Cost-Benefit Analysis of Two Successful Innovation Cases

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I. Introduction

A. Background

For different accountability purposes and to inform the development of future innovation programming, the Program Design and Performance Division of Agriculture and Agri-Food Canada's (AAFC) Innovation Programs Directorate (IPD) is developing a bank of success stories illustrating the results of innovation programming by examining specific cases. To support this work, cost-benefit analyses (CBA) on two such cases were conducted to estimate their return on investment. The success story bank is intended to serve three main objectives:

- Inform the next policy framework development;
- Increase accountability by providing information for program evaluations, the GF2 mid-term report, Departmental Performance Reports, etc.; and,
- Highlight success stories to communicate to producers, stakeholders, and external audiences.

A "success story" case, herein referred to as a "case", is an innovation resulting from work supported by AAFC that has been commercialized or broadly adopted by the sector, that has a major impact, and for which we can measure benefits in terms of return on investment. This will inform the development of the next innovation program as well as provide evidence of the impacts of such programs.

At the outset of this study, AAFC identified two cases which met the above requirements: swath-grazing and the development of midge-resistant wheat. To gather information on these cases, AAFC conducted interviews with the primary scientists responsible on both cases, as well as an industry representative for the swath grazing case. The interviews covered major milestones for the development along the innovation continuum as well as benefits, requirements for adoption, and results in terms of commercialization and industry adoption. The interviews confirmed considerable benefits of both cases, and the availability of sufficient data to conduct CBA.

This report presents the results of ex-post CBA analyses of the two innovation cases funded through AAFC programming and identified by IPD. For each innovation case, it was necessary to calculate the Net Present Value of benefits and the Benefit:Cost Ratio. In addition, it was necessary to explain other intangible impacts which could not be quantified in dollar value, such as environmental and health benefits.

B. CBA Methodology

The following section provides a step-by-step overview of the CBA conducted to assess the return on investment for the two cases, as follows:

1. Develop a stream of annual costs incurred to develop the innovation: This includes not only costs incurred by AAFC, but also the costs incurred by provincial governments, industry, and producers.

2. Develop a stream of annual gross quantifiable benefits derived from the innovation: The benefits (e.g. cost savings, reduced losses) include the benefits achieved by producers each year in the relevant areas in Canada each year since the innovation was developed. The benefits stream contains not only benefits already achieved but also projected benefits in future years.

3. Convert the streams of gross benefits and costs into a net present value using a discount rate.

4. Determine the net benefits by subtracting the net present value of the stream of costs from the net present value of the stream of gross benefits.

5. Determine the benefit:cost ratio by dividing the net present value of the stream of gross benefits by the net present value of the stream of costs.

6. Determine other intangible impacts such as environmental and health benefits.

C. Outline of Report

The next chapter of the report summarizes the findings of the benefit cost analysis related to the swath grazing innovation. Chapter 3 contains the findings related to the midge resistant wheat innovation.

- Reduced farm labour requirements.

III. Midge Resistant Wheat Innovation

A. Description of Innovation

Orange wheat blossom midge is a pest that can significantly reduce crop yield and grade. Crop damage occurs when the midge larvae feed on the developing wheat kernel. Grain damage ranges from a slight change in shape, to a kernel that is completely shrunken and deformed, to complete abortion of the kernel. The damaged kernels can cause downgrading in wheat samples and many are blown out of the combine during harvest.

Work on developing midge tolerant wheat varieties began in 1996 when genetic resistance to the midge was detected in some soft winter wheat varieties. By 2002, scientists in Winnipeg had determined that a single gene, known as *Sm1,* confers midge resistance. When the midge insect begins to feed on the seed, the *Sm1* gene causes the level of phenolic compounds (naturally occurring organic acids in wheat kernels) to elevate more rapidly than in wheat kernels without the *Sm1* gene. The higher levels of phenolic acids cause the midge larvae to stop feeding and the larvae starve to death. The mechanism that triggers the production of phenolic acids does not operate if midge larvae are not feeding on the seed, and in addition, these acids are reduced to normal levels by the time wheat reaches maturity, thus not affecting the quality or food value of the harvested grain.

By 2010, the first midge tolerant varietal blends of certified CWRS wheat seed were being commercially grown by Western Canadian grain producers. As shown below, several spring wheat varieties have since been developed by Canadian wheat breeders at AAFC in Winnipeg and Swift Current, and the Crop Development Centre at the University of Saskatchewan:

- AC® Unity VB
- AC® Goodeve VB
- AC® Glencross VB
- AC® Fieldstar VB
- AC® Shaw VB
- CDC Utmost VB
- AC® Conquer VB
- AC® Vesper VB
- AC® Enchant VB
- AAC Marchwell VB
- CDC Titanium VB
- AAC Jatharia VB
- AAC Prevail VB
- AAC Cameron VB
- AAC Tenacious VB

B. Study Methodology

To determine the costs incurred by AAFC related to the midge resistant wheat innovation, the available cost information provided by AAFC was reviewed. To review the costs incurred by other organizations as well as to obtain information on the benefits of the midge resistant wheat innovation, the following individuals were contacted:

- Ian Wise, Research Scientist AAFC (retired)
- Mike Espeseth, Communications Manager, Western Grains Research Foundation
- Barb Kammener, Finance Manager, Western Grains Research Foundation
- Curt McCartney, Research Scientist, AAFC
- Kofi Agbor, Crop Development Centre, University of Saskatchewan
- Jeff Reid, General Manager, SeCan
- Brenda Trask, SeCan
- Michael Jackman, Commercialization Officer, AAFC
- E. Ann de St Remy, Office of Intellectual Property and Commercialization, AAFC
- Cezarina Kora, Senior Strategy Coordinator, Pesticide Risk Reduction Program, AAFC

A review of the research reports and other relevant publications related to midge resistant wheat was also conducted, and a list of sources consulted is included in Appendix 1 of this document.

C. Costs

Approximately $16.3 million in funding has been and will be provided to develop midge tolerant wheat from 1997 to 2019. Of this total, about $10 million has been provided by AAFC, while the remainder has been provided by a number of organizations including SeCan, Western Grains Research Foundation, the Alberta Crop Industry Development Fund and the Saskatchewan Agriculture Development Fund.

D. Benefits

Adoption Rate of Midge Tolerant Wheat

Since the launch of the first commercial midge tolerant wheat varieties in 2010, the industry has witnessed strong uptake of the technology. As indicated in the following table, approximately 2 million acres of midge tolerant wheat have been planted each year from 2013 to 2015. During this period, the proportion of total wheat acreage in western Canada planted in midge tolerant wheat was approximately 17%.

Adoption Rate of Midge Tolerant Wheat in Western Canada

Year	Number of Acres of Midge Tolerant Wheat	Total Insured Acres of Wheat Planted	Proportion of Acres Planted in Midge Tolerant Wheat
2013	2,051,968	12,900,819	15.9%
2014	1,992,843	10,860,133	18.4%
2015	1,937,420	11,438,627	16.9%
Average	**1,994,077**	**11,733,193**	**17.0%**

Benefits of Midge Tolerant Wheat

The most tangible benefit of midge tolerant wheat is the reduction of production losses. Midge damage occurs when midge larvae feed on developing wheat kernels. Affected kernels are shrunken and deformed, leading to reduced yields and grade-related losses. A detailed investigation of midge damage to wheat was conducted by the Cereal Research Centre (Wise et al.). As indicated in the following table, the financial loss

incurred by all wheat producers as a result of midge damage was an average of $62.1 million per year during the seven year period from 2004 to 2010.

Yield Loss and Financial Loss to Producer Caused by Midge in Western Canada

Year	Yield Loss	CWRS Production (millions of metric tonnes)	Production Loss (thousands of metric tonnes)	CWRS No. 1 Price (per metric tonne)	Loss to Producer (millions)
2004	0.07%	14.58	10.2	$205.10	$2.1
2005	0.24%	15.04	36.1	$195.14	$7.0
2006	3.61%	16.18	584.1	$212.89	$124.4
2007	5.46%	11.59	632.8	$372.06	$235.4
2008	0.74%	15.39	113.9	$311.36	$35.4
2009	0.32%	16.15	51.7	$236.80	$12.2
2010	0.33%	15.22	50.2	$344.96	$18.0
Average	**1.54%**	**14.88**	**211.3**	**$268.33**	**$62.1**

A study undertaken by AAFC (M. Jackman) estimated that the annual economic losses caused by midge were approximately $40 million dollars for western Canada wheat farmers.

The two studies mentioned above (Wise et al. and M. Jackman) examined the overall loss to all wheat acres in western Canada and they included every field, whether it has any midge or not. However, for the fields that have midge the actual yield loss is much higher than the average indicated in the above two studies. Some industry representatives indicated that farmers who grow midge tolerant wheat report benefits amounting to $36 per acre (based on a 15% yield loss on a yield of 40 bushels per acre for wheat priced at $6 per bushel). Other industry representatives indicated that the net savings resulting from midge tolerant wheat range from $20 to $70 per acre, depending on the extent of midge infestation. For the purposes of the cost benefit analysis, we have conservatively assumed the net savings, taking into account the increased seed cost of midge tolerant wheat varieties for the producer, to be approximately $20 per acre.

It was assumed that the acreage planted in midge tolerant wheat will remain at the current level of about 2 million acres over the next 15 years and that all midge resistant wheat has been planted on acres previously affected by midge infestation. Consequently, the annual savings resulting from midge tolerant wheat are estimated to be about $40 million per year. The assumption that the adoption rate of midge will remain at the current level of about 2 million acres or 17% of the total wheat acreage planted is based on the following: midge infestations have declined in recent years according to some individuals interviewed, and use of midge resistant wheat is expected to reduce the size of the wheat midge population over time; seeds for midge resistant wheat varieties are more expensive than some other wheat varieties; some farmers are employing other non-pesticide pest reduction practices such as ensuring there are sufficient predators (e.g. wasps and other biocontrol agents) to control midge populations; and some farmers will continue to use pesticides to deal with midge infestations. Another factor that may constrain the adoption rate of midge tolerant wheat is some farmers have recently become interested in planting wheat varieties that are resistant to fusarium head blight, a fungal disease of cereal crops that affects kernel development.

E. Cost Benefit Analysis

To undertake the cost benefit analysis, we have converted the streams of gross benefits and costs into present value using a discount rate. A discount rate of 2% has been employed as it is the average Bank of Canada rate for long-term real return bonds (i.e. exclusive of inflation) during the last 20 years, and the projected rate for the next 10 years.

Based on the discounted cash flow analysis, the total gross benefits (1997 net present value) of the midge tolerant wheat innovation are estimated to total $468 million. By subtracting the net present value of the costs of about $12.2 million to fund the midge tolerant wheat innovation, the net benefits (1997 net present value) of the midge tolerant wheat innovation are approximately $455.8 million. By dividing the net present value of the total gross benefits by the net present value of the total costs, the benefit cost ratio of the midge tolerant wheat innovation is approximately 37:1.

F. Other Benefits

Some of the other benefits achieved by midge tolerant wheat are as follows:

- Midge-tolerant wheat varieties eliminate the need to use insecticide as a control method. This results in reduced labour requirements because farmers do not have to spray for midge.

- Because it eliminates the need for spraying insecticide on the fields, midge-tolerant wheat also results in considerable environmental benefits to the soil and air. It is also safer for the farmer because the need for spraying chemical insecticide is eliminated, and safer for non-target insects which are not affected by midge resistant wheat as they would be by insecticides.

- Planting of midge-tolerant wheat has a free-rider effect because neighboring wheat fields that do not plant midge tolerant wheat are likely to benefit as well.

- Midge-tolerant wheat varieties offer flexibility in crop rotations and seeding dates.

Appendix 1: References Reviewed

Swath Grazing Innovation

- Vern Baron, Raquel Doce, John Basarab, and Cambell Dick, Swath Grazing Triticale and corn compared to barley and a traditional winter feeding method in central Alberta, Published on the web May 2014
- S.C. Sheppard, S. Bittman, G. Donohoe, D. Flaten, K.M. Wittenberg, J.A. Small, R. Berthiaume, T.A. McAllister, K.A. Beauchemin, J. McKinnon, B.C. Amiro, D. MacDonald, F. Mattos, and K.H. Ominski, Beef cattle husbandry practices across Ecoregions of Canada in 2011, Published on the web 4 February 2015
- Western Canadian Cow-Calf Survey, 2014 Western Canadian Cow-Calf Survey Aggregate Results, Western Beef Development Centre, June 2015
- Saskatchewan Forage Council, An Economic Assessment of Feed Costs within the Cow/Calf Sector, Western Canadian Feed Innovation Network, September 2011
- Farm Environmental Management Survey, Statistics Canada Catalogue no 21-023-X, 2011

Midge Resistant Wheat Innovation

- Midge Tolerant Wheat website www.midgetolerantwheat.ca/wheat/solution.aspx
- Five years of midge tolerance, website www.country-guide.ca/2015/04/23/five-years-of-midge-tolerance/46541/
- Ian L. Wise, Stephen Fox, Marjorie Smith, Cereal Research Centre and Norm Woodbeck, Canadian Grain Commission, An estimate of annual financial losses by producers caused by damage to hard red spring wheat by the wheat midge, *Sitodiplosis mosellana*, in western Canada,
- Michael Jackman, Case study for Midge Resistant Wheat, AAFC