Returns to Pulse Crop Research & Development and the Management of Intellectual Property Rights

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A Report Funded by the Saskatchewan Pulse Growers

Final Report

by

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Executive Summary

Saskatchewan Pulse Growers (SPG) was established in 1984. Since that time, this grower funded agency has been collecting a check-off from growers to support development of the pulse sector in Saskatchewan.

The pulse sector has grown very rapidly in the last twenty five years and has risen to a position where farm cash receipts from pulse crops consistently account for more than 10% per cent of all Saskatchewan farm cash receipts. More than 20,000 producers have grown pulse crops in the province in recent years. Saskatchewan pulse crop producers dominate Canadian pulse production and have gained prominence in the world markets for pulses. The sector has been a major source of new revenue for agricultural producers and new business opportunities for input suppliers and processors. The continual growth in global food demand and the growing imperative to reduce fossil fuel use suggests a bright future for the pulse sector and high rates of return to innovation.

Many factors have contributed to the growth of the pulse sector. A major engine of growth is the process of innovation, which includes basic research, applied research and the transfer of research outcomes into the marketplace. Along with other players, SPG has been heavily involved in the innovation process. Other players include private firms and public institutions who conduct pulse research and the private and public institutions that pay others to conduct research. The partnership effort that goes into achieving research results must not be overlooked, although the focus of this report is on the SPG activities that have gone into advancing pulse crop research and development.

Research Objectives

The objective of this research project is to build on the 2003 study to answer important questions pertinent to the SPG.

The analysis and the report are structured around three main questions:

1) Have investments and outputs over the past five years changed the rate of return and benefits to producers from SPG investments?
2) What are the likely rates of return to producers for recent investments in processing utilization?
3) Are historical rates of return to research sustainable in a world of increasing intellectual property right protection and what strategies can be employed by SPG to maintain freedom to operate and the ability for producers to capture returns from research discoveries?

The Returns to Breeding and Development Acceleration

The analysis in this report estimates the returns to research and development (R&D) from the levy funded research expenditure of Saskatchewan Pulse Growers (SPG) from 1984 to 2008. The returns are estimated by measuring the stream of costs and benefits for producers, consumers and value added sectors.

This study uses a standard Benefit Cost Analysis (BCA) methodology, the same as Gray and Scott used in 2003 to estimate SPG returns. The study is updated to 2008 to include more recent returns to SPG research. In the BCA actual and counterfactual scenarios are used to estimate the stream of benefits and costs corresponding to the "with" and "without" worlds of SPG expenditures committed to date. In an effort to provide conservative estimates, all committed research expenditures are considered as costs, whereas benefits only accrued to varieties and research outcomes that were produced by 2008. To include the reasonably anticipated benefits from recently developed varieties, R&D benefits are estimated for the 1984 to 2012 (short term) and for 1984 to 2024 (long term). In both of these scenarios future variety benefits are assumed to decline over time.

A summary of the estimated benefit/cost ratios and internal rate of return are presented in Table E.1. The outcomes of SPG research expenditures to 2008 will produce a stream of benefits to 2024 with net present value in excess of 1.6 billion dollars with producers, consumers and value added sectors each receiving about 1/3 of these benefits. Producers receive a net benefit of $682 million dollars.

As detailed in the report we estimate that producers earn an internal rate of return (IRR) of 39.0% for the short term and 39.5% for somewhat less conservative long term scenarios on SPG R&D expenditures. This excellent rate of return is far above market interest rates, and significantly higher than those measured in 2003.

The Benefit/Cost (B/C) ratios are also very high. As shown in Table 1, the producer B/C for the SPG research to date is 15.8 to 1 over the 1984 to 2012 period and 20.2 to 1 for the 1984 to 2024 period. *A 20 to 1 B/C rate means that SPG research investments have created $20 in benefits for every dollar invested by producers, even after accounting for the time value of money.*

These very high benefit cost ratios are not uniform across research categories. Investment in genetics research had a B/C ratio of 27.8 to 1 over the long run whereas Development Acceleration B/C was about 15.8 to 1. The somewhat lower return to the Development Acceleration perhaps suggests the industry in maturing.

To answer the question, "*Have investments and outputs over the past five years changed the rate of return and benefits to producers from SPG investments?*" we compare the 2008 return estimates to the 2003 estimates. As shown in Figure 1, where both the 2008 and 2003 estimates are side by side in 2008 dollars, it is evident that the producer surplus estimates are significantly higher in the 2008 study. This is even more evident when comparing the rate of return. Despite five years of additional investment, the *rate of return* to producers doubled from the 2003 study to 2008 study. This suggests that the SPG program has become more productive over time, which no doubt is due to the accumulation of knowledge and germplasm within the research organizations. The greater increase in the returns from breeding versus development acceleration activities, suggests that breeding should remain a priority for the organization.

Table 1: Summary of Benefit/Cost Ratios due to SPG Expenditures

	Genetics Research	**Development Acceleration**	***Total Impact***
Net Benefits Present Value to 2024 (million 2008 Dollars)[1]			
Producer Surplus	345.2	337.2	682.5
Consumer Surplus	218.9	311.0	529.8
Value Added Sectors	111.5	371.5	483.0
Time Period 1984 to 2024			
Producer Ben/Cost[2]	27.81	15.77	20.19
Producer IRR[3]	39.5%	40.4%	
Industry Ben/Cost[4]	26.91	23.29	24.61
Time Period 1984 to 2012			
Producer Ben/Cost[2]	15.50	16.01	15.82
Producer IRR[3]	39.0%	40.4%	
Industry Ben/Cost[4]	19.57	23.43	22.02

Notes:
[1]The benefits are calculated in proportion to the amount of total R&D expenditure SPG are contributing.
[2]The producer benefit cost ratio is calculated on the portion of the check-off cost borne by producers and the benefits accruing to producers.
[3]The internal rate of return is the return to the stream of benefits given the cost of generating the benefits.
[4]Industry benefit cost ratio is calculated on all SPG expenditures and all benefits accruing to producers and non producers.

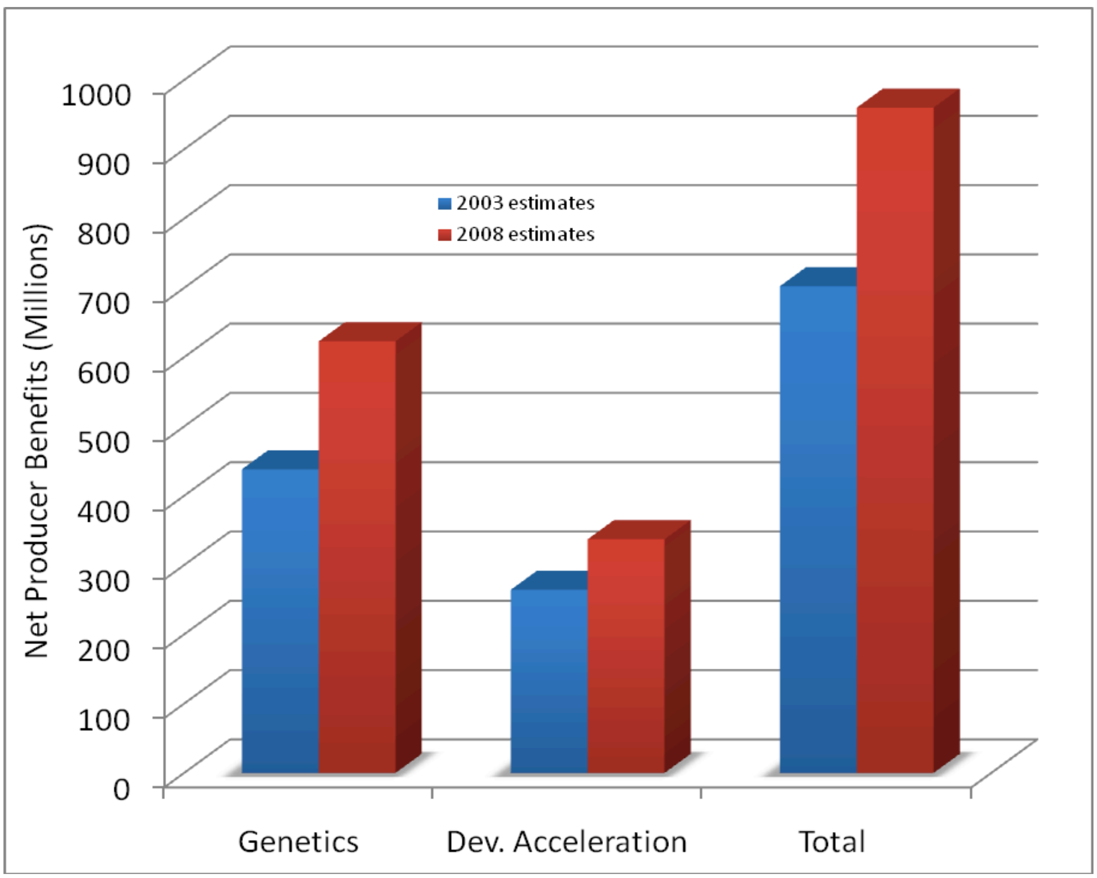

Figure 1: Comparison of 2003 Model Estimates with 2008 Model Estimates

The Grower Returns to Pulse Processing Research

The SPG has recently begun spending a significant portion of their research dollars in value added processing research. This research covers a wide range of products and processes, each designed to increase the value of processing output and thereby expand the market for pulses. Upon reviewing the data, it became clear that most of the processing research is so new it has not yet been commercialized. Given that benefits have not yet become evident, it is very difficult to approximate or make general statements about the rate of return to these research activities.

Given the lack of data, we were unable *to answer the question "*What are the likely rates of return to producers for recent investments in processing utilization?" Instead, we decided to build a spreadsheet model that can be used as a tool to make an *ex ante* assessment of the rate of return to processing research. The model combines the yearly cost of research with the yearly expected impact on processing demand with market parameters to approximate the returns from processing research projects. This tool not only allows the user to calculate expected returns, it helps the user to understand what parameters are important in generating the rate of return. Table 2 illustrates the quantities of processing required for various pulse crops to generate a given rate of return.

Table 2: The Volume of Incremental Pulse Demand Required to Various Producer Rates of Return on a $1,000,000 SPG Processing Research Investment[1]

Producer Internal Rate of Return	peas	lentils	chickpeas
	(000 t/yr required)		
5%	23	13	139
10%	40	23	236
20%	97	56.7	561
40%	370	224	2068

Source: The Rate of Return Calculator (see Section 3 for details)

[1] Assuming a six year delay between SPG research and the incremental demand and after 6 years the incremental demand decreases at 15% per year.

Intellectual Property Management

In an environment where the protection of intellectual property is becoming the norm for the private and public sectors there is a need to assess the SPG practices. In this study, we examined whether the current practices are creating value for producers, whether the SPG is able to form suitable partnerships with private industry and finally if there are emerging issues of non-cooperation and freedom to operate issues. To address these issues, we reviewed the current practices and used economics to analyze the incentives created by these practices. Personnel from private companies involved in research and development, private breeders and members of public research institutions were then interviewed to get their informed assessment of SPG policies and how the system was functioning.

The policies used for releasing varieties were consistent with maximizing returns to producers. The General Variety Release Program was very effective in getting new seed to producers in a competitive and timely fashion. The seed growers were also satisfied with this program.

The Tender Release Program, where small niche varieties and classes of pulses are licensed exclusively to a private company for development and marketing in return for royalties is a mechanism that provides the incentives necessary for the development of these markets. While one breeder indicated this program could potentially be a hindrance to three party research agreements, more open release program for these types of products would not attract the necessary investment for market development.

Other examples of very effective IPR management include the agreement with BASF for Clearfield technologies, and the international marketing of IPRs through private firms. The rights for international distribution of pulse varieties lie with SPG, however SPG turns these rights back to the CDC on a variety by variety basis. The CDC in turn has tendered the international distribution rights for each crop to private companies, which are the International Agents.

The investigation into knowledge sharing and freedom to operate revealed a very collegial relationship among pulse breeders. Similar to what Galushko (2008) found in wheat research, there is still a great deal of good will among breeders that facilitate the sharing of knowledge and germplasm. The research sector remains healthy from this perspective.

From the interviews and the review of the IPRs policies the SPG have been very effective in managing IPRs for the benefit of the growers. Many of their management policies can serve as examples for other sectors to follow.

The short answer to the question: “Are historical rates of return to research sustainable in a world of increasing intellectual property right protection and what strategies can be employed by SPG to maintain freedom to operate and the ability for producers to capture returns from research discoveries?”is yes. Given the excellent record of SPG IPR management, and the continuing cooperative atmosphere among researchers, the current system is operating very well and there are no foreseeable threats to continued high rates of return to research.

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1.0 Introduction

Saskatchewan Pulse Growers (SPG) was established in 1984. Since that time, this grower funded agency has been collecting a check-off from growers to support development of the pulse sector in Saskatchewan.

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Many factors have contributed to the growth of the pulse sector. A major engine of growth is the process of innovation, which includes basic research, applied research and the transfer of research outcomes into the marketplace. Along with other players, SPG has been heavily involved in the innovation process. Other players include private firms and public institutions who conduct pulse research and the private and public institutions that pay others to conduct research. The partnership effort that goes into achieving research results must not be overlooked, although the focus of this report is on the SPG activities that have gone into advancing pulse crop research and development.

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To answer these questions, the analysis and report is organized into three sections; Section 2 deals with benefit/cost analysis for crop research, Section 3 addresses the returns to processing research, and, section 4 deals with intellectual property management.

2.0 Estimating the Economic Benefits of Pulse Research and Development in Canada

Section 2.1 contains a background on the Pulse crop sector to 2008 as to seeded area, varietal adoption rates and R&D expenditures. Section 2.2 contains a brief description of the model used to estimate the returns to research and development. The results of the projected returns to pulse crop R&D using the new model over the 1984 to 2012 and 1984 to 2024 periods are presented in Section 2.3[1]. A summary and conclusion are in Section 2.4.

2.1 Background

2.1.1 Pulse Crop Production in Saskatchewan

The area seeded to pulse crops in Saskatchewan over the 1984 to 2007 period shows an increasing trend primarily due to increased lentils and field pea seeded area as shown in Figure 2. Area seeded to chickpea after the dramatic increase to 2001 and collapse to 2003 is showing steady growth as chickpeas become established as an option in crop rotations as agronomic and varietal improvements are made. The seeded acres for each class of pulse crop used in the model are from the Saskatchewan Specialty Crop Report (SCR) (Appendix A Tables A.1 to A.8). The areas for the specific class of lentil and chickpea for 1998 to 2004 used in the model were estimated using data from the SCR and Saskatchewan Plus Management.

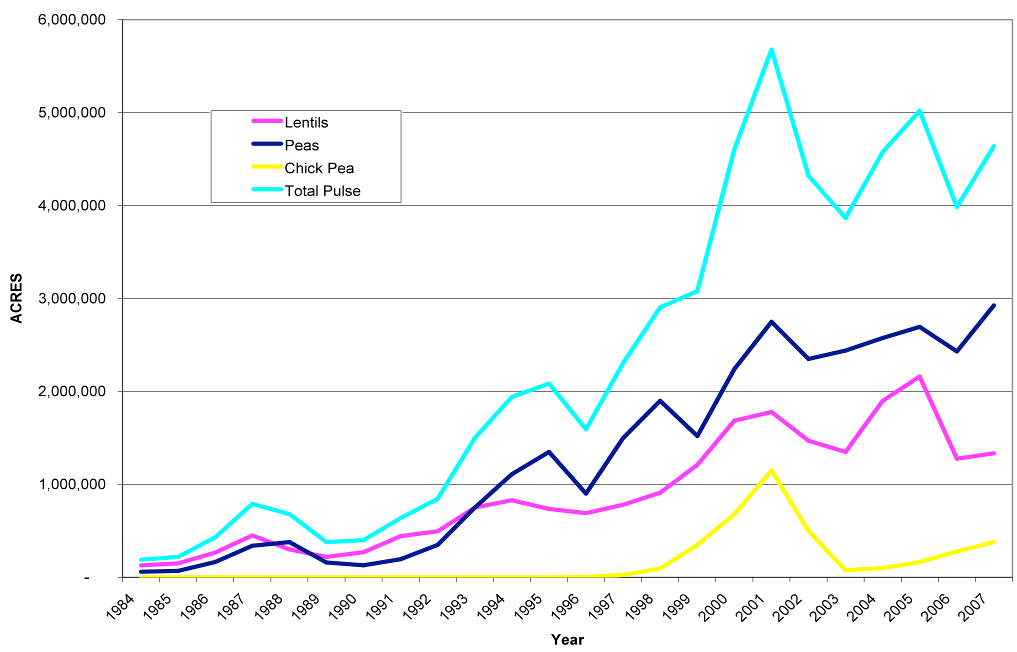

Figure 2: Area of Pulse Crops in Saskatchewan 1984 to 2007
Source: Specialty Crop Report, Saskatchewan Ministry of Agriculture various years.

[1] A comparison of the estimates projected for the 1984 to 2008 and 1984 to 2020 periods in the 2003 report to the estimates generated using the updated model are presented in Appendices E and F.

2.1.2 CDC Varietal Adoption

Saskatchewan Crop Insurance Management Plus data for the years 1998 to 2007 was used to estimate the adoption rates of CDC/SPG varieties. The Management Plus data provides a sample of the area seeded to pulse crops ranging from; 6.5% to 28.9% for peas; 11.7% to 30.8% for lentils; 17.5% to 59.0% for chickpea depending on the year. The rate of adoption of CDC varieties developed with SPG funding by crop varietal type is presented in Table 3.

Table 3: CDC/SPG Varietal Adoption Rates 1998 to 2007

Field Pea	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Yellow	0.0%	0.0%	0.0%	2.4%	8.8%	19.3%	28.3%	26.7%	26.7%	44.7%
Green	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	7.0%	11.6%	20.8%	29.6%
Maple	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.7%	16.6%	24.9%	34.6%
Lentil										
L. Green	0.0%	0.0%	2.9%	24.7%	53.1%	54.0%	62.5%	80.1%	89.8%	91.9%
M. Green	0.0%	0.0%	0.0%	26.1%	19.1%	8.5%	34.4%	36.8%	21.2%	36.1%
S. Green	0.0%	2.8%	47.2%	90.9%	83.6%	90.6%	87.6%	88.0%	92.3%	93.1%
Red	0.0%	0.0%	0.0%	0.0%	0.0%	14.1%	70.8%	93.6%	98.6%	99.3%
S. Red				100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chickpea										
L. Kabuli	0.0%	0.0%	0.7%	9.3%	41.2%	57.1%	64.2%	52.1%	64.5%	91.0%
S. Kabuli	0.0%	0.0%	4.5%	17.7%	44.1%	16.9%	13.6%	7.3%	16.6%	55.8%
Desi	2.5%	3.0%	12.4%	18.2%	33.6%	0.0%	0.0%	0.0%	4.6%	13.3%

Source: Authors' calculations from Saskatchewan Management Plus data, Saskatchewan Crop Insurance Corporation.

CDC/SPG varieties have a substantial market share in the Yellow, Green and Maple classes of Field Pea. The release of new varieties since 2003 has resulted in an increased share of the market especially for the Green and Maple classes. CDC/SPG lentil varieties dominate four of the five lentil classes. New varieties in the Large Green and Small Green classes have been able to cut into the dominant market shares once held by the industry standard varieties of Laird and Eston. Growth in the adoption rate of CDC/SPG Chickpea varieties in the Large Kabuli class has been steady. However, for the Small Kabuli and Desi classes the growth has been highly variable over this period. These data are also used in the estimation of the yield and fungicide impacts of genetic research and development due to CDC/SPG varieties. The data used in the model for the genetic improvement affect along with the estimates by class is presented in Appendix A Tables A.1 to A.8. Lentils and Chickpea are by varietal class while field pea is for the entire sector.

2.1.3 Pulse Sector Expenditures on Pulse Research and Development

The average and total amount spent on pulse crop research by agency is presented in Table 4. There has been a shift starting in the 2000-02 period to greater amounts of funding of pulse crop research by SPG. In the most recent period 2003-08, SPG was the major source of funds for pulse crop research at 86.4% of the total spent by the three organizations. The increase in the levy combined with the expansion of seeded area has resulted in substantially greater funds for SPG to allocate to R&D. The present value of the annual expenditures on pulse crop research by funding agency is used to calculate the share of the research funded. Over the 1984 to 2008 period SPG has funded 55.4% of the research. This is up from the 37% used in the 2003 model.

Table 4: Average Annual Expenditures on Pulse Crop Research by Period

Years	ADF/AFIF[1]	SPG[2]	WGRF[3]	Total
1984-89	529	73	148	750
1990-94	648	144	95	887
1995-99	1,556	450	124	2,130
2000-02	1,455	1,148	124	2,727
2003-08	386	2,924	74	3,384
Total (84-08)	20,346	24,322	2,651	47,320
Years	**ADF/AFIF[1]**	**SPG[2]**	**WGRF[3]**	**Total**
1984-89	70.5%	9.7%	19.7%	100%
1990-94	73.1%	16.2%	10.7%	100%
1995-99	73.1%	21.1%	5.8%	100%
2000-02	53.4%	42.1%	4.5%	100%
2003-08	11.4%	86.4%	2.2%	100%
PV 84-08[4]	41.2%	55.4%	3.4%	100%

Source: Authors' estimates from SPG project files, WGRF Endowment Fund projects and Gray and Scott, 2003.
[1]ADF/AFIF - Agricultural Development Fund/ Agri-Food Innovation Fund
[2]Saskatchewan Pulse Growers Research and Development expenditure.
[3]Western Grain Research Foundation.
[4]Share of the total present value of the stream of expenditures by funding agency.

The allocation of funds for projects by type of R&D which SPG are involved with over the 2003 to 2013 period is presented in Table 5 (a detailed account is given in Appendix C Table C.2). Development of new varieties and improved disease resistance through genetic improvement captures 72% of the SPG R&D budget. The amounts for varietal improvement (Breeding) include the amount of field pea research for the Pea Genetic Improvement Program for 2006 and 2007 for Agriculture Canada, CDC and Private Industry. In total SPG provides 62% of the total research funds, while Agriculture Canada (9%), NSERC (7%) and ADF/AFIF (6%) provide most of the public monies for the projects. Universities and Agriculture Canada are the primary suppliers of Agronomy R&D.

Table 5: SPG Projects Allocation of Funds by Institution 2003 to 2013

Institution	Agronomy	Breeding[7]	Processing
Sask Pulse Growers	12%	72%	17%
Agriculture Canada	39%	50%	11%
Pulse Canada	26%		74%
CDC[1]	7%	92%	
U of S	62%	21%	17%
Other Universities	100%		
Research Groups	100%		
Other Research Ins	10%		90%
ADF/AFIF[2]	16%	71%	13%
NSERC[3]	11%	85%	4%
CSGA[4]	100%		
APGA[5]	100%		
CARDS[6]			100%
Other Public & Private	26%	43%	31%

Source: Authors' estimates from SPG project files.
[1]CDC- Crop Development Centre.
[2]ADF/AFIF Agriculture Development Fund/ Agri-Food Innovation Fund.
[3]NSERC - Natural Sciences and Engineering Research Council.
[4]CSGA- Canadian Seed Growers Association.
[5]APGA - Alberta Pulse Growers Association.
[6]CARDS- Canadian Adaptation and Rural Development.
[7] Breeding amounts include the investment in R&D as reported for the Pea Genetic Improvement Program 2006 and 2007, Agriculture Canada $1,000,000; CDC $1,878,600 and Private Industry $889,982.

The allocation of SPG funds for R&D by area (Agronomy, Breeding, Processing) is presented in Table 6. Several research projects had multiple crops as subjects of the research, especially those related to processing. Funds were divided evenly between the crops even though the benefits of the research are unlikely to accrue on an even basis.

Table 6: SPG Allocation of Funds by Crop Type and Purpose 2003 to 2013

Crop	Agronomy	Breeding	Processing
Bean	1.3%	12.6%	9.0%
Lentil	31.9%	20.0%	34.4%
Pea	23.0%	32.7%	35.3%
Chickpea	26.4%	17.7%	8.2%
Fababean		9.1%	1.5%
General	17.5%	7.9%	11.7%
Total	**100%**	**100%**	**100%**

Source: Authors' calculations from SPG Project Reports.

The amount of funds administered by producer controlled institutions in western Canada over the 2003 to 2013 time period directly affecting the pulse crop sector is presented in Table 7. Since, most of the pulse crops grown in western Canada are in Saskatchewan, it is not surprising that most of the funding is derived in that province.

Table 7: Producer Controlled Funds or Check-off used for Pulse Sector R&D

Institution	2003 - 2013	%
Alberta Pulse Growers	1,165,151	4.5%
Manitoba Pulse Growers	1,232,002	4.8%
Western Grain Research Foundation	447,230	1.7%
Saskatchewan Pulse Growers	23,005,590	89.0%
Total	**25,849,973**	**100%**

Source: Financial Statements of the Institutions.

2.2 Model Description

This report uses the model developed by Gray and Scott, 2003 to estimate the economic impacts due to the SPG activities in advancing pulse crop research and development (for a detailed description of the model see Appendix D). The model measures the economic costs and benefits as changes in consumer and producer surplus along with the changes in the value added sector.

Producer surplus is the difference between the gross revenue from pulse crop production and the marginal costs required to produce the crops. The marginal cost for each unit of production is equal to the supply curve for the industry in a competitive industry. The model estimates a linear supply curve for peas, lentils and chickpea for each year of the analysis (1984 to 2024). The annual variable costs are estimated from the supply curve and are then subtracted from the gross revenue to arrive at the producer surplus.

Consumer surplus is the difference between the price consumers are willing to pay for pulse crops and the actual price paid at the farm level. A linear demand curve is used in estimating the consumer surplus for each year of the analysis. The consumer surplus is calculated as the difference in the price that consumers were willing to pay and the price actually paid for each unit sold. The consumer benefit estimated in the model is the sum of the benefits gained by the final user (whether domestic or foreign) and the intermediaries in the pulse industry.

The economic impact of the value added sectors include those activities in Saskatchewan that are directly related to pulse crop production in Saskatchewan. Estimates of the value added industries of inoculant production, agriculture machinery manufacture, pulse crop processing and the hog industry are produced in the model. The increased pulse production due to SPG activity results in increased benefits for these value-added industries.

The returns to research are estimated firstly by calculating the 'factual' (what exists) from past and future costs and benefits due to SPG activities. The second step calculates the 'counterfactual' as what would have happened or will happen without SPG activities. In attributing the benefits due to SPG activity the model uses a proportionality rule, calculated as 'X' per cent of the research resources supplied by SPG, then 'X' per cent of the benefits of the research is attributed to SPG.

To compare the costs and benefits over time the model adjusts the values to 2008 dollars by accounting for inflation and then adjusts for the time value of money using a 5% real discount rate. Future prices and production are set as a rolling 5-year average for 2008 onward. The model scenarios used in this analysis are the long term (1984 to 2024) and short term (1984 to 2012). The model gives the estimates of the SPG impact as 1) genetic improvement due to varietal improvement in yield and disease resistance; 2) general development affect due to research in non-genetic disease management, fertilizers and inoculants, weeds and insects, feed use and product quality, machinery and facilities, and general agronomy. The benefit cost ratio is calculated as the present value of the stream of benefits divided by the present value of the cost stream. The internal rate of return is the discount rate that equates the benefits to the costs in present value terms.

2.3 Results

The time periods for the estimation of the returns to R&D were extended by four years from those used in the 2003 model. The model was updated with actual data for the 2003 to 2007 and 2008 where available. The long term scenario is from 1984 to 2024 which is best at capturing the full affect of the SPG research expenditures on the return to the pulse crop sector. The short term scenario is from 1984 to 2012 which captures the near term affects of the present research.

2.3.1 Benefit/Cost Analysis for Genetic Improvement Research

Yield and disease genetic improvements for peas, lentils and chickpea are estimated at $622.9 million present value over the1984 to 2024 period. Since SPG contributed 55% of the genetic research cost to develop the varieties, the producer surplus attributed to SPG is $345.2 million. Given that $12.41 million of the research costs were borne by producers, the benefit cost ratio is estimated to be 27.8 to 1.0. Over the 1984 to 2024 period a grower can expect to receive $27.81 for every $1.00 invested in R&D. An estimated internal rate of return of 39.5% is generated over the 1984 to 2024 period for the investments in genetic research.

Over the 1984 to 2012 period, the producer surplus attributed to SPG is estimated at $192.4 million, resulting in a benefit cost ratio of 21.0 to 1.0. The estimated internal rate of return over the short term is 39.0%.

A summary of the results of the estimated returns to pulse crop research over the 1984 to 2024 and 1984 to 2012 time periods are presented in Tables 8 and 9, respectively. The entire results are presented in Appendix C Table C.3. The yearly producer surplus generated by the SPG (Factual) and without SPG investment (no genetic development) is presented in Figure 3. The benefits of the SPG investment in genetic research clearly start to show in 2004 and continue to accrue after the investments have stopped. The rate of adoption of CDC/SPG varieties and longevity of the varieties is the underlying driving force behind the amount of producer surplus that can be generated from investment in genetic research.

Table 8: Pulse Crop Research Present Value Benefits Costs ($ million) 1984-2024

	Genetics Research	Development Acceleration	Total Impact
Benefits:	**Net Present Value (million $)**		
Producer Surplus	345.2	337.2	682.5
Consumer Surplus	218.9	311.0	529.8
Value Added Sectors	111.5	371.5	483.0
Costs:	**Net Present Value (million $)**		
SPG Expenditure	25.10	43.77	68.88
Cost Borne by Producers	12.41	21.38	33.79
Benefit/Cost Ratio:	**$ Return/ $ Invested**		
Producer Ben/Cost	27.81	15.77	20.19
Producer IRR	39.5%	40.4%	
Industry Ben/Cost	26.91	23.29	24.61

Table 9: Pulse Crop Research Present Value Benefits Costs ($ million) 1984-2012

	Genetics Research	Development Acceleration	Total Impact
Benefits:	**Net Present Value (million $)**		
Producer Surplus	192.4	342.4	534.8
Consumer Surplus	199.3	311.0	510.4
Value Added Sectors	99.5	372.3	471.8
Costs:	**Net Present Value (million $)**		
SPG Expenditure	25.10	43.77	68.88
Cost Borne by Producers	12.41	21.38	33.79
Benefit/Cost Ratio:	**$ Return/ $ Invested**		
Producer Ben/Cost	15.50	16.01	15.82
Producer IRR	39.0%	40.4%	
Industry Ben/Cost	19.57	23.43	22.02

Figure 3: Producer Surplus 1984 to 2024

2.3.2 Benefit/Cost Analysis for General Improvement Research

Accelerated development enables producers to capture the returns to research and development sooner than would be the case without investment. The estimate of this effect on producer surplus over the 1984 to 2024 period is $337.2 million. The benefit cost ratio is estimated at 15.7 to 1.0, given the $21.3 million present value cost of the research investment. Due to the estimate of production after 2008 being a 5 year rolling average, accelerated growth has limited impact on the producers' surplus for the 1984-2012 scenario. As a result, producer surplus and the benefit/cost ratio are similar at $342.4 and 16.0 to 1, respectively.

2.3.3 Total Benefit/Cost Analysis for Growers

The benefits obtained through genetic research and development acceleration are combined to get the total benefit and cost of SPG R&D. The combined present value of producers' surplus is $682.5 million over the 1984 to 2024 period. The present value of the total cost of the R&D borne by producers is $33.79 million resulting in a benefit/cost ratio 20.1 to 1. Over the 1984 to 2012 period, producers' surplus is $534.8 million from the $33.79 million investment cost, resulting in a benefit cost ratio of 15.8 to 1. The affect of development acceleration is depicted in Figure 4.

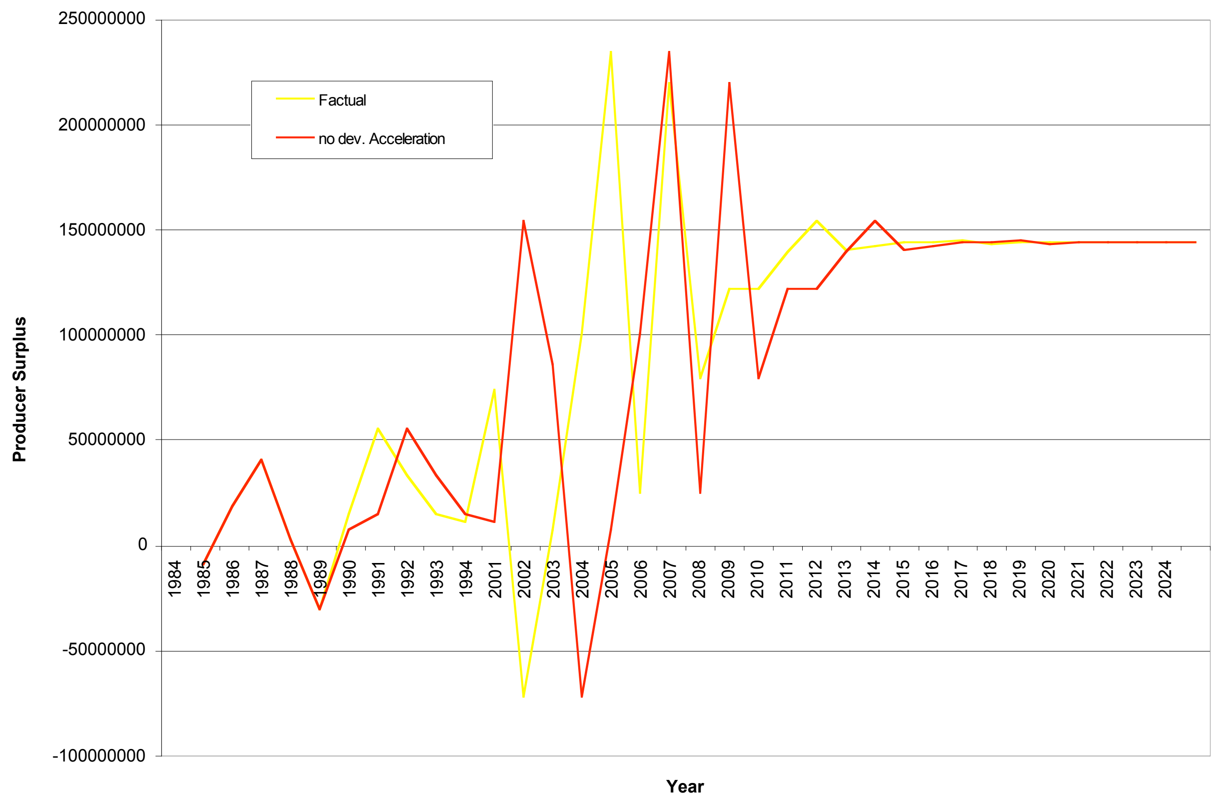

Figure 4: Development Acceleration Affect on Producer Surplus

2.3.4 Value Added Impacts of Crop Research

Processing activity due to increased pulse production as a result of SPG R&D investment is estimated to be $442.3 million and $429.5 million over the 1984 to 2024 and 1984 to 2012 periods, respectively.

The value added due to the SPG affect on pulse crop production in the Saskatchewan farm implement manufacturing industry is estimated at $28.0 million additional sales in the 1984 to 2024 period and $29.9 million for the 1984-2012 scenario.

Inoculant sales due to the extra activity in the pulse crop sector as a result of SGP activity in Saskatchewan is estimated to generate $10.6 million and $10.2 million over the 1984 to 2024 and 1984 to 2012 periods, respectively.

Increased pulse crop use in feed rations in Saskatchewan due to the accelerated development by SPG is estimated to have increased the producer surplus by $2.1 million in both the 1984 to 2024 and 1984 to 2012 periods.

2.4 Results Summary and Conclusions

High rates of return to pulse crop research and development due to SPG expenditure have been verified by the results of the analysis done for this report. The high rates of adoption of varieties developed by the CDC through SPG funding are the underlying driving forces for the high rates of return to genetic research. Development of varieties that meet both producer needs for a variety and the needs of the end use consumer are important in attaining high rates of adoption.

Although the amount of SPG expenditure on R&D increased substantially over the 2003 period the return to research was higher than what was predicted in the 2003 report. The producer benefit/cost ratio for genetics research and the internal rate of return were significantly higher. A high internal rate of return (IRR) of 39.0% and 39.5% are estimated for the short and long term scenarios due to SPG R&D investments, respectively. For every dollar that the producer has invested or committed to invest in pulse crop R&D over the 1984 to 2012 period, the benefit stream accruing to the producer is $15.82 in producer surplus. Over the long term, $20.19 will be returned in producer surplus for every dollar invested in pulse crop R&D. Investment in genetics research returned $27.81 and $15.5 for every dollar spent by producers over the long and short run, respectively.

Although SPG expenditure has doubled, the return to genetics research is estimated at 5 times those obtained in the 2003 model estimates up to 2008 and increases to 8 times greater through 2024. The returns to the industry through value added activities is higher in the 2008 model estimates for both the 2008 and 2024 periods relative to the 2003 model estimates. Development acceleration is higher than for the 2003 estimates; however the 2024 estimate is 97% of the 2008 estimate. In total even though SPG expenditure increased by 47%, the return was 52% higher for the 2008 model estimates and projected to be 74% higher for the full impact to 2024. It seems that even with the doubling of SPG expenditure, the point of diminishing returns to research in the pulse sector has not been reached.

3.0 Estimating the Benefits of Value Added Research

3.1. Recent Process and Utilization Research

While SPG has a long history of investing in research for genetic improvement, crop disease, and general agronomy, it has only been since 1998 that money has been invested in processing and utilization research. Between 1998 and 2002, the majority of research projects in this area included work in the feed market, with specific focus on feed pea utilization in hog rations. SPG also supported research of pulses in the food market with projects such as the cooking quality of lentils, the evaluation of the laxative value of pea fibre and the use of Near Infrared Reflectance Spectroscopy (NIRS) to predict the canning quality of pulses. These research projects laid the foundation for the current research being supported by SPG in the food and feed sectors.

In 2002, a research and development strategy was outlined by SPG, where investment into value added pulse projects was included as the focal point of the strategy. Between 2002 and 2004 there was a very modest increase in research funding available for processing and utilization. It was not until 2005, that there was a considerable increase in the amount of money invested in this area of research.

Significant investment, over half a million dollars, began in 2005, when a call for value added projects for pulses (with the exception of beans) was sent out from SPG in June 2005. The funding made available for value added projects was in excess of $1 million over three years with some projects receiving matching contributions from organizations such as Agriculture and Agri-Food Canada (AAFC), and the University of Saskatchewan. This dramatic increase in funding for processing and utilization research supported that mandate set out by SPG in 2002, and initiated work on twelve new projects in this area. Projects include research in utilization in both the food and feed sectors and in processing technology.

In the food sector, research is currently being conducted on pulses as functional foods and as ingredients in food products. Research at the University of Saskatchewan includes the use of pulses as an extender in meat products and measuring the impact lentil consumption has on the energy level of soccer players. At the University of Toronto, pulse flours are being incorporated into trial diets of pre-diabetics to measure the effect the low glycemic index associated with pulse flours has on the test group. SPG is also funding work by Wendy Dahl at the University of Florida on the creation of a pulse puree for care patients who cannot swallow. Previous work by Dahl included a study that incorporated pea hulls in muffins for increased fibre in care homes for the elderly. This research into the utilization of pulses in food products has the potential to introduce pulses into new markets.

Pulses have been found to be beneficial ingredients in feed for animals. Previous studies have done significant work on pea-canola ration mixes for the hog industry and on the development of a system of rapid identification and evaluation of superior feed peas. SPG has also assisted in research to improve rumen by-pass value of pea protein, to establish optimum inclusion rates for peas in feed pelleting and to assess peas as a feed source for aquaculture. These projects have all been beneficial to find alternative markets for pulses that are feed quality due to adverse growing conditions. The current research project in the feed sector involves the inclusion of peas in poultry rations to reduce the use of antibiotics in the feed.

SPG is supporting work done by AAFC that has a specific focus on extraction processes and component uses in peas, chickpeas and lentils. While it is known that certain components of pulses, such as pea hulls, have health benefits when included as an ingredient in foods, there must be uses found for the remaining parts of the pea, such as the starch, in order for the fractionation of pulses to be economically feasible.

An additional consideration with component use is the extraction method of the component. The extraction method of these components can influence the way the component behaves and its potential usefulness. SPG supports research projects that focus on extraction methods for components such as protein and amylase. Research on extraction methods and component use will increase the probability that feasible, sustainable uses for pulses will be discovered and increase the demand for pulses in the long term.

The expanded investment in processing and utilization research is consistent with the SPG strategy to increase the value added activity surrounding pulses. The ultimate purpose for investing in processing and utilization is to increase demand for pulses and increase returns to producers. With investment in this area being relatively new to SPG research projects, actual returns to producers are not able to be calculated at this point. For the purposes of this project, a general theoretical model was developed that outlines the effect of an increase in demand from the introduction of innovations.

3.2 A Framework for Estimating Rate of Returns (Rate of Return Calculator)

Pulse Growers in Canada have recognized that pulse processing research can expand the market for pulses by creating new profitable uses for derived products. The SPG have made considerable investments in processing research. A key decision factor is the rate of return to research. In all cases research programs should have the expectation of yielding a rate of return higher than what producers can earn in the market place. When research dollars are limited they should be allocated to those activities that have the highest rate of return.

In section 2.0 of this report we estimated the return to SPG crop research, based on 25 years of investment and research outcomes. Unfortunately, most pulse processing research has taken place since 2003, as such it is still too early to observe the outcomes of this research. This lack of "*ex post*" (after the fact) data mean that investment decisions have to be made on "*ex ante*" (before the fact) knowledge and using informed expectations about research outcomes.

The *ex ante* analysis requires expectations about the costs of the research project, the probable expected outcomes of the project including the impacts on producer surplus. Two of the elements for the ex ante analysis are likely to exist at the time of the research proposal. The science experts have developed a budget for the project and can speak to possible outcomes in terms of new products and potential volumes of new processing demand.

To more easily calculate how much an anticipated increase in demand from processing research will benefit producers, a benefit/cost calculator was developed using a simple economic model. This spreadsheet model is provided to SPG as part of this project. The economic model is designed to estimate the impact that the additional demand will have on pulse prices, and translate this price increase into benefits for producers. By comparing these benefits over time to the SPG expenditures, the calculator is able to estimate the expected benefit cost ratio and the internal rate of return for a research project.

At the core of the calculations is the global market demand resulting from the processing research. As illustrated in Figure 5, the discovery of innovations such as health benefits associated with pulses, or a new processing technique, will increase the world demand for pulses and shift the demand curve from D_T to D_T'. The extent of the demand shift will depend on the innovation. In response to the shift in the demand curve, the price will increase, as will the quantity of product produced. The amount of the changes in price and quantity are dependent on the elasticity of supply and demand.

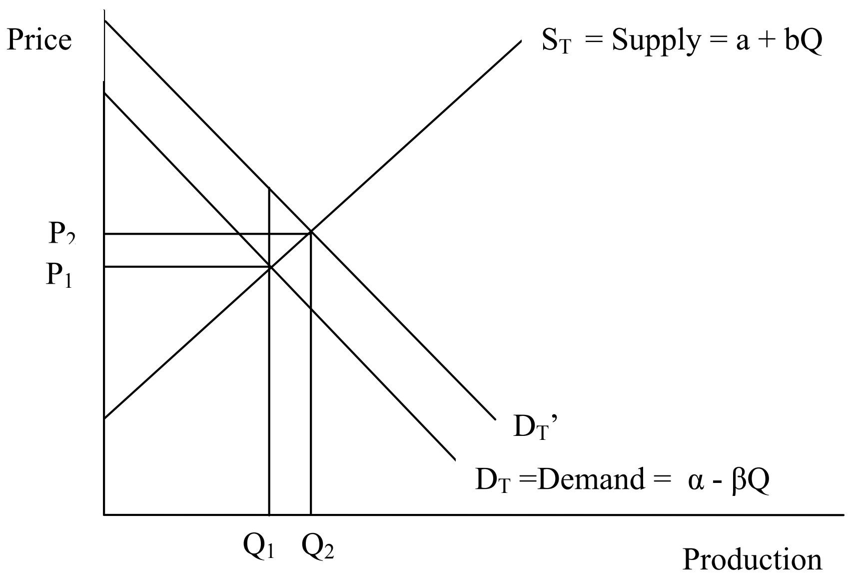

Figure 5: Theoretical Model for Supply and Demand of Pulses with Introduction of Processing and Utilization Innovation

The impact on prices can be closely approximated knowing the size of the global market, the extent of the increase in the demand, the elasticity (slope) of global supply and the elasticity (slope) of the global demand. As can be seen in Figure 5, an increase in the quantity demanded shifts the demand curve to the right, which in turn increases the market price. This increase in market price in turn increases producer income. The size of the price increase will depend on how much demand is increased and the slope of the supply and demand curves. The flatter the supply and demand curve the smaller the price impact will be from a given increase in the demand. [2]

The increase in Saskatchewan producer income from an increase in price is a straightforward calculation and approximately equal to the price increase multiplied by the Saskatchewan

[2] Mathematically the price impact can be calculated by the following formula: $\frac{\Delta P}{P} = \frac{1}{\varepsilon_S - \varepsilon_D}\frac{\Delta Q}{Q_G}$,

where $\frac{\Delta P}{P}$, is the proportional change in price, ε_S is the global elasticity of supply, ε_D is the global elasticity of demand, and $\frac{\Delta Q}{Q_G}$ is the change in quantity demanded divided by the Global quantity demanded.

production levels of the crop. Given the expected demand increases, the slope of the global supply and demand curves, and the quantity produced in Saskatchewan, the model is able to estimate the producer benefits in each year.

The cost of the research projects are needed to calculate net present value and rate of return. The costs should represent the additional costs that SPG incur to have the research done. Given that it is levy-funded research, some of the levy costs are borne by the buyers of pulses and some is borne by sellers. As described by Alston and others, the proportion of the levy cost born by the SPG can be calculated as a function of the global elasticities of supply and demand, and the SPG share of global production.[3]

The Cost-Benefit Estimator is embedded within a spreadsheet. The user of the calculator must provide estimates of the research project costs in each year, and their estimates of the foreseeable additional market quantity of demand that will be generated as result of the research into the future. The worksheet contains projections, Saskatchewan production levels, global production levels, and elasticities of supply and demand, for lentils, peas and chickpeas. Once the crop is selected these figures are combined with the inputted information about a specific project, to approximate the net present value of the project for SPG producers. A second worksheet takes this same information and estimates the Internal Rate of Return for the research project.

The output of the model is intended to be a rough estimate of the rate of returns for individual projects, and allows the user to do a number of “what if” scenarios. For example, “What if the impact begins in five years rather than three years; how does this affect the rate of return? What if the probability of success falls to 50%; are the net benefits positive?” As a tool, the calculator should assist the SPG in funding decisions.

Table 10 illustrates the incremental quantities of utilization required for various pulse crops to generate a given rate of return. For the sake of illustration it is assumed that the one million dollar investment in research, results in an annual increase in utilization that occurs six years later. The level of utilization is maintained for six more years and then decreases by 15%per year after that, as new technologies replace the old.

[3] More specifically, $L\sigma_{SPG} = \dfrac{(1 - \dfrac{Q_{SPG}}{Q_G})\varepsilon_S + \varepsilon_D}{\varepsilon_S + \varepsilon_D}$.

Table 10: The Volume of Incremental Pulse Demand Required to Various Producer Rates of Return on a $1,000,000 SPG Processing Research Investment[1]

Producer Internal Rate of Return	peas	lentils	chickpeas
	(000 t/yr required)		
5%	23	13	139
10%	40	23	236
20%	97	56.7	561
40%	370	224	2068

Source: The Rate of Return Calculator
[1] The reported figures are calculated assuming a six year delay between SPG research and the incremental demand and after 6 years the incremental demand decreases at 15% per year.

As shown in Table 10, a million dollar investment pulse processing and utilization research has resulted in considerable incremental demand for pulse in order to yield a high rate of return to producers. For instance, 20% rate of return, which is below the return for breeding activities, would require about 97,000 tonnes of additional pea demand per year commencing six years after the research investment was made. The slightly lower figure for lentils reflects the more inelastic demand for lentils, and the far larger figure for chickpeas, reflects a smaller Saskatchewan production base that could benefit from a price increase.

Finally, a word of caution; the calculator is only as good as the numbers that are inputted into it. The user should be fully familiar with the underlying structure of the model, and must take care in the projections used in the analysis. A careful analysis should also show how changes in estimated demand will impact the cost benefit results.

4.0 Intellectual Property Management in the Saskatchewan Pulse Breeding Industry

4.1 Introduction

Over the last decades the world crop research industry in general and the Canadian one in particular, has undergone significant transformations. The developments have not been uniform across different crops, however. Breeding research in some crops such as wheat, barley and pulses historically was and is still predominantly in the public domain, while some breeding industries such as canola, cotton and soybeans have witnessed a dramatic shift from publicly to privately financed R&D with the private sector currently playing a dominant role in breeding research. A shift to privately financed R&D has been paralleled by the development of stronger intellectual property rights regime for plants. IPRs, as a mechanism to promote innovation, are important where the private sector is concerned; however, there is no doubt that a propensity of the private sector researchers to protect genetic materials is also spilling over to the public sector.

According to the growing literature, there are a number of negative effects associated with stronger IPRs. IPRs provide a temporary monopoly power, which allows the seed developer to charge a higher price for the innovated seed. Therefore, IPRs make new technologies more expensive and can slow down the adoption process. IPRs can also impede public research or change its nature in a number of ways. First, the prospect of financial gains may increase the unwillingness of researchers to share information and research materials with one another. Sharing may become extremely limited at early stages of the research process before patents or plant breeders' rights are secured, thereby delaying breakthroughs in the industry and impeding the realization of research efficiencies and complementarities (Walsch et al 2005). Second, access restrictions on enabling technologies can increase the cost of conducting research in public institutions. In some cases, accessing all pieces of IP may become prohibitively costly, thereby shutting public researchers from potentially promising areas of research. Third, cumulative nature of plant breeding contributes to a lot of overlap between current research and intellectual property already created in the industry. In a world of overlapping and interwoven claims to intellectual property the freedom to operate, or in other words, the ability of the developer to commercialize his technology without infringing valid intellectual property rights of others, is becoming a pressing issue (Phillips and Onwuekwe 2007).

For the above reasons, the effectiveness of IPRs as a mechanism to foster innovations and speed up their adoption is being questioned and a careful assessment of the IP arrangements is needed. The purpose of this part of the report is to review IPRs practices in the Saskatchewan pulse breeding industry and evaluate their impact on adoption of new varieties and research environment.

4.2 Survey outline: Data collection

Personal/telephone interviews were arranged with two pulse breeders from the CDC, one bean breeder from AAFC in Lethbridge and two industry participants involved in distribution of niche varieties. Interviews with breeders followed a semi-structured set of questions and the breeders were welcome to discuss the current Variety Release Program and impact of IPRs on their research.

To draw a comparison between the pulse breeding industry and other breeding industries in Canada such as canola and wheat, the above interviews are complemented with interviews with canola and wheat breeders conducted in January – March 2007[4].

4.3 Intellectual Property Rights and Commercialization of New Pulse Varieties in Saskatchewan

One of the first legislation in Canada to regulate the distribution of seeds was the Seeds Act (1923). Although the primary objective of the Seeds Act was to prevent seed salesmen from selling bad varieties (Kuyek 2004), the sections pertaining to the use of a variety name should be considered an attempt to protect plant varieties. More specifically, the Seeds Act prohibits a sale of seed "under a grade name or designation so closely resembling an established grade name" (Seeds Act, 2(a)-(b)). Thus, while the farmers could save the seed for replanting purposes and exchange harvested seed with their neighbours (a practice referred to as brown-bagging), they could not advertise or sell it using the variety name.

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[4] For a detailed discussion of the interview process for canola and wheat breeders see Galushko (2008) and Oikonomou (2008).

The Seeds Act, however, did not prohibit the sale of seed as "common grade" or "unclean", thus making brown-bagging a legal practice. Therefore, under the Act the seed developer did not have exclusive rights for distribution and marketing of the variety and this had a potential to undermine research efforts in the Canadian breeding industry and, in particular, where the private investment was concerned. To reduce the inefficiencies associated with lack of IPRs in the breeding industry, in 1990 Canada passed Plant Breeders' Rights (PBRs) legislation. Any plant breeder can claim PBRs on his/her varieties and the holder of a PBR is granted exclusive rights to multiply, distribute and market the protected varieties.

The Canadian PBRs Act is based on the 1978 revisions to the UPOV convention and is different from the most recent revision in that it does not extend coverage to "essentially derived varieties and harvested materials". The PBRs Act contains two exemptions – the research exemption and the farmer exemption. The former allows the use of the protected material for breeding or research purposes without the permission from the owner of the protected material. The latter allows farmers to use the harvested material for reproduction purposes on their own land. The farmers are not allowed to sell or give the seed to other farmers by variety name and under the current PBRs Act brown-bagging is considered an infringement. When new crop varieties are conventionally bred and protected only by PBRs, the enforcement of IPRs becomes an issue because of the difficulties associated with identifying the seed and proving infringement in the court. In some sectors such as wheat, for example, saving the harvested seed and illegally selling it to other farmers is a growing practice. In the Midsouthern US, for example, 35-50% of all wheat acres are sown with seed gotten illegally (Leonard 2002).

The incentives to buy the seed from neighbours rather than use the certified seed are especially strong when the seed companies charge royalties on their varieties. When royalties are too high, production of seed on the farm may be cheaper than buying the certified seed and in this case sharing of seed among farmers may become a preferred practice. Seed saving practice and brown-bagging, in its turn, may pose a significant threat to future development of the breeding industry, particularly in crops where public support is declining, because brown-bagging reduces the ability of seed developers to appropriate the rents and collect royalties on their seed, thus discouraging the participation of the private sector in breeding research. It is therefore important to design the system in which brown-bagging will have a minimal negative impact on research incentives. The pulse breeding industry in Western Canada is a success story in this respect and in the following we provide a discussion of how the pulse commercialization model employed in Saskatchewan eliminates any need for PBRs and, therefore, avoids dealing with the issues pertaining to enforcement of PBRs, and at the same time ensures a continued inflow of funds into pulse breeding research.

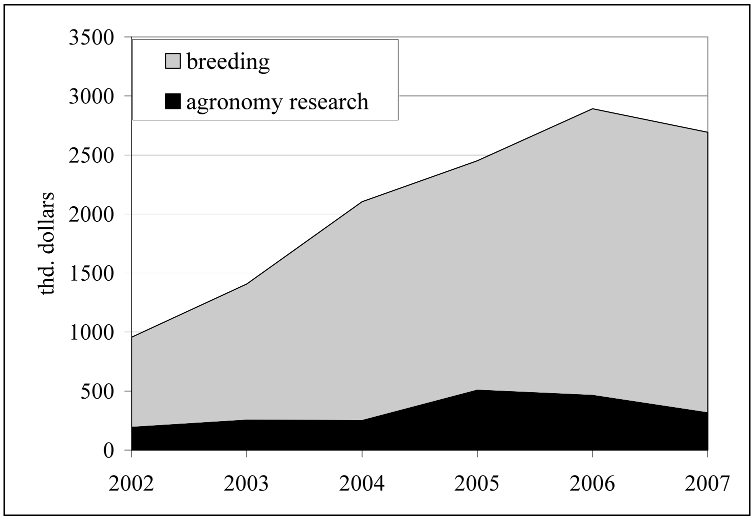
There are a number of instruments the Saskatchewan Pulse Growers (SPG) use to release new pulse varieties and ensure their quick adoption. These include the Variety Release Program (VRP) and Tender Release Program (TR). There are also special arrangements for international distribution, CLEARFIELD lentils agreement with BASF and the Pea Genetic Improvement Program – they all play an important role for development and adoption of new varieties in Saskatchewan. In the following sections we discuss each of these arrangements and assess IPR management practices in the pulse breeding industry in terms of incentives to innovate, information/ knowledge flows and freedom to operate. Personal interviews with pulse breeders and industry participants serve as a basis for assessment of the performance of the current IP system in pulse breeding and the interview process is briefly described in the next section.

4.3.1 IPRs and the General Variety Release Program

Inventions in plant breeding are unique and different from other inventions because most plants have the ability to reproduce themselves and carry the bred-in traits from year to year. Therefore, pedigreed seed can be purchased only once and then the harvested seed can be replanted, thus yielding benefits to the farmer over a number of years. Self-reproducing nature of plants and the possibility of acquiring seed at a lower cost through self-production or from neighbours creates incentives for farmers to engage in brown-bagging.

When brown-bagging is common the abilities of the seed developer to collect royalties on seed sales to recoup R&D expenditures are undermined and this discourages involvement in crop breeding research and this effect is particularly strong where private companies are involved. Even when varieties are protected by PBRs and brown-bagging has no legal status, PBRs legislation *per se* does not protect from it because of enforcement issues. In pulse breeding, for example, it would be hard to enforce PBRs and prevent sharing of seed among farmers because the farmer saved seed and the "pedigreed" seed are not distinguishable unless the farmer advertises that he has seed of variety *x* for sale. Therefore, PBRs do not guarantee royalty revenues for seed developers as they are not self-enforceable and alternative mechanisms have to be developed to allow breeders and, private breeders in particular, to recoup R&D expenditures and encourage involvement in research. In the canola sector, for example, PBRs have been successfully complemented by Technical Use Agreements that forbid seed saving by farmers. The SPG Variety Release Program that is described next, is another success story, showing that PBRs and their enforcement are not a requirement for pulse breeding.

Under the VRP pulse varieties are released to Select seed growers, who multiply the Breeder seed through the Pedigreed seed system. Seed is released with no royalty requirements. In Saskatchewan a 1% compulsory check-off is collected on all commercial sales at the first point of sale and is reinvested in pulse breeding research. The advantage of this system is that, while it never tried to prevent brown-bagging and, in fact, brown-bagging of pulse varieties is common and allowed, it eliminates the negative impact of seed saving on pulse breeding research because revenues no longer depend on royalties from seed sales but rather come from the1% check-off (however the 1% check-off is not applicable to Pedigreed seed sales). This ensures a continued flow of funds into pulse breeding for Saskatchewan (see Figure 6)



Source: Compiled from the SPG annual reports

Figure 6: SPG Funding of Agronomy and Breeding Research in 2002-2007

It should be mentioned that all lentil, pea and chickpea varieties released through the VRP are also released to Alberta Select seed growers in return for financial support to the CDC breeding program from the Alberta Pulse Growers. Since the check-off in Alberta is refundable, SPG's policy is to provide Breeder seed of new pulse varieties only to those growers who have paid the check-off and haven't requested a refund. This does not prevent growers who have requested a refund from purchasing Pedigreed seed of new varieties in years following the sale of Breeder seed. It only prevents Select seed growers who have requested a refund from purchasing Breeder seed from the VRP. Therefore, if a select seed grower wants to replace his variety with a new one and has requested a check-off refund, he/she will have to wait for a year or two before the Pedigreed seed becomes available. Growers (seed or commercial) don't have to replace their varieties every time a new one is released. Many growers plant the same variety (whether it is Pedigreed seed or brown-bagged) for several years before replacing their seed stocks with a newer variety.

The above discussion suggests that the SPG Variety Release Program helps overcome a lot of issues associated with PBRs. In fact, it completely eliminates the need for PBRs for domestic release. As was indicated by the pulse breeders from the CDC, "the SPG Variety Release Program is really quite a unique relationship – it is not really a model followed elsewhere in the world" and "the SK system is the most effective and the simplest one. The focus is on the growers. In other places, for example, they are seeking for protection of their varieties with PBRs. But if you look back at it, it is a very small crop – you don't get a lot in terms of royalties". Therefore, the current commercialization model ensures more efficient allocation of time for research because it saves the time that would be spent on applications for PBRs. In the wheat sector, for example, the seed companies that commercialize new varieties require the breeders to obtain PBRs and the interviews with the wheat breeders in Western Canada revealed that paperwork associated with PBRs represent a significant cost in terms of time that is not compensated by extra benefits that PBRs yield in the form of increased royalties (Galushko 2007).

4.3.2 Tender Release Program

Niche varieties/market classes are those pulse varieties/market classes with some or all of the following characteristics: varieties which are not broadly adapted to Saskatchewan; have limited demand (therefore price is very sensitive to supply); are unique or highly differentiated; represent a new market class, new product or new market; have identity preservation requirements. First, it is obvious that if niche varieties/market classes were released under the Variety Release Program then no individual company would have an incentive to develop the market because other companies would free ride and sell their varieties on that market, thus leading to rent erosion for the market developer. The tender release program has been put in place to create incentives for private firms to develop markets for certain niche varieties/market classes through granting of exclusive rights for distribution and sale of these varieties/market classes. This system, therefore, protects the market developer from competition from other companies/exporters.

In the past, tenders were awarded on a variety by variety basis. However, there were a number of inefficiencies associated with this. For example, the markets were developed for a specific class of pulses and if the private company won a tender for a specific variety only, then next year another company could come and win the exclusive distribution rights for the next variety in that same market class. In the end, the two companies would have to share the market, which would reduce profits and incentives to engage in niche market development.

Recently, the tender release program was transformed into one where the entire market class is tendered to a particular private company for a specified length of time (7-10 years). Tendering the whole market class rather than a single variety is much more efficient and as was stressed by the industry participants "[the class based tender release system] combined with selection of the right partner in the niche market can actually turn it into a larger scale market".

It is still too early to assess the performance of the niche variety distribution system, however, as the interviews suggest "the system works fine". One industry participant indicated that, given one has to spend at least four years on commercialization, extending the time frame from 10 to 15 years would be a desired change.

While the tender release system guarantees the development of niche pulse varieties in Saskatchewan through a transfer of a portion of royalties from niche variety marketers to the CDC, the interviews with pulse breeders identified a potential hindrance to commercialization of new technologies associated with the current set up. The current scenario suggests that if any of the breeders at the CDC were approached by the third party who wanted to work with the CDC in variety development, the CDC would have to seek a formal approval from SPG to work with that firm. Even though that company funds the particular research it is interested in, there will have to be a three-party agreement: the firm – the CDC – the SPG. As was indicated by one breeder, "this would add a layer of complexity to get any arrangement with the third party that we might want to get involved in". So, the current system could either slow down or stop some new potential activities. One example was brought forward by the CDC breeder where it took a long time to have things straight and get the approval from the CDC, which delayed the research for about 2 years. This delay cannot be solely attributed to SPG taking time to grant permission because the involvement of University of Saskatchewan lawyers contributed significantly to a delay, however, the time it took to obtain the approval from SPG also played a role.

The bean commercialization model in Alberta is in some respects similar to the niche variety release program and helps avoid a lot of IPRs infringement issues. It works as a closed loop system. The AAFC and Viterra[5] sign a five-year Collaborative Research and Development agreement according to which Viterra funds research at the AAFC and in return it gets the first right of refusal. Alberta pulse producers and Viterra work like a co-op with the seed production being performed on a contractual basis so that all the harvested seed has to be sold through Viterra. Viterra controls about 95% of bean production in Alberta. Therefore, under this set-up, while possible, brown-bagging is not a viable option because the farmers using illegal seed would not be able to sell their harvest to Viterra and looking for alternative marketing channels could be a significant additional cost to farmers.

4.3.3 International Distribution of Pulse Varieties

The rights for international distribution of pulse varieties lies with SPG, however SPG turns these rights back to the CDC on a variety by variety basis. The CDC in turn has tendered the international distribution rights for each crop to private companies, the International Agents. The International Agents perform the trials for the new varieties abroad, investigate the market in other countries and apply for PBRs if necessary. For example, for chickpea varieties developed at the CDC Canterra – a seed company - is the International Agent. Canterra has trials in Australia, New Zealand and the US for any new chickpea varieties for which SPG has turned back the rights to the CDC. Canterra also takes care of IPRs internationally and undertakes measures to enforce these rights.

In order to give the Saskatchewan pulse growers an opportunity to enjoy the benefits of the newly released varieties and have a comparative advantage on the global pulse market, SPG requires a one year lag between releasing the varieties in Saskatchewan and Alberta, and offering them for international distribution.

The major advantage of this system is that it allows for the extraction of rents from foreign users of pulse varieties developed at the CDC. Prior to 2005, new varieties were released through SPG with no method of preventing cross border (Canada-US) seed sales. As a result, foreign growers, especially in the US, where growing conditions are the most favourable for growing pulse varieties bred for Saskatchewan, were active users of the CDC research effort but did not contribute to research funding as the Saskatchewan growers did through compulsory check-off. To make the rules of the game fair and to force the foreign growers to contribute to breeding research at the CDC, the pulse varieties are now distributed internationally through the International Agents, who collect royalties on seed sales and return some portion to the CDC breeding program. Distribution rights for varieties released since the inception of the Variety Release Program in 1997 have been retroactively awarded to the International Agents. As was

[5] Viterra is a private company that controls 95% of bean acres in Alberta

indicated by the breeder from the CDC, "some of the varieties are really good in the US, so sometimes we get decent royalties – $80,000 or even $100,000 dollars".

4.3.4 CLEARFIELD Lentil Agreement with BASF

When new varieties are developed by the private sector, each private company has an incentive to protect its technologies, including germplasm. IP protection gives a temporary monopoly power on the market and allows the company to charge a high price for its technology. In some sectors such as canola, for example, large private companies do not only control the end variety but have a complete ownership of germplasm used to develop that variety. As a result, all superior germplasm is concentrated in the hands of the private sector with no comparable technologies available to farmers at a reasonable cost.

A special arrangement is employed by SPG to avoid a situation described above and the SPG agreement with BASF is an illustrative example. CLEARFIELD (CL) lentils were developed as a result of collaboration among BASF, the CDC and SPG. CL lentils are distributed, royalty-free, through the Variety Release Program. The only requirement is that the grower of CL lentils must sign a CL commitment each year he/she intends to plant CL lentils. CL lentil varieties are created through a back-cross breeding program, run in conjunction with the lentil breeding program at the CDC. The CL trait is incorporated into the most promising varieties, creating a two-three year time lag between the release of a new lentil variety and the release of a comparable variety with the CL trait. The current arrangement ensures that Saskatchewan pulse growers have access to superior technologies at reasonable prices.

4.3.5 Distribution of Pea Varieties Owned by Private Companies

Saskatchewan emerged as a world leader in pea production in the early 1990s, largely on the strength of pea varieties developed in Europe (Steve 2005). However, European companies shifted their research efforts away from the Saskatchewan pulse industry because of inabilities to compete with SPG given that SPG was releasing CDC varieties on a royalty-free basis. Acknowledging the importance of research efforts for sustainable long-term development of the industry, SPG established the Pea Genetic Improvement Program (PGIP), designed to provide a return on research investment to other breeding institutions developing pea varieties for Saskatchewan. As part of the program, SPG provides a research contribution to other breeding institutions in accordance with their share of Saskatchewan Pedigreed and commercial pea acreage.

4.4 IPRs and Research Environment in the Breeding Industry

As intellectual property rights proliferate worldwide, the Canadian research industry is facing new constraints and questions. Stronger IPRs accompanied by increased involvement of the private sector in breeding may transform the research environment in the breeding industry. On the one hand, private profit oriented breeding companies may have an incentive to restrict access to their technologies since this would give them an advantage on the market for new varieties. On the other hand, a propensity to patent/protect by the private sector may spill over to the public sector as public researchers are encouraged to enclose their knowledge in order to use it as a bargaining chip with others.

The canola sector is an illustrative example of how IPRs are able to transform the culture of free sharing and flow of information and genetic material. When the canola research started, research was conducted solely by public institutions and the research atmosphere was characterized by free movement of ideas and genetic resources among researchers. Things have changed dramatically over the last decade as the private sector became predominant in the canola breeding industry. As Figure 7 illustrates the general perception among the canola breeders is that secrecy has increased over the last 5-10 years and this is supported by such statements as "Everybody knows what everyone else is doing but nobody talks about it. Secrecy has increased to ridiculous levels" (Oikonomou 2007).

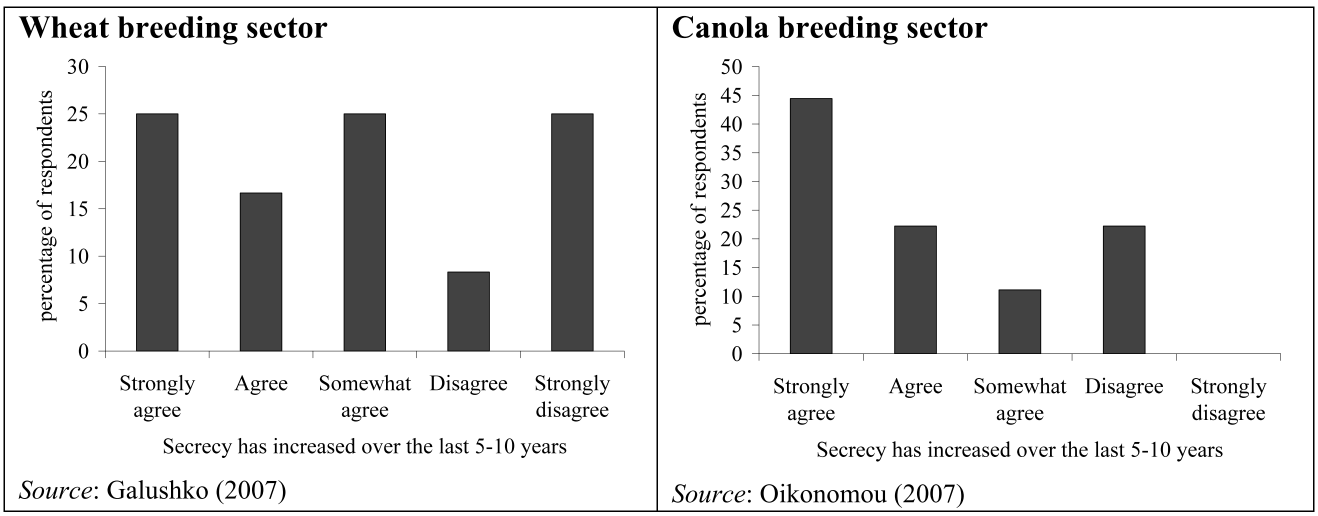


Figure 7: Secrecy in the Wheat and Canola Breeding Sectors

The wheat sector also seems to be moving towards increased secrecy with two-thirds of respondents [wheat breeders] believing that the research environment has become more secretive. Although it has been by a number of breeders that the public nature of research in wheat breeding contributes to information disclosure: "at least in the wheat breeding world the majority of players are public institutions so there is no such degree of secrecy as with other crops" (Galushko 2007).

Even though pulse production has significantly expanded in Canada over the last decade, pulses are still a relatively minor crop on the global scale with the world area under pulse crops accounting for about 5% of the total world area under field crops[6]. Therefore, seeds of pulse crops cannot bring enormous value to their developers. This, combined with the state of available breeding technologies, has not attracted much interest on the part of the private industry. Currently, the global pulse breeding industry is predominated by public institutions. Chickpea breeding on a global scale, for example, is conducted only by public institutions or

[6] This can be contrasted to wheat that encompasses about 16% of the world arable land.

universities. While there are a number of small private breeding companies in beans and peas in Canada, Western Europe and Australia, their share in breeding is small relative to the share of public institutions. The structure of research funding and the driving forces behind *public* research have repercussions on the IP arrangements in the pulse breeding industry.

Public nature of breeding contributes to a very open environment in the pulse industry. With so few pulse breeders on a global scale and the predominance of public institutions, IPRs on research inputs haven't gained prominence in the pulse industry with information/germplasm flows being quite fluid. This is supported by the following quotes from the pulse breeders in Western Canada: "I don't see much secrecy in the pulse breeding industry. We are sharing all the time. To be honest with you, private companies are really good at sharing. There are private bean breeding programs in Ontario primarily and they have been very generous. Every time I wanted to use their lines for research purposes they said yes[7]" and "As breeders we are very open. That's how we make progress[8]".

[7] Personal communication with the bean breeder from AAFC, Lethbridge
[8] Personal communication with the chickpea breeder at the CDC, Saskatoon

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Appendix A: Genetic Impacts by Crop and Varietal Type

Table A.1 Genetic Impacts on Yield and Fungicide Costs - Field Peas

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Cost/ applied ac[5]	% Use	Fungicide Savings/ seeded ac	Total Acres[6]
1998	1.00	1.00	0.0%	0.00%	$4.60	10%	$0.46	1900
1999	1.00	1.00	0.0%	0.00%	$4.60	10%	$0.46	1520
2000	1.08	1.00	0.0%	0.00%	$4.60	10%	$0.46	2240
2001	1.08	1.00	1.9%	0.15%	$4.80	10%	$0.48	2550
2002	1.08	1.00	6.4%	0.51%	$4.90	10%	$0.49	2350
2003	1.08	1.00	15.3%	1.22%	$5.00	10%	$0.50	2440
2004	1.08	1.00	22.7%	1.81%	$5.00	10%	$0.50	2575
2005	1.10	0.90	22.2%	2.00%	$5.00	10%	$0.50	2695
2006	1.16	1.00	25.2%	4.04%	$5.00	10%	$0.50	2431
2007	1.18	1.00	41.9%	7.54%	$5.00	10%	$0.50	2925
2008	1.18	1.00	41.9%	7.54%	$5.00	10%	$0.50	2613
2009	1.18	1.00	41.9%	7.54%	$5.00	10%	$0.50	2648
2010	1.18	0.90	41.9%	6.78%	$5.00	10%	$0.50	2662
2011	1.18	0.80	41.9%	6.03%	$5.00	10%	$0.45	2656
2012	1.18	0.70	41.9%	5.28%	$5.00	10%	$0.40	2701
2013	1.18	0.60	41.9%	4.52%	$5.00	10%	$0.35	2656
2014	1.18	0.50	41.9%	3.77%	$5.00	10%	$0.30	2665
2015	1.18	0.40	41.9%	3.01%	$5.00	10%	$0.25	2668
2016	1.18	0.30	41.9%	2.26%	$5.00	10%	$0.20	2669
2017	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.15	2672
2018	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2666
2019	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668
2020	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668
2021	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668
2022	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668
2023	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668
2024	1.18	0.20	41.9%	1.51%	$5.00	10%	$0.10	2668

Source: Author's calculations from various sources
1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 3 years then declines at 10% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Fungicide costs for peas are for the control of Powdery mildew plus the application cost, Guide to Crop Protection and the Custom and Rental Rate Guide, Saskatchewan Ministry of Agriculture various years.
6. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.2 Genetic Impacts on Yield and Fungicide Costs –Large Green Lentils

	CDC	Variety	Variety	CDC	Fungicide		Fungicide	
	Yield	Depreciation	Adoption	Yield	Cost/	%	Savings/	Total
Year	Index[1]	Index[2]	Share[3]	Impact[4]	applied ac[5]	Use	seeded ac	Acres[6]
1998	1.00	1.00	0.0%	0.00%	$18.00	45%	$8.10	600
1999	1.10	1.00	0.0%	0.00%	$18.00	45%	$8.10	635
2000	1.10	1.00	2.9%	0.29%	$18.50	45%	$8.33	850
2001	1.11	1.00	24.7%	2.72%	$19.00	45%	$8.55	750
2002	1.12	1.00	53.1%	6.38%	$19.50	45%	$8.78	710
2003	1.12	1.00	54.0%	6.47%	$20.00	45%	$9.00	730
2004	1.14	0.95	62.5%	8.32%	$20.00	45%	$8.55	1150
2005	1.16	0.95	80.1%	12.18%	$20.00	45%	$8.55	1320
2006	1.24	1.00	89.8%	21.56%	$20.00	45%	$9.00	535
2007	1.24	1.00	91.9%	22.05%	$20.00	45%	$9.00	560
2008	1.24	1.00	91.9%	22.05%	$20.00	45%	$9.00	859
2009	1.24	1.00	91.9%	22.05%	$20.00	45%	$9.00	891
2010	1.24	1.00	91.9%	22.05%	$20.00	45%	$9.00	833
2011	1.24	0.95	91.9%	20.95%	$20.00	45%	$8.55	736
2012	1.24	0.90	91.9%	19.85%	$20.00	45%	$8.10	776
2013	1.24	0.85	91.9%	18.74%	$20.00	45%	$7.65	776
2014	1.24	0.80	91.9%	17.64%	$20.00	45%	$7.20	802
2015	1.24	0.75	91.9%	16.54%	$20.00	45%	$6.75	785
2016	1.24	0.70	91.9%	15.44%	$20.00	45%	$6.30	775
2017	1.24	0.65	91.9%	14.33%	$20.00	45%	$5.85	783
2018	1.24	0.60	91.9%	13.23%	$20.00	45%	$5.40	784
2019	1.24	0.55	91.9%	12.13%	$20.00	45%	$4.95	786
2020	1.24	0.50	91.9%	11.03%	$20.00	45%	$4.50	782
2021	1.24	0.45	91.9%	9.92%	$20.00	45%	$4.05	782
2022	1.24	0.40	91.9%	8.82%	$20.00	45%	$3.60	783
2023	1.24	0.35	91.9%	7.72%	$20.00	45%	$3.15	784
2024	1.24	0.30	91.9%	6.62%	$20.00	45%	$2.70	783

Source: Author's calculations from various sources
1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Fungicide costs for lentils are for the control of Anthracnose plus the application cost, Guide to Crop Protection and the Custom and Rental Rate Guide, Saskatchewan Ministry of Agriculture various years.
6. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.3 Genetic Impacts on Yield and Fungicide Costs –Small Green Lentils

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Cost/ applied ac[5]	% Use	Fungicide Savings/ seeded ac	Total Acres[6]
1998	1.14	1.00	0.0%	0.00%	$18.00	45%	$8.10	100
1999	1.14	1.00	2.8%	0.40%	$18.00	45%	$8.10	175
2000	1.14	1.00	47.2%	6.61%	$18.50	45%	$8.33	310
2001	1.14	1.00	90.9%	12.73%	$19.00	45%	$8.55	280
2002	1.14	1.00	83.6%	11.71%	$19.50	45%	$8.78	150
2003	1.14	1.00	90.6%	12.68%	$20.00	45%	$9.00	150
2004	1.17	1.00	87.6%	14.89%	$20.00	45%	$9.00	360
2005	1.18	1.00	88.0%	15.84%	$20.00	45%	$9.00	330
2006	1.19	1.00	92.3%	17.53%	$20.00	45%	$9.00	244
2007	1.21	1.00	93.1%	19.56%	$20.00	45%	$9.00	255
2008	1.21	1.00	93.1%	19.56%	$20.00	45%	$9.00	268
2009	1.21	0.95	93.1%	18.58%	$20.00	45%	$8.55	291
2010	1.21	0.90	93.1%	17.60%	$20.00	45%	$8.10	278
2011	1.21	0.85	93.1%	16.63%	$20.00	45%	$7.65	267
2012	1.21	0.80	93.1%	15.65%	$20.00	45%	$7.20	272
2013	1.21	0.75	93.1%	14.67%	$20.00	45%	$6.75	275
2014	1.21	0.70	93.1%	13.69%	$20.00	45%	$6.30	277
2015	1.21	0.65	93.1%	12.71%	$20.00	45%	$5.85	274
2016	1.21	0.60	93.1%	11.74%	$20.00	45%	$5.40	273
2017	1.21	0.55	93.1%	10.76%	$20.00	45%	$4.95	274
2018	1.21	0.50	93.1%	9.78%	$20.00	45%	$4.50	274
2019	1.21	0.45	93.1%	8.80%	$20.00	45%	$4.05	274
2020	1.21	0.40	93.1%	7.82%	$20.00	45%	$3.60	274
2021	1.21	0.35	93.1%	6.85%	$20.00	45%	$3.15	274
2022	1.21	0.30	93.1%	5.87%	$20.00	45%	$2.70	274
2023	1.21	0.25	93.1%	4.89%	$20.00	45%	$2.25	274
2024	1.21	0.20	93.1%	3.91%	$20.00	45%	$1.80	274

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Fungicide costs for lentils are for the control of Anthracnose plus the application cost, Guide to Crop Protection and the Custom and Rental Rate Guide, Saskatchewan Ministry of Agriculture various years.
6. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.4 Genetic Impacts on Yield and Fungicide Costs –Medium Green Lentils

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Cost/ applied ac[5]	% Use	Fungicide Savings/ seeded ac	Total Acres[6]
1998	1.00	1.00	0.0%	0.00%	$18.50	45%	$8.33	10.0
1999	1.00	1.00	0.0%	0.00%	$18.50	45%	$8.33	20.0
2000	1.01	1.00	0.0%	0.00%	$18.50	45%	$8.33	25.0
2001	1.01	1.00	26.1%	0.26%	$19.00	45%	$8.55	75.0
2002	1.01	1.00	19.1%	0.19%	$19.50	45%	$8.78	152.5
2003	1.01	1.00	8.5%	0.09%	$20.00	45%	$9.00	117.5
2004	1.01	1.00	34.4%	0.34%	$20.00	45%	$9.00	97.5
2005	1.07	1.00	36.8%	2.58%	$20.00	45%	$9.00	130.0
2006	1.07	1.00	21.2%	1.49%	$20.00	45%	$9.00	48.0
2007	1.07	1.00	36.1%	2.53%	$20.00	45%	$9.00	50.0
2008	1.07	1.00	36.1%	2.53%	$20.00	45%	$9.00	88.6
2009	1.07	1.00	36.1%	2.53%	$20.00	45%	$9.00	82.8
2010	1.07	1.00	36.1%	2.53%	$20.00	45%	$9.00	79.9
2011	1.07	1.00	36.1%	2.53%	$20.00	45%	$9.00	69.9
2012	1.07	0.95	36.1%	2.40%	$20.00	45%	$8.55	74.2
2013	1.07	0.90	36.1%	2.27%	$20.00	45%	$8.10	79.1
2014	1.07	0.85	36.1%	2.15%	$20.00	45%	$7.65	77.2
2015	1.07	0.80	36.1%	2.02%	$20.00	45%	$7.20	76.0
2016	1.07	0.75	36.1%	1.90%	$20.00	45%	$6.75	75.3
2017	1.07	0.70	36.1%	1.77%	$20.00	45%	$6.30	76.4
2018	1.07	0.65	36.1%	1.64%	$20.00	45%	$5.85	76.8
2019	1.07	0.60	36.1%	1.52%	$20.00	45%	$5.40	76.3
2020	1.07	0.55	36.1%	1.39%	$20.00	45%	$4.95	76.2
2021	1.07	0.50	36.1%	1.26%	$20.00	45%	$4.50	76.2
2022	1.07	0.45	36.1%	1.14%	$20.00	45%	$4.05	76.4
2023	1.07	0.40	36.1%	1.01%	$20.00	45%	$3.60	76.4
2024	1.07	0.35	36.1%	0.88%	$20.00	45%	$3.15	76.3

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Fungicide costs for lentils are for the control of Anthracnose plus the application cost, Guide to Crop Protection and the Custom and Rental Rate Guide, Saskatchewan Ministry of Agriculture various years.
6. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture and the Management Plus data from Saskatchewan Crop Insurance for 1998 to 2003. Total Seeded Acres are calculated from 2008 onward as the rolling 5 year average.

Table A.5 Genetic Impacts on Yield and Fungicide Costs –Red Lentils

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Cost/ applied ac[5]	% Use	Fungicide Savings/ seeded ac	Total Acres[6]
1998	1.00	1.00	0.0%	0.00%	$19.00	55%	$10.45	190
1999	1.00	1.00	0.0%	0.00%	$19.00	55%	$10.45	380
2000	1.00	1.00	0.0%	0.00%	$19.00	55%	$10.45	475
2001	1.13	1.00	11.8%	1.54%	$19.00	55%	$10.45	675
2002	1.13	1.00	71.9%	9.35%	$19.50	55%	$10.73	458
2003	1.13	1.00	63.6%	8.27%	$20.00	55%	$11.00	353
2004	1.16	1.00	80.2%	12.83%	$20.00	55%	$11.00	293
2005	1.16	1.00	95.1%	15.22%	$20.00	55%	$11.00	380
2006	1.16	1.00	98.8%	15.80%	$20.00	55%	$11.00	449
2007	1.20	1.00	99.3%	19.87%	$20.00	55%	$11.00	470
2008	1.20	1.00	99.3%	19.87%	$20.00	55%	$11.00	389
2009	1.20	1.00	99.3%	19.87%	$20.00	55%	$11.00	396
2010	1.20	1.00	99.3%	19.87%	$20.00	55%	$11.00	417
2011	1.20	0.95	99.3%	18.87%	$20.00	55%	$10.45	424
2012	1.20	0.90	99.3%	17.88%	$20.00	55%	$9.90	419
2013	1.20	0.85	99.3%	16.89%	$20.00	55%	$9.35	409
2014	1.20	0.80	99.3%	15.89%	$20.00	55%	$8.80	413
2015	1.20	0.75	99.3%	14.90%	$20.00	55%	$8.25	416
2016	1.20	0.70	99.3%	13.91%	$20.00	55%	$7.70	416
2017	1.20	0.65	99.3%	12.91%	$20.00	55%	$7.15	415
2018	1.20	0.60	99.3%	11.92%	$20.00	55%	$6.60	414
2019	1.20	0.55	99.3%	10.93%	$20.00	55%	$6.05	415
2020	1.20	0.50	99.3%	9.93%	$20.00	55%	$5.50	415
2021	1.20	0.45	99.3%	8.94%	$20.00	55%	$4.95	415
2022	1.20	0.40	99.3%	7.95%	$20.00	55%	$4.40	415
2023	1.20	0.35	99.3%	6.95%	$20.00	55%	$3.85	415
2024	1.20	0.30	99.3%	5.96%	$20.00	55%	$3.30	415

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Fungicide costs for lentils are for the control of Anthracnose plus the application cost, Guide to Crop Protection and the Custom and Rental Rate Guide, Saskatchewan Ministry of Agriculture various years.
6. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture and the Management Plus data from Saskatchewan Crop Insurance for 1998 to 2003. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.6 Genetic Impacts on Yield and Fungicide Costs – Large Kabuli Chickpea

	CDC	Variety	Variety	CDC	Fungicide	
	Index[1]	Index[2]	Share[3]	Impact[4]	seeded ac	Acres[5]
Year	**Index**	**Index**	**Share**	**Impact**	**seeded ac**	**Acres**
1998	1.00	1.00	0.0%	0.00%	$0.00	153.1
1999	1.20	1.00	0.0%	0.00%	$0.00	44.3
2000	1.20	1.00	0.7%	0.14%	$0.00	307.0
2001	1.20	1.00	9.3%	1.87%	$0.00	558.2
2002	1.20	1.00	41.2%	8.24%	$0.00	226.8
2003	1.20	1.00	57.1%	11.42%	$0.00	34.3
2004	1.20	1.00	64.2%	12.84%	$0.00	51.8
2005	1.25	1.00	52.1%	13.02%	$0.00	110.0
2006	1.30	1.00	64.5%	19.36%	$0.00	168.0
2007	1.57	1.00	91.0%	51.90%	$0.00	230.0
2008	1.57	1.00	91.0%	51.90%	$0.00	118.8
2009	1.57	1.00	91.0%	51.90%	$0.00	135.7
2010	1.57	1.00	91.0%	51.90%	$0.00	152.5
2011	1.57	1.00	91.0%	51.90%	$0.00	161.0
2012	1.57	0.95	91.0%	49.30%	$0.00	159.6
2013	1.57	0.90	91.0%	46.71%	$0.00	145.5
2014	1.57	0.85	91.0%	44.11%	$0.00	150.9
2015	1.57	0.80	91.0%	41.52%	$0.00	153.9
2016	1.57	0.75	91.0%	38.92%	$0.00	154.2
2017	1.57	0.70	91.0%	36.33%	$0.00	152.8
2018	1.57	0.65	91.0%	33.73%	$0.00	151.5
2019	1.57	0.60	91.0%	31.14%	$0.00	152.7
2020	1.57	0.55	91.0%	28.54%	$0.00	153.0
2021	1.57	0.50	91.0%	25.95%	$0.00	152.8
2022	1.57	0.45	91.0%	23.35%	$0.00	152.6
2023	1.57	0.40	91.0%	20.76%	$0.00	152.5
2024	1.57	0.35	91.0%	18.16%	$0.00	152.7

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture and the Management Plus data from Saskatchewan Crop Insurance for 1998 to 2003. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.7 Genetic Impacts on Yield and Fungicide Costs –Small Kabuli Chickpea

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Savings/ seeded ac	Total Acres[5]
1998	1.00	1.00	0.0%	0.00%	$0.00	6.9
1999	1.00	1.00	0.0%	0.00%	$0.00	24.2
2000	1.06	1.00	4.5%	0.27%	$0.00	75.6
2001	1.06	1.00	17.7%	1.06%	$0.00	279.5
2002	1.06	1.00	44.1%	2.64%	$0.00	91.8
2003	1.59	1.00	16.9%	9.95%	$0.00	18.3
2004	1.59	1.00	13.6%	8.00%	$0.00	42.2
2005	1.59	1.00	7.3%	4.33%	$0.00	25.0
2006	1.59	1.00	16.6%	9.77%	$0.00	59.0
2007	1.59	1.00	55.8%	32.90%	$0.00	80.0
2008	1.59	0.95	55.8%	31.26%	$0.00	44.9
2009	1.59	0.90	55.8%	29.61%	$0.00	50.2
2010	1.59	0.85	55.8%	27.97%	$0.00	51.8
2011	1.59	0.80	55.8%	26.32%	$0.00	57.2
2012	1.59	0.75	55.8%	24.68%	$0.00	56.8
2013	1.59	0.70	55.8%	23.03%	$0.00	52.2
2014	1.59	0.65	55.8%	21.39%	$0.00	53.6
2015	1.59	0.60	55.8%	19.74%	$0.00	54.3
2016	1.59	0.55	55.8%	18.10%	$0.00	54.8
2017	1.59	0.50	55.8%	16.45%	$0.00	54.4
2018	1.59	0.45	55.8%	14.81%	$0.00	53.9
2019	1.59	0.40	55.8%	13.16%	$0.00	54.2
2020	1.59	0.35	55.8%	11.52%	$0.00	54.3
2021	1.59	0.30	55.8%	9.87%	$0.00	54.3
2022	1.59	0.25	55.8%	8.23%	$0.00	54.2
2023	1.59	0.20	55.8%	6.58%	$0.00	54.2
2024	1.59	0.20	55.8%	6.58%	$0.00	54.3

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture and the Management Plus data from Saskatchewan Crop Insurance for 1998 to 2003. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Table A.8 Genetic Impacts on Yield and Fungicide Costs –Desi Chickpea

Year	CDC Yield Index[1]	Variety Depreciation Index[2]	Variety Adoption Share[3]	CDC Yield Impact[4]	Fungicide Savings/ seeded ac	Total Acres[5]
1998	1.00	1.00	2.5%	0.00%	0	44.9
1999	1.00	1.00	3.0%	0.00%	$0.00	172.7
2000	1.01	1.00	12.4%	0.12%	$0.00	297.5
2001	1.01	1.00	18.2%	0.18%	$0.00	312.3
2002	1.01	1.00	33.6%	0.34%	$0.00	181.4
2003	1.03	0.95	0.0%	0.00%	$0.00	24.4
2004	1.05	0.95	0.0%	0.00%	$0.00	6.1
2005	1.08	1.00	0.0%	0.00%	$0.00	30.0
2006	1.25	1.00	4.6%	1.14%	$0.00	51.0
2007	1.25	1.00	13.3%	3.31%	$0.00	70.0
2008	1.29	1.00	13.3%	3.84%	$0.00	36.3
2009	1.29	1.00	13.3%	3.84%	$0.00	38.7
2010	1.29	1.00	13.3%	3.84%	$0.00	45.2
2011	1.29	1.00	13.3%	3.84%	$0.00	48.2
2012	1.29	1.00	13.3%	3.84%	$0.00	47.7
2013	1.29	0.95	13.3%	3.65%	$0.00	43.2
2014	1.29	0.90	13.3%	3.46%	$0.00	44.6
2015	1.29	0.85	13.3%	3.27%	$0.00	45.8
2016	1.29	0.80	13.3%	3.08%	$0.00	45.9
2017	1.29	0.75	13.3%	2.88%	$0.00	45.4
2018	1.29	0.70	13.3%	2.69%	$0.00	45.0
2019	1.29	0.65	13.3%	2.50%	$0.00	45.3
2020	1.29	0.60	13.3%	2.31%	$0.00	45.5
2021	1.29	0.55	13.3%	2.11%	$0.00	45.4
2022	1.29	0.50	13.3%	1.92%	$0.00	45.3
2023	1.29	0.45	13.3%	1.73%	$0.00	45.3
2024	1.29	0.40	13.3%	1.54%	$0.00	45.4

Source: Author's calculations from various sources

1. CDC Yield index is calculated from the Pulse Crop Regional Variety Trials as published in the Varieties of Grain Crops, Saskatchewan Ministry of Agriculture various years.
2. Variety depreciation index is calculated from the actual and projected release dates, remain at 100% for 5 years then declines at 5% per year to 20% minimum which represents the ongoing contribution.
3. Variety Adoption Share is calculated from Saskatchewan Management Plus data for 1998 to 2007, for 2008 onward it is the 2007 estimate.
4. Is calculated by adjusting the yield index by the depreciation index and the percentage of area of CDC varieties.
5. Seeded acres '000 from 1998 to 2007 are from the Specialty Crop Report, Saskatchewan Ministry of Agriculture and the Management Plus data from Saskatchewan Crop Insurance for 1998 to 2003. Total Seeded Acres is calculated from 2008 onward as the rolling 5 year average.

Appendix B: 2003 Model Estimates Compared to 2008 Model Estimates

Table B.1 Difference in the 2003 & 2008 Estimates of the 1984-2008 Economics of R&D

Column	A	B	C	D	E	F
	Total	Yield	Disease		Devel.	Total
Industry Impacts	**Genetics**	**Genetics**	**Genetics**	**Inoculants**	**Accel.**	**(A+E)**
Lentils	**Net Present Value (million $)**					
gross revenue	59.7	-0.1	59.8	-37.1	14.2	73.9
variable costs	11.1	4.9	6.2	-35.3	-5.9	5.2
producer surplus	48.5	-5.0	53.6	-1.9	20.1	68.7
consumer surplus	12.9	-5.6	18.6	-16.1	2.2	15.1
Peas						
gross revenue	231.4	229.0	2.5	155.5	140.8	372.3
variable costs	124.8	123.1	1.7	60.2	85.1	209.9
producer surplus	106.6	105.8	0.8	95.2	55.8	162.4
consumer surplus	33.3	32.4	0.8	2.0	11.2	44.4
Chickpeas						
gross revenue	56.5	56.5	0.0	32.8	-46.5	10.0
variable costs	28.5	28.5	0.0	-0.2	-38.2	-9.7
producer surplus	28.0	28.0	0.0	33.0	-8.3	19.7
consumer surplus	-5.4	-5.4	0.0	-11.6	-13.0	-18.4
Total Impact						
gross revenue	347.6	285.4	62.2	151.2	108.6	456.2
variable costs	164.4	156.5	7.9	24.8	41.0	205.4
producer surplus	183.2	128.8	54.4	126.4	67.6	250.8
consumer surplus	40.7	21.3	19.4	-25.7	0.4	41.1
Industry value added						
hogs	0.0	0.0	0.0	0.0	0.0	0.0
processing	60.8	49.9	10.9	26.5	19.0	79.8
Sask machinery	3.8	6.2	-2.4	-0.6	7.4	11.2
inoculants	0.7	0.5	0.2	-0.2	0.3	1.0
Total value added	65.3	56.6	8.7	25.6	26.7	92.1
SPG share	0.23	0.23	0.23	0.00	0.00	0
SPG Impacts	**Net Present Value (million $)**					
gross revenue	306.7	245.7	61.0	15.1	108.6	415.3
variable costs	187.4	161.8	25.6	2.5	40.9	228.3
producer surplus	119.3	84.0	35.3	12.6	67.6	186.9
consumer surplus	69.8	49.5	20.3	-2.6	0.4	70.2
Industry Value Added						
hogs	0.0	0.0	0.0	0.0	0.0	0.0
processing	53.7	43.0	10.7	2.6	19.0	72.4
Sask machinery	3.8	4.6	-0.8	-0.1	7.4	11.1
Inoculants	1.1	0.8	0.2	0.0	0.3	1.4
total value added	58.6	48.4	10.2	2.6	26.7	85.5

Source: Authors' estimates from the updated 2008 model and the Gray and Scott 2003 model.

Table B.2 Difference in the 2003 & 2008 Estimates of the 1984-2020 Economics of R&D

Column	A	B	C	D	E	F
	Total	Yield	Disease		Devel.	Total
Industry Impacts	Genetics	Genetics	Genetics	Inoculants	Accel.	(A+E)
Lentils	Net Present Value (million $)					
gross revenue	219.4	122.0	97.4	-34.2	33.2	252.7
variable costs	105.4	76.3	29.2	-47.8	15.7	121.2
producer surplus	114.0	45.8	68.3	13.7	17.5	131.5
consumer surplus	67.5	40.0	27.5	-13.7	5.4	72.9
Peas						
gross revenue	342.7	339.9	2.8	266.5	92.9	435.6
variable costs	270.0	268.7	1.3	197.3	52.4	322.4
producer surplus	72.7	71.2	1.5	69.2	40.4	113.2
consumer surplus	81.0	80.3	0.7	46.5	11.8	92.8
Chickpeas						
gross revenue	89.4	89.4	0.0	-0.5	-68.4	21.0
variable costs	36.9	36.9	0.0	-35.4	-70.9	-34.0
producer surplus	52.5	52.5	0.0	35.0	2.5	55.0
consumer surplus	3.9	3.9	0.0	-26.5	-12.4	-8.6
Total Impact						
gross revenue	651.5	551.3	100.2	231.8	57.7	709.2
variable costs	412.3	381.9	30.5	114.0	-2.7	409.6
producer surplus	239.2	169.5	69.7	117.8	60.4	299.6
consumer surplus	152.4	124.1	28.3	6.2	4.7	157.1
Industry value added						
hogs	0.0	0.0	0.0	0.0	0.0	0.0
processing	114.0	96.5	17.5	40.6	10.1	124.1
Sask machinery	3.1	5.8	-2.8	-2.6	2.5	5.6
inoculants	2.4	2.0	0.4	0.4	0.3	2.6
Total value added	119.4	104.3	15.1	38.4	12.9	132.3
SPG share of impact	0.22	0.22	0.22	0.00	0.00	0
SPG Impacts	Net Present Value (million $)					
gross revenue	530.8	439.0	91.8	23.2	57.7	588.5
variable costs	360.8	316.6	44.2	11.4	-2.7	358.0
producer surplus	170.0	122.4	47.6	11.8	60.4	230.5
consumer surplus	155.9	127.0	28.9	0.6	4.7	160.6
Industry Value Added						
hogs	0.0	0.0	0.0	0.0	0.0	0.0
processing	92.9	76.8	16.1	4.1	10.1	103.0
Sask machinery	3.5	4.4	-0.9	-0.3	2.5	6.0
Inoculants	2.3	1.9	0.4	0.0	0.3	2.6
total value added	98.7	83.1	15.6	3.8	12.9	111.6

Source: Authors' estimates from the updated 2008 model and the Gray and Scott 2003 model.

Appendix C: Pulse Sector Research and Development Expenditures

Table C.1 Saskatchewan Pulse Growers Research and Development Expenditures

Year	Research & Development[1]	R&D Adj. for Op. Costs[2]	Genetic Improvement R&D Adj. for Op. Costs[3]	Grower Check-Off
1984	-	1,131	713	34,586
1985	14,528	27,807	17,518	115,957
1986	61,675	82,626	52,054	217,321
1987	63,200	88,119	55,514	329,342
1988	97,350	132,392	83,406	285,223
1989	125,915	166,898	105,145	208,998
1990	101,693	137,307	86,503	256,377
1991	108,166	162,124	102,138	374,388
1992	176,453	236,175	148,789	474,017
1993	150,897	197,342	124,325	273,037
1994	180,319	246,032	155,000	797,719
1995	293,467	413,113	260,261	1,027,955
1996	390,250	569,558	358,822	1,260,803
1997	274,183	412,288	259,741	1,229,280
1998	642,522	787,693	496,246	1,509,240
1999	675,962	850,896	536,064	1,617,061
2000	1,377,334	1,622,945	1,022,455	2,408,818
2001	1,482,703	1,791,726	1,128,787	2,748,418
2002	1,120,689	1,438,259	906,103	2,478,225
2003	1,577,179	1,919,031	1,208,989	3,075,810
2004	2,256,786	2,666,018	1,679,591	4,369,329
2005	2,916,282	3,353,461	2,112,680	5,184,037
2006	3,746,287	4,168,848	2,626,374	4,852,436
2007	3,368,087	3,861,643	2,432,835	6,578,792
2008	2,772,924	3,193,800	2,012,094	4,812,081
2009	3,012,073	3,448,754	2,172,715	5,159,335
2010	3,163,131	3,605,301	2,271,340	5,317,336
2011	3,212,500	3,655,669	2,303,072	5,343,996
2012	3,105,743	3,553,034	2,238,411	5,442,308
1984-2012	**36,468,298**	**42,789,990**	**26,957,686**	**67,782,225**

Source: Author's calculations base on SPG expenditure and revenue data.

1. Includes net research and development expenditure plus beginning in 1997 net expenditure on the variety release program.
2. Research and development expenditure plus 50 percent of SPG operating costs.
3. Genetic improvement R&D is adjusted by 63 percent to account for operating costs.