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Genetic Modification-Free Zones: Comments

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This paper is one of a collection of three related papers

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[1]A discussion paper for public consultation was released in December 2001 and an opportunity provided by the Minister of Agriculture, the Hon. Kim Chance MLC, for public comment on the potential role of Genetic Modification-free zones in the Western Australian farming system

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1. Introduction

Export Grains Centre Ltd (EGC) aims to ensure that the farmers of Western Australia have a wide choice of world-class crop varieties. Therefore EGC has an interest in technical and commercial issues that affect the availability of new varieties to farmers.

The Commonwealth Gene Technology Act 2000 covers health and safety aspects of GM crops for people and the environment. However in its matching legislation the WA Government may reserve specific areas for growing GM or non-GM crops for marketing purposes (section 21 (1) aa). The WA Gene Technology Bill 2001 (p14-15) states:

" *21. The Ministerial Council may issue policy principles*

The Ministerial Council may issue policy principles in relation to the following-

ethical issues relating to dealings with GMOs;

(aa) recognising areas, if any, designated under a law of Western Australia for the purpose of preserving the identity of one or both of the following-

- *GM crops;*
- *Non-GM crops,*
- *for marketing purposes;*
- *matters relating to dealings with GMOs prescribed by the regulations for the purpose of this paragraph.*

Before issuing a policy principle, the Ministerial Council must be satisfied that the policy principle was developed in accordance with section 22 of the Commonwealth Act.

*Regulations for the purpose of subsection (1)(b) may related to matters other than the health and safety of people or the environment, but must not derogate from the health and safety of people or the environment.***"**

GM technology has the potential to improve community health, lower environmental risks, make agriculture more sustainable and lower farm costs (1, 9). Much of the debate on GM technology focuses on perceived lack of benefits set against community concerns on effects of GM crops on the health and safety of people and the environment. The current discussion in WA is over Roundup Ready (RR) Canola;

i.e. canola varieties that tolerate the herbicide glyphosate. Liberty Link (LL) canola may also be released but Liberty is not a major herbicide of winter cropping in Australia, where as glyphosate is the predominant knockdown herbicide used in minimum tillage.

The Act quoted above makes it clear that on issues of health and safety of people and the environment the Commonwealth legislation takes precedence. However section 21 (1) aa provides the State with the power to declare where particular crop types (GM or non-GM) may or may not be grown for marketing purposes. The issue is whether it makes technical and commercial sense for the agricultural industry of WA.

This paper covers a broad based discussion of the general situation in the use and benefits of GM crops, followed by a specific consideration of the issues involved in deciding whether the declaration of GM / non-GM zones for Canola in WA is sensible and justifiable on technical or commercial grounds.

2. Background data

2.1 The total areas of GM crops grown world wide since 1996

Table 1: Total area of GM crops worldwide and % GM Canola Crop in Canada

Year	Area (m ha)	Year on Year Change (m ha)	Year on Year % change	% GM Canola Crop in Canada
1996	1.7	1.7	-	5
1997	11.0	9.3	547	21
1998	27.8	16.8	153	38
1999	39.9	12.1	44	55
2000	44.2	4.3	11	57
2001	52.6	8.4	19	63
Total	177.2	-	-	-
Mean	-	10.2	-	-

Table 1 shows that **GM technology has been and continues to be taken up at an unprecedentedly rapid** rate since it became readily available for a limited range of crops, characteristics and countries in 1996.

2.2 The major producers of GM crops in 2001

Four countries used GM technology on a large scale in 2001. They are: the USA (35.7m ha), Argentina (11.8m ha), Canada (3.2m ha) and China (1.5m ha) (2). **Three of these countries are major competitors with Australia exporting agricultural produce into world markets and the fourth (China) is a major market for Australian produce (3).**

2.3 The major crops in which GM technology has been used

In 2001 the major use of GM technology was in 4 crops, soybeans (33.3m ha), maize (9.8m ha), cotton (6.8m ha) and canola (2.7m ha). Maize and soybeans are relatively minor crops in Australia and neither is of any significance in WA (3). Cotton is important to Australia (Value 1-1.5 $billion/year) but currently is of minor significance in WA (3). Canola is an important crop Australia wide, with some 1.6m tonnes/annum production over the last 5 years (1997-2001) (3, 7). Most of the crop is exported and our major competitor is Canada (3).

2.4 The genes most frequently used in GM Crops

Herbicide tolerance is the gene most frequently used in GM Crops, followed by Bt insect resistance (1, 2.). Herbicide resistance is currently the only GM product available in Canola, and the majority of this is grown in Canada where it is grown on some 60% of the area. **There is no segregation into GM and non-GM crops in Canada** (1, 5).

2.5 General Health Issues

Since 1996 over 500 million tonnes of transgenic food and feed has been produced and, despite the StarLink fiasco, the risks from consuming GM foods that have been approved by national registration bodies for release, are no greater than consuming non-GM foods and in some cases is less. **Bt maize has reduced health risks.** Mycotoxin levels caused by fungi that gain entry to maize kernels from damage caused by the corn borer have been significantly lowered (1). There have also been very significant reductions in the amounts of insecticides and herbicides used on GM compared to non-GM crops, **reducing risks to both operators and the general public** (1, 9).

2.6 General Environmental Issues

Bio-safety, particularly in terms of the use of Bt genes and their impact on non-target insect life and the escape of any transgenes into other species are issues of concern to the general public. **The use of Bt genes has significantly reduced the amounts of insecticide used on GM crops and there has been a significant increase in both the diversity and total numbers of insects in Bt crops as compared to crops having conventional insect control using insecticides** (1). The gene flow issue for WA relates particularly to canola and is addressed in detail later in the paper and in Appendix 1.

2.6 General Benefits of Using GM Crops

In a general review of benefits of GM crops James (1) identified the following as having been scientifically established:

- Reduction in the use of pesticides
- Improved insect pest management
- Improved weed control
- Increased area of non-till and related benefits from improved soil conservation, and water quality and greater sustainability of agriculture
- Lower levels of mycotoxins in Bt corn
- Reduction in pesticide poisonings
- Improved returns to growers (for details on Canola see section on the Canadian Canola Industry, section IV 1)
- Sharing of benefits between different sections of the community, with the major benefit going to farmers, but significant benefits going to the developer, seed industry and consumers.

3. Issues Specific to Canola

3.1 The regulatory framework in Australia

The regulatory management of GM products in Australia sits under the Office of the Gene Technology Regulator (OGTR), an independent body, set up under Federal legislation, oversighted by the Department of Health and responsible to Parliament. **The key objectives of the OGTR are to ensure that the use of Gene Technology does not cause health or safety problems for people or the environment.** The OGTR liases with other appropriate government regulators to ensure that it meets its obligations to the community. It has very strong regulatory authority, backed up by punitive fines and prison options.

There is matching state legislation that in Western Australia can designate areas where the use of Gene Technology may be restricted for commercial, but not for health or environmental reasons which is covered by the federal legislation.

3.2 Benefits of Herbicide resistant to the Canadian Canola Industry

The advantages of growing herbicide tolerant varieties of Canola were assessed by the Canola Council of Canada (6) and summarised by James (1) as:

- More effective and efficient weed control – ease and flexibility of management was the key advantage cited by growers.
- Earlier seeding, access to higher yielding varieties, improved moisture availability and earlier harvesting were additional drivers in the adoption of herbicide resistant canola.
- An increase in yield of approximately 200 kg/ha equivalent to a more than 10% increase in yield.
- Cleaner harvest with less dockage for unclean grain.
- An increase in the use of minimum tillage (an increase of over 1 million ha) and a reduction in the use of summer fallow compared with conventional canola.
- Cost of weed control for the herbicide resistant canola was 40% less than for conventional canola although number of sprays increased slightly on average from 1.76 to 2.07.
- A reduction in amount of active ingredient used by 1055 t in 1997 and 6000 t in 1998.
- Fuel savings associated with growing herbicide resistant canola of 9.5m litres in 1997 and 31.2 m litres in 2000.
- An economic advantage of A43.26/ha 1999 (1) (note: 1$A = $0.509US). This equated to an economic benefit to Canadian herbicide resistant canola growers of $66 million in 1999. The ABARE estimate for 2000 was $A37/ha for those farmer using GM as compared to non-GM technology (4).

Dr. Linda Hall, an Agriculture Canada scientist visiting WA in 2000 stated at a public seminar that the use of herbicide resistance GM technology had turned Canola in Canada from a Cinderella crop into a workhorse crop.

If, as is likely the Canadian experience is repeated in WA, and the Government declares statutory GM free zones, is it prepared to compensate growers who wish to grow GM crops for the benefits forgone?

3.3. Canola in WA

In 1999 a survey of 150 WA farmers found that the reasons for including canola in crop rotations were: profitable cash crop (80%), as a disease break in crop rotations (90%) and for weed control in the rotation (73%) (7).

Canola is important to WA and the 1990's saw a rapid rise in the area planted from 16,700 ha in 1991 (8) to 909,000 ha in 1999 (3). Since then the area has fallen, to 530,000 ha in 2000 and 360,000 ha in 2001 (3, 6) and is likely to fall further in 2002. For the past three years production was 989,000; 350,000 and 360,000 thousand tonnes respectively (3, 6).

The recent reductions in area in WA are due to several things, lack of suitable varieties for medium to low rainfall areas especially as the last two years have not been favourable for Canola in these areas, concerns about dockages for oil levels below 40% in eastern areas, problems with weed control particularly Brassica weeds, the level of input costs, concerns about diamond backed moths and potential flow on rotational effects due to the high nutritional demands of canola. All of these factors tend to reduce the profitability of canola in farm rotations.

Most of the WA canola crop is exported. Thus farmers need to be able to access all the technical opportunities and benefits available to competitors if the export canola industry in WA is to thrive. If our competitors can access technical advantages (see IV 2) that provides them with approximately $A40/ha more in their gross margins (1, 4), and this is not available to WA growers either through reduced costs or better prices then the profitability of the WA canola industry will fall and with it the tonnage produced. The other benefits identified by farmers from growing canola may also be lost to the industry.

The core issues facing farmers and Government assessing the use of RR Canola varieties are: what are the implications of growing RR Canola on the price of WA canola in the world market place; what are the impacts on the costs of production and what are the impacts on yield of using GM technology. For growers who wish to remain GM free, besides the issues for farmers using GM varieties, other issues include the risks of contamination of their crops either by pollen from GM crops or from self seeded plants growing locally. Both groups also face the issue of the potential of Brassica weeds to develop resistance to glyphosate either through wide hybridisation or through mutation. These issues will be addressed in turn.

3.4. The price of GM Canola and ability to sell the crop

3.4.1. Price

There is no evidence that the price of non-GM canola is more than the price of GM canola (4, 7). There may be small niche markets (container load size) that might pay a significant premium for non-GM Canola. However in discussions with JR International, a major canola trader based in Winnipeg, and currently setting up an office in Melbourne, a premium of about $C40 / tonne is needed to make segregation and identity preservation worth while. The evidence for a high valuable niche market for canola in WA is slight and can be estimated from the area of organic canola grown. The total area of organic canola grown in WA in 2001, estimated by members of the D of A involved in canola development and organic farming (pers comm), was between 120 and 400 ha out of a total area of production of 360,000 ha (between 0.03% and 0.1% of the crop). The fact that the area of organic canola area is trivial is not surprising, the canola oil products are identical, there are major weed problems of growing canola without herbicides and the crop is very nutritionally hungry and providing adequate nutrition using organic systems on a large scale is very difficult to achieve. Any price differential is not enough to tempt many farmers into growing organic canola.

Also the major life science companies are abandoning research on the development of speciality oils as they do not expect significant premiums for these and the cost of producing them are large. Any benefits for speciality canola are likely to be on the scale of container loads and should be managed as such.

3.4.2. Marketability

There is no evidence that Canada, where segregation of product does not occur, has lost market. In absolute terms Canadian exports 1991-1995 (pre release of GM varieties) averaged 2.76 m tonnes, whereas 1996 –2000 (post release of GM crops) exports averaged 3.58 m tonnes (up 30%). The tonnage being exported to Japan (a most demanding importer) showed a similar trend for the same periods and averaged 1.86 m tonnes pre GM and 2.13 m tonnes post GM (up 15%) (3, 8).

3.5. Costs of producing GM canola

To date these is no indication of the price of GM seed or any technology fee in Western Australia. However the experience of Canada suggests that the technology is robust, and that the costs of production are similar to those for non-GM crops ($A317/ha for GM v $303/ha for non-GM)(4).

3.6. Yield and profitability of GM v non-GM Canola

The Canadian experience in 1999 and 2000 suggests advantages in profitability for GM crops of about $A40/ha (1, 4). This comes from increased yields and fewer dockages. Until GM crops are grown in WA it is not possible to compare yields and returns for local farmers, but there is no reason to expect that the situation will be significantly different from the Canadian experience and yield increases may be much better in WA. Triazine tolerant (TT) varieties are not used in Canada and so the yield of non-GM varieties in Canada is not reduced by some 15% due to TT yield drag (7). **Therefore yield potential is likely to increase dramatically with the release of the new RR varieties that replace TT varieties.** Yields will surge further as F1 hybrid RR varieties are introduced. These factors are likely to increase the profitability of WA canola growers. Profitability for Monsanto requires profitability for WA farmers.

3.7. What is the situation for growers who wish to remain non-GM?

There are two components to this question, what are the effects of farmers who grow GM canola on the delivery status of their neighbours who grow non-GM crops and what are the implications post farm gate on keeping the crops separate.

3.7.1. Pollen movement from paddocks of GM canola

The key issues in the first component relate to pollen movement and the impact of self-sown canola in stubble paddocks or on roadsides. The paper "Genetically modified canola in Western Australia: Industry issues and information" (7) carries a paper by Dr .M Rieger (Attachment 1) on pollen movement from canola crops under Australian conditions. Figure 2 of that attachment plots the level of outcrossing on a per paddock basis (mean of 3 values per paddock, closest, intermediate and furthest from the pollen source) for some 62 paddocks at various distances from the pollen source paddocks.

I have divided the number of observations in Figure 2 of Rieger's paper on percentage of tolerant seedlings per paddock into a series of cells based on the distance from the pollen source and different levels of out crossing. The results are presented in Table 2.

Table 2: Number of times that outcrossing, at different levels, was detected per paddocks at various distances from a pollen source (data from Rieger, in Attachment 1, Figure 2, Reference 7)

Distance from pollen source (m)												
Level of out-crossing (%)	0	500	1000	1500	2000	2500	3000	3500	4000 >4500		No of times Out crossing detected	% of times Out crossing detected
	500	1000	1500	2000	2500	3000	3500	4000	4500			
>0.08	0	0	0	0	0	0	0	0	0	0	0	0
0.06 - 0.08%	0	0	1	1	0	0	0	0	0	0	2	3.2
0.04 - 0.06%	0	2	1	1	0	1	0	0	0	0	5	8.1
0.02 - 0.04%	4	0	1	0	0	0	0	0	0	0	5	8.1
>0 - 0.02%	12	3	5	2	3	0	0	0	0	0	25	40.3
0%	10	2	4	4	3	1	0	0	1	0	25	40.3
Total	26	7	12	8	6	2	0	0	1	0	62	100

Note that no outcrossing was detected at distance of more than 3000m, from inspection of Figure 2 the distance was much closer to 2500m.

Using the levels of outcrossing observed in the Table together with their frequency I have calculated the effect of a farm growing GM Canola on its immediate neighbours to estimate the "ultimate worst case" contamination situation and the "average worst case" situation in terms of the expected level of GM seed in material harvested from the neighbours non-GM paddocks. I have examined the implication of this for delivery of grain and on the level of GM seed in self saved seed.

In both the "ultimate and average worst case" situations the GM crop was grown around the edge of the GM property, so that in all directions the distance between the GM crop and the neighbours' boundary is minimised. At the same time the neighbours all grew their non-GM canola crops in paddocks adjacent to their neighbours GM crop. This situation is highly unlikely in practice but allows examination of the "worst case" situations. Details of the calculations are given in Appendix 1.

The outcome of **the "ultimate worst-case" scenario is that the maximum level of outcrossing between the GM and non-GM crops would be 0.07%** (the highest level detected, but this occurred only once out of the 62 observations by Rieger (1)). The "average worst case" scenario takes account of the frequency of the different levels of outcrossing observed by Rieger (% of times outcrossing detected column in the table above). In this situation **the level of outcrossing from the GM to the non-GM canola crops would be reduced from 0.07% to 0.013% a five fold reduction**. Both cases are well below the levels of the best detection systems currently available (7, attachment 4) and **one and two orders of magnitude respectively less than the EU and Japanese proposed adventitious level of GM presence in non-GM products of 1%** (1).

At distances greater than 2560 m no cross-pollination was detected. With the sampling system used by Rieger (7) this equates to an upper limit for cross-pollination of less than 0.0003% at 2560m. When the size of WA grain farms, road and other reserves and rotational limitations on growing canola are taken into account, the impact in one year of a farmer growing a GM canola crop on the level of transgenic seed in non-GM grain delivered by a neighbour are vanishingly small and several orders of magnitude below the proposed EU/Japanese adventitious level of 1% for accepting non-GM canola. **On the basis of delivery of non-GM grain there is no commercial case for declaring GM free zones.**

3.7.2. Saved seed

The next issue is what is the impact of retaining non-GM seed when a neighbouring farmer has grown a GM crop closer than 2.56 km from the seed crop in a previous year?

If clean seed is needed, then with a little care and discussion with neighbours it should be possible on WA grain farms to grow seed crops at more than 3000 m from a neighbour's GM crop. **The seed needed for 350ha is about 1.5 tonnes and even in low yielding situations would only require 2ha to grow.**

The Hardy-Wienberg law states that in situations of no selection, the gene frequency will remain constant in a population over generations. **The level of the RR gene in the seed will not increase unless there is a selective advantage for the RR gene**.

3.7.3. Self sown seed in stubbles and on roadsides

A selective advantage would occur if stubbles from a previous canola crop are sprayed with glyphosate, any self-sown canola carrying the RR gene is selected and all other canola plants would die. It is important that canola stubbles are handled in such a way that this does not occur. Several options are available to do this, eg: use alternative herbicides that kill canola, cultivated the paddock or return the paddock to pasture and graze heavily.

Alternatively a farmer might spray a canola crop or stubbles containing a very low level of RR plants from natural cross-pollination to increase the percentage of RR plants from their maximum worst-case level of 0.07% to a very high frequency. This was the basis of a recent court case in Canada where a farmer claimed that RR pollen had contaminated his crop. The judge found that the only way the level of contamination claimed on his farm was possible was from positive selection. The farmer had done this so that he did not have to pay Monsanto a technology use fee; basically he stole the technology. He also duped the Greens movement to support him, and obviously they and the legal team did not appreciate the implications of the Hardy-Wienberg law on the farmer's case.

Another source of GM pollen is from self sown GM plants in laneways and on roadsides. These do not provide a mass pollen source, such as occurs from paddocks of GM canola, but rather a very sparse and infrequent pollen source. Their impact on paddocks of non-GM canola, unless selection is applied will be negligible and significantly less than the case outlined for pollen movement from GM crops in IV 7 A outlined above.

The issues raised above on pollen movement are all within the control of the farmers involved and with care will be reduced significantly below the "average worst case" or eliminated. **Their impact will not raise the level of contamination by GM of non-GM crops to anywhere near the level of adventitious contamination proposed by the EU and Japan**.

With the use of identify preservation and/or quality assurance schemes on farm to manage the already incredibly low biological and farm management risks, then **there is no commercial case for declaring GM free zones** on the basis of risks associated with retained seed, self sown canola in stubble paddocks or road side individual plants.

3.8. The development of RR resistant Brassica weeds

3.8.1. Related domesticated types

Attachment 2 of Reference 7 is a paper by Dr. P Salisbury on “Potential gene flow from Canola (Brassica napus) to other cultivated Brassica species and to weed species”. This reviews the current understanding of the crossing risks to near relatives of Canola. There are risks of crossing between near canola crop relatives such as B. rapa (Both crop and vegetable types), B juncea (Both crop and condiment types) and B. napus (Both forage and crop types). This is only a risk when these crops are grown near by and flower at the same time. The risks are significantly less than those considered for contamination between GM and non-GM crops of Canola in section 7 above. For many combinations they are zero as canola and vegetable Brassica crops are not grown in the same regions and/or season as canola. If farmers are growing other Brassica species as well as canola, and the non-canola Brassica seed is bought in each year (the usual case), then there is no risk of carryover from any chance crossing that might occur.

3.8.2. Canola relatives that are weeds

The risks of out-crossing to canola relatives that are weeds (eg Raphanus raphanistrum, Wild radish; Hirschfeldia incana, Buchan weed; and Sinapsis alba, Charlock) are very low and the risks of further integration into the weedy species are significantly lower again. However the risks are not zero. There is therefore a very small risk that the RR gene could move from Canola to its wild relatives.

However at the same time there is also a significant risk that glyphosate resistance will develop naturally in Brassica weeds from natural mutation and selection. Such resistance has already evolved in wild radish to other herbicides and in ryegrass has evolved to glyphosate. This is a natural process and occurs whenever a biological system is altered. In agriculture for example, changing from cultivation to minimum tillage changes the weed, disease and pest spectrum affecting crop production. The issue here is will resistance develop quicker by crossing from RR canola or from minimum tillage systems using glyphosate on paddocks pre plant? The modelling evidence of Dr A. Diggle of the Western Australian Department of Agriculture suggests that it will take at least 7 cycles of growing canola (28 years) for cross pollination to provide a significant herbicide problem in wild radish, whereas the work of Prof. S Powells also suggests that 7 cycles of herbicide use is sufficient for herbicide resistance to evolve naturally.

Either way farmers must manage the development of herbicide resistance in weeds by rotating herbicides, if they do not they will loose their efficacy. **This is not a GM v non-GM issue but a herbicide management issue for all crops and crop types**.

Herbicide resistant weeds are an on-farm issue as crop weeds are weeds of disturbed land. Should glyphosate resistance occur in weedy Brassica species, this will be important for farmers but not for the environment as Brassica weeds are poorly adapted to undisturbed natural environments. Also glyphosate is not likely to be used in these situations and so no selective advantage is available to weeds carrying glyphosate resistance.

On the basis of the arguments developed here on gene flow between species **there is no commercial case for declaring GM free zones.**

3.9. Post farm gate issues:

Post farm gate issues are further from my level of expertise, and only some general comments are appropriate.

The key issue in grain handling is to keep different products separate and that appropriate procedures and monitoring systems are in place to ensure this. However the cost of these systems must be significantly less than the price advantages gained from them or the over all profitability of the industry will be reduced. Canadian experience, quoted above, suggests that the premium needs to be significant ($C40/t) to be worthwhile.

The advantages from the use of GM canola, as demonstrated in this paper and elsewhere (1, 7) are many and have been estimated to be worth some $A40/ha to our Canadian competitors who are using this technology in the world market. It does not make commercial sense to significantly increase our marketing costs for short term political reasons and at the same time deny the option of using this technology to sections of the farming community by declaring GM and GM free zones. **There is no commercial case for declaring GM free zones** post farm gate, this will increase costs to an industry that is already at a significant cost disadvantage to its major international competitor.

4. Conclusions

If Canadian experience is replicated in WA, there will be very significant cost savings for farmers using Genetically Modified (GM) canola. Economic studies show farmers are the major beneficiaries of GM technology; also significant benefits went to the community and providers of the technology.

- There is no indication of any significant price or marketability benefit from segregating GM and non-GM canola.
- There are likely to be major costs and no compensating price increases from segregating non-GM and GM zones and maintaining separate pools post farm gate to the detriment of all growers.
- Growing GM crops next to non-GM crops will not impact on their marketability as, even in the high unlikely “worst case” scenario discussed here, the level of contamination by GM pollen is at least one and more likely several orders of magnitude less than the adventitious level of 1 % of GM in non-GM product proposed as the Japanese and EU standard.
- Without legislation, good identity preservation and quality assurance will allow farmers to provide non-GM grain, if it makes

commercial sense to do so.

- Gene flow from Canola to other species is an on farm and environmental issue, not a commercial one. It comes under the Commonwealth Act and the OGTR.
- In its commitment to public consultation the Government of Western Australia has asked stakeholders for their views on this legislation. This paper addresses one aspect, namely the commercial impact of legislated GM free zones.

The paper concludes that **there is no commercial case either on a production, handling or marketing basis for declaring GM free zones.**

Is the Government prepared to compensate growers for losses related to their being in a GM free zone?

It is much more sensible to let the market, rather than the regulators, decide how much and where GM and non-GM crops are grown.

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5. Attachment 1

The Method of calculating the level of transgenic grain delivered in the "*Ultimate worst case*" and the "*Average worse case*" scenarios discussed in section IV.7

The farms:

The size of farms is 2000 ha, and square in shape having sides of 4.472 kms.

The GM canola growing farm had non-GM canola growing neighbours on the E and W boundaries that were immediately adjacent and on the N and S boundaries the neighbours are off set 50%. This means that 6 neighbours have boundaries immediately against the GM farm. In the case of the 2 E/W neighbours the joint boundary is 4.472 kms long, and half that for the 4 N/S neighbours

Farming systems:

Each farm has 70% under crop (1400ha) and crops canola on 25% (350ha) of the cropped area. This is the maximum area possible on a 1:4 rotation to minimise the risk of a blackleg epidemic.

Geographical distribution of the Canola crops:

The GM farmer at the centre of the non-GM growers grows his 350 ha of GM canola along his boundary fence in a strip 205 m deep. This minimises the distance between his GM crop and any non-GM canola his adjacent 6 neighbours might grow.

The 6 adjacent non-GM growers all grow their canola crops along the boundary with their GM canola neighbour. The 2 E/W neighbours plant in a configuration 4.472 km NS along the boundary and 0.783 km E/W into their properties. The 4 N/S neighbours plant 2.236km along their E/W boundaries and 1.566 kms N/S into their properties.

This over all configuration masses the non-GM canola crops of the neighbours along the boundary fence line of the farm where the GM crop has been planted. This configuration is highly unlikely in practise. Even if it did occur it would only be a 1:4 year event because of disease limitations on rotational options.

Calculation of the "*Ultimate worst case*" and the "*Average worse case*" scenarios:

From the table on p9 it is seen that the highest level of out crossing detected by Rieger was 0.07%. This occurred on two out of 62 occasions (3.2% of the time). In the ultimate worst case scenario this was assumed to be the level of outcrossing that occurred in all directions and independent of distance i.e. all the neighbours' non-GM canola crops had this level of outcrossing evenly over their whole farms.

In fact as you might expect from directions of prevailing winds, local topographic effects, distance from the pollen source, different times of flowering due to varietal or planting date effects etc., the observed level of outcrossing differed with distance and paddock.

Nearly all the observed levels of out crossing were less that 0.07% (96.8% of the time) and were often very low (0.01% or 0 both occurring 40% of the time).

Because we know the level of outcrossing and its frequency it is possible to weight the level by the frequency to obtain the "average worst case" scenario.

In 100 t of non-GM canola, pollen flow would cause

3.2 t to contain 0.07% GM canola from pollen = 0.00224 t GM

8.1 t to contain 0.05% GM canola from pollen = 0.00405 t GM

8.1 t to contain 0.03% GM canola from pollen = 0.00243 t GM

40.3 t to contain 0.01% GM canola from pollen = 0.00403 t GM

40.3 t to contain 0 GM canola from pollen = 0.00000 t GM

Total GM in 100 t = 0.01275 t GM

This turns out to be 0.01275%, or less than 1/5 of the level for the "ultimate worst case" scenario.

It should be noted that in reality the levels of outcrossing are likely to be significantly less than this as the arrangement of paddocks of GM and non-GM crops used to calculate these two worst-case scenarios is highly improbable. Also at distances greater than 2560m Rieger did not detect any out crossing. On the 2000ha farms modelled here an area of more than 850 ha on each property will be more than 2560 m from their neighbour's GM crop and the GM neighbour will not be growing his crop around the perimeter of the farm. This discussion does not take into account the decisions of more distant neighbours on growing GM or non-GM crops as the impacts are negligible.

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