BSPB
promoting innovation

Plant breeding

The business and science of crop improvement




British Society of Plant Breeders

Origins of plant breeding

The constant aim of plant breeding is to improve the quality, diversity and performance of agricultural and horticultural crops. The overriding objective is to develop plants better adapted to human needs.

None of the major food crops grown in Britain are native to this country. Many bear only a passing resemblance to the wild plants from which they were developed.

As shown on the opposite page, the cereals, potatoes, root crops and oilseeds which make up the familiar patchwork of our farmland have their origins in many different parts of the world. They have all been adapted, through plant breeding, to thrive under UK growing conditions.

An age-old tradition

Modern plant breeding is a sophisticated, high investment business, but its origins stretch back thousands of years to primitive farmers who selected the best plants in one year to provide seed for their next crop. This selective breeding was the first human refinement of natural plant evolution. Recent scientific and technological developments have allowed a greater rate of improvement.

It was Gregor Mendel who, in the mid-19th century, first provided a scientific explanation of genetic inheritance. His conclusions on the relationship between inherited characteristics in the offspring and the genetic makeup of the parents were the theoretical basis for classical plant breeding.

Mendel's work went largely unrecognised in his own lifetime, and it was not until the early 20th century that it was rediscovered to become the basis of modern scientific plant breeding.

A modern industry

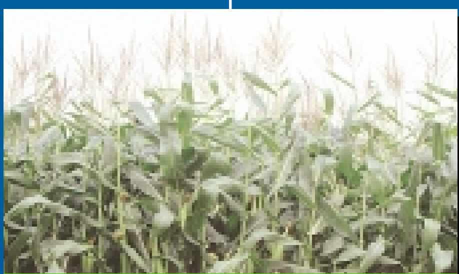
Until the early 1960s, plant breeding in Britain was largely confined to publicly funded research. This situation changed dramatically in the mid-1960s, with the passing into UK law of the 1964 Plant Varieties & Seeds Act. This legislation introduced a system of royalty payments on individual plant varieties, known as Plant Breeders' Rights, and triggered a rapid expansion of plant breeding as a commercial enterprise in its own right.

Today, much of the basic research into crop science is still conducted by public sector research organisations, but the majority of commercial plant breeding takes place within the private sector. Some 60 plant breeding companies, based in the UK, are active across the entire spectrum of plant species from the major arable crops through to ornamental garden shrubs and flowers. In total, the plant breeding sector employs around 5,000 people, and supports a further 5,000 jobs in seed production and distribution.

Plant breeding remains a vital industry to keep Britain competitive on world markets. The need for new varieties, adapted to our unique growing conditions, is never ending, driven by the challenges of new disease pressures, changing market requirements and shifts in agricultural and environmental policies.

This handbook introduces the business and science of plant breeding in Britain.

BSPB

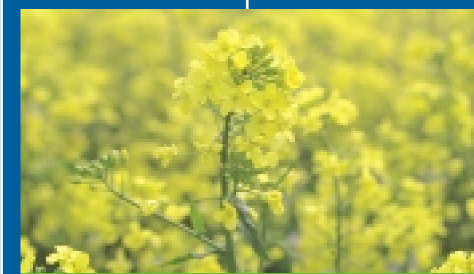


Maize

Maize crops used for grain and animal fodder are derived from wild races originating in Central America.

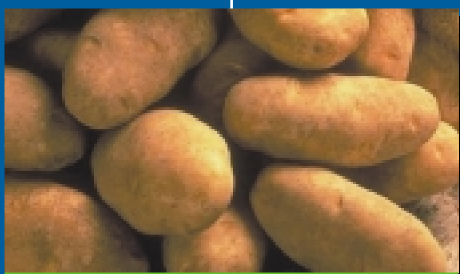
Sugar beet

Modern varieties of sugar beet have been developed from wild ancestors native to Central Europe.



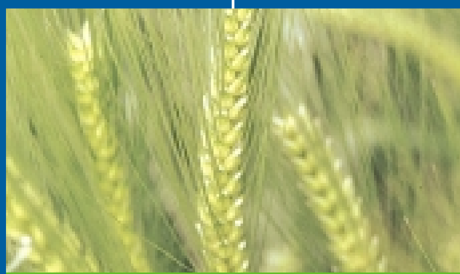
Oilseed Rape

Like many crops within the brassica family, oilseed rape has its origins in wild species native to China.



Potatoes

Wild ancestors of the modern potato still grow in parts of South America.



Wheat & Barley

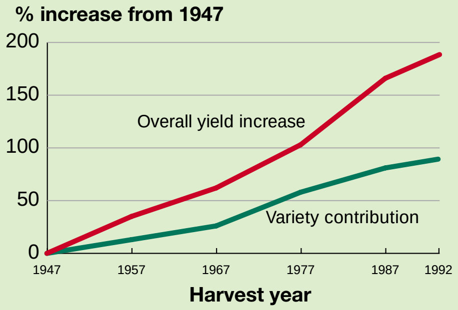
Small grain cereals, the mainstay of UK crop production, are derived from wild grasses of the Middle East.

Improving crop performance

The dramatic gains in agricultural productivity seen in the second half of the last century are often linked uniquely to increased mechanisation and the widespread introduction of fertilisers and agrochemicals.

This 'Green Revolution' would not have been possible without the huge genetic improvements made to the crops. Plant breeding has contributed around half of the threefold increase in UK wheat yields recorded from 1947 to 1992 and yields have continued to improve since then (see graph).

Increase in UK wheat yields 1947-92



Source: NIAB

Plant breeding can directly improve the performance of crops in different ways.

Productive yield

Developing crop varieties which convert more of their biomass into productive yield is the single biggest contributor to improved crop output. The introduction of shorter-strawed cereals is a striking example of how this has been achieved, by transforming more of the crop's productive energy into valuable grain.

Physical characteristics

Changing a crop's physical structure can also contribute to increased yields. For example, the development of semi-leafless varieties of field peas helped to boost intrinsic yield. It also stimulated the growth of stabilising tendrils, which significantly improved the crop's standing ability so reducing crop losses at harvest.

Disease resistance

Genetic resistance to disease enables crops to realise their yield potential – it can also mean reduced use of agrochemicals. Plant breeding has significantly improved the genetic resistance of crops against the threat of viral and fungal infection. Key examples include resistance to blight in potatoes, rhizomania in sugar beet, and barley yellow mosaic virus in cereals. The challenge of breeding resistant varieties is constant because new strains of disease develop naturally.

Timing of maturity

Plant breeding technology has brought major improvements in the uniformity with which crops ripen ready for harvest. This not only reduces potential crop losses at harvest (as in the case of pod shatter in oilseed rape), but has also improved growers' ability to mechanise harvesting operations. In the field vegetable sector, for example, the labour intensive (and unpleasant!) task of picking crops such as cauliflower, broccoli and Brussels sprouts has been transformed by the development of improved varieties.

Other agronomic factors

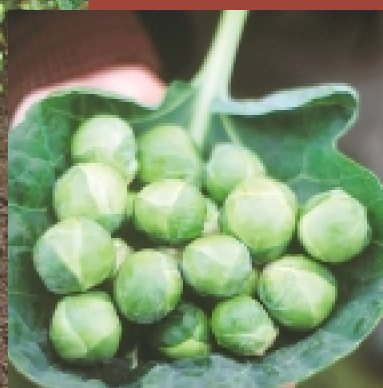
By improving crops' ability to cope with a range of other agronomic pressures, advances in plant breeding continue to underpin progress in agricultural productivity. They include:

- genetic resistance to pests, such as nematode resistance in potatoes
- shorter crop life-cycle, to expand a crop's geographical growing areas
- stress tolerance, such as frost resistance in field vegetables, to extend the seasonal availability of home-grown fresh produce.

The development of shorter-strawed cereals and semi-leafless peas has resulted in varieties with higher yields and improved standing power.

By shortening the growth period in forage maize, plant breeders are expanding the area in which this relatively new crop offers a viable home-grown forage option for Britain's farmers.

Improved genetic resistance to diseases such as blight in potatoes and yellow rust in cereals has helped minimise crop losses and reduce the need for agrochemicals.



The introduction of hybrid breeding technology has transformed productivity, availability and uniformity within the UK fresh produce sector.

Improving crop quality

Alongside progress in keeping Britain's farmers competitive through improved productivity, developments in plant breeding have also brought significant gains in crop quality.

Gone are the days when Europe encouraged farmers to concentrate solely on maximising output, assured that their crops would find support under the Common Agricultural Policy.

Today, as production-based support and barriers to international trade continue to be reduced, Britain's growers must compete with the best in the world, on quality and cost of production.

Consumer expectations of food are also more exacting. This is reflected in tighter quality specifications along the food chain.

Plant breeders have responded with a continuous stream of new varieties, tailored to the needs of specific end-markets.

Cereals

Britain's historical dependence on North American imports of wheat for breadmaking has been reversed over the past 40 years thanks to improvements in baking technology and the development of high protein, hard milling varieties of wheat. Until the mid-1960s, imported wheat typically accounted for up to 65% of our breadmaking requirements. Today as much as 90% of our bread is produced from home-grown varieties.

In barley, improvements in malting quality have underpinned a fourfold increase in the volume of beer brewed per tonne, from around 2,000 litres in 1950 to nearly 8,000 litres today. The quality of malting barley varieties grown in Britain is internationally recognised, with export markets from the near Continent to the Far East.

Oilseed rape

Oilseed rape has become a major home-grown source of vegetable oil and animal feed within the past 30 years. The rapid expansion of this important break crop from 50,000 hectares in the mid-1970s to around 500,000 hectares today can be linked to two major breakthroughs in plant breeding. Varieties for food use were first developed in 1970. These contain reduced levels of erucic acid in the oil, making it more suitable for human consumption. This was followed in the late-1980s by 'double-low' varieties, which also offered reduced levels of glucosinolates in the residual meal to improve quality for animal feed.

Potatoes

In the potato sector, plant breeders have responded to increasing consumer demands for quality and choice. Fresh produce counters now boast a bigger range than ever, from traditional main-crop varieties through to baby new, baking and salad potatoes. Breeding programmes have also targeted processing and catering markets, with specific varieties used to produce crisps, instant mash and chips.

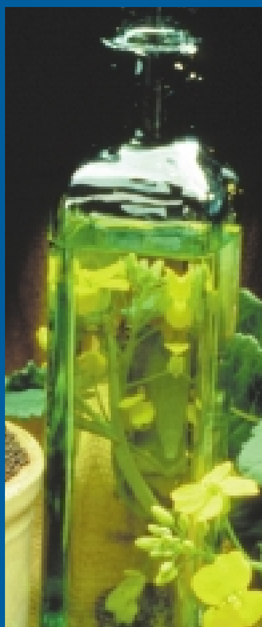
Sugar beet

Higher root yield and increased sugar content have combined to double sugar production per hectare in the past 50 years. The introduction of monogerm seed, allowing seeds to be planted individually rather than in clusters, ensures genetic improvements are fully realised in the field.

Pulses

As interest in home-grown sources of protein has increased, breeders have developed varieties of peas and beans for specialist markets – freezing and canning for human consumption, flaking for pet food, and tannin-free varieties for animal feed.

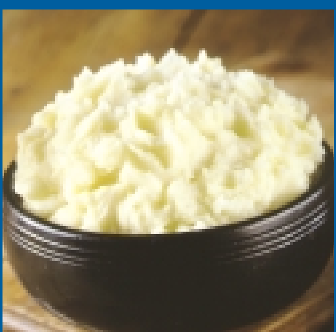
Not all types of wheat produce the perfect loaf. By improving the quality of home-grown wheat for breadmaking, plant breeders have helped reverse our dependence on North American imports.

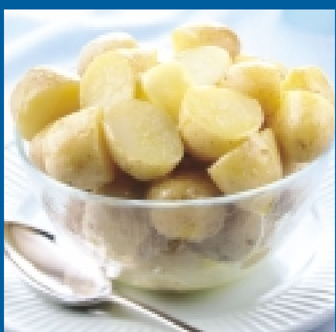


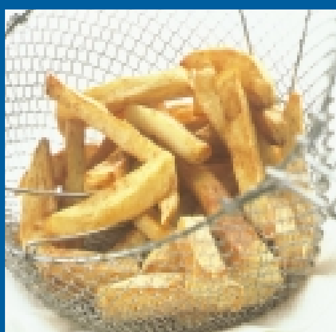
Modern varieties of oilseed rape offer healthy vegetable oils for food use and high protein meal for animal feed.

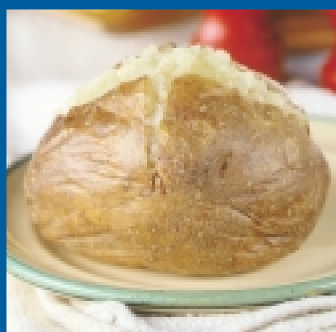
The quality of British malting barley is forging markets at home and abroad. Brewers as far afield as China have ordered shipments of grain from the UK.

Potato quality has been tailored to the needs of a range of end uses.







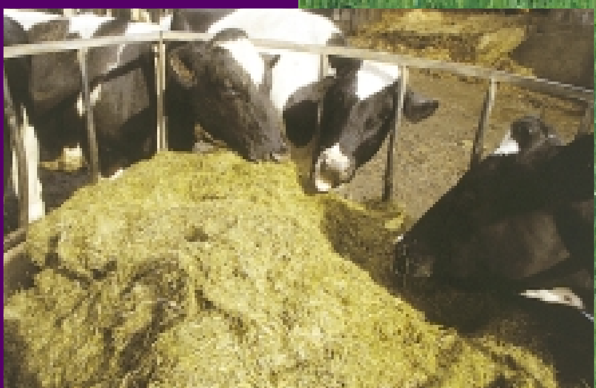


A diversity of uses

Breeders are continually adapting crops to suit many different applications. Nowhere is this diversity more evident than in the market for grass varieties.

From traditional grazing and forage crops in agriculture, plant breeders have also developed a range of grasses for sports, gardening and amenity uses.

A range of high energy, palatable grasses have been adapted for year-round intensive grazing and silage production. ► ▼



National List trials at Crossnacreevy, Northern Ireland. Each new grass variety must undergo statutory testing prior to marketing.

Amenity grasses have been developed for a range of uses, from general low maintenance landscaping to hard-wearing lawns and ornamental turf.

Breeders have adapted grass varieties to suit many different sporting uses. Football pitches need a compact, hard-wearing turf, quick to regenerate after wear and tear.

For golf greens, a dense, close-knit turf is required, tolerant to close-mowing and rolling to produce a truly even playing surface.

Creating a new variety

The creation of each new variety is a complex, costly and skilled operation. It is also painstakingly slow – today's breeding programmes are already looking ten years ahead to the needs of farmers, consumers and the environment at the end of the next decade and beyond.

Techniques vary between crop species, but the scientific principles of plant breeding remain unchanged from Mendel's first discovery that selected parent plants can be cross-pollinated to combine desired characteristics.

Plant characteristics are determined by genes – units of hereditary material that are transferred from one generation to the next. Since each plant contains many thousands of genes, and the breeder is seeking to combine a range of traits in one plant, such as high yield, quality and resistance to disease, developing a successful variety is an extremely lengthy process – up to 12 years in the case of cereals, even longer for potatoes.

Plant breeding has been compared to playing a fruit machine – not with three reels, but several hundred. The skill of the plant breeder lies in improving his chances of hitting the jackpot by combining all the desired characteristics in the same variety.

Conventional breeding

Conventional plant breeding involves crossing carefully chosen parent plants, then selecting the best plants from the resulting offspring to be grown on for further selection.

For cereals, hundreds of individual crosses are carried out by hand to create seed for the first filial (or F1) generation. The resulting F1 plants are uniform, but in the following generation several hundred thousand different plants are produced. Because of the way genes work, the new combinations produced from each cross are not revealed until the second (F2) generation. It is this enormous diversity of new gene combinations which may hold the key to a successful new variety.

The plant breeder's task is to select the plants most likely to meet his breeding objectives. Seed from the best of these F2 plants is grown on in small rows or plots and the best plants again selected – this process is repeated year after year until only the very best plants remain.

As promising new lines emerge, tests are conducted on each plot to assess factors such as yield, disease resistance and end-use quality.

Once the best lines are purified to ensure that every plant has the same characteristics, the process of multiplying seed begins. These 'inbred' lines are then ready for entry into official trials, some six to ten years after the initial cross.

Hybrid breeding

For some crop species, the seed supplied to growers is that produced from the first cross between selected parents. The resulting varieties, known as F1 hybrids, offer potential advantages in crop performance. Hybrid breeding is widely used to produce varieties of field vegetables, maize and oilseed rape.

F1 hybrids are unique in expressing 'hybrid vigour' in the growing crops for a single year. This may result in higher yields, greater uniformity, or improvements in quality. Unlike inbred lines, F1 hybrids do not breed true year after year and their performance gains are not maintained in subsequent generations.

Conventional plant breeding involves crossing carefully chosen parent lines by hand, then selecting the best plants from the resulting offspring to be grown on in trial plots for further selection.

Enhanced breeding

With increasing knowledge and improved technology, breeders have developed ways to enhance the speed, accuracy and scope of the breeding process.

There are several ways to reduce the lengthy interval between the first cross of selected parents and establishing true-breeding lines of promising new varieties. For example, maintaining parallel selection programmes in northern and southern hemispheres allows two generations to be produced each year. Single seed descent produces very small plants under restricted growth conditions. Large numbers of these plants are cultivated in artificial growth rooms, with two or more generations produced in a year. In potatoes, mini-tuber breeding speeds up the slow multiplication process by producing miniature plants under greenhouse conditions.

More recent laboratory techniques enable breeders to operate at the level of individual cells and their chromosomes.

In certain crop species, such as potatoes and oilseed rape, it is possible to produce new varieties in the laboratory through **protoplast fusion**. Individual plant cells with their outer walls removed are fused, and the fused cells then induced to divide and grow in a culture medium. Whole plants are eventually regenerated containing new combinations of genes from the two parents.

Embryo rescue and **assisted pollination** allow breeders to expand the range of available characters by making crosses between species which would not produce viable offspring outside the laboratory.

Double haploid breeding enables breeders to produce genetically uniform lines within one generation. This effectively by-passes the lengthy process of self-pollination and selection normally required to produce true breeding plants.

Latest developments in genetic science have greatly improved our understanding of how plants behave, offering additional ways to enhance the breeding process.

Genomics – by mapping the genetic makeup, or genome, of crop species, scientists can identify the exact position and function of individual genes. Genome mapping has revealed striking similarities in the genomes of different crop species, such as rice, wheat, barley and rye. This information is already helping to broaden the scope and precision of current breeding programmes.

Marker assisted breeding – allows breeders to determine whether desired traits are present in a new variety at an early stage in the breeding programme.

Genetic modification – enables individual traits to be added, modified or deleted in a plant variety without reshuffling two complete genomes. This extends the range of characters at the breeder's disposal, and enables specific genes to be expressed in a crop plant without the introduction of unwanted characteristics.

Proteomics – allows breeders to understand how genes behave in different parts of the plant and under different growing conditions.

Maintaining genetic diversity

Maintaining biodiversity is central to the process of crop improvement. It is in every breeder's interest to ensure that the gene pool from which new traits are selected remains as extensive as possible.

Plant breeders created the first gene banks in the 1930s to conserve the valuable genetic diversity within past and present varieties, as well as landraces and wild relatives of cultivated crop species. Plant breeding is integral to ongoing initiatives to identify, classify and conserve existing biodiversity.

From artificial growth facilities to modern laboratory techniques, plant breeders use new technology to improve the speed, accuracy and scope of the selection process.

Testing plant varieties

Before any new crop variety can be placed on the market, it must undergo statutory testing under a process known as National Listing. Successful varieties are placed on a National List or register of varieties approved for marketing.

National Listing rules are determined on a European basis, and apply to all the major agricultural and vegetable crop species. Official trials are conducted, in most cases for a minimum of two years, to test each new variety for a range of characteristics which together determine its uniqueness, its genetic uniformity, and its value to growers and the rest of the food chain.

National Listing is extremely rigorous – the majority of varieties entered do not complete the process. In winter wheat, for example, only a quarter of varieties entered for National Listing during the 1990s were finally approved.

National Listing – DUS

All varieties entered for National Listing are assessed for Distinctness, Uniformity and Stability (DUS). In the case of cereals, some 30 individual characteristics of the plant are inspected to verify that it is **distinct**, ie clearly distinguishable from other varieties, that its characteristics are **uniform** from one plant to another, and that the variety is **stable** in that it breeds true to type from one generation to the next.

National Listing – VCU

For agricultural crops, National Listing also involves trials to establish a variety's Value for Cultivation and Use (VCU). This provides an assurance to growers that only varieties with improved performance or end-use quality can be officially approved for sale.

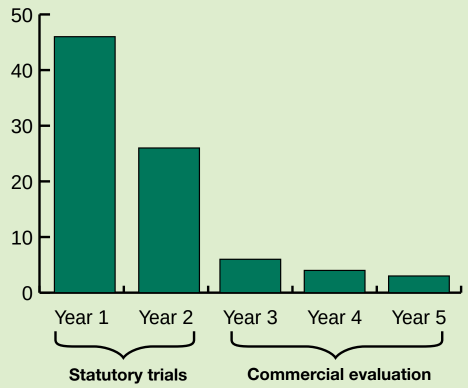
Recommended & Descriptive Lists

Once a new variety has been added to the National List, it is cleared for marketing. However, its success in the market place is by no means guaranteed. Further independent trials are conducted each year to compare the performance and quality of the best varieties. These trials provide the basis for detailed information and advice to growers and their customers.

As shown in the following illustration for winter wheat, the process of statutory and commercial evaluation can take up to five years. Only a handful of varieties clear all these hurdles, which are in addition to the many years spent testing and selecting in the breeder's own trials programme.

Winter wheat varieties in trials

(average 1992-98)



Source: NIAB

Genetically Modified Varieties

In addition to the tests described above, varieties produced using genetic modification must also pass through a separate process of regulatory scrutiny. European law, applied in the UK by Government departments and their expert advisory committees, specifies that that no GM crops can be marketed until they have been assessed and approved in terms of human health, food safety and the environment.

The cross-border movement of genetically modified organisms (GMOs) is regulated at a global level under the internationally agreed Biosafety Protocol.

Diagram shows a conventional breeding programme for cereals. Additional tests are introduced at each stage in the process as the promise of a new variety emerges.

	Select parents		Selection criteria			
Generation		Trial stage	Crop performance	End-use quality	Seed stock	Marketed seed
F1	800 crosses					
F2	2 million plants		Disease			
F3	400,000 plants	Ear rows	Disease, field characters, maturity, lodging and uniformity			
F4	12,000 lines	Progeny plots		In-house quality tests		
F5	1,200 lines	In-house trials (1 location)	Yield, disease, field characters, maturity, lodging and uniformity			
F6	300 lines	In-house trials (3 locations)		Industry end-use testing by processors		
F7	50 lines	In-house trials (6 locations)				
F8	5 lines	National List trials (DUS & VCU)		Independent quality testing	0.5 ha breeders' seed	
F9	3 lines	National List trials (DUS & VCU)			1.5 ha breeders' seed	1 ha pre-basic
F10	2 lines	Commercial evaluation			8 ha breeders' seed	40 ha pre-basic
F11	1 line				Stock maintenance	C1 multiplication C2 commercial

Variety maintenance and identity preservation

As well as developing new varieties, plant breeders maintain the genetic purity of existing lines and pre-commercial seed supplies year by year. This process is costly and time-consuming, but essential to maintain the quality and performance of each variety.

For cereals, variety maintenance begins after a few years of selection trials, when the promise of a variety is just emerging. At that stage, all that exists of what may become a widely grown variety is a single row containing around 100 plants.

The breeder then bulks up supplies of the purified lines of breeder's seed into pre-basic and then basic seed. Each year specialist seed growers are used to grow basic seed for the first generation of certified seed – or C1 seed. After one more year this becomes C2 seed, the main source of certified seed used by farmers.

The plant breeder continuously maintains breeder's seed for the process of multiplication through pre-basic, basic, C1 and C2 seed to ensure the variety's performance and quality year after year.

Greater emphasis is now being placed on preserving the identity of individual varieties after harvest, both to conserve quality characteristics and to meet consumer demands for assurances about the integrity and traceability of their food.

Seed certification

Seed of an approved variety can only be marketed if it meets strict quality criteria. Seed quality standards are laid down in UK and EU law, and policed by agencies appointed by Government.

The UK's official seed certification system offers an independent assurance of quality to growers. Minimum standards apply for varietal identity, purity and germination capacity. In addition, strict limits apply to seed-borne diseases, and the presence of physical impurities such as weed seeds.

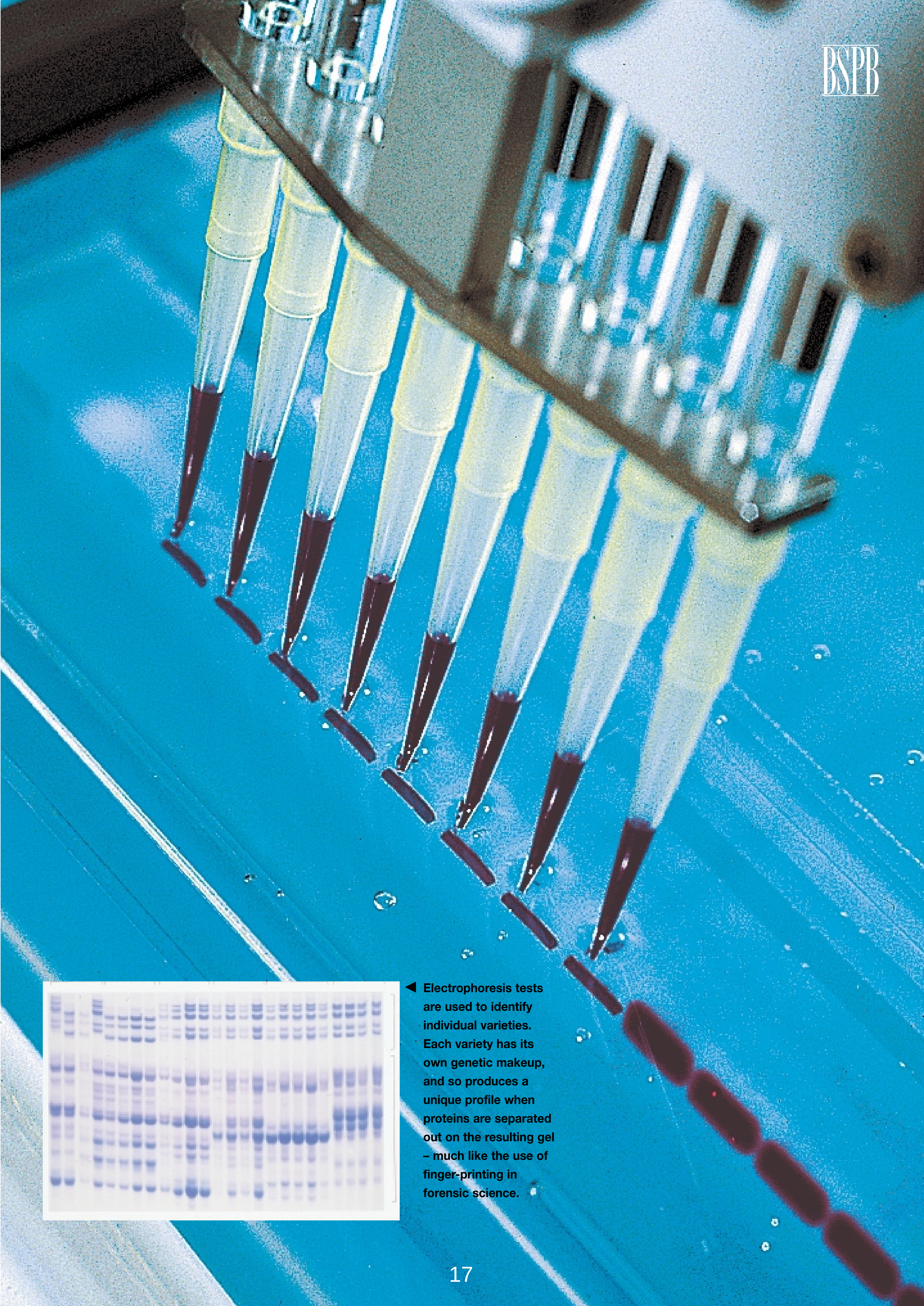
Around 9% of the UK arable area is used to multiply the pure lines of seed from the plant breeder into certified seed. Several thousand individual crops are involved, each grown under specific management regimes to ensure the purity and integrity of the resulting seed is maintained. To gain certification, every seed crop must undergo crop inspection and seed testing.

Seed certification underpins the health and purity status of the major arable crops in Britain. It offers an independent benchmark of quality on which buyers of seed and their customers depend.

Farm-saved seed

For certain crop species – particularly small-grain cereals – growers can opt to save their own seed for sowing the following year provided care is taken to ensure that the crop remains healthy and free from impurities, and that the resulting seed is carefully conditioned and cleaned.

Without independent testing for germination and freedom from seed-borne diseases, however, farm-saved seed can harbour risks to growers which may not become apparent until well into the growing season. Many growers choose certified seed for the peace of mind that quality and performance is independently assured.



◀ Electrophoresis tests are used to identify individual varieties. Each variety has its own genetic makeup, and so produces a unique profile when proteins are separated out on the resulting gel – much like the use of finger-printing in forensic science.

Plant breeding in the future

Success in any line of business depends on being able to anticipate and respond to changing market requirements. Such is the long-term nature of developing a new crop variety that plant breeders are in the unenviable position of forecasting their customers' demands at least five, and probably nearer ten years, in advance.

Plant breeding objectives will continue to be shaped by changes in agricultural and environmental policy. There is no doubt that while improvements in crop yield and end-use quality remain of paramount importance, the future for British agriculture lies in crop production systems which deliver both economic and environmental benefits.

Increasingly, plant breeders are targeting varieties suitable for low input and organic regimes. It is already estimated that genetic improvements in disease resistance alone save British farmers more than £100 million a year in reduced agrochemical use and improved yield. A range of other factors also determine a variety's suitability for low input, integrated farming systems. They include the crop growth cycle, straw strength and susceptibility to weed competition, as well as the variety's ability to thrive in a range of soil types, climatic conditions and rotational patterns.

Novel crops

Breeders continue to adapt novel crops for UK growing conditions. New varieties of sunflowers and soya beans are already creating market opportunities in the food sector. Post-BSE, attention has focused on using more home-grown fodder in animal feed. For plant breeders, this means enhancing energy and protein levels in traditional forage crops, and developing the potential of new crop species, such as lupins.

Non-food crops

The use of crop plants for industrial, non-food applications is an area of increasing interest. Developments in plant breeding could underpin a transition from many crude, industrial processes towards renewable, field-based production of specialist chemicals, textiles and biofuels. Quick-growing biomass crops such as willow coppice and miscanthus are already fuelling UK power stations, and there is huge potential to develop oilseed, starch and fibre crops for a wide range of products including lubricants, pharmaceuticals, dyes, plastics, flooring, paper and clothing.

New traits

Pioneering research by British scientists is opening up new possibilities for crop improvement.

Examples from current research include the use of genetic modification to overcome grey mould infestation in strawberries – not possible through conventional breeding because no resistance genes exist in the world strawberry germplasm.

Similar techniques offer ways to control the ripening process in fruit and vegetables, to extend storage life, and improve flavour and texture for consumers. It will also increase the seasonal availability of home-grown produce, so reducing the distance food is transported.

Modern biotechnology can be used to improve human nutrition. Recent research by British scientists includes the development of vegetables containing increased levels of cancer-fighting nutrients, and apples which really do keep the dentist at bay by protecting against tooth decay.

◀ Novel crops such as lupins and sunflowers are being developed for UK growing conditions

◀ In the future, biomass crops like miscanthus may offer an important source of renewable fuel

◀ Modern biotechnology may help to solve the problem of grey mould resistance in strawberries

Who pays for plant breeding?

Plant breeding involves a major investment in people, technology and facilities. Research and development takes place over many years, with no guarantee of success.

Developing an individual variety is expensive. The cost of maintaining a typical UK wheat breeding programme, for example, is estimated at £1.5 million per year. These costs are increasing as customer requirements become more demanding.

The breeder's only return to fund the ongoing process of crop improvement is a royalty on seed sales. Only varieties which succeed in the market place are rewarded.

Plant Breeders' Rights

Plant breeders are awarded a form of intellectual property on each new variety through an internationally agreed system of Plant Breeders' Rights. Licensing the use of the breeder's intellectual property, through seed production, allows royalties to be collected on seed sold. This is similar to the intellectual property protection offered via copyright on books and CDs.

In the UK, Plant Breeders' Rights were first introduced in the 1960s, with the passing into law of the 1964 Plant Varieties and Seeds Act. This legislation offers protection for breeders by ensuring that a new variety can only be marketed if it has been approved for National Listing – and is therefore distinct from all other varieties.

The introduction of Plant Breeders' Rights has delivered protection and return for individual breeders' past efforts. It also stimulates further research and improvement across the entire industry by ensuring that all protected varieties are freely available for use in future breeding programmes. Known as the 'breeder's exemption', this process has underpinned the major advances seen in crop development over the past 40 years.

For most crop species, royalty payments are collected by the British Society of Plant Breeders, acting on breeders' behalf.

Farm-saved seed payments

The need to maintain investment in increasingly costly plant breeding programmes led, in 1991, to international agreement that the concept of Plant Breeders' Rights should be extended to cover farm-saved as well as certified seed. Farmers have a long tradition of saving seed of improved varieties for replanting from one season to the next. This agreement recognised the breeder's contribution to the progressive genetic improvements enjoyed by growers saving their own seed. It was incorporated into European law in 1994.

Since 1996, an industry-wide system for collecting payments on farm-saved seed has operated for certain crop species in the UK. Payment levels are lower than royalty rates on certified seed, and apply only to the most recent varieties. The system is supported across the farming industry as a means to safeguard future investment in crop improvement.

Patents

Recent developments in technology have also seen the emergence of patent applications in relation to plant breeding. This is particularly the case where technologies can be applied to several different varieties of the same crop, or across a range of different species. Such developments cannot be protected under the variety-specific system of Plant Breeders' Rights.

The use of patents where living organisms are concerned continues to arouse controversy, but future research will not take place unless some mechanism exists to reward and promote sharing of knowledge.

For every ...

... 8,000 pints of beer

... 1,150 loaves of bread

... 600 kg of sugar

... £1 in royalty is reinvested in plant breeding.

Plant breeding for a world community

There is enormous potential for plant breeding to benefit less developed parts of the world, where food security is critical as populations continue to increase.

In particular, advances in genetic technology may offer more versatile solutions than conventional systems of crop improvement. For example, scientists in Britain are pioneering important research to develop salt and drought tolerance in crop plants. This may help to alleviate the devastating effects of crop failure in arid regions such as sub-Saharan Africa.

Private and public sector initiatives to share knowledge and expertise are already in place. They include commitments to provide Vitamin A enhanced rice and virus resistance in sweet potatoes free of charge to developing countries.

International arrangements to recognise genetic resources as the sovereign property of individual nation states will stimulate further programmes of technology transfer and benefit sharing between industrialised and less developed regions of the world.

Plant breeding – improving the quality, supply and nutritional value of our food.

The British Society of Plant Breeders

The British Society of Plant Breeders was established in 1987 when the Plant Royalty Bureau and the British Association of Plant Breeders combined to form one dedicated organisation for UK plant breeding. This merger is reflected in BSPB's dual role – royalty collection and industry representation.

Royalty collection

Acting on members' behalf, the Society licenses, collects and distributes seed royalties and farm-saved seed payments on eligible varieties of the following agricultural and horticultural crop species:

- Cereals
- Field peas and beans
- Fruit
- Herbage
- Oilseeds
- Potatoes
- Vining peas and beans

A small percentage of royalties are retained by the Society to cover running costs. BSPB is a not-for-profit organisation.

Industry representation

BSPB members comprise virtually 100% of public and private sector breeding activity in the UK. The Society represents the industry on technical, regulatory and intellectual property matters. This involves regular liaison with UK government departments, EU institutions, farming organisations and other national and industry bodies. BSPB actively promotes plant breeding's role in underpinning progress and competitiveness within our food and farming industries.

Internationally, BSPB is an active member of European and worldwide plant breeders' organisations.

BSPB structure

The Society is managed by a Board of senior executives from member companies. Administration is carried out by a small permanent staff. Several Working Parties advise the Board on a range of topics, from legislation and intellectual property to biotechnology and commercial matters. In addition, there is a network of Crop Groups to deal with specific technical matters. Staff from member companies participate on these advisory committees.

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