

# THE CURIOUS LEGACY OF GMO AGRICULTURE

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*The 10-year history of commercialized GM field crop agriculture has exposed a bizarre dichotomy: a) a failed technology, b) which exists only by externalizing costs of production to everyone else. To a degree unparalleled by any other agriculture technology, GM has failed to return social benefit - intellectually or economically - from the many billions of dollars in public funding and diverse entitlements it has received. Thirty years of aggressive support and promotion by Canadian and other governments have yielded a total of two (2) commercialized traits - herbicide tolerance and Bt - which jointly account for almost 100% of all land sown to GM crops in on the planet; a seed trade in which 10 companies control 55% of the global market; and a legacy of academic ag-related departments dominated by molecular genetics. Yet government funding policies, undeterred by the failure of this globally rejected technology, continue to prioritize GM rather than organic or other non-proprietary approaches to agricultural issues. Unlike organic farming, a truly staggering array of costs are externalized by commercialized GM crops. Examples include liability for uncontrollable but proprietary gene encroachment onto neighboring farm properties, the loss of premia due to GM contamination of organic and other identity-preserved crops, and the lemon effect of global GM rejection on prices received by all producers of a given crop, owing to failure to segregate into GM and non-GM streams. Implications of sustained government support for GM-based agriculture, to the detriment of organic and other approaches are considered.*

## Introduction

The currently posted Canadian Biotechnology Strategy (<http://biostrategy.gc.ca/english/view.asp?x=520>) could plausibly lead one to presume that biotechnology is reshaping the landscape of the agriculture and food sector in Canada.

The scientific revolution in the late 20th century spawned thousands of biotechnology companies globally – including hundreds in Canada – that are developing a broad spectrum of products and services which are transforming everything from the foods people eat, to the quality of health care they receive, to the integrity of the physical environment.

How then, can one reach the shocking conclusion that GM is, in fact, a failed technology? How did government get it so wrong? And what are some of the social repercussions of this colossal misjudgment? The following paper will first draw upon 10 years' worth of commercial GM crop performance in the field to challenge the cheerleading of the Canadian Biotechnology Strategy. The mythology surrounding the biotech revolution will then be briefly analyzed, in an effort to understand how government and academia could have so

fully embraced such an underperforming technology, to the virtual exclusion of more holistic, “public good” approaches to agriculture. An analysis of the costs externalized by GM agriculture will conclude the paper.

### **GM: A failed technology?**

Enthusiastic boosterism aside, and despite a 10-year run of:

- investing billions of dollars in funding from Canadian taxpayers to promote, develop, and regulate biotechnology,
- approving some 55 transgenic, plus almost 20 mutagenic “plants with novel traits” or PNTs for unconfined release ([http://www.hc-sc.gc.ca/fn-an/gmf-agm/appro/index\\_e.html](http://www.hc-sc.gc.ca/fn-an/gmf-agm/appro/index_e.html)) (FIG 1), and
- proclaiming the widespread adoption of biotech crops by Canadian farmers,

the inescapable fact remains that almost all GM land in Canada and in the world is occupied by crops fitted with just 2 traits - either or both of herbicide tolerance (HT<sup>1</sup>) and Bt. In 2005, global GM land was split among just 4 crops - soy, corn, cotton, and canola, at 60, 24, 11, and 5%, respectively - with 95% of all GM land was found in just 6 countries - US, Argentina, Brazil, Canada, China, and Paraguay, at 55, 19, 10, 6, 4, and 2%, respectively (Beckie et al., 2006). While crop varieties fitted with a GM gene are called “GM varieties”, it worth remembering that each of these crops has tens of thousands of genes, of which all the rest result from conventional plant breeding.

A technology that manages to market just 2 traits, in 4 industrial crops, grown in 6 countries, despite cornering the market through a multi-billion dollar buyout campaign, backdropped by 30 years of aggressive government and institutional promotion, would have to be considered an abject failure by any objective analyst. Failure to commercialize useful genetics manifests in economic failure. According to Gary Pisano’s 2006 text *Science Business: the Promise, the Reality, and the Future of Biotech*, the entire biotech sector would have been in the red throughout its history were it not for *Amgen* and *Genentech*. Contrary to the perception given by the Canadian Biotechnology Strategy, only one in five biotech companies even has a product.

In at least one respect, however, biotechnology has been efficacious, and that has been in consolidating the global seed trade. As reported by the ETCGroup (2007), the top 10 seed corporations now account for 55% of commercial seed sales, and 64% of proprietary seed sales on the planet. Monsanto alone now accounts for one- third of all seed sales, and more than one-fifth of the global proprietary seed market. The far-reaching implications of this pattern are beyond the scope of this paper, but suffice it to say, that what is good for business is not necessarily good for society and the environment which sustains it.

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<sup>1</sup>HT can be conferred through mutagenic as well as transgenic processes. Imidazolinone tolerance (IMI) is derived from mutagenesis, while glyphosate tolerance (GLY) and glufosinate ammonium tolerance (GLU) are both transgenic. Other types of transgenic herbicide tolerance have also been commercialized, as bromoxynil, sethoxydim, and sulfonylurea tolerance, but were uncompetitive or have been withdrawn in Canada

## Ten years of field experience

Of the four globally predominant GM crops, three are grown regionally in Canada, as discussed by Beckie et al. (2006).

- Canola is predominantly a western crop, while corn and soybeans are grown largely in Ontario and Quebec. Some **95%** of the land sown to canola was herbicide tolerant (HT) in 2005. By 2006, producers' choices were limited to a single non-HT cultivar, in competition with 48 private sector HT cultivars distributed among GLY and GLU tolerant cultivars and a lesser number of IMI tolerant cultivars.
- By 2005, **60%** of soybeans grown in Canada were genetically modified, and all of the HT cultivars were GLY tolerant.
- In the same year, corn hybrids tolerant to either GLY or GLU were roughly equal in sown acreage, jointly accounting for **35%** of total area sown to corn in eastern Canada.

Is the technology really a failure when it is taken up by so many farmers? The magnitude uptake of GM crops by Canadian farms is often cited to infer willing acceptance or even preference for the technology. However, the landbase sown to GM crops may reflect other motivating factors such as the lack of choice. Access to non-GM seed of desirable varieties (see canola above) may be limiting. Given the impossibility of genetic isolation (Clark, 2004), particularly for canola, threat of legal action for unavoidable crop contamination – as occurred with Percy and Louise Schmeiser – may also have increased GM market share (see Mauro and McLachlin, in press). With the global corn, soy, and especially canola markets already a “done deal”, the farmer revolt against the introduction of GM wheat in 2002 may be a better indicator of how farmers think about GM crops.

## Survey results?

How well has biotechnology served Canadian agriculture? Curiously, it is not possible to authoritatively address the question of GM benefit to Canadian farmers. Unlike the periodic surveys published by U.S. government agencies, neither the Canadian nor Ontario governments have made public any survey of farmer experiences with GM crops.

A recent academic survey of western Canadian farmer experiences with GM canola is literally the first opportunity, in a refereed format, to gauge how GM canola has impacted Canadian farmers. From a 2003 survey of 370 farmers, greatest cited benefit among technology users (n=298) was operational, including timing and efficacy of weed control, facilitating farming of a larger landbase (Mauro and MacLachlin, in press). Among 10 ranked benefits, increased yield was 6<sup>th</sup> and increased revenue ranked last. Among 10 cited risks, of greatest concern were loss of markets, loss of farmer rights under the Technology Use Agreement, higher seed costs, and lawsuits. A SSHRC-funded documentary film, *Seeds of Deception* (<http://www.seedsofchange.org/?p=about>) by the same authors, puts a human face to farmer experiences and perceptions of the future of GM crops. It is particularly revealing that these farmer-identified risks are absent from the GM risk assessment process institutionalized by the Canadian government.

## Yield?

What about the promised benefits of higher yield, reduced biocide dependence, and improved profitability? None of the GM traits in commerce today are designed to increase yield. Thus, for an HT crop to increase yield relative to that achievable with conventional weed control in a non-GM crop, requires an intractable weed problem. Similarly, for an insect resistant (IR) crop (e.g. Bt corn) to outyield a non-Bt corn of the same genetics requires a significant problem with the target of Bt corn - European cornborer, a pest which occurs sporadically and unpredictably. Yield impacts from weed or insect control method also need to be vetted over years, as resistance effects can exacerbate future weed or pest problems.

Evidence of a yield advantage for GM crops is very limited. In a 10-year review of the Canadian experience with HT crops, Beckie et al. (2006) cited ON evidence from public variety trials showing not an increase but a 4% yield *decrease* in GM soybeans and the absence of yield benefit from GM corn. Ferrell and Witt (2002) did not detect corn yield differences in a 2 year trial comparing GLY with other herbicides.

In a hand-weeded trial, Elmore et al. (2001a & 2001b) demonstrated a yield drag in RR<sup>2</sup> soy under controlled conditions. After first demonstrating that glyphosate, per se, did not affect yield of RR soybeans, they compared 5 backcross-derived pairs of sister-lines (RR v. non-RR) at 4 locations over 2 years. The RR sister lines averaged 5% less than the non-GM lines, leading to the conclusion that the yield drag associated with the RR trait resulted from the RR gene or the gene insertion process itself - not the applied glyphosate or any other genetic difference. An analysis by Elisason (2004) of chronological trends in national soybean yield in the US suggested a flattening of yield following the release of GM soy (**FIG 2**). A similar trend was exhibited by provincial mean soy yields in Ontario (**FIG 3**).

In a 2-year trial over 5 western Canadian locations, HT outyielded conventional canola weed control practices in just 6 of 30 contrasts, all occurring at sites and years of particularly problematic weeds (Harker et al., 2000). A 1998 producer survey commissioned by the Canola Council of Canada, itself the proprietor of a GM canola cultivar, reported a 10% yield advantage for GM canola (cited in Beckie et al., 2006). The higher yields of GM canola were attributed to better weed control, and to the use of higher yield potential cultivars. In other words, the GM yield advantage was attributed to the lesser effectiveness of competing weed control options and to the higher yield potential of the conventionally bred cultivars into which the GM trait was fitted, relative to that of available non-GM cultivars.

Thus, available evidence does not support claims that GM technology has increased crop yield, particularly for corn and soybean. Any actual yield increase associated with GM to date has occurred within one of the following scenario: high weed or target insect pest pressure or comparison with non-GM varieties of different and lesser genetic potential.

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<sup>2</sup>RR or Roundup Ready is the trade name for Monsanto's GLY tolerant gene

## Biocide use?

Do GM crops reduce biocide use? With just HT and IR to work with, it is difficult to imagine how switching to GM crops could reduce herbicide or pesticide use. Beckie et al. (2006) cited primarily web-mounted reports and unpublished data as evidence of biocide use reductions for HT canola and soybeans. However, most such reports pertained to the first 5 years of GM field crop production and were not in the refereed literature. Beckie et al. (2006) acknowledged that the tank mixes including other herbicides, as has been necessitated by the evolution of resistant weed biotypes in more recent years, negate this claimed benefit of GM crops. Weed resistance to GLU, which accounts for roughly a third of western canola, has not been reported. However, repeated reliance on GLY crops and widespread use of glyphosate for a variety of other applications has generated glyphosate-tolerant weed biotypes, which can now be controlled only with additional herbicides, more frequent applications, and higher herbicide application rates.

A total of 55 weed biotypes spread over 13 species are now tolerant to glyphosate, of which 35 were detected in soy or cotton fields starting in 2000 ([www.weedscience.org](http://www.weedscience.org)). Of the 35, 27 were reported from the US, with 5 from Brazil, 1 from Argentina, and 1 from the rest of the world, paralleling global use patterns of GLY technology. In response to growing weed tolerance for glyphosate, rate of herbicide (glyphosate plus other herbicides) application to GM soy in the US increased between 1996 and 2004 at a rate of 0.07 lb a.i./ac/year ( $r^2 = 0.87$ ), while rate of herbicide application to non-GM soy decreased at a rate of -0.05 lb a.i./ac/year ( $r^2 = 0.73$ ) (calculated from Benbrook, 2004).

Almost all insecticides used on corn in Canada are for corn rootworm, but the target of the types of Bt corn commercialized to date in Canada is predominantly the European cornborer. If the intent was to reduce biocide use through GM, this type of Bt corn was a poor choice because European cornborer is sufficiently difficult to control with insecticidal sprays that very little insecticide is actually used on it. Thus, replacing non-Bt corn with Bt-corn necessarily had a negligible effect on reducing use of insecticides which are not used in the first place.

Thus, claims that GM technology reduces biocide use in Canada are increasingly difficult to justify, given the compounding effects of GLY-tolerant weed biotypes and the choice of Bt corn active against European corn borer.

## Profitability?

Economic returns to GM technology have been compromised by the cost of the technology and by global market rejection of GM crops. According to one Manitoba farmer, “The loss of [European] markets due to GM had a huge financial impact. This was likely larger than cost of controlling volunteers or benefit of easy weed control” (Mauro and McLachlin, in press). Cost of seed and chemical inputs increased for Bt corn, at the same time that global market rejection dropped the value of US corn (**FIG 4**). Between 1996 and 2001, Benbrook (2001) calculated that US farmers paid at least \$659 million in price premia to grow Bt corn, but returned just \$567 million, **for a net loss of \$92 million** attributable to GM. Introduction of

GM traits without regard for the infrastructural changes needed to accommodate dual stream GM and non-GM streams reduced marketability and profitability of export crops.

In sum, agricultural biotechnology has been a spectacular failure, both in terms of the paucity of traits that have been commercialized successfully, and in the poor performance of the traits which have entered the marketplace. Can a technology that is so widely adopted by Canadian farmers really be considered a failure? The answer to such a question depends very much on whether or not farmers actually had a choice, and if so, what benefits they perceived in adopting the technology. The near absence of objectively derived survey information impedes informed discussion of this question. The primary advantages reported by Canadian canola growers were in ease of operation, facilitating timely weed control over larger areas. The industry-claimed advantages in yield, reduced environmental impact from reduced dependence on biocides, and greater profit have not been realized. Perhaps a more incisive question might be whether Canadian farmers would continue to grow GM crops if they had the choice to do it over. Given what they now know about the marketability of GM-contaminated grains, farmer resistance to GLY wheat suggests they may not.

### **The myth of the Biotech Revolution**

If agricultural biotechnology has in fact returned so little societal good, while contributing to the wholesale consolidation of the seed trade, why does government continue to promote the Canadian Biotechnology Strategy and pump good money after bad into institutional biotechnology research? By putting so much social capital into that one basket, have they foreclosed on other approaches to agricultural issues?

To paraphrase McCarthy (2007), what happened to the biotech “revolution”? Nightingale and Martin (2004) presented evidence that rather than portending the much anticipated “revolution” in technological change, biomedical biotechnology is instead diffusing like many technologies, in slow and incremental fashion. Yet, they noted that science and technology policy in many countries continues to adhere to the persistent, if mistaken dogma that biotechnology will deliver revolutionary advances in novel drugs, therapies, crops, and livestock. The social cost of mistakenly granting “revolutionary” status to biotechnology is only now being discussed in the academic literature.

According to Hopkins et al. (2007), much social capital has been staked on the mythology of the biotech revolution, not least being the sustained, annual investment of substantial public funding at every level of government. The expected biotech revolution has had the benefit of such government policy initiatives as:

- targeted funding programs, which necessarily deny funding to other areas of endeavor,
- the stimulation of knowledge and technology networking, particularly between academics and industry,
- the provision of funding and technical support for spin-off firms,
- tax credits for research and development initiatives, and
- streamlining and simplifying regulatory requirements.

Yet, the resultant upheaval in institutional, regulatory, and academic structure and function to prepare the way for the expected biotech revolution may, in fact, have been misguided. In the biomedical field, Hopkins et al. (2007) documented that while biotechnology has indeed increased the number of drug “targets”, the expected outcomes in terms of new drugs, or genetic tests for disease susceptibility, or new gene therapies have been disproportionately slow, in relation to the extraordinary investment of public as well as private funds and entitlements. A similar analysis has not been reported for agricultural biotechnology, but the lackluster performance reported above would be consistent with this analysis of biomedical trends.

For academia, the legacy of misjudging biotechnology to be not just one but seemingly the only portal into the future is a compromised institutional capacity to do anything else. Over the 30 year history of biotechnology, agricultural academia has replaced itself in order to capitalize on the flow of public and private funding newly available in molecular genetics, genomics, and genetic engineering. For example, almost half of the roughly 40 active faculty and research scientists in the Plant Agriculture department of the University of Guelph described their own research programs in such terms in 2008 (<http://www.plant.uoguelph.ca/directory/faculty/faculty.htm> ).

Commercial U.S. biotechnology relies heavily on “public science” to support and legitimate patent applications. In a study of the patents of 119 U.S. biotech firms, McMillan and Hamilton (2007) found that 72% of the citations shown in the “prior art” section of each patent were from public science, including government as well as academic institutions.

Space does not permit further elaboration of this vital issue, but the practical implications of sparse offerings of conventional breeders, physiologists, and ecologists by crop science departments have already been noticed by the agricultural sector. Repeated cohorts of graduates trained in molecular genetics rather than in plant breeding or cropping systems or agroecology will constrain decision-making in future agricultural policy and direction.

### **The externalized costs of agricultural biotechnology**

An issue which is not yet widely recognized is the degree to which GM crops have become commercially viable only by externalizing costs of mitigation and downstream harm to those who have chosen *not* to grow a GM crop, and to society and the environment at large. It is difficult to imagine another agricultural innovation – whether precision farming or oxygen-limiting silos or even biocides – which has imposed such a remarkable and wholly

unavoidable burden on everyone else, and for so little benefit to anyone other the proprietor of the technology.

### **Volunteer crop HT costs imposed on non-adaptors**

To a remarkable degree, those declining to purchase GM technology are being obliged – for their own protection – to absorb costs to allow the technology to benefit adopters. For example, in a workshop on the management of HT crops, the CFIA (2003) reported that most

workshop participants felt that control of HT volunteers, in-crop as well as in fallow, is a manageable agronomic issue for current HT crops (canola, corn, and soybean). Discussion centered around increasing need for development of **more elaborate, as well as site-specific**, weed management strategies, not only for controlling HT volunteers but also for minimizing the selection pressure for HT biotypes in weed species...also noted that adoption of these weed management strategies **will not be limited to adopters but also extend to non-adopters...**

Implicit in this statement is the need not just for adopters but also for non-adopters to absorb the extra costs created by the increasing intractability of HT volunteers (e.g. more elaborate, as well as site-specific... strategies). The presumption that non-adopters will necessarily *also* have to absorb these same remedial or mitigation costs - when they are under no contractual obligation to anyone - reflects the literal uncontainability of this technology. In effect, field crop biotechnology exists only by downloading or externalizing costs to all, so that some may benefit.

An effort has been made to isolate the organic sector as the primary naysayers for biotechnology. A polarizing, straw man argument has evolved between the needs or “rights” or a few organic practitioners to negate the needs or rights of those seeking to use GM crops. Accordingly, it is worth emphasizing that the following partial list of externalized costs is what is being imposed on conventional farmers - non-adopters as well as adopters:

- More expensive herbicides to cope with HT volunteers and weeds (controlling RR-wheat volunteers, for example, does not have a cheap alternative comparable to 2,4-D for RR-canola volunteers)
- Company withdrawal from herbicide and HT crop development, due to sector domination
- by RR-crops, reducing herbicide rotation options and exacerbating selection for resistance
- Research, testing, and redesign of seed production protocols and trade practices to avoid contamination of pedigreed seed
- Costs of stewardship education and compliance monitoring for dealers, growers, applicators, and extension agents
- Infrastructural costs to establish dual stream handling, storage, and shipping protocols for marketed crops
- Delayed planting and realigning field plantings to mitigate against neighbor cropping patterns; changes to crop choice specifically to employ alternate herbicides, and other managerial practices to cope with HT volunteers
- Coping with a persistent soil seedbank of HT canola (or wheat?) volunteers owing to shattering losses at harvest (Friesen et al., 2003)
- Lost production and profit from refugia set aside to sustain the effectiveness of Bt crops
- Costs for testing and monitoring for GM contamination, and lost premia when contamination is detected
- Lost markets for IP products - including but not limited to organics
- Threat of liability for inadvertent patent infringement.

The primary risk to organic farmers is loss of certification from inadvertent contamination and/or spray drift.

### **The lemon effect**

Furtan et al. (2003) referred to GLY wheat as a lemon, in that inability to segregate GM from non-GM would effectively sour the entire export market for wheat, as has already happened for US corn and soy and for Canadian canola. They calculated that the proposed introduction of GLY wheat in Canada would cause losses of \$46 and \$32 million annually to the adopters and non-adopters of the technology, respectively, while bringing in a positive \$157 million to Monsanto. Wheat producers would lose whether they grew GM or not because 82% of those who import Canadian wheat say they won't accept GM wheat, and it is not possible to segregate.

ISU economist Wisner (2005) calculated that with 46 countries now labelling for GM ingredients, introduction of GM wheat in the US would reduce the wheat export market by 20 to 37%. Market rejection figures were derived from a 2004 survey by the USDA FAS, as well as earlier surveys by US Wheat Associates and the Canadian Wheat Board. Market rejection of wheat would quickly depress wheat from food to feed grade, depressing prices not simply of the wheat but also of competing feed grains - another externalized cost.

For growers of hard red spring wheat in the northern Great Plains, the "optimistic" scenario of Benbrook (2005) found that non-adopters (70% of farmers) would lose US\$5.60/ac in income - owing to a 4% decline in market price - while adopters (30% of farmers) would lose US\$11.03/ac in net cash receipts owing to higher cost of seed as well as the 4% lower market price. The whole industry (13 million ac in hard red spring wheat) would lose \$94 million a year under the optimistic scenario.

### **Biopharmaceutical Crops**

These costs can only become more onerous when biopharmaceutical crop contamination becomes an issue. Smyth et al. (2004) reported a global total of 134 biopharmaceutical field trials occurred between 1992 and 2002, of which 62 were in the U.S. and 53 were in Canada. Of these, maize accounted for 46, followed by tobacco with 25, and canola with 17. The contamination radius for corn and canola ranges from hundreds to thousands of meters. To date, regulations governing commercialization of biopharmaceutical crops have not been formalized.

### **Lost premia**

Spatial isolation is one of the few options available to a non-GM grower seeking to protect their crop from contamination. Ma et al. (2004) determined that 200 m was sufficient to reduce contamination of a non-GM maize field to <1% from an adjacent Bt-maize field. Based on this estimation, if the non-GM crop was organic, economic losses from employing a 200 m isolation zone to reduce contamination to <1% could be calculated assuming:

- a square 100 ac field measures 636 m on a side
- organic corn yield is conservatively assumed to be 80% of the provincial average (131.3 \* 0.8 = 105 bu/ac)
- price of #2 yellow corn (mean of Chicago, Minnesota, and Detroit prices for Week of 10 Oct 07) is \$10.80/bu for organic and \$3.28/bu for conventional  
<http://newfarm.org/opx/product.php?prid=42>
- corn within the 200 m buffer separating the organic from GM-corn is sold as conventional corn

Organic corn growers lose from 22 to 60% of their gross receipts if obliged to sacrifice from 1 to 4, 200 m wide buffers to safeguard a 100 ac crop from neighboring GM corn fields (**Table 1**). For a 100 ac corn crop yielding 105 bu/ac at today's prices, that means an annual loss of \$24,950 to \$68,040. The same calculation could be done for white food grade or high amylose corn, which must also be free of GM contamination.

Fractional and potentially absolute dollar losses would increase as field size decreases. With a mean ON farm size of 233 ac (<http://www.omafra.gov.on.ca/english/stats/census/summary.htm>), most corn fields are actually *smaller* than 100 ac - meaning greater losses. Although based on a number of broad assumptions, this simple analysis reveals the economic burden imposed involuntarily on organic producers, so that their neighbors can grow GM crops.

**Table 1. Gross receipts (US\$) from 100 ac of organic field corn with 200 m buffers to safeguard against GM contamination from the adjoining fields**

	Degree of GM Maize in Surrounding Fields				
	None	1-side	2-sides	3-sides	4-sides
Organic (\$10.80/bu)	\$113,400	77,740	53,293	26,464	15,614
Conventional (\$3.28/bu)	-	10,814	16,186	26,402	29,687
TOTAL from 100 ac	\$113,400	88,554 (-22%)	69,480 (-39%)	52,866 (-53%)	45,301 (-60%)

All of these hidden costs - whether imposed on adopters, non-adopters, or society at large - are excluded from standard cost:benefit analyses for GM crops, specifically because they are imposed involuntarily and unavoidably on everyone else. Unlike users of some innovations - such as precision farming or oxygen limiting silos - users of GM technology necessarily and unavoidably harm their neighbors because of global rejection of GM crops. In the absence of regulations ensuring liability for the lost income and other harms externalized by GM crops, it is no exaggeration to say that ag biotech has become the tail wagging the dog of agriculture today.

## Synthesis

We are left then with a conundrum. Biotechnology is a technology that was accorded the status of “revolutionary” and given every opportunity over 30 straight years to become so. Yet, it has succeeded in capturing ever larger fractions of sown cropland with a portfolio consisting of 2 traits, only through market domination by a select few particularly aggressive mega corporations. Market share increases by denying farmers access to non-GM seed, aided by government recalcitrance in holding industry accountable for internalizing its own costs.

The contrast with organic farming could not be more stark. Organics is an approach to farming which is, effectively, a free, holistic, public good in contrast with the costly, linear, and proprietary offerings of biotechnology. Organics has received virtually no institutional support in Canada until very recently, and even that was given in a manner calculated to minimize benefit. Organics has grown up from the ground up, by its own bootstraps, proud to be labelled as such in direct response to growing public demand. Biotechnology has been imposed involuntarily and unavoidably upon producers and consumers, rejecting every call for mandatory labeling in Canada. The social good of organic farming, which is recognized and indeed subsidized as such in the EU, is received, but unacknowledged as such, in Canada.

The visualization which comes to mind is that of a V, with Canadian government, academic, and industrial interests marching along one branch, while society marches down the other one. At some point, institutional leaders and decision makers will look back and see that nobody is following them.

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Figure 1. GM submissions over 15 crops, authorized for unconfined release by Health Canada between 1995 and 2007

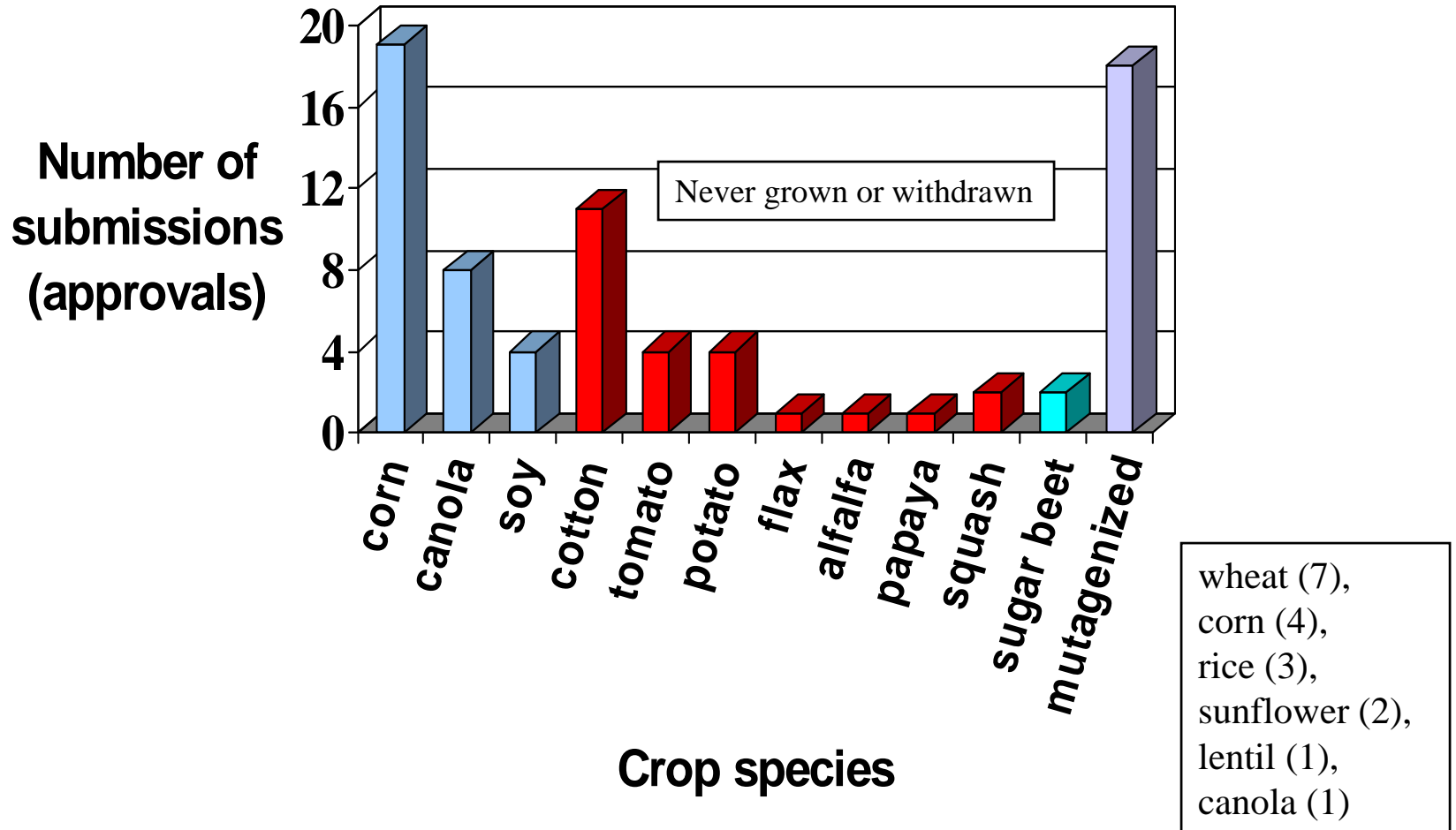


Figure 2. Introduction of RR soy and flattening of US soybean yields (Eliason, 2004)

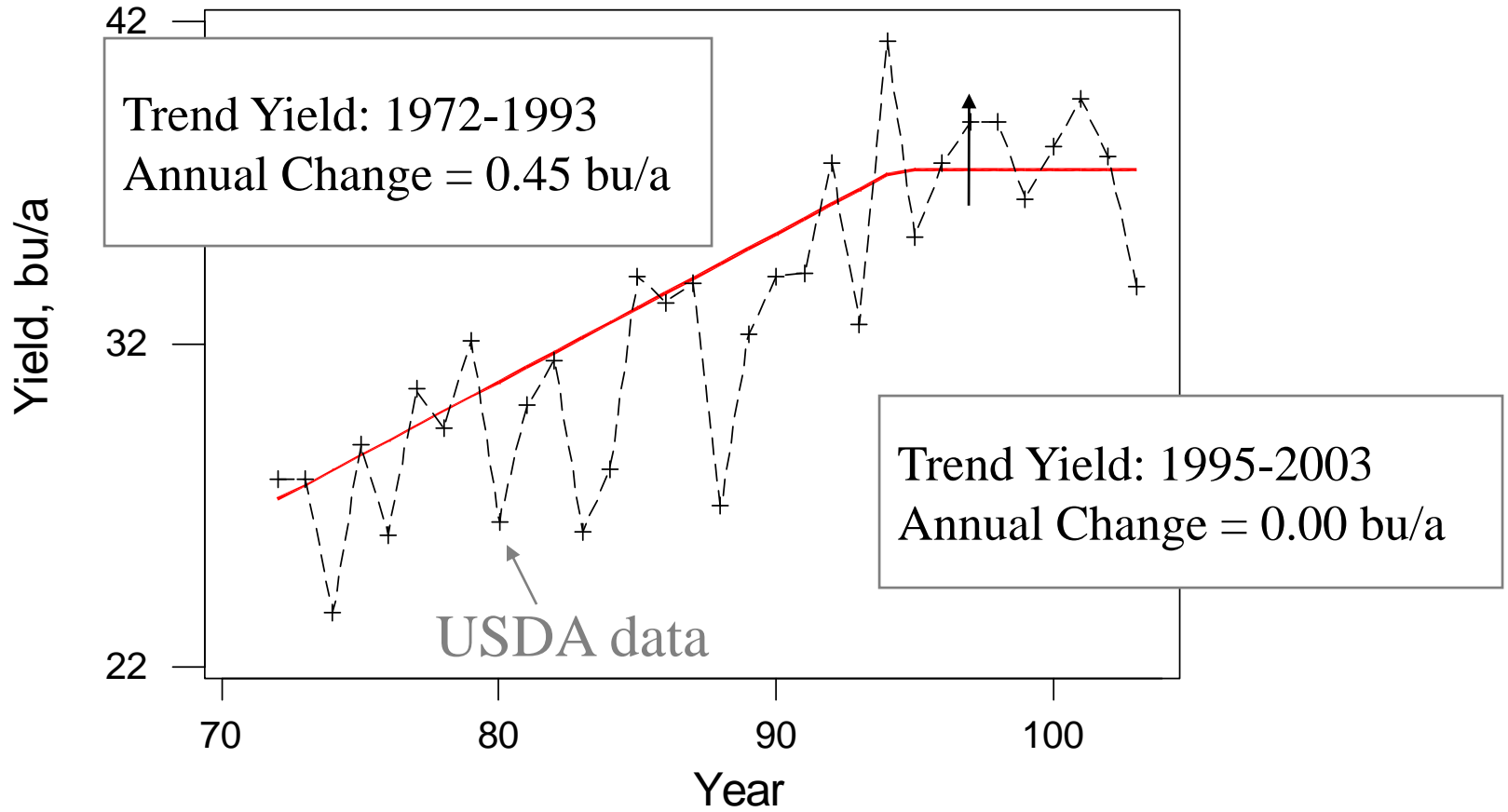


Figure 3. Ontario soy yield trends between 1981 and 2007, before and after release of GLY-soy

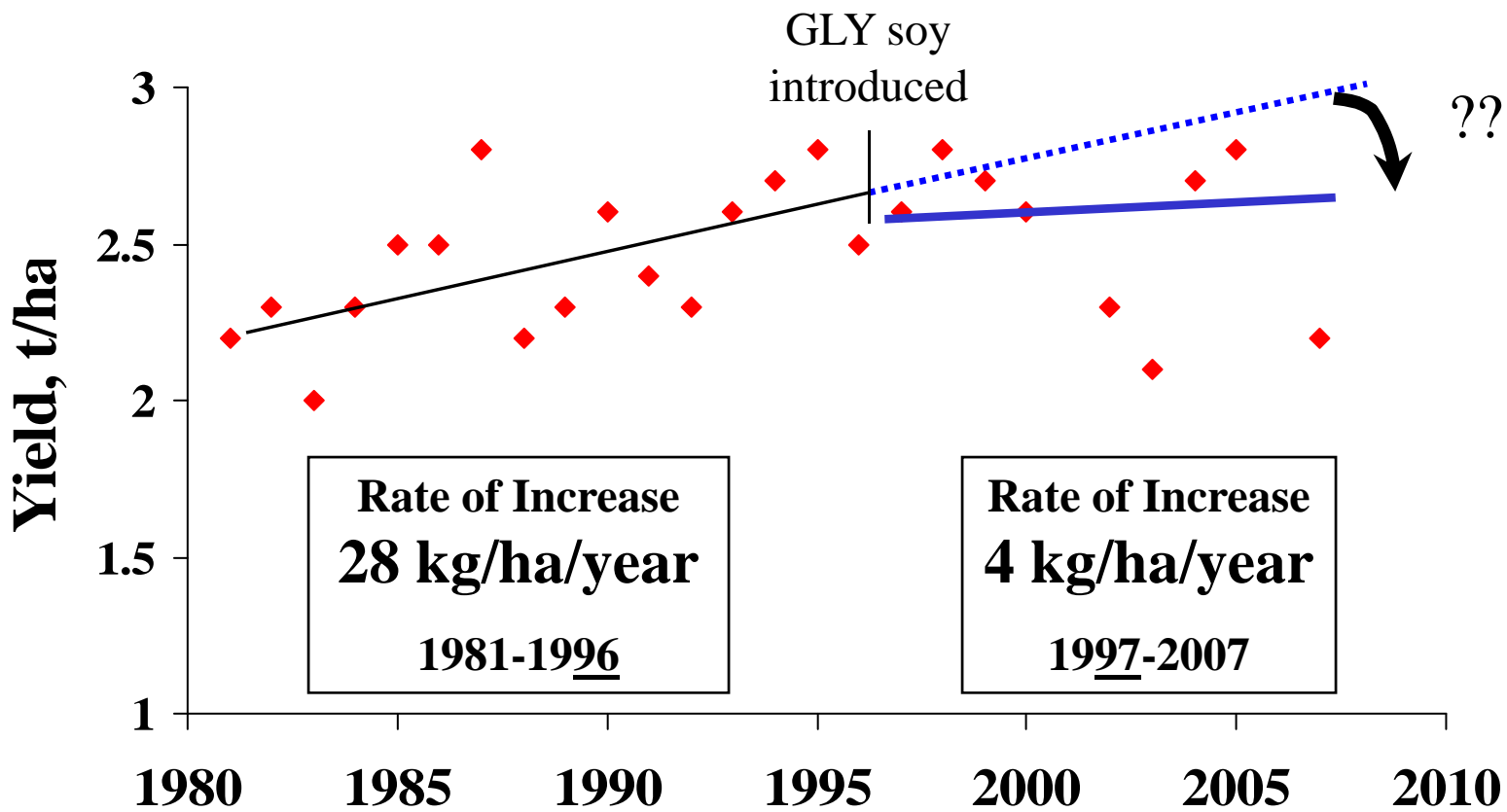
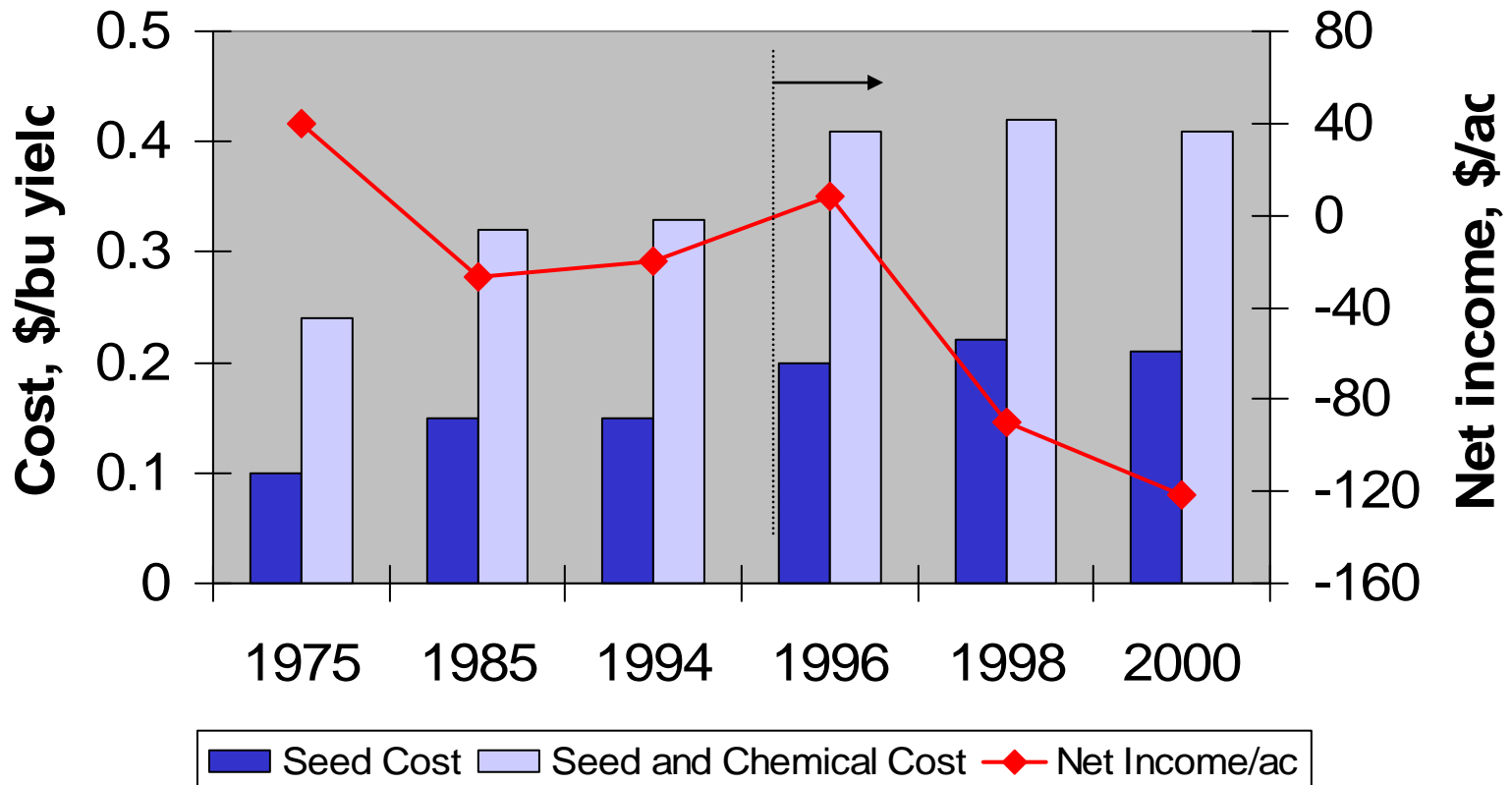


Figure 4. Seed and chemical cost (\$/bu) and net income/ac with release of Bt corn in US



Adapted from Benbrook, 2002

Figure 5. Illustration of spatial implications of mitigation buffers to reduce GM corn contamination below 1%

