New Zealand Nuffield
Farming Scholarship Trust.

To GE or Not to GE?
New Zealand's Dilemma

Report by
Adrian Gault

Tablelands Road, R.D.1, Opotiki
New Zealand
2001

Executive Summary

The purpose of this report is to comment on the debate and issues surrounding the Genetic Engineering (GE) debate in relationship to whether New Zealand should allow the use of GE technology or not.

In determining whether New Zealand should allow the use of GE, this report looked at some of the issues impacting on New Zealand agriculture. The report identifies the fact that the New Zealand economy has a dependence on the agricultural sector and that that sector is very vulnerable. This report recommends that New Zealand agriculture needs to form stronger lobby groups, enhance agriculture's image through positive promotion, and encourage New Zealand agriculture and its associated industries to invest more resources into research and development. These recommendations are suggested to counteract and restrict the increased compliance cost imposed on New Zealand, created through urbanisation and the shift of political power to the urban voter, to improve the understanding and profile of agriculture and to ensure that New Zealand Agriculture maintains its comparative advantage.

Before the completion of this report, the Royal Commission on Genetic Modification released its findings. This report supports the Royal Commissions findings, to the precautionary use of GE technology. It also recommends that New Zealand Agriculture and its associated industries continue to lobby for the right to use GE as a means of maintaining its comparative advantage in the international marketplace and as a tool to enhance the environmental sustainability of agriculture.

Table of Contents

1.Introduction

The New Zealand Nuffield Farming Scholarship Trust provided the opportunity to research the debate and issues surrounding Genetic Engineering (GE). I endeavoured to keep an open mind regarding the debate about whether New Zealand should embrace GE or remain GE free.
I, like the majority of New Zealanders, knew very little about GE. What the technology involves? What are the potential benefits derived from this new technology and what are the potential risks? Without that type of information I could not make an informed decision, nor could I debate one way or the other.

As part of the Nuffield experience, the scholars from New Zealand and Australia were taken on a two-week study tour of Singapore, Malaysia and Thailand. We were then joined by scholars from France, Canada, and Zimbabwe and were provided with a further three week briefing tour of the United Kingdom (UK), Brussels and France. These tours involved meetings with farming leaders, politicians, consultants and management of leading agricultural industries and numerous visits to agricultural enterprises.

These tours, along with the three months researching as an individual scholar in the UK, United States of America and Canada, has provided sufficient information to come to some conclusions regarding the GE debate. It also highlighted several areas outside the GE debate that New Zealand agriculture needs to address.
This report offers several recommendations derived from those conclusions.

2. Conclusions

2.1 New Zealand Agriculture and its associated industries are coming under increasing pressure and restriction from legislative processes and compliance cost. These factors are removing the ability of New Zealand Agriculture to remain internationally competitive. Urbanisation has shifted the political voice away from the rural sector making it more difficult for agriculture to gain sufficient lobby weight to achieve a favourable outcome or minimize the impact of imposed governance.

2.2 Urbanisation has removed the majority of the world's population from Agriculture. Increasingly more people have no knowledge of agriculture or the production of food. Agriculture has also been saddled with a poor reputation. Often portrayed as an "environmental badboy", an industry that delivers low financial returns, and one not as "sexy" as a life in a suit and fast car, has, created a negative response by the public to Agriculture and has created a shortage of qualified, skilled and motivated workers within Agriculture.

2.3 New Zealand's agricultural competitors are catching us up. This has occurred because many of our competitors do not face the same levels of legislation or compliance cost that our industry incurs. Secondly, many countries are applying science and technology by means of investment into research and development to close the distance in international competitiveness.

2.4 Genetic Engineering has the potential to enhance on-farm productivity, improve our environment and help us develop new products and improve existing products. However there are some

risks, particularly in that there has been insufficient research into the long-term impact of GE in the food chain and in the environment in general.

New Zealand has some of the most stringent rules and regulations in the world that oversees the approval process relating to GE.

New Zealand relies on agricultural exports to underpin its economy. Agriculture exports must remain internationally competitive. To do this New Zealand farmers need to have the "tools" to keep our industries competitive. GE is one of those tools our industries could explore and utilize to remain competitive.

2.5 New Zealand Agriculture and it's associated industries must undertake comprehensive market research to ascertain the impact of GE in the food chain on consumer perception . Currently in many markets New Zealand's "Clean green image" it's "100% Pure New Zealand" and it's "Natural" images and sales pitches are very successful. GE could alter that perception and give valuable market share to our competitors. Market research will be a key factor to determine whether consumer perception has shifted sufficiently to ensure there is no negative response to GE food production.

3. Recommendations

That;

3.1 New Zealand Agriculture and especially the grassroots farmer need to strengthen their political lobby in order to maintain an internationally competitive industry. Agriculture needs to encourage and promote it's members to work together to form stronger lobby groups and promote it's members to stand for election to District and Regional councils, and also National politics.

3.2 New Zealand Agriculture needs to promote itself more effectively, to ensure a better understanding by the public and also to attract and retain the skilled people required to develop the industry.

3.3 New Zealand Agriculture needs to invest heavily into Research and Development and continue that investment into the future.
Technology, in particular Biotechnology will provide New Zealand Agriculture and its associated industries with the ability to develop new products and create improved and alternative value chains.

3.4 New Zealand Agriculture and its associated industries need to lobby Government for the right to be able to use Genetic Engineering. This will enable them to have the ability to retain their competitive advantage internationally.

3.5 New Zealand Agriculture and its associated industries need to undertake extensive market research to gauge consumer reaction to GMO's in the food chain, especially in the European Union, Asean and Japanese markets. It is important not to "tarnish" New Zealand's current, very marketable "clean, green image".

4. Discussion

New Zealand Agriculture an overview

New Zealand is primarily an exporting nation. New Zealand's economy is underpinned by being able to sell agriculture produce for foreign currency. Approximately 60-70% of New Zealand's overseas earnings are derived from agriculture and its associated industries. New Zealand's major markets tend to be the heavily populated developed Northern Hemisphere countries, particularly in Europe and USA and in the Southern Hemisphere, Australia, however the developing Asean countries are becoming increasingly more important.
New Zealand's competitive edge has been created through a forgiving climate, its comparatively low cost grass-feed pastoral systems, coupled with high quality assurance standards, and a "free market" (unsubsidised) economy. The free market policy adopted by New Zealand has forced New Zealand primary producers to become more efficient. They are more attuned to the end consumers needs and have the flexibility to change and adapt to the prevailing market conditions, unlike many of their subsidised counterparts in competing countries.

4.1 New Zealand's Vulnerability

The New Zealand agricultural sector and ultimately the whole New Zealand economy are very vulnerable due to its dependence on agricultural exports. Changes in world agriculture commodity prices, fluctuations in exchange rates, the impact of catastrophic world events and the vagaries of foreign countries market requirements, exposes our economy to factors beyond New Zealand's control. Due to the significance of agriculture to the New Zealand economy, a decrease in agricultural returns permeates through the whole New Zealand economy.
New Zealand is also geographically removed from its highly competitive and often subsidised marketplace, a marketplace, which is changing rapidly. Changing world population demographics are altering consumer and political behaviour. Consumers are becoming more discerning, demanding better food quality, food safety and food

that is produced in an environmentally sustainable and humane fashion. However, those same consumers are not prepared to pay more for their demands and so those extra cost of compliance are generally passed on and absorbed by the industry and ultimately by the primary producer. These growing compliance costs are diminishing New Zealand Agriculture's comparative advantage.

Changing consumer and political behaviour

Two major factors that are affecting consumer and political behaviour, are the ever-increasing population size and urbanisation.
The world's population is increasing at a rate of 250,000 people per day. The Population Reference Bureau projects that the world's population will grow to 8.4 billion in 2025, with the largest growth occurring in Asia, the populations of the more developed countries, such as United Kingdom and USA are remaining relatively stable.
The natural resources necessary to feed these people are declining. Land area available for agriculture and fresh water are limiting factors and these resources are coming under increasing scrutiny from politicians and the public to ensure they are used in a sustainable manner. Land area for agricultural use is increasingly coming under pressure from urban sprawl and many areas around the world have been "raped" by landowners that have farmed the land unsustainably and are now unproductive. Some areas of land have been polluted through a combination of reasons, carelessness and neglect from humans and some areas by natural phenomena, e.g. increasing salinity and other climatic events. The increased demand on land and resources has brought about a change in the way consumers view and regulate the environment. This will impact directly to farming practices.

Urbanisation has been an on-going phenomenon. Today we see many cities around the world with populations over ten million. The urban drift has meant that the shift of political power has moved overwhelmingly to the urban sector. As the more developed countries economic dependence shifts away from agriculture to areas such as the service sector they become more removed from agriculture and the level of understanding of the food production process diminishes. In Europe, and especially countries that have large populations, such as

the United Kingdom, (58 million people in a country approximately the same land mass as New Zealand that has 4 million people) many of the urban people have no understanding of the processes of food delivery. They do not understand how milk gets into a bottle, or how or where the meat comes from in their Steak & Kidney pie. All they expect is that when they go to a supermarket, or corner dairy, that the food item will be there, it will be safe to consume and that it is affordable. The importance of agriculture and the basic fundamentals of agriculture as the basis of food production are no longer a core part of the education curriculum. Today children could name most of the prehistoric Dinosaurs, and yet if asked many could not name a breed of cattle or sheep.

As with all democracies, majority rules and with the political vote lying with the urban voter, rural communities can become subjected to regulations initiated by urban dwellers with little consideration of the cost or pragmatism of the regulation to the rural community or the countries economy.

In the United Kingdom (UK) for instance, the agricultural sector has imposed on it rigid environmental and animal welfare legislation. UK agriculture provides approximately 1% of GDP and employs less than 2% of the workforce (<500,000). It's political lobby is small compared to many of the urban based lobby groups such as the Royal Society of Protection of Birds (RSPB), The Royal Society of Protection from Cruelty to Animals (RSPCA) and Greenpeace that have a strong financial base created through a large predominantly urban membership. Increasingly, UK and the European Parliaments are imposing tougher regulations on agriculture, adding significant costs of compliance into the production system, making UK agriculture uncompetitive. In fact if it were not for the subsidies received from the European Parliament's Common Agricultural policy, many UK farmers would have "gone to the wall".

Interestingly, although the public have demanded higher environmental and animal welfare standards, and thus increasing the cost of food produced locally, they will go out and buy cheaper imported food that has been produced without the same regulation.

Dr Sean Beer, Senior lecturer in Agriculture at Bournemouth University, England suggests that "consumers are exporting their ethical problems along with rural jobs". He adds, "If consumers really are so ethical why do they consume so little organic food, free range eggs and food from free trade labels?"

The issue of "fair trade" is one that is also growing in stature. This comes about due to competing countries not having to comply to the same regulation and/or working conditions as the local economy. Thereby, giving a competitive edge to that country in that they can produce food and export it cheaper than the importing country can produce it. Arguing that the cheaper cost of production is that countries comparative advantage could counterbalance this argument.
The adoption of Fair Trade practices can create an additional trade barrier to exporting nations such as New Zealand. To continue to supply produce into these highly regulated markets often we are required to meet the same standards, and thus have the added compliance cost.

The Power of the Supermarkets

Increasingly, more consumers are purchasing their food through the supermarket. Over 90% of packaged food products are sold through a supermarket. However only about 50% of fresh meat & fish, fruit and vegetables and bread are bought in a supermarket although this is increasing rapidly as the food retailers amalgamate. The major structural trend in the food sector has been one of seeking economies of scale. (Hughes 2001). It has been predicted that by 2005 there will only be 6-7 major supermarket chains dominating the food retail sector. Wal-Mart, one of the USA's biggest supermarket chains has expanded into Europe. It has recently purchased ASDA on of the UK's leading supermarket chains. Another UK supermarket chains TESCO's and French supermarket giant Carrefours have expanded into Asia, in an endeavour to expand their dominance of the retail food sector. This dominance of the retail food sector exposes suppliers, such as the New Zealand producers to the power of the supermarket.
New Zealand producers need to work together to ensure they have supplier economies of scale to meet the global requirements of the multinational food companies. The rationalisation of the supply base will mean powerful supermarket food buyers will increasingly depend upon fewer dedicated suppliers. The New Zealand Dairy Industry through it's recent merger, forming the worlds 9th biggest dairy company and the Kiwifruit Industry's "single desk" marketing are good examples of industries rationalising the supply base to build supplier-power in the market place. TESCO's have already moved to

rationalize its supplier base. Previously they had 300-400 UK potato suppliers, today they prefer to deal with 3-4 suppliers. This has reduced the cost of sourcing product, through less man hours arranging produce, but also it has streamlined their purchasing operations. Similarly in the frozen lamb section, they have only one supplier, Bernard Matthews Ltd. Bernard Matthews has one of the highest brand awareness in the UK. Currently Bernard Matthews Ltd. sources all of its frozen lamb from New Zealand because of the consistency of product and the relative competitive price they have to pay for the product.

These factors further highlight the vulnerability of New Zealand Agriculture. There is a clear need for suppliers in New Zealand to work together to form strong supply bases, and to form strong horizontal and vertical strategic alliances within their value chains to remain the preferred suppliers.

4.2 The Need to Develop Strong Agricultural Lobby Groups and Promote Agriculture in New Zealand

The vulnerability of New Zealand agriculture and ultimately the New Zealand economy necessitates the need for stronger lobby groups and better representation in the political arena. Agriculture in New Zealand is coming under increasing pressure from the same type of urban lobby as the UK. Already, legislation such as the Resource Management Act has added compliance costs to our primary productive sector both in terms of time delays while gaining consent but also in the cost of administration and of obtaining consent. With environmental initiatives such as the Kyoto Protocol, (dealing with the reduction of Greenhouse gases) which if ratified could increase the cost of agriculture production. There is a need for farmers and agricultural industry to pool resources to lobby to gain positive outcomes for Agriculture.

There is also a need to encourage better rural representation at Local, Regional and Central levels of government. Urbanisation coupled with our National political voting system, Mixed Member Proportionality (MMP) has weakened rural New Zealand's political position. Under MMP, electorate size is derived on a population basis, therefore as most of the population resides in the larger centres they achieve more electorates and more politicians.

To remain competitive, agriculture must be able to gain sufficient lobby weight to achieve favourable outcomes or at least minimise the impact of imposed compliance costs.

New Zealand agriculture and its associated industries need to promote the industry in a positive manner, to ensure the public has a better understanding of agriculture and to highlight the importance of agriculture to New Zealand's economy.

Agriculture has been saddled with the image of the black singlet and gumboots brigade. Most press releases and news items portray the negative aspects of farming. Droughts, flooding, stock losses, poor returns, farm fatalities are all part of agriculture, however agriculture also has many positive aspects and these need to be highlighted more frequently to improve the image of agriculture and to increase awareness of the industry to the wider public.

Today agriculture is a highly technical and skilled profession. Science and technology has improved farmers understanding of the processes of plant and animal physiology. Farmers are able to farm more efficiently using resources in a more sustainable way than previous generations. Farmers and agricultural workers require a higher level of education and skills to operate their operations efficiently and effectively. Attracting skilled people into the agricultural workforce has been difficult due to a culmination of negative publicity of its industry, and conversely the positive lure of large salaries, flashy cars and perks of city employment.

New Zealand Agriculture and its associated industries need to attract those skilled motivated owners and employees, to ensure the future development of the industry.

4.3 The Need for Investment into Research and Development

The international marketplace is changing continuously. Consumers are demanding higher quality and better food integrity. To date New Zealand agriculture has met the challenge of the marketplace and in many instances has carved out a significant market share for good financial reward. Unfortunately, many of New Zealand's competitors have closed the gap, either through new product development, low cost production, or the adoption of new science and technology or the culmination of them all.

To maintain our competitive edge New Zealand agriculture must extend the product life cycle of its produce, create new products and values chains and add new qualities to our existing products.

Every product has its own product life cycle (PLC). See diagram below. When graphed, the PLC follows a sigmoid shaped curve. Sales develop slowly through the development stage, increasing through the growth stage, plateau out over the maturity stage, and finally declining in the death stage.

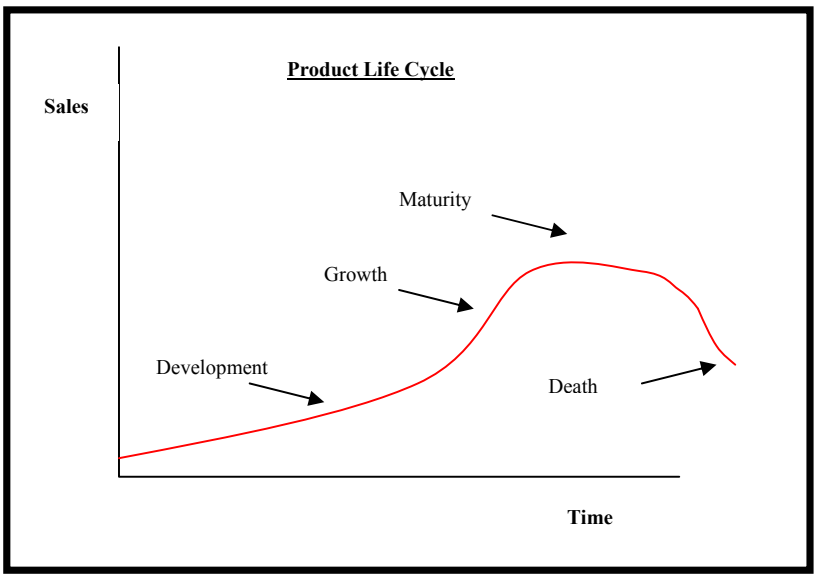


Diagram 1. Typical Product Life Cycle

The continual challenge for producers, manufacturers and retailers is to extend the Growth phase, maintain the product as long as possible in the Maturity phase and also the development of new products. This is generally achieved through marketing and advertising, which develops new markets and expands existing markets, and, by investing into research and development (R&D) which can add new product qualities, and help develop totally new products.

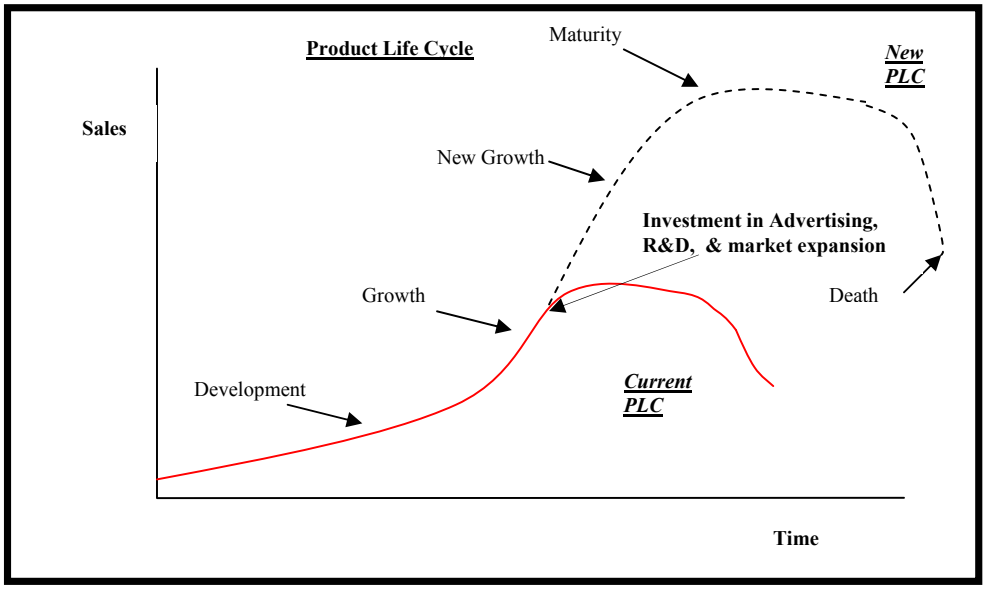


Diagram 2. The Effect of Advertising, Market Development and R&D on the PLC

By adding new qualities to products such as: health benefits –e.g reduced salt, low fat, increased fibre etc that is, catering to the growing health conscious; or medicinal benefits – healing properties; or improved food safety- longer shelf life, improved packaging, more hygienic production processes, fulfils the demands of the consumer and can re-launch a "dying" product. Like-wise the creation of totally new products from existing raw products creates new marketing opportunities.

Science and Technology has advanced dramatically over the last decade, especially in the biotechnology field, with the completion of the mapping of the human genome and the genomes of several plant species.

Investment in R&D is a fundamental requirement for the on going development and future growth of a nations economy such as New Zealand's, which is based around its biological based exports.

Surprisingly, where many of our competitors are investing more into R&D, here in New Zealand we see many instances where fewer resources are being directed towards R&D: (e.g. Reduction of Government funding available for science and research; and the reduction of the levy paid by wool growers for industry good development).

4.4 The Genetic Engineering Debate

The basis of this report is to evaluate whether New Zealand should allow the use of Genetic Engineering (GE) technology or not?

Defining the Debate

The current debate about genetic engineering in agriculture focuses on the safety of foods derived from GE crops, and the impact on the environment of these crops. The issues of the debate are: consumer confidence in the regulatory processes; perceptions of the need for the technology; ethical concerns about moving genes across species barriers; concerns over long term damage to the environment and/or human health; and business and trading issues related to consumer choice. (BBSRC, GM Agriculture in the UK)
Much of this GE debate has been polarised between the various pro- and anti- GE lobby groups. Both sides have been guilty of accusing the other of being irresponsible. With much of the debate worldwide being based around emotive rhetoric rather than a study of the facts. Leighton Jones, of the Campden and Chorely Food Research Association, England comments;

> " In the heat of the debate, it is easy to forget that DNA is and always has been, part of our daily diet. Daily, each of us consumes millions of copies of many thousands of genes. Many of these genes are fully viable at the point of consumption, and in most cases we do not know what they. We are right to take seriously the development of genetically modified foods, to debate the issues that their use raises, and to question critically the risks and benefits they present. At the same time, however, it is important to tackle these rationally and on an informed basis".

New Zealand has recently completed a Royal Commission of Enquiry into Genetic Modification. The Commission of enquiry took 14 months and cost $6.3 million and has been one of the most comprehensive studies undertaken by any country on the GE topic. Its subsequent report concluded that being GE-free, was not viable option for New Zealand and recommended that it take a cautious approach to the release of GE.

The information available on the GE debate is now freely available for public scrutiny. Today, biotechnology companies are more transparent in their operations and research than they were 2-3 years ago. There has been a realization by them that if they are to progress in this field they need to take the public with them. The Internet has also assisted this process by opening up thousands of sites for information distribution and dissemination.

Current GE Production

Cropping

Currently, about 60 GE crops have been released commercially in 12 countries. In excess of 40 million hectares of GE crops are grown throughout the world. USA and Canada account for approximately 80% of the world's GE crops (32 million ha). Other significant growers of GE crops are Argentina (6.4 million ha) and China (400,000 ha) and Australia (400,000ha).

The main crops that have been grown are corn, canola, soybeans and cotton. Many other crop species have been genetically altered and are commercially grown, potatoes, tomatoes, rice, papaya etc however these are grown in less significant volumes. Globally, approximately 25,000 field trials of GE crops have been carried out to date. Most commercial plants could utilise GE technology and in many instances research is being carried out around the globe on a wide variety of plants.

Early GE developments have been centered on the reduction of input costs for crop farmers. That is, on herbicide tolerance and pest resistance. The major reason why this occurred is that this technology was relatively simple and the company that providing this technology (Monsanto) was primarily involved in the field of herbicides and pesticides. Today, GE research has shifted focus to product quality research, as shown by the number of field trial work being carried out in the USA (see table below) in 1999 compared to the work carried out in 1996.

TRANSGENIC FIELD TRIALS					
	Year				
	1987	1990	1993	1996	1999
Herbicide tolerance	67%	22%	33%	24%	24%
Insect resistance	22	21	22	23	9
Virus resistance	11	29	16	16	--
Bacterial resistance	--	5	2	1	--
Fungal resistance	--	4	4	8	6
Agronomic properties	--	3	2	3	6
Product quality	--	8	18	17	52
Marker genes	--	3	1	3	--
Nematode resistance	--	--	<1	--	--
Other	--	6	2	5	3

Table 1. Summary of US Transgenic Field Trials

The uptake of GE crops by US farmers over the last 5 years has been quite dramatic. In 1996 approximately 5% of the total Soybean crop was GE. By 2000 in excess of 50% of the total crop is GE. The uptake of GE cotton in the US is equally impressive, from 10% of the total crop in 1996 to over 65% in 2000.

Animal Production

Although some animal GE has occurred, the main thrust of research has been at the microorganism level such as improving animal and human vaccines and in the production of a milk yield-enhancing hormone. Research involving animal GE is more contentious and receives more debate than research involving plants. This has slowed the acceptance of GE work in the animal production sector. An advance in cloning technology has added controversy to the GE debate especially to the ethical and moral issues surrounding GE.

Until a greater understanding of animals' genomes develops, and as specific genes are identified that are beneficial for improving productivity, delivering health or environmental benefits, GE technology in commercial animal production will be minimal. Much of the GE research has been based around isolating specific marker genes, to identifying those beneficial genes. Having identified the marker genes associated with the required trait, conventional breeding programmes are used to develop commercial operations. Currently there is a lot of work being carried out in several countries, trying to identify genes that control: fecundity; animal health problems such as worm

resistance, facial eczema, foot-rot; and animal production, enhanced meat quality, reduction of methane gases etc.

Much of the research being carried out in the animal production sector can be superimposed into the human health field. As most animals share similar genes and gene sequences, often-new discoveries in the animal sector can be used directly in the Human research sector.

Benefits of Using GE Technology

Despite the debate surrounding GE technology, the potential of this technology is very evident to the commercial world and also has the potential to deliver benefits to human health and the environment. Consumers could benefit through better quality, better tasting and more nutritious foods.
Farmers can benefit by, using more efficient farming methods and growing crops which impact less on the environment.
Mankind can benefit from: an improved environment; an improved food resource for impoverished nations (although many of the problems facing these nations are political problems and science could not solve them alone) and countries with extreme climatic conditions, both drought prone and colder countries; and by providing a viable method of distributing medicine via edible vaccines.

Better Food Quality and Nutritional Value

Consumers have become more discerning about food quality and safety issues due to the recent food scares which have occurred around the world and especially in Europe after the Bovine Spongiform Encephalopathy (BSE) and the Foot & Mouth disease outbreaks in the UK and Europe.
GE technology is providing benefits to the food industry by increasing shelf-life of produce, delayed ripening for improved shipping and adding beneficial traits to processed foods to improve the nutritional and health status of those foods. E.g. Tomatoes - have been modified to delay fruit ripening and

increase the shelf-life of the produce, reducing wastage: Rice - has been GE enhanced to contain enough beta-carotene to meet the daily requirements for Vitamin A. Vitamin A deficiency affects 400 million people worldwide and can lead to learning disabilities and blindness: Potatoes – GE modified to increase starch content, reducing the amount of oil absorbed during frying helping to reduce heart disease:

GE technology also has the potential of decreasing the allergenicity of food. Food allergies afflict a significant proportion of consumers. To date the only method of preventing an allergic reaction was to avoid the food causing the allergy. GE technology has provided the technology to remove the allergenic protein in such foods as peanuts.

Researchers are developing edible vaccines. These vaccines are being genetically incorporated into food and plants, as a method of delivering them to consumers. This technology would be useful and an inexpensive method of administering vaccines throughout the world and especially to developing countries that do not have the infrastructure to physically vaccinate.

Helping to protect our Environment

GE has the potential to enhance our environment. The growing world population is putting huge demands on the environment. Through pollution, the reduction of land area available for agriculture, and the increase demand for food and water.

Better farming practices coupled with improved genetic characteristics of plants and animals can assist in the conservation of our natural resources and help the sustainability of agriculture.

Agriculture is coming under increased pressure to be more environmentally friendly. Traditional agriculture can cause widespread erosion of topsoil and uses large volumes of water. GE technology has promoted the use of conservation tillage. Herbicide tolerant crops have enabled a reduction in the level of cultivation by reducing weed infestations and in some cases enabling the farmer to plant directly into old crops without cultivation. Insect tolerant crops reduce the pesticide use and increase the efficiency of the fertiliser that is applied. The reduction of pesticide use also benefits the communities living

and working in those agricultural areas by exposing those people to fewer chemicals.

Further benefits to the environment from herbicide and pesticide tolerant crops comes in the way of savings in fuel and wastes created in the manufacture, transportation and application of these chemicals. Dr Ronald Smith of Auburn University USA concluded from a study comparing conventional insecticides usage on a traditional Cotton crop, to that of a pesticide resistant Cotton crop covering 5 million acres (2 million Ha): In the manufacturing process savings would be made in terms of 3.46 million pounds of raw material, conserve 1.48 million gallons of fuel oil and eliminate 2.16 million pounds of industrial waste; in terms of savings in the transport and storage of the insecticide, 416,000 fewer gallons of insecticide would need to be transported and stored saving 604,000 gallons of fuel oil; In terms of application of insecticide the GE crop applied 1.04 million fewer pounds of insecticide in 2.5 fewer applications, requiring 416,000 insecticide containers; saving application time and conserving 2.41 million gallons of fuel and 93.7 million gallons of water needed to apply the chemical.

GE crops are also assisting in the preservation of the environment by increasing yields and by modifying plants to grow in adverse conditions such as dry areas or high salinity areas. As the need to grow more food for the growing population, more and more of the rain forest and wildlife are being removed to make way for food production. This is having an adverse affect on our climate and our environment. Through GE research, scientists have developed crops that can produce higher yields, without needing more inputs. They have also modified crops to be more drought tolerant and salt tolerant enabling countries that have adverse conditions to increase the yields of their crops and hopefully reduce the need to fell rainforests etc.

Another novel benefit that has evolved from GE technology to enhance the environment is in the development of plants for bioremediation that is the decontamination of land either naturally polluted or as a consequence of industrial contamination. Plants that can remove ionic mercury, and

degrade hydrocarbons or nitrates from soils have been developed and are being field-tested.
Although not currently commercially viable, researchers have been able to develop plants that produce high value polymeric compounds including carbohydrates (for the production of non-calorific sweeteners) and biodegradable plastic that could replace plastic derived from hydrocarbons.
Other benefits of this new technology are in the conservation of our natural flora and fauna. New Zealand has many introduced species in its native bush, which has been responsible for the reduction in numbers of many plant and animal species. The possum is one pest that has been identified as destroying flora that many natives and some endangered species survive on. To date 1080 poisoning has been the preferred method of control. However, this has also poisoned many other animals as well as the possum. GE technology has the potential to create a specific fertility suppressor that would reduce the level of possum infestation without harming other species.

Benefits to Agriculture

GE crops are assisting farmers to reduce farm-input costs and to increase yields. With the introduction of herbicide tolerant and pest resistant crops, farmers have been able to reduce their input costs, save time and increase yields. All culminating in better returns to the farmer.
The technology has also enhanced agriculture, improving its sustainability by becoming more environmentally friendly.
GE technology has also successfully protected valuable crops from being wiped out. GE turned around the Papaya industry in Hawaii. The papaya ringspot virus (PRV) stunts the growth and eventually kills the tree. The fruit is malformed and is unmarketable. Transgenic papaya has resistance to the PRV and has saved the US $45 million dollar industry. Similarly in the banana industry in Kenya, GE is being used to regenerate the trees through pest resistance.
GE crops can provide better animal nutrition. By optimizing proteins and key amino acids, the productivity of those animals has increased.

The technology has the potential to add new qualities to existing products and create new products. This gives farmers more options to be successful.

Risks of Using GE Technology

As with any new technology, there are concerns over the safety of the technology. GE is a new technology that has the potential to radically change plant and animal breeding programs, create new products and alter existing ones. Although this technology has been utilized in commercial operations, critics believe there has not been sufficient time to analyze the impact of this technology in the environment and its long-term effects, if any on humans.
The main areas of concern are; Damage to plants, insects, birds and soil organisms; Genes escaping to another species; Resistance to herbicides or insecticides and recombination of viruses: Loss of biodiversity.

Damage to plants, insects, birds and soil organisms

The move to the use of herbicide tolerant crops should lead to a reduction of herbicides used, however it is claimed that a more broad spectrum herbicide will now be used, which could be more toxic. Insect resistant plants may kill other beneficial insects and are more effective at killing target insects. By creating a better kill of target insects may deprive other organisms of food such as birds. In fact in some countries a refuge area consisting of the conventional crop must be grown in conjunction with a GE crop to allow a safe haven for the pest to survive.
Scientists do not have a clear picture of how a GE crop affects soil microorganisms, fungi and insects. This could have an impact on crop residues breaking down in the soil.

Genes escaping to other species

One of the concerns with GE crops is the prospect that the new gene may “escape” via cross-pollination or seed dispersal to non-GE crops or close relatives of the species. For example GE Oilseed rape which is herbicide tolerant has been found to cross

with wild turnip to form hybrids that display the herbicide tolerant trait.
The transfer of genes from GE crops to non-GE crops of the same family is increased if grown adjacent to each other. The organic lobby has serious concerns in this area and believes that there should be no GE crops as contamination would lose their organic status, or at least have extensive buffer zones between such crops.

Resistance and Recombination
With herbicide tolerant crops, there is an increase in the use of a single herbicide, instead of the conventional spray programme that uses a mix of herbicides. The concern is that resistance to that single herbicide will develop rendering it useless for that crop. Likewise with insect resistant crops, it is thought that over time the target insect will develop a resistance to the toxin in the GE crop so that the crop will no longer work.
Critics of GE technology believe the technology could initiate the formation of uncontrollable viruses. Viruses naturally recombine to create new viruses, it is thought that some of these viruses will emerge from GE applications.

Loss of Biodiversity
Man's interaction with the surrounding environment has impacted on the diversity of the flora and fauna. It is thought that GE could see mono-cultures of plants and animals develop. Crops that can not compete as well as the new GE crops will not be grown therefore reducing the number of varieties. The loss of an insect from the food chain could cause the destruction of another animal higher up the food chain because you have removed its food source.

Regulatory Control

With all new technology, questions are asked over its safety to humans and the environment. GE technology is no different. In fact it would be fair to say that GMO's and food containing GE, are more widely scrutinized than conventionally grown crops and food.

In the United States of America (USA), three Government agencies work together to ensure food production using GE is safe to eat and protective of the environment. They are the Food and Drug Administration (FDA), the United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA). Current legislation within the USA, requires GE food to be specifically labeled, only if, their composition or nutritional content is "significantly different from their conventional counterparts or if they pose any health risks". Where there is no significant difference or health risk, USA regulators have determined, that GM foods are as safe as food produced through conventional methods. The USA system of regulatory control puts the onus of the safety of food on Manufacturers. It is their legal obligation to test products extensively to ensure of there safety.

Like the USA, Canada has three major bodies regulating GE production and food. They are the Canadian Food Inspection Agency, Health Canada and Environment Canada. The Canadians take a similar stance to GE as the North Americans, in that if the composition or nutritional content doesn't differ significantly from their conventional counterparts or if they do not pose any health risks then those products are classed as the same. Similarly, labeling of GE foods is only required if there is a significant difference or there is a health risk.

GE Food and technology are subjected to stringent regulation in the UK. The UK comes under regulation by the European Union (EU) Directive. All genetic modification and especially GE is thoroughly tested in the laboratory, but only after being obtaining registration and review from several government departments. To obtain consent to field trail and/or release commercially the application is reviewed by 4-5 Departments of government as well as by other member States of the EU.

In New Zealand, the Environment Risk Management Authority (ERMA) is the regulatory body that oversees the introduction of GE technology. ERMA is an independent government agency. It is, "responsible for protecting the environment and the health and safety of people and communities from the adverse effects

of new organisms (plants, animals, micro-organisms) including GM organisms (GMO's)"Ministry of Health -GM Information Kit
All research, development, field testing and commercial release of GMO's must be approved by ERMA.
The Australia New Zealand Food Authority (ANZFA) develops food standards for both Australia and New Zealand. Currently all foods containing more than 1% of GE product must be clearly labeled to show that it contains GE material.

Maintaining New Zealand's Competitive Edge

As discussed earlier in this report, the New Zealand economy is vulnerable because of it's large dependence on agriculture. It is therefore necessary to ensure that New Zealand maintains its competitive edge.
Many of New Zealand's competitors have invested in research and development including GE technology to narrow the gap between New Zealand and themselves. GE has become a "useful tool" in the advancement of their agricultural industry, improving productivity, developing new products and improving existing ones.
New Zealand agriculture needs to have as many "tools" available to them so they are allowed to compete on a "level playing field". GE is one tool that could benefit and enhance a biological based economy such as New Zealand's.

Public Perception

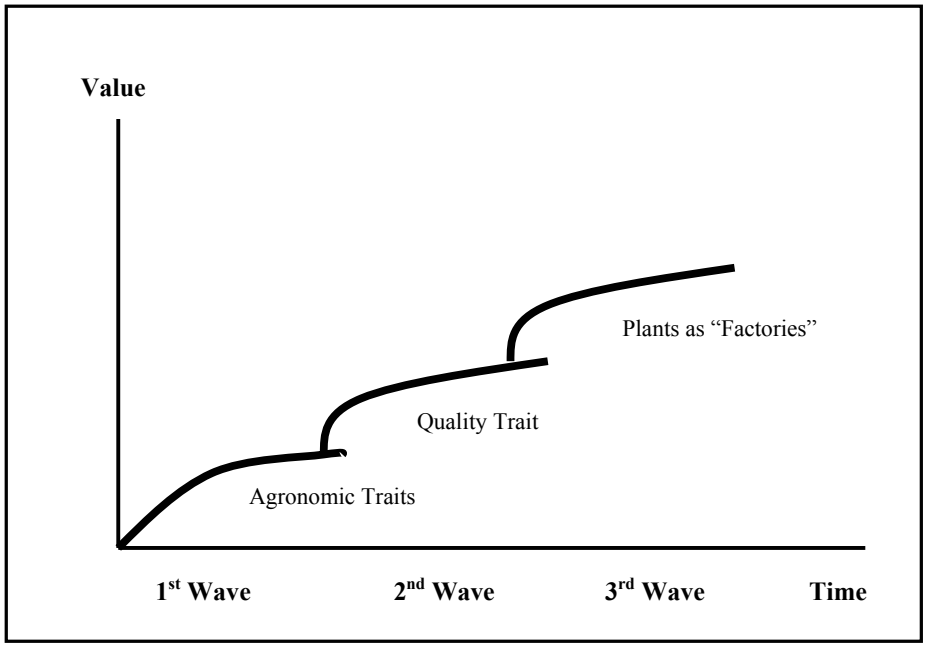
The lack of worldwide acceptance of GE technology by consumers has resulted in restrictions in market access for products containing GMOs. This is a serious concern for New Zealand producers as they rely on being able to access overseas markets to sell their produce.
The public perception of GE is mixed. In the USA, consumers put their trust in the regulatory processes to ensure food and

environmental security. US farmers have a high rate of acceptance.
Food safety issues are the major drivers in the non-acceptance of GE in many EU countries. Europeans have been "scared off science" by outbreaks of BSE and Foot & Mouth Disease. The BSE issue discredited many scientist and politicians who endeavoured to cover up the outbreak and minimise the fallout. The result is the mistrust by the public of most scientist, new science development, (especially in food) and politicians.
In some countries, and in particular developing countries, the acceptance of GMOs in food and GE crops is high. This can be largely attributed to the need for cheap food or any food, in some cases.
Generally, those consumers that can afford to be more discerning are more likely to be less accepting of GMOs in food. Consumer will vote with their wallets. If they accept GE foods they will purchase them. If not, they will boycott them. Clearly, the economic impact will be the main factor in the uptake of GE technology by primary producers.

Most surveys show that consumers believe that the benefits of GE outweigh their risks. Interestingly also, is a survey carried out in Australia by Quantum Market Research, where they sought to find out how concerns about GMOs compared with other food safety issues, such as pesticide residues, food poisoning, and human tampering. The results showed that while they were concerned about GMOs in food, these concerns were less than those in the other categories.

Public perception has been shown to be slowly changing in favour of GE as consumers' receive more tangible benefits from the technology.
Gene technology appears to be moving in phases. The first phase – involves the development of Agronomic traits – that will benefit the producers by reducing inputs, increasing yields and overcoming climatic and environmental challenges. The second phase will see the delivery of benefits to the consumer through the enhancement of quality traits. They will provide healthier, tastier food with longer a shelf life. The third phase

will see plants and animals farmed as “factories” to produce nutriceuticals, pharmaceuticals and other industrial chemicals.



Graph: Depicting the value of various phases of GE technology - Monsanto

New Zealand has promoted its produce to the rest of the world using its “quality”, “natural”, “100% pure” and “clean green image” marketing pitch. These campaigns have been very successful, and along with the word of mouth commendations from tourists about New Zealand, the marketing of our food to the rest of the world has been well received by consumers.

When considering the issue of whether New Zealand should allow the use of GE, and before committing to it on a commercial level, it must ensure that public perception of the technology has wide spread acceptance.

There is little doubt that GE technology can benefit New Zealand agriculture and the environment. Resources allocated by the industry for Research and Development must increase, allowing researchers to continue to develop new products and enhance existing products to maintain New Zealand’s competitive edge. However, before the commercial release of any GMOs, extensive market research needs to be carried out to ensure that the market will readily accept those GE products so that the industry and hence New Zealand’s economy does not suffer as a result.

5. Acknowledgements

I would like to thank the New Zealand Nuffield Farming Scholarship for the opportunity to become a Nuffield Scholar.
The scholarship has been a life changing experience. Having the opportunity to compare New Zealand agricultural systems to other countries agricultural systems, to view the complexities of world trade issues and the many politic pressures in several other countries has been invaluable.
I would also like to thank:

- The many Nuffield Scholars and their partners who offered their hospitality and assistance. I would especially like to thank UK Nuffield Director Steven and Gillian Bullock, Dr Lisa and David Cargill, Janet White, Dr Sean & Anne Beer, and the 2000 Nuffield Scholars that traveled (put up with me) to Asia and through Europe.
- The many organisations, businesses and individuals that made time to meet with me and assisted with information for the writing of this report.

Most importantly, I would like to thank my family. Firstly I would like to acknowledge the sacrifice my wife, Julie and our children Rachel and Mitchell gave, to enable me, the opportunity to be away from home for 5 months and secondly to Gordon (father), Fiona (Sister) and our staff who ensured that our farming business continued successfully.