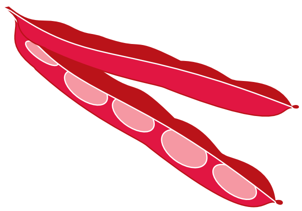
SECTION TWO

NEW GENETICS IN THE EMERGING WORLD



Orphan crops are vital to the economies of developing countries due to their suitability to local agro-ecological and socio-economic conditions.

This section looks in depth at the ways in which the modern revolution in plant science, including our newly discovered capacity to alter crop characteristics through marker-assisted breeding (MAS) and genetic modification (GM), is currently being applied to the challenges of food security in both the developed and developing worlds. The innovations described here result from our increasingly detailed understanding of the information contained within the genomes of plants as well as the pests and pathogens that threaten production. Integration of this information through so-called "-omics" technologies (such as genomics and proteomics), bioinformatics and modelling, coupled with suitable agrochemicals and farming practices, gives us the best chance of meeting global challenges of supply and demand in a sustainable manner.

A recurring theme here is that all available technologies – both conventional and modern genetic ones – should be evaluated and deployed as appropriate. Conventional plant breeding, for example, can be combined with genetically engineered traits such as insect resistance and herbicide tolerance to create crops with better pest and weed control. This has been successfully demonstrated in many of the major staple crops – maize, rice, cotton, soybeans – resulting in the decreased use of agricultural chemicals and improvements in productivity.

Argentina's triumph

There are several encouraging, if not dramatic, instances of economic and environmental benefits from the new agricultural genetics. In Argentina, for example, the introduction of a GM soybean which is resistant to the herbicide glyphosate rapidly transformed the whole agricultural sector – a success only possible because of the existence of the appropriate mechanisms for smooth technology transfer, biosafety regulation and technological assessment.

Africa's potential

The particular problems of Africa are also examined in this section, with a wide-ranging overview of the major challenges facing African smallholder farmers and the positive impacts on productivity that can be achieved by combining native traits, MAS and GM approaches with more conventional methods. For potential benefits to be realised on a wide scale, however, public attitudes towards plant breeding and GM technology – and its safety – also need to be taken into account. The fact that only four African countries have embraced GM crops at the time of writing may reflect the ambivalent, if not hostile, attitudes towards GM crops of many non-governmental organisations and a large section of the people of Europe, one of Africa's principal trading partners. This is reflected in the Declaration of the 9th Annual Meeting of African Science Academies, which took place in November 2013 in Addis Ababa.

What is the potential scope for improving the yields of crop plants by modern genetic methods? To date, the primary goals of plant breeders and farmers have been to maximise the macronutrient and calorific yields of the major grain crops such as wheat, maize and rice. Other important staples and so-called orphan crops – banana, sorghum, cowpea, pigeon pea, plantain, millet, sweet potato and cassava, for example – have been relatively neglected. These make up a group of crops that are vital to the economy of developing countries due to their suitability to the agro-ecology and socio-economic conditions, but which remain largely unimproved. In the future, this imbalance should be addressed. Not only should science play its part in improving macronutrient levels (carbohydrates, proteins and fats), it must also contribute to enhancing the micronutrient content (essential vitamins and minerals) in the interests of human health. Genetic engineering and conventional breeding have already been used to improve the content of essential vitamins and minerals in a number of crops – such as vitamin A in Golden Rice.

Insect resistance

Another key target for genetic improvement is insect resistance. For many people in Africa the black-eyed pea – or cowpea – provides a rich source of protein, starch, vitamins and minerals. Mainly cultivated by women farmers, it is economically and nutritionally the continent's most important legume, thriving on poor soils and with extremes of rainfall. But for all its versatility the cowpea has been a neglected – orphan – crop. Although breeders have managed to produce plants with high potential yields, these have suffered immense losses through insect infestation. Now, though, a GM insect-resistant transgenic cowpea has been developed to overcome the expense, inefficiency and harm to people and the environment from poisoning through insecticide use.

Science should play its part in enhancing the micronutrient content of crops like sorghum, one of Africa's most important staples.


H.F. Schwartz/USDA

India's issues

The food security problems facing India are also explored in this section. Despite the fact that the Green Revolution in India in the 1960s turned the country into a net

China has invested heavily in developing transgenic varieties of crops, including sweet peppers.

food-exporting country, India has failed to benefit from more recent biotechnological developments, including GM food crops, in improving yields and meeting regional needs. Currently there is something of an impasse facing the adoption of GM crops – such as insect-resistant aubergine (brinjal) and Golden Rice – due to widespread anti-GM activism. The tangle of issues that have eclipsed India's efforts to help its poor through technological innovation are analysed in some detail.

Investment in China

A different kind of problem faces China. Here, industrialisation, urbanisation and general economic development have eaten into the land available for farming. Yet the relentless demand for food of an expanding population, and for animal feed as increasing wealth leads to greater meat consumption, continues apace. Since 1978, China has enjoyed considerable success, however, in developing new germplasm and hybrid breeding technologies which, along with high agrochemical use, have substantially increased the productivity of rice, maize and wheat. Over the past 30 years, China has invested no less than US$ 3.5 billion in transgenic research on 52 species of crop plant (and some animals), which will undoubtedly have positive impacts on food security and productivity in the future – provided appropriate regulations are adopted.