Starting a greener revolution

Working towards a sustainable food supply

Ginny Page

How can we produce more food using less water, fewer chemicals and no more land? Ginny Page investigates.

Global food fights

Most of us in the UK can't imagine lasting more than a few hours without eating something tasty and don't expect we would ever have to. Plenty of affordable food pours into our shops from all over the world – but will it always be this way?

In 2008 food scarcity led to riots in some countries, and increases in food prices sent shocks around the globe. The world was reminded that producing enough food for our growing population was a challenge we cannot ignore.

Food security is a big issue on the international agenda. It refers to a situation where everyone has continuous access to safe, healthy food. Any major threat to crop production could be a global issue of food security.

A big challenge

The United Nations predicts there will be about 9 billion people on Earth by 2050. That's 50% more than today's population and millions already go hungry. Also, as some countries become wealthier, more people are expected to adopt a Western diet full of dairy products and meat. It seems the richer we get, the more protein we want on our plate. More animals being farmed means more grain needed to feed them. These changes mean that in the lifetime of today's teenagers the world is probably going to have to increase its grain production by a massive 100% from current levels.

Surely the answer is simply to use more land and grow more crops? Back in the 1960s, a 'green revolution' in the use of industrial fertiliser and pesticides on specially selected crops caused a boom in food production. But in 2010 we are much more aware of how changes in agriculture can risk damaging the environment (see Box). We need a 'greener revolution' for the 21st century.

As countries develop economically, people increasingly adopt western-style diets with more fast foods, including meat.

A farmer plants a new crop in his fields, Vietnam.

Key words
food security
green revolution
sustainability
GM crops

Food *v.* environment

Plants need nitrogen to grow and its availability is a major factor in growing nutritious crops. Although about 80% of the air around us is nitrogen, most plants can't use it directly and need it in the form of nitrate or ammonium. Farmers have been adding these compounds to soil in the form of manure for centuries, but it wasn't until the discovery of the Haber-Bosch process in 1908 that it became possible for industrial chemists to synthesise nitrogen fertiliser on a grand scale. It may have helped us grow more crops over the last century, but this process demands a lot of energy, using more fossil fuel than any other agricultural practice. Nitrogen fertilisers also cause dangerous pollution when they leach into groundwater, and lead to the release of the greenhouse gas nitrous oxide into the atmosphere. Clearly we need to limit their use.

So how can science help?

Plants are our ultimate source of food because of photosynthesis – the process by which plants convert energy from the sun into a form that animals can eat and use. As with other plants, crops are affected by water availability, soil quality, pests, disease and weed competition. Add in the effects of climate change increasing stresses such as heat, drought, salinity and flooding, and we have a lot of plants under pressure.

We need to identify crop plants that have the capacity to withstand these pressures, and can be grown using sustainable agricultural practices. Do these 'superhero' plants already exist? If they don't, what are the alternatives? Science and technology have important parts to play in the development of a sustainable food supply, but we must not forget the importance of social, economic and environmental factors – see Figure 1.

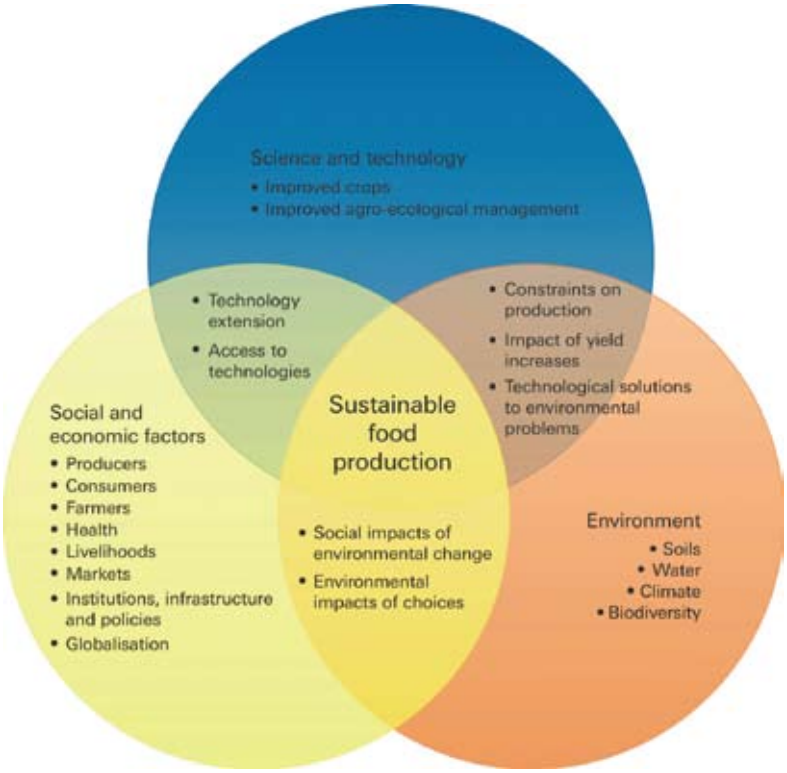

Figure 1 *The factors involved in sustainable food production*

Genetic treasure hunts

Before the days of gene technologies the only way plant breeders could tell whether a plant had a particularly useful gene was to grow it and find out. Much of the time the answer was 'no', or 'not sure', and many months could be wasted. Today we can search for genes by looking at thousands of plants in a single experiment. Once we have found genes for, say, resistance to a fungus in wheat, we can try targeting them in breeding programmes or transferring them into crops using genetic modification (GM).

Wheat blotch, a fungal disease, affects the yield of this important crop.

Current GM technologies involve inserting novel genes into a crop plant of the same species (cisgenic) or another species (transgenic). But the application of GM techniques has been controversial. The only GM crop being grown commercially in Europe is *Bt* maize – the latest version of which contains six genes transferred from the bacterium *Bacillus thuringiensis*. These *Bt* genes produce proteins which are toxic to a range of pests who feed on the maize plants. Some people are concerned that *Bt* maize may pose a threat to the environment or food safety. But as yet there is no scientific evidence to suggest that these threats are any greater than those from using lots of insecticides.

Sometimes we can find useful genes from old varieties of crops that farmers abandoned years ago, or from wild plants. UK scientists have identified a gene from a wild relative of potato that provides resistance against a really nasty strain of potato late blight – one of the most damaging crop diseases in recent history.

Partners in pest control

Millions of hectares of crops are lost to pests and diseases every year. Scientists are exploring ways to manage pests without the need to make genetic changes to crops. In East Africa, life can depend on good maize crops but farmers can lose up to 40% due to moths whose larvae bore into the plant stems.

A collaboration between African and UK scientists has resulted in a 'push-pull' system of pest management making use of other plants which have evolved a range of effective defence mechanisms against the moths. When grown round the edge of the maize field, Napier grass 'pulls' the moths away from the crop because the chemicals it produces are more attractive. It also exudes a substance deadly to the moth larvae if they burrow into its stem. If moths do make it past the border, they can be 'pushed' away from the maize plants by the repellent properties of the silverleaf plant grown in rows between the crop. Silverleaf is a legume so can also enrich the soil by fixing nitrogen.

No single solution

Scientists are working on lots of new ideas at the moment: enabling more plants to form symbiotic relationships with nitrogen-fixing bacteria; developing perennial crops; growing drought-resistant wheat; and computer-designing plants able to thrive in a high CO_2 world. We may not know for another 10 years or more which of these ideas will work best, but we do know none of them will guarantee food security on their own.

A plant scientist at work at the John Innes Research Centre, Norwich, UK.

Difficult decisions, big opportunities

When deciding which technologies we should use, we must compare what costs and benefits they bring to human health, the environment, society, and both local and global economies. Two big questions we need to ask:

- Will the new technology or practice limit risks to the environment and human health?

Even Darwin noticed that his cabbage seed stocks could be contaminated by pollen from purple kale grown nearly half a mile away. Genes move in this way all the time. But what might happen if genes from transgenic crops were transferred into other plants nearby? Whilst there is no evidence to date of GM crops causing environmental damage or harm to human health, existing regulation says that scientists must assess all theoretical risks before releasing any GM plant into the environment.

- Will the new technology or practice bring real benefits to farmers and their families?

More harm than good can result from imposing new technologies on people who are not ready to use them. Scientists need to work alongside farmers to understand their ways of working and learn from their experience so that the research will be of maximum benefit.

There are also concerns about the impacts of businesses in protecting their research investments. By using patents to protect their 'intellectual property', companies may prevent others from understanding their ideas enough to make products more cheaply, or adapt technologies to meet local needs. Where research could lead to benefits for poor people, there are good arguments for it to be funded by organisations not seeking large profits.

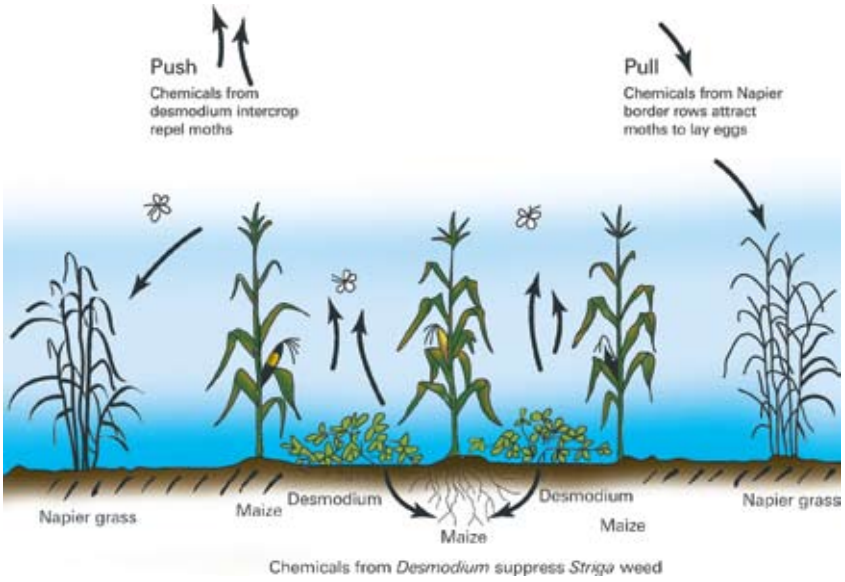

Figure 2 *The push-pull system use in Africa to manage maize pests. Source: The Gatsby Charitable Foundation*

Can we feed the world?

Of course just growing food isn't enough to ensure that hungry people get to eat it. The food has to be harvested, stored and transported from where it is grown to where it is to be eaten or processed without losing its nutritional value. Sometimes that involves many days and thousands of miles. In the case of food aid going to people in countries made desperate by earthquakes or droughts, food can travel across the world only to be stuck on a runway because there are not the roads or trucks to get it to the people who need it.

To really achieve food security as part of a greener revolution we need to involve not just scientists, but many others, from politicians to aid workers, from farmers to business people.

Ginny Page is Director of the Science and Plants for Schools (SAPS) programme and is based in the Cambridge University Botanic Garden. *She thanks the Royal Society and the John Innes Centre (JIC) for their help with this article.*

Try this!

Look for changes in prices of foods in your local supermarket and see if you can find out why.

Read *The Death of Grass* by John Christopher – a science fiction novel set in a world where a terrible virus is killing off all forms of grass.

Discuss who you think should fund research on new crops, what regulation needs to be in place, if more people should be vegetarian, and whether the only solution to food security is to slow down population growth.

Look here!

Find out more about developments in crop science:

http://royalsociety.org/Reapingthebenefits/
http://www.foodsecurity.ac.uk/
http://www.ukfg.org.uk/