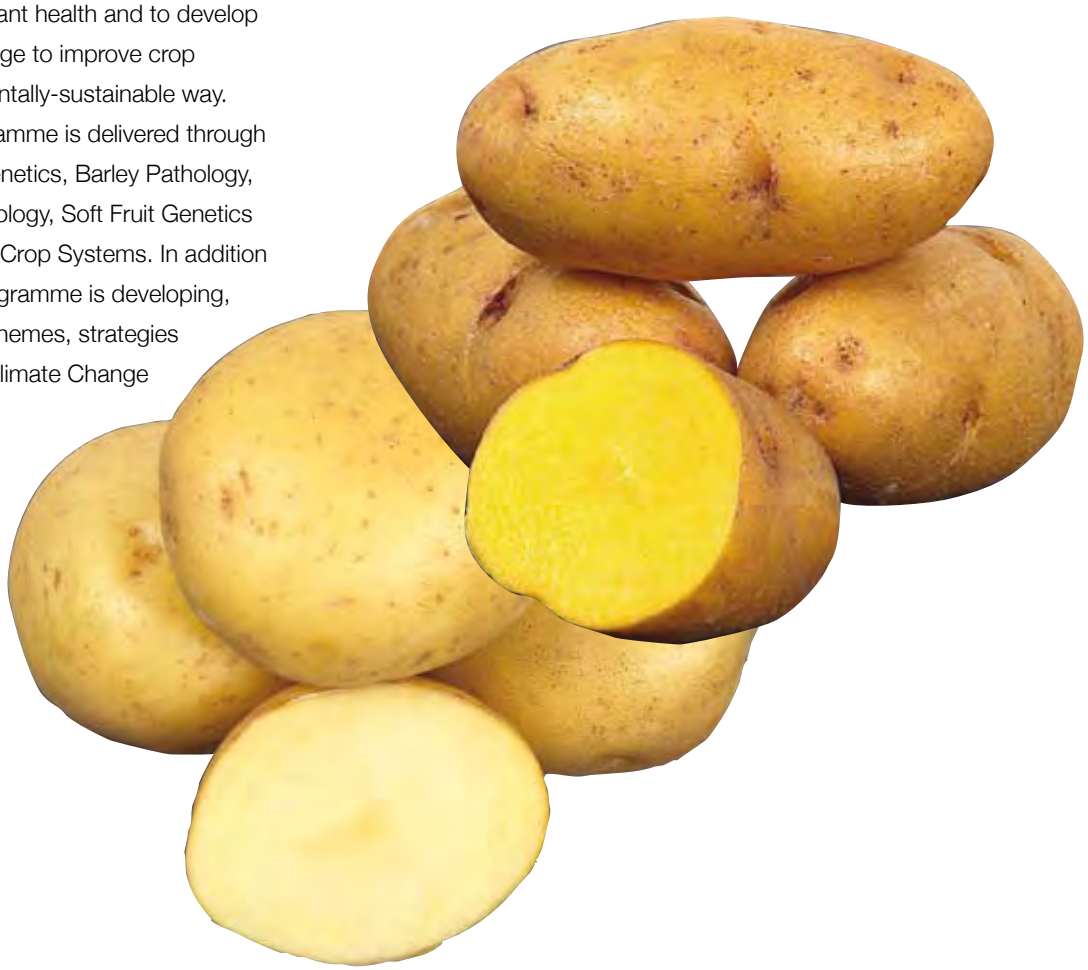
SCRI and its principal customer, RERAD

The SCRI Group receives about 70% of its funding from the Scottish Government through its principal customer and partner RERAD for a defined programme of research.

SCRI coordinates the RERAD-funded programme "Profitable and Sustainable Agriculture – Plants" which aims to deliver RERAD's requirements as laid out in their research Strategy for 2005-2010. The programme involves inputs from SCRI, BioSS, the Macaulay Institute and the Scottish Agricultural College and will be a major component of the SCRI Group's research portfolio during the first half of the current plan. The commissioned research has three high level scientific objectives: 1) Genetics for Sustainability 2) Plant Pathology for Sustainable Crop Production and 3) Designing Crops for Sustainable Production. The major aims are to identify and exploit novelty in genetic resources for the benefit of end-users, to develop and deliver tools which improve plant health and to develop and deliver tools and knowledge to improve crop management in an environmentally-sustainable way. The research within the programme is delivered through six work packages- Barley Genetics, Barley Pathology, Potato Genetics, Potato Pathology, Soft Fruit Genetics & Pathology, and Sustainable Crop Systems. In addition to the work packages the programme is developing, within its three cross-cutting themes, strategies to address a) Responses to Climate Change b) Environmental, Social and Economic Sustainability and c) the Protection of Biodiversity.

The programme also has the responsibility to ensure timely and appropriate knowledge transfer to, and exchange with, relevant end-users and stakeholders. During the period of this plan, SCRI will continue to develop and apply contemporary scientific tools and approaches to deliver solutions to some of the major issues facing Scottish agriculture and its interface with environment. These research outputs, while clearly relevant to Scotland's needs, also have significant global scientific relevance.

Although the programme has a five year timeframe for funding, the metrics of its success will become apparent over a range of timescales. In the short term, work on gene flow and soil resilience is providing information to various policy development groups while in the longer term the tools and knowledge developed with RERAD support will lead, with commercial partners, to the improvement of crops and to new crop varieties.



Management of Research

Research at SCRI is planned and managed to fulfil the requirements of two important drivers: first, that the outcomes of our research should make a clear contribution to sustainable economic growth in Scotland (required by RERAD); and second that the outputs of our research should have impact on, and be recognised by, the global scientific community (required by granting bodies). These twin drivers are important to SCRI's employees and our customers, and are key determinants of SCRI's research activities; they ensure a dynamic equilibrium between problem/project orientation on the one hand and science/hypothesis drive on the other.

Science at SCRI is conducted through four science programmes with specific research contracts (e.g. RERAD work packages) delivered by appropriate groups of scientists from across different programmes. Cross-programme working already occurs (e.g. in the integrated barley pathology group and in studies to improve resource use efficiency) and is expected to increase during the planning period as the funding of multi-disciplinary and inter-disciplinary research increases.

In addition to the four science programmes located at Dundee, BioSS operates as a multi-site programme providing statistical consultancy and research.

Additionally, there is close collaboration with the University of Dundee Division of Plant Sciences (part of the College of Life Sciences in the University of Dundee) who are co-located and contribute to several of the science programmes through joint research initiatives and student supervision.

Within each science programme, scientists contribute through membership of groups which promote the advancement of science and aid management. These groups are flexible in composition and sufficiently agile to facilitate reconfigurations at short notice.

The composition of each programme is:

Genetics:

Leader Robbie Waugh (associate leader David Marshall)

Groups:

Genome biology	Glen Bryan
Applied genetics	John Bradshaw
Genes and development	Craig Simpson
Biodiversity	Joanne Russell
Bioinformatics	Dave Marshall

Plant Pathology:

Leader Lesley Torrance (associate leader Paul Birch)

Groups:

Pathogen genomics	Paul Birch
Plant-pathogen interactions	Michael Taliansky
Pest and disease management	Adrian Newton
Cell biology	Alison Roberts
Environmental pathology	Ian Toth

Plant Products and Food Quality:

Leader Derek Stewart (associate leader Howard Davies)

Groups:

Plant products	Derek Stewart
Food quality	Howard Davies and Mark Taylor

Environment Plant Interactions:

Leader Philip White (associate leader Paul Hallett)

Groups:

Plant-soil interactions	Paul Hallett
Resource capture	Philip White
Agroecology	Geoff Squire

BioSS:

Director David Elston

BioSS is a unit that serves several research organisations in Scotland and specialises in the development and application of the quantitative methodologies that underpin scientific research in four broad application areas. BioSS has its own vision statement "to improve science and society through an understanding of variation, uncertainty and risk" and an associated mission statement “to develop and apply quantitative methodologies with a rigorous mathematical and statistical basis”.

Research themes

Process and systems modelling	Glenn Marion
Statistical methodology	Chris Glasbey
Statistical bioinformatics	Dirk Husmeier

Application areas

Plant science	Christine Hackett (acting)
Animal health and welfare	Iain McKendrick
Ecology and environmental science	Mark Brewer
Human health and nutrition	Graham Horgan

University of Dundee Division of Plant Sciences:

The new Division of Plant Sciences was established in October 2007 as a joint SCRI/College of Life Sciences initiative. The research of the Division explores the mechanisms by which plants grow and develop in response to their environment. This basic research is combined with relevant translation into crop improvement, biofuel development, biotechnology and the assessment of biodiversity. Plant Sciences research groups are associated with SCRI research Programmes and strong interactions and collaborations have been established over the last six years, many supported by joint funding. The main interests of the seven research groups and their primary links are:

How plant pathogens trigger, suppress or manipulate host defences (Paul Birch - links with Plant Pathology)

Messenger RNA processing and gene expression (John Brown – links with Genetics)

Structure, evolution and biodiversity of crop plant genomes (Andy Flavell – links with Genetics)

Manipulations of plant metabolism using reverse genetics (Claire Halpin – links with Genetics)

The dynamics of plant-aphid-microbe associations (Steve Hubbard – links with Environment Plant Interactions)

Plant ecophysiology and adaptation to environmental stress (Lyn Jones – links with Environment Plant Interactions)

Regulated gene expression controlling flowering (Gordon Simpson – links with Genetics)

Science priorities of the Science Programmes

Each of the science programmes has a clear description of its scientific responsibilities and an understanding of its contribution to the SCRI strategy. Outputs are communicated to end users in a variety of media including publications and oral presentations, but a particular focus of SCRI is to ensure that the outputs of our research are presented through a series of web portals targeted at relevant sectoral (academic, commercial and public) policy groups. The scientific hypothesis and major objectives of each programme for the planning period are described below.

Genetics

Description: The programme conducts innovative basic and applied genetical research to identify and associate variation in genes and genomes to variation in phenotypes which are relevant to end user needs.

Hypothesis: Understanding and utilising genetic biodiversity by exploiting the power of genetics can provide a platform for long-term crop improvement and promote the development of environmentally enhanced and sustainable production systems.

Five year objectives:

- High throughput SNP-based genetic mapping will extend to all our major crops. Association mapping will gain increased significance and genes and markers associated with relevant traits will be identified in breeder relevant germplasm.
- Structural genomics efforts will continue in the areas of potato genome sequencing and barley physical mapping and sequencing. Whether or not to sequence the Rubus and Ribes genomes will be assessed.
- Opportunities emerging from new technologies, including 'genotyping by sequencing', 'predictive' and 'systems' biology, will be seized and computational tools that simplify the interpretation, display and application of high resolution of genetic analysis will be a focus of development activities.
- Forward genetics efforts (gene isolation by positional cloning) in all our crops will take advantage of the developments in structural genomics, genetic mapping technologies, characterised mutants, germplasm development and phenotyping.
- The potential for increasing or manipulating the pattern of recombination along the large cereal chromosomes will be investigated by building on information emerging from Arabidopsis (and yeast), and by characterising a series of impaired barley meiotic mutants.
- Post-transcriptional control of gene expression in plant development and stress responses will be investigated globally and through analysis of targeted genes and pathways (e.g. flowering time control) to integrate transcriptional and post-transcriptional networks of regulation
- Release of improved cultivars of potato and soft fruits will be maintained. A judicious programme of pre-breeding and germplasm development will allow us to respond appropriately and rapidly to changes imposed by climate change and other environmental concerns.

Plant Pathology

Description: The programme conducts strategic research on economically important pathogens and pests of potato, barley and soft fruit to understand pathogenicity and disease processes. Plant pathology research spans pathogen genomics and comparative genomics, plant-pathogen interactions and epidemiology of pathogen populations. We are also interested in how environmental changes will impact on disease incidence and the emergence of new strains or new pathogens and resistance durability. The discoveries and innovations are used to deliver crop improvement through the twin mechanisms of host resistance and disease control.

Hypothesis: Sustainable pest and disease management can be achieved through a detailed understanding of pest and pathogen biology, pathogen variation and plant defence mechanisms.

Five year objectives:

- Contribute to the sequencing, annotation, comparative sequence analysis and exploitation of the genomes of the potato pathogens *Erwinia carotovora* ssp. *atroseptica*, *Phytophthora infestans* and *Globodera pallida*; and the barley pathogen *Rhynchosporium secalis*.
- Advance understanding of cellular and molecular mechanisms of disease resistance and susceptibility through studies of plant and pathogen gene function. The effects of abiotic stresses (temperature, CO_2 and drought) on resistance specificity and durability will also be investigated.
- Characterise pathogenicity factors in economically important pathogens leading to a better understanding of mechanisms underlying pathogenicity, horizontal gene transfer, (a)virulence and intraspecific variation.
- Integrate genetic, biochemical and functional data for a better understanding of disease mechanisms and resistance durability.
- Understand the mechanisms of pest and pathogen spread, disease development and factors driving evolution and population change particularly with regard to changing climate and management practices.
- Combine knowledge of disease epidemiology and pest and pathogen biology with rapid diagnostic techniques to develop effective control strategies for integrated pest and disease management systems.
- Investigate the population dynamics of and interactions between plant pathogens, plants and other microbial communities in managed systems.

Plant Products and Food Quality

Description: The programme conducts research into the chemical, biochemical and genetic bases of quality and bioactivity in plant-derived foods and products. It aims to enhance the health benefits of foods to the public by improving the nutritional and organoleptic properties of both raw and processed products and to establish diversification of the non-food crops sector via bioactive plant product research.

Hypothesis: Understanding the key biological factors and mechanisms during plant development will allow the bioactivity, quality and nutritive values for the end user to be tailored and optimised in biodiverse and sustainable production systems.

Five year objectives:

- Characterise the life cycle of the potato tuber using metabolomics, biochemical and molecular biological methods to understand key factors affecting crop utilisation by the potato industries.
- Develop biochemical and molecular methods to understand and characterise the key metabolic drivers of nutrition and organolepsis in potato and soft fruit, and their response to the environment
- Determine the major bioactive compounds in crops with emphasis on soft fruit.
- Develop and exploit a suite of approaches to characterise multiple phytochemical traits in food and non-food crops.
- Establish and develop a plant-derived bioactives programme of research.

Environment-Plant Interactions

Description: Research in the EPI Programme seeks to describe, understand and predict how the environment impacts on plants, and how plants modify their environment. We focus on the efficient use of resources, such as light, carbon, water and minerals, and the development of sustainable and resilient arable ecosystems fit for global and environmental change.

Hypothesis: Economically viable cropping systems can be developed that sustain a greater functional diversity of vegetation and food-webs, and result in more efficient and resilient agro-ecosystems.

Five year Objectives:

- Identify genetic and environmental factors improving (a) root growth and resource acquisition and (b) physiological use-efficiency of essential mineral elements and water by crops for sustainable economic and environmental benefits.
- Develop non-invasive imaging of roots and root-rhizosphere-soil processes, to study the interactions between roots and their physical, chemical and biological environment.
- Develop a suite of critical biological, chemical and physical indicators of soil quality and use these to monitor, understand and advise on soil resilience, sustainability and environmental quality.
- Characterise intra- and inter-specific genetic, phenotypic and community diversity in seedbanks and their consequences for agro-ecosystem function.
- Define the balance of plant traits that support sustainable fluxes of energy and matter in managed ecosystems.
- Identify and characterise key mechanisms underpinning plant interactions with other organisms for sustainable crop management and ecosystem services.
- Quantify patterns in functional diversity of arable plant and invertebrate communities, and to determine the impact of crop management on biodiversity and ecosystem functioning.

BioSS

Description: BioSS undertakes research, consultancy and training in mathematics and statistics as applied to agriculture, the environment, food and health. Research is partitioned into three themes: statistical bioinformatics; statistical methodology; and process and systems modelling. Scientific areas of particular expertise include: plant science; animal health and welfare; ecology and environmental science; and human health and nutrition. BioSS bridges the gap between the mathematical sciences and sciences such as biology that are traditionally more qualitative. Key aspects of the programme of knowledge exchange include: development of software products; delivery of training courses for scientists; and supervision of PhD students.

Five year objectives:

- Improve performance of methods for detecting mosaic structures in multiple sequence alignments, incorporate these in the BioSS-produced TOPALi package and adapt the package to exploit the accessibility and computing power of emerging GRID technologies.
- Develop methods to integrate different types of postgenomic data including gene expression profiles, promoter sequences and protein interaction data via Bayesian Networks to improve our ability to learn about molecular signalling pathways and regulatory networks.
- Develop methods to model complex interactions in epidemic processes in plants and animals, such as *in vivo* models of *E. coli* O157 population dynamics incorporating multiple, spatially-structured, colonisation sites.
- Develop improved models for spatio-temporal analysis of water quality data, and identify effects at different spatial and temporal scales.
- Ensure statistical methods are used where appropriate to improve the efficiency of research conducted by our scientific collaborators, strengthening the conclusions and giving due weight to the evidence base supporting the conclusions.

New Investments

SCRI's internationally competitive expertise, technical capacity and reputation will be sustained by new investments in people and facilities including:

- A vigorous element of quantitative biology in all research programmes drawing on advanced capabilities in bioinformatics, statistics and modelling. We shall seek to apply computational and mathematical techniques to integrate results from interdisciplinary studies of complex systems. This will enhance our understanding of managed ecosystems.
- Technology platforms that are up-to-date, can be efficiently accessed and utilised, and complement other local infrastructure. We shall exploit our strengths in established and emerging technology platforms (e.g. genetics, genomics, transcriptomics, ionomics and metabolomics) to broaden applications, provide greater depth of knowledge and expand opportunities.
- Development of Balruddery Farm as a new experimental platform that will enable our research capacity to be directed towards the development of sustainable production systems with environmental and biodiversity benefits. This will contribute to our status as a LEAF Innovation Centre.
- Development of research capacity and a coherent programme of research relevant to climate and environmental change including a suite of controlled facilities that will allow fast phenotyping and interactions between plants, pests, pathogens and other organisms to be studied.
- Appointment of new staff with expertise in fields that will advance our science programmes and high-level themes (e.g. modern agronomy, climate change science and field genetics).

Partnerships and Collaboration

Partnerships and collaborative arrangements are an essential element of high quality research allowing critical mass to be achieved and faster progress with particular research questions. We have developed several strategic partnerships that have enhanced our capability for basic, strategic and applied research, and enabled product development. In the planning period it will be essential to sustain these partnerships while simultaneously developing a much closer working relationship with scientists at the Macaulay Land Use Research Institute.

Particular attention will be given to the following partnerships:

- CGIAR Links – SCRI has MoUs with the International Centre for Potato Research (CIP) in Peru and the International Centre for Agricultural Research in the Dry Areas (ICARDA) in Syria. These international centres give access to international germplasm collections and various consortia for research.
- SAC – The development of complementary crop and soil research programmes has been aided by the RERAD programme of research and by the MoU signed by the two organisations. Joint research proposals are emerging from the scientists involved and these will continue to be nurtured during this plan. There are opportunities in the "New Institute" for increased collaboration with the economic scientists at SAC.
- European links – There is increasing interest in the evolution of a northern European consortium to examine issues of sustainable crop production in the

light of climate change. We already have formal links with Bioforsk (Norway) and ILVO (Belgium) and closer links with several Scandinavian countries are planned.

- China links - The following MoUs have been signed with Chinese organisations: Chinese Academy of Agricultural Sciences Institute of Vegetables and Flowers (CAAS-IVF), Sichaun Academy of Agricultural Sciences (SAAS), Jilin Academy of Agricultural Sciences, Biotechnology Research Centre, National Centre of Transgenic Plant Research and Commercialisation (JAAS-BRC), Nanjing Institute of Soil Science (CAS), Nanjing University and Jilin Agricultural University and Professor Li Yadong for maintenance and propagation of soft fruit. MRS is a party in a cooperative joint venture 'Danasia' established in the Peoples Republic of China. The other parties are: Beijing Jinaoudun Science and Technology Development Co Ltd; Berrifine A/S, The Industrialisation Fund for Developing Countries. This includes an exclusive licence to nine varieties of soft fruit for growing and marketing in the PRC.
- Universities – The postgraduate research studentship scheme has facilitated interactions with a wide range of UK universities including Aberdeen, Abertay, Edinburgh, Glasgow, Nottingham, Reading, St Andrews and Sussex. In addition we have MoUs with the Michigan State University, USA and the University of Adelaide, Australia with whom we shall expand activities during this plan.

- Business and commercial interactions – MRS will maintain our existing customer base, especially for breeding contracts, and pursue new contacts to develop, especially, our environmentally-related portfolio of products. MRS has negotiated access to two major seed funds (Genomia and the Rainbow Seed Fund) that are investing in technologies with commercial potential. This access to early stage commercial funding is essential to enable a portfolio of technology-based businesses to be developed. In addition, MRS has been instrumental in several important capacity building initiatives, including Interface (targeting Scottish SME's), Genecom (to employ a new Business Development Manager to work alongside the MRS team), and Dundee SME Innovation Portal (targeting Tayside Companies). These initiatives have already led to several commercial collaborations.
- MONOGRAM and the SOIL CIPs – Close interaction with research institutes in England (John Innes Centre and Rothamsted Research) and Wales (Institute for Biological and Environmental Research) is already well advanced with participation in cross-institute programmes (CIPs) in soil science (SOIL) and crop genomics and genetic improvement of cereals (MONOGRAM). These programmes demonstrate SCRI's commitment and contribution to the UK research base, and offer opportunities for coordinated UK-wide research projects.

Education and training

SCRI has a well-established scheme for funding postgraduate studentships enabling students to undertake a PhD research project for 3-4 years in partnership with an SCRI scientist and a university collaborator. SCRI will fund half the cost of the studentship and the university the other half. To date about 30 studentships have been awarded and it is intended to maintain this programme through this Plan.

Knowledge Exchange

SCRI has a significant focus on appropriate and timely knowledge exchange (KE) to ensure that value for money is obtained from both public and private research funding. Strategically, our KE activities are directed towards several major stakeholder groups and audiences including scientists, land-based industry, policy makers and the public. SCRI exploits several routes and media in support of KE including peer reviewed publications, lectures, conferences and workshops, websites, open days, press and television interviews, demonstration activities and public awareness days. Importantly, KE includes advice to policymakers through advisory bodies, strategy groups and position papers. Commercially, we are engaged in technology development with, and transfer to, several industrial sectors and have an active policy of intellectual property protection where it is relevant for our business. Our product development provides an important route to translate scientific knowledge into superior products and services and makes our scientific developments widely available while ensuring the relevance of our science.

knowledgescotland
Science Policy Connections Online

SCRI is an enthusiastic member of knowledgescotland, an online resource for policymakers and Government stakeholders that is focused in the food, health, environment and rural sectors. Our partners are:

- Macaulay Land Use Research Institute
- Moredun Research Institute
- Rowett Institute of Nutrition and Health
- SAC (Scottish Agricultural College)

The project, supported by Scottish Government, is designed to assist policymakers develop improved knowledge and understanding in the food, health, environment and rural sectors.

Science Achievements 2004-2008

Research by SCRI scientists, published in the prestigious Nature journal, has shown that a key conserved portion of virulence proteins produced by the late blight agent, *Phytophthora infestans,* is required to target these proteins inside the host plant cell during infection. The finding has generated widespread excitement as the sequence identified in *P. infestans* proteins resembles a recently reported translocation signal in virulence proteins of the malaria parasite.

Working with the Moscow State University SCRI has investigated programmed cell death (PCD) and the role it plays in plants' defences against infection. The outcome is a commercially significant finding.

We have developed a novel small fluorescent protein with scientists at the Universities of Edinburgh and Glasgow. It provides a new tool to study cellular processes.

A detailed survey of populations of the late-blight pathogen (Phytophthora infestans) in British potato crops has been conducted. Tests using a range of P. infestans genotypes against five commonly grown potato varieties demonstrated that one particular genotype (13_A2) is particularly aggressive, especially at lower temperatures. These results and their implications have been widely reported to the industry.

SCRI played a major role in the farm-scale evaluation for winter oilseed rape, as part of a consortium with the Centre for Ecology and Hydrology and Rothamsted Research. The work showed that GM herbicide tolerant winter rape gave no advantage to energy interception by the crop and would increase the grass weed problem later in the rotation. The results influenced government policy on the adoption of Genetically Modified Herbicide-Tolerant winter rape.

As part of the 'Baseline Study' of arable east Scotland, a comprehensive assessment was made of the seedbank in arable-grass fields from the Black Isle to East Lothian in collaboration with SAC. This work will allow researchers to assess the dual roles of arable plants as weed burden and base of the food web, and is a major part of a wider study of the biophysical and economic state of Scotland's fields.

SCRI has successfully located genes controlling the majority of the morphological and developmental variation that has previously been identified in barley. This was achieved by genotypically characterising a 'legacy' collection of 977 nearly isogenic lines known as the 'Bowman mutant collection' with a recently developed gene-based mapping platform.

SCRI has contributed to sequencing a portion of the tomato chromosome 4 and is using this as a framework for the development of an equivalent potato chromosome 4 sequence under the auspices of the International Potato Genome Sequencing Consortium.

A system for analysing multiple (300) plant alternative splicing events simultaneously has been developed. The system is being used in collaboration with over ten labs in Europe and South America.

The finding that messenger RNA (mRNA)-associated proteins are found in the plant nucleolus has led to the unexpected discovery of mRNAs in the nucleolus. Moreover, the nucleolus is enriched in mRNAs which are improperly processed, detected by an mRNA quality control mechanism and destroyed. This link between the nucleolus and mRNA quality control is unique to plants and demonstrates a new function for the nucleolus.

A metabolomic exploration of phytochemical diversity in a range of potato cultivars and landraces showed that there is potential within this material for further quality trait enhancement. The work has been extended to embrace a significantly broader biological range including the Commonwealth Potato Collection (CPC).

Substantial evidence has been obtained that berry polyphenols have potent effects on the growth and development of cancer cells. The invasiveness of cancer cells was shown to be severely retarded by components found in raspberries. Related studies showed that these components are likely to reach the colon are where the inhibitory effect would be exerted.

Using a combination of metabolite analysis and transcriptomics, new factors that influence potato flavour have been identified and characterised. It has also been demonstrated that enhanced potato flavour, scored by a sensory panel, correlates with the content of umami compounds and the levels of these taste compounds are particularly high in tubers from *Solanum phureja* cultivars.

Scotland's Public Health Minister, Shona Robison, MSP visiting SCRI

Outputs bringing practical benefits 2004-2008

Collaborative research with the Universities of Dundee (Divisions of Civil Engineering and Applied Computing) and Cambridge (Plant Science Department) has developed new methods for quantifying the mechanical interactions between roots and the soil. The results are being used by road and rail authorities to help prevent landslips.

EnPrint® is a DNA fingerprinting technology for the rapid and accurate analysis of water quality. A spin-out company has been incorporated to commercialise this technology.

Selenium-biofortified bread was produced by Marks and Spencer Ltd. based on the expertise developed by the Defra Sustainable Arable LINK "BAGELS" consortium, which included SCRI. This research demonstrated that dietary Selenium intake in the UK can be increased simply by applying Selenium fertilisers to wheat crops.

SCRI together with IPK-Gatersleben and the University of California has released two genotyping systems for general use by the barley genetics and breeding research communities. Already widely-adopted the technique brings precision, robustness and integration to all genetic studies in this crop.

SCRI released a major version of the GERMINATE database to support data sets associated with the Commonwealth Potato Collection. The aim is to assist

in the selection of germplasm for potato improvement. GERMINATE is similarly supporting a public / private initiative in barley association genetics. (AGOUEB)

Innovative graphical genotype analysis software called 'Flapjack' has been released and is currently being used by all collaborating commercial partners in the SA-LINK AGOUEB project and numerous academic labs around the world.

Since 2004 Mylnefield Research Services Limited, on behalf of SCRI and its commercial partners, has had significant success with the following products:

- The raspberries Glen Doll and Glen Fyne have been commercially released and applications for plant variety rights have been submitted for a further two raspberries shown to have some tolerance to root rot.
- Loch Maree, a blackberry with a sweet flavour and beautiful pink double blossom has been commercially released.
- Big Ben, a blackcurrant specifically aimed at the fresh market has been released and is licensed to Winterwood Farms. Two processing blackcurrants 'Ben Starav' and 'Ben Klibreck' bred for Glaxo SmithKline (GSK) have been released to GSK growers.
- A new Swede 'Gowrie' has been developed in partnership with Limagrain. Swede varieties bred at SCRI account for approximately 42% of the UK market.
- Three new potatoes bred at SCRI have entered the National List. All are phureja types licensed to Greenvale AP. One of them, 'Mayan Queen', was available through Tesco stores in 2008.
- Vales Sovereign, a potato licensed to Greenvale AP, won the 'Tesco best new variety in fresh produce' award in December 2008. It is now being sold throughout the Tesco chain. Tesco has marketed the variety as: "The world's first environmentally friendly potato needing less water and fertiliser than other varieties."

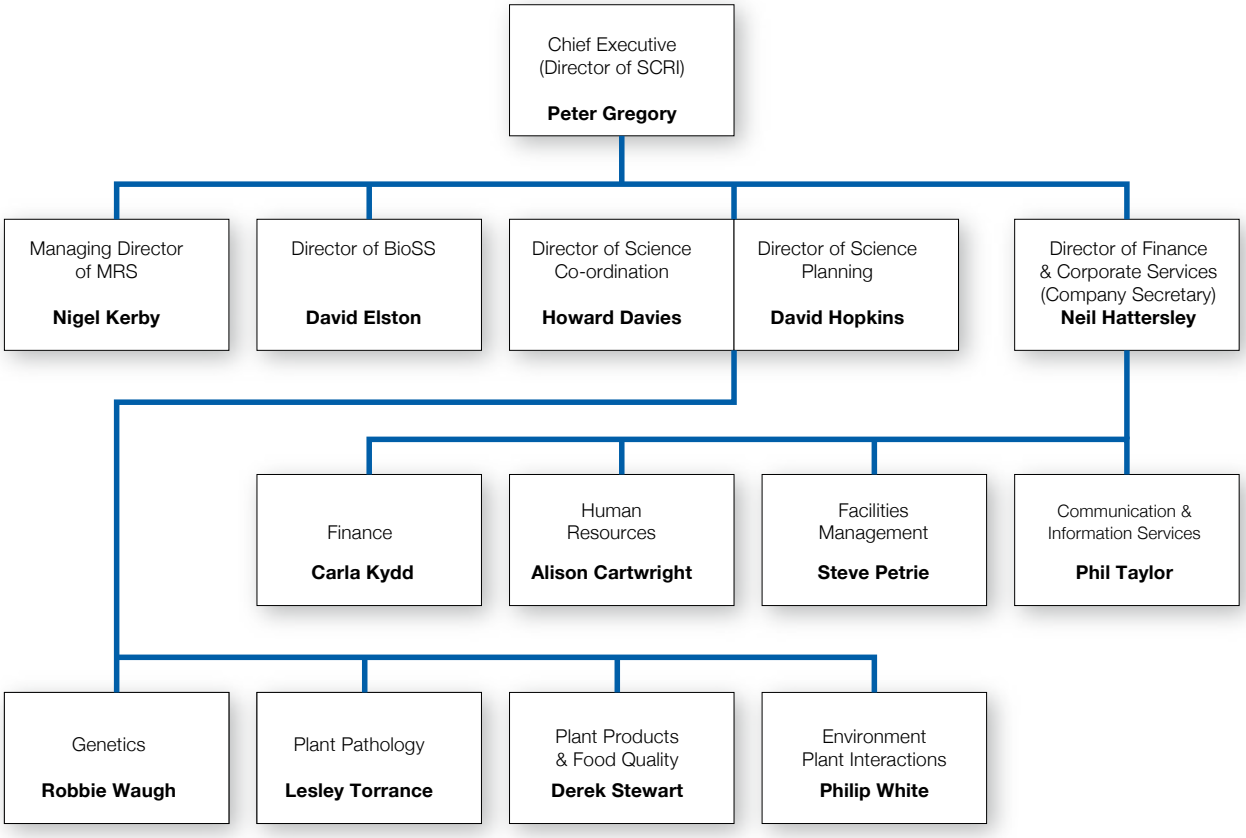
Since 2004, MRS has filed three patents in the name of SCRI for inhibition of gene expression, alpha-copaene, and a method of gene transfer.

SCRI is developing bread containing 20 per cent barley, which is shown to reduce cholesterol and cut the risk of heart disease. The commercial development is being pursued via collaborative EU funding and with European SMEs.

A rapid molecular diagnostic test to detect potato cyst nematode (PCN) in soil samples has been developed jointly with SASA. It compares very favourably with the microscopic test which is currently in use and can also be used to detect PCN in commercial soil samples. The test is currently being evaluated in Slovenia, France and Belgium.

We have developed real-time tests, improved DNA extraction methods and sampling strategies that have made possible the rapid and accurate quantification of potato pathogen DNA in plants, tubers and soil. These pathogens cause tuber blemish diseases that affect the quality of seed and ware crops in the UK and around the world. Collaboration with SAC Aberdeen has resulted in the delivery of commercial diagnostic tests and advice to growers for effective integrated control strategies.

Management of the SCRI Group



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