

Chapter 16

Transgenic Flax and the Triffid Affair



Camille D. Ryan and Stuart J. Smyth

16.1 Introduction

Common flax (*Linum usitatissimum* L.) was one of the first crops cultivated by man used in food and linen cloth production in Europe and Asia, dating back to 5000–8000 BC (Berglund 2002). Today, there are two types of flax produced, seed flax for oil and fiber flax for the stem fiber. Fiber flax has an average annual global production of 500,000 hectares and is predominantly grown in China, the Russian Federation, and in Western Europe. Approximately 3.5 million hectares of oilseed cultivars (also referred to as linseed) are grown in Canada, India, China, the United States (US), and Argentina. Flax is used in the production of various industrial products including linen, fiber composites, paints, inks, and linoleum. Flax has grown in popularity as a nutritional supplement for its value as an essential omega-3 fatty acid for both human and animal consumption with the introduction of low linolenic acid flax varieties over the past several years (Galushko and Ryan 2012). It is often consumed raw or is used in whole-grain products such as cereals and breads. In 2014, Health Canada approved a health claim that linked consumption of ground whole flaxseed with lowered blood cholesterol levels, a major risk factor for heart disease (Health Canada 2014).

Other than a few brief intervals in the 1960s and 1970s, Canada has been the global leader in flax production, followed by the United States, China, and India.

C. D. Ryan
Bayer CropScience, St. Louis, MO, USA

S. J. Smyth (✉)
Department of Agriculture and Resource Economics, University of Saskatchewan,
Saskatchewan, Canada
e-mail: stuart.smyth@usask.ca

Flax production in Canada ranged from a low of 500,000 tons to nearly 1.1 million tons in the first decade of this century, with an annual average of just over 700,000 tons between 2000 and 2015. Only a small portion of this is consumed domestically, averaging about 20% per year, with the export value averaging over C\$200 million. Canada's export markets include the United States, China, Japan, Australia, Mexico, the United Kingdom, and Brazil. However, by far, Canada's largest export market for flax is Europe. On average 75% of Canada's production is exported to Europe each year, although in peak years, it has risen to well over 80%.

Given Canada's dominance as a global flax producer, private and public investments have been made into developing cultivars that enhance both productivity and oilseed quality. Transformation processes used in development include conventional breeding techniques as well as mutagenesis. Triffid flax was a flax variety that was genetically engineered for resistance to soil residues of sulfonyleurea-based herbicides. Developed by the Crop Development Centre at the University of Saskatchewan over the period of the mid-1980s to the mid-1990s, the new variety was designed to provide growers with an alternative to continuous cropping of wheat and other cereals. It also provided a profitable oilseed option to the millions of hectares of canola production. This chapter tracks the history of Triffid, from its early development to its deregistration in 2001, to Triffid's discovery in the EU food supply chain in 2009 and the ongoing trade problems that have since ensued.

16.2 Background of Genetically Modified Flax to 2001

Researchers at the Crop Development Centre (CDC) at the University of Saskatchewan conducted research on several varieties of transgenic flax and after several years of field trials, selected variety FP967 to submit for registration to the Plant Biotechnology Office¹ (PBO) of Agriculture Canada in February 1994. This variety is more commonly known by its marketing brand name of CDC Triffid. In May 1996, the PBO gave partial approval to CDC Triffid. It was determined to be substantially equivalent to conventional flax varieties in terms of specific use and safety for the environment and for health. However, at that point in time, CDC Triffid only received approval for animal feed use. In a Canadian split-run decision, this new flax variety received approval for animal feed use only in 1996 (McHughen et al. 1997) and subsequently entered a seed multiplication program. Full variety release, including Health Canada's approval for Triffid to be marketed for human consumption, was not granted until 1998.

The implementation of the 1998 EU moratorium on GM crops and foods presented a formidable obstacle for the Canadian flax industry. Approximately three-quarters of the flax production in Canada at the time was exported to Europe, and

¹The PBO was the forerunner to the Canadian Food Inspection Agency, which was the independent regulatory agency created when the PBO was removed from being an office within the Department of Agriculture and Agri-Food Canada in 1997.

the commercialization of a GM flax variety alarmed the European importing firms. While the canola industry had an effective identity preservation program in place to manage GM varieties and continued to supply the European and Japanese markets (1995–97) (Smyth and Phillips 2001), the flax industry did not have this option because of the dominant role of the European market. European importers were adamant that they would reject flax imports from Canada if GM flax was grown commercially.

Varietal registration (which allowed for seed multiplication but not commercial production) was granted in May 1996, and pedigreed seed production was initiated. Seed multiplication continued in 1997, and by the end of the 1997 harvest, there was an estimated 5000 tons of pedigreed CDC Triffid seed in existence in Canada. That year turned out to be the final year for multiplication of GM flaxseed. At that point, existing seed stocks of CDC Triffid were identified and contained in separate grain bins in compliance with pedigreed seed production regulations.

By late 1997 to early 1998, it became apparent to the Canadian flax industry that the proposed (at that time) EU moratorium would proceed. Discussions about how to handle the situation were initiated and led by the Flax Council of Canada (FCC). It was determined that all of the existing contained seed stocks would remain that way until a suitable location could be found to crush the flaxseed. Coordinated by the FCC, a CanAmera Foods crushing plant in Altona, Manitoba, was eventually contracted to crush the flax. The meal was subsequently mixed into livestock feed and fed to Canadian livestock, while the oil from the crush was diverted into industrial applications. All breeder seed stock held by the CDC was incinerated. This effectively removed all breeders' seed from pedigreed seed growers contracted to multiply the seed.

To ensure that CDC Triffid flax would not jeopardize future export markets, the developers of the variety applied to deregister the transgenic flax variety. This process was initiated in 2000 and by 2001 the Canadian Food Inspection Agency (CFIA) had officially deregistered CDC Triffid flax. This meant that it was illegal to produce or distribute this variety anywhere in Canada, but not illegal to grow it.² As agricultural history would write it, Triffid became the first transgenic crop technology to be withdrawn from the Canadian market. The Canadian flax industry believed that varietal deregistration in 2001 represented an end to Triffid and any trade issues associated with GM flax. Unfortunately, this was not to be the case.

²Many crop varieties are deregistered as they are replaced by new varieties. The new varieties have superior yield and disease resistance, and the old varieties become obsolete and are deregistered. In an industry where bin run seed is common and variety comingling can occur, making it illegal to grow a deregistered variety would be a logistical nightmare, so it is only illegal to sell and/or market a deregistered variety as that particular variety. It is not illegal to unintentionally grow a small percentage of a deregistered variety as part of another crop. When this happens, the shipment is downgraded to animal feed and enters that market (at a lower price) rather than the human food market.

16.3 The Re-emergence of GM Flax: 2009–2016

In July 2009, the EU reported that a Canadian shipment of flax had tested positive for the NPTII marker indicating a GM event. At this point, it was assumed that GM canola or some other GM crop had comingled in the shipment. However, by September 2009 the EU's Rapid Alert System for Food and Feed (RASFF) was notified by a German company that its bakery/cereal products had tested positive for Triffid.³ Notification on the RASFF system is "equivalent to an air siren going on in the EU" (Ryan and Smyth 2012; Ryan and McHughen 2014). It is an incredibly effective communication tool. This notification in September was the first of more than 100 over the next several months that would report Triffid in bakery goods, cereals, and other products made by companies throughout the EU.⁴

With the EU having a zero-tolerance regulation for comingling of unapproved GM events, it meant that Canadian flax exports were in violation of this regulation and that all Canadian flax shipments would be rejected until Canada could guarantee that their flax shipments did not contain even trace amounts of GM flax. The Canadian seed trade industry responded swiftly to the initial notification. Stakeholders such as the Flax Council of Canada, the CFIA, and the Canadian Grain Commission (CGC) mobilized quickly in order to mitigate what threatened to shut market access for Canadian flax producers. With winter approaching and the looming closing of the St. Lawrence Seaway, stakeholders were highly motivated to ensure that markets opened before the winter freeze-up, usually sometime in December. This export option is not available for the three winter months of January, February, and March. Figure 16.1 shows the crop year export figures for Canadian flax to Europe, highlighting the impact of Europe's zero-tolerance policy during the height of Triffid concerns. Canadian flax exports to Europe were down by 51% when compared to the crop year just prior to the detection of GM flax. As is evident, the final quarter of the calendar year is the peak export period for flax to Europe.

The FCC and the CFIA met together in Brussels, Belgium, on October 19, 2009, to work with DG Sanco (Directorate General for Health and Consumer Affairs) and other EU stakeholders. The objective of the meeting was to develop a testing protocol to manage the situation in Canada (European Commission 2009). The protocol was immediately launched in the Canadian market, quickly establishing a system of sampling and testing of flax stores (one test for every 5000 bushels). Samples that tested positive at levels greater than or equal to 0.01% for Triffid⁵ would not be accepted for

³Please refer to the initial (full) notification recorded as RASFF 2009.1171 at: https://webgate.ec.europa.eu/rasff-window/portal/index.cfm?event=notificationDetail&NOTIF_REFERENCE=2009.1171.

⁴One hundred and eleven (111) notifications were filed with the RASFF between September 8, 2009, and January 18, 2011. A notification dated July 28, 2010, was qualified as a "border rejection" by Finland.

⁵No detection at a 0.01% level, 19 times out of 20.

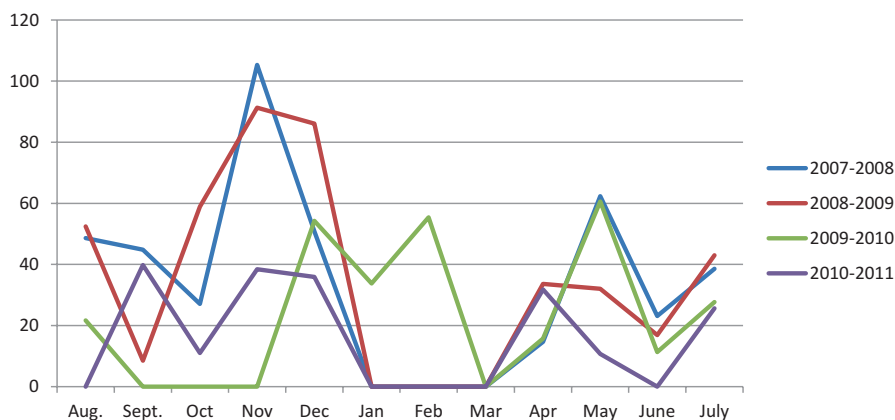


Fig. 16.1 Month over month flax exports to the EU 2007–2011 (000s tons) (Data Source: Canadian Grain Commission database, available at: <http://www.grainscanada.gc.ca/statistics-statistiques/ecgwf-egcfb/ecgm-megc-eng.htm>. NOTE: Some of the December 2009 exports were able to be shipped through the St. Lawrence Seaway, but much of this month's exports, as well as those of January and February 2010, were either railed to the port of Montreal and exported or exported through the West Coast of Canada, substantially adding to the export costs in Canada)

import into the EU market (FCC 2009). According to James (2010), Canadian flax averaged a failure rate of 20% at EU ports during the last 6 months of 2009.

By early 2010, following much speculation, the source of the Triffid contamination was identified by the Flax Council of Canada. It originated from two of the CDC pedigreed flax varieties – CDC Normandy and CDC Mons (Booker and Lamb 2012; Young et al. 2015).

Speculation did not end there. There were also allegations that some seed growers had held back seed after deregistration in the hopes that EU policy and consumer opinion would change and the market could take advantage of this valuable flax variety. It was widely communicated, although not verifiably proven that the subsequent farm testing revealed that one sample had tested positive for Triffid at a level of 100% purity. This would have been entirely possible as there were no tests capable of accurately testing flax at the time that it was deregistered, for the presence of Triffid at very low levels. Additionally, the widespread low-level presence of Triffid flax across the Canadian growing belt was speculatively due to pollen or gene transfer. The notion of “flow” and spread of flaxseed, however, is much more complex than that. Flax primarily self-pollinates so seed-mediated gene flow is probably a more important factor in terms of gene flow. There are two scenarios at work in seed-mediated gene flow. First, there is *persistence* of the cultivar (where it was previously grown). For growers that did not rotate for 3 years, volunteer flax may have *persisted* in fields, and this could potentially have included small amounts of volunteer Triffid flax. Secondly, there is seed mixing and movement by equipment

(seeders, combines, trucks, etc.) that may account for *dispersal* of the GM flaxseed in trace amounts. Flaxseed sticks like glue when it is wet and exhibits static cling properties when it is dry. Both wet and dry, flaxseed will inevitably stick to farm equipment. While great care is taken by the seed growers to prevent this, a few seeds can get stuck in a combine or in seeding equipment. It only takes a handful of Triffid plants, combined with another flax variety, to produce as many as 1000 seeds at harvest. This could quite easily account for some of the widespread low-level presence of Triffid across the flax-growing region in Canada. Seed movement has many pathways, and it is quite likely that all pathways outlined above accounted for the widespread low-level presence of Triffid (Hall 2012).

In the end, the most likely cause of the low level of GM flaxseed comingling was the cross-pollination between different varieties of breeders's seed at the University of Saskatchewan. In the late 1990s, the official variety development standards for the planting distance between like varieties of crops in confined field trials were determined to be 3 feet. This meant that field plots of Triffid would have been grown a mere 3 feet from plots of other non-GM flax varieties during development. As cross-pollination occurred, the breeders's seed varieties in the neighboring plots would thus have a very low level of Triffid present in the breeders's seed of new flax varieties. Again, there were no tests available at this time that could have detected the presence of the GM flax in the breeders's seed of other flax varieties.

Testing was conducted on CDC Normandy and CDC Mons in January of 2010, and both tested positive for Triffid at 0.01%. These two varieties – both essentially deemed obsolete at the time – were withdrawn from the program, seed stores were destroyed, and varieties were deregistered on August 1, 2013. By early March of 2010, after extensive testing, extremely low indications of Triffid contamination were discovered in a low number of other breeder seed samples of four other varieties: CDC Bethune, CDC Sorrel, CDC Sanctuary, and CDC Glas (FP 2300). These varieties tested positive at trace levels well below the 0.01% detection level. Rather than withdrawing or destroying these varieties, they were reconstituted. First, individual plants were tested for the presence of Triffid, and those deemed Triffid-free were used as a seed source for the reconstitution process. The seed increase was then sent to New Zealand to a partnering organization where it was grown under confined conditions where flax has not been grown on the land for at least 5–10 years. Once cultivated, the seed was tested again to ensure that it was transgene-free. When the reconstitution process was completed in 2012, the seed was transported back to Canada for introduction into the foundation seed program and was distributed to seed growers and to seed companies and multiplied.

An event-specific assay has since been developed to detect FP967 T-DNA (Young et al. 2015). As part of the requirements for the EU and in keeping with the contractual obligations of the Protocol, testing of Canadian flax is ongoing. In fact, testing is conducted repeatedly all along the value chain, from farm-held stores of flax to the elevator and at ports where flax shipments await export.

16.4 Economic and Trade Impacts of Triffid Flax

Fully capturing the economic costs of Triffid flax is a difficult process. The social costs from farm gate to plate are even more difficult to pin down. That being said, however, we were able to estimate the costs associated with demurrage and quarantine, the testing costs, and other costs associated with segregation along the value chain. This is outlined in Table 16.1. In total, the costs incurred in Canada from 2009 to 2011 are estimated at almost \$30 million.

The EU, too, sustained significant costs all along its value chain, estimated at over \$50 million (CDN) (COCERAL/FEDIOL 2010; Babuscio et al. 2016). Together, the initial trade disruption costs on both sides of the Atlantic from the EU detection of GM flax were estimated to have reached C\$80 million (Ryan and Smyth 2012; Babuscio et al. 2016). This cumulative figure includes the cargo ship quarantine costs, initial flax testing costs, and lost business opportunities within the European flax industry.

As part of the resolution of the import ban that the EU placed on Canadian flax in September 2009, Canada agreed to enact a Farm Stewardship Program for a 5-year period. The objective of this program was to ensure the Canadian flax industry and international flax import markets that Canadian shipments of flax would be free of GM flax.

In the winter of 2009–2010, protocols were developed, and an industry-wide testing program of flaxseed commenced. This 5-year testing program concluded in February 2014. The costs of this program are presented in Table 16.2. As the stewardship program was part of the Canadian Government’s commitment to facilitate the lifting of the EU’s import ban (enacted in 2009), funds to cover a portion of the testing costs were made available through Agriculture and Agri-Food Canada.

Table 16.1 Total estimated costs associated with the Triffid event in Canada (2009–2011)

Cost category		Notes	Source
Demurrage/quarantine costs	\$12,000,000 ^a	As of September 2010	Authors’ calculations
Testing costs	\$3,900,000 ^b	2009–2011	Authors’ calculations
Cost of segregation, other costs for breeders, certified seed suppliers, producers, grain companies, AAFC, and SaskFlax	\$13,185,217	2009 to 2011	Dayananda 2011
Total estimated costs:	\$29,085,217 CDN		

Source: Ryan and Smyth (2012)

^aThis cost estimate is calculated as follows: \$30,000 (CDN) per day which is equivalent to \$1 million (CDN) per month. We conservatively estimate a total of 12 months with this level of costs

^bBased on the number of tests conducted (26,000) as reported by FCC and assuming a conservative (average) cost per test at \$150, we estimate total testing costs (2009 to 2011) at almost \$4 million (CDN)

Table 16.2 Canadian flaxseed testing costs (\$CAD)

Time period	AAFC	Producers	Industry
Aug 2009–Feb 2014	\$1,000,000	\$1,000,000	\$1,340,000
Mar 2014–Jun 2015	NA	\$500,000	Unknown
	\$1,000,000	\$1,500,000	\$1,340,000+

Source: Booker, Lamb, and Smyth (2015)

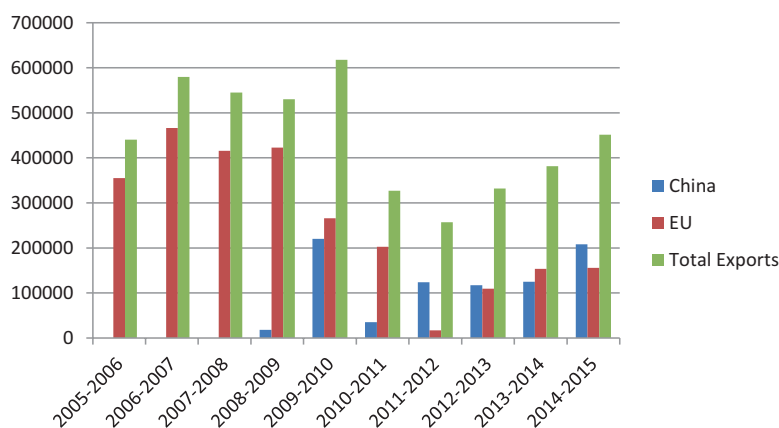


Fig. 16.2 Canadian flax exports to China and the EU, 2005–2015 (in 000 tons) (Source: Canadian Grain Commission 2015)

These funds were used to offset the cost of producer seed testing. Testing on all seed was required prior to seeding to ensure that any GM flax was removed from the crop production cycle. The flax export industry was responsible for testing costs at the railcar to point of export, with costs estimated at \$1.34 million for the 5-year testing period. Cumulative testing costs in Canada from 2009 to 2014 are estimated to have been \$3.34 million.

Following the conclusion of the 5-year stewardship program in 2014, the Federal Government's participation, through AAFC, ended, and testing costs have since been borne by producers and industry. The Flax Council of Canada estimated producer testing costs at \$500,000; costs to the flax industry are not known. Given the cost ratio from previous years, it would not be expected that industry's cost would be lower than that of the producers. A conservative estimate of the cost of testing all flax exports to the EU for the 6 years, from initial detection to present, would be in the range of \$4–5 million.

Additional opportunity costs were incurred from the periodic loss of the EU market (Fig. 16.2). The decline in EU flax exports was partially offset by the addition of China as an export destination. Chinese importers knew that Canadian flax exports to the EU had declined and that Canada had flax surpluses (despite declining flax production). This allowed China to import Canadian flax at a lower price than offered by EU flax importers.

While flax production has nearly fully recovered to pre-GM flax detection levels, the EU market has not recovered. As observed for other commodity markets that have been required to contend with coexistence challenges (rice and corn), export markets typically do not recover to previous levels. Prior to GM flax detection, Canada exported an average of 75% of the flax it produced to the EU. Over the past 3 years, EU flax imports have, on average, represented one-third of the flax produced in Canada. The Chinese export market does not fully account for the loss of 40% of Canada's flax export market.

What is not clear is when the testing of flax will end. The EU has a threshold of 0.1% for unapproved events and GM flax occurrence rates are well below this level. Therefore, all flax exports adhere to the EU standards for unapproved GM events. In theory, the Canadian flax industry should be able to end all flax testing and stewardship program requirements. And while this makes perfect sense from a logical commodity export market perspective, it does not from a politically driven one. There is no incentive for the EU to end their demand that every shipment of flax from Canada be tested to guarantee that it is free of GM flax. In fact, given the EU's recent policy change that allows Member States to individually decide whether they will allow the production of GM crops, it is anticipated that individual Member States will be averse to allowing an end to the testing protocol.

Conversely, what incentive is there for the Canadian flax industry to end its testing of flax? Historically, the EU has been the single most important export market, and the industry has a strong preference to see commodity trade return to pre-2009 levels. Ending the GM testing protocol could potentially make EU flax importers nervous about importing Canadian flax and drive them to seek alternative flax markets. The political sensitivity of testing has now become embedded within the flax trade between Canada and the EU and is likely to be viewed as entrenched. Therefore, this cost will likely have to be borne by producers and the flax industry going forward. The continued occurrence of false-positive tests presents an ongoing challenge to flax exporters.

With international flax trade between Canada and the EU still adversely affected by an incident from 2009, there is little indication that a resolution to the problem will be found in the recent Comprehensive and Economic Trade Agreement (CETA) between Canada and Europe. This trade agreement does mention the thorny issue of GM crops and other products of biotechnology but is incapable of providing a resolution. Article X.03: Bilateral Cooperation on Biotechnology states: "The Parties agree that cooperation and information exchange on issues related to biotechnology products are of mutual interest. The dialogue covers any relevant issues of mutual interest to Canada and the EU, including, ... any trade impact related to asynchronous approvals of biotechnology products or the accidental release of unauthorized products, and any appropriate measures in this respect" (Government of Canada 2016). While clearly recognizing that international commodity trade has been disrupted, there is no mechanism for resolution identified, other than further ongoing discussions and dialogue.

16.5 Conclusions

The Triffid issue represents an unfortunate turn of events for Canada's flax industry. Triffid flax became the agricultural "poster child" for all that can go wrong with a transgenic crop variety in a zero-tolerance export market. While prices have recovered to some degree, the Triffid experience has left many flax growers discouraged. It was fortunate for the Canadian flax industry that China swooped in at the most vulnerable point and bought up a majority of the flax in early 2010. This helped to offset some of the economic losses that the industry incurred. Some stocks were shipped to the United States during that time as well. In the meantime, the Russian Federation and the Ukraine have leapt in and increased production to service short supplies in the EU flax market. It is not surprising that Canada has lost market share to these two countries. Linseed production in former Soviet Union countries increased by an estimated 45% to 480,000 metric tons in 2011 from the previous year (Ruitenber [2011](#)). By 2013, linseed production levels fell to just over 300,000 metric tons, which demonstrates a correction in the market. Still, that production level in the Russian Federation is triple what it was prior to 2009.

As time has passed, a certain amount of complacency around the Triffid issue has set in on the part of the EU. Despite this, there has been little to no resumption of exports into the food market as Canadian growers just do not want to take the risk. The EU's industrial market is being looked after, however, so the EU is relatively happy at this point.

Despite this, the Triffid issue has not been completely resolved. The Canadian industry is not where it needs to be. According to the Stewardship agreement with the EU, the industry still has to test, and that represents ongoing costs for the Canadian flax industry. According to the Flax Council of Canada ([2011](#)), however, "...the situation *is* workable...."

Economic impacts are very difficult to quantify. Some costs are explicit. Others less so and are time or opportunity cost related. This makes it difficult to attach a specific number to costs associated with the Triffid issue. One thing is for certain though, significant costs were incurred on both sides of the Atlantic.

When low level presence (LLP) events are detected or coexistence thresholds exceeded, agreements to their resolution clearly need to firmly establish "sunset clauses" or define the timeline for when the testing protocol will end; otherwise, as is evident from the situation described above, the likelihood of testing for the minute presence of GM material will continue indefinitely. Commodity export markets are not capable of providing market signals with respect to when testing protocols should end; therefore, it is crucial that those involved in the implementation of such protocols establish clear and concise timeframes regarding how long the testing period will last. Upon reaching the end of the agreed period, the testing should cease at point of export. A perfectly valid option is for the importer to incur the cost of continued testing, but the cost of such testing should no longer be borne by the exporting market.

The case of the low-level presence of GM flax in shipments to the EU demonstrates the vital importance of establishing clear definitions for the timelines of any commodity testing protocol at the point of protocol implementation. As shown above there are no economic incentives present in the Canada-EU flax trade market in the 2 years since the end of the Stewardship program. Alternatively, there has been no political incentive to find a resolution to this trade distortion, given the CETA negotiation process and agreement that paralleled the GM flax problems. As this case study demonstrates, when economic and political incentives are lacking, clear definition of timelines is required in the negotiation of any such testing protocols. Without clear and firm timelines, the costs of testing will be borne by exporters, even when the presence of LLP of GM commodities is below the rate of false positive.

References

- Babuscio T, Hill W, Ryan CD, Smyth SJ (2016) The Canadian and European impacts from the detection of GM flax. Chapter 14. In: Kalaitzandonakes N, Phillips PWB, Smyth SJ, Wesseler J (eds) The coexistence of genetically modified, organic and conventional foods: government policies and market practices. Springer Publishers, New York
- Berglund DR (2002) Flax: new uses and demands. In: Janick J, Whipkey A (eds) Trends in new crops and new uses. ASHS Press, Alexandria, VA, pp 358–360
- Booker H, Lamb E (2012) Quantification of low-level GM seed presence in Canadian commercial flax stocks. *AgBioforum* 15(1):31–35
- Booker HM, Lamb EG, Smyth SJ (2015) Ex-post Assessment of Genetically Modified, Low Level Presence of Canadian Flax. *Transgenic Research* 26(3):399–409
- Canadian Grain Commission (2015) Canadian grain exports (Annual). CGC, Winnipeg, MB. Available online at: <http://www.grainscanada.gc.ca/statistics-statistiques/cge-ecg/cgem-mecg-eng.htm>. Accessed 28 Aug 2015
- COCERAL/FEDIOL (2010) Low level presence of GMOs not authorized in Europe: the linseed CDC Triffid case. Report. July
- Dayananda B (2011) The European union policy of zero tolerance: insights from the discovery of CDC Triffid. Thesis. Available online at: <http://library2.usask.ca/theses/available/etd-06272011-111926/>
- European Commission (2009) Summary record of the standing committee on the food chain and animal health. Available online at: http://ec.europa.eu/food/committees/regulatory/scfcah/modif_genet/sum_19102009_en.pdf. Accessed on 12 Nov 2009
- Flax Council of Canada (2009) GMO flax update 19th October 2009. Available online at: <http://www.flaxcouncil.ca/files/web/GMO%20Flax%20Update%2019%20October%202009.pdf>. Accessed on 20 Oct 2009
- Flax Council of Canada (2011) 2010/2011 Flax sample testing program: approved labs and test submission forms. Available online at: http://www.flaxcouncil.ca/files/web/2010-2011%20Testing%20Program_Sept1_R26.pdf. Accessed on 28 Sept
- Galushko V, Ryan CD (2012) Intellectual property rights (IPRs) and knowledge sharing in flax breeding. *Int J Technol Glob* 6(3):171–187
- Government of Canada (2016) Canada-European union: comprehensive economic and trade agreement (CETA). Available online at: <http://www.international.gc.ca/trade-agreements-accords-commerciaux/agr-acc/ceta-aecg/index.aspx?lang=eng>. Accessed 24 May 2016

- Hall L (2012) Personal communication with Linda Hall, Associate Professor, Department of Agricultural, Food and Nutritional Science, University of Alberta. April 2nd
- Health Canada (2014) Summary of health Canada's assessment of a health claim about ground whole flaxseed and blood cholesterol lowering. http://www.hc-sc.gc.ca/fn-an/alt_formats/pdf/label-etiquet/claims-reclam/assess-evalu/flaxseed-graines-de-lin-eng.pdf
- James T (2010) Presentation to the Canada Grains Council Meeting, Winnipeg
- McHughen A, Rowland GG, Holm FA, Bhatti RS, Kenaschuk EO (1997) CDC Trifid transgenic flax. *Can J Plant Sci* 77:641–643
- Ruitenbergh R (2011) Russia to grow more linseed as Canada falters, oil world says. Bloomberg News. Available online at: <http://www.bloomberg.com/news/2011-09-20/russia-to-grow-more-linseed-as-canada-falters-oil-world-says.html>. September 20. Accessed on 27 Sept
- Ryan CD, McHughen A (2014) Tomatoes, potatoes and flax: implications of withdrawn products. Chapter 51. In: Smyth SJ, Phillips PWB, Castle D (eds) *Handbook on agriculture, biotechnology and development*. Edward Elgar Publishing Ltd., Cheltenham, UK
- Ryan CD, Smyth SJ (2012) Economic implications of low-level presence in a zero-tolerance European import market: the case of Canadian Trifid flax. *AgBioforum* 15(1):21–30
- Smyth SJ, Phillips PWB (2001) Competitors co-operating: establishing a supply chain to manage genetically modified canola. *Int Food Agribus Man Rev* 4:51–66
- Young L, Hammerlindl J, Babic V, McLeod J, Sharpe A, Matsalla C, Bekkaoui F, Marquess L, Booker H (2015) Genetics, structures, and prevalence of FP967 (CDC Trifid) T-DNA in flax. *Springerplus* 4:146