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Agronomic and consumer considerations for Bt and conventional sweet-corn

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Abstract *In this farm-to-fork trial, genetically engineered (GE) Bt sweet-corn and Bt potatoes were grown side-by-side with conventional varieties in the 2000 growing season at a farm and market in Hillsburgh, Ontario, Canada. The Bt sweet-corn required no insecticides. From an economic perspective, only the first planting had pest pressure high enough to warrant the higher seed cost of the GE variety. The sweet-corn harvested throughout the trial was segregated and labeled, and direct consumer evaluation of purchasing preferences was conducted. Overall, the Bt sweet-corn outsold the conventional sweet-corn by a margin of 680 dozen (or 8,160 cobs) to 452.5 dozen (or 5,430 cobs). A limited number of intercept interviews were conducted after consumers made their purchasing decision. The majority of consumers interviewed said they were more concerned about pesticides than genetic engineering; however, taste and quality also had a strong influence on purchasing decisions.*

Introduction

Genetically engineered (GE) Bt crops have been designed to resist some types of insect damage and, in some commodities, reduce the need for chemical insecticides. *Bacillus thuringiensis* (Bt) is a gram-positive soil bacterium that produces an insecticidal protein in the form of a crystal. The insecticidal proteins are commonly designated as cry proteins and the genes encoding the proteins are known as cry genes (Lambert and Peferoen, 1992). The Bt-toxin is regarded as an environmentally friendly insecticide because of its target specificity and its decomposition to non-toxic compounds when exposed to environmental factors (Gould, 1995). For the Bt endotoxin to be effective, the insect must ingest it (Webber, 1995) before it is broken down by environmental factors such as ultraviolet light. One advantage of genetically-engineered Bt-corn is that the insecticidal protein has been incorporated into the plant, limiting environmental exposure. Insecticidal properties of Bt can vary in activity against insects within a single insect order. The toxins encoded by the cry genes are toxic to Lepidopterans such as the European corn-borer.

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While agricultural biotechnology, and more specifically Bt crops (US Environmental Protection Agency, 2000), have been extensively evaluated in a scientific setting, and have been the source of numerous public opinion surveys (Kamaldeen and Powell, 2000), they have rarely been evaluated in the purchasing environment where consumers actually make buying decisions.

Surveys have found that most Canadians have heard of biotechnology and many of its applications (Einsiedel, 2000) with awareness being greatest for medical applications (Decima Research, 1993; Einsiedel, 1997). This awareness is increasing (Angus Reid Group, 2000; Einsiedel, 2000). Canadians have indicated concern over the use of biotechnology in general. Consumer concern appears to be higher for genetic engineering than for other applications of biotechnology (Angus Reid Group, 2000; Decima Research, 1993; Einsiedel, 2000). However, research indicates that consumer acceptance of the products of genetic engineering are unlikely to be determined by attitudes to the technology overall. Rather, support may be based on recognition of tangible benefits of specific applications (Bruhn *et al.*, 1992; Decima Research, 1993; Einsiedel, 2000; Frewer *et al.*, 1994; Hoban, 1997; Sheehy, 1996; Zimmerman *et al.*, 1994). It is evident that Canadian consumers are concerned about the safety of the food they eat and, although bacteria and pesticides have been identified as the top concerns (CFIA, 1998; IFIC, 2000), concerns over genetically altered foods may increase as media coverage and consumer awareness increase.

Public perception research also indicates a high level of concern among the public over the use of pesticides in agriculture (Peterson, 2000) specifically concerning human health and environmental impacts. This is similar to their perception of agricultural biotechnology and, although some studies indicate that pesticides are still a greater concern than genetic engineering, biotechnology is less well understood than pesticide use agriculture (Peterson, 2000). This concern has led to the development of newer pesticides that break down faster in the environment and further minimize human health risk when used appropriately. Synthetic pyrethroids and Bt foliar spray are approved for use on sweet-corn; however, they are limited because of reduced effectiveness at high temperatures (Zeneca Agro, 2000).

This experiment was designed to examine the comparative costs and benefits of producing Bt and conventional sweet-corn and potatoes, from the primary producer through to consumer purchasing preferences.

Materials and methods

This research took place at Birkbank Farms, a 200-acre small-fruit and vegetable farm owned by Jeff Wilson, in Hillsburgh, Ontario, Canada (Blaine *et al.*, 2000). Hillsburgh is approximately 60km from the Greater Toronto area. Beginning May 17, 2000, three test plots were planted with genetically engineered Bt and conventional sweet-corn to simulate commercial production conditions. Each eight-acre plot was planted with four different varieties of corn in 20-row blocks, in random order. The corn varieties were:

- genetically engineered Bt yellow – Variety: Attribute, GSS0966;
- genetically engineered Bt bi-colour – Variety: Attribute, GSS0977;
- conventional yellow – Variety: Prime Time; and
- conventional bi-colour – Variety: Bi Time.

For each planting, two spray lanes were left between every ten rows. The corn was planted in three different plantings to simulate commercial production and provide the continuity of supply that the fresh sweet-corn market demands, and to determine the value of the Bt technology throughout the growing season as opposed to a "window" of critical pressure.

The first planting was completed on May 17, 2000, using a commercial planter with a seed population of 47,690 seeds/hectare and was simultaneously side-dressed with 100kg/ha of 12-36-12 nitrogen-phosphorus-potash. The varieties were planted in the following order: (from north to south) 20 rows Bt yellow; 20 rows conventional bicolour; 20 rows Bt bicolour; and 18 rows conventional yellow.

The second planting was completed May 28, 2000, using a seed population of 45,465 seeds/hectare and was side-dressed with 133kg/ha of the same 12-36-12 n-p-p. The fertilizer application was increased for this planting, as the plot was located on a part of the farm that is not irrigated.

The third planting was completed June 28 using a seed population of 45,465 seeds/hectare and a fertilizer application of 88kg/ha of 12-36-12 n-p-p. The planting order from west to east was: 20 rows conventional bi-colour; 20 rows Bt bi-colour; 20 rows conventional yellow; and 20 rows Bt yellow. There was a small area in the middle of this field that could not be planted as it was covered in water.

A contact herbicide bromoxynil (product name "Pardner": manufactured by Aventis Crop Science, Regina, Saskatchewan) was used on all three plantings on July 2 and fertilizer was applied at 79lbs/ac on July 16 (12-36-12 n-p-p). The conventional corn on all the plantings was sprayed with the fungicide chlorothalonil (under the product name "Bravo": manufactured by Syngenta Crop Protection, Guelph, Ontario) for rust on August 15. All pesticide applications were made according to an integrated pest management (IPM) program in which professional pest control advisors, called scouts, checked the corn plots twice per week looking for European corn-borer (ECB) as well as aphids and beneficial insects such as ladybeetles. The scouts then provided reports on pest pressure with recommendations on spray timing and frequency. The first and second plantings of conventional corn were sprayed for ECB and ear-worm on August 14 with Carbofuran. Half the conventional corn in both plots was sprayed with DIPEL DF (Bt foliar spray manufactured by Abbott Laboratories, Illinois, USA). The corn was sprayed on the recommendation of IPM scouts. Carbofuran is a member of the carbamate class of pesticides derived from the basic carbamic acid moiety (Davidson, 2001).

The first planting was ready for harvest on August 28. The genetically engineered Bt corn required no pesticides aside from the herbicide spray and fertilizer treatments. The conventional corn sprayed with Bt foliar required five treatments and the other half was sprayed with three applications of Carbofuran. The first application was early in the season and sprayed at a rate of 0.4L/hectare to control flea-beetles, a vector for Stewart's wilt, while the remaining applications were at a rate of 1.1L/hectare. All insecticides were sprayed using guidelines specified by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA, 2000).

In the second planting, the genetically engineered Bt sweet-corn again did not require any pesticide sprays, while the conventional sweet-corn was sprayed with two applications of Carbofuran and one application of cypermethrin at 280ml/hectare (a pyrethroid under the product name "Cymbush": manufactured by Zeneca Agro, Calgary, Alberta).

The third planting had the same herbicide and fertilizer applications as the other two plantings; however, the conventional sweet-corn was sprayed with two applications of cypermethrin and one application of Carbofuran.

The sweet-corn was harvested by hand, segregated and packed on to labeled skids, and stored in cold storage until sale.

Economics

A comparison of the farm-level profitability between the Bt and conventional sweet-corn varieties was carried out. All the input factors (in Canadian dollars; items priced in US dollars were exchanged at a rate of $1.51:US$) are shown in Table I. Land rental and management were provided by Jeff Wilson. Land rental included both dry land rental at Cnd$679.52 per hectare and irrigated land at Cnd$1,359.03 per hectare. Fixed and variable costs for field operations were specified at Cnd$301.46 per hectare.

Machinery costs consisted of machine operator costs and the rental of a fertilizer spreader. A flat rate of Cnd$12.00 per hour was paid. The operator spent 5.19 hours per hectare on the sweet-corn. The cost of the fertilizer spreader rental was Cnd$17.30 per hectare.

Sweet-corn labour costs included the IPM scouts, harvest, and packing and cooling costs. IPM scouts checked the sweet-corn twice per week. As described above, the sweet-corn was harvested by hand to diminish damage to cobs. Packing and cooling costs were based on 200 $\times$ 5 dozen bags per acre at Cnd$2.00 per bag.

Purchased inputs included seed, fertilizer and pesticide costs. Sweet-corn seed costs were based on the purchase of 100,000 seeds of the four varieties in the trial. Fertilizer application costs were specified by OMAFRA, while herbicide applications were performed at a rate of 50g active ingredient per hectare. The pesticide costs were based on the number of spray applications.

Table I.
Detailed sweet-corn field expenditures

	$
Machine operator 5.9hrs/ha × 7.7ha @ $12.00	604.80
Seed: BSS-0977 × 100,000 seeds	682.00[a]
Bi Time × 100,000 seeds	341.00[a]
Attribute Bt × 100,000 seeds	682.00[a]
Prime Time × 100,000 seeds	361.00[a]
Seed total	2,066.00[a] (3,100.00[b])
Fertilizer as per OMAFRA $160.00/ha × 9.7ha	1,560.00
Fertilizer Spreader Rental $17.30/ha × 9.7ha	168.00
Herbicides $91.43/ha × 9.7ac	888.00
Insecticides, 1 spray cymbush, (cypermethrin) @ 17.30/ha × 4.85ha, Furadan (Carbofuran) @ $79.00/ha for conventional corn	468.00
IPM Scouts $29.65/ha × 9.7ha	288.00
Fixed and variable costs for field operations $301.46/ha × 9.7ha as per budget	2,928.00
Harvest cost $407.70/ha for hand harvest × 9.7ha	3,960.00
Packing and cooling based on 494 × 5 doz bags/ha @ $2.00 per bag, bag included $1,976.77/ha × 9.7ha	19,200.00
Total for field portion of research	33,164.00

Notes: [a] US$; [b] CA$

Communications

On May 27, 2000 a meeting was held at Birkbank Farms to inform local residents and neighbors about the planned project and to address any concerns among members of the community. Prior to this, letters were hand-delivered to all the immediate neighbours and an advertisement was placed in the local newspaper, which explained the basics of the project and invited members of the community/public to the information meeting on the farm.

Throughout the project, posters and bookmarks were displayed in the Birkbank farm market, which also briefly described the project and gave contacts for more information. This was all done to establish and maintain open communications with the customers of Birkbank farms and others.

Information pamphlets on Bt sweet-corn were developed and tested on a consumer audience. These pamphlets were also available in the market as background information on Bt sweet-corn and included ways to obtain more information on Bt and other genetically engineered crops.

A press release was issued nationally and a press conference held in Toronto on May 14 to announce the research. Throughout the summer, the project was featured in stories in the television, radio and print media. Three press releases were issued in total; one announcing the project, one describing the opening of the farm walking trail, and the last highlighted the harvest and some of the agronomic findings.

An interactive Web page was developed (www.plant.uoguelph.ca/safefood/bt-sweet-corn/bt-index.htm) as a tool for communicating relevant aspects of the project and its progress to the media, industry, research community and interested members of the general public. The Web site contained information on all the research protocols, background information on Bt sweet-corn and other Bt crops, a weekly update on the research (including online video footage), and any press releases and relevant news items.

Consumers

The sweet-corn was available for purchase in the market at Birkbank Farms and fully labeled, along with information on the number of sprays used and relative costs to produce. The Bt foliar spray (DIPEL) did not control the European corn-borer or ear-worm adequately. As a result, this third option was described to consumers but was not offered as a choice for purchase. The two types of corn were presented in separate wooden bins labeled with either "genetically engineered Bt sweet-corn"or "Regular sweet-corn". The non-Bt corn was labeled as "Regular" as opposed to "non-Bt" or "Conventional" for simplicity. There were approximately 30cm of space between the bins that was filled with corn-bags and pamphlets to prevent the corn from inadvertently mixing. Employees in the market kept both corn-bins filled to the same level throughout the day. The genetically engineered Bt corn and the conventional corn were both sold for the same price at Cnd$3.99/dozen. Pamphlets with background information about the project were also available in the market. On several weekends, free samples of both conventional and Bt sweet-corn were available at the front of the market.

A short questionnaire was conducted as an intercept interview. It consisted of four closed response questions, one open-ended question, and five demographic questions. The questionnaire was pilot-tested at the farm on 20 customers and it was determined that five questions were ideal to avoid overburdening the participants. The main questions assessed current awareness of genetically engineered foods, level of trust in various information providers, factors that influenced their choice to buy Bt or non-Bt sweet-corn, and whether respondents were more concerned with pesticides or genetic engineering. Non-demographic question phrasing was based on questions used in previously published and validated research.

The inclusion criterion for participants was that they had to buy corn in the market or be offered the choice to consume Bt or non-Bt corn. Once they had made their choice and purchased/consumed the corn, they were approached and asked to answer the questionnaire. The small sample size was due to the dynamics of a commercial market and is by no means nationally representative; it is, however, a representative sample of Canadians exposed to labeled and segregated GE sweet-corn and potatoes, since the Birkbank farm market was the only site in Canada that offered such a choice. Surveys were conducted in the farm market as well as two other locations where consumers were offered Bt and non-Bt corn: Canada's Outdoor Farm Show and the

International Plowing match. Since these are farm shows, the respondents are not representative of the entire population.

Any questions the respondents asked about genetically engineered foods in the market were recorded, as well as their comments. Basic content analysis was conducted on the comments to get an overview of customers' initial reactions to the market display and the option to purchase genetically engineered foods. These qualitative comments were coded as positive, negative, neutral or questioning in nature, then each category was coded for seven main themes: pesticides; environment; taste/quality; apathy; testing; emotional response; and lack of information. The themes were picked after studying the data and identifying categories that were descriptive of the data. A second researcher independently verified this coding system and data. During sampling, some consumers who sampled the corn had questions or comments about the technologies and these questions were also recorded.

Sales of both types of corn were recorded from August 30, when the corn was first harvested, to October 6, at which time the conventional sweet-corn could no longer be sold due to a shorter shelf life. Small amounts of the Bt sweet-corn were sold over the next two weeks; however, these were not included in the sales figures, because, although they were labeled, there was no conventional corn available for comparison.

Results

Sweet-corn

The Bt sweet-corn required neither insecticide nor fungicide applications, unlike the conventional sweet-corn. The ECB and ear-worm pressure were greatest in the first planting of corn and the cool, wet weather experienced during the 2000 growing season in southern Ontario made it most difficult to control ECB and ear-worm effectively, leading to the heavy applications of Carbofuran. The second and third plantings experienced a reduced level of infestation and, due to the cooler weather, the insects were controlled effectively using cypermethrin in place of Carbofuran in several instances. The scouts also noted that such pesticide sprays killed non-target insects.

Picking and packing were found to be less time-consuming for the Bt than the conventional sweet-corn because of significantly reduced worm damage on the Bt corn. Subsequently, the packers did not have to fully examine each ear of corn to grade it, unlike with the conventional corn, and could therefore pack much faster and more efficiently.

Segregation of the sweet-corn varieties was difficult from picking through to storage. With four different varieties in the same field – bi-colour and yellow in both conventional and Bt – it was labour-intensive to keep all four separate, especially since workers were often harvesting two varieties at a time. Ultimately, the labour constraints precluded the grower from keeping the Bi-colour separate from the yellow, so only the Bt and the conventional were kept separate.

Other difficulties observed were the need to keep detailed and accurate records on where each variety was planted, and having separate containers for holding and transporting the corn from the field. Farm workers also had to be trained and monitored to ensure that they kept track of which variety they were picking and labeled them correctly.

Economics

The only data differentially measurable between the Bt and conventional sweet-corn were in the purchased inputs, which included cost of seed, fertilizer and pesticides. For the Bt sweet-corn, the Bt seed and fertilizer made up the total costs. The premium paid for the Bt seed did, however, allow for a reduction in insecticide costs. The insecticide costs on the conventional corn varied among the three plantings, as changes in insect pressure and weather conditions allowed for changes in the insect management regime. The input costs for the Bt sweet-corn were $7,000.59 for each planting. The first planting of conventional had total costs of $7,290.80, close to $300 greater than the Bt. The second and third plantings of conventional corn, at $6,829.54 and $6,626.97 respectively, cost slightly less than the Bt due to less insect pressure and the cooler weather, which allowed for the use of less costly pyrethroid insecticides.

Sales

Corn sales for the period during which both Bt and non-Bt corn were available are displayed by day in Figure 1. The numbers in the Figure are per bag of five dozen corn. Bt sweet-corn sales were consistently higher than regular

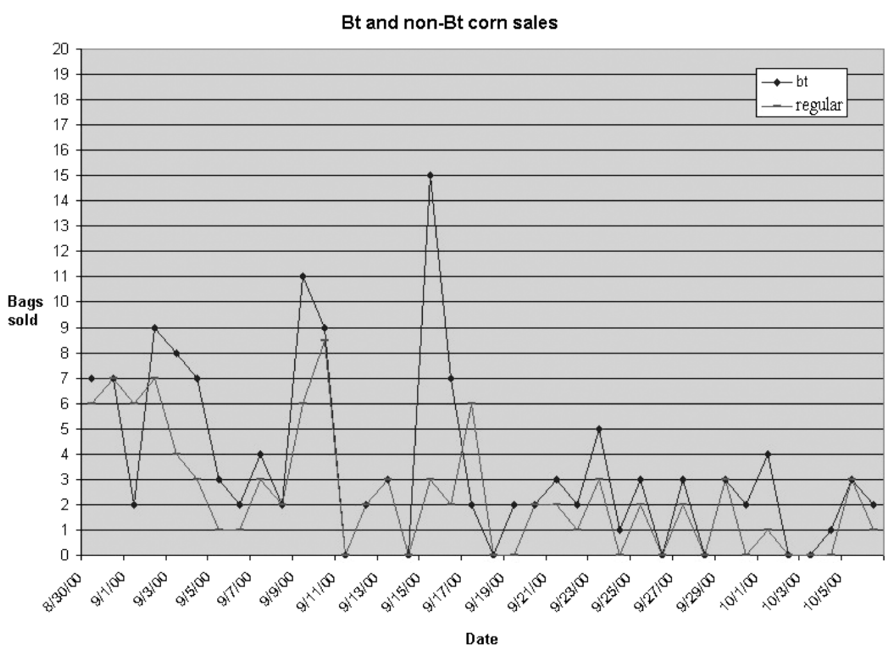

Figure 1.
Chart of sales of Bt and regular sweet-corn

sweet-corn sales. In total, over the five-week period, 136 bags or 8,160 individual cobs of Bt corn were sold and 90.5 bags or 5,430 individual cobs of conventional. The spikes on the graph indicate weekend days, at which time the business in the market was significantly higher. Total sweet-corn sales dropped off dramatically in the middle of September, as it does every year, as children return to school in early September, the number of social events such as corn roasts drop off and people generally lose interest in fresh sweet-corn-on-the-cob.

In addition to the on-site retail market, a significant percentage of the produce grown at Birkbank Farms is sold to larger retail outlets. When asked if they would allow a product information display similar to the one at the Birkbank farm market for a consumer research study in a supermarket setting, the large retailers refused. One stated that the chain did not want any of the controversy it perceived to be associated with a labeled, genetically engineered whole food.

According to the professional scouts, worm damage varied between 10-20 per cent on the conventional corn and 1-2 per cent on the Bt sweet-corn. In the market, eight to ten cobs out of 100 of the conventional were thrown out daily due to worm damage, whereas almost no Bt corn was thrown out for this reason. The Bt sweet-corn was also found to have a longer shelf life. The last harvest of sweet-corn was on September 26. The corn was then kept in cold storage and sold as needed. The regular sweet-corn lasted until October 6, after which the quality was so poor that it could not be sold. The Bt sweet-corn was saleable until the week of October 20.

Purchasing factors

The number of surveys conducted at the actual farm market was very low because of the high level of repeat customers and unwillingness by the researchers to disrupt the market business. When asked whether they would buy GE corn (or had bought GE corn), 23 out of the 34 respondent Birkbank Farm customers ($n = 34$) said they would buy it, nine respondents said they would not and two did not know. When asked why they would buy, the top answers were taste/quality, and fewer pesticides; of those who would not buy the GE corn, the primary reasons were environmental concerns, health and safety, ethical reasons, and a perceived need for additional safety testing.

When asked whether they were concerned more about pesticides or genetic engineering, the majority (24 respondents) felt pesticides posed more of a threat. Four respondents were equally concerned about both, two were more concerned about genetic engineering and only one person was not concerned about either.

A total of 115 comments were recorded over 13 weekend days, while free samples of both types of corn were being given away. The majority, 30 per cent of all comments recorded in the market, were positive towards Bt sweet-corn. Questions made up the next largest component at 24 per cent and there were equal numbers of negative and neutral comments (22 per cent in each case). Of all the comments, 50 per cent were related to taste and quality, which was expected, as the comments were often being recorded while the respondents were tasting the corn.

Of the positive comments, the majority were about taste and quality. The second most common topic was pesticide use. For example, a very common statement was "I like the fact that they used fewer insecticides on the Bt one." The remaining comments that did not fall into one of the two categories above were classed as apathy – that is they were all along the lines of "I don't really care if it's genetically engineered or not".

With regard to the negative comments, most of these were, again, taste/quality comments such as "I think the regular corn tastes better." The rest of the comments were split between comments about environmental concerns and purely emotional responses. Comments relating to environment were primarily about gene flow; for example, "I am worried about the genes escaping into the wild." Emotional responses were comments where the respondent could not articulate a reason for their statement, for example, "I am nervous about genetically engineered foods, I don't even want to try it." Two customers interviewed refused to buy any corn. One cited concerns over cross-contamination, while the other had general concerns about the project.

Other considerations

Bt potatoes

Superior variety potatoes, genetically engineered to contain Bt and conventional, were planted side by side on a ten-acre plot. Approximately half the field was planted with the Bt superior potatoes and the other half with conventional superiors. From north to south the planting was as follows: 40 rows GE Bt potatoes; ten rows conventional superior with Actara in furrow; 20 rows conventional with no treatment; and 20 rows conventional with Actara in furrow. Another four acres of headland were also planted with Bt potatoes.

The potatoes were grown using the basic integrated pest management (IPM) system that is used on potatoes throughout the farm. The professional scouts checked the fields twice each week for the following insects: Colorado potato beetle, tarnish plant bugs, potato leaf hoppers, aphids, beneficial insects present such as ladybeetles, and for diseases including rhizoctonia and blight.

The potatoes were harvested during the last week in September. They were first dug by a wind-rower and subsequently harvested mechanically. The potatoes were graded and then segregated into large wooden bins, labeled, and placed into storage.

The Bt potatoes were also segregated, labeled as GE or regular and sold in the market. The potatoes were sold in 10lb bags. Potato sales were tracked for the first month; however, it became too difficult for the market workers to keep track of sales. Bags of potatoes sold much more slowly than the corn, and there was very little consumer interest in the potatoes, possibly because they were in bags and the customers could not see the actual potatoes

As with the Bt sweet-corn, the Bt potatoes did not require any insecticide applications. Applications of herbicides, fertilizer, and fungicides were the same for both varieties. All pest management strategies were found to be effective in controlling the insect damage. The conventional potatoes had higher pest pressure and greater damage to plant leaves. The Bt potatoes exhibited no insect damage throughout the growing season and were therefore much healthier. Dead beneficial insects were observed between the rows of conventional potatoes but were not observed by the scouts in the Bt potatoes. Developmentally, both varieties of potatoes matured at the same rate until bloom. After this point, the genetically engineered Bt potatoes matured at a slower rate and took two weeks longer to reach maturity than the conventional potatoes. Economically, there was little direct cost difference between the Bt potatoes and the conventional potatoes in terms of inputs. This did not take into account differences in yields (the potatoes were planted in a commercial context; therefore an accurate yield comparison was not possible), segregation costs, or time savings from not spraying.

Discussion

From an economic perspective, the data indicate that financial benefits from Bt sweet-corn may only be realized in years when ECB pressure is medium to high. It also may not offer an economic benefit to farmers who plant late in the season and thus avoid the peak period of insect pressure. The findings are limited to one farm during one season and may not be representative of other farms in Ontario and no conclusions can be drawn as to whether the effects are scale-dependent. This economic analysis does not take into account benefits such as decreased labour costs due to a reduction in packing time, reduced waste/loss from worm damage and increased shelf life.

The reduction in insecticide applications had additional benefits to the grower in terms of significant time savings and reduced the risk to grower and farm workers from drifting sprays. Also, by only planting sweet-corn for late harvest, farmers often miss out on price premiums, as sweet-corn prices drop throughout the season. Farmers plant corn early despite high insect pressure to coincide with the peak consumer demand for fresh market sweet-corn of mid- to late August.

Identity preservation/segregation is another cost that must be taken into account when evaluating the value of Bt crops. Some farms may not be equipped to handle the costs of segregation, when deciding which varieties to plant and in which markets they will be sold. There is a further problem of potential human error with segregation. Adequate segregation requires trust in farmers to keep adequate records as to where each variety is planted, and in farm workers to remember which they are picking, to keep the varieties separate, and properly labeled.

From the limited questionnaires it appears that the majority of those who bought GE foods felt they were beneficial in some way, while those who would not buy the Bt corn felt they were harmful. The percent of people who said they would buy or did buy Bt corn was slightly higher than the percentage of Bt corn sold compared with regular corn; however, many customers bought both types to evaluate differences for themselves, which may account for this discrepancy. Taste and quality were important factors to consumers when purchasing fresh market sweet-corn, especially when price was not a factor. The fact that the majority of the comments were positive is also consistent with the sales figures. Both the survey data and qualitative data/comments indicate that the main influences over customers' decision to buy Bt corn were taste and quality, decreased pesticide use, and curiosity. Many people opted to buy both or just purchased a small number of the Bt to "try it out." Research has indicated that consumer acceptance of GE foods will be based on the recognition of tangible benefits (Bruhn *et al.*, 1992; Decima Research, 1993; Einsiedel, 2000; Frewer *et al.*, 1994; Hoban, 1997; Sheehy, 1996; Zimmerman *et al.*, 1994). The data indicate that some of the customers at the Birkbank farm market felt that a reduction in pesticide use was a tangible benefit that may have influenced their decision to purchase the Bt sweet-corn. Other surveys have consistently shown that North American consumers are concerned about the use of chemical pesticides in agriculture (van Ravenswaay, 1995), rating pesticides as more serious a hazard to food safety than genetic engineering (CFIA, 1998; IFIC, 2000).

The labels on the produce bins may have influenced consumers to buy, just because they were there or perhaps because there was detailed information provided. A few customers in the market, on reading the short labels, were observed to fill their bags with the regular corn, pause halfway through, and read the large signs above the bins, which explained the pest management regime for each. They then proceeded to empty their bags and refill them with the Bt sweet-corn. This example illustrates two points. First, that pesticide reduction is an attribute valued by some consumers at Birkbank Farms. Second, it indicates that simply labeling foods as GE and GE-free or Bt and non-Bt may not aid consumer decision making. Many customers at the Birkbank farm market knew very little about GE foods, especially when it came to specific benefits and risks. At the same time it seems many customers have very little knowledge of how conventional crops are produced and the associated levels of pesticide use.

Surveys have shown that levels of perceived trust in promoters and regulators of technologies are the most accurate predictors of consumer support (Dittus and Hillers, 1993). People who demonstrate low trust have the highest concern about possible risks regarding pesticides and agricultural biotechnology (Frewer and Shepherd, 1994). Those with high trust perceive greater benefits from both products. The high sales numbers for the Bt sweet-corn may also be a result of high trust in the farmer, as sales were tracked in the farm market. The Wilsons have been farming in this area for over 20 years and know many of their customers from the community. This is supported by results from a recent survey (Ipsos-Reid, 2001), which found that both Canadian and US consumers have the greatest confidence in farmers' markets to provide them with safe, healthy food, over retailers, government, and food manufacturers.

This research is a starting-point and describes the experience of one farmer on one farm during the 2000 growing season. This research should be continued over several years and involve other growers and retail outlets to get a truer sense of both grower and consumer interest in genetically engineered crops compared with other agricultural technologies. A comparison with organic growing methods and organic produce would also be useful in terms of comparative costs and benefits of the different methods.

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