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THE FAILURES OF GENETICALLY MODIFIED ORGANISMS (GMOS): RESISTANCE, REGULATION, AND REJECTION

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ABSTRACT

Genetically modified organisms (GMOs) have been contentious for more than three decades. Only 24 countries grow GMOs commercially. Four countries (USA, Canada, Brazil and Argentina) account for 85% of the global GMO hectares. Four crops (soy, corn, cotton and canola) account for 99% of GM hectares. Despite the veneer of social validity that regulators cast, the GMO sector has failed to gain a social licence. Where GM labelling is required, food manufacturers avoid GM ingredients. GMOs have failed to gain price parity with their non-GM counterparts, and they attract price penalties. Segregation of GMOs and non-GMOs has failed (with a tolerance of 0.9% GM contamination in so-called non-GM canola). GM has failed the coexistence test with a GMO growers contaminating neighbouring farms. GMOs are a biosecurity fail, with test plots of GM canola planted in the late 1990s still monitored two decades later for rogue canola plants. Most GMO crops are glyphosate dependent. Glyphosate is globally subject to massive litigation claims and awards, and is implicated in the causation of multiple cancers. Mechanisms for compensating farms contaminated by GMOs are lacking. The GMO industry has taken no responsibility for contaminations. GMOs are a threat to the organic sector and the maintenance of certification and price premiums. Most countries (88%) do not grow GMO crops. This paper considers the global experience of GMOs and the Australian experience as a microcosm of the global experience and as a case study.

Keywords: *Genetically engineered crops, GM canola, GM cotton, Marsh v Baxter, glyphosate*.

INTRODUCTION

The global adoption of genetically modified organisms (GMOs) has been limited despite three decades of robust marketing. Four countries of North and South America account for 85% of global GMO hectares: USA (40%), Brazil, (26%) Argentina (12%), and Canada (7%). Another 20 countries have some GMO crops. The global total of GMO hectares is 189.8 million hectares. (ISAAA, 2017a). Most countries (88%) have no GMO hectares.

Globally, four GMO crops account for almost all (>99%) of the world's GM crops: soy (50%), corn (31%), cotton (13%), and canola (5%) (ISAAA, 2017a). Two of

these 'big four' commercial GM crops, cotton and canola, are grown in Australia (OGTR, 2018b). Most countries (n=17) with commercial GMO grow just one or two GM crops (OGTR, 2018b). Any GM crop in Australia must be first approved by the Office of the Gene Technology Regulator (OGTR), based in Canberra. As elsewhere, there has been a bifurcation of views. GMOs have, from the outset, met with scepticism and rejection by Australian consumers, while being embraced and promoted by Australian university agriculture departments and the CSIRO (e.g. OGTR, 2019). This disparity of views persists to the present time. The clash of views is perhaps a part of the modern trend, borne of recent experience, to distrust experts (Shaw, 2016). The present paper examines the global experience of GMOs, it draws on the Australian experience as a case study, and it reveals multiple facets of the failures of the GMO farming sector.

MATERIAL AND METHODS

The present paper draws on multiple sources, including surveys of consumer attitudes over the past decade, longitudinal price data of GMOs, longitudinal plantings data of GMOs, legal trial and appeal documents, including evidence and judgements in the Marsh v Baxter case (where an organic grower, Marsh, sued a neighbouring GMO grower, Baxter, for economic losses, including loss of organics premium, due to loss of organics certification caused by GM contamination), and documentation (including submissions, hearings transcripts, and the official report) of the Parliamentary Inquiry into mechanisms for compensation for economic loss to farmers in Western Australia due to contamination by genetically modified material.

RESULTS AND DISCUSSION

Australia offers a microcosm of the global experience of GMOs.It is a minor player in the world of GMO agriculture, and it accounts for 0.4% of the world's GMO agriculture (ABCA, 2019; Cotton Australia, 2019; ISAAA, 2017b). There are two GM crops commercially grown in Australia, GM canola and GM cotton (ISAAA, 2018). GMO agriculture in Australia accounts for 0.2% of Australian agricultural hectares (492,000 ha of GM canola plus 282,000 ha of GM cotton = a total 774,000 ha of GM crops, compared to a total 394,000,000 ha of Australian agriculture land) (ABCA, 2019; ABS, 2018; Cotton Australia, 2019). Given the experience of the past two decades, there appears to be little prospect of those GMO hectares increasing in the immediate future. Ten facets, including social, economic, agronomic, commercial and ecological aspects, of the failures of the GMO sector are documented.

Social license failure

Consumers of the world avoid GM foods. A multi-national study of consumers (n=23,000) across 17 countries, reported that 60% of Chinese consumers reject GM food, for Mexico and Italy the figure is 49%, and for Spain, Russia, France, and Brazil the figure is 45% (GfK, 2017).

As elsewhere, the results of community surveys conducted in Australia over more

than a decade reveal that GM food and crops have failed to achieve a social licence. There is no majority support for GMO food in Australia. In one survey (n=1,100), 66% of respondents were either "concerned" (39%) or "alarmed" (27%) about "Genetically modified GM foods", with a further 7% responding as either "Neutral" (4%) or "Don't know" (3%), and only 28% responding that they were either "excited (9%) or "hopeful (19%) (MARS, 2011). These results reveal community disdain for GMO foods and are consistent with previous similar surveys (e.g. MARS, 2008, n=1,100).

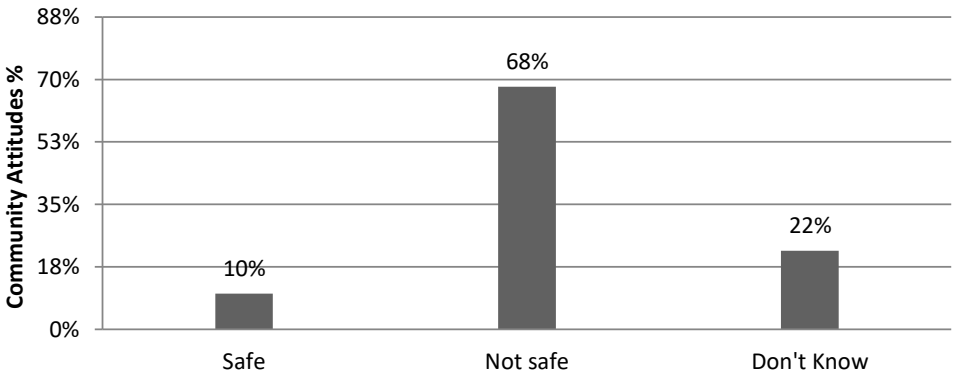


Figure 1. Australian community attitudes to "the use of genetically modified (GM) technology to produce food" (n=1,255) (author's graph; data source: Cormick & Mercer, 2017).

A survey commissioned by the OGTR (n=1,255), reported a minority (38%) of the community supported GM food and crops. This was consistent with 34% of respondents reporting their "willingness to eat GM foods". Only 10% of respondents reported that it was "safe" to grow GM in their own state or territory while 68% of respondents reported that it was "not safe" to grow GM in their own state or territory (Cormick & Mercer, 2017) (Fig. 1).

Retail failure

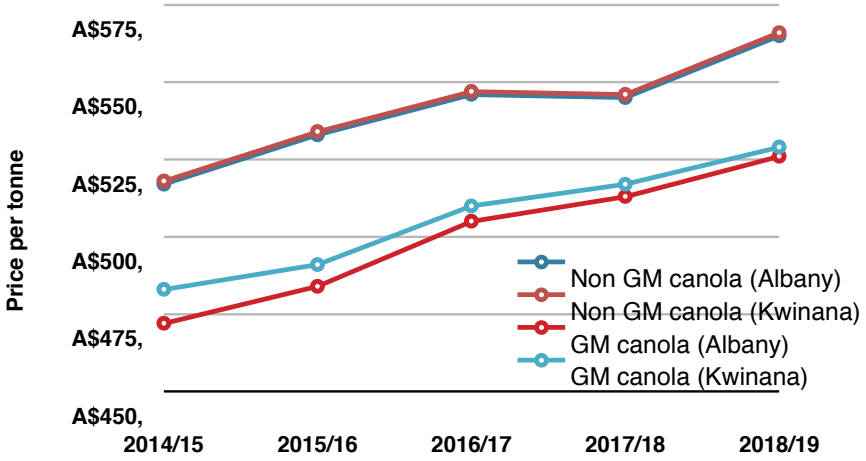
Where manufacturers are required to declare GMO ingredients in their products, they opt to avoid such ingredients**.** For example, GMO food products are required to be labelled as such in Australia (FSANZ, 2016). The consequence of this labelling requirement is that there are no GMO food products offered for sale in Australian supermarkets. The food processors, suppliers, and supermarkets have collectively and clearly made the judgement that Australian consumers have no appetite for GM foodstuffs in their diet, and that the inclusion of GM ingredients would damage their brand. Some products, for example Zafarelli pasta products, state on their packaging "Free of Genetic Modification" (Zafarelli pasta is Australian made from Australian grown durum wheat). GMO food is absent from Australian supermarket shelves and this outcome reflects (a) the food regulation

requirement to label GMO ingredients on the pack, (b) the resistance of Australian consumers to buy such products, and (c) the recognition, in the marketplace, of the prevailing negative consumer sentiments regarding GMOs.

Price failure

In the global market place, GMO crops attract a price penalty, in the region of 10% to 25% for GM soy (Açıkgöz, 2018). By choice or circumstance, the GM sector operates a 'sell cheap' price regime. Based on five seasons of data and two delivery depots, the price penalty for GM canola in Western Australia is 7.2%. Over the seasons and across the depots, the annual price penalty for GM varied from a low of 5.3% to a high of 9.2% (Paull, 2019b) (Fig. 2). About 21% of Australian grown canola is GM (OGTR, 2018b). For GM cotton, no price comparison is available because over 99% of Australia's cotton is GM (Cotton Australia, 2018).

Figure 2. Average annual price per tonne of GM canola versus non GM canola



(graph source: after Paull, 2019b; data source: Taylor, 2019).

Biosecurity failure

Once introduced into an environment, GMOs are challenging to eliminate or contain (Agapito-Tenfen et al., 2017). Australia's island state, Tasmania, has the strictest biosecurity regime of all Australian states and territories. There has been a GMO Moratorium in place fin Tasmania since 2001 and this persists to the present time (DPIPWE, 2019).

In the late 1990s to 2000, Monsanto and Aventis conducted field trials of GM canola at 57 sites in Tasmania. The sites have been monitored for the past two decades with multiple audits. Every audit has identified rogue canola plants, despite containment practices, with the number of plants declining (DPIPWE, 2014; Paull, 2019d) (Fig. 3).

These unwelcome GMO intruders into the Tasmanian landscape appear to be contained to the original trial sites, but not eliminated, even after two decades of auditing and containment practices. The data from the Tasmanian experience show

the persistence of GMOs in the landscape and the serious challenge of eliminating them once introduced, even in the circumstance here of limited experimental field trials which fall well short of commercial release.

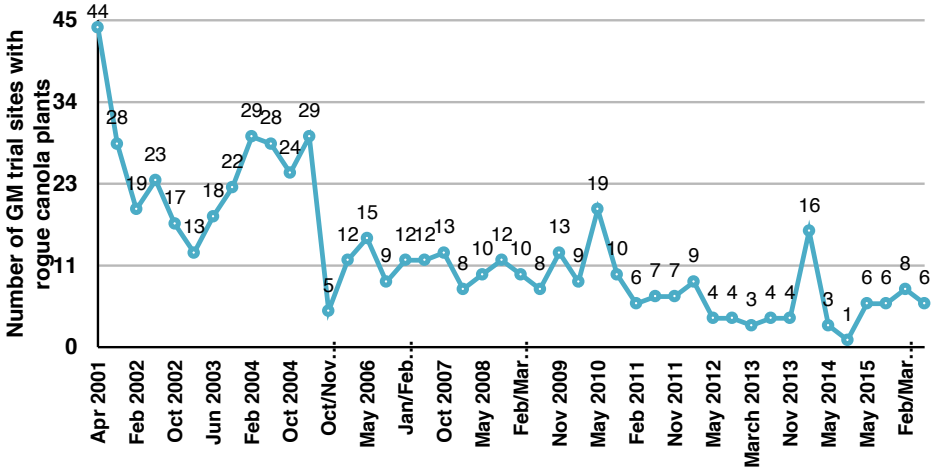


Figure 3. Monitoring of the 1990s GMO trial sites continues to find rogue canola plants at GMO trial sites in Tasmania even after two decades.

Segregation failure

Contamination by GMOs of their non-GMO analogues is a global phenomenon (Price & Cotter, 2014; Sharratt & Chopra, 2019). Importing countries, including China and South Korea, have rejected shipments of produce, including wheat and corn, due to GMO contamination (Chung, 2016; Lopez, 2013).

Table 1. The two classes of canola offered in WA as described by the grain handler (neither are without GMOs), with a 'fair description' added by the present author (CBH, 2019).

Canola Grade	Marketing Description	Specified Characteristics	Fair Description
CAN	"Non GM Canola"	"Certified GM free to Maximum adventitious presence of 0.9% GMO. Suitable for Human Consumption and Biodiesel production. ISCC EU Certified".	**Canola with GM contamination ≤ 0.9%**
CAG	"Canola"	"Suitable for Human Consumption and Biodiesel production. ISCC EU Certified".	**GM Canola**

When an exemption was made to the GM moratorium in Western Australia (WA) to allow GM canola in 2010 (Paull, 2015b), the exemption was made on the

assurance that GM and non-GM grain could coexist and a grain-handling segregation regime could and would avoid contamination of non-GM grain by GM grain. This promised segregation has been a failure. The assurances of strict segregation promptly failed as the impracticability of strict and effective segregation was revealed in practice. The outcome for WA (a state of 2.5 million km^2, larger than France, Spain, Germany, Portugal, Poland, Italy and UK taken together) is that canola exported from WA is graded as 'CAG' (= GM canola) or 'CAN' (= non-GM canola but with an allowed contamination by GM canola of up to 0.9%) (CBH, 2019). So, although the 'CAN' grade is described as 'non GM' by the grain handler, it is not GM-free (and is not non-GM in the usual usage of the language) (Paull, 2019b) (Table 1). This history of ongoing GMO segregation failures, in WA along with the biosecurity issues of the persistence of rogue canola plants in Tasmania from GMO trials of two decades ago, supports the case that GMOs are properly regarded and managed as invasive species (Paull, 2018a).

Stability failure

The number of countries growing GMOs is shrinking. It appears to have peaked at 29 countries in 2010, and from there its has shrunk progressively, to 28 in 2012, 26 in 2016 and to 24 presently (ISAAA, 2010, 2012, 2018).

The second GM crop that is grown in Australia is GM cotton, and most (>99%) of Australia's cotton production is GM cotton (Cotton Australia, 2018). Cotton growing is Australia has always been controversial for a variety of reasons, including that cotton is a 'water hungry' crop and Australia is a dry continent where water is precious and droughts are regular, the crop is grown as a broad-acre monoculture and relies on 'crop dusting' planes to apply a smorgasbord of biocides, with the attendant spray drift contaminations exacerbated by the aerial application of these toxic chemicals, and with the attendant contentious contamination of waterways. GM cotton has been grown in Australia since 1996 (OGTR, 2018a). In the period since then, the areas sown have varied wildly from year to year (Figure 4). Current plantings of cotton in Australia are less than they were in 1996/97. The industry does not exhibit any stability but instead exhibits erratic fluctuations (from a high of 599,630 ha in 2010, to a low of 68,585 ha in 2007, to presently 282,000 ha in 2018) (Fig. 4).

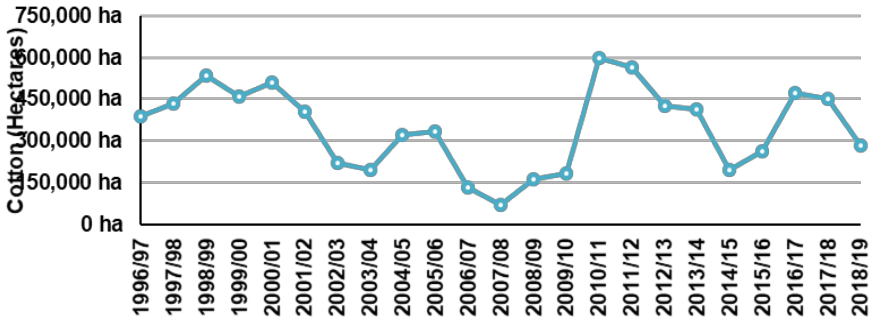


Figure 4. Cotton plantings in Australia have been erratic (author's graph; data source: Cotton Australia, 2019).

Coexistence failure

GMO farms have not proved to be 'good neighbours' to non-GMO farms (CBC News, 2004; McLachlin et al., 2001). GM canola was approved for release in WA in 2010 with the assurance that GM and non-GM cops could coexist. This immediately proved to be false. That first GM canola crop in WA contaminated a neighbouring organic farm, which, as a consequence, lost its organic certification. The representation had been made at the time of the initial approval that if there were contaminations that there were adequate common law remedies to recover losses. When put to the test, this assurance ultimately proved to be false (Paull, 2015b). The organic farmer (Marsh) sued the GMO farmer (Baxter) for the economic loss caused by the loss of the organic premium. The loss was agreed between the parties at A$85,000 (US$60,000; €53,000). The liability (but not the actual contamination) was contested by the GMO farmer at every legal step, as the case moved from the WA Supreme Court, to the WA Court of Appeal, and finally to the highest court in the land, the High Court of Australia. The legal costs of the GMO farmer were paid by Monsanto. The organic farmer lost the case at every step, and costs were awarded against the organic farmer.

The Marsh v Baxter case established that (a) GM crops can contaminate a neighbouring farm with impunity (the facts of the contamination were not contested although the judge preferred to characterise the offending events as 'incursions' rather than 'contamination') (Martin, 2014), that (b) there are no effective common law remedies for such contamination, and (c) a farmer suing a neighbour for losses due to GM contamination faces years of litigation (in this case, all fruitless), and risks bankruptcy, since the legal costs of the Marsh v Baxter case exceeded A$,2,000,000 (US$1,410,000; €1,250,000) (Paull, 2015a, 2015b).

Contamination failure

Non-GMO farmers bear the burden of GMO on-farm contaminations, and there are no ready solutions to this iniquity. Following a change of government in WA in 2017 (to Labor), there was the acknowledgement that the Marsh v Baxter case demonstrated that the common law remedies for GM contamination were deficient.

The WA Legislative Council (upper house of the WA bicameral parliament) established a Parliamentary Inquiry to consider "mechanisms for compensation for economic loss to farmers in Western Australia caused by contamination by genetically modified material" (EPAC, 2018). Public submissions were called for, and evidence was admitted in a series of hearings. The report of the Inquiry was disappointing. Various mechanisms were submitted and considered by the committee but none were recommended for implementation (Swinbourn, 2019) (Table 2). The committee was unable to determine the extent of contamination events occurring across the state. Members observed that the Marsh v Baxter case had had a "chilling effect" (e.g. Collins, 2018, p.4; May, 2018, p.9; Paull, 2018b, p.6) in silencing farmers experiencing GMO contamination because litigation had proved so expensive in terms of time and money in the Marsh v Baxter case and had ultimately only achieved further penalisation of the contaminated party.

Table 2. Options for a compensation mechanism considered (but not progressed) by the WA Parliamentary Inquiry (Paull, 2019a).

#	Proposed mechanism	Result
A	Status quo, i.e. Do nothing	The recommended outcome in the Inquiry Report
B	Levy GM industry	Not a recommendation in the Inquiry Report
C	Technology Licence Bond	Absent in the Inquiry Report
D	Non-GM farmer Insurance	Not readily available (or at all) in the marketplace
E	GM farmer Insurance	Not readily available (or at all) in the marketplace
F	Compulsory Third Party (CTP)	Not a recommendation in the Inquiry Report
G	Government pays	Absent in the Inquiry Report

The Parliamentary Inquiry was the last 'great hope' that some good, for the non-GM farming sector, might come from the WA experience of GM contamination and the Marsh v Baxter case. No such happy outcome was achieved. A GMO-contaminated party faces the prospect of no proven common law remedy and the might of Monsanto's purse (which backed GMO farmer Baxter in court and indemnified his risk). It would be a brave and perhaps foolhardy Australian farmer who next takes on Monsanto/Bayer GM contamination in the light of the Marsh v Baxter case which has now run its course and exhausted its legal options.

Uptake failure

GMOs account for 3.8% of the world's agricultural land and although this has been creeping up, the adopter base has been shrinking. Globally, the number of countries planting GMOs peaked in 2010 (n=29) and has been declining since then (currently n=24) (ISAAA, 2010, 2018). Australia's OGTR (established in 2000) has approved

the commercial release of GM cotton since 2002 and GM canola since 2003 (OGTR, 2019), nevertheless GMOs only account for less than 0.2% of Australian agriculture hectares (Fig. 5).

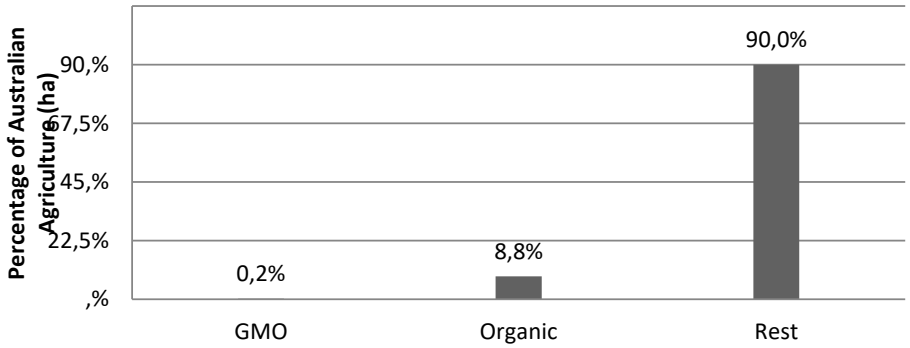


Figure 5. The distribution of three mutually exclusive types of agriculture in Australia.

The percentage of the canola crop in WA that is GM canola has been in decline since 2015 (Fig. 6). The most recent figures reveal that GM canola planting has declined while total canola plantings have increased: "The proportion of canola sown to Roundup Ready varieties contracted to 18% of the area. This was related to the increase in canola area (from 1.2 in 2016 to 1.4 million Ha in 2017) … and a small decrease in the area of GM canola sown" (Bucat, 2018, p.5).

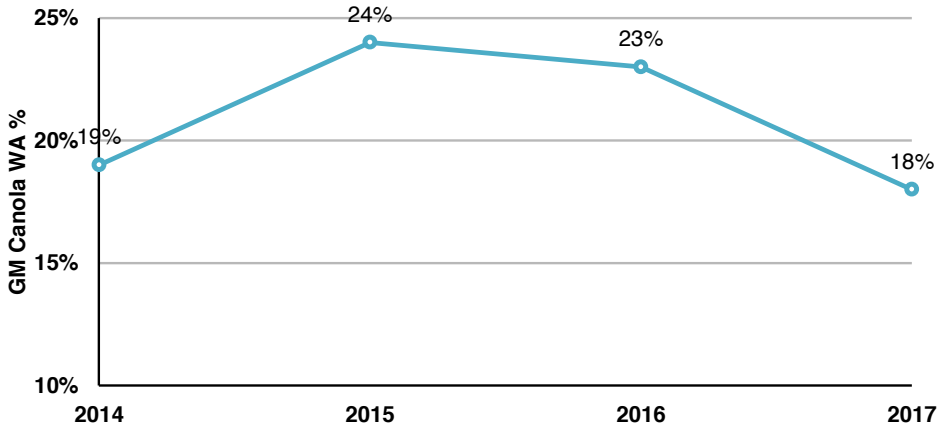


Figure 6. Percentage of the WA canola crop that is GM canola.

Glyphosate failure

Most of the world's GMOs are herbicide tolerant, with variations of Monsanto's GM Roundup Ready (RR) soy, corn, cotton and canola the most popular (ISAAA,

2018). The GM canola crop in Australia is a glyphosate dependent crop (Monsanto's RR canola). Glyphosate is a problematic herbicide, it is a declared carcinogen (OEHHA, 2019), it is ingested by adults and children via a variety of routes including food and beverages (Cook, 2019), and it is currently under consideration of being banned in multiple jurisdictions.

There have recently been several landmark decisions awarding damages for cancer caused by glyphosate, in one case, US$80 million (Rosenblatt, 2019), in another, US$289 million (Bellon, 2018), and in another, US$2 billion (Davis, 2019). There are a further 9,300 more plaintiffs in USA (Bender, 2018). The first lawsuit has been filed in Australia, with more forthcoming (Houston & Vedelego, 2019). This is a global problem for Monsanto and its new owner Bayer.
The case for GM canola (RR canola) has been built on foundations that are in the process of being swept away in a blizzard of litigation. Glyphosate is a cancer causing herbicide that is a faltering cornerstone for the GM industry to have staked so much, including reputation, in Australia and elsewhere.

CONCLUSION

The GMO industry has failed major tests, including, the lack of social licence, attracting price penalties, lapses of biosecurity, segregation, stability, coexistence, contamination, narrow uptake base and market penetration, and glyphosate dependence. Australia offers a microcosm for considering these failures. Australia is a major player in global agriculture and in global agriculture exports (Rural Bank, 2018), but it is a minor player in the world of GMOs. In line with global consumers, the Australian public have failed to concede a social licence to this industry and remain skeptical about GMOs. The GM hectares in Australia are in decline for the two GM crops, GM canola and GM cotton. There is a price penalty for GM canola of 7.2% compared to non GM canola (no comparison figures are available for GM cotton versus non GM cotton). GM canola is a glyphosate dependent crop and its percentage of the canola crop in Australia may be anticipated to plummet now that cancer lawsuits are in propect, if glyphosate use is banned, and if glyphosate residues are implemented at zero-tolerance by the market.

In contrast to the declining GM sector, the organic sector in Australia, and the world, is in the ascent and Australian organics now accounts for 51% of the world's certified organic hectares (Paull, 2019c). Australia is far from the world's loci of pollution, and has many other natural advantages for 'clean and green' food and fibre production. GMO farming puts at risk 'Brand Australia' as a clean and green source of premium food and fibre. Extrapolating from present trends, we may foresee GMO production further retreating in Australia, as resistance is maintained within Australia and rejection is entrenched and increasing internationally as discerning markets and consumers say 'no' to GMO imports.

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