Crop engineering fights food poverty

The current wisdom in agricultural innovation is to engineer crops to better withstand the effects of climate change. But will this help combat world poverty?

The prospect of soaring food prices and global warming has brought food security and climate-change concerns to the top of the international agenda. Agriculture now faces the double challenge of dealing with the impact of climate change at the same time as increasing production to meet the food demands of a global population projected to reach 9.1 billion by 2050.

Climate-change adaptation, a must for the agricultural sectors, will require substantial technical and financial investment in order to achieve food and nutrition security, particularly in food-insecure developing countries.

Many of the challenges facing the agriculture sector can be linked to socio-economic, environmental and technological trends and issues – with climate change an exacerbating factor, rather than the driving force of change. Rising temperatures and changing rainfall patterns; changes in sunshine levels and in concentrations of atmospheric carbon dioxide (CO_2); and increasing frequency of weather events currently considered extreme: all these would affect operations, productivity and the range of products offered by the sector.

Traditional crops

There has been a good deal of research into developing new high-yield, resilient crops but it is traditional food crops and other plant varieties worldwide that are in urgent need of protection from climate change and other environmental stresses. The UN's Food and Agriculture Organisation (FAO) is leading a campaign to develop specific policies to conserve and make wider use of plant varieties for generations to come.

"The conservation and sustainable use of plant genetic resources for food and agriculture are crucial to ensuring that the world will produce enough food to feed its growing population in the future," Alberto Sandoval, senior natural resources officer at the FAO explains.

He points out that the global gene-pool of more than one and a half million samples of plant genetic material governed collectively and multilaterally by signature countries under the International Treaty on Plant Genetic Resources for Food and Agriculture constitutes the basis for more than 80 per cent of the world's food derived from plants. This is possibly the most important tool for adapting agriculture to climate change.

The Treaty's 'Benefit-Sharing Fund' is being used to support farmers and breeders in 21 developing countries to adapt key crops to the new conditions brought on by climate change, floods, droughts, plant pests, plant diseases and other factors.

"The effects of climate change on agriculture do not respect national borders, they cover entire agro-ecological zones," Sandoval says. "For this reason, the portfolio of projects is taking a pioneering approach in generating a global knowledge base. Some of these projects will help us to establish clear priorities and action plans across borders for future actions."

One such project is based in a potato sanctuary in Peru, where community members combine traditional knowledge with efforts to conserve native varieties, improve production and ensure food security.

"Farmers are the key actors in the conservation and sustainable use of food crops and they struggle with all the changes that are happening," explains Sandoval. "If we work with a solid scientific basis and the integration of farmers, we will see results in two years when these projects will be over."

20:20 Wheat

Despite such programmes, crop research is fundamental to delivering a sustainable and secure food chain for a snowballing population. One such project, taking place in the UK at Rothamsted Research, is the 20:20 Wheat Programme, which aims to provide the knowledge base and tools to increase potential wheat yields in the UK to 20 tonnes per hectare within the next 20 years.

Wheat provides a fifth of human calories, but since 1980 the rate of increase in wheat yields has declined. The average farm yield of wheat in the UK is currently around nine'tonnes per hectare and the world average is about three tonnes per hectare.

The UK chief scientific adviser Sir John Beddington has stated the world is heading for a perfect storm of events where demands for energy, water and food will increase dramatically with an underlying threat of climate change over the next 20-40 years. "The challenge for global agriculture is to grow more food on not much more land, using less water, fertiliser and pesticides than we have historically done," he says.

The programme, which is funded by the Biotechnology and Biological Sciences Research Council (BBSRC), will seek ways to improve the quantity and quality of wheat through genotype improvement, improved photosynthetic efficiency, altered canopy and root architecture, modified seed development and enhanced nutrient utilisation efficiency.

"Wheat is the world's number one staple crop and has not benefited from the attention afforded to corn and soybeans in recent years,"

Professor Martin Parry, head of the 20:20 Wheat Programme at Rothamsted Research, states. "Rothamsted Research has the established collaborations and vision to deliver this programme as it has world-renowned expertise in photosynthesis, plant architecture, nutrient use, wheat bioinformatics and wheat pathogenomics."

But the programme is not just about UK wheat yield. Researchers hope that this ambitious target will help focus efforts to create multiple technologies that could benefit the world. Getting stable wheat yield increases in Africa, for example, by two tonnes per hectare could have a significant effect on global food security.

"The purpose of setting ourselves a grand challenge like 20:20 Wheat is much more complex than the achievement of the final objective," Professor Parry continues. "It also serves as a focal point for effort and a unifying theme for collaborative ventures, which could not be achieved by an individual or a single team.

"Take Nasa's objective to put a man on the Moon. This Apollo programme not only achieved its goal, but also generated hundreds of new products that are commonplace today including lens coatings on spectacles, integrated circuits for computing, the fax machine and athletic shoes from Moonboots."

Fossil fuel

Another major problem for the sector is that its heavy dependence on fossil fuels is undermining its ability to feed the world, perpetuating poverty and undermining efforts to build a more sustainable world economy.

The world's food production systems – from the farms where food is grown to further along the processing and marketing chain – consume 30 per cent of all available energy. Some 70 per cent of that energy consumption happens after food leaves farms, as it is transported, processed, packed, shipped, stored, marketed and prepared. A significant amount of all energy used in the food chain – about 40 per cent – is lost due to food losses and waste (globally one-third of all food, around 1.3 billion tonnes, is thrown away or lost to spoilage each year.)

Meanwhile, almost three billion people have limited access to modern energy services for heating and cooking, and 1.4 billion have zero or limited access to electricity.

"Higher costs of oil and natural gas, insecurity regarding the limited reserves of these non-renewable resources and the global consensus on the need to reduce greenhouse gas emissions, could hamper global efforts to meet the growing demand for food, unless the agrifood chain is decoupled from fossil fuel use," Sandoval says. Without access to electricity and sustainable energy sources, communities have little chance to achieve food security and no opportunities for securing productive livelihoods that can lift them out of poverty.

"To feed the planet, the world's food production systems require energy," Sandoval adds. "At the same time, food production isn't just using energy, it is also wasting it. Yet there are huge opportunities to improve energy efficiency in the food chain, as well as to produce sustainable energy within agriculture; these opportunities must be explored boldly.

"Cheap energy sources are becoming progressively more scarce, and energy markets more volatile. Feeding a growing world population will require a 60 per cent increase in food production by 2050, but we are not going to be able to meet that goal the way we did during the Green Revolution, relying on fossil fuels. A very different approach is required."

According to FAO, the energy-smart model of food production involves increasing the efficiency of direct and indirect energy use in agri-food systems, without lowering productivity as well as using more renewable energy as a substitute for fossil fuels in the agri-food chain.

Soil tillage for land preparation is typically the single most energy-consuming operation in a cropping cycle – conservation agriculture, zero tillage and other sustainable intensification farming techniques can reduce the amount of energy used on farms.

Additional steps available at the farm level include greater use of fuel-efficient engines, relying less on non-organic fertilisers and pesticides by adopting integrated pest and weed management techniques, and shifting to crop varieties and animal breeds that require fewer inputs.

Climate-smart agriculture

Crop research is, however, something for the future. Many regions around the world are already struggling under food shortages that are being exacerbated by climate change. Financial assistance as well as technology sharing is required such as that achieved through a £5m joint FAO and EU scheme aimed at helping Malawi, Vietnam and Zambia transition to a climate-smart approach to agriculture.

Climate-smart agriculture is an approach that seeks to position the agricultural sector'as a solution to these major challenges. It involves making changes in farming systems that achieve multiple goals: improving their contribution to the fight against hunger and poverty; rendering them more resilient to climate change; reducing emissions; and increasing agriculture's potential to capture and sequester atmospheric carbon.

"We need to start putting climate-smart agriculture into practice, working closely with farmers and their communities," Sandoval says. "But there are no one-size-fits-all solutions – better climate-smart farming practices need to respond to different local conditions, to geography, weather and the natural resource base.

"This project will look closely at three countries and identify challenges and opportunities for climate-smart agriculture and produce strategic plans tailored to each country's own reality," he adds. "While not all solutions identified will be universally applicable, we can learn a lot about how countries could take similar steps and begin shifting to this approach to agriculture."