Conditions for co-existence of genetic modification in a pasture based system – a farmer perspective

W.B.R. ROLLESTON
Blue Cliffs, RD24, Timaru, New Zealand
william.rolleston@southpacificsera.co.nz

Blue Cliffs Station in South Canterbury was taken up by Henry Poingdestre in 1856, 5 years after my great-grandfather, George Rhodes and his brother Robert drove a flock of sheep from Banks Peninsula to The Levels Station to establish the first run in South Canterbury. It was from George that McKenzie famously stole 1000 sheep in 1855 and was caught in the now named Mackenzie Pass, only to escape again into the mist the same night.

The Levels was sold following George's death in 1864, but in 1879 his son, Robert, bought Blue Cliffs Station, situated just to the south of the old Levels property, to become its fourth owner. It has been in our family ever since, subsequently run by my grandparents, Dr Randal and Airini Woodhouse and now by me and my brother John.

Blue Cliffs Station was 36 500 acres (14 771 ha) when my great-grandfather bought and leased it. Over the last 137 years the leasehold land was given up and freehold land sold in the face of land tax and other policies designed to break up the large estates. Our family has purchased a number of neighbouring properties in the last decade and so the station now stands at just over 5000 ha. It consists of a mixture of rolling downs (55%) and hill country (45%) ranging in elevation from 131 m to 1180 m a.s.l. at the highest point on the Hunters Hills.

The property is managed as a sheep and beef breeding and finishing operation, running 26 000 stock units (SU) with a sheep:cattle SU ratio of around 50:50. Table 1 provides a summary of the grass and crop mix under cultivation on the downs. The hill country is predominantly native tussock over-sown with clover and ryegrass. Over the last 500 years the native bush has retreated to the hill gullies in the face of a drying climate, natural and man-made fires.

In 2015, I visited AgResearch's Grasslands facility with other farmers from South Canterbury to see the genetically modified (GM) ryegrass that had been developed. The GM ryegrass plants contain a high metabolisable energy (HME) system enabling them to produce 16 and 18 carbon chain lipids and store them in a protein sphere, protecting the lipids from internal catabolism. According to in-lab testing and observation, the GM ryegrass has a 20% increase in photosynthesis giving a 40-50% increase in production, a 10% increase in metabolisable energy and, potentially, a 30% reduction in water demand. *In vitro* rumen assays have measured a 15-23% decrease in methane production. A supplementary feeding trial suggested animals could eat 16% less of the GM ryegrass for the same liveweight gain. A potential benefit of this is a lower total N load on pasture and reduced nitrous oxide emissions, making this forage a valuable tool for reducing nitrate leaching and greenhouse gas emissions from livestock. Of most interest was the enthusiasm for this development of the other farmers in the group and I was surprised by their agitated response to the fact that this grass was trapped in the laboratory.

The regulatory process and likely practical restrictions in New Zealand have meant the HME system is currently being trialled in the USA in soyabean; eventually extending to ryegrass and alfalfa. American farming interests are closely following these trials.

GM has been a contentious issue in New Zealand since the early 2000s when the then Labour government set up the Royal Commission on Genetic Modification. The major conclusions of the Commission were that a 100% organic or a GM-free future was not realistic or to New Zealand's benefit, nor was total deregulation of GM. The Commission said New Zealand should proceed with caution on a case by a case basis, preserving opportunities.

The purpose of this paper is to consider the use of genetically modified organisms (GMOs) in the context of our pastoral farming system and to stimulate

Table 1 Areas currently cultivated and supporting various crops on the rolling downs of Blue Cliffs Station.

	Hectares cultivated annually
Perennial ryegrass/timothy/clover	116
Perennial ryegrass/plantain/clover	50
Italian ryegrass/clover	85
Lucerne	37
Kale	138
Fodder beet	82
Total cultivated	**508**

ISSN 2463-2872 (Print) ISSN 2463-2880 (Online)

discussion about what co-existence might look like in New Zealand agriculture. How can a product such as the HME ryegrass be used and what would need to be considered to make co-existence work?

GMOs and their products are controlled both internationally and nationally. The international agreement is the Cartagena protocol which sets up a register for notification for the trans-border movement of living GMOs.

More relevant to New Zealand trade and to farmers producing meat are the market access requirements and the customer requirements for products which may have been produced using GM. These two requirements are often very different and are commonly confused when trade in GM products is discussed.

Market access requirements are those requirements which allow products to be traded across borders and sold in foreign markets. For instance, the European Union (EU) allows the importation of GM animal feed provided it is non-viable. Perversely, the EU ignores the use of GM (e.g., enzymes) in cheese and beer making. The EU has also approved certain GM products for human consumption but requires a GM label where the level of GM presence is above 0.9%. In Japan the level is 5%. Unapproved GM food is not permitted at any level. The EU does not make a distinction between animals eating GM or conventional feed. Both are considered non-GM. Europe imports about seven billion Euro of GM animal feed per year. In fact, there are no countries in the world which restrict the importation of animal products where the animals have been fed GMOs or GM products in their diet. So as a farmer thinking about growing a GM grass or feed there are no country level restrictions to be concerned about.

Customer requirements are more complex. Those consumers who want to avoid GM products have four choices:

- buy Organic
- buy "GE-Free" labelled product
- buy "Non-GM" labelled product
- avoid GM labelled product.

The organic movement has shunned GM and there are a variety of standards around the world. In the USA, for example, the USDA organic standard prohibits the use of GMOs and their products are tested, but there is no specific tolerance level, rather, inadvertent presence of GMOs would trigger an investigation and recommendations for improvement. In an animal production system "organic" would mean not having GM animals and avoiding GM animal feed, however, the use of GM vaccines appears to be allowed.

"GE-Free" labels have not really been used, as commerce regulators around the world have taken a purist view of such a claim. Inghams, for example, was pulled up in New Zealand for claiming they had GM-free chickens when they could not guarantee their chickens had not been fed imported GM soyabean or cotton meal. That is, if a claim of "GE-free" is made, the producer needs to show more than the product itself is free of GE material. "GE-Free" labelling is likely to require a very high burden of proof requiring verification to give reasonable assurance. From the commerce regulator's point of view it is likely that a "GE- free" claim would be unacceptable if the animal had been treated with a GM vaccine, been fed a GM trace nutrient or if GM was involved in any part of the production system, even if the product itself contained no GM material.

In the absence of GM labelling (until recently) in the USA the "Non-GMO Project" was created to provide consumers with a choice to eat non-GM food. The Non-GMO Project claims this sector to be the fastest growing in the marketplace with more than 2800 verified brands, representing nearly 40 000 products and more than US$19.2 billion in sales. To put this in perspective, however, the USA food sector was worth US$5.32 trillion in 2015, so the demand for non-GM represents less than one percent (0.36%) of the USA food sector. Nevertheless, of relevance to me as a producer, the Non-GM Project has a tolerance for animal feed of up to 5% GM content on average across the year.

The USA is the largest user of agricultural GM in the world and also tops the production of organic food. Organic production utilises about 1-2% of agricultural land while 90-95% of farmers use GM in the crops in which it has been approved. In addition, New Zealand's GM-free (i.e. tested GM-free) corn seed also comes from the USA suggesting that co-existence exists where there is a will.

The USDA organic information suggests the following preventative practices for farmers with reference to genetic modification:

- plant seeds early or late to avoid organic and GMO crops flowering at the same time (which can lead to cross-pollination)
- harvest crops before flowering or sign cooperative agreements with neighbouring farms to avoid planting GMO crops next to organic ones
- designate the edges of their land as a buffer zone where the land is managed organically, but the crops aren't sold as organic
- thoroughly clean any shared farm or processing equipment to prevent unintended exposure to GMOs or prohibited substances.

The organic standards in Australia and New Zealand call for zero tolerance of GM in any food and zero tolerance on the certified farm. The reasonableness of such a standard was tested in Western Australia in a landmark case between two neighbours – organic grower, Steve Marsh and GM canola grower Michael Baxter. Sheaves of GM canola blew from Baxter's property onto the edge of Marsh's oats field. Marsh's organic status was revoked by the certifier and he sued his neighbour. The High Court found in the GM farmer's favour rejecting that any harm had been caused to the organic farmer and suggesting that the organic grower should have sued the certifier for setting an unrealistic standard. The case was appealed and the organic farmer lost again. This time the court said that the organic grower had every right to grow organic crops but had no right to impose those standards on his neighbour.

Thus for GM to be used in New Zealand the government would need to determine where the balance of rights should lie. Should all farmers be denied the opportunity to use GM for the convenience of growers who want to set a personal standard? Or should the government allow rules and practices which give a reasonable level of protection to enable products to be traded internationally?

If the former, then many potential uses of GM would be beyond our reach. If the latter, then (for animal feed at least) no regulation would be required.

Just as we have free speech but we are not allowed to defame (i.e. our free speech has limits) so it is likely that a balanced approach would be found with respect to those who want to grow GMOs and those who want to avoid them.

If a standard were set for GM growers that provided a reasonable expectation for non-GM growers then any higher level of assurance would be the responsibility of the non-GM grower.

Given the requirements for organic and Non-GMO Project certification, and the tolerance levels in food used internationally for food labelling, a 1% level might be a useful place to start with respect to the grasses and crops used by livestock farmers in New Zealand. That is, if a neighbour who wants to avoid GM takes no preventative measures he/she would have a reasonable expectation that no more than 1% of the species in question would be cross-pollinated by the neighbour's GM crop. This of course would be at the closest point and would likely reduce moving away from the boundary.

Exactly what practices would be required would depend on the plant species, its reproduction and how it is used in the agricultural system. Stewardship programmes could be voluntary or industry standards, or regulated as part of a conditional release of a GMO. In the main, stewardship programmes would be aimed at limiting the production and/or spread of pollen or seed from the GM plant. Seed should also be considered in any stewardship programme particularly with respect to equipment hygiene but in the species considered here the characteristics of the seed means it unlikely to move in the field further than pollen.

There are four main factors relating to pollen to consider:

- species and method of dispersal
- the management of the crop and the role of flowering
- pollen deposition and the distance it travels
- receptive plants fertilised as a result of the pollen deposition.

So it is important to consider gene flow rather than simply pollen dispersal. Gene flow depends on pollen viability, receptive flowers, fertilisation and seed development.

Grasses (including corn)

For example, a number of gene flow studies have been carried out on forage grasses that are wind pollinated such as ryegrass and tall fescue, including at AgResearch in New Zealand. Pollen has been detected up to 1 km from such crops but gene flow is limited to 30-50 m for ryegrass and 150 m for tall fescue.

Corn (another grass) produces large amounts of pollen (a 1 ha field can produce as much as 10^{11} pollen grains per season) and this is detectable 4.5 km away at thousands of grains per square metre, but the gene flow rate declines rapidly, so that a distance of only 10-50 m is sufficient to keep gene flow at below 1.0%. In addition, except for corn seed production, the corn used is generally an annual hybrid so no seed is collected.

Considering the large amounts of pollen produced by corn and the rapid decline in pollen concentration with distance, the biggest barrier to gene flow is the competition with pollen from any corn plants in closer proximity to the receiving plant. Such a biological barrier will also be affected by the area of GM varieties compared to non-GM varieties; the greater the area of GM varieties compared to non-GM varieties the less effective such a biological barrier would likely be. As already noted, most corn seed comes from the USA where over 90% is GM, so while the amount of pollen dispersal seems large, co-existence of GM and non-GM is possible.

Blue Cliffs Station has produced whole crop silage from time to time and flowering is essential for effective production. While one of our neighbours produces maize silage he does not produce corn seed, nor sweetcorn, and the next nearest seed producer is more than 5 km away. If our neighbour were keen to avoid GM corn, strategies such as ensuring a buffer distance between the GM and non-GM crops of say 30-50 m could be used. This buffer area could contain non-receptive plants or non-GM corn to increase the proportion of non-GM pollen. Cultivars with different flowering times could also be chosen.

Perennial grasses would require a different approach and so stewardship protocols could be deployed to reduce spread to extremely low levels (well below the 1% target).

These could include:

- a 150 m buffer zone (of non-receptive crops)
- controlling flowering by grazing or topping pasture
- growing a variety with different flowering dates (so that in neighbouring farms the amount of receptive plant flowers would be minimal),
- not allowing a GM ryegrass pasture to develop to full reproductive state (e.g., not producing hay, silage or baleage).
- if producing hay, silage or baleage, managing the surrounding pastures to minimise receptive flowers.

Another approach might be to develop plants which produce no pollen as Scion is developing in trees. There has been plenty of protest about so called "terminator genes" but in practice we do not save grass seed, hybrids do not reproduce true to form, and sale of modern cultivars is already covered by plant variety rights, so any supplier is paying a royalty to the developer.

In the case of the HME ryegrass, the plants require a specific fertiliser regime, and it is anticipated that any wild unmanaged volunteer plants would be at a competitive disadvantage compared to conventional ryegrass plants and, therefore, less likely to persist in the longer term. Carefully designed field trials are required to confirm this likelihood.

Can the protocols outlined above be used for outdoor development? Narrow legal definition of field trials and strict criteria for them, such as the requirement to remove all reproductive structures, would make field trials impractical in New Zealand. However, if the aim is to ensure that the GM ryegrass does not establish in New Zealand and provided the GM ryegrass has no competitive advantage, then it may be possible to consider conditional release in a way that creates an equivalent framework to field trials as they are defined overseas.

Insect pollinated crops

Insect pollinated crops such as lucerne and brassicas have a different pollen distribution pattern than wind-borne pollen and are influenced by factors such as the placement of bee hives and competing pollen sources. For example, gene flow has been detected from a single garden plant in a nearby field some 800 m away. That is, a single viable pollen could be carried some distance by insects. However, if we consider the target of <1% gene flow at the closest distance, then similar principles to gene flow for wind pollination would apply as indicated in Table 2.

We could also be informed by the MPI Seed Varietal Certification Programme requires the following minimum distances between cross-pollinating species (Table 3):

Brassicas

When using brassicas on Blue Cliffs Station for forage it is not desirable to allow them to become reproductive, thus pollen production and therefore gene flow is limited. The distance between paddocks would be easy to maintain as the hectares grown are a small proportion of the arable land area of the property. Our neighbour grows brassica seed crops such as turnips and mustard. He participates in the New Zealand Seed Crop Isolation Distance Mapping Scheme (SCID) which facilitates seed purity standards by farmers mapping the crops they intend to grow. The scheme is run by Assure Quality and is vested in the Seed Quality Management Authority of which Federated Farmers is a member. It aims for "no off types in the seed line" (a much higher standard than the one we have chosen) and has isolation distances of around 1000 m or greater, however, our neighbour has no concerns knowing that the brassicas grown on Blue Cliffs Station are used for forage. We would expect GM varieties to be no different.

Table 2 Isolation distances known to achieve <1% gene flow in various crops.

	Type of pollination	Distance (m) and degree of gene flow (%)	
Brassica Crops	Insect	50	0.02
		100	0.01
Corn	Wind	50	<0.9
Ryegrass	Wind	150	<1.0
Lucerne (alfalfa)	Insect	4	0.20
Tall fescue	Wind	150	detected
		200	not detected

Table 3 Minimum distances (m) between cross-pollinating species.

	For areas 2ha or less	For areas larger than 2ha
Grasses and herbage legumes		
To produce Breeders and Basic Seed	200	100
To produce 1st Generation Seed	100	50
Cruciferous kinds (except kale)	For all areas	
To produce Basic Seed	400	
To produce 1st Generation Seed	200	
To produce Basic Seed	700	
To produce 1st Generation Seed	400	
Kale		
To produce Basic Seed	700	
To produce 1st Generation Seed	400	

Lucerne

Lucerne is maintained in the paddock for several years, giving it the opportunity to flower. The measures needed under a good stewardship programme could include:

- a 150 m buffer zone
- management of flowering through grazing or cutting when only a few blooms are appearing (say 10%), and
- control of any feral plants or volunteers.

In addition, AgResearch's HME lucerne may also require specific fertiliser management which would make it less competitive than conventional lucerne, particularly when both are grown under optimal conditions.

The success of such a programme could be monitored through the genetic markers which are known for GM crops, such as gene promotor or novel protein sequences.

Gene editing

Monitoring plants produced using new gene editing techniques, such as CRISPR-Cas9, will not be easy. Gene editing is likely to be used extensively by plant breeders due to its accuracy, predictability and low cost. These techniques do not introduce foreign DNA and the results are often indistinguishable from organisms produced through conventional non-GM techniques such as radiation mutagenesis.

As livestock producers on Blue Cliffs Station inadvertent use of GM crops may occur, particularly as new gene edited crops are not being regulated in many of the countries where they were developed. It also means that international trade barriers, described earlier are unlikely, even to the extent they exist now.

Gene editing techniques have been categorised as genetic modification by anti-GM purists and that will be for them to grapple with. For the remainder, gene editing offers an exciting new level of plant breeding with little downside, particularly if deregulation by our trading partners continues.

Conclusion

This paper has attempted to give a perspective on the considerations necessary as farmers in our particular location if we were to use GM forage crops or grasses in our livestock system. I have tried to put this in the context of the real life situation and current market requirements.

GM is assessed on a case by case basis so the technical aspects are not detailed here, but I hope this paper will provide a "straw man" to stimulate thought and discussion on what co-existence might look like when GM crops and grasses become a reality in New Zealand.