SCRI: an historical perspective

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The Scottish Crop Research Institute (SCRI) was formally established recently in 1981 and may be regarded as having a very short history. However, its forebears, the Scottish Plant Breeding Station (SPBS) and the Scottish Horticultural Research Institute (SHRI), from whose amalgamation SCRI arose, both have distinguished histories of achievements which have clearly influenced the directions and strengths of research at the present Institute. Therefore, it is instructive to document some of the major initiatives from their inception and their development to the present day.

SPBS

SPBS was established in 1921, along with several other research institutes, when it became realised by farmers, landowners and the Government that agricultural productivity and efficiency in the UK had fallen well behind that in other countries in Europe and the rest of the world. Furthermore, the UK had recently emerged from the 1914-18 war which had demonstrated its dependence on imports of basic foodstuffs from around the world. Investment in scientific research was seen as one solution to remedy this situation. The initiative to establish a body to improve the yield and quality of varieties of crops grown in Scotland came primarily from the farmers and landowners who were members of the Highland and Agricultural Society of Scotland. A Committee was formed, that later became the Scottish Society for Research in Plant Breeding (SSRPB), to appeal for funds to set up a research station, and the Government of the day pledged to match the amount collected. By 1920 £22,500 had been collected and a total of £45,000 was available. A Government Registration and Seed Testing Station had been established a short time previously at East Craigs, Edinburgh and the new Scottish Plant Breeding Station shared the site, occupying Craigs House on the estate. Montagu Drummond was the first Director of Research, although he moved to the Chair of Botany at Glasgow University within four years. His place at SPBS was taken by W. Robb in 1925 who held the position until retirement in 1950.

The object of the SSRPB was stated to be "the establishment of a thoroughly equipped station for the improvement of agricultural plants. The improvement to be attained partly by selection and partly by the creation of new varieties possessing those qualities which will make them most profitable under Scottish conditions". Thus the objective of SPBS was strictly practical and it was to be guided by the Society rather than the Government. The Society, being composed primarily of interested growers, would ensure that the practical aim of the Station would be met, in so far as it was feasible.

Craigs House, 1921.

The first crops to be grown at Craigs House were oats, barley and potatoes. Collections of varieties were obtained and their performances monitored to determine which were best suited to local conditions. The main tasks were enumerated as:-

1) Collection and classification of suitable living material;

2) Isolation of pedigree strains (pure lines);

3) Comparative trials of varieties, pedigree strains etc;

4) Hybridisation of pedigree strains, varieties and species.

Soon after the establishment of SPBS, improvement of swedes and turnips, and ryegrass, cocksfoot and timothy grasses were included within the remit. Thus the foundations were laid for progress towards the stated aims in all of the crops throughout the 20s and 30s.

The three major figures in this phase of the history of SPBS were W. Robb, the Director who led the work on oats, J.W. Gregor, who conducted the grass programme and W. Black, appointed in 1926, who was in charge of potatoes.

Staff numbers accommodated in Craigs House grew slowly and steadily over the first 25 years of its existence but by 1945 further impetus to the development of

agriculture and the attainment of self sufficiency in basic foodstuffs was given by the emergence from the war years. As a consequence, additional staff were appointed, supported financially by the Department of Agriculture for Scotland, and it soon became apparent that the premises at East Craigs were inadequate for the larger staff numbers and the facilities that they required. In 1947, the University of Edinburgh purchased the Bush Estate south of Edinburgh and negotiations began for SPBS to acquire some of the land on which to build a new research station. The new laboratories and ancillary buildings at Pentlandfield were officially opened by the Secretary of State for Scotland in July 1955. By this time, the Government, through the Scottish Office, was providing most of the financial support with advice from the Agricultural Research Council, although the SSRPB retained a strong interest in the direction of the work of the station, as it had done throughout its history. J.W. Gregor was Director from 1950-1965 during the transfer from East Craigs to Pentlandfield. N.W. Simmonds succeeded J.W. Gregor in 1965 and was replaced by R.C.F. Macer in 1976.

Pollination of brussels sprouts 1964.

Cereals, brassicas and herbage crops

At the time of the establishment of SPBS, oats were a major cereal crop for animal fodder and for human consumption, and the selection and breeding objectives were to produce varieties with early ripening characteristics, resistance to lodging and with low levels of husk and fibre. The earliest varieties produced were Bell and Elder followed by Albyn Express and, much later, in the 50s, Shearer and Pentland Provender. By the late 30s, damage caused by stem eelworm (*Ditylenchus dipsaci*) was recognised and efforts were made to produce resistant varieties. In later years, as barley supplanted oats as the major animal feed crop, work on oats was gradually attenuated and was effectively concluded by 1981.

The programme on grasses was predominantly directed towards selection of land races that were adjudged to be most suitable for growing in Scotland and there was a strong emphasis on improvement of upland grassland through ecological observations of the interactions between genotypes and the local soil and climatic environments. Several strains of cocksfoot, timothy and perennial ryegrass with the prefix Scotia were selected and marketed.

Forage brassicas were, and still remain, an important component of livestock husbandry in Scotland and early efforts at SPBS were directed towards selection and improvement of swedes, turnips and kales. V.M. Davey was appointed in 1926 and developed the concept of pedigree breeding in which repeated selfing increased the homogeneity within the crop without, in some instances, resulting in in-breeding depression. Several varieties which have been released in recent years have their origins in Davey's selection programme. Leafy brassicas, eg kale and rape, were included in the programme from the 1950s and led to substantial research into the genetics and cytology within the genus. Inter-specific crosses were made and differences in ploidy level overcome to create new forms and greater variability. Resistances to clubroot (*Plasmodiophora brassica*) and mildew (*Erysiphe cruciferarum*) were also incorporated by this technique. The culmination of this programme was the production by I.H. MacNaughton of an inter-generic hybrid between *Raphanus sativus* and *B. oleracea* called Raphanobrassica which outyielded all other forms of leafy brassica available. Although the programme on breeding brassicas as forage crops declined throughout the 1980s, current interest in the genus as a source of industrial oils and possibly fibre could lead to a resurgence of research to build on the expertise accumulated in earlier years.

Potatoes

Potatoes received a great deal of attention from the inception of the Station. Collections of genotypes were obtained from various sources but particularly from J. Wilson of St Andrews University, a botanist who had already successfully transferred a resistance gene to late blight (*Phytophthora infestans*) from *Solanum demissum* to *S. tuberosum*. The damaging effects of pests and diseases were particularly recognised in potatoes and much effort directed towards identifying sources of resistance and transferring them into commercially acceptable varieties. Wart disease (*Synchytrium endobioticum*) and late blight were the first diseases to receive attention and produced directly contrasting results. Although wart was extremely damaging, soil borne and long

lived, durable resistance was found early during the research programme and has provided a long term answer to the problem. Resistance was a dominant character and easily transferred into new varieties and the fungus pathogen was relatively immutable. In contrast, late blight proved, and continues to be, a much more intractable problem. Much has been written about the search for a genetic control of blight and further accounts will appear in 1995, the 150th anniversary of the blight epidemic in Ireland and Western Scotland. Sources of resistance were found in wild species, particularly *S. demissum*, and transferred to *S. tuberosum* prior to the foundation of SPBS and latterly extensively by Black and his co-workers. The resistance was controlled by dominant major genes, designated R genes, and they conferred hypersensitivity within the host. However, within a few years of the introduction of an R gene in a new potato variety, the pathogen had adapted and overcame the resistance mechanism causing the new variety to become as susceptible as its predecessors. Successively new genes were identified and introgressed into new varieties only to succumb to further new races. Using a host differential series, Black demonstrated the existence of a total of 11 R genes but by 1944, he was beginning to doubt the probability of success using single major resistance genes. The failure of this approach was illustrated by the fate of Pentland Dell introduced in 1961 which contained three separate R genes, but which had succumbed to outbreaks of foliage blight in England by 1967.

Pentlandfield, 1977.

Black became an international authority on blight and the Station received many isolates for characterisation and distributed many seedlings containing R genes throughout the world. Having become convinced that R genes would never provide a durable control of blight, his attention turned to other mechanisms. During the course of screening work with complex races of the pathogen, it was observed that some genotypes containing the same R genes were less susceptible than others. Attention turned to this field resistance and additional sources were sought within wild species. Although it was polygenically controlled, field resistance was successfully incorporated into new clones. Ironically, the first widely grown field resistant variety was Roslin Eburu exported to Kenya in the early 60s where it gained popularity partly because of its tolerance to blight. Present day varieties such as Brodick, Torridon and Stirling are direct descendants of this programme and show high degrees of field resistance. In modern conditions of European agriculture, large applications of fungicides to control blight remain normal practice and consequently, the demand for durable, genetically determined resistance is not great except from the organic movement. However, should constraints be placed on the usage of fungicides in the future, the products of the SPBS programme and Black's pioneering work will achieve their rightful preeminence.

By 1929, the importance of virus diseases of potatoes had become recognised and an application was made to the Empire Marketing Board for financial assistance towards the cost of buildings and equipment for research on this topic. The unit was established at Craigs House in 1931 and Barton Wright and G. Cockerham were appointed. Barton Wright resigned in 1935 but Cockerham continued and led the group until he retired in 1969. Other members of the group included D.A. Govier and T.M.W. Davidson. It is noteworthy that C.H. Cadman, who later joined the staff of SHRI and became its Director in 1965, was a member of the group from 1939-43. The early work concentrated on characterising the several virus diseases in potatoes, particularly viruses X, Y and S and potato leafroll virus, and distinct strains within each virus were identified. The group were amongst the first in the UK to introduce diagnostic serological tests in 1948. Alongside the work of characterising the viruses, searches for effective resistance to them were underway and commercial varieties were found which contained dominant genes conferring immunity to virus X and some strains of virus Y. In addition, wild strains were screened for exotic forms of resistance to transfer into the breeding programme. Resistance to PLRV was found to be polygenic and present in some cultivated varieties and hybrids with wild species. One successful outcome of the research was Pentland Crown which had a high degree of resistance to PLRV and to virus Y. The emphasis on virus diseases remains to the present with useful sources of resistance available to many of them and now supplemented by transformation tech-

nology using the virus coat protein genes and other genetic constructs.

Resistance to potato cyst nematode (*Globodera rostochiensis* and *G. pallida*) was added to the list of breeding objectives in 1949 when the effects of extensive infestation of ware fields were recognised. By 1951, a gene for resistance to *G. rostochiensis* was demonstrated in *S. andigena* in collaboration with Ellenby at Newcastle. The gene, H_1, was quickly incorporated into a new variety, Pentland Javelin, released in 1968. Javelin did not achieve the preeminence of its competitor, Maris Piper, but the widespread cultivation of varieties with the H_1 gene led to the selection of the second PCN species, *G. pallida*. Resistance to this species has been found in *S. vernei* but, being polygenic, is more difficult to transfer to cultivated varieties. Nevertheless, several recent varieties, e.g. Eden, show good resistance to both *G. rostochiensis* and *G. pallida*.

Throughout the history of SPBS, other diseases have been added to the list under investigation, e.g. common scab, gangrene and blackleg, and there has always been a consciousness of the importance of introducing material that is at best resistant, or at least, not highly susceptible. This emphasis of pest and disease resistance is in contrast to most commercial breeding companies where the objectives of yield, appearance and quality predominate on the assumption that most pests and diseases can be adequately controlled by application of agrochemicals and that introducing resistance is, of necessity, a long term costly exercise. The advantage of a state supported institute such as SPBS was that it did not rely on the profit motive alone and included research on sources of resistance and their transfer to varieties for the public good in the long term.

Although emphasis was laid on strategic studies of resistance to disease, nevertheless on purely commercial grounds, the products of the genetics programme achieved substantial success as ware varieties. In 1971, Pentland Crown was the leading variety in the UK and, together with Pentland Dell, the two varieties occupied about one-third of the total UK crop. Although the popularity of varieties change, material from the SPBS programme has always maintained a presence in the top varieties grown in the UK. Changes in the administration of publicly-funded research heralded by the reports of Rothschild and Barnes (referred to below) have not hindered the progress of breeding new varieties of potatoes although they have substantially changed the way in which this is achieved. Much closer collaboration and partnership with commercial companies have resulted but they continue to exploit the expertise and improved genetic resources elaborated in the earlier years.

At the heart of the continuing improvement and introduction of new genetic material is the Commonwealth Potato Collection and this is becoming an even more valuable resource as the new technologies of genetic transformation and tissue culture allow combinations of genetic material that were hitherto impossible by conventional crossing techniques.

Barley

By 1962 it became obvious that barley had largely supplanted oats as the dominant cereal for animal feed and trials began in collaboration with Plant Breeding Institute, Cambridge, to trial selections for their suitability for Scottish conditions. A crossing programme was started in 1966 when additional staff were appointed to conduct the trials. By this time, N.W. Simmonds was Director and he criticised the narrow genetic base of the UK cereal crops and advocated a wide crossing programme with exotic germplasm. Early on in the research, selections were made on the basis of high diastase and high amylase characters to improve their acceptability to maltsters. Initially, disease resistance was not considered a priority but by 1970 when the potential of mildew to reduce yields was realised, resistance to this disease and to *Rhynchosporium*, yellow rust and brown rust were included in the programme. Because of the importance of the malting and brewing industry in Scotland, the emphasis on malting quality, its determinants and genetic control remain active research topics today. In addition, climatic conditions prevalent in Scotland may require genotypes that differ from those grown elsewhere.

SHRI

SHRI was founded in 1951, largely as a result of the concerns of the Scottish fruit growers. Raspberries had been introduced as a crop into several locations in Angus and Perthshire around 1900 where they produced excellent crops due to favourable climatic and soil conditions. The crop was grown on smallholdings and most of it was transported by rail to jam manufacturers in England. Initially, large yields were obtained but by the 1920s the vigour and yield of plantations were seriously affected. Strawberries were an important crop in Lanarkshire at around the same time and they suffered a similar decline. A Scottish Horticultural Advisory Committee was established in 1927 to advise the Department of Agriculture and it frequently referred to a need for research to solve the problems of the industry. Investigations into the strawberry prob-

Mylnefield farm, 1951.

lems were centred on the West of Scotland College of Agriculture at Auchincruive and R.D. Reid was appointed in 1930 to investigate possible control measures. He found soil sterilants and fungicides unsuitable and turned to selection of clones that survived on a plot of land that was known to be heavily infested by what was to be identified later as a soil-borne fungus, *Phytophthora fragariae*. He was successful and Auchincruive Climax was introduced in 1947 as the first of a series of strawberry varieties that were resistant to red core. Reid and his co-workers were later transferred to the staff of SHRI although the strawberry breeding unit remained at Auchincruive until 1980.

The problems of the raspberry growers were referred to East Malling Research Station in Kent and during the 1930s infection by viruses was established as the cause of the decline in yield and vigour. R.V. Harris supervised the work from East Malling and C.H. Cadman, who later became Director of SHRI, was appointed as a resident assistant in 1943, transferring to Dundee from SPBS. This then established the Scottish Raspberry Investigation Unit and further staff were appointed including C.A. Wood as pomologist. By 1946 the Horticultural Research Committee recommended the founding of research centres in Scotland for fruit, vegetable and glasshouse crops. Mylnefield Farm near Dundee was identified as a prospective site for the research station and was purchased by the Department of Agriculture for Scotland in 1950 along with the neighbouring farm of Bullionfield which together provided c. 100 ha experimental land. SHRI was formally established in 1951 and took over the staff of the Raspberry Investigation Unit with T. Swarbrick as the first Director.

Professor T. Swarbrick addressing dignitaries at the official opening of the Institute on June 16, 1956.

The emphasis initially was on raspberries and by 1951 a system of introducing virus-free foundation stocks had been developed to provide planting material for new plantations which helped to revive the failing industry. Several aphid-borne virus diseases had been characterised in the crop and Cadman later discovered that soil-borne nematodes transmitted raspberry ring spot. The early concentration on virus diseases resulted in SHRI becoming a major centre for research in this area led initially by Cadman and from 1966 by B.D. Harrison. D.L. Jennings was appointed in 1957 to lead the breeding of new varieties and Glen Clova, the first product of this programme and the forerunner of all the more recent Glen series of varieties, was introduced in 1971. Since then SHRI varieties have dominated the Scottish crop and have been exported worldwide.

Strawberry breeding continued to produce a series of varieties including Talisman and Red Gauntlet at Auchincruive, and blackcurrants and blackberries were also included in the breeding programme at Invergowrie.

Main laboratory and administrative buildings at SHRI, with the new wing completed in 1960.

Alongside the breeding, pathology and agronomy of soft fruit, an active programme on vegetable crops developed, largely to support the increasingly important vegetable processing industry in the east of Scotland. Breeding efforts on cabbage, Brussel sprouts, beans and carrots were initiated, together with agronomic and pathological work.

Aerial view of SHRI, 1965.

The Amalgamation

Throughout the 60s and 70s, the numbers of staff and research topics at both SPBS and SHRI expanded as a result of Government policy to encourage the development of science and technology for the benefit of the UK. The Institutes were administered by the Department of Agriculture for Scotland acting on advice from the Agricultural Research Council who operated on the Haldane principle of minimal interference of research scientists operating within broad terms of reference for the Institutes under its control. This system allowed scientists of the status of Black, Cockerham, Reid, Cadman and others to develop their own lines of expertise and innovation unhampered by excess administration or a high expectation of results. Clearly, the achievements of both organisations in providing advanced technology and improved crop varieties to the benefit of Scottish agriculture and horticulture were evidence of the success of this philosophy. However, a radical change to the administrative system was heralded by the Rothschild report published in 1972 in which it was recommended that a substantial proportion of the funds administered by the ARC in England should be transferred to the Ministry of Agriculture, Fisheries and Food. A Chief Scientist was appointed in the Ministry who would oversee the allocation of funds and the concept of the Ministry as a customer and the ARC as a contractor was established. These moves began the increasing trend towards Government intervention and requirement to demonstrate accountability in the publicly-funded research institutes. The days of the autonomous research institute had passed with the establishment of the Joint Consultative Organisation designed to control and monitor results at each institute. By 1975, the ARC initiated discussions on areas of overlap of research within the Agricultural Research Service and concluded that research on potatoes, forage brassicas and barley should continue at SPBS but that work on grasses and clover should be terminated. Raspberries and blackcurrants would remain at SHRI and culinary vegetables would be transferred to the National Vegetable Research Station.

Further rationalisation was deemed desirable and in 1978 a Working Party was set up by the Secretary of State for Scotland to examine the arrangements for commissioning and organising research at SPBS and SHRI. The Working Party recommended the amalgamation of the two establishments on the site at Invergowrie under the name of the Scottish Crop Research Institute. The combined Institute came into being officially on 1 February 1981 and a substantial capital building programme to accommodate the staff and equipment to be transferred from Pentlandfield was initiated at Invergowrie. In addition, Gourdie Farm was acquired to bring the available land to a total of 200 ha. The transfer to the Invergowrie site was a phased operation and was not completed until 1991. Several factors contributed to the decision to effect the amalgamation and to locate the combined Institute at Invergowrie. Both SPBS and SHRI had become large establishments with clear areas of expertise but also weaknesses and it was perceived that there was considerable complementarity between them that could be exploited by bringing them together. For example, the genetic and breeding expertise on potatoes at SPBS would benefit from the fundamental research on plant physiology and pathology that had developed at SHRI. There would be economies of scale in running one large organisation rather than two separate establishments and there was adequate land for building expansion and for field trials immediately adjacent to the laboratory area at Invergowrie. The remit given to SCRI by a Programme Review Group that reported in 1980 was “to do the research needed to sustain and increase crop production in Scotland and northern Europe ... with emphasis on plant breeding, crop physiology, agronomy and crop protection. It will concentrate on potatoes, spring barley, forage brassicas,

raspberries and blackcurrants." C.E. Taylor, Director of SHRI from 1971 oversaw the negotiations for the amalgamation; J.R. Hillman became Director in 1986.

In 1987, the Macaulay Institute for Soil Research was amalgamated with the Hill Farming Research Organisation and some staff and resources at Aberdeen concerned with plant science, soil microbiology and chemistry were transferred to SCRI. Also in 1987, SCRI became responsible for administering the Scottish Agricultural Statistics Service.

In the years since 1981, further changes have taken place to the structure and remit of SCRI. The Barnes report of 1988 introduced the concept of "near market research" and required the beneficiary of research to pay for it. In agriculture this was interpreted as the farming industry in general and forced researchers to look towards commercial companies and levy boards etc to provide funds to support work which would be of direct practical value to the industry. In particular for SCRI, the designation of the production of new crop varieties as a near market operation created problems, as this had been recognised as a primary function of the Institute at the time of the amalgamation. Nevertheless, there was sufficient adaptability within the system to allow for the formation of a Consortium and to enter into partnerships with commercial plant breeding and seed specialist companies to share the costs and proceeds of introducing new varieties to the market place. The move towards independent income generation from the products of research also led to the formation of Mylnefield Research Services Ltd in 1989 as a commercial trading arm of the parent charitable Institute.

Another major change from the remit given to SCRI in 1981 has been the move from emphasis on research of benefit to northern Britain to a much greater international role. Research on many of the crops investigated at SCRI is relevant to countries growing those crops outside the UK and increasingly the Institute acts as a focus for the introduction of new technologies in crops such as potato and raspberries that are relevant worldwide. Furthermore, research scientists are attracted from many countries to acquire knowledge and techniques developed at the Institute. In addition, the range of crops under investigation has extended to include many that are not grown in Scotland because the facilities available are relevant to tropical and subtropical species. There has also been substantial developments in molecular biology and cell and plant physiology with increases in staff and research projects, many of which have their origin in earlier work at SPBS or SHRI.

The legacy of the early years

Both SPBS and SHRI were founded on the needs of local Scottish growers to solve problems of poor productivity. Many of these problems were pathological in nature and in some cases their resolution lay in attempts to produce new varieties with genetically controlled resistance as demonstrated by the case histories of late blight of potatoes and virus diseases of raspberries outlined above. In the course of these developments, a large body of expertise on crop genetics and breeding was built up and collections of wild species and primitive varieties made to search for and transfer desirable characteristics into crop varieties. Concurrently, it was inevitable that research into the pathogens should be undertaken to characterise resistance-breaking strains and physiological races. Although the increasing sophistication of chemical control methods has to some extent lessened the absolute necessity for durable resistance mechanisms to be incorporated into varieties, increasing public unease about chemical residues in food and the environment and the pathogen's ability to acquire tolerance to chemical controls suggest that intrinsic host resistance will remain a high priority in the future.

The modern technologies of molecular biology rely heavily on the collections and knowledge acquired in the earlier years of the Institute. Furthermore, the selection and establishing the agronomic value of any genetic transformance will depend on the skills developed during conventional procedures of breeding and selection.

SCRI can draw on a long and distinguished history of research and achievement to support and enrich current efforts to improve crop production methods and to understand the basic mechanisms underlying plant growth and development.

SPBS

M. Drummond	1921-25
W. Robb	1925-50
J.W. Gregor	1950-65
N.W. Simmonds	1965-76
R.C.F. Macer	1976-81

SHRI

T. Swarbrick	1951-65
C.H. Cadman	1965-71
C.E. Taylor	1971-81

SCRI

C.E. Taylor	1981-86
J.R. Hillman	1986-present

Table 1 Directors of research.