Abstract

With the introduction of GM varieties into a crop production and supply system comes the risk that, through gene flow or co-mingling, that there is potential for some products in that supply chain to be disadvantaged in the market place if there is price or market access discrimination. If an industry such as the Australian maize industry is to access the benefits of new plant technologies and at the same time avoid losses due to compromised markets, then strict programs need to be implemented to manage product integrity.

In Australia, the maize industry is entirely based on non-GM cultivars, but overseas there is a range of new traits being introduced into maize and other crop species that potentially represent new market opportunities – insect tolerance traits, herbicide tolerance traits, nutritional traits and traits that can act as the basis for new industrial and pharmaceutical industries.

If Australia is to avail itself of these new technologies then it faces, for each crop, a formidable task to achieve the regulatory freedom to operate, a freedom that will be based upon the industry’s capacity to implement practical and economic co-existing production strategies that enable segregated supply chains to operate within defined tolerances for adventitious presence of specified materials such as genetically modified products.

Introduction

In the context of this discussion co-existence is usefully defined in a recent policy document issued by the Queensland Government (2005) as “…the ability to grow and manage along the supply chain both genetically modified (GM) and traditional (grown either conventionally or organically) crops in a way that avoids unwanted mixing and delivers products at predetermined market specifications”. Seed producers and others will be familiar with the broad requirements of coexisting supply chains that manage other issues such as varietal seed purity and specialist crops.

Before examining the detailed processes of co-existence management, it is necessary to take a wider view of issues that would need to be addressed if the commercial cultivation of genetically modified maize is to occur at some point in this country. There are four parallel paths of development that are critical if the Australian maize industry is to achieve freedom to operate status with genetically modified maize.

Involvement of a commercial seed supplier

Any move to establish genetically modified maize as a commercial crop will require one or more seed companies to be willing to invest in variety development and distribution. This would appear to pose an immediate and significant limitation, as without a supply of suitable genetically modified cultivars for use in at least the major production environments the industry cannot progress down this path.

It is noted that no work is currently underway to introduce genetic events appropriate for our maize production systems into local high performing germplasm. Since 2000 there have not been, according to the Office of the Gene Technology Regulator (2005), any applications for restricted or unrestricted releases of genetically modified maize into the environment in Australia.

Given that it is highly unlikely that cultivars with desired GM traits and capable of high performance in our environment would be identified off shore, this only leaves the industry with one way ahead - seeking to convince a seed company that has access to GM events wanted by the local maize industry to invest in introducing them into a range of elite local germplasm. Should this occur, it would then commence a process that required significant investment in research and development to incorporate these events and to undertake the field testing to identify the elite parents that would then form the basis of that new GM cultivar in Australia.
This process will take time – probably in excess of four years. The strategic weakness in this critical path is the size of the Australian maize seed industry, which may not be of a scale that warrants the level of investment needed.

Commonwealth licensing

**Licence for intentional release into the environment**

All dealings with genetically modified organisms in Australia come under the jurisdiction of the Gene Technology Regulator, who administers the Gene Technology Act 2000 (Cmth). Within that regulatory environment is the requirement that genetically modified organisms may only be legally released into the environment if licensed for that purpose by the Regulator. Licensing involves a stringent assessment process that evaluates whether the release of the genetically modified organism poses any greater risk to human health and to the environment than conventional cultivars.

Such applications for a licence are made by the technology owner, typically a seed company or plant breeding institute, and require the provision of an extensive technical case for the Regulator’s critical examination.

The assessment of a licence application requires mandated public consultation and may take nine months or more for a restricted licence, longer for an unrestricted licence.

**Licence for use in food**

The previous licensing process does not extend to approval to use the organism or its products for human consumption - that is a separate approval, granted after appropriate assessment, by Food Standards Australia New Zealand under sec 1.5.2 of the Food Standards Code. In the case of maize, the major GM events in use overseas have already been granted approval.

To seek freedom to operate with maize cultivars containing any other genetic events than those listed in the Food Standards Code would require an application to be made to FSANZ seeking approval. This assessment process also has several mandated stages and may take in excess of a year.

Compliance with state regulations and policies

**New South Wales legislation**

NSW has, under the Gene Technology (GM Crop Moratorium) Act 2003, the capacity to declare a moratorium on the cultivation of any genetically modified food plant, but to date only genetically modified canola has been the subject of such an order, an arrangement that currently stands until March 2008.

While research and development into the incorporation of the GM events into local elite maize germplasm could proceed at laboratory level with only Commonwealth approval, the subsequent establishment of research and development field trials would appear to require a case to be successfully made to the NSW Minister for Agriculture to not implement a Moratorium Order for genetically modified maize under the Gene Technology (GM Crop Moratorium) Act 2003 (NSW).

**Queensland co-existence policy**

Queensland does not have legislation regulating the cultivation of GM crops, but the Queensland Government (2005) policy document on co-existence stands as a clear statement of how that Government expects the development of GM cropping industries to proceed. This framework is established on six principles that:

- Offer freedom of choice to farmers, supply chain participants and consumers;
- Are transparent, and enable consultation;
- Are based on science and practical process management;
- Minimise impacts on others;
- Can be assessed on a case-by-case basis; and
- Can be monitored and reviewed.
With appropriate isolation precautions, field trials of GM maize would appear able to proceed in Queensland if a Commonwealth licence were to be granted for release into the environment.

**Supply chain agreement on co-existence arrangements**

*General principles of co-existence management*

The introduction of a GM production stream into an industry such as the maize industry would see the development of three categories of supply chain:

- Undifferentiated markets that do not discriminate between GM and non-GM product, and which accept unrestricted co-mingling of these products;
- Non-GM markets which accept co-mingling with GM product up to a specified threshold. This is frequently the legislated GM threshold above which labeling of food will be required to reflect its GM content; and
- Non-GM markets wanting a near zero level of GM product, guaranteed through identity preservation systems. Maize produced by organic systems is included in this category as well. Due to sampling variability, it is not technically possible to give a 100% assurance that a grain lot is 100% non-GM. Instead, a standard is used that gives a high (but not absolute) confidence that no GM was detected by a nominated analytical process. Current PCR analytical technology can detect the presence of known GM events down to levels of approximately 0.01% in grains.

Co-existence will require the development of agreed thresholds for the adventitious presence of GM traits at a few key points along non-GM supply chains, and the development of risk management strategies to enable these thresholds to be routinely met. These adventitious thresholds may be set by regulation, by industry standard or by contract. The risk management strategies, whose primary purpose is to keep adventitious presence of GM material in non-GM supply lines below the defined threshold levels, become translated into management protocols that are communicated to those in the supply chain that need to know and apply them.

At the farm level, adventitious GM levels in non-GM production arise through:

- GM seeds in sowing seed arising from cross-pollination or physical admixture in the seed supply;
- GM seeds present in seeding equipment;
- GM volunteer plants from previous crop rotations germinating in the non-GM crop;
- GM pollen ingress from neighboring GM crops;
- GM pollen ingress from feral GM plants in the neighborhood;
- GM seed present in harvesting, transport and storage equipment.

**Issues relating to maize**

Maize is a strongly out-crossing (circa 95%), wind-pollinated species (Glover 2002). It has relatively heavy pollen (Brookes et al. 2004) that, while dispersed by wind, tends to fall to ground rapidly over a relatively limited area. Separation of synchronously flowering GM and non-GM maize fields by relatively short distances of 20 to 50 meters typically results in very little pollen mediated gene flow, and the penetration of pollen into neighboring maize crops at those distances is largely limited to the near-edge rows, so that the average GM content across the whole non-GM field is usually well below 1%.

Maize does not shed seed naturally and has a limited dormancy period, so that the presence of volunteer GM maize plants after seed bed preparation for a subsequent non-GM maize crop is minimal.

Despite the commercial and regulatory challenges that face the introduction of any genetically modified crop, particularly food crops, it is encouraging that the management of coexisting GM and non-GM maize has already been addressed elsewhere with very encouraging results that would appear to be at least partly transferable to Australia.
Co-existence of GM maize in Spain

Maize is a major summer crop in Spain (April/May sowing, October harvest), where nearly 500,000 ha are sown annually, mostly under irrigation. About 20% of this is ensiled, with the remainder producing about 4.2 Mt of grain. An additional 3 Mt of maize is also imported annually from France, USA and Argentina. About 90% of locally produced maize is used for animal feed. Wet and dry milling occurs near major ports, and uses a significant quantity of imported maize. The regions of Catalunya and neighboring Aragon produce together about 26% of the Spanish maize crop. For largely climatic reasons, these two regions are the areas most infested by two species of the corn borer caterpillar, making the use of Bt cultivars attractive to the local industry.

Following EU approval for a limited range of GM maize varieties in 1998 (prior to the moratorium on granting approvals for new GM crops established by the EU Council of Ministers in 1999), Bt varieties have been made available in limited quantities to be grown commercially under industry-based co-existence arrangements in Spain, and now comprise nearly 15% of the area sown to maize. Spain, as an EU member, complies with EC Regulations 1829/2003 and 1830/2003 which prescribe that food and feed products that contain more than 0.9% genetically modified organisms must be labeled accordingly.

During this period it has been demonstrated that co-existence is possible under Spanish circumstances (Brookes and Barfoot 2004), and this has been increasingly substantiated by monitoring programs (Alcalde and Bachmann 2005), by field research into gene flow (Melé et al. 2005), and by modeling of gene flow at landscape level using tools such as MAPOD® (Angevin et al. 2001). It is now accepted in the EU that it is technically possible for GM, non-GM and organic maize to be produced in co-existence as long as appropriate practical management measures are in place (Messéan et al. 2005).

In Spain during this period all GM maize was sold through normal marketing channels to the livestock feed industry, an industry that was already an importer/user of GM soybean. There was no segregation of GM and non-GM maize, as the food and starch industry (and the small sector of the feed industry) that used non-GM maize was able to source this readily from those regions of Spain not growing GM maize. The food industry appears to arrange contract supply from areas where local cooperative arrangements are made with the end-user for a small price margin (a margin of approximately 3%, (Mariné 2005)). Production and supply are carried out to meet end-user quality requirements, including pest control, which is undertaken by the end-user at their cost to ensure appropriate choice of chemical and timing of application.

GM maize growers were provided with crop management protocols as part of their user agreement with the seed supplier (Mariné 2005). These included guidelines for separation distances to non-GM crops, the incorporation of buffer rows of non-GM maize, the management of insect resistance to the Bt trait, and above all the need to communicate with neighboring growers.

In mid 2005 the Spanish Ministry of Agriculture issued a decree that will formally regulate the handling, planting, isolation, harvest, storage, inspection and record keeping in relation to GM crops up to first-buyer stage (Ferrer 2005). This new legislation is intended to add robustness to the current co-existence arrangements, and is to be in place in time for the sowing of the 2006 maize crop.

This will dictate that farmers intending to grow GM maize:

- Notify local agricultural authorities in advance of the variety, area to be sown and site location for inclusion in a public register.
- Establish a 50 m isolation zone from any non-GM maize. Where such a separation cannot be established, the GM crop is required to have a buffer of non-GM maize, which is to be harvested and labeled as GM maize. The dimensions of this buffer are not yet finalized, but may be defined as two passes with the harvester.
- Must follow strict procedures for planting, harvesting, drying, storage and delivery. This will include the dedication of specific harvesters to GM maize, with those harvesters not to be used for the harvesting of non-GM maize.
• For resistance management reasons, where insect resistant maize varieties are sown, 20% of the area is to be sown to non-GM varieties.

• Must keep all seed labels, together with any other evidence of complying with the decree, for a period of five years.

A minimum of 5% of the area sown to GM crops will be inspected annually for compliance. During the period June to September local agricultural authorities will monitor compliance through an extensive program that will involve sampling and testing crops in the neighborhood of registered sites. At this stage it appears that the costs of compliance will be borne by the national and regional governments.

Seed for sowing non-GM crops will be required to meet a minimum threshold for adventitious GM presence. To date the EU has not set such a standard, and there is considerable speculation as to what this threshold might be.

The production of maize in organic systems is not common in Spain, and amounts to less than 0.2% of maize production (Maríné 2005). Only two claims appear to have been reported relating to the adventitious presence of GM material (Alcalde 2005).

**Key issues for introducing GM maize into Australia**

The introduction of GM maize into Australia will require a coordinated program involving several parallel streams of development. As mentioned above, the introduction of desirable GM traits into local elite germplasm has to be undertaken, and licences gained for field evaluation and subsequently for commercial use. State governments need to be fully satisfied that the industry as a whole has, and is committed to, a plan for coexistence, and this is a matter that the industry’s leadership will need to give serious attention to if it wishes to proceed towards accessing GM crop technology.

The regulatory requirements in Australia are somewhat less stringent than in the EU. In Australia, the labeling threshold for GM content is 1.0%, compared to 0.9% in the EU, and the labeling requirement in Australia only applies to food materials, and does not include a requirement to label products destined for the livestock feed industry.

The development of a coexistence plan will require the involvement of all stakeholders in the supply chain, and the Queensland Government’s framework for co-existence provides a ready made structure.

Lessons may be learnt from the Spanish experience and the extensive EU research and modeling into gene flow already undertaken, although we must also understand that in Spain only about 10% of the GM maize that is grown is done so in a co-existence situation. The remaining 90% of GM maize is grown in areas where all maize is sold to the livestock feed industry that is already a heavy user of imported GM soybeans, and where buyers do not differentiate on GM status (Brookes 2004).

There are also developments in Germany in preparation for an expansion of GM maize growing in that country. In the difficult German legislative environment that ascribes strict liability for any economic loss arising from the presence of GM material to growers of non-GM crops, the German grain trading company Maerka is implementing a pilot scheme in a region of Germany to purchase GM maize as well as non-GM maize from fields adjacent to the GM crops if produced under Maerka’s special quality assurance system. (Pohl 2005).

This system is heavily based on the adoption of defined Good Agricultural Practice, good documentation (including information about non-GM fields neighboring each GM field), segregation through separate machinery, storage and handling, and sampling/testing to identify non-conforming product.

A critical element of a coexistence plan will be the determination and agreement with end-users of practical and achievable thresholds for adventitious GM presence in non-GM maize, and how these will be formalized. Without these, co-existence cannot operate.
Other critical elements will need to ensure that:

- non-GM seed meets an agreed threshold for adventitious GM levels;
- farmers using GM understand and comply with the coexistence rules and the management protocols required to minimise gene flow to neighboring non-GM crops. This may include a variety of measures involving isolation zones, buffer rows, windbreaks, and non-synchronous flowering;
- some dedication of seeding, harvesting, transport and storage may be needed, or at least consideration given to sequencing machinery use so that non-GM applications are concluded before commencing work in GM crops. There may be a need for increased on-farm storage to increase the capacity for segregation;
- sampling and testing will be needed to ensure that co-existence is working. This represents potential added cost.

Part of any strategy for coexistence might well seek to maximize the opportunity for spatial solutions that reduce the overall risk of co-mingling in supply chains over large grain collection areas.

Research and Development organizations might well consider the merit of giving funding assistance to the modeling of pollen flow with the view to validating existing EU work against the Australian landscape and environment and to provide an improved technical basis on which to manage gene flow through good agricultural practice.

Conclusions

Australia may well be able to adapt co-existence management strategies in place in Spain and other parts of the EU.

The path to the commercial use of GM corn in Australia, however, will not be politically forward. It will be dependant on the willingness of at least one seed company to invest in Australian germplasm development, and will require industry leadership to articulate the vision, engage the stakeholders, and lead the supply chain consultative process developing practices, thresholds and supply chain arrangements.

References


