Estimating the Economic Benefits of Biotechnology in Canada's Canola

Canola refers to varieties of rapeseed that have been explicitly bred for human and livestock consumption when processed into meal and oil. Canola has become a dominant cultivar in Canada due, in part, to the introduction of modern biotechnology, and the industry has experienced substantial growth. The paper provides a current overview and assessment of the importance of biotech canola to the Canadian economy. It also examines the economic benefits of new biotechnology at the farm level, including a recent estimation of the producers' benefits. We estimate that producers' benefits were just under $2 billion in the 2023/24 crop year. Lastly, the implications of the results for research policy are discussed.

Keywords: *Biotechnology, Canola, R&D, Economic Benefits, Producers' Benefits*

Introduction

Canola is a type of oilseed rape bred at Canada's federal research station in Saskatoon and at the University of Manitoba in Winnipeg, Manitoba, in the early 1970s (Canola Council of Canada, 2024a, 2024b). The researchers had worked to reduce the levels of some of rapeseed's non-food oils and acids. Canola was developed to ensure that new varieties of the seed and, in turn, the resulting oil and meal products were deemed safe for human and animal consumption. The first registered variety with low levels of both erucic acid and glucosinolates, or "double low", rapeseed cultivars. The success of Canola as a crop has been a fascinating story of public and private biotechnological innovation.

The agricultural sector worldwide faces significant challenges amid constrained research budgets, increasing pressures from population growth, and shifting consumption patterns and dietary preferences. It has been demonstrated that agricultural productivity growth has slowed, particularly in the world's wealthiest countries. Alston, Beddow, and Pardey (2010a) attributed the global productivity slowdown to underinvestment in certain types of productivity-enhancing agricultural research and development (R&D). Canada's canola crop may appear more productive in terms of higher commodity prices and improved varieties; however, by all reasonable estimates, there is still underinvestment in agricultural research.

There is substantial evidence that investment in biotechnology, where some property rights have been assigned, can contribute to growth and benefit farmers, consumers, the environment, and the economy as a whole (e.g., EASAC, 2013; United Nations, 2017; FAO, 2022). However, optimal policies and regulations designed to foster investment must adapt as societal needs change, as does the market structure and the crops that dominate a landscape. The policies and regulations in place must be assessed to ensure further growth in the sector.

Governments in Canada and around the world have historically played a significant role in agricultural research (e.g., Malla and Gray, 2003, 2005; Malla and

Brewin, 2019a). During the 20th century, most crop research was conducted by public institutions, and the resulting products were held in the public domain. At the root of support for public agricultural research was the notion that the innovator could not capture all the benefits of research, as benefits “spilled over” to adopters. The introduction of modern biotechnology and strengthened Intellectual Property Rights (IPRs) has conferred monopolistic rights on innovators, stimulating increased private investment in agricultural research. These changes were particularly apparent in the Canadian canola sector, which has undergone significant alterations over the last three decades. The large influx of private investment in Canadian canola has led some to conclude that there is no longer a role for public investment in crop research. Others have raised concerns about potential adverse effects of privatizing agricultural research, such as reduced “freedom to operate” for some breeding firms. The canola sector has experienced fragmented research and patent/IPR ownership, as well as mergers and acquisitions, and, more recently, a growing need for gene-trait cross-licensing agreements. Gene trait cross-licensing agreements have raised concerns about economies of scale in biotechnology and the close relationships new agreements necessitate between the few dominant firms remaining in the sector. Furthermore, there have been concerns that the commercialization of a second generation of biotech products could suffer from the underuse of resources and less innovation (the tragedy of the anti-commons). There have also been concerns about the pricing of new canola varieties, the rules governing the use of new technology, potential crowding out of private investment, and the appropriate role for government in today’s biotech industry.

In contrast to the case of canola, wheat and pulse research has mainly been publicly funded in Canada (e.g., Malla and Brewin 2019a). Wheat represents the other major crop in Canada around the same area as canola, while pulse crops represent a smaller cluster of crops. However, the area devoted to pulse crops has significantly increased since the 1980s, and Canada has become a leading producer, exporter, and research leader for pulses worldwide. A large portion of pulse research is producer-funded through the mandatory Saskatchewan Pulse Growers (SPG) check-off. The question that arises is whether today’s government involvement in canola and other crop research is suitable, sufficient, and adequate. Comparing experiences across different locations and crops can provide valuable quantitative and qualitative insights into the effects of privatization and innovation policies.

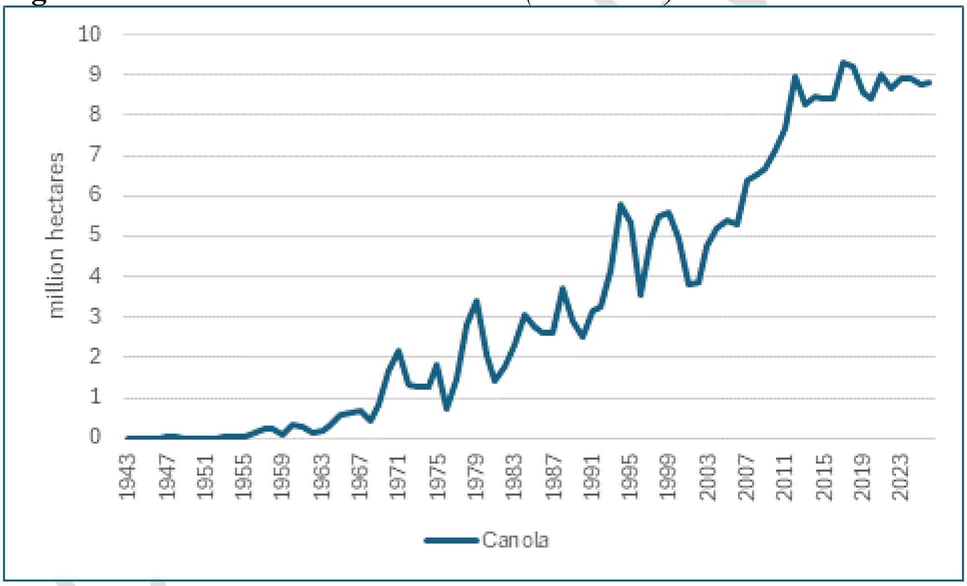
The goal of this study is to develop a broader understanding of how agricultural crop research, related regulations, policies, and key industry trends have evolved in the Canadian canola industry, and to consider how these changes impact farm returns and what that means for future public innovation policy. Specifically, the objectives of this paper are to provide a current assessment of biotechnology's importance, examine its economic benefits, estimate the benefits to producers, and explore policy implications.

An Overview of the Importance of Canola in Canada

A canola sector overview starts with the story of canola's rise in Canada from a very minor crop used to make industrial oil to the largest generator of farm income in Canada as of 2024. Figure 1 illustrates the evolution of the seeded area over time, reaching a current level of over 8 million hectares. Canola is seeded on around one-third of all arable land in Canada – another third is seeded to wheat, and a third for a range of other crops, including corn, soybeans, barley, lentils, and peas (Statistics Canada, 2026).

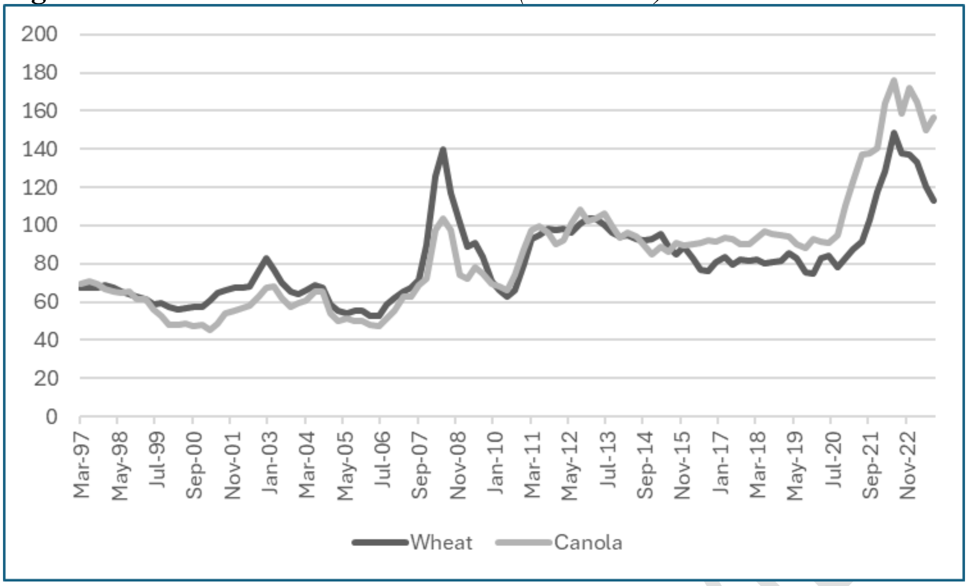
The gain in area was not due to prices, at least not until recent peaks. Wheat was the dominant crop in Canada from its colonization until about 2010. The prices for wheat, canola, and all oilseeds and cereals have generally moved together because worldwide cereals and oilseeds are planted on the same ground – prices adjust as buyers bid for acres in the spring. This typically keeps the returns to cereals and oilseeds in balance. Figure 2 shows Canadian wheat and canola prices as an index of the 2012 price from 1997 to 2012. It is clear that the two crop prices have moved fairly close together until the end of the series.

Figure 1. *Canola Area Seeded in Canada (million ha.)*



Source: Statistics Canada, 2026

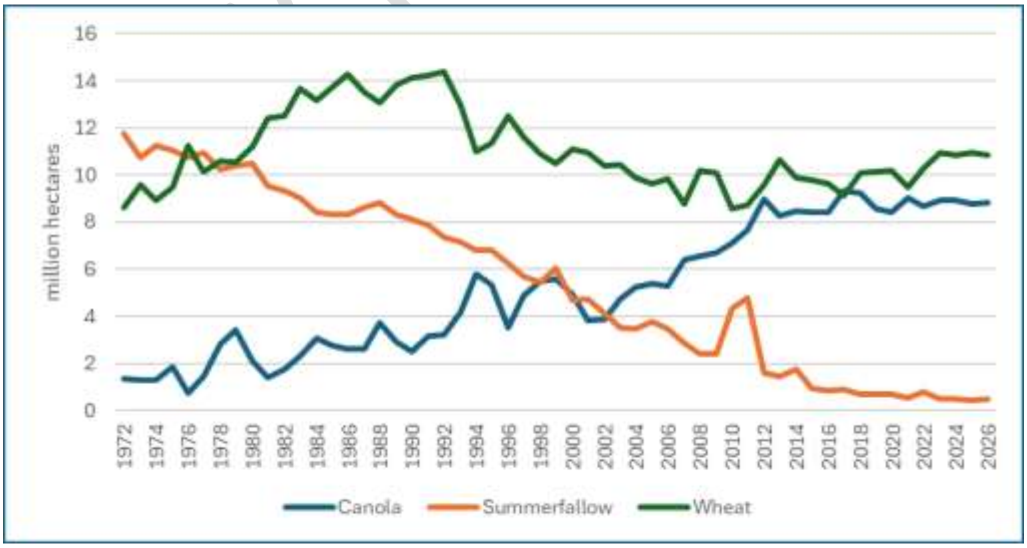
Figure 2. *Canola and Wheat Price Index (2012=100) 1997 to 2023*



Source: Statistics Canada, 2025

Canola played a significant role in changing the use of summer fallow in Canada and offered a valuable addition to crop rotations centred on wheat and barley for most of Canada. Figure 3 shows the reductions in wheat and summer fallow areas as the canola area increased. These rotational choices were part of the growing canola area in the 1970s and 1980s and represent a major shift in soil health; however, this paper will focus on the yield and herbicide impacts of biotechnology in canola, particularly the rise of Herbicide-Tolerant (HT) seed varieties since 1996.

Figure 3. *Areas left in Summer Fallow and Seeded to Wheat relative to Canola in Canada 1972 to 2026*



Source: Statistics Canada, 2026

Table 1 lists the 20 most successful varieties of canola seed in Canada over time. The crop's area increased with the development of the Echo seed in 1965. Still, it improved with the introduction of Tobin, a Polish variety with a shorter growing season that performed well in Canada's northern prairies (Brewin and Malla, 2015). The area experienced another surge in 1984, when Westar was developed. All three of these varieties were developed at Agriculture Canada Research Stations (Brewing and Malla, 2015). Although some Herbicide Tolerant (HT) varieties were developed using patented traits in 1996, it was the InVigor technology of the early 2000s that helped ramp up the area seeded to canola in Canada, and two varieties (5440 and L150) are now among the top four in area ever seeded to a variety (Brewin and Malla, 2015). The InVigor technology continues to lead in terms of the areas seeded in 2025 (Yield Manitoba, 2025). InVigor utilizes glufosinate (Liberty) HT in competition with glyphosate (Roundup) HT varieties, and as InVigor was explored, Bayer also identified male sterility, which facilitated less costly hybridization for canola. This path to hybridization enabled significant gains in hybrid vigour in canola varieties, especially with Bayer, which held the patent in Canada for LibertyLink HT until a recent merger between Monsanto and Bayer led to the sale of the InVigor Canola patents to BASF. After 2003, all of the most popular canola seed varieties were both HT and hybrid. Because hybrid seeds suffer a significant yield drop in the second generation, farmers are willing to pay for new hybrid seed every year, which helps drive private investment, along with the HT patents, which also drive seed investment.[1]. Together, the increased yields and reduced herbicide costs facilitated effective weed control within our wheat and canola rotations.

[1] The tradition of farmers saving seed in the wheat market and early canola varieties led to farmers pushing back on the fees charged by Monsanto for seed containing the first patented traits. The Case of Percy Schmeizer versus Monsanto ended up in Canada's Supreme Court and is told in the 2020 movie "Percy" starring Christopher Walken.

Table 1. *Top 20 Canola Seed Varieties by Seeded Area 1969 to 2012*

Rank	Variety	Yield In	Type of HT	Breeder	Year	Area in Ha
6	Echo	109.1	Conv.	Agriculture Canada	1965	3,999,714
19	Span	100.1	Conv.	Agriculture Canada	1971	2,255,389
5	Torch	100.1	Conv.	Agriculture Canada	1973	4,657,145
10	Tower	109.0	Conv.	Agriculture Canada	1974	3,044,723
2	Tobin	90.1	Conv.	Agriculture Canada	1977	9,408,145
7	Candle	87.0	Conv.	Agriculture Canada	1977	3,511,164
12	Regent	102.0	Conv.	Agriculture Canada	1978	2,933,710
1	Westar	122.0	Conv.	Agriculture Canada	1984	10,433,682
13	Legend	123.0	Conv.	Svalöf Weibull AB	1989	2,725,085
11	AC Excel	119.3	Conv.	Agriculture Canada	1991	2,951,079
8	Hyola 401	121.7	Conv.	Advanta Canada Inc.	1992	3,257,502
16	45A71	127.5	CLRFLD	Pioneer Hi-Bred Prod. Ltd.	1996	2,536,230
18	Quest	126.5	RR	Agricore Cooperative Ltd.	1997	2,324,224
15	46A76	152.5	CLRFLD	Pioneer Hi-Bred Prod. Ltd.	2000	2,575,559
20	45H21	160.4	RR	Pioneer Hi-Bred Prod. Ltd.	2002	2,168,118
4	InVigor 5020	167.9	LL	Bayer Crop Science	2003	5,487,043
9	InVigor 5030	171.8	LL	Bayer Crop Science	2003	3,104,999
14	InVigor 5070	177.9	LL	Bayer Crop Science	2003	2,582,199
3	**Invigor 5440***	186.1	LL	Bayer Crop Science	2007	6,577,964
17	**Invigor L150***	188.3	LL	Bayer Crop Science	2010	2,525,350

Source: Brewin and Malla, 2013

The Direct Benefits of Biotech Canola for Producers

In the mid-1990s, when the first HT fees were being collected, the seed companies charged more for the technology than the average farmer was willing to pay. Fulton and Keyowski (1999) demonstrated that the average Saskatchewan farmer would incur a loss by adopting any of the available HT Varieties in 1996. There was likely strong demand for farmers with weed problems, such that the herbicide gains and improved yields from reduced weed competition had a better payback than the average farm. As time progressed, competition among seed growers and technological advancements began to alter the calculus within seed firms, and farmers started earning significantly more from adopting HT hybrids than from sticking with cheaper, publicly bred, open-pollinated varieties.

In 2015, Malla and Brewin estimated the total direct benefits to farmers in Canada for the 2011/12 crop year from biotech innovations in canola. They estimated that gain to be over one billion Canadian dollars a year, using the data in Table 2 and summing the last line. These gains are based on reduced herbicide costs and higher yields that swamp higher seed costs when any one of three HT seed systems was used. Roundup Ready (RR) varieties enabled farmers to spray Roundup on their canola crops to control weeds. Liberty Link (LL) and Clearfield allowed the application of two other herbicides. By 2012, 93% of the seeds used by farmers in Canada were either RR or LL, and most were also produced with hybrid strains. The yields in Table 1 were based on the 2011 crop, with an average yield of 1.9 t/ha. As of 2023, the yield had improved to 2.17 tonnes per hectare, and prices had increased to $ 715 per tonne (AAFC, 2025). The area seeded also increased from 8 million ha in 2011 to 8.86 million ha in 2023 (AAFC, 2025).

Table 2. *Gains To Canola Farmers by the Seed System Adopted Relative to Open Pollinated (2011/12)*

Farmer System Costs	Roundup Ready	Liberty Link	Clearfield	Open Pollinated
Seed Cost ($/ha)	$97.74	$91.76	$91.64	$33.84
Herbicide Cost ($/ha)	$12.35	$28.55	$33.76	$74.10
TUA ($/ha)	$37.05	$25.56	$30.21	$0.00
System Cost ($/ha)	$147.14	$145.88	$155.61	$107.94
Gross Returns				
Yield (tne/ha)	1.90	1.91	1.72	1.57
Commodity Price ($/tn)	$530	$530	$530	$530
Expected Gross ($/ha)	$1,007	$1,012	$912	$832
Less System Costs ($/ha)	($147)	($146)	($156)	($108)
Net Farm Returns ($/ha)	$860	$866	$756	$724
Area by System (Ha)	3,680,000	3,760,000	480,000	80,000
Gain over Open	$ 499,380,048	$ 534,900,608	$ 15,277,920	

Source: Malla and Brewin (2015)

Table 3. *Gains To Canola Farmers by the Seed System Adopted Relative to Open Pollinated (2023/24)*

Farmer System Costs	Roundup Ready	Liberty Link	Clearfield	Open Pollinated
Seed Cost ($/ha)	$97.74	$91.76	$91.64	$33.84
Herbicide Cost ($/ha)	$12.35	$28.55	$33.76	$74.10
TUA ($/ha)	$37.05	$25.56	$30.21	$0.00
System Cost ($/ha)	$147.14	$145.88	$155.61	$107.94
Gross Returns				
Yield (tne/ha)[1]	2.17	2.18	1.96	1.79
Commodity Price ($/tn)[1]	$715	$715	$715	$715
Expected Gross ($/ha)	$1,552	$1,560	$1,405	$1,282
Less System Costs ($/ha)	($147)	($146)	($156)	($108)
Net Farm Returns ($/ha)	$1,404	$1,414	$1,249	$1,174
Area by System (Ha)[1]	4,075,600	4,164,200	531,600	88,600
Gain over Open	$ 938,532,579	$ 998,186,180	$ 39,774,200	

Source: Authors' update of Malla and Brewin (2015)

Table 3 presents an updated version of Table 2, incorporating the 2023 yield and area in Canada, as well as the 2023/24 average price (AAFC, 2025). With higher yields, near-record-high prices, and increased area, the value of the direct impacts of biotech changes to canola on Canadian farmers was just under $2 billion in the 2023/24 crop year. At the time of writing, the price has returned to its previous level, having traded above $610/t for most of the last three years (AAFC, 2025).

Benefits to Other Firms and Indirect Impacts

GlobalData (2024) estimated the direct economic contribution of canola farmers and the seed companies that supply these new seed systems to be $13 billion. The value of canola to the rest of the canola value chain, including exporters, crushers, oil bottlers, and meal feeders, as well as the benefits to end users, was estimated to generate an additional $5.7 billion in direct economic impact.

In 2019, Malla and Brewin (2019b) presented a theory related to socially optimal research and development expenditures related to crop innovation. In the presence of low public investment and significant positive externalities from a trading crop, it can lead to substantial underinvestment in terms of the public good. Most researchers who have examined Canadian public investment in crops have suggested that we are underinvesting (e.g., Gray et al., 2001; Malla and Gray, 2003, 2005; Malla et al., 2004; Alston et al., 2010b; Gray, 2014). Underinvestment in the canola sector has improved, with a path towards Intellectual Property Rights (IPR) in herbicide-tolerant and hybrid seed systems; however, it remains lower than expected, given the significant returns to firms that discover the next great canola seed. However, even if research efforts were optimal to meet the needs of the current sector in terms of private returns, there could be underinvestment if canola production generates environmental and health-related public goods for Canadians.

There have been several meta-analyses, which are analyses of other studies, that link canola oil consumption to reduced cholesterol levels (e.g., Ghobadi et al., 2018; Amiri et al., 2020; Pourrajab et al., 2022; Shen et.al. (2023). Shen et.al. (2023) concluded that "Apart from unsaturated fatty acids, there are nine functional components in rapeseed oil that contribute to its anti-microbial, anti-inflammatory, anti-obesity, anti-diabetic, anti-cancer, neuroprotective, and cardioprotective, among others. These nine functional components are vitamin E, flavonoids, squalene, carotenoids, glucoraphanin, indole-3-Carbinol, sterols, phospholipids, and ferulic acid, which themselves or their derivatives have health-benefiting properties." Therefore, canola or rapeseed oil has a wide range of health-promoting effects, including those related to cardiovascular disease (CHD), obesity, cancer, diabetes, and others.

There have also been several studies linking canola production, genetically modified crops, and biotechnology to environmental benefits such as climate change mitigation, greenhouse gas emissions reduction, increased carbon sequestration, reduced soil and water contamination, reduction in herbicide application, chemical use and toxicity (e.g., Biden et al. 2018, Kovak, et.al., 2022; Brookes, 2022; Smyth, et.al., 2024). For example, Brookes (2022) considered the environmental impacts of genetically modified crops and estimated that the greenhouse gas emission savings (including fuel-related savings and soil carbon storage) are equivalent to 23.6 billion kg in global agriculture. Kovak et al. (2022) calculated that the greenhouse gas emission savings (from fuel-related savings and soil carbon storage) are equivalent to 33 million tons of CO_2 equivalents per year in the EU. This is comparable to the opportunity costs of delaying the adoption of GM crops in North America. Biden et al. (2018) estimated that carbon emission savings (fuel use only) amount to 24.2 million kilograms in Australia, or the opportunity costs of delaying the adoption of GM canola, as seen in Canada (2004-2014).

Concluding Comments

Canola has become a major crop in Canada primarily due to the introduction of modern biotechnology. The paper provides a current assessment of the economic consequences of new biotechnology. Specifically, it examined the importance of biotechnology and the economic benefits it brings, and estimated the benefits to producers.

It has been demonstrated that significant benefits are associated with the new biotech canola varieties, including increased area seeded to canola, expanded variety options, reduced herbicide costs, and higher yields. There have also been substantial benefits to producers and other firms, as well as the indirect benefits of biotech canola development in Canada. The study estimated that the value of the direct impacts of biotech changes to canola on Canadian producers was just under $2 billion for the 2023/24 crop year. Overall, the economic benefits of biotechnology are very substantial.

However, the high rate of returns on canola research investment suggests underinvestment in research. Hence, more research investment is needed, and the government's role is still vital in today's biotech canola industry. Government policies that can stimulate more private R&D investment in the biotech canola industry, such as government subsidies on the cost of private R&D investment or research output, and the public provision of basic research, are essential. Additionally, increased public R&D investment in applied research is also crucial. Appropriate policies and programs could contribute to further growth of the canola sector, increase overall economic benefits, and increase social well-being.

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