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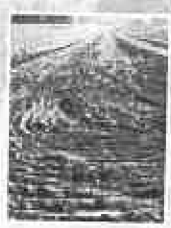
Future Developments in Crop Biotechnology

Issue Paper 6 • 2003



Agricultural Biotechnology in Europe

Promoting an open and informed dialogue

The potential of modern biotechnology

Introduction

So far in this series of issue papers, we have mainly covered topics relating to the biotech crops already grown and traded commercially. Now we are going to look into the future; not just at a vision of what might happen many years down the road, but also at developments further along the pipeline, some of which could be a commercial reality within five years.

That biotechnology has great potential in agriculture is clear. In this paper, we will give a snapshot survey of new applications, ranging from those which might soon be submitted for marketing approval to those still being worked on in universities. There is a range of developments, some from the companies who are members of ABE, some from other smaller companies, and some developed in public institutions. They have two things in common: real definable benefits, and demonstrated feasibility.

Already, crop biotechnology benefits society by allowing farmers to grow high quality food more efficiently, with more consistent yield and with reduced environmental impact. What we will show in this paper is that there are a large number of beneficial applications still in development. Some of these would be difficult to achieve using available "conventional" breeding techniques, others would be impossible to accomplish in any way other than genetic modification. As with any development process, not all of these will come to fruition, but we believe many will.

Whatever the situation regarding approval of new products in Europe, many of these crops will be grown in other parts of the world. Some of the produce will undoubtedly then be imported into the EU, following regulatory approval. We hope that we Europeans will also have the opportunity to benefit more directly by allowing our own farmers the choice to grow such crops.

Types of benefit

The genetically modified (GM) crops currently grown - mainly herbicide tolerant or insect resistant - deliver real benefits to farmers and society, such as lower costs, improved yields and reduced environmental impact. There will be many others in this category, but most of those discussed below give additional benefits, for example further increased yield potential or improved nutrition.

Here, we focus on developments for food or feed use, particularly crops with improved quality traits. However, to do justice to the breadth of applications, we also cover some examples in the areas of environmental benefit, improved food production efficiency, pharmaceutical production and non-food crops.

In each category, we summarise several developments. Some sources of further information are given at the end of the paper.

Quality traits: improving our food

To date, commercial GM crops have delivered benefits in crop production, but there are also a number of products in the pipeline which will make more direct contributions to food quality. A few of them are covered in this section.

1. Bananas with better keeping properties

Since bananas are not grown commercially in Europe and do not keep well once ripe, they are picked green for shipping and ripened under controlled conditions before being sold. After this, the ripening process continues rapidly, and there is a high degree of wastage because the fruit becomes overripe and can develop brown spots and a mealy taste when eaten.

Syngenta scientists are working on a solution that would have benefits for the grower, shipper, retailer and consumer. They are developing a long life banana that ripens faster on the tree and can therefore be harvested earlier. This gives the fruit better green life for transportation and handling and a better yellow life at the retail and consumer level (staying firm and yellow for 3-6 days longer). The company expects that this development could be commercial by 2006.

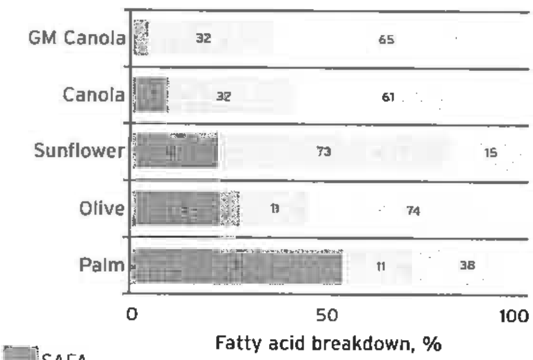
2. Improvements to oilseed crops

The various commercial oil crops grown around the world - palm, soya, olive etc - all have their particular characteristics. These oils are traded internationally and may be blended to give the nutritional and/or functional properties needed for different markets or applications. However, there are limitations to what can be achieved in this way at an acceptable cost.

Biotechnology has a role to play in producing nutritionally desirable oils in common crops. The biosynthetic pathways that allow plant cells to produce the individual fatty acids of which oils are composed are well understood. This knowledge allows scientists to modify parts of these pathways to control characteristics such as the level of saturation of the oil. The resulting oils may, for example, have an improved nutritional profile or be more suitable for frying.

One current example of such a development is GM canola (oilseed rape) with a very low content of saturated fatty acids (SAFA) compared to conventional canola, sunflower, palm, and olive oils (see figure 1).

Figure 1: Control of fatty acid composition of rapeseed oil



SAFA
PUFA
MUFA

(Source: Monsanto) SAFA = Saturated Fatty acids; PUFA = Poly-Unsaturated Fatty acids; MUFA = Mono-Unsaturated Fatty Acids

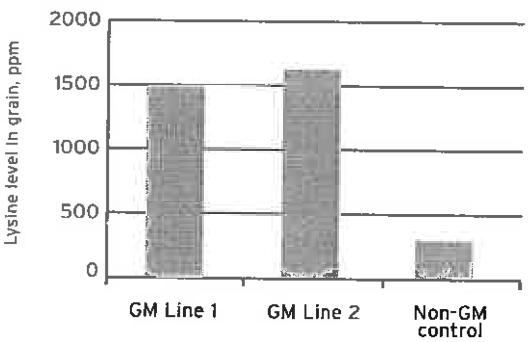
In a similar way, oils with very high levels of mono-unsaturated fatty acids (MUFA) can be produced; these are not easily available from conventional crops. In the longer term, cost-effective sources of the nutritionally important poly-unsaturated omega-3 fatty acids may also be available by modifying broad acre crops. At present, the main dietary source is oily fish, which build them up in their tissues by eating the algae which are the primary producers. Increased consumption of these oils, either by eating fish or taking supplements, has been shown to significantly reduce the risk of cardiovascular disease.

Scientists are now including the algal enzymes necessary to produce these specialised fatty acids directly into common crop plants. When these crops are grown commercially, not only will there be a plant-derived, bland tasting source of these oils, but pressure on dwindling fish stocks may be reduced.

3. Maize with improved feed value

One of the major animal feed crops is maize, both in Europe and North America. However, maize by itself does not provide a fully balanced diet for animals such as pigs and chickens. It is deficient in lysine - an essential amino acid - and has a lower than ideal level of total protein. Several companies have now developed GM maize lines with both increased protein levels and higher percentages of lysine (see figure 2 for an example of how lysine levels may be increased).

Figure 2: Improved protein quality in maize



(Source: Monsanto)

This and similar developments have a number of potential benefits:

- The improved amino acid balance achieved by increasing the lysine content improves the value of the maize as feed and reduces the need for dietary supplements
- There is an increased total protein and energy level
- The value of the grain is increased by €15-30 per tonne

Together, these can help to improve profitability in the feed chain while keeping the price of meat and other animal products low.

4. Tomatoes with high levels of flavonols

A tomato variety modified to stay firm when ripe (Flavr Savr®) was the first GM crop to be grown commercially (in 1994 in the USA). A similar development was the basis of the first GM consumer product to be sold in Europe: canned tomato purée, made from tomatoes with better processing characteristics, available in the UK from 1996.

In 2001, academic scientists working with Unilever reported that they had produced a tomato with a significantly increased level of flavonols. Flavonols are normally present in tomato skin at low levels, but are also found in tea and onions in higher amounts. They are powerful antioxidants (compounds which reduce the damage done to cells in the body), and there is evidence that they play a role in preventing heart disease and cancer when consumed at higher levels than are commonly found in the diet.

The researchers introduced a gene from another plant (petunia) to enable the tomato to produce more of a particular enzyme. The result was an increase in flavonol level by nearly 80 times in the tomato skin, with no effect on flavour. Importantly, the majority of this protective chemical survived processing into tomato paste: most of the antioxidants in tomatoes are found to be more biologically available after cooking.

It will be a number of years before such tomatoes are available commercially, assuming they clear all the regulatory hurdles, but they could be an important contribution to a healthy diet.

5. High lycopene tomatoes

A similar development - this time tomatoes with higher levels of the antioxidant lycopene - was announced in 2002 by American scientists at Purdue University in Indiana[1]. They inserted a gene isolated from yeast, which enabled the tomatoes to produce 2-3 times as much lycopene as controls.

Lycopene is the substance which gives the tomato its characteristic colour, and this fruit is already one of the best dietary

1 Handa A, Mattoo A; Engineering polyamine accumulation in tomato enhances phytonutrient content, juice quality and vine life; Nature Biotechnology; Vol 20; June 2002; pp613-618

sources of the antioxidant. It is similar to carotene, but has more powerful protective effects against some health problems. For example, men eating ten or more servings of tomato sauce or tomato a week have been found to have their chance of developing prostate cancer almost halved. There is also evidence that tomato consumption can reduce heart disease by lowering the level of a substance called LDL cholesterol in the bloodstream. LDL (low density lipoprotein) is the so-called "bad" cholesterol, which is implicated in cardio-vascular diseases. Interestingly, antioxidants such as lycopene are found to be much more effective when consumed as part of the tomato than when given as pure dietary supplements.

This development also provides a mechanism for allowing other fruits and vegetables to produce this valuable compound.

6. Maize with improved Vitamin E balance

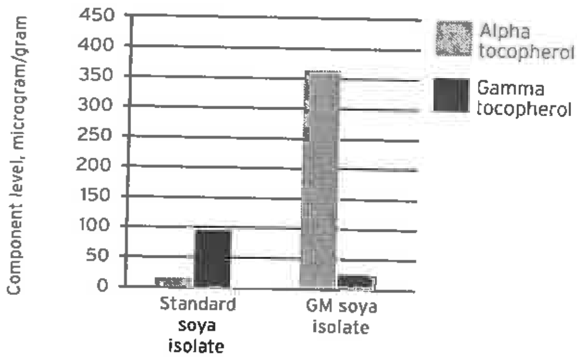
Maize, like other major cereal crops, contains a certain amount of Vitamin E, the generic name given to a group of compounds known as tocopherols. These have important antioxidant properties (protecting cells from damage which could lead to cancer and other diseases) and are also essential in the human reproductive cycle.

The two main forms of Vitamin E in maize are α- (alpha-) and γ- (gamma-) tocopherol. Normally, γ-tocopherol represents about 80% of the total Vitamin E content of maize. However, α-tocopherol is the more active of the two compounds, with proven health-protecting effects, and better sources of it would be valuable. Scientists at the University of Illinois have used current knowledge on the biosynthetic pathway of Vitamin E components to target genes coding for particular enzymes in the plant Arabidopsis (a simple plant from the mustard family commonly used in biotechnology research). The modified plant makes 95% of its tocopherol in the desirable α form, while increasing the overall level of this component 80-fold (see figure 3). They are now modifying maize plants in a similar way, but commercial growing may still be many years away.

7. Soya bean with improved protein

Soya protein, in addition to its contribution to the body's nitrogen requirement, has other beneficial effects on health. Not least of these is the cholesterol lowering effect: the American FDA allows a claim to be made if 25 grams of

Figure 3: Vitamin E levels in Arabidopsis

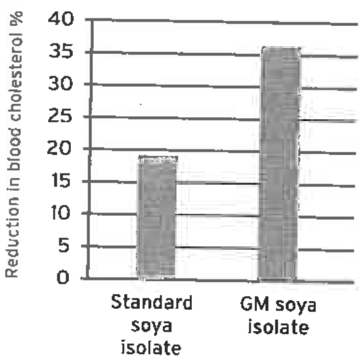


(Source: Rocheford et al: 2002)[2]

soya protein is consumed per day. However, this is a large part of the total daily protein requirement, and is not easily incorporated into the diet.

Researchers at Monsanto have developed a soya bean which they hope will make it easier for the average consumer to get the health benefits. They have modified the bioactive peptides in soya to produce a protein isolate with improved cholesterol reducing properties (see figure 4). When this is fully developed, it holds the potential for a significant reduction of the level of soya protein necessary to achieve a worthwhile degree of cholesterol reduction and hence lowering of the risk of cardiovascular disease.

Figure 4: GM soya for improved cholesterol reduction



(Source: Monsanto)

Plants which benefit our environment

Other applications of modern biotechnology will result in environmental benefits, and in this section we look at some of these.

2 Rocheford et al; Journal of the American College of Nutrition; Vol 21(3); pp 121-198S; 2002; Enhancement of Vitamin E level in Corn

1. Maize with improved phosphorus availability

Large quantities of cereal crops are fed to animals. They provide the major supply of nutrients to the animals' diet, but are not always fully digested. In particular phosphorus (an important mineral for bone development) is present to a large extent in the form of compounds called phytates, which cannot be metabolised by certain animals, including poultry and pigs.

There are two consequences of this:

- The animal may need to receive additional forms of phosphorus for healthy growth
- Some of the phosphorus from the grain appears in the manure and can lead to groundwater pollution

One company – Syngenta – is developing improved strains of maize which will overcome these problems. They are modifying maize plants to produce a very high level of their own phytase, an enzyme which breaks down phytates and releases the phosphorus, and is often added as a supplement to animal diets. The high phytase maize can then be included directly as a component of the diet of both pigs and poultry. This crop is in a late stage of development, and could be available well within five years, assuming regulatory approval.

2. Stress tolerant crops

In France, a team working for Groupe Limagrain is developing varieties of maize which have a better tolerance to drought. Incorporation of a gene from sorghum – a naturally hardy plant – enables conventional maize to thrive with lower rainfall. This is particularly important as pressure on fresh water supplies continues to build: developments such as this which reduce the need for irrigation while retaining high yields will prove invaluable.

Similar work is under way to produce other crops with tolerance to drought and other stresses. For example, South African academic scientists are looking at the aptly named resurrection plant, which can exist for years in deserts. Although apparently dead, the plants start to grow again as soon as it rains. Identifying the genetic basis for this behaviour and incorporating some of its components into crop plants for arid areas could avoid the complete failures of harvests in times of drought.

Researchers working for BASF in Germany have been able to transfer genes which give salt tolerance from a moss to a test plant, and are now planning to do the same with crops. Saline soil is a problem in many parts of the world, and has been made worse by long-term irrigation which can bring salt to the surface. Creating plants which could grow under such conditions would reduce the need for agriculture to encroach on other fragile environments.

Scientists at the University of California and the University of Toronto have jointly developed tomato plants capable of growing in saline soils[3]. They are not only able to grow in soils which conventional plants could not tolerate, but can store the excess salt in the leaves so that the fruit have a normal level of saltiness. This development could be ready for commercialisation in three years.

In November 2002, scientists from Cornell University published a paper in which they reported a major step forward in production of stress-tolerant rice[4]. They were able to add bacterial genes to allow the rice plant to produce levels of a sugar sufficient to protect it from drought and also enable it to grow in saline soils. This special sugar – trehalose – protects the various components of the plant cells and should allow greater yields under difficult conditions. This technology is now available for public sector institutions to apply as they wish. The Cornell team is also using the same technique to develop stress-tolerant wheat and maize.

Many of these examples are potentially of major benefit to the developing world, where nearly all suitable land is already used for farming and populations are set to continue rising. Assuring consistent yield, even in times of drought or where the soil has been degraded, will mean far less encroachment on forests and marginal lands to produce more food. The benefits would be both to people and the environment.

3. Bioremediation: arsenic-tolerant plants

A team of researchers based at the University of Georgia has recently published a paper in which they describe a workable system to enable plants to metabolise arsenic and remove it from contaminated soil[5].

This system has been demonstrated in Arabidopsis, a simple plant in the mustard family which is widely studied by biotechnologists. They inserted two genes from a common bacterium, which together make a dramatic difference to the metabolism of arsenic by the plant.

3 H Zhang, E Blumwald; Transgenic salt tolerant tomato plants accumulate salt in foliage but not in fruit; Nature Biotechnology; Vol 19; Aug 2001; pp 765-768

4 A Garg, R Wu; Proceedings of the National Academy of Science; November 2002

5 O P Dhankar et al; Engineering tolerance and hyperaccumulation of arsenic in plants by combining arsenate reductase and γ-glutamylcystein synthetase expression; Nature Biotechnology; Vol 20; Nov 2002; pp 1140-45

The addition of these genes means that Arabidopsis, to which arsenic is normally toxic, can thrive on contaminated soils and transport the arsenic preferentially to its leaves. There, it is combined with sulphur to form a compound which is less biologically available (and less toxic). The trial plants grew 17 times more fresh shoots, and accumulated two to three times as much arsenic per gram of tissue than wild-type plants. At this stage of development, this gives the potential for each plant to remove 30-50 times as much arsenic from the soil compared to conventional plants. They can then be harvested and safely disposed of, leaving the soil ready for planting other crops.

Plants which increase food production capacity

Although crops delivering direct benefits to consumers or the environment will obviously be significant, some of the most important applications will be those which enable higher yields to be produced. For the industrialised world, where we already produce surpluses of some foods, this does not at first sight seem necessary. However, with low commodity prices, farmers are under more pressure than ever to produce higher yields. Most Western consumers have seen their food shopping bills halved in real terms in the last 50 years, largely because food production has doubled, and they continue to demand cheaper and even better quality food.

The situation in the less developed world is different. The vast majority of the estimated additional 2-3 billion people who will inhabit this planet by the middle of this century will be born in developing countries, where the need to produce more food on the same or less land will be critical. On top of this, Africa has been almost completely by-passed by the developments in agriculture which have been of such benefit to Asia. Of course, there are also important and complex social and political aspects to the problem of feeding this burgeoning population, but tackling these will only be effective if sufficient food is available in the first place. In this section, we cover a few of the developments which may help to increase future global food security.

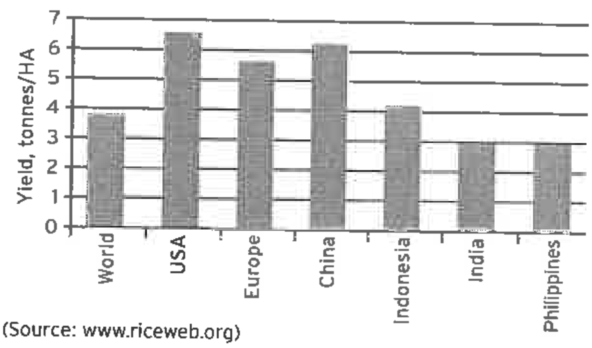
1. High yielding rice

Rice is unique amongst the major world crops in being almost entirely consumed by people rather than animals. It forms the staple diet of vast numbers of people in South and Southeast Asia. Major efforts are devoted to breeding improved varieties, but rice is at a disadvantage to other cereals in having a less efficient photosynthesis pattern. This limits the maximum yield which can be produced for a given area of land. Currently, most of the irrigated land, on which 70% of the world rice crop is grown, is already sown with varieties having a yield potential of 10 tonnes per hectare, the highest possible so far.

Fortunately, the International Rice Research Institute (IRRI) in the Philippines has a programme which will help to improve rice yield. This year, IRRI plans to introduce the more efficient "C4" genes from maize into rice plants adapted for local use. This builds on work reported in 2000 by scientists from Japan and Washington State University. They added these genes to produce additional enzymes – including pyruvate orthophospate dikinase – which enabled yield increases of up to 35% to be achieved in field tests in China, Korea and Chile. The IRRI has a target of 20% improvement in yield potential. The actual yield will vary with factors such as climate and level of fertiliser used.

The intention is to use these maize genes together with introduced disease-resistance traits to give consistent high yields for a growing population. Figure 5 gives some information on current rice yields, showing the great potential for improvement in parts of Southeast Asia.

Figure 5: Comparative rice yields



(Source: www.riceweb.org)

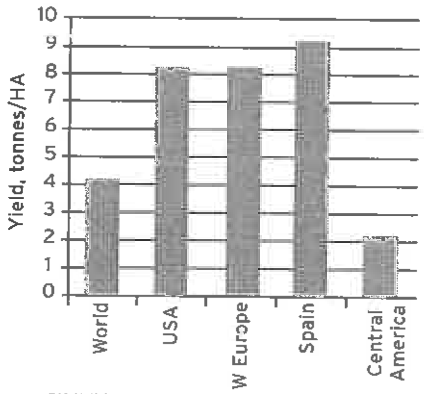
2. Maize for acidic soils

Over 40% of the soil in tropical regions is naturally acidic. This means that the aluminium present in the soil is made more available to plants. Unfortunately, aluminium is toxic to most plants, and crops therefore fail to thrive. In poor, weathered soils typical of sub-Saharan Africa, it is estimated that 80% of yield losses are due to soil acidity and water stress. One way of improving this situation is to return organic matter, including plant residues, to the soil. Unfortunately, poor crops mean that the vicious cycle of low yield/low residue/high acidity then continues. Other soils, not considered suitable for growing crops at all at present, could be used for agriculture in the future if this problem could be surmounted.

In Mexico, maize is the staple crop, and on poor soil can produce only meagre yields. However, it is in this country that a team from the Centro de Investigación y Estudios Avanzados (CINVESTAVin) is developing a simple system to overcome this. Having proved that citric acid added to soil is effective in binding aluminium and other toxic metals, so allowing plants to grow normally, bacterial genes to enable plants to produce their own citric acid in the roots were added to tobacco and papaya plants. Both of these species were then able to grow normally on acidic soils.

With the feasibility established, the team moved on to maize, as a major staple crop grown in the tropics. Work on maize has been in progress for several years, and it is hoped that the project will be close to commercialisation within five years. Figure 6 shows how yields in a region such as Central America compare to those in the developed world.

Figure 6: Comparative yields of maize



(Source: CIMMYT)

3. Virus resistant sweet potato

Sweet potatoes are grown as a versatile staple crop in sub-Saharan Africa, as an alternative to the more traditional cassava. However, the potential of this crop has not been fulfilled because of its susceptibility to a range of viral diseases which can massively reduce yields.

A group in Kenya has set about producing sweet potato plants which are resistant to the so-called feathery mottle virus, a common factor in the development of a range of diseases in combination with other viruses. In collaboration with Monsanto, they introduced resistance genes into a number of sweet potato plants, which then underwent field trialling in 2001. There are still several years of conventional breeding work involved in producing high-yielding, locally-adapted varieties for East African farmers, but this viral resistance is likely to be of real benefit to small-scale agriculture in the region.

Pharmaceutical production

Plants may be bred not only to supply desirable nutrients as part of the everyday diet, but also to produce medicines. Many pharmaceuticals are already produced with the help of modern biotechnology using cell culture or fermentation in factories. However, plants provide an attractive alternative in some instances. There are, of course, additional issues regarding how and where such plants will be grown, since they must not be allowed to enter the food chain, but these are not insurmountable if the benefits are great enough. Two examples will illustrate the sort of products currently in the development pipeline.

1. Maize to benefit cystic fibrosis sufferers

A French company (Meristem Therapeutics) has developed technology which allows plants to produce specific proteins which are used in healthcare. They also have the technology to extract and process these proteins to that they are ready for use by patients.

A current example is the adaptation of maize to produce a lipase (fat-digesting enzyme) which is resistant to breakdown in the highly acid conditions of the stomach and can therefore be taken orally by patients. The primary use for this product is for sufferers of cystic fibrosis, a genetically-determined disease which causes the production of extremely thick, sticky mucus in the lungs and pancreas. One of the main effects of this disease is that digestive enzymes are prevented from reaching the intestine; food is therefore very poorly digested and patients get little nourishment from their diets.

This major symptom is currently treated by taking large doses of pig pancreas extract, which is not effective in all cases. Because it is less easily broken down in the stomach, the plant-produced enzyme should be much more effective for the estimated 130,000 cystic fibrosis sufferers worldwide (30,000 in Europe). Following pre-clinical safety assessment, this plant-produced enzyme is now in Phase II clinical trials in France and Germany, and is expected to be on the European market by 2004.

2. Vaccines from fruit and vegetables

Vaccines to protect us from infectious diseases are generally prepared as pure compounds in pharmaceutical factories, and must then be distributed under chilled conditions to reach the patient in a standardised active form. This is fine for industrialised countries, which have ready access to sophisticated, temperature-controlled storage and transport systems. However, in many less developed countries, where childhood vaccination is less common and the infrastructure is much less developed, distribution of vaccines to rural areas is extremely difficult and costly.

Scientists in America hit upon the concept of producing vaccines in fruit and vegetables, which could be consumed directly and so deliver the vaccine in a protected form, with no need for refrigeration or injections. The banana was seen as an ideal vehicle – a staple crop commonly grown in tropical regions. The reality, unfortunately, is not quite that simple, as the bananas have to be grown in the right place at the right time and care must be taken both to segregate them from the conventional crop and to ensure that children receive a standardised dose of the vaccine. The solution has been to develop a vaccine-producing banana, which is then freeze-dried to give an ambient stable powder containing a standardised dose.

Another university group in Philadelphia is taking a similar approach to developing vaccine systems such as for hepatitis and rabies. They have gone a long way down the road to commercialisation: initial clinical trials have been done using lettuce which produces hepatitis B vaccine, and spinach containing rabies vaccine. It is reported that these applications are only 2-3 years away from being fully developed. Not only will the production of vaccines in this way be simpler, but there will also be enormous cost reductions. This will benefit both the sophisticated but over-stretched healthcare systems in the industrialised world and the populations of less developed countries who do not have good access to medical facilities.

Non-food crops

Although our focus is on food, we shouldn't forget that agriculture is also a source of other valuable goods: cotton, wool and sisal, for example. As we move towards a greater use of renewable raw materials for industry, and as we try to make our production processes more efficient, there will be a greater emphasis on non-food crops, and biotechnology will undoubtedly have much to offer.

1. Low-lignin trees for paper-making

Vast areas of forest are managed purely to provide wood pulp for paper-making. In order to make paper, the clean cellulose fibres of which it is made must be separated from other components of the wood. In particular, lignin (a structural component) has to be removed chemically, creating a by-product for which there are few uses, and producing potentially polluting waste streams.

Several teams of scientists have modified trees to produce a lower level of lignin. The intention is that these could then be used to make paper in a more efficient process giving less waste. The lignin cannot be removed entirely, however, since the tree would then have insufficient strength. At a university in the USA, alder trees were developed in 1999 which had half the lignin and 15% more cellulose than conventional trees. They also grew faster.

Because of the long lifecycles of trees compared with food crops, the commercialisation of such developments may be ten years or more away. However, the importance should not be underestimated. Longer term benefits may include:

- Significant reduction in energy use and effluent from pulp and paper-making industries
- Increased productivity of managed softwood forests, reducing pressure on natural mixed woodland
- The possibility of increasing lignin content for firewood (higher energy value) and construction (improved structural properties), again lessening the pressure on mixed woodland

2. Energy crops

As more focus is put on renewable sources of power for the future, many countries are looking at various ways to use plants for this purpose. In both North and South America, for example, there are significant programmes to produce ethanol, which is then used as a component of car fuel. The US Senate has called for a tripling of the use of ethanol for this purpose. Ethanol is produced by using an enzyme (amylase) to break down starch into sugars, which are then fermented by yeast to produce alcohol. Syngenta has a project to make maize which produces its own amylase. Because this makes for a more efficient process, it may reduce the cost of ethanol by up to 10%.

Conclusions: the future of sustainable food supplies

This brief survey has really only scratched the surface of developments in crop biotechnology. In many cases, biotechnology will have been used because it is the best (or perhaps only) way to achieve the result.

Genetic modification can contribute to sustainable agriculture, and to the improvement of food security, quality and safety. It is a powerful tool which has enormous potential when properly applied. As we look to the future, it is one of the keys – in combination with the best of conventional plant breeding, sound agricultural practices and efficient processing and distribution systems – to the development of fully sustainable food supply chains.

In addition, we are beginning to see an increasing interest in crops for non-food uses. Tailoring plants to be as useful as possible, so continuing the long tradition of agricultural development, will be made easier and more predictable through use of modern biotechnology.

And as agriculture is called upon to produce more food, more fuel and more industrial raw materials, productivity of existing farmland must continue to increase unless we are to encroach further into marginal lands and reduce wildlife habitats. Modern biotechnology will also play a key role in achieving this goal.

Sources of further information

Many reports are found in the scientific press and more general news services. Further information on some developments will be found on the website of the company involved. There are also a number of (mainly web-based) sources on information, including:

- Harvest on the Horizon: Future Uses of Agricultural Biotechnology; Pew Initiative on Food and Biotechnology; September 2001
- Journal of the American College of Nutrition; Vol 21; No 3(S); Supplement: The Future of Food and Nutrition with Biotechnology
- http://www.colostate.edu/programs/lifesciences/TransgenicCrops/
- www.bio-scope.com
- www.whybiotech.com
- www.checkbiotech.org
- http://www.utoronto.ca/jcb/_genomics/top10ng.pdf (Top ten biotechnologies for improving health in developing countries)

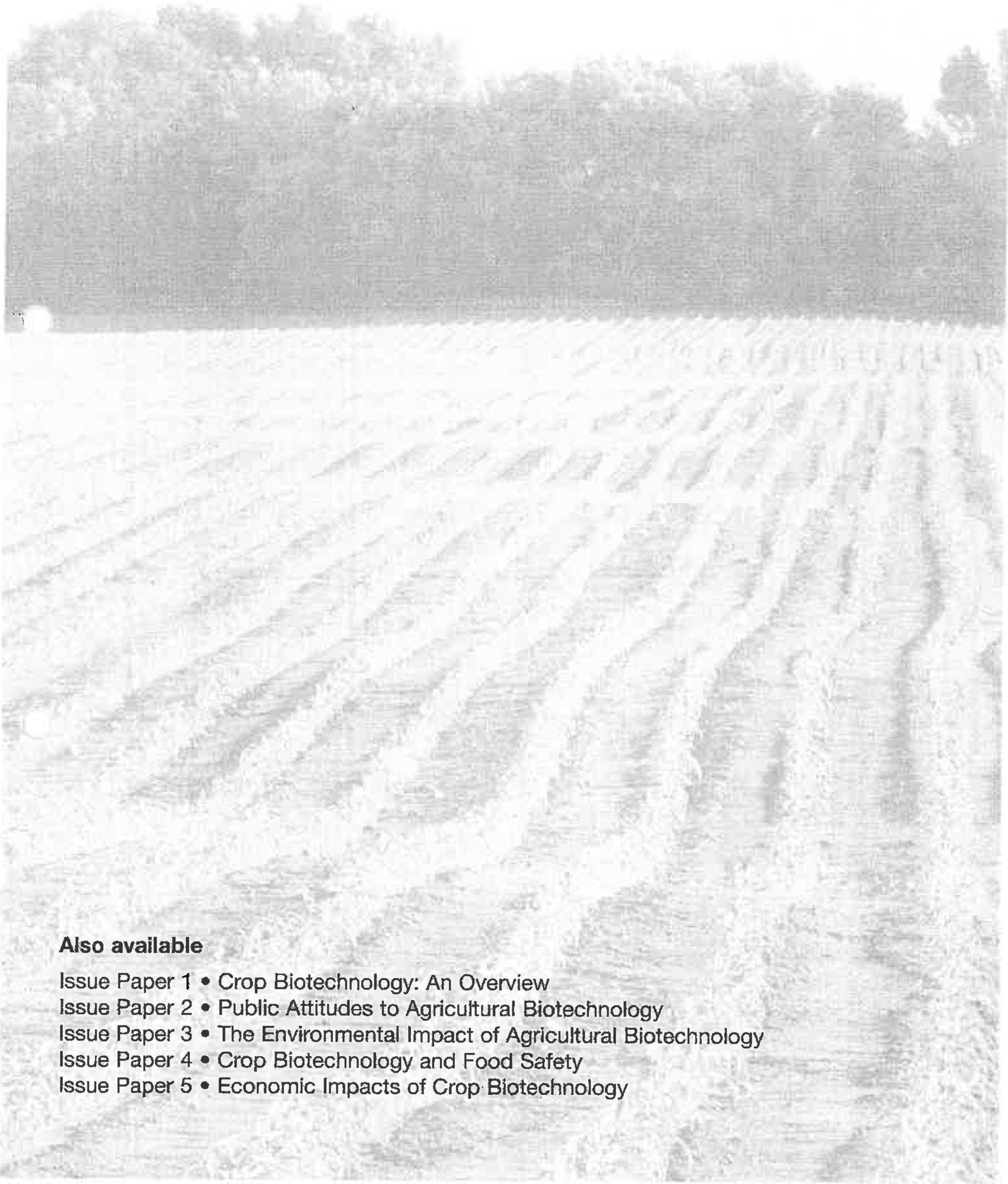
Who we are

The companies involved with the development of agricultural biotechnology believe strongly that biotechnology has the potential to enrich our lives in many ways. We recognise, however, that the introduction of genetically modified crops and foods has raised concerns in many European countries. Our industry has an ongoing commitment to scientific research and testing, and to ensuring that products are developed and commercialised in a responsible and safe manner. We also recognise that the success of any new technology in Europe needs to be based on respect for people's viewpoints. The biotechnology industry believes that consumers should be as informed as possible. The agricultural biotechnology industry is therefore working with various organisations across Europe to improve transparency and to foster a useful dialogue on agricultural biotechnology. Our efforts focus on broad and serious communication to a range of audiences – media, NGOs, policy-makers, retailers and others – with the aim of listening to and respectfully addressing the concerns of European citizens as well as making information available about our industry and this technology. The following companies are participating in this effort:

BASF	Bayer CropScience
Dow Agrosciences	DuPont
Monsanto	Syngenta

Our aim is to increase the dissemination of information and contribute to an informed debate about crop biotechnology. If you are interested in receiving more information about agricultural biotechnology, please contact Peter Wynne Davies at:

info@ABEurope.info or consult the ABE website at www.ABEurope.info



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