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Genetic Engineering: Policy and Science since the Royal Commission: Insoluble Problems

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Summary of Analysis

Relevant new evidence has appeared since the Royal Commission on Genetic Modification (RCGM) delivered its report. The report was deficient in its expectation of what further research was likely to uncover or how events would unfold.

There is growing recognition that some of the general problems that were raised in criticism of the use of GE organisms, especially as crops and in food, are more serious than initial enthusiasm for the technology, and the Report of the RCGM, would have indicated. Recent international scientific reports have renewed scepticism concerning assessments of the safety of GE food and of the effects of GE crops on agricultural and natural ecosystems.

The RCGM downplayed evidence expressing concern of inevitable contamination of conventional crops if GE crops were allowed to be grown in New Zealand. The RCGM expressed no overriding concern about the inability of scientists to assess the risk of unexpected effects caused by genetically engineered organisms in the environment, or devise ways to manage the harm eventuating from them.

Recent experience with seed imported from the North America to New Zealand has demonstrated the wide extent of GE contamination in grain and seed stocks in that region. The contamination of non-GE crops due to outcrossing from GE crops can no longer be regarded as a potential problem that ought to be mitigated. Whenever GE crops are grown or harvested near non-GE crops, contamination seems inevitable. There is growing recognition that seeds can be carried long distances on farm machinery, and by other means, to cross with relatives, making the containment of transgenes virtually impossible.

The RCGM served the interests of GE industries by refusing to endorse a GE-free policy under which the normally accepted level of contamination would be set at zero.

The RCGM recommended that the precautionary threshold for releasing genetically engineered organisms into the open environment in New Zealand should be lowered. Establishing the category of Conditional Release will create new opportunities for GE-based agriculture while effectively ensuring that the opportunity of maintaining the current GE-free status of enterprise will be lost.

Conditional Release will require the public to accept involuntarily the possibility of an increasing level of GE material in some foods, even when they are certified organic or GE-free. The final effect of new legislation will be to establish a more permissive regime for the growing of transgenic species in the open environment.

Summary of New Opinion

The report of the Expert Panel on the Future of Food Biotechnology of the Royal Society of Canada recommended adoption of a much more precautionary approach to the approval of GE crops than that of the RCGM. The Panel also expressed serious concerns about the undermining of the scientific basis for risk regulation due to growing conflicts of interest within the scientific community.

The Lancet warned of the possible undesirable effects from GE crops stating that they may threaten biodiversity, decrease the richness and variety of foods, and make farmers dependent on chemical and biotech companies. Health concerns mentioned were allergenicity, gene transfer, especially of antibiotic-resistant genes, and the movement of genes from GE plants into conventional crops.

A report by the Royal Society (UK) said that the way genetically-modified food is tested for safety in Europe must be improved before any new GE plants are declared fit for human consumption.

American Scientist has published a review warning of the difficulties in measuring the risks of possible environmental impacts, including increased reliance on herbicides, the creation of new pests, harmful effects on non-target species and the disruption of ecosystem processes.

Summary of New Reports and Findings

- Initial results from very large farm trials of GE crops conducted in the UK confirm that there are all sorts of secondary effects generated when apparently minor genetic modifications are made to plants.

- Potatoes engineered to deter one pest have been found to attract another, demonstrating the virtual impossibility of taking account of all of the ecological consequences of making small changes in the biochemistry of an organism.

- In India, GE cotton under drought conditions has been a failure relative to non-GE cotton.

- Five years after authorities exempted the coat protein of the Papaya Ringspot Virus from restrictions on its production in GE fruit, new bioinformatic screening techniques show that it is a potential allergen.

- Roundup Ready soybeans contain DNA that its creators did not know they had introduced into it.

- A British study has reported GE material found in honey two miles away from GE crops.

- Traces of genetically modified grains, especially soybeans and corn, are repeatedly creeping into US wheat supplies. Similar problems are surfacing in Australia.

- A biotechnology firm failed to follow US government regulations for the containment of corn that had been engineered to produce a pig vaccine. As a precaution, 63 hectares of nearby corn were ordered destroyed, as were about 10 tonne of harvested soybeans.

- UK farm trials of GE crops were suspended for a time after it was discovered that illegal GE canola had been mixed with other GE crops grown in 14 fields in England and Scotland.

- A study has shown that genes move reasonably readily from wheat to jointed goatgrass, a major weed in wheat-producing areas of western US.

- Weeds that have acquired stacked resistance to more than one herbicide have been reported in Canada.

- Experimental studies confirm that genes passing from crops to weeds can persist for generations, rather than disappearing quickly due to the lack of any positive selective pressure.

- Commercial transgenes, or parts of them, have found their way into native maize in remote locations of Mexico.

- A theoretical study of the effects of specific novel genes in crops shows how wild plants are threatened by gene flow from crops.

- The direct transfer of genes from bacteria to mammalian cells has been demonstrated.

- The natural trafficking of genes between chloroplasts and nuclei has been found to occur rapidly, scotching one of the methods proposed to contain plant transgenes.

- In the past seven years, several weed species have been found with Roundup resistance.

- Differences have been found in soil microbial communities around GE canola and conventional canola.

- It has been found that some Bt-resistant insects are actually able to digest and utililise the toxin protein, potentially increasing the fitness of resistant populations.

- At low toxin levels Bt-resistance is inherited in a codominant or weakly codominant rather than recessive fashion, making refugia potential liabilities rather than assets.

- According to US government figures nearly one-fifth of farmers in the midwest are ignoring federal rules concerning refugia.

- The Bt toxin exudes from the roots of plants and accumulates in soil, and retains insecticidal activity for at least 6 months, bound to particles in the soil.

- Bt corn, especially one that expresses toxin at high levels, appears to damage non-target monarch and black swallowtail caterpillars in the wild.

Conclusion

Continuation of the moratorium on applications for the release of genetically organisms into the environment of New Zealand is probably the only way to preserve our opportunity of remaining virtually free of contamination and other problems associated with GE crops.

Introduction

Since the Royal Commission on Genetic Modification (RCGM) delivered its report[1] in July 2001, relevant new evidence has appeared on the national and international scenes. Much of it is the result of ongoing research and experience gained concerning the effects of genetically engineered (GE) crops. Some of the evidence comes from new scientific findings. It is now possible to evaluate the analysis, conclusions and recommendations of the RCGM, as well as the adequacy of recent government reports and decisions, in light of more complete information.

The scope of the RCGM was unusually broad, making it virtually impossible for the Commission to validate all of its judgements with the rigour expected by experts in any one field, especially molecular biology or environmental science. The outcome was that the judgments in the RCGM report were slanted according to how much sympathy the Commission found with different participants in the enquiry. The Commission had to decide whose predictions to trust when it guessed what was likely to be thrown up by future findings in various fields. In respect of future scientific findings the Commission seems to have relied on the optimistic projections of those eager to promote uses of genetic engineering as minor modifications of established activities.

Subsequent to the report of the RCGM, government departments have been given the task of devising procedures for implementing its recommendations. Most of the burden of deciding how to modify the rules governing the growing of GE crops has fallen on the Ministry of Agriculture and Fisheries (MAF). MAF's evaluations of the consequences of GE agriculture in New Zealand have done nothing to diminish the dominance of industry interests.[2] This has now flowed through into Cabinet Decisions[3] whose final effect will be to establish a more permissive regime for the growing of transgenic species in the open environment.

Implementation of one of the central recommendations of the Commission, the establishment of a category of Conditional Release,[4] requires that the public accept involuntarily the possibility of an increasing level of GE material in some foods, even when they are certified organic or GE-free. MAF has provided Cabinet with a novel legitimation for allowing the planting of transgenic crops that will make this outcome inevitable: contamination of organic crops from nearby GE crops is just like spraydrift;[5] it is bound to happen to some extent, so we may as well adjust to it now and then allow it to happen in a managed fashion.

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[1] Report of the Royal Commission on Genetic Modification, Report and Recommendations, (Printlink, Wellington) 27 July 2001. **Unless otherwise stated, references are to this document.**
[2] "Government Response to the RCGM: Report on Managing the effects of GM organisms and coexistence of primary production – Paper 1: Overview"; "Paper 2: Practicalities of Specific Issues", Office of the Minister of Agriculture
[3] "Government Response to the RCGM: Legislative Changes For New Organisms: Paper 1: Overview", POL Min (03) 8/6; "Paper 2: Practicalities of Specific Issues" POL (03) 8/7; "Paper 4: Conditional Release and Enforcement", CAB Min (03) 4/3;
[4] p125, Recommendation 6.8
[5] MAF Paper1 (Ref 2), p2, para 8

In this short survey, we discuss the results of studies and assessments that post-date the Report of the RCGM. We find the report to be deficient in its expectation of what further research was likely to uncover or how events would unfold; and that the government, especially MAF, has been uncritical in its determination to continue satisfying the desires of the powerful economic sectors in whose favour the RCGM decided: industries wanting freedom to move into the use of GE organisms in the open environment of New Zealand.

Regulatory Changes

The only really practical consequence of the RCGM's overarching approach to "preserving opportunities" was the recommendation that the precautionary threshold for releasing genetically engineered organisms into the open environment in New Zealand should be lowered. [6] A new enabling mechanism, designated Conditional Release, was devised by the Commission, details to be worked out on a case-by-case, location-by-location basis involving new procedures to be developed by the Environmental Risk Management Authority (ERMA) and the Ministry of Agriculture and Fisheries (MAF), and perhaps local authorities.[7]

The point of establishing a category of Conditional Release was to make it possible to introduce genetically engineered organisms into at least a part of the New Zealand environment without putting an applicant to all of the bother of proving that the organism is so completely safe that there could be no significant effects from it being grown absolutely anywhere, which is what would be allowed in the case of full Commercial Release. This was the RCGM's way of creating new opportunities for GE-based agriculture while effectively ensuring that the opportunity of maintaining the current GE-free status of enterprise would be lost, especially for organic farmers and others who regard the current status as a strategic asset. The RCGM was quite clear about what GE release, even Conditional Release, would mean but reassured us that "timely monitoring … will increase the ability to … repair any damage quickly".[8] MAF was then given the job of working out how the fallout from GE plantings could be managed and has now suggested a number of measures that it regards as appropriate, including the use of existing communications networks and mediation services to smooth pathways and settle disputes.[9]

The thrust of the approach adopted by the RCGM and later MAF was the same as that whereby ERMA administers the Hazardous Substances and New Organisms (HSNO) Act: the environmental effects of releasing GE organisms can be managed. All that is needed better to mitigate any deleterious outcomes are updated procedures for management. The Commission believed that GE organisms can be contained, even after they have been conditionally released, or at least that any breach of containment would be such a minor imposition that the public should just have to

[6] Ch 13, p331-340
[7] pp123-5, para 96-100; p125, Recommendation 6.8
[8] p336, para 33
[9] p177, Recommendation 7.7; p339, Recommendation 13.2

bear it so that industry can preserve its opportunities. MAF's new procedures aim to keep conditionally released GE crops relatively separate from others but the overall approach is to minimize adverse effects, not to make restrictions so stringent that prevention of adverse effects would be guaranteed.

In reaching its conclusions the RCGM had to form a view of the extent of the effects that would be likely to arise from releasing GE organisms into the environment. In coming to its judgment, the RCGM went back over much of the ground that had been covered previously in ERMA's deliberations over applications for field trials and the commission reached conclusions consistent with the way ERMA has always ruled. The main conclusions were:

(i) horizontal gene transfer is so rare that the likelihood of transgenes from GE crops finding their way into other species can be made so low as to cause no concern;[10]

(ii) pollen movement is so restricted that GE crops can be grown inside buffer zones without affecting other crops.[11]

There was implicit recognition of the possibility of HGT into soil bacteria and this is now the subject of government-funded research, but lack of knowledge in this area was not seen as any reason for stringent measures such as a moratorium on depositing any transgenic material in soil.[12] The RCGM recommendation was concerned only with possible effects of genetically modified trees on soil.[13] There was also explicit concern about the transport of pollen by bees on account of honey producers' desire to maintain their GE-free status.[14] This problem has now been given consideration by MAF with the likely result that apiarists will be able to find out where GE crops are being grown, putting the onus on them to avoid contamination by appropriately siting their hives.[15]

The RCGM decided that it would be acceptable to impose certain effects on the public in conflict with what GE-free groups want. Although the RCGM was careful not to spell out its conclusion, it accepted that some degree of contamination in crops and food will be a virtually inevitable result of granting some industry wishes. This is the approach that has now been adopted by the European Union, where up to 0.5% of unauthorized GE content is allowed in food, provided that the offending organism has been assessed as risk-free.[16] The Commissioners seem to have had the feeling that contamination could be kept at a level that any reasonable, properly educated person would think is totally insignificant. Dismissing evidence that any significant adverse effects are at all likely to arise, the RCGM backed the case-by-case release of GE organisms on a basis that the whole process can be and will be properly managed by authorities such as ERMA and MAF.

The RCGM had such certainty that adverse effects arising from even Conditional Release could be kept to an insignificant level that they did not recommend the

[10] pp49-53, para 29-41; p57, para 54-57; p53 "Kaatz's Bees"
[11] p145, para36-37; p177, para 155-158
[12] p133 para 144
[13] Recommendation 7.4
[14] pp151-152, para 59-63
[15] MAF Paper 2 (Ref 2), pp5-7, paras 20-30
[16] BRIDGES Trade BioRes, Vol. 3 No. 13, 11 July 2003, http://www.GEinfo.org.nz/072003/04.html

application of the Precautionary Principle.[17] While calling their approach "precautionary", the RCGM did not see any need to follow the essential premise of the Precautionary Principle: that residual uncertainty is no reason for postponing measures to mitigate potential harm. It was recommended that any residual uncertainty should be addressed by further research, not by measures that would restrict industry.

The new MAF procedures will not address the problem of possible unexpected effects, the outcomes of which we are most uncertain. The mitigation of such effects is the responsibility of ERMA in setting the conditions for release. What MAF is concerned with are specific questions of how standards of regulation and certification can be adjusted to allow selected GE organisms to coexist with established agricultural production and the natural environment. Much is made of the fact that current rules of certification for organic production neither allow nor exclude unintended contamination with material from GE organisms. This was supposed somehow to prove that being totally free of GE material is not an overriding concern for organic farmers.[18] On that basis, contamination resulting from Conditional Release is compatible with standards for organic production, even if it is regarded as an undesirable outcome. All we have to decide is what level of contamination should be regarded as harmless and the 1% level allowed in non-GE food by the Food Standards Australia New Zealand (FSANZ) and in non-GE seed by the European Union (EU) are cited as indicative of what could be approved.[19] This had already been signalled by the RCGM in a quotation from a Life Sciences Network witness: "to ensure successful coexistence of organic and GMO canola crops, all growers need to accept similar standards of purity to those currently used for canola seed production worldwide, allowing, for example, a threshold of up to 1% off-types".[20] A South Australian Parliamentary Committee is holding up any commercial release in that state until it is proven that co-existence of GE and non-GE crops is actually possible.[21]

New Reports and Findings

During the last two years a number of reasonably general reports or expert opinions about genetic engineering have been published expressing or advising the need for more caution. This trend is exactly the opposite of what the RCGM seems to have expected: that sound regulatory practice and experience would, perhaps slowly, begin to settle more generally the outstanding questions and concerns as they arise case by case. Quite the contrary appears to have happened in the period since the

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[17] Principle #15 of the 1992 Rio Declaration on Environment and Development. The Rio Declaration Precautionary Principle states: In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

[18] MAF Paper 1 (Ref 2), p8, para 32

[19] MAF Paper 1 (Ref 2), pp5-6, paras 20-22

[20] MAF Paper 1 (Ref 2), p10, para 37; p6, para 21

[21] "Co-existence bar 'set very high' in SA", ABC News, July 18, 2003, http://www.GEinfo.org.nz/072003/05.html

RCGM reported. There is growing recognition that some of the general problems that were raised in criticism of the use of GE organisms, especially as crops and in food, are more serious than initial enthusiasm for the technology, and the Report of the RCGM, would have indicated. And now, even after all of the examination and regulation that has been brought to bear in an effort definitively and completely to characterise the GE flagship crop, Roundup Ready soybeans, it turns out that the plant contains DNA that its creators did not know they had introduced into it.[22]

The 261-page report of the Expert Panel on the Future of Food Biotechnology of the Royal Society of Canada[23] became available while the RCGM was still in progress, but only very limited reference was made to it in relation to a single topic.[24] The more general conclusions and recommendations were ignored. The report of the Canadian Panel makes a number of recommendations that display far greater scepticism and caution than the point of view adopted by the RCGM. In particular, the Panel expressed serious concerns about the undermining of the scientific basis for risk regulation in Canada due to a number of factors, including "the extensive and growing conflicts of interest within the scientific community due to entrepreneurial interests in resulting technologies and the increasing domination of the research agenda by private corporate interest".[25] The situation in New Zealand is no different in this respect from prevailing conditions in Canada, but the RCGM paid scant attention to the problem and provided no basis for a pertinent recommendation addressing the problem.[26] In regard to the general problem of a precautionary approach, the Panel recommended that, "where there are scientifically reasonable theoretical or empirical grounds establishing a *prima facie* case for the possibility of serious harms to human health, animal health or the environment, the fact that the best available test data are unable to establish with high confidence the existence or level of the risk should not be taken as a reason for withholding regulatory restraint on the product".[27] This is entirely contrary to the approach adopted by ERMA and backed by the RCGM. Further, the Panel recommended "that Canadian regulatory agencies and officials exercise great care to maintain an objective and neutral stance with respect to the public debate about the risks and benefits of biotechnology in their public statements and interpretations of the regulatory process"[28] and called for "a review of the problems related to the increasing domination of the public research agenda by private, commercial interests, and make recommendations for public policies that promote and protect fully independent research on the health and environmental risks of agricultural biotechnology".[29] In contradistinction to this attitude, the RCGM put no further onus of responsibility on scientists and concluded with mention of testimony to the effect that possible lack of scientific integrity posed

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[22] 'Characterisation of the Roundup Ready soybean insert', European Food Research and Technology, 213:107-112 http://www.biotech-info.net/mystery_DNA.html (New York Times, 15 August 2001) http://www.biotech-info.net/RR_DNA_Belgium_study.html

[23] Expert Panel on the Future of Food Biotechnology of the Royal Society of Canada "Elements of Precaution: Recommendations for the Regulation of Food Biotechnology in Canada", January 2001

[24] pp225-226, paras 160-168

[25] Canadian Panel (Ref 23), page ix

[26] p64 para 77-80

[27] Canadian Panel (Ref 23), Recommendation 8.3, page x

[28] Canadian Panel (Ref 23), Recommendation 9.1, page xi

[29] Canadian Panel (Ref 23), Recommendation 9.4, page xi

no significant problem.[30]

The scope and style of the Canadian report indicates that the RCGM failed to go to the core of the problems that genetic engineering poses for New Zealand society *as it actually functions currently*. Instead, the RCGM left established power relationships in place while the concerns of the non-expert public, whom the RCGM was supposed to serve, were set aside. Favour was shown toward those, many of them experts, who have the prospect of extracting some sort of gain from the intrusion of GE products into our national systems of agriculture and food production. The government is now continuing down that path, bolstering up the position adopted by the RCGM as if it were the expression of an ultimately precautionary approach in line with all reliable scientific opinion. However the position of the RCGM no longer finds itself at the happy centre of the spectrum of attitudes to GE.

A recent expression of expert opinion, an editorial in the leading British medical journal *The Lancet*,[31] warned of the possible undesirable effects from GE crops stating that they "may threaten biodiversity, decrease the richness and variety of foods, and make farmers dependent on chemical and biotech companies, through the use of sterile seed or chemical products that would have to be purchased yearly". In addition health concerns mentioned were "allergenicity; gene transfer, especially of antibiotic-resistant genes, from GM foods to cells or bacteria in the gastrointestinal tract; and 'outcrossing', or the movement of genes from GM plants into conventional crops, posing indirect threats to food safety and security". The article went on to question the soundness of the evidence on which the World Health Organisation based its conclusion that "all GM foods currently used have been assessed for safety and are not likely to present risks for human health". The RCGM on the other hand saw no need to offer any warnings of the sort appearing in *The Lancet*, painting a picture of well-functioning regulatory processes through which severe harm could eventuate only as a result of completely unforeseen drastic misfortune, and any such outcome could be avoided if the procedures were tightened up just a little here and there as recommended.

Similarly, a review in *American Scientist*[32] has warned of the difficulties in measuring the risks of possible environmental impacts, including increased reliance on herbicides, the creation of new pests, harmful effects on non-target species and the disruption of ecosystem processes. Initial results from very large farm trials of GE crops conducted in the UK confirm that there are all sorts of secondary effects generated when apparently minor genetic modifications are made to plants. The press report states[33]

> The three crops in the trials, GM maize, oilseed rape and sugar beet, have all behaved differently to the conventional varieties grown beside them. Some have destroyed more insects and weeds than conventional varieties, although one crop, believed to be maize, is thought to have had a more positive effect on killing unwanted common 'weeds'.

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[30] p65, para 80

[31] Editorial, The Lancet, Vol 360, No. 9342, 26 Oct. 2002, http://www.biotech-info.net/how_safe.html

[32] Marvier M, American Scientist Vol.89, No. 2, March-April 2001, http://www.biotech-info.net/transgenic_ecology.html

[33] The Independent, August 2, 2003

Another report describes just how specific such effects can be – potatoes engineered to deter one pest were later found to attract another,[34] demonstrating the virtual impossibility of taking account of all of the ecological consequences of making small changes in the biochemistry of an organism. The lowered fitness of GE cotton under drought conditions[35] and other Bt plants under normal conditions[36] are further cases in point. The RCGM expressed no overriding concern about the inability of scientists to assess the risk of, or if they eventuate, manage the harm arising from unexpected effects caused by GM organisms in the environment.

In relation to GE food, a report released early last year by the Royal Society (UK) said that the way genetically-modified food is tested for safety in Europe must be improved before any new GE plants are declared fit for human consumption. [37] There was recognition of the need for the battery of tests required of GE foods to be spelt out much more clearly. The report recommended that the testing regime be independently scrutinised so that companies cannot submit selective data about their new GE products or carry on generating data until they get the answer they want. By way of contrast, the RCGM lauded the standards applied by ANZFA and left the impression, as it did so often, that the main problem lay with concerns expressed by the non-expert public rather than any deficiency in our national institutions.[38] However the reality has proved to be different as an example from the US shows. Five years after authorities exempted the coat protein of the Papaya Ringspot Virus from restrictions on its production in GE fruit, new bioinformatic screening techniques show that it is a potential allergen.[39] There is no indication that scientific information and processes are either complete or certain enough to allow GE food to be safely regulated.

We now turn attention to several important issues that impinge on the conclusions of the RCGM concerning GE crops about which new information has since come to light.

Containment of pollen

The Royal Commission was impressed by evidence that "the vast majority of canola pollen travels less than 10 metres" and that "that some pollen grains might be transported by wind over distances of 32 metres, but around 75% of the total pollen was captured within 6 metres of the parent plant". Events leading to dispersal "by wind up to 1.5 kilometres and by insect transfer up to 4 kilometres" were described

[34] Birch ANE, Geoghegan IE, Griffiths DW & McNicol JW, Annals App. Biol. 140:143-149 (2002)
[35] Shah M & Banerji D , The Hindu, 24 August 2002, http://www.hinduonnet.com/thehindu/2002/08/24/stories/2002082400081000.htm
[36] Adam D, Nature 421:462 (2003)
[37] From New Scientist online News http://www.newscientist.com/hottopics/gm/gm.jsp?id=ns99991877, 4 February 2002; http://www.newscientist.com/hottopics/gm/gm.jsp?id=23290100, 9 February 2002
[38] pp227-229, paras 172–178
[39] Kleter G and Peijnenburg A. BMC Structural Biology 2:8-19 (2002)

as "extreme cases", although some monitoring studies "showed pollen had dispersed up to 400 metres from large release areas of transgenic canola".[40] A British study has since reported GE material found in honey two miles away from GE crops.[41] In discussing the dispersal of transgenic canola the RCGM came back to "evidence that seed loss and dispersal from harvesters and grain transport trucks represents the main mechanism for the long-range dispersal of canola, regardless of its transgenic nature".[42] The implicit logic of their argument seems to have been that because movement of transgenes as a result of pollen dispersal will be swamped by seed dispersal in food supply systems, pollen dispersal will prove to be of little concern even if it does occur in the New Zealand context.

The problem of cross-pollination of non-GE crops from GE crops surfaced in late 2002 when it was found that a biotechnology firm had failed to follow US government regulations for the containment of corn that had been engineered to produce a pig vaccine. As a precaution, 63 hectares of nearby corn were ordered destroyed, as were more than 10 tonne of stored soybeans that had been harvested even though it was contaminated with "volunteer" GE corn.[43]

Contamination and escape

The RCGM downplayed evidence expressing concern of inevitable contamination of conventional crops if GE crops were allowed to be grown in New Zealand. The major conclusions of a witness called by the Bio Dynamic Farming and Gardening Association in New Zealand were that "crops and weeds were spread in many ways: by wind, waterways, and farm machinery and trucks" and that "once the Roundup Ready crop 'escaped', despite best efforts it was impossible to control". The RCGM portrayed these as observations of an amateur, things that he perhaps noted from his experience. "It appeared to the Commission that Mr Affleck raised some important concerns" but his overriding claim that "some degree of genetically modified crop contamination was now present across the entire Canadian prairie" was reported as a mere comment.[44]

The Commission made a special feature[45] of dismissing Percy Schmeiser's celebrated challenge to Monsanto's assertion of ownership over their patented Round-up Ready seeds. The RCGM shied away from the fundamental problem that GE seeds carry rights of ownership and through contamination spread the multi-nationals' legal control over agriculture far and wide. Any concern of this sort was portrayed as coming from anti-genetic modification campaigners wanting to exemplify perceived evils and the frequent references to the Schmeiser case were a nuisance that the RCGM considered "[did] not help solve any of the issues before it". The RCGM seemed to be saying that farmers who know their seed stocks have been

[40] p146, para 36-37
[41] Sunday Times, 15 Sept 2002
[42] p146, para 37
[43] Ellstrand NC, Plant Physiology 132:1770-1774 (2003)
[44] p147, paras 40-41
[45] p147, "Percy Schmeiser and Monsanto"

contaminated with GE seeds, which would seem to be all farmers on the Canadian prairie, should just start paying the patent holders and stop complaining.

Recent experience with seed imported from the North America to New Zealand has demonstrated the wide extent of GE contamination of grain and seed stocks in that region. The RCGM appears to have had some appreciation of how matters were likely to evolve; they were certainly warned adequately by those concerned about the consequences. But instead of clearly stating that widespread contamination could be expected within a reasonably short time if GE crops are released in New Zealand, the Commissioners chose to deliver a message that they thought would be more palatable to members of the public who were disturbed by the truth. It was noted that New Zealand's biosecurity measures are internationally recognised but that "it is difficult to keep all genetically modified organisms out of the country".[46] However, restricting international sources of supply to those with effectively zero level of contamination was not considered as a sensible proposition for New Zealand, even if it were to be the wishes of the majority.

The attitudes expressed by the RCGM have been reinforced in confidential advice given to the Ministry for the Environment by scientists from Crown Research Institutes. The final conclusion of advice to government on the coexistence of GE and other crops is that "the USA experience demonstrates that GM and non-GM crops can effectively coexist despite highly publicised cases such as Starlink corn".[47] However new tests reveal that traces of genetically modified grains, especially soybeans and corn, are repeatedly creeping into US wheat supplies casting serious doubt on any possibility of maintaining GE-free wheat if the GE wheat is grown commercially.[48] Problems are surfacing in Australia.[49] In similar vein, UK farm trials of GE crops were suspended for a time after it was discovered that illegal GE canola had been mixed with other GE crops grown in 14 fields in England and Scotland.[50]

Outcrossing

The RCGM took a similar tack in its consideration of outcrossing – cross-pollination between compatible relatives of crops. It concurred that "isolation distances [between crops] were not intended to prevent outcrossing but to reduce outcrossing to an acceptable level".[51] The interests of GE industries were then served by the commission's refusal to endorse a "GE-free" policy under which the normal level of acceptability would be set at zero. New Zealanders in favour of such a policy were

[46] p148, para 46
[47] Christey M & Woodfield D, "Coexistence of genetically modified and non-genetically modified crops", Crop and Food Confidential Report No. 427, June 2001
[48] Tests find traces of GM crops in US wheat supply, Reuters, 30 May 2003, http://www.planetark.com/dailynewsstory.cfm/newsid/21017/story.htm
[49] http://www.GEinfo.org.nz/082003/04.html
[50] Kelbie P & Woolf M, Ministers suspend GM crop-testing, The Independent, 16 August 2002, http://www.biotech-info.net/suspend_testing.html
[51] p177, para 158

offered the protection of improbability: GE crops grown in New Zealand are *unlikely* to become weeds or cross with other species. [52]

On the other hand, there are continuing reports of plants gaining new traits, apparently as a result of outcrossing from transgenic crops. It has been shown that it is possible for genes to move from wheat to jointed goatgrass, a major weed in wheat-producing areas of the western USA[53] and so-called "superweeds" that have acquired stacked resistance to more than one herbicide have been reported in Canada.[54] Experimental studies reported at a recent conference confirm that genes passing from crops to weeds can persist for generations, rather than disappearing quickly due to the lack of any positive selective pressure.[55]

Evidence has also emerged that commercial transgenes, or parts of them, have found their way into native maize in remote locations of Mexico.[56] Mexican authorities are reported to have confirmed the basic fact of transgene contamination but the source and pathway of contamination remains unknown. [57] There is growing recognition that seeds can be carried long distances on farm machinery, and by other means, to cross with wild relatives, making the containment of transgenes virtually impossible.[58] Gene transfer from GE to non-GE crops has been further documented when Pioneer Hi-Bred International Inc. was fined in Hawaii for failing to notify authorities of the results of tests proving contamination.[59]

A recent theoretical study of the effects of specific novel genes in crops shows how wild plants are threatened by gene flow from crops.[60] The study is based on models of genetic assimilation (crop genes replacing genes in wild populations) and demographic swamping (wild populations shrinking because crop-wild hybrids are less fertile) and is particularly relevant to transgenes introduced into crops that are grown on a large scale. Most domesticated plant taxa mate with wild relatives somewhere in the world, and gene flow from crop taxa may have a substantial impact on the evolution of wild populations.[61]

The contamination of non-GE crops due to outcrossing from GE crops can no longer be regarded as a potential problem that ought to be mitigated. Whenever GE crops are grown near non-GE crops, contamination seems inevitable. New Zealanders are

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[52] pp143-145, para 29-35
[53] Zemetra RS, Weed Science 46:313-317 (200) http://www.biotech-info.net/wheat_abstract2.html
[54] New Scientist Online News, 5 February 2002, http://www.newscientist.com/hottopics/gm/gm.jsp?id=ns99991882
[55] "Genes passed from crops to weeds persist for generations", Ecological Society of America Annual Meeting, 9 August 2001, http://www.biotech-info.net/genes_persist.html
[56] Quist D & Chapela IH, Nature 414:541-543 (2001)
[57] San Fran Chronicle, 26 August 2002, http://www.biotech-info.net/hot_seat.html
[58] Briggs H, "GM seeds 'spread by human activity'" BBC News, World Edition, 18 June 2003, http://news.bbc.co.uk/2/hi/science/nature/2998000.stm
[59] Washington Post, 24 April 2003
[60] Haygood R, Ives A & Andow DA Proc. Royal Soc., London B, 22 Sep 2003, p1879 "Consequences of recurrent gene flow from crops to wild relatives", http://www.twincities.com/mld/pioneerpress/news/local/states/wisconsin/63867 37.htm
[61] Ellstrand EC, Prentice HC & Hancock JF, Ann. Rev. Ecol. Systematics, 30:539-563 (1999)

not likely to be any more fastidious than people of other nationalities in following regulations designed to reduce the probability of contamination.

Horizontal Gene Transfer

The RCGM gave some brief consideration to phenomena of horizontal gene transfer (HGT), the inter-species transfer and subsequent inheritance of DNA sequences.[62] HGT events can cause significant evolutionary transitions, but such large-scale, long-term effects arising as a result of HGT effected by genetic engineers was ignored by the RCGM.[63] Noting that there is little definitive scientific information concerning rates of HGT, the commission restricted its main consideration of the effects of HGT to whether it was likely to occur as a result of humans consuming GE food, especially GM food containing the Cauliflower Mosaic Virus promoter gene. After much broader consideration of the CaMV 35S promoter and its effect on HGT, a recent expert review concluded "that release of approved transgenic crops containing viral sequences pose substantial and unnecessary risks".[64]

Although it had been suspected that 41 human genes are of bacterial origin,[65] it has now been shown that under some circumstances DNA can be transferred directly from bacteria to mammalian cells.[66] This gives cause for more serious attention to be paid to the contention that transgenes are intrinsically unstable and more likely than others to be involved in further trans-species HGT.[67] The engineering of insects by using mobile transposon elements also gives cause for concern.[68] New studies point more definitely to the role of viruses in HGT between plants.[69] The RCGM practically dismissed concerns about trans-gene instability on the basis that GE promoter elements had not been found in non-GE foodstuffs[70] and later pointed to techniques being developed to mitigate any such problems.[71] One of the methods proposed to reduce outcrossing and HGT is to express genes in the chloroplasts of plant cells. Chloroplasts, unlike the nuclei of plant cells, are not incorporated into pollen.[72] But this proposal must now contend with the finding that the trafficking of genes between chloroplasts and nuclei can occur rapidly in plants.[73]

HGT is a natural phenomenon that can have biological significance of enormous

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[62] pp49-51, para 9-36
[63] p56, para 51
[64] Latham JR & Steinbrecher RA, "HGT of viral inserts from GM plants to viruses", GM Science Review Meeting of the Royal Society of Edinburgh, 27 January 2003
[65] International Human Genome Sequencing Consortium, Nature 409:860–921 (2001).
[66] Waters VL, Nature Genetics 29:375-376 (2001)
[67] M-W Ho, Witness Statement to ACRE, 14 Feb 2002, http://www.biotech-info.net/best_secret.html
[68] J Cummins, I-SIS Report, 15 March 2001, http://www.biotech-info.net/piggybac.html; M-W Ho, I-SIS Report, 19 March 2001, http://www.biotech-info.net/genome_invaders.html
[69] G Harper, R Hull, B Lockhart & N Olszewski, Ann. Rev. Phytopathol. 40:119-36 (2002)
[70] pp46-48, para 16-22,
[71] pp54-55, para 42-46
[72] p54, para 44
[73] Huang CY, Ayliffe, MA & Timmis JN, Nature, doi:10.1038/nature01435 (2003) http://www.nature.com/nsu/030203/030203-8.html; Stegemann S, Hartmann S, Ruf S & Bock R, PNAS 100:8828-8833 (2003)

proportions. Scientific knowledge of its frequency and specificity is still very rudimentary. The introduction into the biosphere of the products of human experimentation with HGT (which is what most genetic engineering amounts to) would seem foolhardy. The RCGM failed New Zealanders with its recommendations that ways be found to allow transgenic organisms (produced by artificial HGT) into the environment. It was given ample expert advice that the manifestation of unintended effects of GE organisms was likely to be the norm.

Bt crops, refugia and resistance

The RCGM recognised that growing crops engineered with the Bt insecticide gene could have broad consequences and recommended that appropriate agencies develop a strategy before the release of any Bt-modified crops in New Zealand.[74] It was recommended that the strategy take account of the concept of refugia. These are nearby patches or zones of non-Bt crops whose designed effect is to allow non-resistant insects to thrive, swamping out any emerging insect resistance to the toxin in the modified plants. However, it has now been found that some Bt-resistant insects are actually able to digest and utililise the toxin protein. This unanticipated nutritional effect of Bt transgenic crops could have the effect of increasing the fitness of resistant populations.[75] The insect genes for resistance to the Bt toxin have to be recessive for refugia to work, but new studies show that at low toxin levels resistance is inherited in a codominant or weakly codominant rather than recessive fashion. [76] Further studies point to Bt corn damaging non-target monarch and black swallowtail caterpillars in wild, particularly Sygenta's Bt "event-176" corn that expresses the toxin at 40 times the level of some other brands. Syngenta is now withdrawing event-176 Bt corn from sale[77] leaving varieties that express lower levels of the toxin and therefore more likely to support the emergence of resistant insects.

United States authorities recommend areas as large as 20% of the crop to serve as refugia. Farmers' non-compliance with requirements for non-GE refugia around GE crops has further raised fears of the emergence of Bt-resistant insects. According to US government figures nearly one-fifth of farmers in the midwest are ignoring federal rules concerning refugia.[78] In any case, it is accepted that refugia will need treatment with conventional insecticide somewhat defeating the purpose of creating Bt plants in the first place.[79] In India, Bt cotton has been grown in an essentially unregulated fashion with seed being kept from year to year.[80]

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[74] p143, paras 25-28; Recommedation 7.1
[75] Sayyed AH, Cerda H, Wright DJ, Ecology Letters 6:167-169, (2003)
[76] Liu Y-B, Tabashnik BE, Meyer SK, Carrière Y, & Bartlett AC, J. Econ. Entom. 94:248-252 (2001) http://www.biotech-info.net/bollworm_resistance.html
[77] Pearce F, New Scientist Online, 11 Sep 2001, http://www.newscientist.com/hottopics/gm/gm.jsp?id=ns99991274
[78] EPA and USDA Position Paper on Insect Resistance Management in Bt Crops, 27 May 1999, http://www.mindfully.org/GE/EPA-USDA-Position-27may99.htm
[79] Clarke T, Nature 424, 116 (10 July 2003); doi:10.1038/424116a
[80] Jayaraman KS, Nature Biotechnology, 20:1069 (2002)

The endemic presence of a pesticide or the widespread application of herbicide results almost inevitably in the emergence of strains of pests or plants resistant to the applied selection pressure. In the past seven years, several weed species have been found with Roundup resistance. The resistance has come about not through gene transfer from GM herbicide-tolerant crops but through natural selection.[81] It has also emerged that Round-up Ready canola can lose herbicide resistance after infection with the cauliflower mosaic virus, most likely due to transcriptional gene silencing of the transgene. [82]

In relation to human health issues, it now emerges that the US Environmental Protection Agency assesses Bt toxicity on the basis of only one acute test with high doses of transgenic Bt toxin (made in bacteria, not corn) in one rodent study (either rats or mice). If high doses of this Bt do not cause toxicity in the short term, they assume that low doses of transgenic Bt made in corn will not cause problems either. For conventional chemical pesticides, EPA requires both short-term (acute) and long-term (chronic) toxicity tests in animals, including tests for organ toxicity, carcinogenicity, and reproductive effects.[83]

The RCGM was correct to recommend caution with respect to the introduction of Bt crops into New Zealand, but it failed to lay down the ultimate aim of regulation – the proper safeguarding of the environment against Bt-toxin becoming an endemic background feature of our agricultural systems.

Effects on soil ecosystems

The Report of the RCGM makes considerable mention of the potential impact of GE organisms on soil. Both the rate of horizontal gene transfer to soil microbes and the irreversibility of such effects were of concern to submitters,[84] especially changes in soil composition[85] and fertility. [86] Other submitters mooted the idea of using GE organisms to overcome problems of soil salinity[87] and instability[88]. The RCGM advocated field tests as a "semi-contained" way of conducting research into the effects of GE organisms on soil ecology[89] and it was noted that CRI projects already included "quantification of the effects [of transgenic plants expressing insecticidal toxins] on the soil ecosystem, including soil foodweb composition, biomass and nutrient status".[90] The effects of GE trees, especially on soil, received special attention from the commission.[91]

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[81] Reference to Round-up resistant plants
[82] Kaff NS, Kreike MM, Covey SN, Pitcher R, Page AM, & Dale PJ, Nature Biotechnology 18, September 2000, http://www.biotech-info.net/CMV_canola.html
[83] Wuerthele S (USEPA toxicologist), Pers. Comm. to LRB Mann
[84] p55, para 49-50; p57 para 54; p155, para 75
[85] p60, para 61
[86] p155, para 75
[87] p140, para 11
[88] p140, para 14
[89] p113, para 48
[90] p58, para 60
[91] pp152-156, paras 64-77

The RCGM made two recommendations related to the effects of GE organisms on soil. The first was that ERMA require research on soil impacts before approving release of GE crops[92]. The second was that an ecological assessment of soil and soil micro-organism effects be required as a part of any proposals to develop GE trees.[93]

Two new pieces of evidence have come to light since the RCGM reported. It has been found that the soil microbial communities around GE canola and conventional canola are indeed different.[94] This was the conclusion of a two-year study into the effects of GE plants on the biodiversity of soil microbes. In the case of Bt corn, one immediate effect has been confirmed. The toxin exudes from the roots of plants and accumulates in soil, and retains insecticidal activity for at least 6 months, bound to particles in the soil.[95]

This is a case in which the RCGM to some extent anticipated later findings, and implicitly recommended that precautionary restrictions be instituted pending results from the necessary studies. However, in light of our poor knowledge of soil ecosystems, firmer steps should have been taken. The RCGM left ERMA with adequate scope in distinguishing between "alteration" and "harm" to allow the Authority to continue with its permissive approach to applications involving uses of GE organisms in the New Zealand environment.

Conclusion

Continuation of the moratorium on applications for the release of genetically organisms into the environment of New Zealand is probably the only way to preserve our opportunity of remaining virtually free of contamination and other problems associated with GE crops. Experience has now shown clearly that transgenes will move down whatever pathways are available. The most likely pathways are those provided by human activity. People create opportunities for gene movement that sound regulation is supposed to preclude, making GE contamination of non-GE crops virtually inevitable. By being concerned mainly with rules and procedures rather than the consequences of human behaviour in the real world, the RCGM set up the islands of New Zealand to become just another country where agriculture would be gradually invaded by the products of genetic engineering.

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[92] p133, Recommendation 6.12
[93] p155, Recommendation 7.4
[94] Kari E, Dunfield KE & Germida JJ, FEMS Microbiol. Ecol. 38:1-9 (2001), http://www.biotech-info.net/rhizosphere.html
[95] Saxenaa D, Floresb S & Stotzky G, Soil and Biology Biochemistry 34:133-137 (2002) http://www.biotech-info.net/events.html