A Brief Guide to Understanding Biotechnology in New Zealand Farming

- Science
- The Issues
- The Future

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Foreword

As a farmer, involved in agriculture all my life, I am passionate about the ongoing success and sustainability of rural industry in New Zealand. Our environment and our attitude mean we are placed favourably to compete in an increasingly competitive global market place. These factors were confirmed to me when I had the opportunity to travel abroad as a Nuffield scholar in 2000. The theme of my study was ' the threats and opportunities that agricultural biotechnology will pose for New Zealand agriculture'. Amongst my conclusions was a concern that farmer's lack of understanding of the technology and the issues involved could be to our detriment. My aim in putting together this booklet is to encourage farmers to address this concern and therefore place themselves in a position to make informed decisions about their future.

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Introduction

Agriculture is no stranger to technology but new technologies rarely receive an enthusiastic welcome, particularly when they relate to emotive issues such as animals and food. Throughout history, people have used and adapted to both the positive and negative aspects of new technologies.

Initially there were over one hundred reasons given by opponents as to why a simple heat treatment process being developed to make food products safer was an unacceptable technology. Without the ability to pasteurise milk, consider where the New Zealand dairy industry would be today!!

Looking back in history, we see the great impact of a number of pivotal events. The internal combustion engine brought on the industrial revolution. New chemical entities broadened our manufacturing capabilities. Information technology has accelerated the creation of our knowledge base. But not all of the impacts of these have been positive.

Albert Einstein said "The significant problems we face today can not be solved at the same level of thinking that we were at when we created them".

Biotechnology itself is not new but for many farmers it is a new way of thinking. Biotechnology is providing us with the ability to solve some of our more challenging problems. Problems in health and medicine, issues of food security and most importantly to farmers, new options for sustainable agricultural development.

The industrial, chemical and information revolutions are our history. The biotechnology revolution offers us options for a healthy farming future.

The Science

Biotechnology is a set of scientific tools, which uses living things to solve problems and make products.

The use of yeasts and bacteria to make bread, beer, wine and cheese are techniques that have been used for centuries. Traditional plant and animal breeding techniques are of more recent origin.

The word ' biotechnology' can be traced to 1917, when it was used to refer to large-scale fermentation production techniques. Traditional biotechnology is also widely used to extract and purify active components from plant and animals to produce drugs, cosmetics and health foods.

Modern biotechnology uses new techniques that provide greater understanding of, and control over, living processes. These new approaches have applications in genetically enhanced crops, parentage verification, and cloning.

Much of biotechnology is about studying or manipulating one or more of the basic components of living things: tissues, cells, proteins, genes or DNA.
New and potential biotechnologies can be classified into three groups, which reflect their key uses.

Briefly ...

- **Knowing more about genes is extremely useful for farmers.**
- **The techniques used in genomics DO NOT alter the genetic make up of plants and animals.**
- **Transferring genes between species will not turn one into the other. 40% of the genes in the potato are the same as those in a toad anyway.**

A Point to Digest

DNA is part of our daily diet. We all consume millions of copies of thousands of genes. Many of these genes are fully viable when we swallow them - in a fruit or vegetable salad for example. In most cases we don't know what these genes do. In processed foods, these DNA sequences may have become fragmented, into unknown portions. When DNA reaches the gut ,it is shredded by enzymes, broken up by acid, and then demolished by bacteria into very small sequences. Animal studies suggest that some fragments can pass into the bloodstream. As we have been eating DNA for thousands of years, does this matter?

Genomics

This is the widely used package of technologies that includes the mapping, sequencing and determination of the function of genes.

Knowing more about genes is extremely useful for farmers. It makes possible the identification of valued traits in plants and animals, enabling more efficient and powerful selective breeding. Confirmation of the pedigree of livestock or plant cultivars is now possible.

For both human and animal health, improved diagnosis and treatment is now possible through the identification of the DNA of the infecting bacteria or virus.
It is important to understand that these techniques DO NOT alter the genetic make up of animals or plants.

Growing New Tissue

These techniques involve the manipulation of living things at the level of cells and tissue rather than at the sub-cellular level of genes and DNA.

These technologies include well established techniques such as plant tissue culture and more extreme, controversial uses such as cloning.

For decades, tissue culture has enabled scientists to grow plant or animal tissues in test tubes for industrial and medical purposes. It is possible to create a whole plant from a single cell. Virus free roses and daphne are routinely produced here in New Zealand using tissue culture.

Cloning is the word used to describe the technique of reproducing something exactly. Propagating cuttings is commonplace amongst gardeners and is an example of cloning plants.

Newer techniques of cloning have been developed which allow a complete organism, for example an animal, to be reproduced asexually from a single cell. Dolly the sheep and Lady the last of the rare Enderby cattle were produced in this way.

In the future this may allow us to short cut traditional reproductive methods and produce specific numbers of highly specialised, tailor made livestock.

Genetic Modification

Genetic engineering allows genes to be removed, turned off or shuffled around. Isogenics involves moving genes within a species.

Transgenics involves the movement of genes from one species to another. Transferring genes between unrelated species is possible because of the genetic similarities of all living things. For example around 40% of the genes in a potato are the same as the genes in a toad

It is important to understand that the transfer of genetic material between unrelated species WILL NOT turn them into each other. It may however allow a beneficial trait to be expressed in the organism to which a target gene is transferred.

Genetic engineering is more commonly applied to bacteria than to any other living thing. Genetically modified bacteria have uses in research and to produce certain biologically active components. Insulin for diabetics has been produced by GM bacteria, containing a copy of a human gene, since 1986. The milk promotant, rBST, or recominbinant bovine somatrotrophin is also produced commercially by GM bacteria. The enzyme Chymosin, used in cheese production is produced using recombinant DNA techniques.

Drugs produced from GM bacteria are often safer than their non GM alternatives as they are not produced from blood products which may carry undesirable viruses.

GM plants are also the products of scientists new ability to move genes around. Crops that contain a gene that gives the plant resistance to herbicides such as glyphosate allows farmers to spray for weeds after the crop has emerged, with no damage to the crop itself. Roundup Ready soy beans are an example of this. Other crops, such as Bt corn and Bt cotton, which have a gene added to produce an insecticidal protein are able to protect themselves from insect pests without the necessity to apply spray. At this stage there are no GM crops grown commercially in New Zealand and the government recently banned applications for commercial introductions of genetically modified crops for two years.

In Australia there are two genetically enhanced crops grown commercially. Ingard cotton covers over 100 000ha and is protected by a natural bacterial pesticide. The BT toxin is useful in combatting the Bollworm, which is calculated to cost the cotton industry around $500m per year. Ingard cotton crops receive 70% less insecticide than normal varieties.

Applications of this Science

It is vital also to understand that not all technologies in use involve genetic engineering. This area is so frequently misrepresented, emotionally railroaded and poorly understood that one could be forgiven for believing it alone encompasses all biotechnology.

Biotechnology is already part of life in New Zealand. Much of the knowledge and technology that our primary industries use to produce, farm, harvest and process our products comes from biotechnology. Current research and development seeks to use some of the newer tools in order to further develop our agricultural systems and ensure we remain competitive in the increasingly aggressive and globalised world markets on which we rely.

For New Zealand agriculture, the possibilities are exciting. There is no doubt that our forage inputs will be enhanced considerably over the next 10-15 years using these techniques.

Rye grass with both higher yields of dry matter and levels of carbohydrate, that is resistant to pests and harsh environments.

Clover that fixes double the nitrogen, is resistant to weevils and produces tannins to combat bloat.

Forage crops with resistance to herbicides and natural resistance to insects will reduce our reliance on expensive, toxic chemicals. These are all realistic possibilities.

More importantly we already have the opportunity to benefit from scientists ever improving knowledge of gene form and function with the DNA analysis now available to verify parentage, eliminate genetic defects from our herds and flocks and even identify cows producing specific milk proteins.

The ability to carry out DNA tests from easily collected hair samples, on newly born calves, will revolutionise the efficiency and accuracy of our herd and sire replacement policy.

As we learn more about the form and function of the 100 000 bovine genes, exciting possibilities will emerge. We will be able to speed up what has traditionally been achieved over decades with conventional breeding programmes. For example, a gene affecting facial eczema could be switched off, or a gene that improves the protein to fat ratio in milk switched on.

If through improved selection we could lift the national lambing percentage by just one percent, this would result in an extra $16 million profit to sheep farmers.

Key Issues

The debate centred on biotechnology in agriculture is dynamic, controversial and often complicated. The issues are vast and some have no easy answers. The following are relevant and important to New Zealand agriculture both immediately and in the future.

Farmer Acceptance

History shows that farmers move quickly to adopt technology that delivers benefits to their farming systems. Electric fences, four wheel farm bikes and artificial breeding are examples of technologies that have been adopted eagerly.

Similarly, farmers in North America and closer to home, in Australia, are embracing biotechnology because they are finding it offers new tools to solve problems in their current farming systems. The uptake of biotechnology has been the most rapid of any new technology in farming.

In the year 2001, the global area under genetically modified crops was around 56 million hectares. This equates to a 26 fold increase in just 5 years. Estimates for the 2002 season show a further 12% increase in the demand for genetically enhanced seed.

Briefly ...

- **The uptake of biotechnology has been the most rapid of any new technology in farming.**
- **Biotechnology is already huge! 2001 – 56 million hectares in GM crops globally.**
- **Difficult to gauge consumer concern because minorities often have the loudest voice.**
- **Media exploit emotive, sensational stories.**
- **Research shows biotech crops are safe to feed livestock and have no impact on the resulting milk, meat or eggs.**
- **Organic export industry accounts for less than 1% of NZ annual ag and hort exports.**
- **Premiums for organic products rely on the balance between demand and supply. People want choice but there is an upper limit to what they are prepared to pay.**
- **There is no scientific proof that organic food is healthier or more nutritious than conventional products.**
- **Great potential for GM techniques to be compatible with organic theory.**

Records show that last year seven transgenic crops were being grown commercially in twelve countries.

Around 90% of the Argentine national soybean crop and 62% of the Canadian Canola crop were herbicide tolerant. In the United States, 33% of corn , 69% of cotton and 68% of soybeans were genetically enhanced for either insect or herbicide resistance.

"We have recently advanced our knowledge of genetics to the point where we can manipulate life in a way never intended by nature. We must proceed with utmost caution in the application of this new found knowledge"

This is from Luther Burbank in 1906, not the Royal Commission on Genetic Modification in 2001. He is referring to genetically modified organisms, but not those modified by gene technology, simply cross-breeding considered so routine today. Think about it!

At any one time it is estimated around 30% of dairy herds in the US are using the milk promotant bST. It is genetic enhancement that has allowed bST to be produced by bacteria in commercial quantities at a reasonable cost.

These high adoption rates are clearly a reflection of farmers' satisfaction with these new products. Farmers are finding benefits such as more convenient and flexible crop management, higher and more reliable productivity and a safer working and living environment through the decreased use of conventional pesticides. Australian cotton growers are reporting reductions in spray applications from nine times per crop to only 3 times.

These technologies are giving farmers the opportunity to produce products that meet the needs of their customers, the consumers, who are becoming increasingly focused on safe production methods, quality outputs and reasonable cost.

Biotechnology offers a positive contribution to environmentally friendly sustainable agriculture.

In the Mainstream Worldwide

Somewhere in the world these GM varieties are being grown commercially

Carnation, Chicory, Cotton, Flax, Maize, Oilseed, Rape, Papaya, Potato, Soybean, Squash, Sweet corn, Tobacco, Tomato

And the list is growing with these crops close to commercial release:
Sugar beet, Rice, Wheat, Bananas

Who's On Board:
Countries with GM crops in commercial production are:
Argentina, Canada, US, Mexico, Spain, Australia, China, South Africa, Russia, Indonesia, India

Consumer Attitudes

Globally there is a great diversity of attitudes towards the use of biotechnology in agriculture. Many scientists and farmers are optimistic and enthusiastic about the prospects. However, the safety of genetically engineered plants for humans and the environment remains a hotly debated issue.

It is difficult to accurately gauge levels of consumer concern as research results and media coverage are frequently biased and taken out of context. Vocal minorities with various political and personal agendas often evoke public fear by using emotional rather than scientifically backed arguments.

Consumer acceptance appears to be influenced by three main criteria :–
1.Perception of risk and benefits
2. Level of knowledge
3. Trust.

As yet consumers, especially those in Europe, do not see biotech crops as a benefit to themselves so are cautious about supporting this new technology. They are not impressed by data showing savings to farmers and profit to multinational corporates when GM corn and soybeans are no cheaper, more nutritious or in any way more useful to consumers.

Acceptable risk is called safety. The balance between perceived risk and potential benefit is unique to every individual. There tends to be a correlation between high levels of concern about GM technologies and a lack of knowledge about the processes involved in genetic enhancement as compared to conventional plant breeding, the extensive testing done to ensure the safety of biotech crops and in fact an overall ignorance of agricultural production systems.

In order for the level of public knowledge and awareness to be enhanced, there must be effective communication channels between the scientists, retailers, regulators, farmers and consumers. We must be wary of the power of vocal minorities in railroading constructive debate.

The BSE and foot and mouth crisis in England, food safety scares in Europe have undermined the public's trust in regulators. They are perceived as being incompetent and dishonest. This, coupled with a tabloid media hungry for emotive, sensational stories has undoubtedly impacted on the European public's response to genetically enhanced products in food.

The consumer ultimately is the King. To reach their potential, new biotech innovations must be accepted by each link in the food production chain. Open, accurate dialogue between all parties will help correct misinformation, generate trust and

Feeding Biotech Crops to Livestock

An area of growing concern for farmers, as a result of increased consumer awareness of food safety issues, is the market pressure being applied, particularly in Europe, to feed livestock on products free from genetically enhanced components. The issue was raised here recently by Tegel who have decided to remove any GM components from their chicken feed. As yet these feeds are not produced commercially in New Zealand but in Australia this is particularly relevant to cotton seed usage and will become a consideration when GM canola goes commercial. It is a potential issue for any farmers feeding grain or other concentrates that include imported products.

GM crops are in the food chain already! In the US, up to 75% of the corn and soybean crops produced ultimately find their end use in livestock feed. Around 30% of this corn and 55% of soybean are genetically enhanced. 20% of the US corn crop is exported.

Industry and consumers are seeking answers to questions about biotech crops:
Are they safe to feed livestock?
How will animals perform when they are fed GM crops?

Are transgenic proteins or DNA going to be present in the milk, meat and eggs that I eat from animals fed biotech crops?
The regulatory process in the US for biotech crops is extremely thorough and comprehensive.

ANZFA, the Australia New Zealand Food Authority, works to develop and maintain laws and systems, which ensure safety and regulate the labelling of food in Australia and New Zealand. Soon we will see all food products with labels indicating whether they include more than 1% genetically enhanced components.

More than 20 independent livestock studies have been completed and these have all concluded that there are no detrimental impacts from feeding livestock biotech crops and animals performance is at least as good as those fed conventional crops.

Additional independent studies show that no transgenic DNA and proteins can be detected in milk, meat and eggs of poultry, lactating cattle or beef cattle when fed on biotech crops.

It is important to understand that retailers and lobbyists acting to prevent the use of biotech crops in animal feeds are doing so as a response to perceived consumer resistance rather than assessments of sound scientific evidence. Unfortunately their actions are sending signals to consumers that are warning them about the food safety of genetically enhanced products when there is no evidence to support this concern. Your roast Tegel chicken will be absolutely no different whether it has had a genetically enhanced diet or not.

Organics

An alternative being proposed is organics. Some people suggest this cannot coexist with the new biotechnologies and should be considered the exclusive way forward. I do not consider this is a viable option. The reality is that organic produce does have a niche in some products and some markets. For NZ in 1999, the organic export industry accounted for less than 1% of our annual agriculture and horticulture exports. Growth figures for many countries appear extraordinary. In Europe and Britain, the organic market has grown 25% each year for the past 10 years but this is from a very small base. For the dairy industry, high import tariffs and our distance from key export targets, like North America and the EU, mean it will remain difficult to compete in the categories of strong demand - the perishable, short shelf life products like milk and yoghurt.

Premiums received rely on the delicate balance between demand and supply. With major supermarkets such as the Iceland chain in the UK aiming to offer organic produce at the same price as conventional, it seems likely that premiums will be eroded and the back pocket of the organic farmer will be the one to suffer. Already in Denmark two thirds of the organic milk being produced is ending up sold as conventional product. There is a growing trend for organic dairy farmers in the UK to be turning back to conventional production as premiums fall.

People want the options to choose what they eat but there is an upper limit to what they are prepared to pay for that choice. Retailers confirm that price plays a huge part in peoples purchasing decisions. There is a difference between the behaviour of citizens and the behaviour of consumers. Citizens are always reported in opinion surveys but it is consumers, in contrast, who make the supermarket tills ring true.

It has been suggested that the future of organic foods depends on there being continued major food scares, BSE and E.Coli are examples. Retailers market organic food as being safe and some cleverly create the perception that GM and even conventional food may be unsafe. I believe it is wrong to scare people about the safety of conventional food and farming practices when many of the arguments are not scientifically proven. There is no sound scientific evidence to suggest that genetically enhanced products are unsafe to human health or the environment. A series of 81 experiments, over 15 years, at a cost of $64 million has led the European Commission to the conclusion that biotech foods are likely to be safer than conventional ones.

Remember, nearly 300 million North American consumers have been eating dozens of enhanced foods for the last 15 years and not a single cough, cold, or allergic reaction can be attributed to the foods produced through biotechnology.

Similarly there is no scientific proof that organic food is healthier or more nutritious option than conventional products. Recently in the UK two major supermarkets were found in breach of the Fair Trading Act for making such claims that they could not substantiate.

Many organic proponents see potential for some GM techniques as being compatible with organic theory in that they involve:

- Low use of toxic chemicals
- Sustainable low tillage cultivation methods
- The farming of livestock in a way that supports health and welfare without detriment to production.

I do not believe the use of biotechnology will negate the opportunity to develop organic systems. Appropriate research, respected regulatory process and the adoption of identity preservation systems will ensure standards are not compromised. As farmers, we must work together, with respect, to ensure we maintain the right to choose the type of production system that fits our objectives and resources.

Biotech at the Local and Global Levels

Biotechnology has the potential to deliver for New Zealand agriculture the factors critical to our on going success:

- Improved productivity through improvements in forage, animal health and genetic gain.
- Enhanced competitiveness by adding value to our export products.
- Positive benefits for environmental sustainability.

The government strategy of "preserving opportunities" as recommended by the Royal Commission on Genetic Modification is a positive but cautious move forward. Some progress can now be made in research with the ending of the moratorium on GM field trials. Helen Clark is correct when she says "Stopping research into GM technology would not have been in New Zealand's best interests".

We must move forward. Already biotechnology is allowing our competitors to lower their input costs, for example reducing feed bills through the use of genetically enhanced soy, maize and canola. Further more, these crops have the ability to produce products that will compete directly with the outputs from our dairy industry. Milk fat faces major competition from the oils of these same crops.

If we resist the options available to maintain our competitiveness, there is no guarantee that consumers will be prepared to pay a premium for the resulting GE free products. It is vital that we monitor closely our markets, especially those of most economic importance and the behaviour and performance of our competitors. I believe timing and planning are critical. There may be a cost in using the tools of biotechnology to our advantage, but there may well be a much greater cost in rejecting the technology. We should be aware of the emotion but concentrate on the facts.

A recent economic analysis looking at New Zealand agriculture over the next 10 years, predicts that if we row against the World tide and go GM free, GDP will fall by over 30% and employment by 56000 jobs. There are 14000 dairy farmers in New Zealand!

Looking Ahead

The rapid growth of biotechnology and its wide significance presents enormous opportunities and creates some great challenges. Both globally and at home, it is difficult to predict the future of GM foods and the broader biotechnology revolution. The challenges facing governments, businesses, research organizations and the public in general include ensuring that balanced, accurate information is freely available, that regulation is sound and effective and that research is adequately funded in order to achieve ongoing innovation.

Globally, public acceptance of ag-biotech products is at a critical juncture. There are signs of consumer resistance in Europe and although opinion research shows a higher sensitivity in the US to the products of gene technology this has not yet resulted in quantifiable changes in general attitude. The current turmoil may be a short-term blip or more likely a period of 5-10 years of disorganisation while minority pressure groups work smartly to influence both public opinion and regulation in pursuit of their various agendas. Government views will differ depending on the importance of the industry to their economies and the strength of the public voice.

In time, I believe we will see a number of successful genetically enhanced food products competing with their traditional and organic counterparts. New products will be introduced that provide clear benefits to the consumer and ongoing research will verify both safety and environmental benefits.

Consumer behaviour may continue to vary globally with non-GM and organic foods selling for a premium in certain markets. Price will remain the most significant determinant influencing consumers purchasing decisions. Our agricultural export industry will need to be innovative, to supply a range of products that both fill customers changing needs and maximise sustainability returns to farmers. Retailers will increasingly demand, on behalf of consumers, choice and consistency in products that are convenient, cost effective and safety assured.

In the Pipeline

Improved crop quality:
- *wheats with better baking qualities*
- *maize with improved characters for animal feed, for example to reduce phosphorus excretion and its associated pollution problems.*

Better defence against disease & stress:
- *drought, frost and salt resistant forage crops.*
- *GM potatoes which can resist nematodes*

Pharmaceuticals in Farming:
- *fruit and veg with higher vitamin and nutritional content.*
- *Human vaccine against hepatitis B in a potato or banana.*

Conclusion

Agricultural biotechnology has the potential to redefine our present systems of farming and food production.

At the on farm level it offers tools to improve those factors which most limit production presently. Progress in the areas of forage quality and quantity, animal health , flock and herd genetic improvement would allow reductions in costs, improved environmental management and overall productivity enhancement.

Beyond the farm gate, gene technologies have the potential to add value to our primary export products and will offer a way to move further out of commodity markets and into value added products. New products have the potential to enhance value in our conventional markets and expand business opportunities in unconventional markets. Those that presently we do not link directly to agriculture, for example health, pharmaceuticals and energy.

Communication, transparency, regulation and science will all play a vital role in ensuring farmers and public alike clearly understand both the risks and the huge benefits that these new developments can offer.

Understand the Issues - Make the Best Decisions

My challenge to farmers is this. You must understand the issues if you are going to make the best decisions. You would never build a new dairy or set of cattle yards without doing your homework first. You would not change the breed of your herd or flock or the composition of your share portfolio based on a weekend article in the local tabloid! This is important. We must not let vocal minorities who know nothing about agriculture plot our destiny based on their emotion.

In the past, the New Zealand primary sector has seen enormous benefits come from scientific research, innovative technology and new developments both on and off farm. If agriculture in the future is to have its grass roots in healthy, viable farming businesses, farmers must understand the issues and overcome the barriers. Biotechnology is a new level of thinking that offers new solutions for remaining competitive long into the future.

" The significant problems we face today can not be solved at the same level of thinking we were at when we created them" Albert Einstein

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