4. CHALLENGES FOR PLANT BREEDING AND GENETIC RESOURCES

There are many aspects of agriculture in the EU where a twin focus on sustainability and innovation is particularly important. One of these is plant breeding, which was the topic of one of the five studies for STOA. Over thousands of years plant breeders, including generations of farmers, developed crops with higher and relatively stable yields and increased resistance to pests and diseases. Improvements achieved through breeding are estimated to be responsible for about a quarter to a half of the large increases in EU farm yields since the 1940s. Plant breeding has become a major European industry, with the seed and reproductive material market worth around Euros 6.3 billion a year and the EU established as the world's second largest seed exporter, with an influence far beyond its borders.

While plant breeding has achieved a great deal, especially with the scientific advances of recent decades, there are concerns about its ability to deliver significant further increases in yields against a background of changing climate and increased water stress. For example, wheat yields may be stagnating in Western Europe because of the impact of heat stress on current varieties. Crop yields in the main productive areas of Europe are already high and the environmental impacts of production are considerable and, in some cases, unsustainable. Crop varieties will be needed that maintain yield under more variable weather conditions without increasing use of water and fertiliser.

Plant breeding for increased productivity and sustainability

For many decades plant breeding has aimed primarily for crop varieties which offer increased yield under optimal, often high-input growing conditions. However, alongside these drivers, a new set of requirements is emerging, seeking a stronger emphasis on sustainability as well as yields, requiring plant breeders to seek:

- Evolving forms of pest and disease resistance – as market shifts and climate change bring new challenges to established crops
- Greater drought and salinity tolerance – in response to continued climate change and the need to reduce reliance on conventional irrigation
- Increased efficiency in the use of nitrogen – a topic which has not always had the highest priority in the past, in part because it has been difficult to achieve without compromising on other desired traits
- Enhanced nutritional qualities in many food crops, contributing to healthier diets

Innovation in plant breeding techniques and genetic manipulation

Plant breeding has been transformed in recent decades by scientific advances which allow far more varieties to be created and screened, which speed up the process of bringing improved crops to market and give much greater scope for innovation. Modern plant breeding has opened up the possibility of bringing together the genes of distantly related or even completely unrelated species, including greater uses of landraces and wild relatives of crops.

Modern techniques now provide a range of possibilities to create new genetic variation, identify and track individuals with desirable traits and combine them in one line or variety. The recent breakthrough in plant breeding has been driven by the ability to use genetic information (marker-assisted selection), combined with advanced phenotypic characterisation techniques (phenotyping platforms), to identify and track desirable multi-gene (quantitative) traits through the breeding process. Improved tissue culture techniques can be used to grow up and multiply plant cells that combine a wider genetic diversity than can be used in conventional breeding.

Yield stability, the ability of a crop variety to produce a reliably high yield in different years (with potentially significant variations in weather) and in different places, will remain a key objective for plant breeding. Continual investment in plant breeding needs to be maintained while adjusting to new conditions and goals. For example, there may be a bigger role in future for participatory breeding programmes, similar to those widely used in organic farming, to help secure yield stability. Here, farmers and researchers collaborate closely through the entire breeding process, with many on-farm trials of crop varieties taking place and farmers involved in selecting the best performers using their particular knowledge and experience.

Within Europe there is a fierce debate between those who regard genetic manipulation either as unethical or undesirable in social and environmental terms and others who argue that it has real potential for increased yields and lower input use. The latter believe that the EU is losing out in plant breeding innovation due to its overall resistance to GM crops. Only two GM crops have been authorised for cultivation, an insect-resistant Bt maize and a starch-modified potato. Only the first of these is grown on a commercial scale, mainly in Spain. This contrasts with the widespread adoption of a small range of GM soyabean, maize and cotton varieties in the Americas, China, India and Australia, predominantly insect resistant or herbicide resistant crops. GM varieties are regulated separately from seeds produced by conventional plant breeding techniques under the EU definition of genetically modified organisms. But other powerful new plant breeding technologies that use aspects of the GM plant breeding process, such as cisgenesis or directed mutagenesis, also enable the introduction of novel traits into crop varieties; some of these could not be achieved, readily or ever, by conventional plant breeding, though others produce crops with very similar functions to conventionally bred crops. These technologies may present some of the same kinds of risk to the environment and biodiversity as GM crops. However, their status as GM or non-GM varieties has yet to be legally defined within the EU.

Whatever the decision on these technologies, there is an argument that it is the novel trait in a crop variety - the outcome of the breeding process – that should be regulated rather than the technology employed. And while the EU's regulatory stalemate on GM crops must be resolved, there is a need to ensure environmental safeguards apply before novel crop varieties with potentially novel hazards go into use. That requires careful research and evaluation of potentially harmful impacts. Achieving a socially acceptable balance between ensuring environmental safeguards and furthering innovation requires a participatory and broad risk assessment and risk-benefit analysis process.

Strengthening the conservation of plant genetic resources and regulating the seed market

Alongside the development of new seeds runs a different but related priority. This is the loss of plant genetic diversity, which breeding programmes may need to draw from on a significant scale in future, not least in facing sustainability challenges. These plant genetic resources include obsolete cultivars, landraces and wild relatives of crops as well as the variety of modern cultivars and seeds. Landraces, locally adapted traditional crops, are generally highly genetically diverse and well suited to low-input farming, but today only a few European farmers cultivate them and much of this genetic variation has been lost. It has also been estimated that at least 11.5 per cent of high priority European crop wild relative species are near extinction due to habitat loss, while many are affected by gene flow and hybridisation with crops. A stronger network of gene banks would help (see Box 3).

Strengthening the conservation and use of plant genetic resources in Europe

There are various European initiatives to conserve crop genetic diversity and wild relatives of crops *in situ* and *ex situ*, but together these are insufficient for the task of conserving the range of diversity necessary for conservation and meeting the requirements of plant breeding. Only 6 per cent of European wild relatives of crops have any genetic material conserved *ex situ*, and there is no estimate of what percentage of landraces are conserved. Conserving this heritage is as much about the future as the past.

Box 3 Plant Genetic Resources

A systematic European network of *in situ* genetic reserves for wild relatives of crops and on-farm conservation sites for landraces is needed, together with support measures for farmers to use and conserve this genetic diversity. The approximately 500 gene banks in the EU should also coordinate more. Better marketing of local and traditional crop varieties could contribute to this conservation effort. The European Innovation Partnership for Agricultural Productivity and Sustainability could take a lead here.

One priority is to adopt the current official plant variety registration system within the EU. Currently this works against the use of genetically diverse seed materials, such as those coming from landraces, which can be exchanged informally among farmers who save some of their own seed. The EU could reduce the administrative burden on those plant breeders and farmers using minor crops and varieties and encourage more diversity in the plant breeding cycle.

The Yield Gap

There is potential on most farms to reduce the yield gap – the difference between the seed's yield potential and the average on-farm yield – but opinions differ as to how large a contribution can be made by crop breeding when there are many other variables involved. The performance of farms within closely related agricultural conditions often shows a remarkable heterogeneity, with double the yield on some farms compared to their neighbours.