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Competitors co-operating: establishing a supply chain to manage genetically modified canola

Stuart Smyth, Peter W.B. Phillips*

University of Saskatchewan, 51 Campus Drive, Saskatoon, SasK., Canada S7N 5A8

Abstract

Identity preserving production and marketing (IPPM) systems are used extensively in the Canadian canola industry to segregate varieties with different traits from the commodity stream. This paper examines one use of identify preserved production and marketing systems for genetically modified (GM) canola. A number of transgenic herbicide tolerant (HT) varieties have been approved for release in Canada since 1995 but delays in approval in other countries led the Canadian canola sector to use IPPM systems to segregate these varieties and direct them toward accepted markets. This paper looks at a number of systems developed for input-trait GM canola, with a focus on the governance mechanisms used.

1. Introduction

The global agri-food sector is in the initial stages of a rapid transformation. Historically, crop production has been pooled for transportation purposes. Today we are witnessing a move toward segregated production. Segregation was initially used by the crops industry to distinguish between grades of grains. The industry has now progressed to the point that it uses segregation for organic production, specially contracts- and buyer-specific purchase requirements. Plant breeding technology over the years has created a large number of varieties with input and output traits that require segregation to maintain their value. Biotechnology has increased the number of varieties requiring segregation, which has led to the rise in use of identity preserved production and marketing (IPPM) systems. As end users continue to refine their purchase requirements, the number of IPPM systems will increase and the volume these systems are capable of handling will rise. Initial grade segregation has

* Corresponding author. Tel.: +1-306-966-4021; fax: +1-306-966-8413.
E-mail address: phillips@duke.usask.ca (P.W.B. Phillips).

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been extrapolated to accommodate the increase in grain varieties requiring IPPM systems. As consumer demand grows in importance in terms of the entire food chain, IPPM systems are expected to become commonplace in Prairie agriculture.

This paper, the first of a two-part study (Phillips & Smyth, 2000), examines five of the many IPPM systems introduced in the canola industry since 1995, concentrating on those systems constructed to maintain regulatory conformity and market access. A number of national regulatory systems have evolved to manage public expectations and concerns about these products. In Canada and the U.S., once regulatory approval is complete, no further private industrial organization is required to maintain market access for genetically modified (GM) canola. For Japan, private firms have chosen to adopt IPPM systems for GM canola to supplement and support the public regulatory system, in effect differentiating new products from old products in order to maintain market access and consumer acceptance. In the case of the European Union (EU), the regulatory system has not approved new varieties expeditiously and the industry has decided it cannot operate profitably there and has abandoned that market for canola. Section 2 describes the background and circumstances leading up to the development of the system. Section 3 presents a theoretical framework for examining the motivations and structure of the IPPM systems. Section 4 provides detail and analysis on the structure and costs of the systems adopted. Section 5 examines some of the implications of this analysis for other products and other markets.

2. Background and circumstances

Biotechnology innovations entered global agri-food markets in 1995 with the introduction of rbST and herbicide tolerant corn, cotton, canola and soybean varieties. Since then the rate of new product introductions has risen sharply, with more than 13 crops already transformed by more than 40 traits. James (1999) estimates that in 1999 genetically modified crops were being produced in 12 countries and that more than 40 new varieties involving input and output traits are in the R&D pipeline and likely will be ready for commercialization before 2005. Given the potential for stacking both input and output traits, the potential permutations and combinations leading to new products are enormous. Canola, a trademarked name for low erucic acid and low glucosinolate rapeseed, actually involves two plants—*Brassica napus* L., a self pollinating variety and *Brassica rapa* L., a cross pollinator—which doubles the number of permutations possible, complicating regulatory compliance.

Irrespective of consumer attitudes, if new varieties introduced in Canada but pending approval in Japan or the EU were allowed to co-mingle with approved varieties, the resulting shipments to export markets would be jeopardised. Table 1 presents the distribution of Canadian production by consumer market. Facing that market structure and the accelerating flow of new products, Canadian companies had three options. The companies could commercialize the new varieties, co-mingle production and lose access to the EU and Japanese markets, which in 1994–1995 imported 42% of the Canadian output. The companies could withhold their new varieties until they were approved in all key markets—Heller (1995) estimates that a regulatory delay of even 1 year decreases the rate of return on a new product by 2.8% while a 2-year delay decreases it by 5.2%. Alternatively, Canadian

Table 1
Canadian canola production and export destinations

	Canadian production (× 10^3 tonne)	Total production consumed domestically (%)	Production flowing to key export markets (%)			
			Total	Japan	EU	U.S.
1990–1991	3,266	22	78	59	1	15
1992–1993	3,872	22	78	42	8	21
1993–1994	5,480	16	84	33	17	24
1994–1995	7,233	26	74	25	17	19
1995–1996	6,436	30	70	28	6	24
1996–1997	5,037	15	85	37	4	31
1997–1998	6,187	16	84	30	1	33
1998–1999	7,288	22	78	25	0	25

Source: exports are the sum of seed, oil and meal trade; retrieved from the world-wide web November 24, 1999 from http://www.canola-council.org/stats.

producers and exporters could accept responsibility to segregate GM from traditional canola and develop a system to provide quality assurance of delivery to the key export markets, which would involve Canadian export companies developing new systems of identity preservation production and marketing.

Developing segregation systems is usually precipitated by consumer demands, producer liability or regulatory requirements. So far IPPM systems have been adopted for seven input trait varieties of canola in order to maintain market access in Japan. All of the systems introduced in 1995–1996 were explicitly designed to maintain technical regulatory access. Neither consumer attitudes nor product liability concerns played much of a role in these systems. Consumer attitudes toward GM agri-food products in 1996 were significantly different to those of consumers today. At least partly due to lack of awareness of GM foods, consumers were not exerting significant pressure for segregation of GM from non-GM foods. North American consumers were voluntarily accepting Flavr Savr tomatoes and rbST milk, Japanese consumers did not raise public concerns about GM foods and even EU consumers, who had just begun to express concerns, were willing to buy some GM foods. In Britain, over 1.8 million cans of tomato paste labelled as being genetically modified were sold from 1996–1998 (Agnet, 1999). Zeneca, the company that introduced the product, could not satisfy the demand of British retailers wanting to carry it. At least partly due to the generally neutral to positive consumer response and partly because of the nature of GM canola, food manufactures and retailers also faced few concerns about liability. Processed canola produces oils, which by their nature do not include any proteins and hence are free of GM elements, while the meal is not directly consumed by people. Rather, it is fed to animals as feed. The food manufacturers and retailers faced fewer risks of GM seeds entering the food chain and contaminating their supplies.

3. The conceptual framework

Ultimately, segregation is about quality. Quality is a multifaceted aspect for any product. Neo-classical economic theory suggests that two key elements are vital to the creation of quality: consumer tastes and preferences; and producer efforts to develop consistent, safe, affordable, attractive fare that meets consumer demand. Theory suggests that most, if not all, of these elements can and should be produced within minimally regulated markets. Increasingly, however, the literature is pointing to variables of trust and confidence in the creation and operation of markets (Fukuyama, 1995; Stiglitz, 1999). Markets for many products are often not able to create, by themselves, the conditions of trust that generate the socially optimal quantities of goods and services produced and consumed. Hence, there is a much more explicit role for public and private regulation in markets than neo-classical theory generally suggests. This is especially true for GM agri-food products, where perceived risks and public uncertainties abound. This section will discuss the theoretical aspects of marketing GM products and identify how this influences the canola industry and its choice of marketing systems.

Tirole (1988) has explicitly identified a basis for integrating trust into conventional consumer theory. He posits that there are three types of goods: search goods, where consumers can visually identify attributes before consumption; experience goods, which require consumption to determine the attributes; and credence goods, where the unaided consumer cannot know the full attributes of consuming a good, at least for some period after consumption. Trust usually is a key element in markets for experience and credence goods.

Applying this framework to genetically modified canola helps to illustrate how and why the industry has responded as it has to the different market circumstances. The search, experiential and credence attributes of canola have historically been assured through a combination of public and private regulatory systems (Table 2). In the production system, the public sector has tended to establish the general environment for private actors to effect transactions. The Canadian Food and Drugs Act set rules for human consumption of low-erucic acid canola, the Feeds Act sets maximum tolerances for glucosinolate levels, the Canada Seeds Act specifies the performance standards for new germplasm, and the Canadian Grains Commissions sets and monitors the standards for the seeds trade. Although processors can grade canola based on visual and physical attributes, such as seed weight, impurities, cracked or green seed, percentage oil content, erucic acid and glucosinolate levels, and potentially the presence of transgenes (Canbra does some grading for GM elements), the retail consumer cannot distinguish any of the key quality differences valued by consumers through simple search procedures or for most attributes through consumption. At the retail level, consumer labelling laws have operated to establish consistency of

Table 2
Product attributes and potential regulatory responses to GM plants

	Search attributes	Experiential attributes	Credence attributes
Public role in setting rules for the transaction	Consumer labelling laws to prevent fraud	Seeds Act Regulations ensuring consistent quality	Health, safety and environmental regulations; product liability and tort laws
Private mechanisms for managing the transaction	Voluntary labelling	Trade marks backed up by IPPM systems	Private warranties and brands backed up by IPPM systems

standards around labels. Meanwhile, the private sector has established common-property or private mechanisms to manage the transactional elements to the attributes. The Canola Council of Canada trademark on canola establishes the marketing standards for use of the name, processors have selected canola seed to meet both government and industry standards, and the industry and private companies have used trademarks to manage their private interests.

This type of public–private regulatory structure was more or less replicated in many other producing and consuming countries. As Kennett, Fulton, Molder, and Brooks (1998) note, the existence of an effective grading system (which involves managing the experiential aspects and credence risks) reduces the need for vertical co-ordination between buyers and sellers of canola. As a product with little variation in consumer preferences in most countries, there was no incentive to establish any managed production or marketing systems. Nevertheless, as Jacquemin (1987), notes, "hierarchies, federations of firms, and markets compete with each other to provide co-ordination, allocation and monitoring. It is only when one organizational form promises for specific activities a higher net return than alternative institutional arrangements that it will survive in the long run."

GM canola has introduced some differences to the system. As noted above, consumers in different markets perceive significantly different risks and have varying levels of uncertainty about the long-term benefits and costs of GM foods. All these credence factors require a much higher level of trust than the other product attributes. In Canada and the U.S., governments have addressed those concerns through their novel food, feed, seed and environmental regulatory systems. In addition, product liability and tort laws help to assure consumers that if dangerous products enter the food chain and cause harm, there are accessible means for consumer action to gain compensation. All of these mechanisms provide the a base of 'trust' necessary for the marketplace to manage transactions, albeit moderated by extensive public and private regulatory measures.

The regulatory systems in Japan and EU have evolved somewhat differently, creating different market concerns. In Japan, the single largest export market for canola, the regulatory system has operated somewhat more slowly than in Canada, with the result that some varieties of GM canola have been approved for unconfined release in North America but approval has been delayed in Japan. To date, no products approved in North America have been rejected in Japan; all have been approved, if with a lag. As a result, the industry had three clear options about how to proceed: they could delay planting in Canada until approved in Japan; they could allow co-mingling of varieties that are both approved and pending in Japan, thereby jeopardising the Japanese market; or they could operate a private IPPM system to segregate and route sales of unapproved varieties to the North American market. As theory suggests, this ended up being a simple economic question, with the research companies assuming costs of \$30–\$40/tonne for a purpose built IPPM system in exchange for accelerated adoption of their varieties, which improved the return on their investment.

The market in the European Union represented a far different proposition because the choice of what to do was less clear. The EU regulatory system was held in such a low level of trust that it was unable to handle consumer concerns around GM canola (Gaskell, Bauer, Durant, & Allum, 1999). The Canadian export industry was faced with the choice of establishing a private regulatory mechanism to assure GM-free shipments, or to forego the market. A number of factors came into play in this case. The EU, while at times a large market for canola, has historically been a marginal, swing consumer. Furthermore, European consumers so far have not shown any willingness to pay a premium for GM-free canola. In this case, the industry decided that the potentially large, permanent costs of an IPPM system to handle the risks in the EU market would not be compensated by either large sustained shipments or price increases. Hence, the industry declined to serve that market once the verifiable stocks of GM-free canola were run-down.

4. Market structures for GM canola

The introduction in 1995 of two HT varieties of canola precipitated the first IPPM system for a GM crop in Canada. As the Government of Canada does not have the legal mandate to govern the exportation of GM canola, the industry chose to take the initiative and develop the export rules needed to assure continued access to foreign markets. The research/seed companies and grain companies shared this task. This group developed a series of strategic alliances vertically through proprietary supply chains and horizontally through the Canola Council of Canada to manage the flow of GM product in order to allay concerns in the Japanese market. This section of the paper focuses on the factors that brought this group together to develop the Japanese market for GM agri-food products and examines how they successfully accomplished the task of developing export regulations.

Monsanto and AgrEvo (now Aventis) have been the two companies at the centre of the effort (Table 3). In the 1995 crop year, they each introduced herbicide tolerant varieties in Western Canada, initially through a seed multiplication program and then through commercial release. The 1995 harvest of approximately 30,000 acres and the 1996 harvest of approximately 240,000 acres were produced under IPPM conditions. Once market access to Japan was assured for the 1997 crop, the IPPM system was abandoned for *B. napus* varieties. Beginning in 1997 and continuing through the 1999 season, a number of Roundup Ready^{TM} *B. rapa* varieties were introduced under IPPM systems. In 1999, the four varieties accounted for 64,000 acres production.

Table 3
Canola acreage under IPPM systems, 1995–1999

	AgrEvo Liberty-Link^{TM}	Monsanto Roundup Ready^{TM} varieties	
	B. napus varieties	*B. napus* varieties	*B. rapa* varieties
1995	25,000	5,000	0
1996	190,000	50,000	0
1997	0	0	Minimal
1998	0	0	50,000
1999	0	0	64,000

Sources: Evans (1999), Saskatchewan Wheat Pool (1999).

Table 4
Key elements in the canola-based IPPM systems, 1995–1999

Links in the supply chain	AgrEvo Liberty Link^{TM} varieties	Monsanto Roundup Ready^{TM} varieties			
	B. napus	*B. napus*	*B. napus*	*B. rapa*	*B. rapa*
Variety names (year approved)	Innovator (1995)	Quantum (1995); Quest (96)	LG3295 (1996)	41P50; 41P51 (1996)	Hysyn 101 RR (1997)
Seed developer(s)	Ag. Canada and Plant Genetics Systems in collaboration with AgrEvo	University of Alberta and Alberta Wheat Pool for three Pools	Limagrain	Pioneer Hi-Bred	Zeneca/Advanta
Grain merchant(s)	Saskatchewan Wheat Pool, Alberta Wheat Pool, Manitoba Pool Elevators	Saskatchewan Wheat Pool, Alberta Wheat Pool, Manitoba Pool Elevators	Cargill	United Grain Growers (UGG)	Cargill
Farmers[a]					
1995	310	480	0	0	0
1996	2,375	1,700	Incl.	0	0
1997	0	0	0	Minimal	Incl
1998	0	0	0	625	Incl
1999	0	0	0	800	Incl
Trucking arranged by					
Pools	Pools	Cargill	UGG	Cargill	
Crushers	Canbra at Lethbridge, CanAmera at Altona and Harrowby	CanAmera at Nipawin and Lloydminster	Cargill at Clavet	Archer Daniels Midland (ADM) at Lloydminster	Canbra at Lethbridge

Sources: Evans, 1999; Button, 1999.
[a] Calculated by authors.

4.1. The systems

By the spring of 1996, Monsanto and AgrEvo had developed a variety of IPPM systems to manage the segregation of GM canola from the traditional canola stream (Table 4). Monsanto had two separate systems—one with the Saskatchewan Wheat Pool, Alberta Wheat Pool and Manitoba Pool Elevators and the other with Limagrain and Cargill—while AgrEvo worked exclusively through the three Pool Elevator companies. In 1997, Monsanto added two additional IPPM systems for Roundup Ready^{TM} *B. rapa* varieties. Each of these systems involved an agreement between the research company, a breeder, a grain merchant, farmers, truckers and an oilseed crusher. The objective of the IPPM system was to segregate the herbicide tolerant canola from traditional canola marketing channels. This meant that the HT canola not touch any part of the export handling system, including elevators, rail cars and port terminals. The 1996 production was delivered to Canadian oilseed crushing plants that had markets for the oil and meal in Canada and the U.S. where regulatory approval had been granted (Saskatchewan Wheat Pool, 1997). In each case, the grain merchant acted as the operating agent for the system, managing the supply chain from seed multiplication to processing.

As shown in Table 4, each of the supply chains began with a specific variety which included a proprietary herbicide tolerant gene which was backcrossed or inserted into a plant by either a contract breeder or by a partner company (e.g., Agriculture and Agri-Food Canada, Plant Genetics Systems, University of Alberta, Alberta Wheat Pool, Limagrain, AgrEvo, Pioneer Hi-Bred or Zeneca/Advanta). Once this variety was registered, Monsanto or AgrEvo contracted with one of the grain merchants (one of the three Prairie Pools Elevator companies, United Grain Growers or Cargill) to manage the development and management of an IPPM system. That company then multiplied the seed, undertook production contracts with specific farmers, arranged delivery from farms to a processor with contract truckers, and arranged for a custom crush, segregation and diversion of the resulting oil and meal into the North American market.

The participating companies all agreed that the herbicide-resistant technology brought real value to producers and all agreed that there was a need to bring this technology to the marketplace. Both AgrEvo and Monsanto acknowledged, however, that if these varieties were co-mingled in the export system, then Canadian canola would be shut out of export markets. In response, private Canadian firms agreed to release materials only if they were approved in the "key canola markets," defined as Canada, Japan, U.S. and Mexico by the Expert Committee for Canola of the Pest Management Review Agency.

Cost estimates were found for two of the five IPPM systems (Table 5). While there is room for debate about the actual numbers, the two estimates suggest that transaction costs for the IPPM system were very high. There are five main areas where additional costs were incurred: by the producer, during transportation; by the processor; in administration and through opportunity costs.

The added cost for producers was due to separate storage requirements of the IPPM system. Farmers were required to store these varieties in separate bins, which at times left some of the bin capacity unused. The cost of inefficient use of on-farm storage was estimated to be \$1/metric tonne (mt).

Table 5
Identified costs of 1996 IPPM system

Cost category	AgrEvo & Manitoba Pool Elevators ($/mt[a])	Saskatchewan Wheat Pool ($/mt)
Producer on-farm costs	$1	$1
Freight inefficiency	$5–$6	$7–$10
Dead freight	$1.50–$2	$2–$3
Processor	$3–$4	$3–$5
Administration	$4	$5
Opportunity cost	$20	$10
Collective subsidy		$5–$7
Total IPPM cost	$34–$37	$33–$41

Source: Manitoba Pool Elevators (1996); Saskatchewan Wheat Pool (1997).
[a] Metric tonne: mt.

The inefficiency in transporting the transgenic canola was more substantial as only selected crushers were used. AgrEvo used the CanAmera sites located at Harrowby, Man., and Altona, Alta., along with Canbra's site at Lethbridge, Alta. Monsanto used a wider array of crushers, including CanAmera at Nipawin and Lloydminster, Cargill at Clavet and Archer Daniels Midland at Lloydminster. Nevertheless, each system used a specific set of crushers. With an average of 40% to 45% of canola production in Saskatchewan, producers often faced lengthy trucking distances. These costs were shared among the producers, seed companies and the grain elevator companies.

Transportation costs were estimated to be higher due to freight inefficiencies and dead freight. Freight inefficiencies are defined as those costs of trucking that exceeded average costs of delivering to the nearest local elevator. A producer would normally deliver canola to their nearest local elevator, but the canola had to be trucked directly to the crushing facility because elevators were excluded in this system. The producers paid a portion of this cost. Dead freight costs relate to the volumes on-farm that had to be delivered as partial loads. The freight inefficiency cost of transporting the HT canola to processors resulted in costs of $7–$10/mt. Dead freight costs were estimated to be $2–$3/mt.

The canola processors faced cost increases due to the IPPM system. A Manitoba Pool Elevators (1996) document notes that "the domestic crusher was obliged to segregate raw transgenic canola seed, transgenic canola oil and transgenic canola meal from traditional stocks under the [IPPM] system developed for transgenic canola introduction." This required the processors to physically clean the production equipment prior to crushing the HT canola (usually during a seasonal shutdown), as well as after the HT run was finished. This was done to ensure that the transgenic canola oil did not co-mingle with oils destined for export markets. The processors involved identified their incremental cost to be in the range of $3–$5/mt.

Many non-recoverable costs occurred in administration. The Saskatchewan Wheat Pool, e.g., actively managed all of the producer contracts it had to ensure that compliance with the terms were met and that co-mingling was avoided. In an effort to ensure the purity of the IPPM system, seed agents from AgrEvo, Monsanto and the Saskatchewan Wheat Pool

(Pool) mapped all the fields in which HT canola was grown. Once harvest commenced AgrEvo, Monsanto and the Pool co-ordinated to ensure that an agent from one of the companies would be on farm during the harvest to inspect the harvested supplies, apply grain confetti and to seal the bin. The confetti had the company logo on one side and a unique grower identification number on the other. This placed a very real constraint on producers while at the same time providing the Pool marketing department with accurate information of where and how much HT canola was available. At this point, the Pool worked with the processors to arrange to have the HT canola trucked to be crushed at a designated oil crushing plant that was just about to have a scheduled shut down and cleaning. Once a crush date was determined, the Pool contracted with commercial truckers to pick up the HT canola from farmers and deliver the HT canola to the designated processors. When the canola was to be trucked, an agent from the Pool was again on farm to inspect to ensure that none of the bins had been opened or tampered with. This process was very difficult due to the simple logistics of trucking grain in the winter in Western Canada. Snowstorms, impassable roads and bad driving conditions all complicated the co-ordination of trucking process. These requirements were all labour intensive and were estimated to cost $4–$5/mt.

The grain merchants also identified an opportunity cost of crops in IPPM systems. In effect, by segregating the seed and being constrained on when and where to bring it to the market, and being forced to move it according to some predetermined plan, severely limited the marketers in trying to lock in high prices in what is traditionally a volatile market. Saskatchewan Wheat Pool (1997) reported that "from a general market perspective, an [IPPM] program like this does not allow for access to all attractive alternative markets. This is a potential cost due to possible increased margin potentials, which cannot be achieved. The potential unrealized profit opportunity could well be in excess of $10/mt." It is not clear, but some of that opportunity cost could have been because North American buyers recognised that they had some market power in the circumstances and exploited it. Furthermore, the grain merchants estimated other unallocated expenses cost all parts of the supply chain an estimated $5–$7/mt. The Saskatchewan Wheat Pool (1997) concluded that "in order to develop and promote this technology, the producer of the technology, AgrEvo [and Monsanto], the producers of the seed, the [Saskatchewan Wheat Pool, Alberta Wheat Pool and Manitoba Pool Elevators], and the beneficiary of the technology, the producer, all contributed to the subsidization of the [IPPM] program."

In total, the two IPPM systems were estimated to cost $33–$41/mt. Based on the acreage involved, it is estimated that the IPPM systems adopted in 1995–1996 cost between $2.8 and $3.5 million for the AgrEvo-based system and $750,000 and $930,000 for the Monsanto-based systems. As noted, all the stakeholders in the IPPM process shared these costs. The producers assumed the identified on-farm costs and some of the increased transportation costs; they did not receive any price formal premium, and in some cases, were forced to take spot prices that were relatively unattractive relative to other markets. The grain company assumed the dead freight costs, a portion of the freight inefficiency and part of the administration cost through their normal operating margins (Saskatchewan Wheat Pool, 1999). The crushers picked up most of the incremental crushing costs. The remaining costs (opportunity cost, administration and other subsidies) were divided and paid by Monsanto and AgrEvo, based on the acreage they had under cultivation. In Monsanto's case, they

Table 6
Net present value of earlier adoption of new canola technologies in Canada

	Percentage acres in GM canola		Revenue impacts of 1 year delay in introduction assuming $15/acre benefit ($M)			
	Actual	Delayed	Actual	Delayed	Absolute difference	Net present value in 1995 of difference
1995	1		2.0	0.0	−2.0	−2.0
1996	4	1	5.3	1.3	−4.0	−3.6
1997	33	4	59.6	7.2	−52.4	−43.3
1998	44	33	89.3	67.0	−22.3	−16.8
1999	69	44	143.9	91.7	−52.1	−35.6
Total	300.1	167.2	−132.9	−101.3		

Sources: GM adoption rates from National Research Council; Canola Council of Canada for acreage; discount rate is 10%; authors' calculations.

expensed this additional cost to research and development costs related to the development of the technology.

The total cost of the IPPM operated in conjunction with the Saskatchewan Wheat Pool in 1995–1996 was estimated to exceed $4 million. The average 5-year farm-gate price for conventional canola, from 1991 to 1996, was $280/tonne. Using the cost increase range of $33–$41, the increased cost of these IPPM systems ranged from a low of 12% to a high of 15% of the average farm-gate price.

These cost increases, however, must be balanced against any expected or realized gains. It is unclear yet what producers gained, but some early figures suggested that farmers gained upwards of $10/acre or $5/tonne benefit from the new technologies (Mayer, 1997), which for most farmers would have more than compensated for their added producer costs. The grain merchants may have gained margins on new volumes since then, which probably have compensated for their incremental system costs: by 1999, an estimated 69% of canola acreage used HT varieties. Furthermore, in most cases, the canola was crushed through subsidiary crushers, increasing their volumes and offsetting some of the incremental costs. Finally, although the research/seed companies may have lost some money due to the costs of the IPPM systems, they gained significantly in terms of market adoption (Table 6). It is very likely that if Monsanto and AgrEvo had introduced the seeds without IPPM systems, farmers would have shunned the new seeds. So the only real choice for early and aggressive adoption was to pay for IPPM systems. In this case, one could argue that the two companies accelerated adoption by at least 1 year, which was estimated to have a net present value in 1995 of more than $100 million. Clearly, the IPPM system for HT canola directed to Japan was a win–win situation.

The results are less clear for IPPM systems for either Europe or for *B. rapa*. Given the uncertainty about Europe, the canola industry made a deliberate decision to abandon the market in 1996. The European market was not a strong export market for Canadian canola—Europe is usually self-sufficient in terms of canola production and actually exports canola when price premiums are available. The canola industry's view was that future European canola exports had limited potential so, once Japan approved GM products, the IPPM system was discontinued, thereby removing all possibility of supplying European canola markets.

Monsanto's IPPM system since 1997 for four *B. rapa* varieties has posed more difficulties. Although the logic is the same as for the *B. napus* varieties, the economics is different. *B. rapa* has taken longer to get approval because of different environmental impacts (the seed can stay in soil for up to 15 years and still germinate). As a result of the longer approval time, and much smaller market (*B. rapa* is estimated to account for less than 10% of canola acreage in Western Canada in 1999) Monsanto has decided to terminate its work on *B. rapa*.

4.2. Governance mechanisms

Although the Seeds Act requires that any new canola variety seeking registration in Canada be an improvement over existing varieties, decisions are made based on agronomic attributes and not potential market impacts. Given delays in approvals in Japan and the EU, the industry was challenged to develop a system that would provide assurances to those import markets that the products shipped contained only approved varieties. This involved three discrete steps. First, the Canola Council of Canada worked with the industry participants to develop agreement that all shipments to Japan and the EU should contain only approved varieties. Second, the individual industry actors developed their own IPPM systems to handle their proprietary products. Third, the Canola Council and the provincial growers' associations worked with the grain exporters and the key regulators and buyers in Japan and the EU to raise confidence in the Canadian solution.

The process began in February 1995 when the Pest Management Regulatory Agency submitted recommendations for approval for two varieties of HT canola to the Expert Committee for Canola (this followed 3 years of regulatory review for feed, food and environmental safety). Agriculture, which oversaw the Seeds Act (that responsibility has since devolved to the Canadian Food Inspection Agency, CFIA), approved the two varieties in March 1995. Once the new varieties were registered through the Seeds Act, the product was fully licensed to be grown and enter the grain handling system, which implicitly includes exports. The CFIA did not have any authority to require the owner of the variety or the canola industry to segregate the new varieties from traditional varieties.

Early in 1995, the Canola Council of Canada asked the Expert Committee for Canola to delay making recommendations for future registrations of genetically-modified canola until such time as the developers could demonstrate that the product had regulatory approval in the defined market (i.e., Canada, U.S. and Japan). Canada and the U.S. had already approved the licensing and importing of GM products. Japan was in the process of developing regulatory policies. Given the limited legal authorities, the regulators were not able to respond.

As a result, the canola industry came together in late 1995 to discuss the concern that the major canola importing countries had not yet developed guidelines for importing GM products. The result of this discussion process was a voluntary agreement between the seed, grain and processing companies to co-operate and to segregate the 1996 production (the limited 1995 production was for seed purposes only and did not enter the handling system). This agreement respected the Canola Council's request that products from these fields not be allowed to reach international markets until the appropriate national regulators approved imports of GM products.

The second stage was to develop the IPPM systems. It was realized early in the process that the project could not be done without the full co-operation, support and involvement of a grain handler. The only way to develop an acceptable and efficient system was to have knowledge of the production process and the marketplace, which only existed in the grain companies. They analyzed grain flow patterns and designed systems, which fit with the market and the grain handling processes currently in place. The Saskatchewan Wheat Pool, Alberta Wheat Pool and Manitoba Pool Elevators, in particular, were instrumental in the early IPPM programs for both Monsanto and AgrEvo. Each company developed a set of procedures that each of the stakeholders (seed companies, producer, grain handler, transporter and processing companies) would apply to IPPM the grain. This involved a team of experts in regulatory affairs, development and marketing departments in the grain and seed/research companies. The teams also kept the Canola Council of Canada and, through the Council, the Canadian regulators fully informed of the entire process, from design to planting and harvest to crushing. This transparent process helped build the trust within Canada that was necessary to convince foreign regulators and buyers of the sincerity of the effort.

While the IPPM systems were being developed, the Canola Council worked with grain exporters, regulators and importers in Japan to convince them that Canada was segregating GM varieties and that problems would not arise in export shipments. Both Monsanto and AgrEvo officials admit that the Council played a vital role in providing the Japanese with the assurances that Canada could and would segregate, which assisted the Japanese to continue to import while the new varieties were under review. This mutually beneficial arrangement contributed to IPPM policy having greater legitimacy in the eyes of Canada's key canola export markets. One of the primary reasons that the Japanese had a large degree of ex ante trust in the Canadian IPPM system was that it was built upon a 20 year relationship. Beginning in 1977, the Canadian and Japanese industry began annual consultations on crop quality and quantity (Adolphe, 2000); these consultations became biannual in 1987. The Canola Council over the years convinced the Japanese that Canada has a credible variety registration system that prevents new varieties from being released without first being approved by industry and government. The lengthy working relationship and understanding of the variety registration system allowed the Japanese to trust that the Canadian canola industry could segregate GM canola and did not demand any additional insurance clauses or right of inspection or testing.

It is extremely doubtful whether an outside group or agency could have developed an effective IPPM system. If the design of the system had been contracted to an outside agency that lacked a fundamental understanding of grain transfer, there is a high probability that the system would not have had the capability to successfully meet the defined objectives. Had the IPPM process been forced upon the industry by government, there is some doubt as to whether this would have produced superior results. AgrEvo and the Saskatchewan Wheat Pool believe that by taking the initiative on this issue and working with the Canola Council, they were able to develop a system that met the needs of Japanese regulators, Canadian farmers and the technology developers. A mandated program might have met the needs of regulators, but it would not likely have encouraged industry funding nor would it likely have been as effective in getting the seed in the hands of as many innovative farmers (a critical goal of the programs). Finally, it is worth noting that the system was effective—there were no documented reports of co-mingling.

5. Conclusions and observations

Market transactions for goods with experience and credence attributes require a high degree of trust, which requires both effective public and private regulatory mechanisms. The canola industry's experience with genetically modified herbicide-tolerant canola illustrates that provided there is a public base for managing credence and experiential issues, the industry can effectively handle many of the market considerations through private identity preserved production and marketing systems. Provided the expected returns exceed the costs, private initiative will work. All industry participants assert that this will depend on tolerance levels for shipments (Kennedy, 1999). Regardless of whether an IPPM system is established to capture value for a GM trait, special crop trait or traditional variety, it cannot deliver a 100% guarantee of purity. Realistic tolerance levels will need to be implemented prior to the increased use of IPPM systems.

Provided realistic tolerance levels can be established, IPPM systems may become a permanent method of capturing attribute value from agri-food product markets. Kennett et al. (1998) observed that grading standards can reduce the need for vertical integration, which is likely true for search and experience goods. Credence goods, however, impose requirements that a grading system cannot handle. Industry participants in those IPPM systems studied observed that the design of every IPPM system will vary depending on the genetics and marketing of the variety involved. Grading, which homogenizes products, would not satisfy the commercial needs of the industry.

If IPPM continues to be required for regulatory and market reasons, it will need to become more efficient. IPPM systems technically work for smaller production but it is unclear whether they would work for larger scale operations. While some stakeholders believe that if an IPPM system were spread over a much larger production, efficiencies would be possible. Others believe that there are too many supply constraints (e.g., trucking, storage) for it to work. While there is room to debate the cost estimates provided by industry, IPPM systems could continue to cost in the \$30–\$40/tonne range if quantities remain small and systems purpose built. If, as was the case in this example, the technology does not impart any perceived consumer benefit, all of those incremental costs will need to be borne in the supply chain, which will likely slow investment in input traits. The focus would likely shift towards seeking output traits that have added value that can help to compensate for the higher costs.

So far all of the IPPM systems developed have been custom built to meet the specifications of the technology owner and the market. The limited horizontal co-ordination between the systems has come through the research companies (e.g., Monsanto and AgrEvo) working with their agents (the grain companies) and through the Canola Council's efforts in export markets. For the most part the grain companies have viewed the IPPM systems as valuable proprietary services. Ultimately, however, these systems are designed to earn trust, which is a cumulative process. Past successful actions can contribute to achieving a higher level of trust but failures in one part of the market can spill-over to other market segments. If IPPM systems are here to stay, then it may not be enough to rely on independent systems.

This research is relevant to those in other grain and oilseed commodities that are considering segregation. The driver of this IPPM system was to ensure that access to foreign markets was maintained even after introduction of a new variety that was not yet approved in those markets. As the demands for segregation change, so to will the design specifications of the IPPM system. Striving to meet a 1% tolerance level (present EU level) with a crop that is an open pollinator may be virtually impossible due to cross-pollination. The possibility of meeting 1% tolerance levels with self-pollinators is much greater. From this research, it is clear that segregation systems require leaders or 'integrators'. The supply chain can be organised and regulated by an integrator at start of the supply chain or at the demand end (as appears to be happening in the U.K.). Furthermore, this research suggests that regardless of where the initiative starts, it is extremely important that that integrator have a financial stake in the outcome. Hence, demand side efforts will require a retailer or manufacturer who can see some benefit, such as a price premium or market share from their activities. The costs are simply too large to do this as a pro bono effort.

There would appear to be two ways in which IPPM systems could be made more efficient. Ultimately, the goal should be to manage risk. One of the pan-industry participants—such as the Canola Council of Canada or the Canadian Seed Trade Association—could become the custom developer or 'integrator' for the system, providing purpose-built but quality assured systems to meet market needs. The difficulty is that neither entity has any equity at stake in the transactions, which might reduce their credibility in the eyes of producers and customers. Alternatively, the industry could adopt an external quality assurance system—such as the International Standards Organization (ISO) or Hazard Analysis Critical Control Point (HACCP) systems—to standardise the process of developing IPPM systems. This would differ from a traditional grading system in that the quality assurance system would assure integrity of process and not the standard itself, which would be a negotiated or contracted feature determined in the marketplace. This would leave the operation of the system in the hands of the firms with equity at stake but could help to build cumulative trust in the system.

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