THE PRODUCER BENEFITS OF HERBICIDE-RESISTANT CANOLA

Murray Fulton & Lynette Keyowski[1]

The commercial sale of herbicide resistant (HR) canola has raised questions about the benefits of this new technology for seed and chemical companies, farmers, consumers, and other players in the supply chain. In this paper, we argue that the pricing and adoption of HR canola in Canada can not be understood if producers are seen as being homogeneous. We develop a conceptual model of producer heterogeneity that represents the distribution of benefits among producers. In this context, some farmers benefit from the new technology leading to adoption, while others do not. Empirical evidence supports this argument. In addition, the new technology co-exists with the traditional technology.

Key words: herbicide resistant canola; producer heterogeneity; benefits; new technology; biotechnology.

Canola is one of the first genetically modified (GM) crops to reach the commercial market in Canada. The focus of genetic modification is the addition of herbicide resistance to canola plants. In 1998, after four years of production, herbicide-resistant (HR) canola comprised 44 percent of total canola production in Canada (see table 1). One source estimates that Canadian HR canola production could reach as high as 70 percent of total production in 1999 (Plant Breeding Institute (PBI), 1998).

Table 1. Acres of Herbicide-Resistant Canola in Canada ('000s acres).

	1996	1997	1998	1999 (projected)
Total Canola	8,843	12,040	13,535	13,941
Herbicide Resistant	350	4,000	6,000	9,600
Percent of Total	4	33	44	69

Sources: AAFC, Canola Council of Canada, PBI, and authors' calculation.

[1]*Murray Fulton is the Director and Lynette Keyowski is a Research Assistant at the Centre for the Study of Co-operatives at the University of Saskatchewan.*

There is a wide array of issues surrounding HR canola, including: (1) whether Canadian farmers should be producing a crop that has not been licensed for sale in the European Union, traditionally one of Canada's largest markets (Western Producer, 1999); (2) the implications of cross-pollination with traditional canola; and (3) the issue of saved seed, which some farmers feel is indicative of increasing concentration in the seed and chemical industries. The question of whether HR canola provides benefits to the farmer and to the rest of the supply chain should be easy to answer. From a strictly economic perspective the answer appears to be quite simple: if the profits from growing HR canola are higher compared to those of traditional canola, then producers benefit. In turn, if producers benefit, then canola supply increases which results in benefits to other sectors of the supply chain.

The purpose of this paper is to show that a determination of the producer benefits of HR canola is much more difficult to obtain than is outlined above. The argument that producers benefit if the relative price of growing HR canola falls depends critically on the belief that all farmers are identical in the agronomic factors they face, the management skills they possess, and the technology they have adopted. If farmers are different in these characteristics, no such easy test of producer benefit is available. Instead, the determination of farmer benefits requires a detailed examination of the agronomic, management, and technology factors facing different farmers.

Table 2. Canadian Canola Acreage ('000s acres), 1986-1998.

Year	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total Canada
1986	92.9	980.0	2,520.0	2,800.0	105.0	6,497.9
1987	40.0	970.0	2,450.0	2,900.0	100.0	6,460.0
1988	55.1	1,600.0	3,850.0	3,600.0	75.1	9,180.2
1989	40.0	1,100.0	3,300.0	2,700.0	69.9	7,209.9
1990	49.9	870.0	2,800.0	2,450.0	80.0	6,249.9
1991	64.3	1,254.8	3,359.1	2,982.1	100.0	7,760.3
1992	35.0	1,550.1	3,100.0	2,750.0	89.9	7,525.0
1993	49.9	1,820.0	4,580.1	3,590.0	100.0	10,140.0
1994	55.1	2,500.0	6,550.1	5,027.1	114.9	14,247.2
1995	89.9	2,350.0	6,200.0	4,450.0	125.0	13,214.9
1996	49.9	1,551.0	4,000.0	3,150.1	91.9	8,842.9
1997	64.9	2,300.0	5,600.0	4,000.0	75.1	12,040.0
1998	65.0	2,750.0	6,250.0	4,350.0	100.0	13,534.8

Diffusion And Pricing Of Canola In Saskatchewan, Canada

With a short growing season, high yields and tolerance to the Canadian prairie climate, canola acreage on the prairies has grown rapidly (table 2). In some regions, canola accounts for nearly 30 per cent of the cropped acreage (table 3).

In recent years, canola varieties that are resistant to certain non-selective herbicides, such as Roundup, have been introduced. The ability to apply a herbicide to an established crop has some agronomic and economic benefits. Production of non-herbicide resistant canola typically requires two chemical applications, one pre-emergent and one post-emergent, where the post-emergent application only controls a limited spectrum of weeds. The one-pass chemical operation characteristic of herbicide resistant canola systems not only improves the yield potential of the crop by removing competition for moisture and nutrients, but also eliminates the cost of additional machine operations over the field.

Herbicide-resistant canola is also becoming more and more appealing as farmers turn to conservation systems of land management. In conservation systems, farmers make minimal passes over the land with tillage equipment. In the zero tillage system, for instance, farmers place the seed and fertilizer directly into the undisturbed soil using a seeder. No other tillage takes place. Conservation systems are being used to maintain higher levels of soil organic matter and to minimize soil erosion.

Since tillage is minimized in these systems, weed control must be carried out solely with chemicals rather than with a combination of chemicals and cultivation, the usual method under traditional land management systems. When producing conventional crops, weed control is done prior to seeding using cultivation or chemical spraying or after seeding using spraying. In most cases only a limited spectrum of weeds can be controlled using post-emergent chemicals. The availability of a canola resistant to a chemical that can control the entire spectrum of weeds gives farmers much more flexibility in terms of the timing and type of weed control.

Table 4 compares the costs in 1999 of the commercially available HR systems with the traditional canola option, as estimated by Pioneer Grain Company. The cost of the conventional canola package is roughly equal to that of the other systems, and even higher than that of the Roundup Ready system. This pricing structure is similar to that found by Mayer (1997) in 1996. Mayer found the cost of the HR system was $43.58 per acre, compared to $49.50 per acre for traditional canola. Table 4 also indicates some yield loss for the non-conventional varieties, although in practice the yield difference clearly depends on location and farm management skills. With higher yields for conventional canola, this system has the higher per acre returns. In spite of lower benefits to HR canola, the proportion of total Canadian canola acreage consisting of HR canola has been rising rapidly since 1996 (table 1). Although there is still a significant area of production in traditional canola, the HR system appears to be dominating.

Table 3. Canola Acreage And Yield By Saskatchewan Crop District, Ten-Year Average (1988-89 to 1997-98).

Crop District	Soil Zone	Canola Acreage as Proportion of Total Crop[a] (%)	Average Yield (kg/ha)
1a	Black	10	468
1b	Black	16	466
2a	Dark Brown	3	406
2b	Dark Brown	7	462
3as	Brown	8	414
3an	Brown	3	481
3bs	Brown	1	388
3bn	Brown	2	501
4a	Brown/Dark Brown	3	518
4b	Brown	1	482
5a	Black	20	457
5b	Black	24	452
6a	Dark Brown	3	479
6b	Dark Brown	14	527
7a	Brown	4	503
7b	Dark Brown	20	488
8a	Black	29	486
8b	Black	25	522
9a	Black	31	472
9b	Black	30	478

Note. [a] Does not include acres in summer fallow or specialty crops. From Agricultural statistics 1997 by Saskatchewan Agriculture and Food, 1998.

Table 4. Canola Product Line – A System Comparison, 1999.

	Roundup Ready	Smart Open Pol	Liberty Hybrid	Conventional Open Pol
System Costs				
Seed Cost ($/acre)[a]	$18.70	18.70	24.75[b]	$13.47
Herbicide Cost ($/acre)	$5.00	$26.20	$22.75	$30.00
TUA ($/acre)	$15.00	None	None	None
System Cost ($/acre)	$38.70	$44.90	$47.50	$43.47
Gross Returns				
Yield (bu/acre)	33.0	31.5	35.7	35.7
Commodity Price ($/bu)	$8.00	$8.00	$8.00	$8.00
Expected Gross ($/acre)	$264.00	$252.00	$285.60	$285.60
Less System Costs ($/acre)	$(38.70)	$(38.25)	$(47.50)	$(43.47)
Gross Returns ($/acre)	$225.30	$213.75	$238.10	$242.13

Notes. [a] Seed cost was calculated assuming a seeding rate of 5.5 lbs/acre. [b] Recommended seeding rate is 5 lbs/acre for Liberty Hybrids. From Pioneer Grain Company Limited.

The pricing and acreage data appear to be contradictory if all farmers are assumed to face the same production conditions and, hence, have the same costs and benefits. The data, however, are not contradictory if it is recognised that producers differ in certain respects. Indeed, farmer diversity is a hallmark of modern agriculture. Farmers differ substantially in terms of age, education, farm size, product specialisation, farm management skills, and the geographical location of their farming operation. Two of the dimensions of the geographical diversity in the province of Saskatchewan, Canada are shown in table 3.

As table 3 illustrates, canola yields and the percentage of acreage devoted to canola differ substantially across crop districts. The crop districts can be mapped against the soil zones in the province. The brown soil zone is located in the South West part of the province and is characterised by lower rainfall, greater evapo-transpiration, and lower soil organic matter. The dark brown soil zone is located to the North East of the brown soil zone and is characterised by higher rainfall, less evapo-transpiration, and more soil organic matter than the brown soil zone. The black soil zone is located along the Eastern and Northern part of the grain growing region of Saskatchewan. It is characterised by much higher rainfall, less evapo-transpiration, and more soil organic matter than the other two soil zones. While the growing season is shorter in this region, the cooler and wetter climate allows a greater range of crops to be grown. Generally speaking, canola production occurs in the dark brown and black soil zones, areas where the average yield is greater.

Farmers also differ in the degree to which they have adopted conservation tillage practices. Conservation tillage requires a different set of equipment than does conventional tillage practices and the cost of this equipment is substantial. The cost of adopting this new technology, along with factors such as degree of risk aversion, farm size, age, and management skills, all contribute to this technology not being adopted by all farmers. Generally speaking, farmers who have not adopted conservation practices do not have the same agronomic and economic benefits of herbicide resistant canola as do those farmers who have adopted conservation practices.

A Conceptual Model Of Differentiated Producers

The heterogeneous nature of farmers and their farm operations suggests that farmer diversity may be an important factor in determining the benefits of a technology such as HR canola. Figure 1 illustrates the basic concepts in a model in which farmers are differentiated along some attribute, whether it is management ability, agronomic factors, or geographic location. The horizontal axis shows the attribute (denoted *A*) that distinguishes farmers. For illustration purposes, the differentiating attribute is assumed to be the type of tillage system adopted by farmers. Other attributes, or attribute combinations, could also be examined.

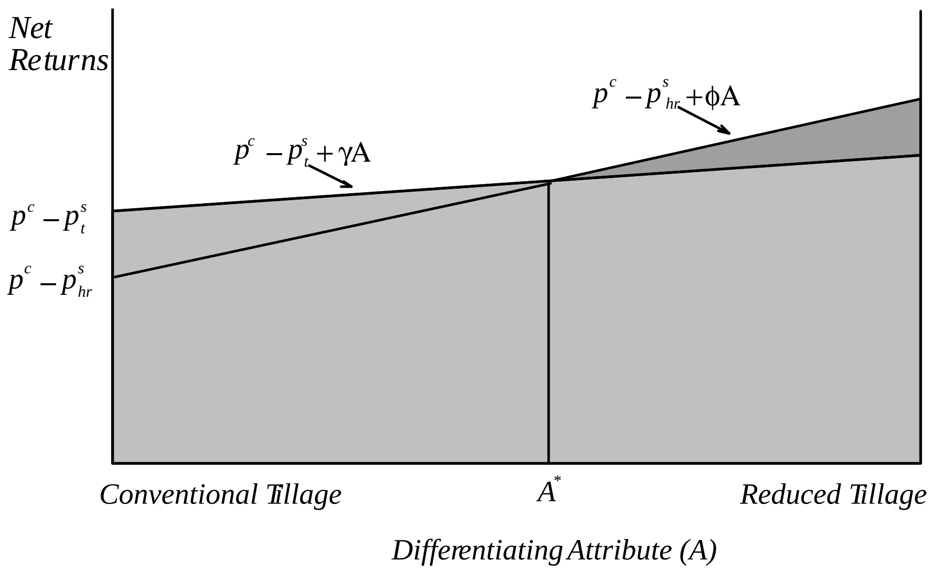


Figure 1. The Benefits Of A New Technology With Differentiated Producers.

Producers located at the extreme left-hand side of the diagram (i.e., those using conventional tillage) receive a net return on their traditional canola production equal to $p^c - p_t^s$, where p^c is the price of canola produced at the farm level and p_t^s is the price of traditional seed. Price p^c is net of all costs besides the cost of seed and chemicals, while price p_t^s includes the cost of seed, plus associated chemicals. Producers that have adopted some form of reduced tillage system (those located on the right-hand side) see higher returns. In figure 1 these higher returns are linearly related to the level of the attribute that distinguishes farmers (in a more general model, these costs need not be a linear function of the attribute). Mathematically, the net return on traditional canola production is equal to $p^c - p_t^s + gA$, where g is the additional benefit associated with a unit change in the differentiating attribute.

Given this cost and benefit structure, the shaded area in figure 1 gives the returns to traditional canola technology. Because farmers are differentiated according to some attribute, the benefit derived from the traditional technology is not the same for all farmers. Specifically, farmers that have adopted reduced tillage receive a greater benefit than do those using conventional tillage systems. This benefit, in fact, provides the incentive for farmers to incur the capital costs associated with the reduced tillage systems.

Now consider the introduction of a new technology such as HR canola. Suppose the cost of this technology is p_{hr}^{s}, where p_{hr}^{s} includes the cost of seed, plus associated chemicals and technology agreements. Producers located at the extreme left-hand side (i.e., those using conventional tillage) receive a net return on their HR canola production equal to $p^{c} - p_{hr}^{s}$. Producers that have adopted some form of reduced tillage system (those located on the right-hand side) see higher returns. Mathematically, the net return on HR canola production is equal to $p^{c} - p_{hr}^{s} + fA$, where f is the additional benefit associated with a unit change in the differentiating attribute.

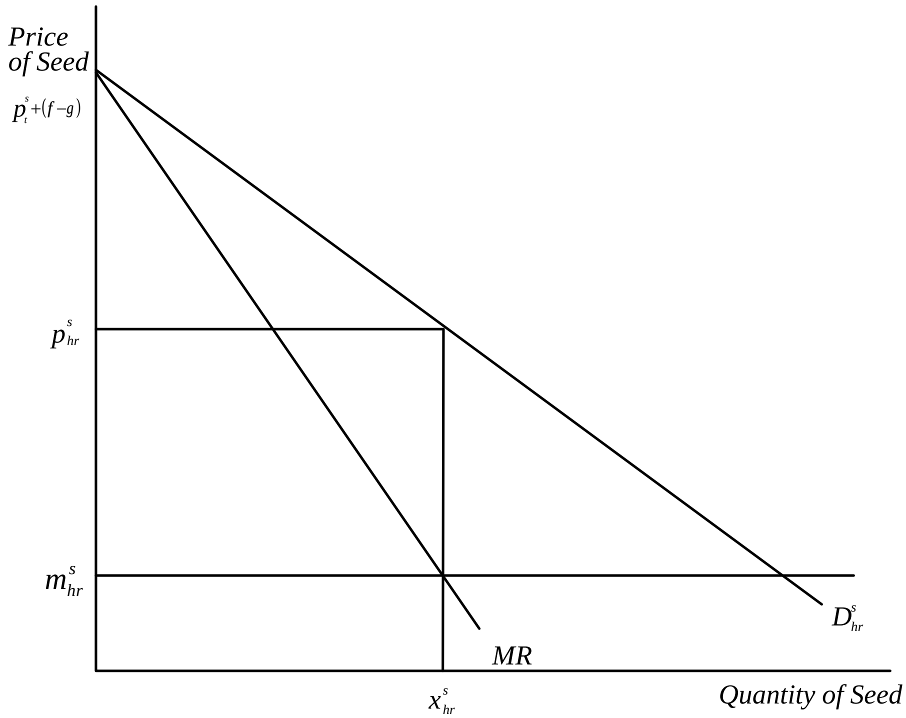
As figure 1 illustrates, producers located to the left of A^{*} find it profitable to remain with the traditional seed, since the returns to it are greater than the returns to the new seed. Producers located to the right of A^{*}, however, find it profitable to adopt the new seed. The hatched area in figure 1 is a measure of the benefits derived from the introduction of the new technology, namely, HR canola. Notice that the farmers that benefit most from the technology are those that have fully adopted reduced tillage. Those farmers with an attribute value that is close to A^{*} obtain only a small benefit from the new technology.

A number of observations can be made from figure 1. First, the model shows that some producers benefit even if only a portion of the market switches to the new technology. Second, the price of traditional seed is a key factor in determining the benefits of the traditional seed, and the benefits of the new technology. Specifically, all else equal, decreases in the price of traditional seed result in an increase in the benefits of traditional canola, a fall in the share of farmers that use HR canola, and a fall in the benefits of HR canola. This result can be seen graphically shifting upward the $p^{c} - p_{t}^{s} + gA$ line. Third, the price of HR seed is an important factor determining the benefits of the new technology. Graphically, an increase in p_{hr}^{s} leads to a downward shift in the $p^{c} - p_{hr}^{s} + fA$ line. This downward shift results in a smaller portion of farmers adopting the new technology and a smaller hatched area.

An important factor influencing the price of HR seed is the market structure of the seed and chemical industry. The market structure of this industry is unlikely to be one of perfect competition because of the presence of intellectual property rights. Figure 2 illustrates how a monopoly firm in the seed and chemical industry determines the price of HR seed. The demand curve facing the firm is given by D_{hr}^{s}. Assuming the marginal cost of producing the seed and chemical package is m_{hr}^{s}, the optimal HR seed price is determined by setting MR (the marginal revenue curve to the demand curve D_{hr}^{s}) equal to marginal cost (m_{hr}^{s}).

The intercept of the demand curve depends on the price of traditional canola seed, as well as on the parameters f and g (see Fulton & Keyowksi (1999) for details of this derivation). Thus, changes in the price of traditional canola, or changes in the relative marginal benefits of the modified over the traditional variety, f and g, influence the optimal HR seed price. Specifically, a reduction in $p_{t}^{s} + (f - g)$ leads to a reduction in p_{hr}^{s}.

Figure 2. Determination Of The Optimal GM Seed Price.



The model can also be easily extended to allow for oligopolistic pricing rather than monopolistic pricing of HR seed. If the industry is not a monopoly, the HR seed price is determined by equating a modified marginal revenue curve with the marginal cost curve (Alston, Sexton, & Zhang, 1997). The modified marginal revenue curve is constructed by rotating the marginal revenue curve towards the demand curve. The degree to which the curve is rotated reflects the degree of market competition. For instance, if competition among the seed and chemical companies is low, the rotation of the modified marginal revenue curve is small and the price of HR seed is close to the monopoly price. If competition is high, the price of HR seed is close to the price under perfect competition. In the case of perfect competition, the modified marginal revenue curve would lie on top of the demand curve.

As noted above, the price of HR seed is one of the factors influencing the benefits obtained from HR canola. As the price of traditional seed falls, the price of HR seed also falls. One implication of this result is that breeding programs that are directed at lowering the cost of traditional canola seed are likely to be important in ensuring that HR canola is priced so that benefits accrue to farmers.

Concluding Remarks

The commercial sale of HR canola has raised the question of the benefits of this new technology to the seed and chemical companies, farmers, consumers, and other players in the supply chain. This paper argues that the pricing and adoption of HR canola in Canada cannot be understood if producers are seen as being homogeneous. To understand the importance of producer heterogeneity, a conceptual framework in which producers are differentiated is developed. A key finding that emerges from this framework is that while some producers do benefit from the new technology, others do not. In addition, the new technology is expected to co-exist with the traditional technology. The paper also shows the importance of the industrial structure of the seed and chemical industry. Increased rates of concentration can be expected to raise the price of HR canola, thereby reducing the benefits of this technology.

The empirical evidence presented in the paper shows that even though HR canola is priced equal to or higher than traditional canola, a substantial number of farmers have adopted the new technology. These observations are consistent with a situation where some farmers derive a benefit from HR canola, while others do not. The magnitude of this benefit is unknown, however, without further research. This research requires a determination of the degree to which farmers are differentiated along one or more characteristics.

References

Agriculture and Agrifood Canada (AAFC). (1999, April). Canadian grains and oilseed outlook. Retrieved May 31, 1999 from the World Wide Web: http://www.agr.ca/policy/winn/biweekly/English/gosd/1999/apr99e.htm.

Alston, J.M., Sexton, R. J., and Zhang. M. (1997). The effects of imperfect competition on the size and distribution of research benefits. American Journal of Agricultural Economics, 79(4), 1252-1265.

Canola Council of Canada. (1998, December). Provincial acreages and yields. Retrieved May 31, 1999 from the World Wide Web: http://www.canola-council.org/Stats/acreageproductionandyield.htm.

Fulton, M.E. and Keyowksi, L. (1999, June). The impact of technological innovation on producer returns: The Case of genetically modified canola. Paper presented at the Transitions in Agbiotech: Economics of Strategy and Policy Conference, Washington DC.

Mayer, H.L. (1997). The economics of transgenic herbicide-tolerant canola. Unpublished master's thesis, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Plant Breeding Institute (PBI). (1998, September). Commercialization of plants with novel traits (PBI Bulletin). Retrieved May 31, 1999 from the World Wide Web: http://www.pbi.nrc.ca/bulletin/sept98/production.html.

Pioneer Grain Company Ltd. (1999). 1999 canola product line. Press Release, Winnipeg, CA: Pioneer Grain Company Ltd.

Saskatchewan Agriculture and Food. (1998). Agricultural statistics 1997. Regina, SA: Statistics Branch, Saskatchewan Agriculture and Food.

Western Producer. (February 25, 1999). EU closed to modified food. Western Producer, pp.14.