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Benefits and risks of gene technology in agriculture

Introduction

2.1 Using biotechnology can be seen as extending earlier methods of plant and animal breeding which date back many thousands of years (Table 2.1).[1] The technology obtains results more rapidly, is more precise, and gives access to a broader genetic base than traditional breeding techniques. These are the features that recommend its use so powerfully to plant and animal breeders. It provides an important tool when integrated with traditional breeding approaches.

2.2 The precision that gene technology offers is possible because the exact segment of a chromosome that determines a desired trait can be identified. With this capacity, traditional breeding programs can be fast tracked by locating seeds or offspring at an early stage, through gene marker technology, and breeding only from them. The Cattle Council of Australia commented on the dramatic increases in precision of genetic improvement that is possible as a result.[2] In addition, genes can be removed from one organism and inserted into another.

2.3 Transgenesis, in which genes are moved from one species or organism to another, allows beneficial genes from any source to be transferred to other species or organisms. The Cooperative Research Centre (CRC) for Tropical Plant Pathology pointed out that, while conventional breeding programs have improved the pest and disease resistance of Australian crops, there

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1 C Hudson, 'How industry adopts new technology', *Gene Technology and Food*, National Science & Industry Forum Report, Australian Academy of Science, April 1999, p. 12; Nugrain, Submission no. 25, p. 6.

2 Cattle Council of Australia, Submission no. 20, p. 3.

are some problems against which the natural germplasm of these crops lacks resistance. Examples of such problems are lack of resistance to:

- the fungus, Sclerotinia, in sunflowers;
- to Aschochyta blight in field peas; and
- to Rhizoctonia root rot in wheat.

The only way in which resistance can be given to such crops is through transgenesis.[3]

Table 2.1 Plant improvement using selection and breeding – historical perspective

Year	World population (m)	Development
8000BC	5	Cereals and pulses domesticated
2000BC	50	Rice, potato, oats, soybean, grape, cotton, banana domesticated
1583	500	Sexuality in plants described
1742		First company devoted to plant breeding and new varieties
1799		First cereal hybrid described
1900		Maize hybrid breeding: Mendel recognised
1927		X-rays used for mutation breeding
1983	5000	First use of gene technology for plants
1999	6000	50m hectares of genetically altered plants

Source T J Higgins, 'Plants', Gene Technology and Food, Australian Academy of Science, April 1999, p. 4.

2.4 Another way in which gene technology will eventually contribute to improving plant and animal varieties is by switching on genes for desired traits that are present in the genome but not currently expressed.[4] Conversely, it should be possible to switch off genes that produce undesirable traits.

2.5 Several examples were provided to the committee of the shorter time to commercial release for GM compared with traditional varieties of crops. Experience in the grains industry is that the time is reduced from 8-13 to 3-8 years.[5] The Dairy Research and Development Corporation estimated that there could be a 30 per cent reduction in time to 3-4 years to commercialisation for pasture plants.[6] The Australian Food and Grocery Council (AFGC) claimed that 'traditional breeding techniques stand to be

3 Cooperative Research Centre for Tropical Plant Pathology, Submission no. 21, p. 1.

4 B J Feder, 'New method of altering plants is aimed at sidestepping critics', *The New York Times Science*, 29 February 2000, p. D3.

5 AWB Ltd, Submission no. 66, p. 3; Grains Council of Australia, Submission no. 65, p. 9; Nugrain, Submission no. 25, p. 6.

6 Dairy Research and Development Corporation, Submission no. 15, p. 2.

eclipsed by the speed of development, and commercial impact, of new plant and animal varieties produced using gene technology'.[7]

2.6 However, Novartis sounded a warning note, pointing out that using gene technology does not necessarily reduce the time taken to develop new products. It can even increase the time needed because the genetic manipulation is complementary to field breeding work, not a substitute for it.[8]

2.7 In addition, although biotechnology has been claimed as an extension of earlier breeding techniques, some of its applications are different. Transgenesis, for example, has not been possible before, and may present new, unfamiliar risks.

> Almost certainly the majority (perhaps all) of the genetic modifications currently brought about using gene technology would never have occurred naturally. It is therefore inaccurate to state that gene technology simply enables what was previously done, to be achieved more efficiently and with more precision.[9]

Benefits

2.8 Many benefits have been identified from the use of GMOs in agriculture. The majority of submissions to the inquiry listed benefits, which are summarised below. Some of these benefits are proven but many more are still on the drawing board. They are expected to emerge but depend on the successful development of the relevant GMOs.

2.9 With gene technology, it is, or will be, possible to breed crop and animal varieties which:

- are better suited to specific, different environments;
- are more efficient at converting nutritional inputs into outputs;
- are more disease and pest resistant;
- are able to withstand herbicides;

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7 Australian Food and Grocery Council, Submission no. 59, p. 4

8 Novartis, Submission no. 26, pp. 5-6. Novartis is a Swiss based life sciences company which has health as well as agribusiness interests. Its seed division is one of the largest seed companies in the world with a turnover of US$900 million in 1998. (K ten Kate & S A Laird, *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit-sharing*, Earthscan, London, 1999, pp. 122-3).

9 Environment Australia, Submission no. 82, pp. 9-10.

- are more productive, in addition to any increases in productivity due to the previous four points;
- will have better keeping qualities;
- will have better processing qualities; and
- be more healthy.

2.10 The characteristics of agricultural GMOs listed above are expected to bring benefits that can be divided, broadly speaking, into those for the farmer, the economy, the environment, the consumer and world food supplies.

Grower benefits

2.11 For the farmer, the main attractions of GM crops at present are the promises of increased productivity and lower input costs. Disease and pest resistant crops need less spraying; similarly, animals with better resistance to disease and pests require less care. As a result, the significant input costs of chemicals, labour and energy are reduced. With herbicide tolerant crops, better control of weeds enhances productivity. It would be possible to make better use of the land with animals better suited to local conditions and climate, and crops better suited to local growing conditions, for example, by being more tolerant of drought, salt or acid. Fertiliser costs could be reduced with crop varieties able to make better use of soil nutrients or to fix nitrogen. Growers improve their marketing options by offering the processor and consumer food of improved quality.[10]

2.12 Some of the types of crops described in the last paragraph are already in use and their usefulness has been demonstrated. In its submission to the inquiry, the National Farmers' Federation (NFF) mentioned a 33 per cent drop in overall herbicide use with herbicide tolerant soybeans in the USA. Herbicide tolerant canola in Canada showed improved quality and a 10-20 per cent yield increase over conventional varieties.[11] Australian experience with Bt cotton is that insecticide use dropped by 40-50 per cent. This has been accompanied by better survival of beneficial predators and parasites, and has reduced the likelihood of contamination of cattle on neighbouring properties with endosulphan which in previous years led to their rejection by export markets.[12]

10 Australian Biotechnology Association, Submission no. 39. pp. 4-5; Australian Sugar Industry, Submission no. 64, p. 5; National Farmers' Federation, Submission no. 36, p. 3; Nugrain, Submission no. 25, p. 8; Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

11 National Farmers' Federation, Submission no. 36, p. 3.

12 Cotton Research and Development Corporation, Submission no. 27, p. 3; Transcript of evidence, 18 October 1999, p. 202.

2.13 The benefits of GM crops to farmers are apparent from the rapid uptake of GM crops in the last few years, as indicated in paragraph 1.4. According to the International Service for the Acquisition of Agri-biotech Applications, by the end of 1998, GM crops had been approved for planting and commercialisation in 17 different countries. They comprised 56 varieties of about 13 different crops, of which squash, corn, canola, cotton and tomato were most widely grown.[13] GM crops have been taken up in the USA much faster than any previous technology,[14] and are also being grown in other countries, notably Argentina and Canada. In mid 1999, when submissions to the inquiry were made, projections for future plantings all showed 'massive' increases,[15] with promises of substantial profits.

2.14 Gene technology offers new possibilities to growers in the form of new products from existing species. It is possible, for example, that plants may eventually be modified to produce industrial chemicals.[16] Trees might be bred that yield timber with properties characteristic of timber substitutes like steel, aluminium, concrete and plastic.[17] A further benefit to farmers comes from the use of gene technology to control pest animal species and exotic weeds.[18]

Benefits to the national economy

2.15 Efficient crop production is essential for the international competitiveness of Australian agriculture. Eighty per cent of agricultural produce is exported each year; in 1998 agricultural exports earned $27 billion.[19] For some crops, such as grains, Australia is an important provider on the world scene. It has 15 per cent of the world wheat trade and, in 1997-98, grains exports earned about a quarter ($5.1 billion) of its farm export earnings.[20] Cotton, sugar and wine are also important export crops.[21]

2.16 Up to this point, Australia's cropping sector has maintained its position in world markets by continual improvements in yield, input costs and product quality.[22] There is evidence, however, that improvements in yields

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13 C James, *Global Review of Commercialized Transgenic Crops: 1998*, The International Service for the Acquisition of Agri-biotech Applications Briefs no. 8, Ithaca, New York, 1998, pp. 2, 3.

14 Cooperative Research Centres Association, Submission no. 40, p. 5.

15 Novartis, Submission no. 26, p. 3.

16 CSIRO, Submission no. 56, p. 2; Grains Council of Australia, Submission no. 65, p. 9.

17 Forest and Wood Products Research and Development Corporation, Submission no. 34, p. 4.

18 CSIRO, Submission no. 56, p. 2.

19 National Farmers' Federation, Submission no. 36, p. 2.

20 Grains Research and Development Corporation, Submission no. 47, p. 4.

21 ABARE, FARMSTATS Australia, March 2000.

22 Grains Council of Australia, Submission no. 65, p. 9; Grains Research and Development Corporation, Submission no. 47, p. 4; Nugrain, Submission no. 25, p. 1.

in Australia have been lagging behind overseas improvements or, in the case of sugar, have plateaued. With access to gene technology, the improvements will come faster and from a broader genetic base. If the resulting varieties are not adopted by, or are not available to, Australian farmers but are with respect to farmers overseas, the profitability of cropping will further decrease for Australians.[23] Access to biotechnology in agriculture is therefore seen as vital to Australia's success as a nation.[24] While access to biotechnology may not be essential in the present climate of negative sentiment towards GMOs, this sentiment may erode and Australian farmers may then find they are at a disadvantage compared with their competitors.[25]

2.17 Another avenue for the economic advancement of Australia is the exploitation of the country's genetic resources. Australia is one of the mega diverse continents of the world and has many endemic species. Its biological resources are relatively unexplored and a potentially rich resource of genes and bioproducts of commercial value.

World food supplies

2.18 The world's population is expected to grow substantially and become increasingly urbanised in the next few decades, giving rise to increased demand for food. AWB, for example, estimated that world wheat consumption will have grown by 38 per cent on current levels by 2020.[26] There is concern about how the growing demand for food will be met. Some see GM crops as a means of improving food security, and helping to meet long term global demands for food which traditional approaches to agriculture cannot.[27]

2.19 Others, however, have challenged the view that GM crops will help to feed the world. They see current and projected food shortages as the result of 'complex social, political and economic forces', for which other solutions are needed.[28] The Organic Federation of Australia (OFA) claimed that the

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23 Australian Raw Sugar Industry, Submission no. 64, p. 4; Nugrain, Submission no. 25, p. 1.

24 Agrifood Alliance Australia, Submission no. 37, p. 2; National Farmers' Federation, Submission no. 36, p. 2; NSW Farmers' Association, Submission no. 38, p. 2; Waratah Seed Co., Submission no. 23, p. 1.

25 M Foster, 'Market implications: genetically modified crops', *OUTLOOK 2000*, ABARE, Canberra, 2000, p. 191.

26 AWB Ltd, Submission no. 66, pp. 2-3.

27 International Federation of Agricultural Producers quoted by the National Farmers' Federation, Submission no. 36, p. 5; Novartis, Submission no. 26, p. 2; NSW Farmers' Association, Submission no. 38, p. 2; Nugrain, Submission no. 25, p. 7.

28 National Genetic Awareness Alliance, Submission no. 54, p. 3.

problem is not one of inadequate food supplies, but of poverty and landlessness.[29]

Environmental benefits

2.20 According to CSIRO:

> There are already domestic and international indications of environmental benefits from less pesticide use (as in the case of Bt cotton) and replacement of rather potent herbicides with more benign herbicides for herbicide tolerant crops … [30]

The health risk to farming communities from exposure to these chemicals is thereby reduced, and the presence of these chemicals in the air, soil, ground water and runoff is diminished.[31]

2.21 Use of herbicides rather than tillage reduces soil erosion and degradation.[32] Reduced tillage also increases the organic matter and decreases the loss of carbon from the soil. By retaining carbon in the soil, global warming caused by the release of carbon dioxide from the soil is lessened.[33]

2.22 The NSW Farmers' Association claimed that GMOs provide the only means by which crop yields can be increased while reducing the chemical dependence of agriculture.[34] Novartis had a similar view; it commented that:

> Genetically modified crops … are a crucial tool through which we are trying to reduce the reliance of agriculture on non-sustainable resources (such as the inefficient use of pesticides and fertilisers, and the potentially degrading effects of mechanical weeding) and replace them with biological knowledge, packaged in the seed.[35]

2.23 Another possible environmental benefit is that GM crops, through allowing more efficient use of cropped land, will reduce the pressure for land clearing, thereby maintaining native vegetation and biodiversity.[36] Furthermore, if better quality timber can be produced that is able to

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29 Organic Federation of Australia, Submission no 24, p. 5.

30 CSIRO, Submission no. 56, p. 2.

31 Centre for Weed Management Systems, Submission no. 9, p. 2; Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

32 Centre for Weed Management Systems, Submission no. 9, p. 2; Mr Brendan Doyle, Submission no. 3, p. 2; Nugrain, Submission no. 25, p. 7.

33 Centre for Weed Management Systems, Submission no. 9, p. 2.

34 NSW Farmers' Association, Submission no. 38, p. 2.

35 Novartis, Submission no. 26, p. 3.

36 Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

substitute for such substances as aluminium and concrete, great savings will be possible on energy costs and greenhouse gas emissions.[37]

Consumer benefits

2.24 Gene technology offers the possibilities of making many improvements to the plant and animal food we eat. Taste, texture, appearance, consistency, keeping qualities and nutritional value are all likely to be targeted for upgrade.[38] Of these characteristics, the most significant improvements will be to nutritional quality. Among the changes suggested in submissions to the inquiry were altered fat, protein and vitamin content, the development of designer oils and starches, the removal of allergens and the reduction of anti nutritional factors.[39]

> The technology may be able to provide nutrients that will overcome deficiencies and reduce the risk of specific diseases. Varying the structure of key molecules can lead to variations in the content, and health effects, of food. Key molecules include:
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> - natural antioxidants, which play a role in atherosclerosis and cancer
> - resistant starches, important in gut health and colon cancer
> - fatty acids, important in cardiovascular disease.[40]

2.25 Foods containing vaccines, antibodies and novel protective products are forecast.[41] Plants may be developed as 'bioreactors', producing pharmaceuticals and pharmacologically active compounds.[42] Work on pharming in animals is under way overseas, for example, producing human pharmaceuticals in milk.[43] GM animals may also become a source of organs and tissues for transplantation into humans, and serve as models for the study of human diseases.[44]

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37 Forest and Wood Products Research and Development Corporation, Submission no. 34, p. 4.

38 Australian Biotechnology Association, Submission no. 39, p. 4; CSIRO, Submission no. 56, p. 2; National Farmers' Federation, Submission no. 36, p. 4; Nugrain, Submission no. 25, p. 7.

39 Australian Biotechnology Association, Submission no. 39, p. 4; Cooperative Research Centres Association, Submission no. 40, p. 5; Grains Council of Australia, Submission no. 65, p. 9; National Farmers' Federation, Submission no. 36, p. 4; Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

40 R Head, 'The implications for nutrition', *Gene Technology and Food,* National Science & Industry Forum Report, Australian Academy of Science, April 1999, p. 8.

41 CSIRO, Submission no. 56, p. 2; Nugrain, Submission no. 25, p. 7.

42 Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

43 Pharming is the production of drugs and other medically important substances in the milk of transgenic domesticated animals.

44 O. Mayo, 'Animals', *Gene Technology and Food,* National Science & Industry Forum Report, Australian Academy of Science, April 1999, p. 5.

2.26 Plant and animal fibres, such as wool and cotton, are also being targeted for improvement.[45]

Other benefits

2.27 Food processors will benefit from gene technology with improvements to the processing characteristics of food. For example, barley with better malting qualities and changed enzyme activity is a possible development.[46] Processing may also become more efficient, productive and environmentally friendly.[47]

2.28 It will also be possible to improve pasture quality, as well as the quality of animal feed; amino acid content and digestibility could be increased and antinutritional compounds reduced.[48]

Conclusions about benefits

2.29 The committee is aware that crops with improved input traits (herbicide tolerance, and insecticide and virus resistance) have so far dominated the market. Improved output (consumer) traits are yet to be widely seen although, at the time of writing its submission in June 1999, Nugrain expected that modified oils would be on the market soon.[49] Furthermore, Novartis suggested that, in the second half of the next decade, the focus for gene technology will be on products offering a direct benefit to the consumer.[50]

2.30 The committee recognises that the benefits of using GMOs in agriculture are not yet widely apparent. As Nugrain pointed out, 'a feature of many new technologies is often the long time lag between their initial emergence and their measurable impact'. Evidence of the benefits that are expected in areas such as improved health and life expectancy will take some time to accumulate.[51]

2.31 In addition, early projections of gains from biotechnology have been 'overly enthusiastic'.[52] A case in point is provided by Bt cotton crops in

45 Cooperative Research Centre for Premium Quality Wool, Submission no. 52, p. 1.

46 Nugrain, Submission no. 25, p. 7; Western Australian State Agricultural Biotechnology Centre, Submission no. 10, p. 1.

47 Australian Food and Grocery Council, Submission no. 59, p. 4.

48 Ag-Seed Research, Submission no. 31, p. 7; Cooperative Research Centres Association, Submission no. 40, p. 5; The Veterinary Manufacturers and Distributors Association, submission no. 76, p. 7.

49 Nugrain, Submission no. 25, p. 8.

50 Novartis, Submission no. 26, p. 4.

51 Nugrain, Submission no. 25, p. 7.

52 Nugrain, Submission no. 25, p. 7.

Australia, as detailed in Box 2.1. A number of other problems have been identified or foreseen in the use of GMOs, as discussed in the next section of this chapter.

Box 2.1 Bt cotton in Australia: have the gains been as great as expected?

Recent reports have shown that the Bt cotton grown in Australia (Ingard®) requires 40-50 per cent less pesticides than conventional crops and, on average, costs $91 less per hectare to produce. Ingard® cotton crop sites contain more beneficial predators and parasites, and are less harmful to the surrounding environment than conventional crops.

However, the success of Ingard® cotton in Australia varies within and between fields, farms, regions, varieties, and seasons. This variability cannot be fully explained. Evidence on cost effectiveness is not clear, and may depend on the success of the crop. A recent report has shown that some Ingard® cotton crops have cost Australian farmers up to $1200 per hectare to produce while others gained an overall profit of $850 per hectare.

While Bt cotton requires less pesticide than conventional cotton, there is some evidence that pesticide applications are increasing. US laboratory studies indicate pest resistance to Bt cotton may be developing five to ten times faster than expected, and the Cotton Research and Development Corporation has found that Bt cotton is not as effective against Australian *Helicoverpa spp.* as it is against American species.

Source: Cotton Research and Development Corporation, Submission no. 27, p. 4; T Long, Report on the Economic Performance of Ingard Cotton for the 1998-99 Season, 1999, p. 9.

Risks and disadvantages

2.32 Several submissions to the inquiry warned of the risks attached to using GMOs. The risks identified were seen as impacting on the environment, health, social and economic conditions, and the developing countries. There are also ethical concerns surrounding the use of genetic manipulation, particularly transgenesis.

2.33 At the root of many of the concerns is the nature of gene technology. The claim that it is a precise process for which the outcomes can be predicted has been questioned. In a statement issued in April 1999, a group of scientists from a number of different countries expressed the view that:

> The technology is driven by an outmoded, genetic determinist science that supposes organisms are determined simply by

> constant, unchanging genes that can be arbitrarily manipulated to serve our needs; whereas scientific findings accumulated over the past twenty years have invalidated every assumption of genetic determinism. The new genetics is compelling us to an ecological, holistic perspective, especially where genes are concerned. The genes are not constant and unchanging, but fluid and dynamic, responding to the physiology of the organism and the external environment, and require a stable, balanced ecology to maintain stability.[53]

Environmental impacts

2.34 A number of negative environmental impacts from using GMOs were raised with the committee during the inquiry. These impacts are summarised in Box 2.2.

2.35 In the view of critics of the use of gene technology such as the Australian GeneEthics Network (AGN), these impacts will add to all the other destructive influences visited on the environment by modern industrial, chemical farming. They will contribute to ecosystem disruption and species extinction, and cause genetic and further chemical pollution.[54]

2.36 Boxes 2.3 and 2.4 examine the risks that have been identified from herbicide tolerant crops and Bt cotton grown in Australia, and detail the measures that have been developed to minimise these risks.

2.37 The committee recognises, as CSIRO pointed out that:

> There are still many unanswered questions about ecological impacts of current GMO technologies, an example being the impact of Bt cotton trash on soil micro organisms. These questions need to be addressed to assuage possible community concerns. A case in point was the laboratory finding of mortality of Monarch butterfly larvae being fed pollen of Bt corn, reported in *Nature* in May [1999].[55]

53 'World scientists' statement: Calling for a moratorium on GM crops and ban on patents', Quoted by the Natural Law Party, Submission no. 45, p. 7. This statement was issued during the 1999 meeting on the UN Convention on Biodiversity held in Cartegena, Columbia to consider the Biosafety Protocol. It was issued by 125 scientists from 24 different countries; the number of signatories had risen to 310 scientists from 36 countries by 18 April 2000 (Institute of Science in Society, http://www.i-sis.org, accessed 31 May 2000).

54 Australian GeneEthics Network, Submission no. 71, pp. 4, 6.

55 CSIRO, Submission no. 56, pp. 6-7.

Box 2.2 Summary of negative environmental impacts of GM crops mentioned in submissions to the inquiry

- Herbicide tolerant GM plants allow more extensive use of herbicides than is possible with conventional varieties. This is already happening and may contribute to a loss of diversity among all forms of life on the land, and in water and soil near the GM plants.
- Herbicide tolerant crop plants are more likely to escape into the wild.
- Pollen drift from herbicide tolerant crops to related wild species, for example of canola, could result in the development of 'super weeds'; this has already happened in a limited number of cases.
- Bt is present all the time in GM crops compared with its more occasional presence when used as a spray; it is feared that the continuous presence of the pesticide will lead to a more rapid build up of pest resistance and greater damage to non target and beneficial insects.
- If crop plants are developed that are better suited to marginal agricultural environments, further clearing of native vegetation and losses of biodiversity may occur.
- If terminator technology were to be used, terminator genes might be spread to other organisms and cause species extinction.
- GM crops are grown, like other modern crops, as monocultures. Monocultures are fragile, unstable and the antithesis of sustainability because they are extractive and rely on intensive, expensive inputs.

Source: *Australian GeneEthics Network, Submission no. 71, pp. 4-5, 6; Go Mark Food Systems, Submission no. 33, p. 12; Heritage Seed Curators Australia, Submission no. 30, pp. 5-6; Mr Arnold Ward, Submission no. 41, pp. 6, 11-12, 17-18; National Genetic Awareness Alliance, Submission no. 54, p. 5; Organic Federation of Australia, Submission no. 24, p. 3; Supplementary submission no. 73, pp. 1-2.*

Box 2.3 Environmental risks of growing herbicide tolerant crops in Australia

There are a number of environmental issues arising from the use of herbicide tolerant crops, none of which are exclusive to GM varieties. The environmental impacts of both GM and conventionally bred herbicide tolerant crops are similar, and with both the impacts may not be realised for a long period of time.

Overuse or misuse of herbicides on herbicide tolerant crops can have a number of environmental effects:

- weed species may develop resistance and become 'superweeds', which might only be controlled with potentially harmful herbicides;
- plants which were previously not significant weed species may become new or worse weeds; and
- the environment may be exposed to greater amounts of harmful chemicals, therefore increasing loss of biodiversity in the surrounding region.

In addition, herbicide tolerant crops may become weedy in other agricultural systems or non-farming areas.

Integrated Weed Management reduces reliance on herbicides and so reduces the risk of the above impacts. It must be coupled with early detection of herbicide tolerant weeds to more effectively manage and minimise potential negative impacts.

Another way in which herbicide tolerant crops may impact on the environment is through cross pollination with closely related species. If the trait for herbicide tolerance is transferred to wild populations, it may promote the development of weediness in those species.

Concerns about the spread of GM material from GM to non GM crops by cross pollination have been addressed by the Genetic Manipulation Advisory Committee (GMAC) through establishing buffer zones around GM crops to minimise this risk. While the extent of buffer zones around a GM crop is determined on a case by case basis, buffer zones around GM canola crops are generally 400 metres. However, a report released last year by the John Innes Centre in the UK found that pollen from GM canola crops can be carried up to 15 km by bees and 160 km by wind.

Source: Australian GeneEthics Network, Supplementary submission no. 85, p. 4; Environment Australia, Submission no. 82, p. 12 and attachment B; National Association for Sustainable Agriculture, Submission no. 74, p. 1.

Box 2.4 Environmental risks of growing Bt cotton in Australia

Concerns have been raised about the possibility of Bt cotton cross-pollinating with conventional cotton or with similar species in the wild. However, research by the CSIRO has shown that a genetic block prevents the transfer of genes from agricultural cotton to similar wild species. Additionally, cotton is naturally self-pollinating, and the possibility of outcrossing to other areas is minimal.

Pest insects can develop resistance to the Bt gene, which may cause unforeseen consequences to the surrounding natural environment. GMAC and the National Registration Authority (NRA) have developed a refuge strategy, which recommends that no more than 30 per cent of a crop be planted with Bt cotton. The interbreeding of resistant and susceptible pests slows the development of resistance.

The effects of Bt cotton on non-target insects, birds and mammals in the surrounding natural environment are not fully known, and may have an adverse effect on regional biodiversity. Researchers in Europe and the USA have recently shown that the Bt gene has the potential to affect at least two insect species apart from the target species.

Other environmental concerns include:

- the build-up of Bt endotoxins in the surrounding soil;
- the possible build-up of Bt in the food chain;
- possible gene transfer and recombination, creating new pathogenic organisms and biological changes to non-target species; and
- effects on neighbouring farms that grow crops with similar pest complexes.

While a number of submissions recognise these concerns, little information has been provided to the committee on measures developed to minimise possible risks associated with these other concerns.

Source: Australian GeneEthics Network, Supplementary submission no. 85, pp. 5-6 and attachment 3; Transcript of evidence, 18 October, 1999, pp. 201, 203, 210; CSIRO, http://genetech.csiro.au/debate.htm, accessed 5 May 2000; Submission no. 56, p. 6.

2.38 According to Environment Australia (EA):

> The novelty of GMOs, the fact they will continue to reproduce after release, the complexity of natural environments and ecosystem processes, and the unknown evolutionary fate of

> inserted genes, all contribute to the difficulties of predicting environmental impacts.[56]

In addition, 'any long-term adverse environmental effects of GMOs may not be known or detected for many years, decades, centuries, or much longer (for example, on evolutionary timescales)'.[57]

Health impacts

2.39 Several concerns were expressed to the committee about the health impacts of consuming GM foods. The points put forward are summarised below.[58]

- Allergies to soybeans are reported to have increased in the UK since the introduction of soybeans from GM varieties.
- It is feared that antibiotic resistant marker genes, which are used in conjunction with other genes to track the transfer of the latter from one organism to another, might be transferred to bacteria that cause serious disease. Similarly, virus particles inserted to confer virus resistance may undergo recombination with others in the environment or in the alimentary tract and produce new pathogens.
- With herbicide tolerant crops, increased use of herbicides is possible; some herbicides, such as glyphosate, are known to have adverse effects on human health. Glyphosate also changes the oestrogen content of soy beans.

2.40 Some aspects of the system for testing the safety of food were queried in submissions to the inquiry. The testing of GM food for safety relies on establishing whether it is substantially equivalent to its conventional counterpart. If it is, no further tests are necessary. Only substantially different foods are exhaustively tested. The use of substantial equivalence as the basis for a test of safety was queried during the inquiry. Doubts have also been cast on the accuracy of substantial equivalence tests, for example those carried out with GM soybeans.[59] It is claimed that some of the testing carried out has been very scant.[60]

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56 Environment Australia, Submission no. 82, p. 2.

57 Environment Australia, Submission no. 82, p. 18.

58 Australian GeneEthics Network, Submission no. 71, p. 5; Heritage Seed Curators Australia, Submission no. 30, p. 8; Mr Robert Anderson (member of the Physicians and Scientists for Responsible Application of Science and Technology), Submission no. 4, Attachment pp. 1- 3; Mr Arnold Ward, Submission no. 41, pp. 12-13; National Association for Sustainable Agriculture, Submission no. 74, pp. 3-4; Organic Federation of Australia, Submission no. 24, p. 4.

59 Natural Law Party, Submission no. 45, p. 11.

60 Organic Federation of Australia, Submission no. 24, p. 4.

2.41 Two recent reports have examined the health impacts of GM foods and found no major safety concerns with their use. The US National Research Council, the research arm of the National Academy of Sciences, reached this conclusion for foods derived from pest resistant GM crops.[61] Four hundred participants at an OECD conference agreed unanimously that 'no peer-reviewed scientific article has yet appeared which reports adverse effects on human health as a consequence of eating GM food'.[62]

2.42 Attention is also being paid to the methods used to assess food safety; the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) will shortly hold a meeting to evaluate the appropriateness of current approaches to food testing, which were established in international meetings held about 10 years ago.

Social and economic impacts

2.43 One of the criticisms made of GM crops is the failure of the promise of higher yields to materialise on a number of occasions. Dr Charles Benbrook, for example, reported inferior performance for GM soybeans grown in trials in the USA.[63] In the case of Ingard® cotton grown in Australia, the results of trials on small plots were not always parallelled when larger acreages were grown (Box 2.1). Furthermore, substantial GM crop failures have occurred occasionally in the USA, for example with Bt and Roundup Ready cotton. Information provided to the committee suggested that some of these crop failures may have resulted from insufficient testing of new varieties before they were released on to the market and inadequate understanding of crop physiology and ecology.[64]

2.44 A report to ABARE's Outlook 2000 conference commented on the fact that agronomic and profit performances of some GM crops 'contrast somewhat with the rapid adoption rates'. It drew attention to several reviews that concluded that the yields and input use of GM crops have been:

> … somewhat mixed with the herbicide tolerant crops but generally favourable with insect resistant ones. The profit performances of

61 Committee on Genetically Modified Pest-Protected Plants, Board on Agriculture and Natural Resources, National Research Council, *Genetically Modified Pest-Protected Plants: Science and Regulation*, National Academy Press, Washington DC, 2000, p. 9.

62 *GM Food Safety: Facts, Uncertainties, and Assessments: Rapporteurs' Summary*, The OECD Edinburgh Conference on the Scientific and Health Aspects of Genetically Modified Foods, March 2000, p. 2.

63 C Benbrook, *Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998*, Ag BioTech InfoNet Technical Paper no. 1, July 1999, p. 1. Dr Benbrook is a consultant on environmental, food safety and pest management issues. His paper reports the results of over 8,200 university based soybean varietal trials carried out in the US.

64 Mr Arnold Ward, Submission no. 41, pp. 13-16.

these crops are even more mixed once the fees that are payable to the owners of these technologies (through seed costs) are taken into account.[65]

2.45 While GM crops may produce lower yields compared with their conventional counterparts,[66] this must be considered in the context of growers' outgoings on other farming inputs, such as control chemicals, which may be reduced.[67] Some growers prefer to use GM crops even if there is no financial benefit to them, because of the environmental benefits.

2.46 Another drawback to using gene technology in agriculture is its likely impact on farm incomes and rural communities. Biotechnology is seen as the latest driver in the industrialisation of agriculture, which has led to falling prices for agricultural products and has squeezed farmers off the land. It is feared that the use of GMOs will further exacerbate these trends.[68] So too might the dominance of a few multinational companies over key gene technologies which gives them the capacity to extract premium prices for GMOs. This issue is discussed further in Chapter 5. Monopoly control of GM crops will also continue the world wide trend of decreasing agricultural biodiversity and reduce the genetic stores from which future crop varieties might be developed.[69]

2.47 News that Monsanto had started work on a 'terminator gene', which will prevent GM plants from producing viable seeds, has also been widely discussed. Saving the seed from one harvest to plant for the next is a farming practice of great antiquity. It will be stopped by the terminator gene and farmers will be forced to purchase new seed each season. Although Monsanto has indicated that it has no intention of using terminator technology in its seed, serious fears have been expressed about the impact of such a system on farmers, especially in the developing world.[70] As discussed in Chapter 6, there is an alternative to using terminator technology to protect the IP in GM varieties without producing non viable seed.

2.48 Another economic influence feared from the introduction of GM crops is the spread of introduced genes into organic or non GM crops growing nearby. For farmers who wish to certify their produce as not containing

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65 M Foster, 'Market implications: genetically modified crops', *OUTLOOK 2000*, ABARE, Canberra, 2000, p. 184.

66 J Grellman, Transcript of evidence, 18 October 1999, p. 204; Mr Wayne Hancock, Submission no. 6, Attachment pp. 139-40.

67 T Long, *Report on the Economic Performance of Ingard Cotton for the 1998-99 Season, 1999*, p. 6.

68 Heritage Seed Curators Australia, Submission no. 30, p. 10; Mr Alan Griffiths, Submission no. 22, p. 3; Organic Federation of Australia, Submission no. 24, p. 4.

69 Australian GeneEthics Network, Submission no. 71, p. 4.

70 National Association of Sustainable Agriculture Australia, Submission no. 74, p. 3.

any foreign genetic material, GM crops represent a serious threat to their economic future.[71] Organic farmers may also suffer if pest resistance to Bt increases.

> … a spray of last resort to organic farmers, that of Bt, is under threat as resistance will be encouraged by wide spread plantings of Bt crops. Early studies in the US are showing that this fear is being realised.[72]

Avoiding and controlling risks

2.49 There are varying views on how these risks and disadvantages should be addressed. At one extreme in the range of attitudes on this subject is the view that there is a very good chance that few of the risks will eventuate and, if they do, they probably can, and will, be addressed. Others are less sanguine about the outcome of using GMOs in agriculture. At least some of the untoward consequences of releasing GMOs into the environment are likely to be irreversible.[73] In so far as GMOs are capable of self replication, it may be difficult to recapture them once they have been released.

2.50 Several submissions to the inquiry took the more alarmist view of the impact of GMOs. They pointed out that time is needed to observe what their long term health and environmental effects will be.[74] As a British report on GM food observed, 'there are all sorts of things that we don't know that we don't know'. Under these circumstances, it is appropriate to invoke the precautionary principle.[75] This principle states, that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation.

2.51 A moratorium on the growing of GM crops was proposed by several organisations.[76] It was suggested that the moratorium should continue for anything from five to 20-50 years, to allow adequate research to be carried out on health and environmental impacts.[77] In addition, consensus should

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71 Organic Federation of Australia, Submission no. 24, p. 6; Supplementary submission no. 73, p. 1.

72 Organic Federation of Australia, Submission no. 24, p. 3.

73 British Medical Association, *The Impact of Genetic Modification on Agriculture, Food and Health: An Interim Statement*, May 1999, p. 12.

74 Ms Lyssa, Submission no. 5, p. 1; Organic Federation of Australia, Submission no. 24, p. 3.

75 *The Politics of GM Food: Risk, Science & Public Trust,* Economic & Social Research Council, Special Briefing No. 5, October 1999, p. 5.

76 For example, the Public Health Association of Australia, Submission no. 57, p. 1.

77 Heritage Seed Curators Australia, Submission no. 30, p. 1; National Genetic Awareness Alliance, Submission no. 54, p. 1; Organic Federation of Australia, Submission no. 24, p. 4.

be obtained among scientific and health professionals on the safety of GMO use before they are released.[78] The National Genetic Awareness Alliance also suggested an assessment of the social and economic impact of gene technology on primary producers.[79]

2.52 In connection with the proposals outlined in the last paragraph, the committee's attention was drawn to recommendations on GMOs made by the British Medical Association (BMA) and by 125 world scientists from 24 countries. These groups took a cautious approach, calling for a 'moratorium on further environmental releases of transgenic crops, food and animal-feed products for at least 5 years'.[80] The BMA also believed that 'any conclusion upon the safety of introducing GM materials into the UK is premature as there is insufficient evidence to inform the decision making process at present'.[81] The Australian Medical Association also considered that 'the jury is still out on the benefits and risks of GM foods on public health and the environment'.[82]

2.53 In 1998, the Royal Society (London) reported its view of further work that it deemed necessary to ensure the safety of GM crops. It warned that the impacts of GM plants should not be considered in isolation, but should be judged in comparison with the impact of managing conventional crops. The recommendations it made included:

- monitoring for the transfer of genes from GM crops to wild relatives and non GM crops;
- review of the recommended isolation distances for plantings of GM crops and other methods of minimising gene transfer;
- replacement of antibiotic resistant gene markers by alternatives and, until alternatives are available, the removal of the marker at an early stage in the development of the GM variety;
- work on the impact of pest resistant plants on beneficial insects, the development of resistance among target insects, and methods of minimising these risks;
- monitoring the impact of greater herbicide use with herbicide tolerant crops;

78 Go Mark Food Systems, Submission no. 33, p. 3.

79 National Genetic Awareness Alliance, Submission no. 54, p. 2.

80 'World scientists' statement calling for a moratorium on GM crops and ban on patents', Quoted by the Natural Law Party, Submission no. 45, p. 6.

81 British Medical Association, *The Impact of Genetic Modification on Agriculture, Food and Health: An Interim Statement*, May 1999, p. 2.

82 Australian Medical Association, 'Ministers' decision positive but: the AMA will be vigilant on details', Media release, 4 August 1999.

- research on virus resistant plants;
- research on the need for long term feeding studies designed test for allergenicity and toxicity; and
- the provision of advice to growers about crop management and rotation.[83]

2.54 According to the BMA, there is also a need to considerably strengthen disease surveillance systems 'to deal with the potential emergence of new diseases associated with GM material which will be obscure and difficult to diagnose'.[84]

Ethical concerns

2.55 Disquiet about the use of gene technology in agriculture reflects in part people's reaction to the new and unexpected and their coming to terms with its implications for how they and their society live. One of the main concerns centres on the perceived unnaturalness of genetic engineering which involves transferring genes between species that do not normally interbreed, particularly when human genes are involved. Such processes are seen by some as violating fundamental natural processes. Heritage Seed Curators Australia (HSCA) drew the committee's attention to HRH Prince Charles' statement that these activities should not be meddled with; they should be left to God.[85]

2.56 The committee is aware that this viewpoint has been challenged by others. For example, Richard Dworkin asked what was wrong with 'playing God' if it enabled us to resist natural catastrophes.[86] Others, such as the Nuffield Council on Bioethics, have suggested that it would, in fact, be unethical not to develop GMOs if they will contribute to alleviating world hunger.[87]

2.57 In addition, from a scientific point of view, the outcomes of genetic manipulation may seem no stranger than naturally occurring phenomena. For example:

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83 The Royal Society, 'Genetically modified plants for food use', 1998, http://www.royalsoc.ac.uk/st_pol40.htm, accessed 12 July 1999.

84 British Medical Association, *The Impact of Genetic Modification on Agriculture, Food and Health: An Interim Statement*, May 1999, p. 13.

85 Heritage Seed Curators Australia, Submission no. 30, p. 4.

86 R Dworkin, 'Playing God', *Prospect*, no. 41, May 1999, p. 40.

87 *Genetically Modified Crops: The Ethical and Social Issues*, Nuffield Council on Bioethics, London, May 1999, p. xv.

> Plants can make haemoglobin, which is usually seen as an animal product. The deep sea dragonfish can make chlorophyll, which is usually associated with green plants. Nature is pretty good at moving genes around and recycling them around. There is nothing that we can do which matches what nature has already done.[88]

The Academy of Science commented that 'it is virtually impossible to decide what is "natural" and what is not after some 10,000 years of plant and animal improvement by humans'.[89]

2.58 HSCA claimed that 'the moral and ethical aspects of developing and using this technology have not been examined at all' and pointed out that 'it is important to consider whether the development of GE organisms offends the religious & moral sensitivities of Australian people'.[90] The consensus conference on gene technology in the food chain held in March 1999 recommended the inclusion of an ethicist in the formulation of major decisions regarding GMO policies.[91] In the drafting of the Gene Technology Bill, this point was recognised and an ethics committee is proposed to advise the ministerial council overseeing the operation of the Office of the Gene Technology Regulator (OGTR).

Conclusions

2.59 The committee is of the opinion that applying gene technology to agriculture can benefit farmers, consumers and the Australian environment and economy.

2.60 The committee realises that there is a range of GMOs; their differing biological characteristics mean that each class of GMO presents a different type and level of risk. It is therefore appropriate that each GMO is considered for use in the light of its own particular characteristics. The risks presented by some may justify a moratorium on them until their nature is better understood, and others can be considered for release promptly. The committee does not believe that there is a case for a complete moratorium on all GMOs. The important point is that each GMO

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88 O. Mayo, 'Animals', *Gene Technology and Food,* National Science & Industry Forum Report, Australian Academy of Science, April 1999, p. 5.

89 Australian Academy of Science, Submission no. 62, p. 1.

90 Heritage Seed Curators Australia, Submission no. 30, pp. 1, 4.

91 *First Australian Consensus Conference: Gene Technology in the Food Chain: Lay Panel Report,* Canberra, March 1999, p. 6.

is examined with care before being used. This matter is discussed further in Chapter 7.

2.61 In the early stages of the development and use of any new technology, the extent and nature of the benefits and risks are not fully known and can only be guessed at. It may be that the AFGC will be proved right in judging that the controlled use of biotechnology 'does not introduce new or additional unmanageable risk factors'.[92] Others, however, are not so sure.

2.62 It is only through extended use and careful monitoring that benefits and risks can be accurately gauged and consensus established on the appropriateness of the technology's use. Until then, extreme claims about the positive and negative aspects of the technology cannot be countered adequately. These claims can, however, help to drive the process of assessing the benefits and risks. The committee considers that the use of gene technology in agriculture is currently at the stage of needing much more work before the benefits and risks of using GMOs are well established. Only then will the best means of maximising benefits and avoiding or minimising risks be better understood.

2.63 The committee is aware that:

- environmental research is carried out by applicants before applying to regulatory bodies for the use and release of GMOs; and
- successful applicants may be required to monitor and report on environmental impacts after commercial release of GMOs.

GM foods that are substantially different from their conventional counterparts also undergo extensive examination before being approved for sale.

2.64 In addition to this research that is specific to the particular GMO under consideration, more general work may also be needed. The committee is aware that CSIRO is developing a multidisciplinary project to provide information and models that will help to understand the effects of GMOs at the landscape scale and their implications for farm management practices. This work will identify the best means of assessing risks and feed into the decision making of regulators.

2.65 ABARE staff have made the economic assessments of GMO crop prospects for Australia which were referred to earlier in this chapter. Consumer reaction will impact on acceptance of GM products and needs to be researched. In this context, AGN recommended a 'full economic

92 Australian Food and Grocery Council, Submission no. 59, p. 5.

assessment of the potential benefits and costs to Australian producers and the whole nation, of a variety of production options'.[93]

2.66 The committee is convinced that research as described above is essential. It believes that more is needed to better establish the nature and extent of the health, environmental and economic benefits and risks posed by agricultural GMOs and their development and options for addressing them. While it is appropriate for those who wish to use GMOs to fund some of this research, there may be occasions, for example, as discussed in Chapter 7, when more fundamental research is required and government funding is appropriate. It is important, with the current level of concern about the safety of GMOs that government is seen to be actively pursuing the public interest by supporting research into, and assessment and management of, the benefits and risks associated with their use.

Recommendation 1

2.67 **The committee recommends the continued use of gene technology, but only with stringent regulation, constant and cautious monitoring, and public reporting.**

Recommendation 2

2.68 **The committee recommends that the Commonwealth government increase funding for research into the potential benefits and risks (environmental, health, social, economic and ethical) presented by genetically modified organisms.**

2.69 The committee envisages that this research and monitoring will be carried out, or commissioned by agencies such as the Australia New Zealand Food Authority (ANZFA), CSIRO, EA, the OGTR and the National Registration Authority (NRA). For example, one of the functions of the Gene Technology Regulator (GTR) is to commission research into risk assessment. The committee believes that suggestions about research topics should be sourced more widely than simply from scientists and public servants within these organisations.

93 Australian GeneEthics Network, Submission no. 71, p. 6.

2.70 As some of the points raised in earlier sections of this chapter have demonstrated, there are concerns to understand how gene technology fits into a broader context. At one level, it is important to see gene technology as just one of the approaches that will contribute to an efficient, sustainable agricultural sector. Avcare, for example, emphasised that, 'in addition to gene technology, conventional breeding, traditional pest control methods, prescription farming and permaculture approaches will all contribute to produce the best outcome for Australia's primary producers'.[94]

2.71 The committee is aware that very large sums of money have been directed towards gene technology both in Australia and overseas. It is concerned that this funding does not crowd out assistance for other approaches to improving agricultural and environmental sustainability.

Recommendation 3

2.72 **The committee recommends that the Commonwealth government ensure that funding for research into improving agricultural productivity and sustainability is allocated equitably across all areas of research.**

2.73 Others have suggested taking an even wider view to assessing where gene technology fits in. The ultimate concern is for rural sustainability that includes protecting employment, communities and the environment.[95] The challenge is to establish the role that gene technology has in this vision.

94 Avcare, Submission no. 61, p. 4.

95 *The Politics of GM Food: Risk, Science & Public Trust*, Economic & Social Research Council, Special Briefing No. 5, October 1999, p. 16.