THE DEVELOPMENT OF POTATO VARIETIES IN EUROPE

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HISTORY

The potato was introduced into Europe from South America sometime between 1565 and 1573. It was first grown in Spain but by the early part of the seventeenth century it was found in the botanical gardens of many European states. This was largely due to the efforts of the botanist Charles d'Ecluse, or Clusius, who received two tubers and a fruit from the Prefect of Mons, Philippe de Sivry in 1588, multiplied the tubers and distributed them to a number of friends. The first botanical description of the potato was published by the Swiss botanist, Caspar Bauhin in 1596. Bauhin also gave the potato its Latin binomial, *Solanum tuberosum*, although he later added *esculentum*. A second description was published in England, where the potato was probably introduced between 1588 and 1593, by Gerard in his 1597 "Herball".

The original introductions were almost certainly from the Andean regions of Peru or Columbia and were of the subspecies *andigena* (hereafter called Andigena potatoes), with a short-day photoperiodic response. Under European conditions they would have produced many stolons but poor yields of late-developing tubers. During the following two centuries, seedlings from these original introductions were selected for yield and earliness, to give rise to clones well adapted to longer summer days. This selection may have been made in hybrids and selfs of only two original introductions (Salaman 1926). By the middle of the eighteenth century the potato had become a universally cultivated field crop in Europe. A major problem was "Curl", a degenerating condition which meant that varieties had a limited life. To overcome this, seedlings were raised from self-set potato fruit and so there were large numbers of varieties. Towards the end of the century a number of distinct varieties came into use, some of which were specified for human consumption and others for animals.

Two events of major importance in the history of potato breeding occurred in the middle of the nineteenth century. The late blight (Phytophthora infestans) epidemics of 1845-46 demonstrated the lack of blight resistance in contemporary varieties. This was not surprising as previous selection had been done in the absence of blight. New varieties were developed with some degree of resistance. These included Paterson's Victoria, Champion and Magnum Bonum, all of which feature in the ancestry of many modern varieties (Figure 1).

Figure 1. Three UK potato varieties grown extensively in the nineteenth century; Champion (top left, introduced 1876), Magnum Bonum (top right, introduced 1876) and Lumper (bottom, introduced prior to 1810 and widely grown in Ireland until 1846, when its failure due to late blight caused the famine).

The second event was the introduction of Rough Purple Chili by the Rev. Chauncey Goodrich of New York in 1851. He obtained it as one of a small collection of tubers via the US Consul in Panama. Goodrich assumed that it was a Chilean variety and since it was well adapted to the long days of New York, this may have been the case (Hawkes 1967). From Rough Purple Chili Goodrich raised a number of selfed seedlings including Garnet Chili, which was widely grown in the USA for many years. Among the varieties derived from Goodrich's stocks were Beauty of Hebron, Russet Burbank and Early Rose. The last named variety, in particular, has been very important in European breeding programmes.

Another source of breeding material in the last century was an Andigena clone known as Daber which was introduced into Germany in about 1830 and gave rise to many new varieties, including President.

The next major stimulus to potato breeding was the spread of wart disease (Synchytrium endobioticum) in the early part of this century. The recognition of field immunity in a few varieties, including Snowflake, led to the breeding of a whole range of wart-immune varieties. Good blight resistance was still being sought, and we can imagine Salaman's delight when he found field immunity, first in S. edinense and later in S. demissum (Salaman 1985). By 1914 he had produced a series of families segregating for resistance, and a programme which was to occupy the minds of many potato breeders, particularly in the UK, Germany and the USSR, for the next half a century had been initiated. The first signs that this major gene resistance was not durable came in 1932 but it was another 30 years before breeding for this type of resistance was abandoned. Nowadays, breeding programmes world-wide are aimed at introducing race non-specific resistance into new varieties. This is not proving to be an easy task; the resistance is controlled by a number of genes and is often associated with undesirable traits such as late maturity.

Degeneration of potato stocks, or "Curl", has already been mentioned. During the early part of this century it was discovered that this phenomenon was caused by a number of viruses. Sources of resistance were identified and breeding programmes initiated. Virus resistance is now a major objective in many breeding programmes, using many different Solanum species as sources of resistance.

Another objective common to many present-day breeding programmes is resistance to potato cyst nematodes (Globodera spp.). Breeding work was made possible by Ellenby (1952) who found resistance to G. rostochiensis in five accessions of Andigena and also in S. vernei. Populations of cyst nematodes which multiplied on clones incorporating this resistance were found in many European countries. This led to the recognition of a range of pathotypes and eventually to two separate species being described, G. rostochiensis and G. pallida, each with pathotypes. Resistance to pathotypes of G. pallida has been found in accessions of Andigena and S. vernei and also in other Solanum species. An international scheme for identifying and classifying potato cyst nematodes was proposed by Kort et al. (1977) and this is presently being modified.

Potatoes have many uses and programmes have been designed specifically to breed for the requirements of the processing and starch industries. Some European countries have a large export market for seed potatoes and have breeding programmes geared to producing varieties suitable for foreign markets.

As will quickly be appreciated in the following chapters, potato breeding technology is rapidly developing, providing new opportunities for crop improvement. Early generation screening techniques are leading to more rapid identification of the superior genotypes. Breeding at the diploid level and exploiting unreduced gametes are providing ways of introducing new sources of variation and transferring them efficiently (Hermundstad & Peloquin, this volume). Just around the corner is the promise of directed variation by genetic manipulation and protoplast fusion. Already we are reaping some of the benefits of molecular biology in the form of efficient virus and viroid detection techniques (Boulton et al., this volume; Flavell, this volume). Tissue culture has resulted in the rapid propagation of breeding material, and the production of variation through regenerating calluses has led to the exploitation of somaclonal variation (Jones, this volume; Thomson, this volume).

Finally, there is the whole new concept of breeding true potato seed (TPS). The best way of producing such seed is still being investigated (Jackson, this volume) but already TPS is having a major impact in some developing countries.

The "humble potato" has come a long way in the past 400 years, but its future looks just as exciting as its past.

For more detailed and fascinating accounts of the origins of the potato in Europe, the reader is referred to Salaman's book "The History and Social Influence of the Potato", recently reprinted (Salaman 1985), and Hawkes' 1966 Royal Horticultural Society Masters Memorial Lecture "The History of the Potato" (Hawkes 1967).

PLANT BREEDERS' RIGHTS

In Britain during the early part of this century, there was a multiplicity of "new" varieties - bogus selections of existing varieties masquerading under new names. Stocks with the new names usually fetched a higher price than those with the original name. This led the National Institute of Agricultural Botany to set up its Potato Synonym Committee in 1919, when over 200 synonyms of one variety, Up to Date, were found. This Committee continued in operation until the introduction of the distinctness regulations for the Plant Breeders' Rights (PBR) in the 1960s.

The concept of PBR is an extension of the ownership of an invention protected by patent legislation. The aim is to provide a fair return on the long term investment required to breed and assess a new variety; this normally takes about 12 years for potatoes. Protection on all propagating material is given for a minimum period of 15 years from the date of registration; this has been extended for potatoes to 30 years in some countries. Royalties are collected on the basis of the area of potatoes grown for seed certification.

The owner of a variety may transfer the proprietary rights on his variety to individuals or companies for the purpose of growing and selling seed material. He has the legal right to exclude others from reproducing, selling, exporting or importing seed of this variety. There are, however, no restrictions on anyone growing a variety exclusively for their own use, or for selling it for consumption, either fresh or processed.

Plant variety production is internationally controlled by the Union pour la Protection des Obtentions Vegetales (UPOV), which was established in 1961. Membership extends to most European countries, Australia, New Zealand, Israel, Japan, South Africa and the United States. Its aim is to promote progress by stimulating plant breeding and facilitating the interchange of varieties between countries. The benefit of UPOV membership is the availability of reciprocal rights, which avoids duplication of effort by both breeders and government authorities. UPOV has produced test guidelines including 107 taxonomic characters which may be used to establish distinctness in potato varieties (Anon. 1974).

Until now PBR has provided protection only for the variety, which is the end product of plant breeding. In future, with the introduction of genetic engineering there is justification for some form of patent protection of certain technological or microbiological processes used to produce a new variety. The legal implications of this concept have been discussed by Lange (1985).

The general consensus of opinion is that PBR have been advantageous in encouraging investment in private breeding and in increasing the numbers of improved varieties. It has been suggested, however, that PBR are responsible for the recent interest of large multinational chemical and oil companies in taking over seed and breeding establishments, and that such companies may restrict access to varieties with improved disease and pest resistance, but this remains unproven.

It has also been suggested that PBR may cause a reduction of government support for state breeding, which may reduce cooperation and exchange of information between the state and private breeders. In most European countries this is not a problem since the state breeders tend to concentrate on doing basic research and providing the private breeders with basic breeding material.

COOPERATION

There is a good spirit of international cooperation in both potato breeding and variety assessment. This is fostered by such organisations as the European Association for Potato Research (EAPR), European Association for Research in Plant Breeding (EUCARPIA), Potato Association of America (PAA), International Potato Center (CIP) and the International Board for Plant Genetic Resources (IBPGR).

In order to help with the collection, conservation, documentation, evaluation, exchange and use of germplasm, guidelines on descriptors have been produced (IBPGR 1977). These include over 100 "passport", taxonomic, agronomic, disease and quality characteristics. More recently a shorter minimum list of descriptors has been produced by the Commission of the European Communities Agricultural Research Programme on Plant Productivity in collaboration with IBPGR (CEC 1985).

MERIT TESTING

Within the European Economic Community (EEC) a new variety can only be marketed if it is included on the Common Catalogue. This is a list of all varieties included on the National List of all member states. A derogation order can be obtained by any member state to prevent a variety being grown in their country if it presents a particular disease or pest hazard.

In order to comply with the EEC Directive for the inclusion of a variety on a National List it must be distinct, uniform and stable (DUS) as for PBR, and have value for cultivation and use (VCU). The testing systems in several countries are described in this volume.

The need for VCU testing to be a statutory requirement has sometimes been challenged, but few agree that the success or failure of a variety should be dictated by market forces alone. Some form of independent merit testing is generally considered necessary for advisory purposes and for protection against exaggerated or misleading claims. However, potato experts agree that it is difficult to predict from trials the future of some potato varieties and that commercial experience may also be required.

Fifty years ago the Scottish potato breeder of the famous "Arran" varieties, Donald MacKelvie (1937), wrote "No one can foretell what will be the verdict of the practical grower on a new variety of potato, or its future in the market, even if it is successful in trials". To a lesser extent this is still true today, and few varieties get beyond the "promising" stage.

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GENETIC RESOURCES

GENETIC RESOURCES: THEIR PRESERVATION AND UTILIZATION

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Centres of diversity ("gene-centres") are areas where wild crop ancestors developed and adapted themselves throughout the ages to what were to become their natural habitats. In these areas, in order to survive as a crop species, coevolution between parasites and host plants and between the environment and plant species in general, took place and cultivation of the better adapted native cultivars commenced (Hawkes 1971).

The rich genetic heritage of the gene pool in these areas is of immense importance to plant scientists and plant breeders who are concerned with the incorporation of resistance to pests and diseases, the improvement of quality characters, and a wider environmental adaptability of cultivated varieties.

Plant extinction is a serious threat in many areas of diversity, due among other things to the introduction of new varieties possessing a narrow genetic base (Hawkes 1979), thus lacking the adaptability of the original flora. Fortunately this "genetic erosion" has attracted considerable interest, particularly throughout the 1960s and 1970s, not only from plant geneticists and taxonomists, but also from governments and official bodies. Increasing concern has resulted in greater efforts to preserve this "treasure of nature".

Inseparably linked to the preservation of this genetic diversity should be its utilization for the continued improvement of cultivatable varieties: without preservation its utilization is impossible, and without utilization preservation becomes meaningless.

GENETIC VARIABILITY

The genus *Solanum*, to which the cultivated potato belongs, contain more than 2000 species (Hawkes 1978), of which close to 180 are tuberiferous, and new species are still being found and described (Hawkes & Hjerting 1983, 1985; Ochoa 1983, a,b).

The total gene pool available for research and breeding purposes consists of, in order of increasing "improvement":

- wild species, including interspecific hybrids
- primitive, edible cultivars and their hybrids; often tolerant, non-degenerating, naturally adapted cultivars
- landraces, the varieties of prescientific agriculture
- materials used in ongoing breeding programmes; often interspecific and intervarietal hybrids
- advanced varieties of present or past cultivation.

Generally speaking, the following are of particular value for breeding purposes: the wild species and primitive cultivars on account of their resistance characteristics, landraces for their quality characteristics, and hybrids of existing breeding programmes and advanced varieties for their agronomic characteristics. Use should be made, however, of as broad a genetic base as practicable, depending on the "crossability" of the particular species and hybrids, the inheritance of the particular property to be incorporated, and the number of backcross generations necessary for upgrading the "species characteristics" to varieties of cultivatable value in order to broaden the genetically based adaptability of modern varieties.

Genetic variability in primitive cultivars and wild species

The centres of diversity of the potato are found in North, Central and South America, namely in Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Paraguay, Peru, SW United States, Uruguay and Venezuela (Dambroth & Schittenhelm 1984; Hawkes 1978).

The centres of diversity are generally grouped into two overlapping geographical areas: the Andean region consisting of the South American gene pool, where such series as ACAULIA, CONICIBACCATA, COMMERSONIANA, MEGISTACROLOBA occur, and the Central American region consisting of the Mexican gene pool, where BULBOCASTANA, DEMISSA, LONGIPEDICELLATA, PINNATISECTA and POLYADENIA are found (Hawkes 1958b, 1978; the taxonomy and nomenclature used is in accordance with Hawkes 1963, 1978). The only series with centres of origin outside these areas are ETUBEROSA, JUGLANDIFOLIA (non-tuberiferous) and PIURANA (Hawkes 1958b). The primitive cultivars *S. ajanhuiri*, *S. goniocalyx*, *S. phureja*, *S. stenotomum* (diploids) *S. chaucha*, *S. juzepczukii* (triploids) *S. tuberosum* ssp. *tuberosum*, *S. tuberosum* ssp. *andigena* (tetraploids) and *S. curtilobum* (pentaploid) are all found in the