A REPORT PREPARED FOR

Alberta Grains

Economic Impact Assessment of Alberta Grains Research Investments

PREPARED BY VALGEN GROUP

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Executive Summary

From 2012 to 2022, Alberta Grains, through its mandatory refundable check-off funding model, strategically invested over $37 million, equivalent to $41.7 million in 2023 dollars, when adjusted for inflation. The investments were directed to five primary research areas: variety development, pest management, crop establishment, core agreements, and other critical projects. This foresight and commitment significantly propelled innovation within the agricultural sector, addressing both immediate and long-term challenges in Alberta's grains industry and extending its impacts further.

Alberta Grains invested $19.2 million or 52% of the total investments in the development and commercialization of new wheat and barley varieties. The rest of the funding can be characterized as pre- and post-breeding research. Alberta Grains collaborated with various institutions, such as the Saskatchewan Wheat Development Commission and Western Grains Research Foundation. For every dollar invested in variety development by Alberta Grains, approximately $1.80 was contributed by partners, while ever dollar Alberta Grains directed to general agronomics attracted $4.30 from co-funding sources.

During the 2012-22 period, a total of 236 wheat varieties were developed and released by 23 different institutions and 82 barley varieties were developed and released by 13 different institutions. Public breeders, including Agriculture and Agri-Food Canada, Alberta Agriculture, and the Crop Development Centre at the University of Saskatchewan, released a majority of these varieties. Alberta Grains investments contributed to 24.7% of wheat varieties and 14.4% of barley that were released.

Not all varieties gain market share. The adoption lag is long and variable for new varieties. Popular varieties can have an effective lifecycle of more than 10 years, with peak adoption taking on average four years following commercialization. Despite the slow pace of varietal adoption, the calculated acreage shares of new varieties reveals substantial market penetration, particularly for those varieties directly funded by Alberta Grains. This study identifies that in the 2015-22 period, 31 new wheat varieties were sown on 41.5 million acres across the prairies and 20 barley varieties used on 5 million acres. Alberta Grains investments in the 2015-2022 period contributed to new wheat varieties sown on 7.4 million acres and new barley varieties sown on 763,616 acres; this represents about 18% of the area that went to new wheat varieties and 15% of the area sown to new barley varieties.

Because of the short period of Alberta Grains investments, we have projected acreages for these varieties for 2023-27. We estimate that the new wheat varieties developed with Alberta Grains support will capture an additional 22.8 million acres and 2.9 million barley acres during the forecast period.

Alberta Grains investments generate returns in a number of ways. First, the investments generated new varieties with higher yields. The total return for all the new varieties supported was estimated, and the portion attributable to Alberta Grains was adjusted downwards to reflect the impact of past research on current outputs (spill-ins were set at 20%) and the portion attributed to the Alberta Grains investment reflects their 20% share of total effort. The varieties

developed between 2015-22 provide an internal rate of return (IRR) over the 2015-27 period of 8.5%, with every dollar invested in variety development generated $3.80 of value. While a significant share of the value from these new varieties was realized in Saskatchewan and Manitoba, the returns on those investments by Alberta Grains and its research partners generated larger returns, so that Alberta producers were better off than if they had not collaborated.

Provincial distribution of gross value created by varieties commercialized, $ millions, 2015-27

	Alberta	**Rest of Canada**
Total value of new varieties	$126.8	$523.9
Value attributed to Alberta Grains	$21.2	$80
Value attributed to research partners	$105.6	$445

Second, Alberta Grains invested in pre- and post-breeding and related agronomic improvements that delivered crop management and disease resistance, enhancing environmental sustainability and farm productivity. The agronomic portion of research undertaken between 2012-2022, provides an IRR of 2.1% for the 2015-27 period, while every dollar invested generated $0.70 of added value. A sensitivity analysis was conducted to establish a range of IRR and ROI values under different scenarios. In the table below, values are provided to illustrate the range of IRR and ROI values for both varietal development and agronomic research investments.

Commercial returns on Alberta Grains investment portfolio, 2015-27

	AG investments in new varieties	**AG investments in agronomics**
Internal rate of return	8.5%	2.1%
- Low scenario	4.9%	-7%
- High scenario	10.6%	7.2%
Rate of return (ROI)	378%	60%
- Low scenario	139%	-73%
- High scenario	617%	299%

Finally, both the investments in research and the added value generated by the new varieties and agronomic research directly add to provincial and national GDP, which generates indirect and induced GDP value. Alberta Grains' efforts over the study period added about $54 million directly to Alberta's GDP; the indirect effects of the purchases to generate that income and the induced impact of that income on spending and investment adds a further $41 million to Alberta's economy. Overall, Alberta Grains' investment program annually add $95 million to Alberta's economy and $272 million to the Canadian economy.

Macroeconomic impact of Alberta Grains investment by activity and location, $ millions

	Direct impacts	Indirect & induced impacts	Total impacts
ALBERTA			
Alberta Grains research investments	18.5	11.5	30
Contribution of new varieties in Alberta	21.2	17.6	38.8
Contribution of agronomic research in Alberta	14.2	11.8	26
Total GDP impact in Alberta	***53.9***	***40.9***	***94.8***
REST OF CANADA			
Alberta Grains research investments	18.5	22.6	41
Contribution of new varieties	82.7	108.1	190.8
Contribution of agronomic research	15.8	24.5	40.3
Total GDP impact in rest of Canada	***117***	***155.2***	***272.2***

This assessment of Alberta Grains research and development efforts suggests a number of strategic opportunities to improve farmer returns.

1. Strategic alignment with emerging agricultural challenges: while continuing investment in cutting-edge technologies and sustainable farming practices, Alberta Grains should ensure its research priorities are dynamically aligned with the evolving challenges and opportunities within the agricultural sector. This involves utilizing the results from the 'Research Priorities Update Survey' to align research funding with the most pressing challenges and opportunities identified by the farming community. Alignment would ensure that investments directly contribute to making the wheat and barley more profitable cropping options.

2. Development of a comprehensive impact assessment framework: to overcome challenges related to monitoring the progress, outcomes, and tangible benefits of funded research projects, Alberta Grains should develop a robust, transparent, and continuous tracking and evaluation framework. This framework would facilitate real-time analysis and adjustments to research strategies, ensuring that investments are yielding the desired impacts and that course corrections can be made promptly. Additionally, by quantifying the impact of research initiatives more effectively, Alberta Grains can better articulate the return on investment to its members and stakeholders.

3. Strengthening collaborations and leveraging partnerships: recognizing that the benefits of Alberta Grains' investments extend beyond provincial borders – and that Alberta also benefits from investments made by other prairie provinces – Alberta Grains should continue to foster interprovincial collaborations. These partnerships can amplify research impacts,

facilitate learning, and enhance the overall resilience and competitiveness of the prairie provinces' grain sectors.

4. Enhance communication and engagement with membership base: Alberta Grains should maintain and enhance engagement strategies, such as the recent survey to update research priorities and the organization's proactive efforts to gather input from its membership base. Regular, transparent communication about research progress, outcomes, and the tangible benefits of investments can strengthen member trust and support while refining the feedback mechanisms will ensure it captures and addresses the evolving needs and challenges of the farming community.

5. Adaptive policy advocacy for supportive research environment: while the organization is already engaged in policy advocacy, there is an opportunity to adapt and intensify these efforts based on evolving research priorities and industry needs. This entails not just advocating for regulatory environments that are supportive of innovative agricultural research and the commercialization of new varieties but also engaging in dialogues with policymakers to ensure that the agricultural research agenda is responsive to technological advancements and market demands.

6. Enhance support mechanisms for the adoption and commercialization of research findings: this involves not just the development of new varieties and technologies but works proactively to ensure that farmers and industry stakeholders have the resources, information, and incentives to adopt these innovations. Tailored extension services, demonstration projects, and economic incentives could facilitate faster and wider adoption of research outcomes. Faster and more complete adoption of new varieties is core to sustaining innovation, productivity and profit in the industry.

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Terms of Reference

Title: Economic Impact Assessment of Alberta Grains Research Investments

Objective: To assess the economic impacts of Alberta Grains crop research investments from 2012-2022.

Outline of Research: Since 2012, Alberta Grains (formerly The Alberta Wheat and Barley Commission and previously the Alberta Wheat Commission and the Alberta Barley Commission) has made investments into the development of new wheat and barley varieties in Alberta. These investments have contributed to the commercialization of new varieties, with improved traits over existing varieties, contributing to higher economic returns for Alberta wheat and barley farmers. This report will provide an assessment of what the economic benefits have been for Alberta wheat and barley farmers from the investments made by Alberta Grains over the period of 2012 to 2022.

The report will:

- ◊ quantify the funds invested by Alberta Grains.
- ◊ estimate the funds that were leveraged from Alberta Grain's investments.
- ◊ identify the number of new wheat and barley commercialized between 2012 and 2022.
- ◊ estimate the increased yield from these new varieties and the economic gains.
- ◊ estimate the economic value of the direct and leveraged investments.
- ◊ estimate the returns on investment for Alberta wheat and barley producers.
- ◊ estimate the diffusion of benefits to producers in other provinces and to consumers around the world via lower prices.
- ◊ estimate the benefits from any patents obtained during the research and from plant breeders rights' on the commercialized varieties.

These estimates will be integrated, providing Alberta Grains with a comprehensive estimate of the economic impacts from their investment.

1. Introduction

1.1 Historical Context and Evolution of Alberta Grains

Alberta Grains represents a significant evolution in agricultural representation in Alberta. This evolution is marked by several key stages.

1.1.1 Formation and early years (2012-2016)

The Alberta Wheat Commission (AWC) was established on August 1, 2012, following the dissolution of the Canadian Wheat Board's control over wheat and barley marketing. This new commission marked a pivotal shift, providing Alberta wheat growers with greater marketing autonomy and a stronger voice in the crop production sector. The AWC focused on research, market development, policy advocacy, and farmer support, establishing a solid foundation for the sector's future growth.

Simultaneously, the Alberta Barley Commission (ABC), with a similar mandate for barley growers, operated in alignment with the goals and strategies of the AWC, focusing on market development, research, and farmer advocacy.

1.1.2 Shared management structure (2017-2022)

A strategic decision was made in 2017 to share a management structure between the Alberta Wheat and Barley Commissions. This was a significant step towards integration, aimed at improving operational efficiency and fostering collaborative initiatives. The shared management structure paved the way for a more unified approach in representing wheat and barley farmers in Alberta.

1.1.3 Amalgamation into Alberta Grains (2023)

The culmination of years of collaboration and consultation resulted in the official formation of Alberta Grains in August 2023. This unified entity, representing both wheat and barley farmers, was a direct response to the agricultural community's call for a more cohesive and powerful voice. Alberta Grains was established to focus on delivering value to farmers, enhancing industry growth, and ensuring sustainability in the grain sector.

1.2 Evolution of AG Research Funding Strategy

The research funding strategy of the Alberta Wheat and Barley Commissions, now unified as Alberta Grains, has seen a progressive development over the years.

1.2.1 Early investments (2012-2016)

In its initial years, the AWC placed a strong emphasis on research and development. The commission's commitment to advancing wheat varieties and agronomic practices was evident in its substantial investment in research projects. This period laid the groundwork for a robust research portfolio that would evolve significantly in subsequent years.

1.2.2 Strategic collaboration and management integration (2017-2018)

The AWC's approach began to shift towards a more integrated and collaborative strategy. This period saw the amalgamation of management with the ABC, which led to a more coordinated approach to research. Particularly, the shared management structure between the wheat and barley commissions facilitated a more coordinated and strategic approach to research funding. This period saw an increase in the amount dedicated to research and an expanded range of funded projects, with an increased focus on leveraging funds and partnerships with other organizations.

1.2.3 Adaptation and resilience (2019-2020)

Despite challenges like the COVID-19 pandemic, Alberta Wheat and Barley Commission continued its commitment to research. There was a notable emphasis on policy advocacy and market development, alongside the ongoing research in wheat breeding. The approach became more adaptive, with a shift towards virtual platforms for international markets and advocacy.

1.2.4 Consolidation and maximization (2023)

With the formation of Alberta Grains (AG), the research funding strategy became more consolidated aiming to be more impactful. The amalgamated organization leveraged the strengths of both commissions to create a more efficient and effective research funding model. The focus was not just on the quantity of investment but also on maximizing the value and impact of each research initiative for Alberta's grain sector.

Throughout this evolution, Alberta Grains (and its predecessor commissions) demonstrated a strong commitment to research and innovation. This commitment was not only reflected in the increasing amounts dedicated to research but also in the strategic approach to selecting and managing research projects. The organization consistently sought to address key agronomic challenges, improve wheat and barley varieties, and enhance the overall competitiveness and sustainability of Alberta's grain industry.

1.3 AG Research Strategy

Over the years, AWC has shown a progressive shift from foundational research investments to more integrated and collaborative approaches, including strategic partnerships and amalgamation with Alberta Barley Commission, aiming to unify forces for more consolidated and efficient agricultural representation. A consistent focus on research and extension programs is evident throughout, despite financial and operational challenges.

The evolution of the research funding strategy by Alberta grain farmers (via AWC, Alberta Barley and AG), sets a critical stage for analyzing the economic impact of these investments, particularly in variety breeding. The sustained and strategic investment in research and development highlights the commissions' commitment to advancing agricultural innovation.

Overall, the AWC annual reports from 2012-2022 showcase a strategic evolution from foundational years to a mature organization with a strong focus on research and development, market expansion, policy advocacy, and educational outreach. Each year reflects a response to both provincial and global agricultural trends, demonstrating a dynamic approach to addressing the evolving needs of wheat producers.

- **2012 – 2013: Foundational years**
  - Research focus: Initial investments in research targeted genetic improvements and agronomic practices, with a notable focus on high-yield wheat varieties and herbicide resistance management. This period was crucial in laying the foundation for future research directions.
  - Organizational strategy: The formation of AWC post-Canadian Wheat Board era marked a shift towards more localized and producer-driven research and marketing efforts.

- **2013 – 2014: Expanding horizons**
  - Research and market development: The AWC showed an increased commitment to research, with a significant focus on the development of wheat varieties. They also started to build the Canadian wheat brand internationally, indicating a strategic shift towards global market engagement.
  - Policy advocacy: The AWC began active involvement in national policy issues such as rail transportation and crop variety registration, highlighting the Commission’s growing influence and strategic foresight in advocating for producers’ interests.

- **2014-2015: Consolidation and Growth**
  - Research portfolio expansion: With 37 projects and $5.5 million in research investment, the AWC demonstrated a robust approach to research, focusing on genetic and disease management improvements. This indicates a strategic commitment to long-term agricultural innovation.
  - Educational initiatives: Increased focus on farmer education and extensive activities, illustrating an understanding of the importance of knowledge dissemination in agricultural advancement.

- **2015-2016: Enhancing commitment and efficiency**
  - Increased research investment: The investment amount and the number of projects indicate a scaling up of AWC’s research endeavors. This aligns with a broader trend in the agricultural sector towards more intensive research and development.
  - Operational efficiency: The move towards a single check-off system for levy collection showcases AWC’s strategic focus on operational efficiency and resource optimization.

- **2016-2017: Strategic partnership and policy engagement**
  - 4R Partnership and transportation advocacy: The initiation of the 4R Partnership marked a significant evolution in the AWC's approach to collaborative research. Their active role in grain transportation reform demonstrates a strategic understanding of the broader agricultural supply chain challenges.

- **2017-2018: Operational and educational focus**
  - Educational campaigns and extension: The 'Life's Simple Ingredient' campaign and 'Next Level Farming' events reflect a strategic focus on brand building and farmer engagement, crucial for long-term sector growth.

- **2018-2019: Financial innovation and continued strategic focus**
  - Innovative programs: AWC introduced FarmCash and continued to focus on research, market development, and policy advocacy. This period marks a blend of operational innovation with consistent strategic direction.

- **2019 – 2020: Strengthening markets and advocacy**
  - Export market development: Efforts to strengthen Canadian wheat's position in global markets indicate a strategic response to changing global trade dynamics. Continued advocacy in transportation and policy reflects an understanding of the interconnectedness of these areas with market success.

- **2020-2021: Maintaining strategic direction**
  - Consistent strategic approach: AWC maintained its focus on key initiatives like research, market development, and educational activities, in line with previous years. Despite pandemic challenges, AWC made significant investments in various wheat research projects, including core breeding agreements and collaborations with universities and other research institutions. In terms of educational and extension activities, AWC expanded them, emphasizing farmer education and knowledge dissemination.

- **2021-2022: Recent trends and initiatives**
  - Continued strategic evolution: Despite financial and operational challenges, AWC sustained its investment in research and extension programs, demonstrating a consistent commitment to innovation and farmer support.

Similarly, the ABC annual reports from 2016 to 2022 detail a journey of strategic growth and adaptation, highlighting a transition from initial research focus areas to a broadened, integrated approach.

- **2016-2017: Foundational focus:** The year marked a strategic emphasis on barley breeding and agronomic practices, setting the stage for future innovation. Investments targeted genetic improvements and resilience against diseases, aiming to boost barley yield and quality.

- **2017-2018: Strategic expansion:** The focus broadened to include collaborative research projects, leveraging partnerships for enhanced impact. Investments in agronomic improvements continued, underpinned by a commitment to sustainable agricultural practices.

- **2018-2019: Collaboration and resilience:** In the face of operational challenges, the commission maintained a steadfast focus on research, prioritizing partnerships and innovative approaches to ensure the continuity of critical research initiatives.

- **2019-2020: Adaptation amid challenges:** Despite global disruptions, ABC adapted its research strategies to continue supporting agricultural innovation, with an increased emphasis on digital platforms for research dissemination and stakeholder engagement.

- **2020-2021: Consolidating for greater impact:** The period was characterised by a strategic consolidation of research efforts, aiming to maximize the efficiency and effectiveness of investments. The focus remained on driving forward agronomic and varietal advancements.

- **2021-2022: Forward-looking strategies:** Sustained investment in research and development underscored a long-term vision for the barley sector, with strategic initiatives aimed at addressing the evolving needs of Alberta's agricultural landscape.

Hereinafter, Alberta Grains will be used to refer to both the Alberta Wheat Commission and Alberta Barley Commission throughout the period of study.

This report is designed to assess how these investments have translated into commercial and economic benefits for Alberta's wheat and barley farmers, particularly through the commercialization of new, improved varieties, and their effect on the larger macroeconomy.

1.4 Global Context for Research Funding

Alberta Grain's strategic shifts in research funding align with global trends in agricultural research, which emphasize sustainable farming practices, technological innovations, and collaborative research models. Alberta Grain's adaptability and responsiveness to changing economic and environmental conditions resonate with global shifts towards more resilient and sustainable agricultural practices.

Agricultural research funding globally has been experiencing a shift, with an increasing emphasis on sustainable agricultural practices and technological innovations. Investments in agricultural research and development (R&D) are critical to meet the United Nations' Sustainable Development Goals for hunger and climate change mitigation. The International Model for Policy Analysis of Agricultural Commodities and Trade framework suggests that additional R&D investments are necessary to reduce hunger and achieve emission reduction targets by 2030 and 2050 (Rosengrant et al. 2021).

In the United States, private sector spending has grown considerably, now accounting for a significant portion of total agricultural R&D expenditures. This trend highlights a shift towards

more private investment in agricultural research, contrasting with the patterns in other countries like China, where private sector expenditures on agricultural R&D are negligible (Plastina & Townsend 2023).

The concept of Sustainable Agricultural Intensification is gaining importance, focusing on productivity gains while improving environmental sustainability. This approach is particularly relevant for funding in the Global South and involves a broad range of innovations, including non-technological areas like business models and policy reforms (Prasad et al. 2023).

However, global total investments in agricultural research remain low, especially in low and middle-income countries, indicating a disparity in global investments patterns. High-income countries are responsible for the majority of global agricultural research spending (55%), while spending in middle-income countries (China, Brazil, India) has risen from 29% in 1980 to 43% in 2015 (Pardey et al. 2016).

The COVID-19 pandemic has also impacted agricultural R&D, revealing vulnerabilities in the food, land, and water systems. The International Water Management Institute emphasizes the importance of strengthening and sustaining the enabling environment for agricultural innovation to meet growing food demands and mitigate climate change impacts (Minh et al. 2021).

1.5 Research Scope and Objectives

Commencing in September 2023, this research project focuses on analyzing Alberta Grains' investments, especially those directed to developing new wheat and barley varieties from 2012 to 2022. The study explores the real-world effects of these investments, particularly in improving crop varieties and the improvements in agronomy both for Alberta's agricultural sector and beyond.

First, this report situates AG investments in the larger market context. The work quantifies the total funds Alberta Grains has invested in crop research, offering a clear view of the organization's financial commitment. The study estimates the additional funds leveraged through these investments, including contributions from government and private sector partnerships.

Next, the study evaluates the impact of Alberta Grains' investments in crop variety development and agronomy. This involves examining how these investments have led to advancements in crop quality and yield, and their broader effects on agricultural practices in Alberta. The study provides a detailed understanding of how these investments have driven agricultural innovation and growth. The analysis is broken into two streams: the specific returns to new wheat and barley varieties commercialized due to these investments; and the returns from the improvements in general competitiveness of grains due to the investments in agronomy and policy.

Third, the study examines the diffusion of benefits beyond farming in Alberta, considering how other parts of the Alberta economy (e.g. input, processing and logistics sectors and consumers), farmers in other prairie provinces and other parts of Canada have been impacted.

2. Comparative Studies on Wheat and Barley Variety Development

In assessing the economic impacts of R&D investments in wheat and barley variety development programs, it is important to recognize the diverse range of values different studies have reported. This literature review explores the factors contributing to this variability and integrating findings from various studies, including the global perspective provided by Alston et al. (2000).
The variability in economic return estimates from wheat and barley R&D is influenced by several key factors.

Methodological differences have a major impact. Studies like the 2022 report by Bolek-Callbeck and Gray (2022), Gray and Malla (2022) and Scott, Guzel, Furton and Gray (2005) demonstrate how methodological approaches influence return estimates. While some studies focus on yield improvements, others consider a broader range of benefits, such as improved disease resistance or adaptability to environmental changes (Table 1).

Regional and temporal context can also influence the results. The context of each study, including the period and location, plays a significant role. For instance, a study focusing on a period of high commodity prices reports higher returns compared to one conducted during a market downturn. Similarly, research concentrated in regions with optimal growing conditions might yield more favorable results than studies in less fertile areas.

Table 1: Studies on rates of return to investments in wheat and barley variety development

Study	**Grain**	**Benefits to costs ratio**	**Internal rate of return (%)**	**Summary**
Gray and Malla 2000	Wheat	n/a	40%	The average estimated rate of return for investments in Canadian wheat research is 40% annually; high rates of return can be attributed in part to the large area of wheat grown and there is no indication that rates of return are decreasing.
Scott, Guzel, Furton and Gray 2005	Wheat Barley	Wheat – 4.6 Barley – 13.1	Wheat – 24.4% Barley – 36.8%	The study found significant returns to the WGRF check-off investments for both wheat and barley. The B/C ratio for producers for the wheat check-off is estimated at 4.4 to 1, meaning that every dollar of check-off invested generates $4.40 of increased producer surplus for Western Canadian wheat growers.

Study	Grain	Benefits to costs ratio	Internal rate of return (%)	Summary
Gray, Nagy and Guzel 2012	Wheat Barley	Wheat – 20.40 Barley – 7.56	Wheat – 36% Barley – 28%	The reported B/C ratios are the present value of producer benefits divided by the present value of costs, each calculated in 2011 dollars with a 5% real discount rate.
Groenewegen, Thompson and Gray 2016	Wheat Durum Barley Oats	Spring wheat – 6.8 Winter wheat – 2.1 Durum – 1.8 Barley – 8.7	Spring wheat – 14.5% Winter wheat – 7.1% Durum – 7.5% Barley – 15.5%	When all CDC costs since 1971 are considered with benefits measured over the 1991-2015 period, the IRR was found to be 14.5% and 7.1% respectively for spring and winter wheat; 7.5% for durum and 15.5% for barley. The B/C ratio is 6.8 and 2.1 respectively for spring and winter wheat; 1.8 for durum and 8.7 for barley.
Bolek-Callbeck, Brown and Gray 2021	Barley	Barley – 26	Barley – 32%	The estimated B/C ratio indicates that for every dollar invested in research the producers benefit is $26. The estimated annual IRR is 32%, which at the time of the study was significantly higher than the market interest rate.
Bolek-Callbeck and Gray 2022	Wheat	Wheat – 32.6	Wheat –33%	For every $1 that producer commissions and the WGRF invested in wheat breeding, they receive $32.6 back, even after the long research lags and the time value of money is accounted for. The IRR is also extremely high relative to most of investments. It is equivalent to having a bank account that earns 33% interest or nearly doubles in value every two years.

Variety development provides benefits to wheat and barley producers through improved margins per acre, with these higher returns due to varieties that either provide higher yields, better disease resistance, improved drought tolerance, and/or genetic traits that are desired by end users. But there is a host of other research in the pre- and post-breeding spaces that improve both breeding productivity and the agronomy that underlies crop competitiveness. Studies indicate that wheat yields have increased by 1.4% to 1.8% per year (JRG Consulting Group, 2015), with some evidence indicating that approximately 50% of this yield gain is due to better agronomic and management practices and 50% due to genetic improvements in newly released varieties.

Alston et al. (2000) undertook a meta-analysis of returns to investment in global agriculture. They found a total of 289 studies with 1,821 estimates of rates of return (Table 2). After removing statistical outliers and incomplete observations, they found 1,128 individual observations which revealed an overall annual rate of return of about 80% for agricultural research projects. Some of these estimates are done as forecasts and others as ex-post assessments. They assessed the various aspects of research design and of the methods of undertaking the estimates to see how those choices affected the returns. They found that adding extension to specific research projects dropped the estimated return by 33% (even though extension projects alone posted an 80% return), field crop research delivered 14% lower return, and both public and public private research delivered 13-35% lower returns than private efforts. They also found that research methodology matters, in some cases a lot. Examining a single (usually highly successful) project bumped estimates up 26% while doing an ex-post review rather than a forecast cut the rate by more than 20%. Considering spill ins and spill outs had only a minor effect (negative and positive respectively) on the estimates.

Table 2: Alston et al. (2000) on the dynamics of research assessment

	Average rate of return
All studies of research	79.6%
Returns relative to all studies of research	(change in percentage points)
Research design: Project includes both research and extension	-33
Research design: Focus on field crops	-13.8
Research design: Public research	-12.9
Research design: Public private research efforts	-34.9
Research design: Private research	0.2
Methodology: Single project	25.6
Methodology: Ex post study	-20.2
Methodology: Considered spill ins	-0.8
Methodology: Considered spill outs	4.4

After the discontinuation of the Western Canadian Deduction by the Western Grains Research Foundation (WGRF) on July 31, 2017—a levy that transitioned funding responsibilities from the Canadian Wheat Board (CWB) to provincial commissions—the landscape of agricultural research funding in the prairie provinces has seen substantial commitments. The WGRF, utilizing reserve funds, continued to enter into funding commitments with wheat and barley researchers through to 2020, demonstrating a sustained investment in these critical areas.

In 2014, wheat and barley producers across Canada contributed approximately $20 million for wheat and $4.5 million for barley through refundable check-off levies. These funds were allocated to various organizations, with the WGRF being a significant recipient, indicating a broad-based commitment to crop improvement and sustainability. Out of the total funds, approximately $6.2 million was directed towards wheat variety development and $1.4 million for barley, primarily by the WGRF. The levies per tonne for wheat and barley varied among the

organizations (Alberta Wheat Commission levying $0.70/t; the Saskatchewan Wheat Development Commission at $0.52/t; the WGRF at $0.48/t for wheat; Alberta Barley and the Saskatchewan Barley Development Commission setting at $0.50/t; the WGRF at $0.56/t for barley) reflecting a diversified approach to funding agricultural research, with a considerable amount directed towards variety development.

The Saskatchewan Barley Commission, as of 2023, mandates a check-off fee of $1.06 per tonne of barley, maintaining its rate from 2022 but with a reduction in investment towards barley research projects, from $2 million in 2022 to $1.4 million in 2023. This adjustment showcases a strategic reallocation of funding within the commission's research objectives.

The Manitoba Crop Alliance (MCA), formed through the amalgamation of five commodity groups in 2020, allocated a total of $3,317,180 to research and production for the fiscal year 2022-23, with 76 of 114 active research projects dedicated to barley and wheat. The MCA's investment in variety development for wheat and barley from 2018 to 2023 amounted to $7,518,879, contributing to a lifetime value of $94,534,545, with 79.3% ($5,960,181) allocated to wheat and 6.1% ($455,596) to barley. The check-off amount for spring wheat is set at $1.00 per tonne, for winter wheat at $0.98 per tonne, and for barley at $1.06 per tonne.

Furthermore, in 2022, the WGRF invested $427,475 in barley research, with a notable portion allocated to variety development ($230,560), and $1,905,821 in wheat research, emphasizing the importance of variety development ($1,062,443) and the Canadian National Wheat Cluster. These investments signify a targeted strategy to enhance crop quality and resilience, aligning with the overarching objectives of boosting agricultural productivity in the prairie regions.

This evolving funding landscape underscores that the Alberta Grains Commission is not the only producer group investing in breeding and agronomics. Wheat and barley producers contribute to check-off levies across the prairie provinces, evidencing a collective effort to support agricultural innovation and sustainability through strategic investments in research and variety development. These efforts are crucial for addressing the challenges of climate change, disease resistance, and yield optimization, ensuring the continued success and competitiveness of Canada's wheat and barley sectors.

3. Methodology

3.1 Basic Structure of Study

This study employs a blend of quantitative and qualitative research methods. Data collected from Alberta Grains' financial records and annual reports spanning 2012-2022 was utilized, as well as provincial information in seed guides and plant breeders' right information.

In appraising the returns to research, we look at both varietal development and agronomic advancement. Several specific steps/assumptions were needed to create a consistent data set to analyze:

- In the first instance, we linked research to registered varieties, paring down the list of impacts that needed to be assessed.
- Second, all yields were re-indexed to maintain a consistent check variety throughout the period of study.
- Third, we needed to assume a time-lag for varietal consideration. Given the average seven-year development period, AG's investments in breeding have been directed at about the halfway point, so we have lagged the start of any returns for three years after the research. We also note that most varieties have a limited economic life. We have made some assumptions about the potential for varieties developed in 2012-22 to continually contribute in future years.
- Fourth, we needed to develop a valuation index for the leveraging of Alberta Grains investments into large breeding projects involving multiple funders.
- Fifth, we needed to consider how to attribute value to Alberta Grains for spill-outs between supported breeding projects and institutions and activities in the broader sector.
- Finally, we reduce the impacts to reflect the spill-ins of past knowledge and development.

We did a similar analysis to assess the impacts of agronomics, only in this case we lack the specific link between research outlays and varieties that deliver improved yield and capture market share. In this part of the analysis, we look at the overall yield gain and competitiveness of wheat and barley relative to other grains, oilseeds, and pulses, and attribute a share of that gain to AG investments.

We also explore the lasting benefits of the training involved in most of these projects. Individuals trained and motivated by these projects often move on and work in this and other fields, generating strong positive returns on their educational investment. Labour economists estimate that graduate degrees work to raise employment rates, lower the incidence of unemployment, and generate strong positive private and social returns in the labour market. We work to estimate those effects.

Finally, we combine our streams of analysis to provide a summative assessment of the macroeconomic impact of AG's investment activities.

3.2 The Period of Study

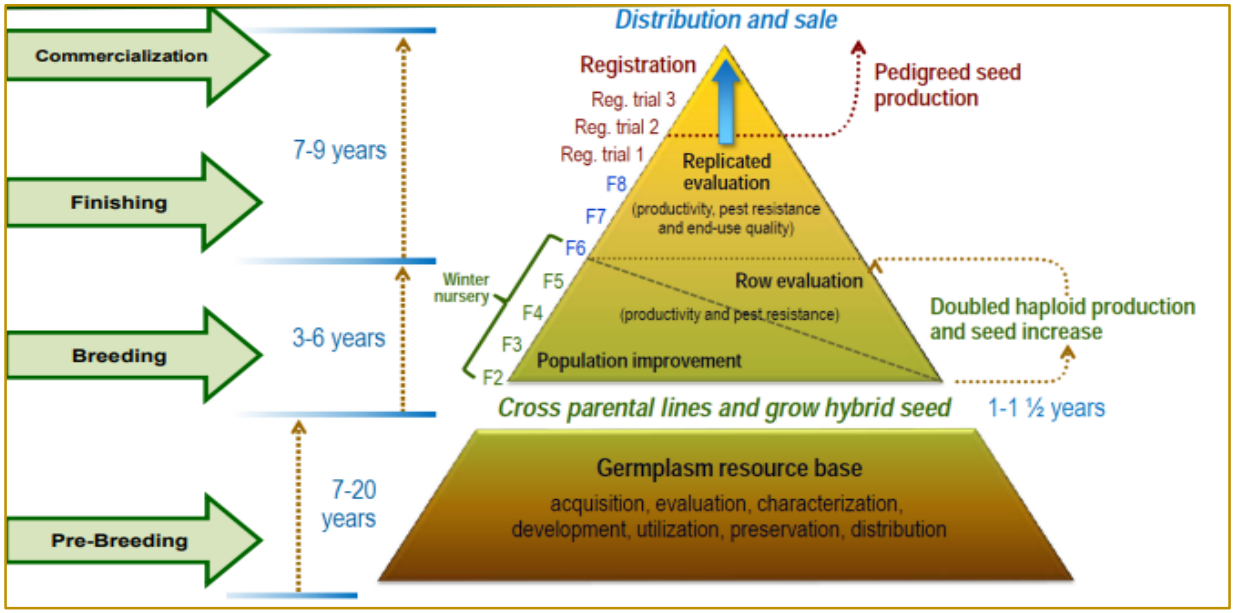
Quantifying the economic value of research requires defining the clear causal pathway, which involves considering the time required to breed, test, register, and commercialize a variety of wheat or barley.

Though lengthy, this process ensures that the varieties reaching the farm improve upon past varieties on factors including yield, pest resistance, disease resistance, and overall adaptability to present challenges in the crop production sector. Even in best case scenarios, when existing germplasms are used to provide overhauled varieties, the procedure can take nine to ten years (Figure 1).

Stages of variety development, as shown in the figure below, include:

- ◊ Pre-breeding, which includes discovery, germplasm development, genomics, development of breeding tools, development of evaluation, etc.;
- ◊ Breeding, which is the breeding of a number of generations of a crop kind;
- ◊ Variety finishing, includes finishing, replication, and registration; and
- ◊ Commercialization, which is the distribution and sale of a registered variety.

Figure 1: Stages in variety development



Variety development, from initial breeding through to the marketing of seed for planting by a farmer involves several years of breeding line evaluations, trait selection and testing followed by field trials, and then finally registration followed by seed multiplication. Depending on the crop type, the breeder, and the complexity of the selection criteria, this process can take upwards of 12 years to reach readiness for commercial sale (AAFC 2013).

Cereal crop breeding in Canada typically involves a minimum of 6 to 7 years (and often more) of plant breeding and selection work, followed by a year or two of early testing to identify superior

lines in the breeding program. AAFC recommends that breeders need to know their breeding targets many years in advance to ensure their success in the marketplace.

The next step is the entry of qualified candidates into the official variety registration recommendation trials. The trial the variety enters is determined by its intended end use (i.e., which wheat class it is intended for) and may also include the targeted zone of adaptation. Expert evaluation teams within the Recommending Committee, one each for breeding and agronomy, disease, and quality assessments, deliberate separately and vote to arrive at their final assessment. Based on this assessment, the voting members of the Prairie Recommending Committee for Wheat, Rye, and Triticale (PRCWRT) then vote on whether the variety has overall merit and can be recommended for variety registration. If the variety is recommended by the PRCWRT (typically in February of each year), the next step is to file a variety registration with the Variety Registration Office (VRO) (AAFC 2013).

In general, if a variety obtains recommendation in the winter (February) of a given year and if the application is sent to the VRO by March of that year, then the variety will be registered in time for planting that crop year. Typically with cereals, the first year of registration is one of very limited commercial sales and instead is focussed on pedigreed seed production.

After seed has been successfully propagated through the seed grower network, the determination of success or failure with a new variety is not near its conclusion. From initial mass release, it may take another five to ten years before a variety is fully adopted by farmers and grown on a substantial number of acres. As such, it may take up to 20 years between the initial investment into a breeding institution until a measurable quantity of economic value (King 2018). This creates a major impediment to economically valuing the breeding investments of Alberta Grains, and greatly diminishes the value of investments within the period under study relative to the potential future value of commercialized varieties. However, it must be considered that funds may not be received at the beginning of the breeding timeframe; rather, funding may be utilized by breeding institutions to support, finalize, and commercialize varieties already under development, especially those in the final stages of development showing promise for broad distribution in western Canada. As such, the lag period has been set as three years, excluding investments made prior to 2015 (Figure 2).

Figure 2: Period of study

2012-14	2015-22	2023-27
AG Investments in R&D		
Included		Excluded
Value Creation		
Excluded	Assessed	Forecast

To reflect this, we have defined the scope of analysis in three periods to reflect the leads and lags between research investments and market impacts. First, the research investment period includes all AG outlays from 2012 to 2022. Second, the direct market impact is limited to the period 2015-22. We do not consider the impact of any varieties introduced before 2015 as none would

be the result of AG efforts, given the ramp-up phase of AG investments and that varieties take about three years to clear regulatory systems and enter the market. Third, the varieties introduced due to AG efforts in the 2015-22 period will deliver benefits for quite a few more years, so we extrapolated those benefits through to 2027, to give a more fulsome estimate of the returns on AG investments.

3.3 Overview of Data Sources and Analytical Techniques

Initializing the data collection process, seed guides were compiled from all relevant jurisdictions including Manitoba, Saskatchewan, and Alberta (BC farmers use the Alberta guide). From Seed Growers' Association webpages in the respective provinces, the 2011-23 Saskatchewan Varieties of Grain Crops, 2011-23 Saskatchewan Seed Guides, 2011-23 Alberta Spring Seed Guides, 2011-22 Alberta Fall Seed Guides, and the 2012-23 Manitoba Seed Guides. The Seed Guides were utilized as the initial resource for varietal information, allowing for documentation of each variety listed in the Seed Guides to build a base of wheat and barley varieties which had reached the commercialization process.

Annual Variety Registration Reports in the Saskatchewan Seed Guide were scanned for newly registered varieties, which were documented within the dataset. In Alberta, Fall Seed Guides were scanned for the "new varieties" section, which contained all new varieties for release in the coming calendar year. These varieties were documented if not already done so in the Sask Seed Guide search. For Manitoba, annual Seed Guides were scanned for new varieties. Data compiled from the seed guides included common name, test identification number, years a variety appeared in each Seed Guide, first-year a variety appeared in each Seed Guide, final year a variety appeared in each Seed Guide, registration status, year of registration, year of recommendation for registration, geographic dispersion of registration (National/Regional), and the projected year of seed availability.

Due to the differences in seed guides across various years and provinces, relevant data points were missing for many seed varieties. Additionally, varieties that were registered but never appeared in the seed guides were limited. As such, additional resources were employed to fill in missing data points, including registered variety spreadsheets sourced from the CFIA, the CFIA online database detailing individual varieties, Prairie Grain Development Committee list of supported varieties from the Prairie Recommending Committee for Oat and Barley, and the Prairie Grain Development Committee list of supported varieties from the Prairie Recommending Committee for Wheat, Rye and Triticale.

To ensure the validity of the data collected, each of the 119 barely and 221 wheat varieties documented between 2012-23 was spotlight searched in each of the seed guides to confirm that the data collected was accurate. Additionally, the year of registration was cross-referenced to the CFIA dataset to ensure the seed guide listings were accurate.

The acreage sown to each variety of wheat and barley grown on the Canadian prairies throughout the period of study was determined to be a requirement for the economic analysis. As such, relevant crop insurance agencies to request data detailing the acreage volumes planted to wheat and barley by variety in the aggregate. Data detailing aggregate acreage was acquired from the

Manitoba Agricultural Services Corporation (MASC), Saskatchewan Crop Insurance Corporation (SCIC), and Alberta Financial Services Corporation (AFSC) to request the required datasets. Once data was acquired, it was converted and compiled into a format malleable for further analysis. The market shares of relevant varieties were listed as the acres allocated to each crop in the years under study.

In determining which of the varieties compiled to date can be attributed to funding from Alberta Grains, a variety of resources were used (Table 3). Publications from the Journal of Plant Registrations and the Canadian Journal of Plant Science were used extensively to discover linkages between funding and varietal development. When the above resources were exhausted, several researchers and executives affiliated with relevant breeding institutions were contacted. Lastly, collecting and listing the annual spot prices for wheat and barley throughout the period of study was deemed necessary. Statistics Canada datasets detailing monthly average wheat and barley prices from 2012-2023 were sourced. These monthly listings were used to formulate annual averages for relevant commodities.

Table 3:Key data sources

Data Gathered	**Source(s)**
Basic Varietal Information	2011-23 Seed Guides (SK, AB, MB)
	CFIA List of Registrations (Wheat & Barley)
	Plant Breeders' Rights Office
	Canadian Variety Transparency Database
	Plant Varieties Journal - CFIA
	Saskatchewan Varieties of Grain Crops
	Annual List of Recommended Varieties
	Personal Correspondence
Acreage by Variety and Year	SCIC Data Provision
	AFSC Data Provision
	MASC Public Database
Varietal Yield	Variety Trial Data (In Seed Guides)
	Yield Alberta Magazine 2012-23
	Yield Manitoba Magazine 2012-23
	Yield Saskatchewan Magazine (2020-23)
Attribution	Canadian Journal of Plant Registrations
	Canadian Journal of Plant Science
	Personal Correspondence
Annual Spot Prices of Wheat and Barley	Statistics Canada Monthly Price Dataset
Alberta Grains investments	Alberta Wheat Commission Annual Reports
	Alberta Barley Commission Annual Reports
	Alberta Grains Commission website
	List of Alberta Grains' funded projects and associated details for this analysis
	Western Grain Research Foundation
	Canadian Barley Research Coalition
	Canadian Wheat Research Coalition

Data Gathered	Source(s)
	Saskatchewan Wheat Development Commission
	Saskatchewan Barley Development Commission
	Agriculture and Agri-Food Canada
	Saskatchewan Ministry of Agriculture, Agriculture Development Fund
	Manitoba Crop Alliance
	Results Driven Agriculture Research (RDAR)
	Alberta Innovates
	Extensive searches on other co-funders' websites to identify and gather information on project funders and funding details.
Comparative literature review	Various articles providing comparative insights relevant to our study of Alberta Grains' investment impact on barley and wheat variety development, all of which are detailed in the reference list.

3.4 Structure of the Rest of the Report

Section 4 examines the direct effects of AG investments, exploring their contributions to the research system, focusing on the scale and scope, how they were allocated, what resources they leveraged or partnered with and flow of new varieties arising from this effort.

Section 5 assesses the impacts of those efforts through investigating the returns on the new varieties, the more general returns to the wheat and barley sectors from improved agronomics and the macroeconomic impact in Alberta and beyond.

Section 6 summarizes the key findings and offers some options for improving the impact of AG investments.

4. Direct impacts of AG investments

4.1 Alberta Grains Outlays 2012-22

Alberta Grains has systematically channeled funds into agricultural research, with a clear emphasis on variety development, crop establishment, and integrated pest management.

4.1.1 Scale and nature of AG investments

Over the 2012-22 AG and its precursor organizations invested a total of $37 million into five main types of research (Table 4).

Table 4: Alberta Grains Commission's cost for each research category, by year

Year	Variety development	Pest management and control strategies	Crop establishment and growth	Core agreements, cluster, and chair funds	Other funded projects	Annual cost
2013	$0	$90,000	$427,332	$1,300,601	$0	$1,847,933
2014	$929,860	$50,000	$494,815	$766,500	$0	$2,241,175
2015	$1,060,000	$60,000	$755,000	$0	$50,000	$1,925,000
2016	$284,998	$523,350	$751,750	$0	$15,000	$1,575,098
2017	$292,000	$200,000	$311,500	$0		$803,500
2018	$1,334,247	$38,000	$1,394,837	$190,717	$304,625	$3,262,426
2019	$2,820,858	$538,500	$2,321,947	$450,000	$227,875	$6,359,180
2020	$11,249,435	$116,500	$697,064	$1,505,000	$629,237	$14,197,236
2021	$883,520	$516,384	$1,422,424	$800,000	$149,352	$3,771,680
2022	$383,250	$71,750	$240,729	$0	$369,250	$1,064,979
Total	**$19,238,168**	**$2,204,484**	**$8,817,398**	**$5,012,818**	**$1,745,339**	**$37,048,207**

For the sake of our work, we have divided the efforts into two parts: variety development and agronomic improvement (which includes pest management and control, crop establishment, cluster and chair programs and other non-breeding projects). About $19.2 million or 52% was directed to varietal development; the rest was directed to agronomic improvement. The distribution of funds and the number of projects by each category year by year reflect AG's response to the shifting agricultural landscape. The data shows a pivot towards certain research areas as new challenges emerge and priorities shift.

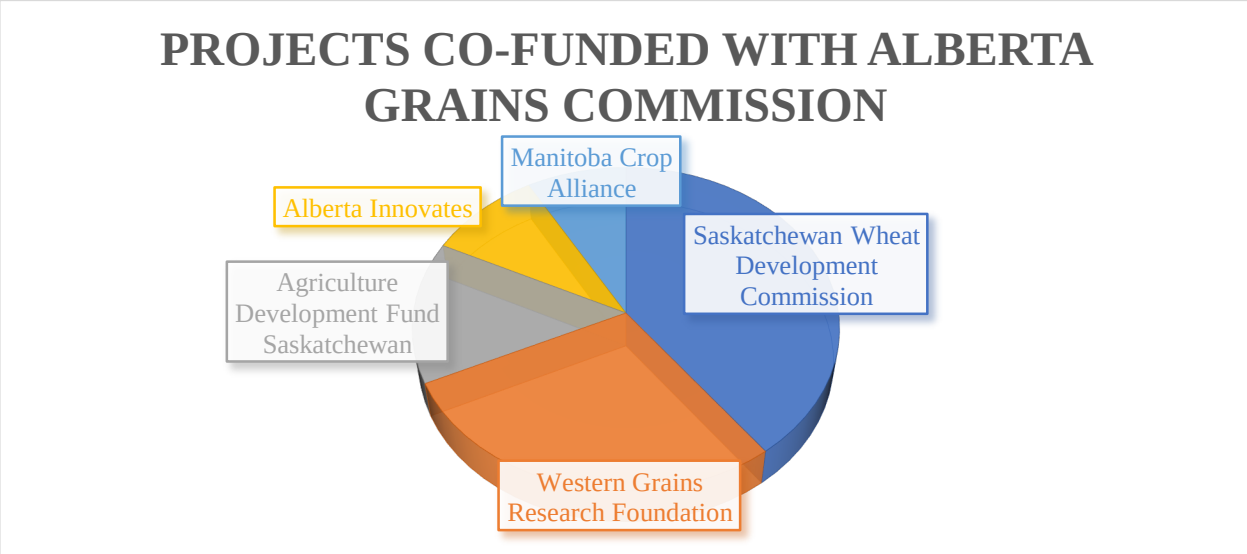
The pattern of co-funding reveals a preference for strategic alliances with organizations like the Saskatchewan Wheat Development Commission and Western Grains Research, both prominent contributors to the total funding to the projects where Alberta Grains Commissions has invested funds as well (Table 5).

Table 5: Lead research organization conducting research projects funded by Alberta Grains

Research organization	Number of projects funded by Alberta Grains
Agriculture and Agri-Food Canada	68
University of Alberta	25
University of Saskatchewan	20
University of Manitoba	8
Alberta Agriculture & Rural Development	7
Alberta Innovates	6

This pattern underscores a regional collective effort in agricultural research and innovation, indicative of a shared vision for strengthening Prairie agriculture (Figure 3).

Figure 3: Pattern of co-funding research projects (2012 - 2022)



A closer look at individual project contributions and added value reveals the importance of a few key principal investigators. This focus in the engagement with research organizations (Table 6) and principal investigators.

Table 6: Main principal investigators leading research projects funded by AG

Principal Investigator	Number of projects funded by Alberta Grains
Dean Spaner	15
Brian Beres	6
Charles Geddes	6
Linda Hall	5
Harpinder Randhawa	4
Nora Foroud	4
Reem Aboukhaddour	4
John Laurie	4
Claudia Sheedy	4

4.1.2 Cumulative real cost of AG investment portfolio

To get a current dollar value of all the investments, we have used the Final Domestic Demand (FDD) deflator, rebased to 2022 = 1.0 (Table 7).

Table 7: Converting outlays into real 2022$

Year	AG outlays on varietal development, current $	AG outlays on agronomics, current $	FDD deflator 2017 = 100	FDD Deflator 2022=1.0	AG outlays on varietal development, 2022$	AG outlays on agronomics, 2022$
2013	$0	$1,847,933	93.9	0.806	$0	$2,292,721
2014	$929,860	$1,311,315	96.1	0.825	$1,127,103	$1,589,473
2015	$1,060,000	$865,000	97.6	0.838	$1,264,916	$1,032,220
2016	$284,998	$1,290,100	98.6	0.846	$336,877	$1,524,941
2017	$292,000	$511,500	100	0.858	$340,326	$596,154
2018	$1,334,247	$1,928,179	101.6	0.872	$1,530,100	$2,211,214
2019	$2,820,858	$3,538,322	103.5	0.888	$3,176,642	$3,984,597
2020	$11,249,435	$2,947,801	105.4	0.905	$12,430,315	$3,257,239
2021	$883,520	$2,888,160	109.4	0.939	$940,916	$3,075,783
2022	$383,250	$681,729	116.5	1	$383,250	$681,729
Total	**$19,238,168**	**$17,810,039**			**$21,530,445**	**$20,246,070**

Source: Statistics Canada, AG Annual Reports, and authors' calculations.

4.2 AG Leveraging

The AG check-off system is designed to pool resources from the collective contributions of individual producers to facilitate significant investments in areas that are crucial for the advancement of the wheat and barley industries in Alberta. Given that Alberta is only one part of the Canadian and global market system, AG (like almost all public and private research efforts) has partnered with others to achieve scale and scope benefits of larger research efforts.

Almost every project AG invests in has partners. Some studies would assume that AG investments leverage those other partners, allowing to count both those partner investments and the whole impact of any resulting researcher findings to the primary organization. While leveraging is important, it is our view that the other organizations would likely spend much or all their institutional funds in similar ways, with or without AG support. So while we identified the amount of funds partnered/leveraged by AG investments, we used the resulting data to scale the proportion of any downstream benefits to the share of the contribution (Table 8).

Table 8: Total value of all supported research (including Alberta Grains share), by funding category, by year

Year	Variety development	Pest management and control strategies	Crop establishment and growth	Core agreements, cluster, and chair funds	Other funded projects	Annual cost
2013	$0	$90,000	$2,713,214	$25,000,000	$0	$28,370,214
2014	$2,100,839	$395,905	$2,663,815	$3,400,000	$0	$8,560,559
2015	$6,000,907	$112,347	$1,700,612	$0	$50,000	$7,863,866
2016	$1,092,513	$2,271,403	$1,368,024	$0	$15,000	$4,746,940
2017	$371,350	$999,623	$960,000	$0	$0	$2,330,973
2018	$2,825,940	$840,900	$4,176,635	$9,015,717	$1,852,075	$18,711,267
2019	$25,456,000	$2,291,362	$4,237,824	$450,000	$227,875	$32,663,061
2020	$13,508,080	$1,001,900	$2,932,837	$1,505,000	$11,196,027	$30,143,844
2021	$1,993,260	$2,926,887	$6,223,429	$800,000	$1,092,975	$13,036,551
2022	$319,612	$788,741	$640,673	$0	$833,875	$2,582,901
Total	**$53,668,501**	**$11,719,068**	**$27,617,063**	**$40,170,717**	**$15,267,827**	**$149,010,176**

Source: AG Annual Reports.

After the first year of operation, leveraging has declined over the remainder of the period of analysis. Over the entire period of this study, the $37 million AG invested leveraged/partnered with others which contributed $112 million, for a 3:1 leveraging ratio (Table 9). Every dollar AG invested in variety development leveraged about $1.80 from partners while general agronomic investments leveraged about $4.30. When all investments are combined the overall leveraging value of each dollar invested by Alberta Grains is $3.02.

Table 9: Aggregate leveraging, by year and total

Year	Alberta Grains' total investment in research	Co-funding contributions	Leveraged funds per Alberta Grains dollar
2013	$1,847,933	$26,522,281	$14.35
2014	$2,241,175	$6,319,384	$2.82
2015	$1,925,000	$5,938,866	$3.09
2016	$1,575,098	$3,171,842	$2.01
2017	$803,500	$1,527,473	$1.90
2018	$3,262,426	$15,448,841	$4.74
2019	$6,359,180	$26,303,881	$4.14
2020	$14,197,236	$15,946,608	$1.12
2021	$3,771,680	$9,264,871	$2.46
2022	$1,064,979	$1,517,922	$1.43
2013-22	**$37,048,207**	**$111,961,969**	**$3.02**

Source: AG Annual Reports and partner’s project and annual reports.

4.3 Development and Commercialization of New Varieties

4.3.1 New wheat and barley varieties registered, 2012-22

Between 2012-22, 23 different institutions developed 236 wheat varieties, including 26 durum, 156 spring wheat, 52 winter wheat and two spelt durum (Table 10). AAFC developed 33% of all varieties, while the Crop Development Centre at USask produced 14%. About 56% of all varieties were released by universities and public breeders. Only eight organizations released an average of one variety a year.

Table 10: Developers of all wheat varieties registered for use in Canada (2012-2022)

Developer	Durum wheat	Spring wheat	Winter wheat	Spelt durum	Total
AAFC	14	55	9		78
CROP DEVELOPMENT CENTRE, USASK	12	17	2	2	33
SYNGENTA CANADA INC.		20			20
CÉRÉLA INC.		18			18
UNIVERSITY OF ALBERTA, FACULTY OF AGRICULTURAL SCIENCES		14			14
C&M SEEDS		3	11		14
SEMICAN INTERNATIONAL (SEED)		6	4		10
CORTEVA AGRISCIENCE		2	7		9
UNIVERSITY OF GUELPH			7		7
PIONEER HI-BRED PRODUCTION LTD.			5		5
PREMIER PACIFIC SEEDS LTD			4		4
SECAN ASSOCIATION		3	1		4
SEED DEPOT CORP.		4			4
LA COOP FÉDÉRÉE		3	1		4
CENTRE DE RECHERCHE SEMICAN ATLANTIC		3			3
LIMAGRAIN CEREALS RESEARCH CANADA		3			3
ALBERTA AGRICULTURE & FORESTRY, FIELD CROP DEVELOPMENT CENTRE			1		1
FP GENETICS INC.		1			1
NUTRIEN AG SOLUTIONS INC.		1			1
PLANTOMAR LTD		1			1
SYNAGRI COMPANY		1			1
WESTERN FEED GRAIN DEVELOPMENT COOP LTD		1			1
Total	**26**	**156**	**52**	**2**	**236**

Source: CFIA Variety registration database.

Over the same period, 13 different institutions developed 82 barley varieties, 29 six-row spring and 52 two-row spring, of which six were hulless (Table 11). Public breeders produced about 48% of the varieties: AAFC 17%; Alberta Agriculture 15%; and CDC 13%. Only four organizations released an average of one variety a year.

Table 11: Barley varieties registered for use in Canada (2012-2022)

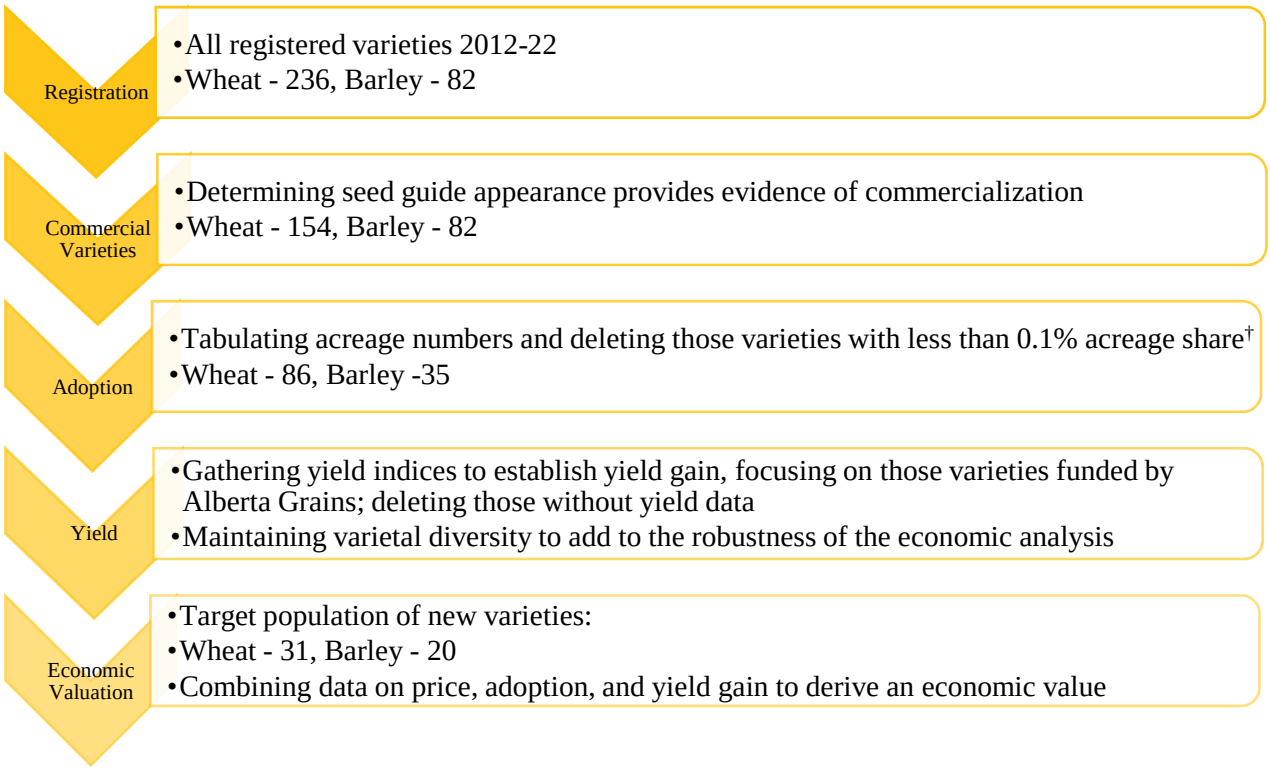
Developer	Barley, six-row, spring	Barley, six-row, Spring, Hulless	Barley, two-row, Spring	Barley, two-row, Spring, Hulless	Total
AAFC	4	1	8	1	14
CÉRÉLA INC.	10	1	1		13
ALBERTA AGRICULTURE & FORESTRY, FIELD CROP DEVELOPMENT CENTRE	5		7		12
CROP DEVELOPMENT CENTRE, UNIVERSITY OF SASKATCHEWAN			8	3	11
CORTEVA AGRISCIENCE	4		4		8
NUTRIEN AG SOLUTIONS			7		7
SECAN ASSOCIATION			6		6
LA COOP FÉDÉRÉE	2		1		3
MOLSONCOORS			2		2
SYNGENTA CANADA INC.			2		2
UNIVERSITY OF GUELPH	1		1		2
MONSANTO CANADA ULC (BAYER CROP SCIENCE CANADA)			1		1
SEMICAN INTERNATIONAL (SEED)	1				1
Total	**27**	**2**	**48**	**4**	**82**

Source: CFIA Variety registration database.

4.3.2 AG's contribution to the new varieties commercialized

All registered varieties developed for western Canada in both public and private breeding institutions were accounted for, if they reached the initial stages of commercialization (Figure 4). This accounts for varieties that may reach farmers' fields during the period of study and ensures that all these varieties are analyzed further.

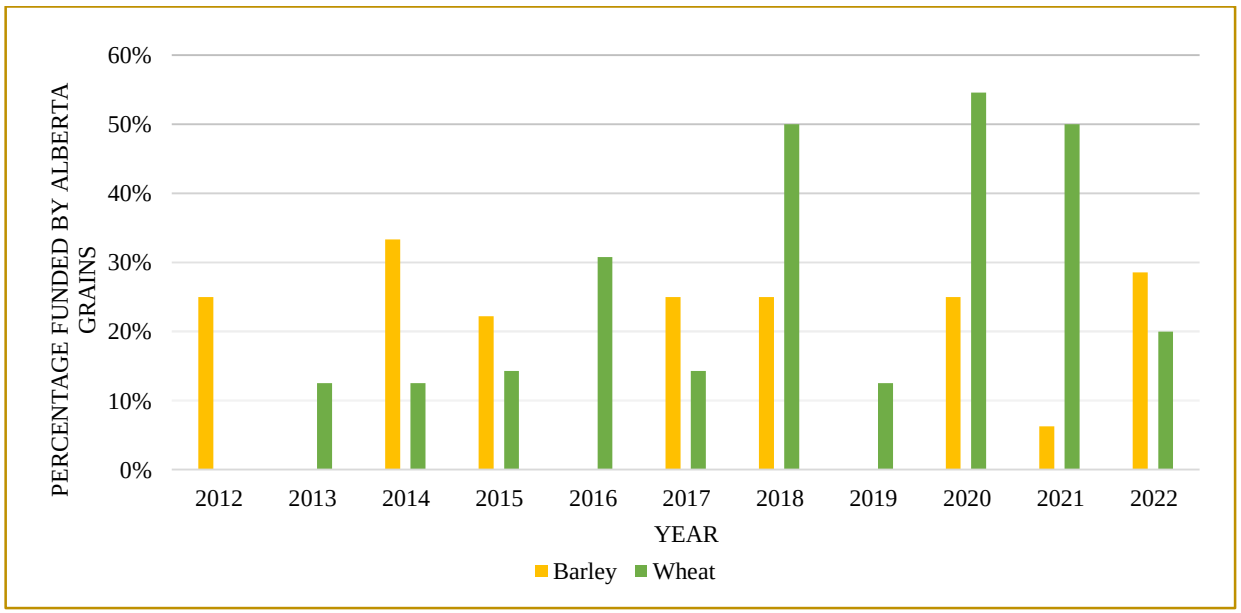
Figure 4: Sorting the varieties for analysis



† Varieties registered as far back as 2020 have negligible impact on the analysis as adoption is barely getting started.

Considering only those varieties that were both registered and showed evidence of commercialization, 14.44% of barley and 24.68% of wheat varieties were co-funded by Alberta Grains. Even when a variety was commercialized, it may have little or no market effect if it is not actively taken up and used by farmers. Given that the data about seed adoption is far from perfect, we were forced to trim the varieties under discussion to keep only a total of 20 varieties of barley and 31 of wheat in the direct economic valuation. Of these, 50% of barley and 61% of wheat varieties were directly funded by Alberta Grains. Evaluating the proportion of varieties funded by Alberta Grains gives insight to the forward trajectory of Alberta Grains plant breeding research investment portfolio. Figure 5 provides detailed analysis of the percentage of varieties registered with ties to Alberta Grains funding. Years of marked success include 2018-22 for wheat and 2014, 2017, 2018, 2020, and 2022 in the case of barley.

Figure 5: Alberta Grains share of all new registered varieties of wheat and barley, by year



From 2012-22, 31 wheat varieties included in the analysis for this report were sown on 41,479,971 acres cumulatively in Alberta, Saskatchewan, and Manitoba representing 36.08%, 15.60%, and 22.71% of total wheat acres, respectively. The 20 barley varieties were sown on 4,994,201 acres from 2012-22, representing approximately 10% of total acreage in the prairie provinces.

Given the average three-year lag between research and commercialization, we have broken the study period into 2012-14 and 2015-22 and have made some forecasts of benefits that will accrue in the near future (2023-27) (Table 12). Of the 38 varieties of wheat and 13 varieties of barley registered, 19 wheat and 13 barley varieties reached adoption levels necessary to meet the acreage share inclusion criterion. Within the primary economic assessment, these barley varieties funded by AG were sown on 763,616 acres across the prairies while the AG-funded wheat varieties were sown on 7,375,751 acres. It is projected that 2,890,649 acres of barley and 22,831,034 acres of wheat will be sown to varieties funded by AG during the forecast period.

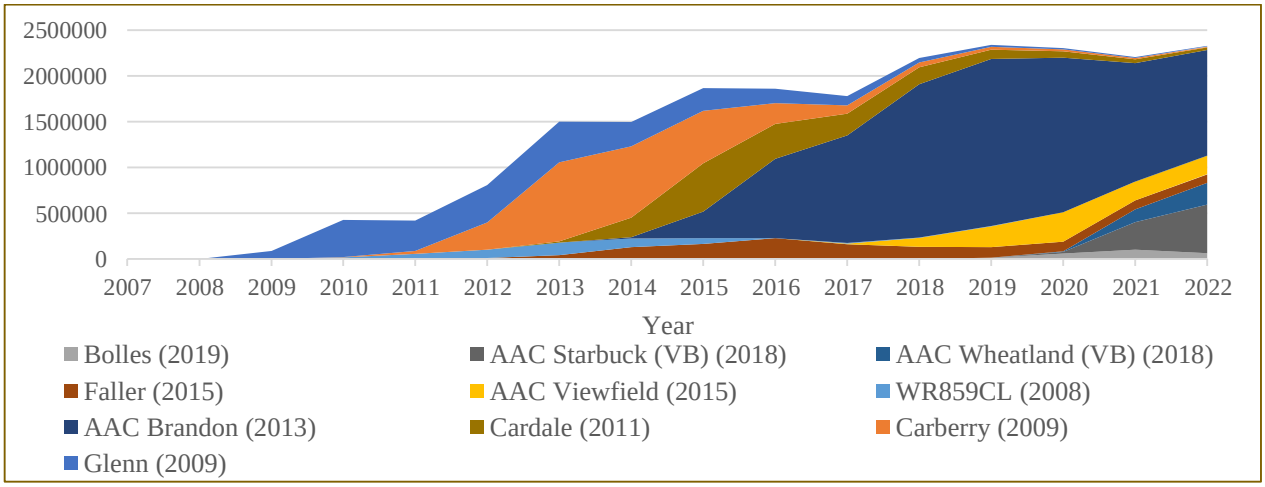
Table 12: Estimated acreage to barley and wheat, by provenance of seed

	All	AG supported	AG % total
Barley			
Number of new varieties	90	13	14%
Actual Acreage 2015-22	9,534,116	560,297	6%
Forecast acres, 2023-27	21,396,495	2,890,649	14%
Wheat			
Number of new varieties	154	38	25%
Actual Acreage 2015-22	32,727,759	7,375,751	22%
Forecast acres, 2023-27	88,308,220	22,831,034	26%

4.3.3 Adoption

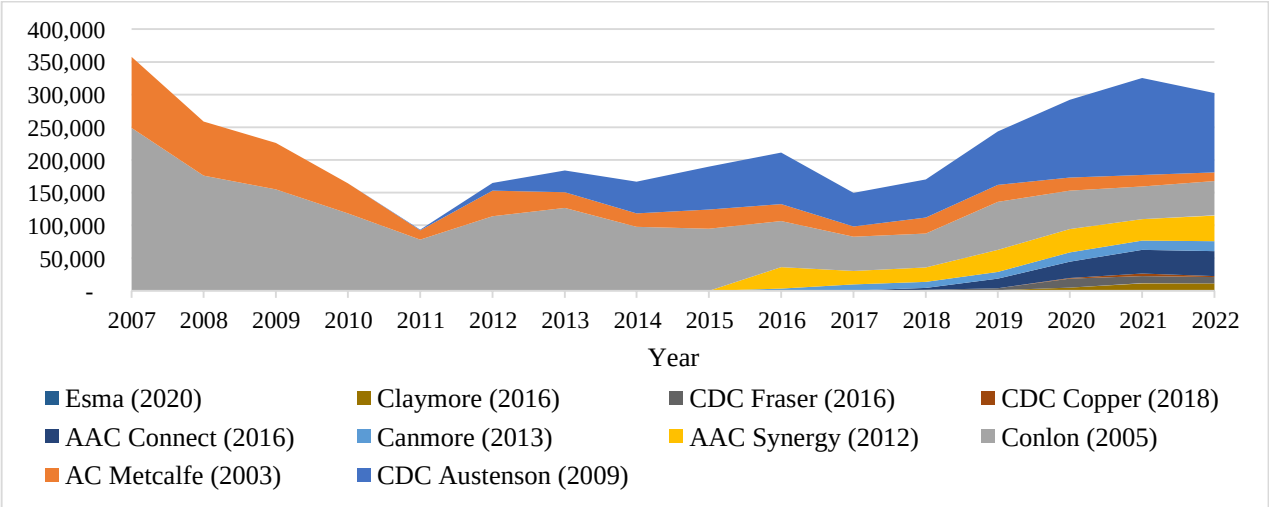
The lifespan of commercialized varieties of wheat and barley is another major driver in the lag between initial investment and realized returns. Observing the peak acreage share of varieties in relation to their year of registration provides multiple insights on the duration between commercialization a broad adoption. Figure 6 displays the acreage share of the top five varieties of wheat across western Canada throughout the period of study, with year of registration provided in parentheses.

Figure 6: Acreage volumes of wheat varieties demonstrating varietal lifespan



As can be observed, the tapering off period from peak adoption to obsolescence takes upwards of 10 years for some popular varieties. Figure 7 shows a similar picture for barley varieties. The time elapsed between varietal registration and peak acres for barley ranges from 7 to 12 years; however, some barley varieties remain in the market for up to 15 years.

Figure 7: Acreage volumes of barley varieties demonstrating varietal lifespan



Many factors undoubtedly influence rates of varietal adoption and relevancy. One driving factor is the use of bin-run seed. Data detailing the pedigreed seed market acreage shares in Manitoba were obtained from MASC. Alberta and Saskatchewan do not track this data. On average, certified seed was planted on 2.65% of the seeded acres of hard red spring wheat and 2.79% of barley acres in the study period. In many years, the top certified variety did not comprise even 1% of the total market share, which is clear drag on uptake and use of new higher yielding varieties.

A few points are worth noting:

- Varieties funded from any source appear in any of the prairie seed guides with a 50% success rate for barley and an 88% success rate for wheat.
- If a variety received Alberta Grains funding the seed guide appearance rate increases to 86% and 100% for barley and wheat, respectively.

This analysis reveals that wheat and barley production is highly influenced by one or two dominant varieties, with these varieties reducing the likelihood of new variety adoption for upwards of a decade. As an example, in 2007 Conlon barley accounted for 71% of the 350,000 acres, while in 2021, CDC Austenson accounted for 21%. Comparably, from 2018-2020, wheat production was dominated by ACC Brandon, accounting for 23%, 30% and 27% of acres, respectively. The prairie-wide popularity of dominant varieties negatively impacts the adoption of subsequent commercialized varieties for short periods of time. This may result in the investment in new varieties failing to reach their full potential due to sub-optimal adoption.

5. Economic Impact

5.1 Farmer Returns from New Varieties

5.1.1 Yield gains from new varieties

Many of the new traits in new varieties influence yield. The primary methodological consideration for determining accurate yield indices was maintaining a consistent check variety. Check varieties changed multiple times throughout the period of study – three times for wheat and twice for barley in Saskatchewan and Alberta, and once for wheat and zero times for barley in Manitoba. The values for Manitoba were reported in bushels per acre, allowing AC Metcalfe to be used as the check variety for barley throughout the period of study, matching AB and SK methodology. All values are reported as indices to remove general agronomic gain from consideration.

AC Metcalfe is the reference check variety throughout the barley spreadsheet in all provinces while AC Barrie assumes this role for wheat. When check varieties changed, an index was developed for the new check variety relative to the old, using Equation 1.

Equation 1: Check variety re-indexing formula

$$NC_{mult} = \frac{AY_{index}}{100}$$

Where:
NC_{mult}= New check multiplier.
AY_{index}= Average yield index from all years in which the new check was compared to AC Barrie or AC Metcalfe.

Using the average of yield of the new check variety, during years in which it was referenced to the previous check variety, provides a yield index to compare all new varieties. By indexing all new varieties to respective check varieties we can identify actual yield growth from plant breeding efforts. This method was adapted from the work of Groenewegen, Thompson, and Gray (2016).

5.1.2 Yield Improvements

Delving deeper into the issue of improvements to overall commodity class yields throughout the period of study provided results in line with expectations. Throughout the period of study, wheat yield grew by 1.14%, 1.29% and 0.97% per annum in Alberta, Saskatchewan, and Manitoba, respectively. Meanwhile, barley yields in Alberta and Manitoba recording annual yield increases of 0.97% and 1.00%, respectively; Saskatchewan yields grew 0.86% per annum. These yield gains are displayed in Table 13. These results can be used with moderate certainty as only the 86 varieties of wheat and 35 varieties of barley for which yield figures were tabulated are included in these results.

Table 13: Average annual yield gain of wheat and barley by province, 2012-22

	AB	SK	MB
Wheat	1.14%	1.29%	0.94%
Barley	0.97%	0.86%	1.00%

It should be noted that these yields are indexed in the varietal trials data collection, eliminating the potential for agronomic gain to drive results. This implies that farmers in Manitoba and Saskatchewan experience higher yield gains, relative to Alberta, allowing these provinces to gain from varietal development to a greater degree.

5.1.3 Adoption and lags

The pace of varietal adoption, that is, the rate at which varieties gain popularity post-commercialization, is often slow. This benefits varieties that gain significant acreage shares by affording long-term success; however, it places new varieties at a decided disadvantage when attempting to enter the market. Additionally, it creates further hurdles in arriving at an accurate return on investment on research investments. Multiple metrics illustrating the rate of adoption

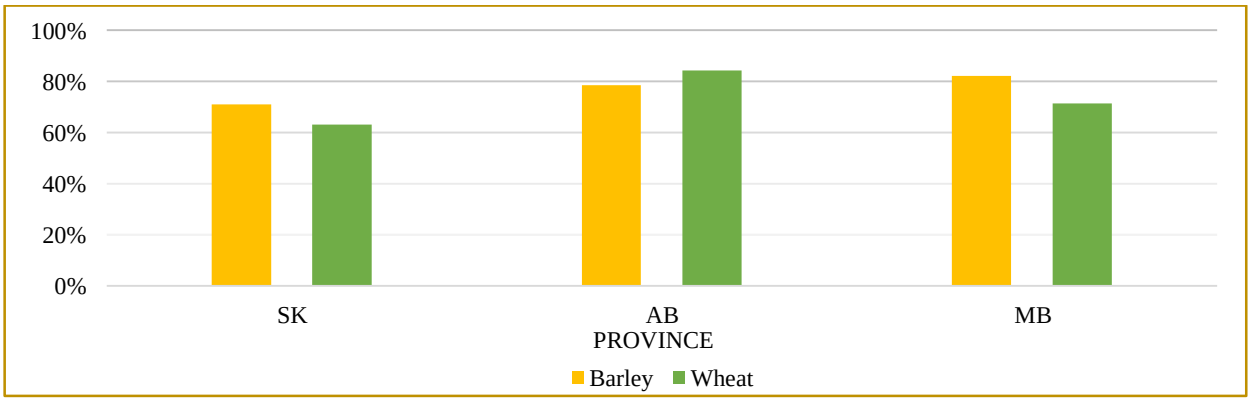
and acreage shares of broadly adopted varieties were tabulated. First, the acreage distribution relative to the period of study were calculated, the values are in Table 14. The values display the vast acreage shares of varieties registered prior to 2012, with most acreage comprised of earlier varieties for both barley and wheat in all three provinces.

Table 14: Acreage distributions relative to the period of study

	AB	SK	MB
Total Wheat Acres	**46,448,313**	**116,336,698**	**35,445,586**
Registered pre-2012	39,151,877	73,467,435	25,313,280
Percent of total wheat	*84.29%*	*63.15%*	*71.41%*
Registered 2012-23	7,296,436	42,869,263	10,132,305
Percent of total wheat	*15.71%*	*36.85%*	*28.59%*
Total Barley Acres	**21,117,575**	**21,334,552**	**4,472,023**
Registered pre-2012	16,569,084	15,158,393	3,671,557
Percent of total barley	*78.46%*	*71.05%*	*82.10%*
Registered 2012-23	4,548,490	6,176,159	800,465
Percent of total barley	*21.54%*	*28.95%*	*17.90%*

These descriptive statistics display how dominant early varieties are when analyzing market share. Figure 8 displays how the overwhelming majority of acres between 2012-22 were planted to wheat and barley varieties registered prior to 2012. Across the prairies, the phenomenon was experienced to a greater degree for wheat than for barley. However, these findings are insightful considering the period of study.

Figure 8: Acreage share (2012-22) of wheat and barley varieties registered prior to 2012

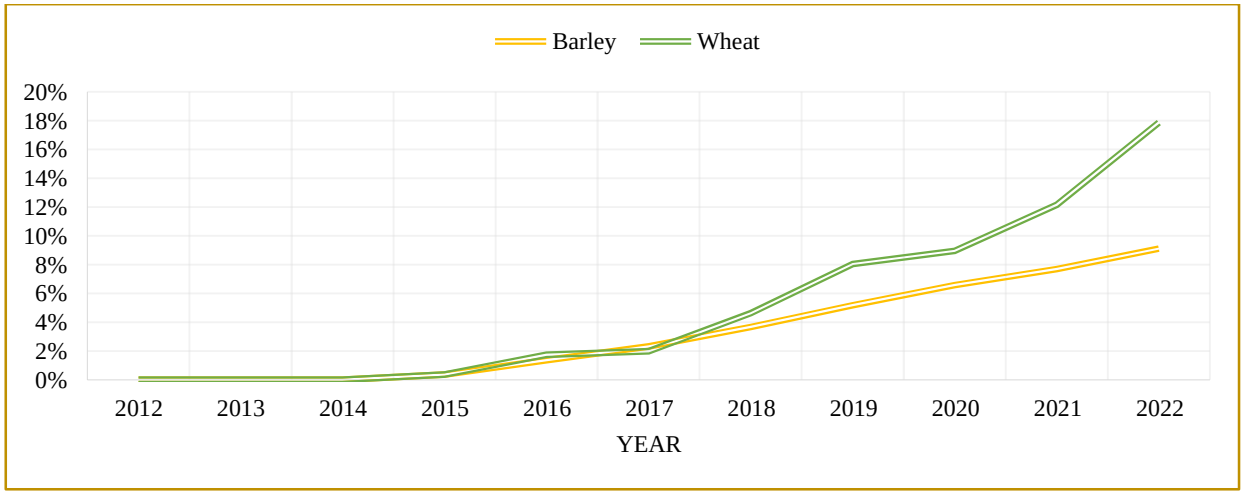


The second metric supporting the methodology of economic valuation analyzes a subset of top performing varieties apart from the main valuation to better demonstrate adoption trends. As such, the top five varieties for both barley and wheat – based on the cumulative percentage of acres dedicated to each variety across the prairies – were subject to further analysis. Findings indicate that the top five varieties for wheat comprise nearly 60% of the acreage share across the prairies, with four out five of these varieties registered prior to 2012. The results for wheat are not entirely dissimilar to that of barley, with three of five varieties registered prior to 2012.

However, wheat varieties did not command the market share of the top five barley varieties, with only one-third of acreage held by these top five varieties. Nonetheless, these statistics display the domination of several varieties over the entirety of the market.

A final factor highlighting how the timeframe influences the assumptions required in the economic valuation is the annual trend in acres planted to varieties funded by Alberta Grains between 2015-22. It is expected the inclusion of the years 2012-14 would not influence direct value creation to a substantial degree as a result. Figure 9 displays the upward trend in acres dedicated to Alberta Grains funded varieties.

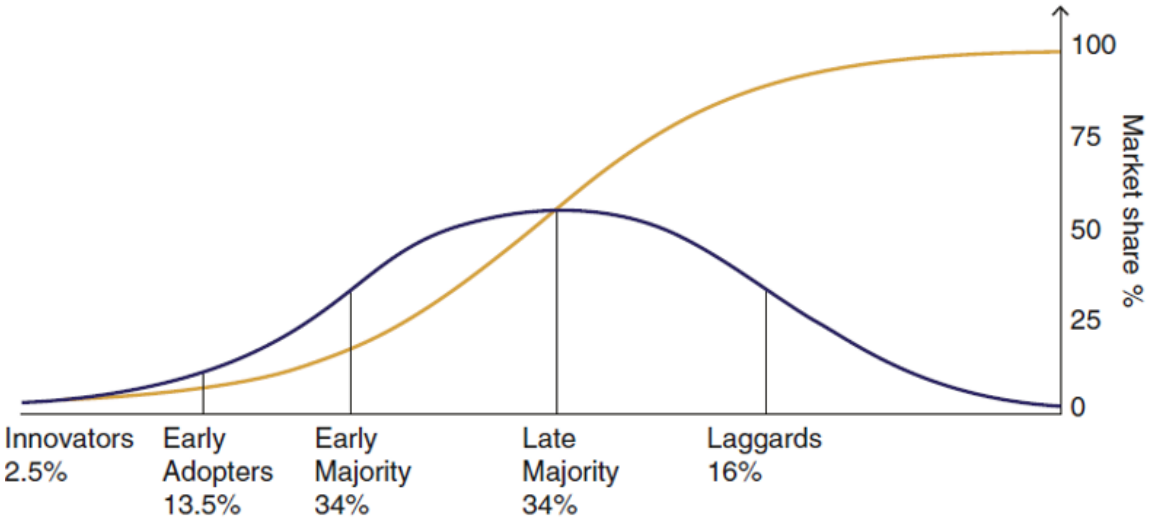
Figure 9: Acreage share of wheat and barley varieties funded by Alberta Grains



The revised timeframe, considering only varieties registered after 2014, accounts for a far lesser proportion of the total acres sown to wheat and barley in the prairie provinces. This was done as the varieties commercialized in 2012, 2013 and 2014, were unlikely to have received AG funding that contributed to commercialization.

We extended the period of impact in the analysis to 2023-27 (Figure 10). We base our projections on theory and evidence, both which suggest that most innovative products follow an adoption curve, where innovators and early adopters reduce a new product to practice and demonstrate the value to many adopters who come later.

Figure 10: Timing of adoption of technological innovations (adopter categorization)



Source: Rogers' diffusion of innovations theory (2003).

When we investigated the introduction and profile of adoption for 60 varieties of wheat and 47 barley varieties in our database, we found the average lag to maximum adoption was 3.7 years for wheat and 3.9 for barley, with the mode of 3 for each (Table 15). This suggests there is a bit of a bias to slower adoption than the theory would suggest. Upon visual inspection, those varieties that gained the largest market shares of both crops were slower to reach the peak, had longer plateaus of high adoption and a slower tailing down of market share. Many varieties, especially barley varieties, were active and competitive for a decade or more.

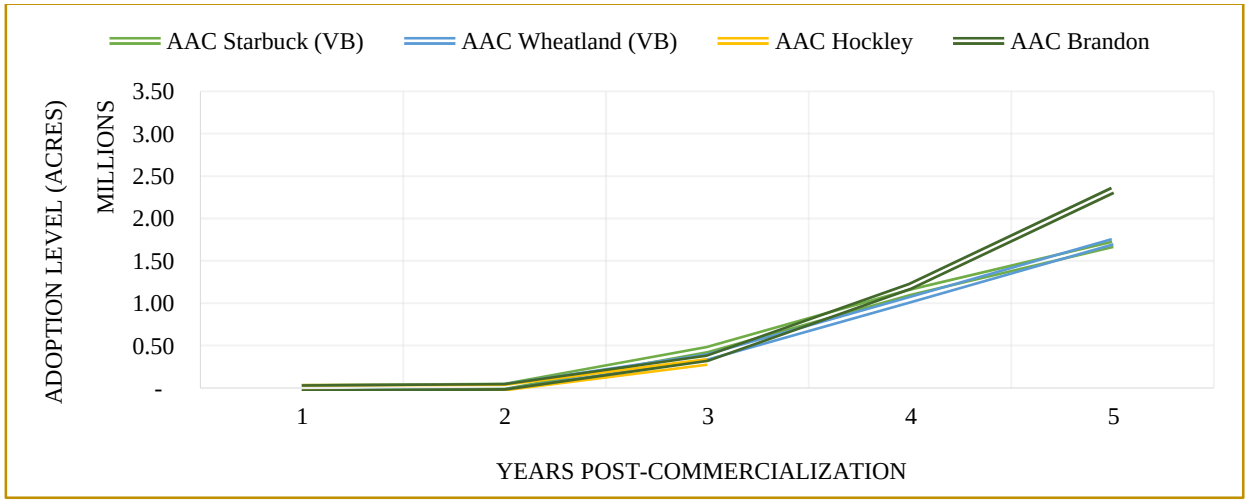
Table 15: Number of years to reach maximum adoption for new varieties since 2011

Number of years to reach maximum adoption	Distribution of wheat varieties	Distribution of barley varieties
2	10	10
3	22	16
4	14	8
5	6	4
6	5	3
7	3	3
8	0	3
Average	3.7 years	3.9 years

Prospects for returns on Alberta Grains investments include several promising varieties in which Alberta Grains funding facilitated varietal development. Wheat varieties showing potential to become market leaders include AAC Hockley, AAC Wheatland, and AAC Starbuck. The market share of these varieties, summed across the prairies, is graphed relative to AAC Brandon in Figure 11. AAC Brandon created the largest ROI of any variety, wheat or barley, included in this analysis. As such, the results display that these three varieties of wheat are on similar trajectories

to that of AAC Brandon in the years following initial release, implying these varieties may create significant ROI in the years to come.

Figure 11: Adoption of AAC Brandon, AAC Hockley, AAC Starbuck, and AAC Wheatland in the first five years post commercialization



We constructed a forecast for adoption for 2023-27 (Table 16). We used an 11-year moving average for total acres as the base, allowed for significant growth in market share for AG varieties based on past performance of new varieties (see Figure 9), yields of AG varieties are known from the 2015-22 period, check yields (which are a function of weather and agronomic factors in the historical period) are simply extrapolated as average. Prices are pulled from Statistics Canada.

Table 16: Forecast acreage for AG grain varieties, 2023-27

Commodity	**Acres (2015-22)**	**Acres (2023-27)**
Wheat seeded to commercial varieties	138,954,290	88,308,220
AG wheat varieties seeded	13,200,396	22,831,034
Percent of total AG	9.49%	26%
Barley seeded to commercial varieties	34,130,011	21,396,495
AG barley varieties seeded	1,619,574	2,890,649
Percent of total AG	4.74%	14%

5.1.4 Assumptions for valuing the AG varietal development investments.

The value of new varieties is a function of:

1. The net gain in yield between the new variety and the check variety.
2. The rate of adoption of the variety (in terms of time, market share and total acreage).
3. The economic life of the new variety.
4. Market prices.
5. Spill-out of knowledge that others use to improve future varieties.

Given the nature of research, once we have an aggregate return from new varieties, we need to consider how to attribute that value to various contributors. There are two main considerations. First, most new varieties are derived from a long and expensive research process. Those costs need to be acknowledged. In this analysis we call those research **spill-ins**. None of the new varieties we are considering are the sole result of AG funding. All projects are jointly funded with others. Overall, AG contributed about 35% of the direct funds to deliver the final product, but we are fairly certain we have undercounted the matching funds. So only 20% of the total returns are attributed to AG in the base case. Table 17 highlights the key assumptions used to assign a value to AG's varietal development program.

Table 17: Key evaluation assumptions

Research Lag	**Three Years**
Attribution factor	0.20 (20%)
Spill-ins	0.20 (20%)
Spill-outs	0.02 (2%)

The Alberta funded research is important, but relatively small. Using the Web of Science data, we can see that in the 2020-23 period, the world employed an estimated 2,750 people years (PY) of research. AG research supports a tiny portion. Much of the research results achieved by AG supported scientists depends on the contributions of this larger system. While we are not able to come up with a definitive percentage, one starting point is to assume that 80% of the benefit we are identifying should be assigned to other sources of knowledge (Table 18).

Table 18: Estimates of global research effort for barley and wheat

2020-2023	**Barley**	**Wheat**
Articles	~1,785 papers annually	~9,150 articles annually
Authors	By 7,138 authors	By 36,640 authors
Average authors per article	4	4
Converting to PY @0.25 py per article	Est. 450 py	Est. 2,300 py

In assigning a dollar value return to the research investments made by Alberta Grains, it is important to remember that AG funded at most 35% of the effort to deliver the varieties identified. Our base case assumes that only 20% of the estimated value is due to AG support. We lowered our base estimate to account for obvious undercounting of research effort by the leveraging partners. Given the check-off data shown above in Section 2, it is clear that each

partner collaborates selectively to advance their research, such that few programs are stand alone. Below we undertake a sensitivity analysis to show the impacts of higher or lower attribution.

Finally, there are **spill-outs**, as current research becomes the base for future success. Following Gray et al. (1999) an index was developed to attribute a portion of yield gains to current plant breeding efforts, with the remainder being attributed to past varietal development prior to the study period. Adhering to the methodology of Gray et al. (1999) and considering the small share of global research coming from the AG system, we started with 2% as the spill-out from their effort on the two Canadian sectors.

5.1.5 Estimating the annual impacts of new AG supported varieties

These valuations are limited to the 20 varieties of barley and 31 varieties of wheat deemed relevant for the economic analysis. Expanding the analysis to include spill-out values for all the unaccounted varieties is necessary. As such, the 8,770,500 acres and 23,784,974 acres sown to varieties of barley and wheat, respectively, registered between 2015-22 were accounted for. Indices were developed to exclude varieties registered prior to 2015 from this valuation. Using the base 2015-22 valuation, it was determined directly funded projects yielded gross returns of $8.05/acre for barley and $12.24/acre for wheat. The subsequent spill-out values were determined to be $0.65/acre and $0.93/acre for wheat and barley, respectively. Using the unaccounted-for acres and per acre spill-out values produces additional spill-out values the economic value created by Alberta Grains in the base-case scenario is *$20,869,441*.

Undoubtedly, the investments made by Alberta Grains in the categories of varietal development and agronomic advancement have made a meaningful impact on wheat and barley within western Canada. We have estimated the impact in two ways. First, we constructed the aggregate outlays and returns for the AG varietal development program in current dollar terms and used Equation 2 to estimate the internal rate of return for the investments.

Equation 2: IRR formula

$$0 = \text{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0$$

where:

C_t = Net cash inflow during the period t

C_0 = Total initial investment costs

IRR = The internal rate of return

t = The number of time periods

A more robust measure of economic value, the internal rate of return (IRR), calculates the interest rate required to set a series of investment payoffs equal to zero. In determining the wider economic impact, that is, the total GDP generated through Alberta Grains value creation in the crop production sector IRR is employed. The gross value created in each year was tabulated, with the attribution and spill-ins applied to both the direct impacts and the spill-outs. Annualized Statistics Canada Final Domestic Demand GDP deflators were used to derive the final gross

economic return under the base-case scenario. Annual value creation to be used in IRR calculations – in current dollars – is contained (Table 19).

Table 19: IRR analysis using current $

Year	Wheat returns	Barley returns	Total returns	AG Costs	Net return
2012	$0	$0	$0	$0	$0
2013	$0	$0	$0	$0	$0
2014	$0	$0	$0	-$929,860	$929,860
2015	$60,843	$5,621	$66,464	-$1,060,000	$1,126,464
2016	$330,586	$59,231	$389,816	-$284,998	$674,814
2017	$703,816	$93,862	$797,678	-$292,000	$1,089,678
2018	$1,672,014	$128,011	$1,800,025	-$1,334,247	$3,134,272
2019	$2,969,406	$282,324	$3,251,730	-$2,820,858	$6,072,588
2020	$2,820,438	$264,542	$3,084,980	-$11,249,435	$14,334,415
2021	$3,552,197	$372,171	$3,924,368	-$883,520	$4,807,888
2022	$12,320,777	$648,310	$12,969,088	-$383,250	$13,352,338
2023f	$10,732,667	$927,429	$11,660,096	-$204,598	$11,864,694
2024f	$12,789,927	$1,017,417	$13,807,344	$0	$13,807,344
2025f	$14,767,227	$1,162,772	$15,929,999	$0	$15,929,999
2026f	$16,898,168	$1,319,927	$18,218,095	$0	$18,218,095
2027f	$19,182,752	$1,488,882	$20,671,634	$0	$20,671,634
2012-22	***$24,430,076***	***$1,854,072***	***$26,284,148***	***-$19,238,168***	***$45,522,316***
2012-27f	***$98,800,818***	***$7,770,499***	***$106,571,317***	***-$19,442,766***	***$87,128,551***

Combining the returns and costs, the IRR was determined to be **8.49%** across the period of study.

Second, we took the same time series data, converted to 2022$ and used Equation 2 to determine the IRR while used Equation 3 to determine ROI.

Equation 3. ROI Formula

$$ROI = \frac{Gross\ Return - Initial\ Investment}{Initial\ Investment}$$

It was established that the investments made by Alberta Grains to support varietal development totaled $21,733,420 from 2012 through 2027. Using this figure, combined with the 2015-27 base-case scenario gross value, the ROI was determined to be **377.89%** (Table 20).

Table 20: Rate of Return analysis using inflation adjusted estimates, 2022$

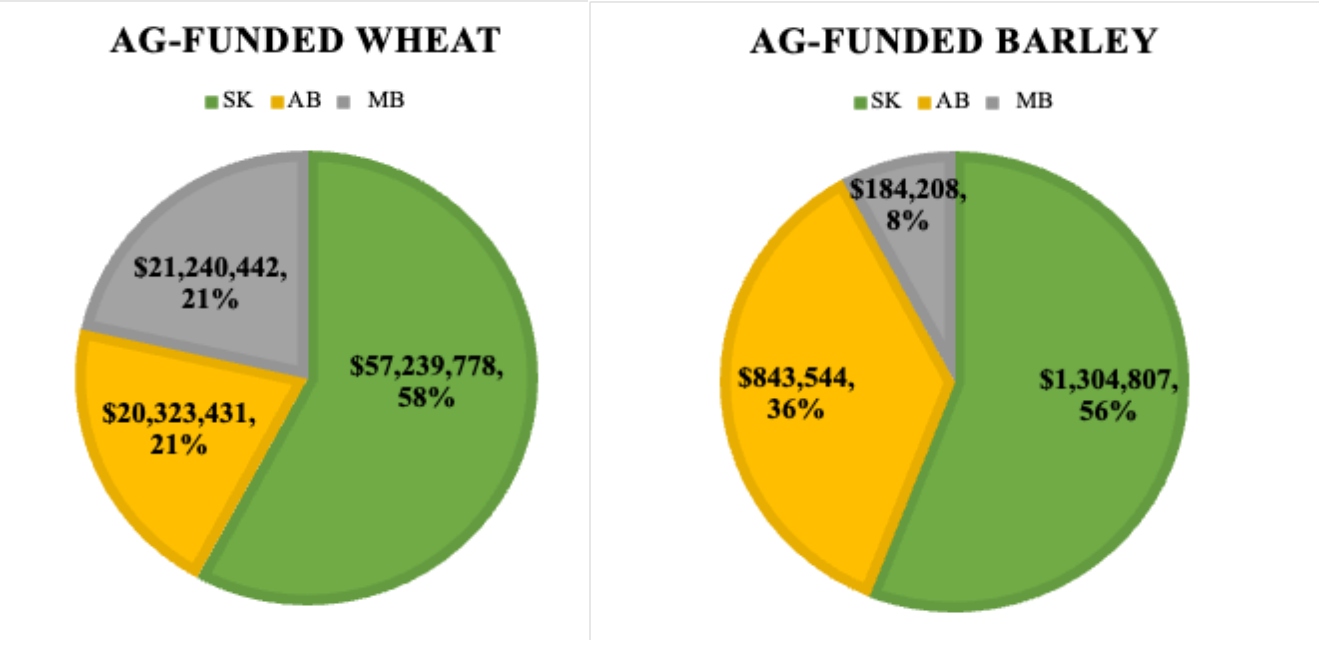
Year	Wheat returns	Barley returns	Total returns	AG Costs	Net return
2012	$0	$0	$0	$0	$0
2013	$0	$0	$0	$0	$0
2014	$0	$0	$0	$1,127,103	-$1,127,103
2015	$72,606	$6,707	$79,313	$1,264,916	-$1,185,604
2016	$390,763	$70,013	$460,776	$336,877	$123,899
2017	$820,298	$109,396	$929,694	$340,326	$589,368
2018	$1,917,447	$146,802	$2,064,249	$1,530,100	$534,149
2019	$3,343,926	$317,933	$3,661,858	$3,176,642	$485,216
2020	$3,116,506	$292,311	$3,408,817	$12,430,315	-$9,021,498
2021	$3,782,957	$396,349	$4,179,305	$940,916	$3,238,390
2022	$12,320,777	$648,310	$12,969,088	$383,250	$12,585,838
2023f	$10,647,487	$920,069	$11,567,556	$202,974	$11,364,582
2024f	$12,441,563	$989,706	$13,431,269	$0	$13,431,269
2025f	$14,077,433	$1,108,457	$15,185,890	$0	$15,185,890
2026f	$15,777,935	$1,232,425	$17,010,360	$0	$17,010,360
2027f	$17,550,551	$1,362,198	$18,912,749	$0	$18,912,749
2012-22	***$25,765,280***	***$1,987,821***	***$27,753,100***	***$21,530,445***	***$6,222,655***
2012-27f	***$96,260,248***	***$7,600,675***	***$103,860,923***	***$21,733,420***	***$82,127,504***

The base case will be used extensively in the economic valuation contained in the report. Sensitivity analysis will be performed to display the impact each index has when values are altered, adding to the validity of the results while providing alternative valuations. Scenario and sensitivity analyses will be further discussed in the sections that follow.

5.1.6 Distribution of value across the provinces

Differences in varietal adoption and acres sown were prevalent between the provinces under study. As such, the gross economic returns from directly leveraged investments, excluding spill-outs, differ for each province. The acres planted to wheat in each province far exceed those of barley, driving the results in Figure 12. Moreover, the per acre value created by each wheat variety funded by Alberta Grains averaged $12.24 compared to a value of $8.05 per acre for barley in 2015-22. Economic returns differ substantially between provinces, displaying the widespread impact of Alberta Grains funding across neighboring provinces.

Figure 12: Provincial portions of direct value creation through wheat and barley, 2015-22



Manitoba realizes the lowest economic return from Alberta Grains plant breeding investments, dedicating far fewer acres to both barley and wheat than Alberta or Saskatchewan. Saskatchewan realizes the most value from Alberta Grains investments into varietal development. Given that Albertan farmers planted the largest proportion of the largest number of acres to varieties receiving funding from Alberta Grains, these results may appear counterintuitive. However, Saskatchewan had the highest yield growth for wheat from 2015 to 2022. Realized grain yields for barley grew at a slower rate in both Saskatchewan and Manitoba throughout the period of study. Gains in forage yield were not accounted for in this segment of the economic analysis.

The gross value created by all varieties commercialized between 2015-22 is displayed in Table 21. Alberta grains can reasonably claim credit for about 16% of the value. While a portion of the value attributed to Alberta Grains spilled out and was realized by Saskatchewan and Manitoba producers, Alberta producers gained from spill-ins of the much larger value created by AG's research partners. In short, Alberta producers gain from this two-way trade, realizing higher returns than if it attempted to undertake researcher alone.

Table 21: Provincial distribution of gross value created by varieties commercialized 2015-22

	Gross Economic Value		
	AB	**SK**	**MB**
Total value of new varieties	$126,776,928	$402,582,706	$121,348,377
Value attributed to Alberta Grains	$21,166,858	$58,544,585	$21,424,650
Value attributed to research partners	$105,610,070	$344,038,121	$99,923,727

5.1.7 Sensitivity analysis, 2012-27

Considering the assumptions required to perform an economic analysis of plant breeding return, namely the attribution and spill-out rates, sensitivity analysis is required to test the impact of parameters on final values. As such, two separate sensitivity analyses were conducted to demonstrate the effect of changes in our base assumptions on the final estimates of impacts. Accompanying the base scenario of 20% for direct indices we used a range of values between 10% and 30% for the attribution rate. We also bounded the 2% spill-out base case with scenarios ranging from 1% to 3%. This provides proportional incremental changes in both indices relative to the respective base scenario.

Associated to the sensitivity analyses, several scenarios were established to provide a range of values to the users of this report. The direct and indirect indices were modified by 5 and 0.5 percentage points, respectively, providing value ranges that match the sensitivity analyses. Given the simultaneous alterations of key indices, the range of gross returns provided in the scenario analysis is larger than that of the sensitivity analysis. This displays the importance of arriving at an accurate index for both leveraged and spillover returns.

Given that the attribution indices are necessary to determine the gross per acre returns, they influence the direct, spillover and secondary spillover calculations required to reach a final gross economic return to plant breeding investments. Consequently, their impact is uniform when following an incremental range of scenarios. Nonetheless, the scenario analysis provides the reader with a variety of alternative valuations while testing the accuracy of the base-case scenario (Table 22). The internal rates of the return were estimated at 8.5% in our base case and ranged from a low of 4.9% with the lowest feasible attribution and spill-out rates to as high as 10.6% with the highest attribution and spill-out rates.

Table 22: Impact of different attribution and spill-out rates on IRR

Attribution rate	**Spill-out rate**				
	1%	**1.5%**	**2% (BASE)**	**2.5%**	**3%**
10%	4.94%	5.28%	5.60%	5.91%	6.21%
15%	6.75%	7.00%	7.24%	7.48%	7.70%
20% (BASE)	8.10%	8.30%	**8.49%**	8.68%	8.86%
25%	9.17%	9.34%	9.50%	9.66%	9.82%
30%	10.07%	10.22%	10.36%	10.50%	10.63%

The return on investment varied considerably under the variety of scenarios and sensitivity analyses conducted, ranging from a low of 139% to as high as 617% (Table 23).

Table 23: Impact of different attribution and spill-out rates on ROI

Attribution rate	Spill-out rate				
	1%	**1.5%**	**2% (BASE)**	**2.5%**	**3%**
10%	139%	155%	171%	187%	203%
15%	242%	258%	275%	291%	307%
20% (BASE)	346%	362%	**378%**	394%	410%
25%	449%	465%	481%	497%	514%
30%	552%	568%	584%	601%	617%

When comparing the sensitivity analyses the results align with author expectations given the characteristics displayed regarding the adoption of new varieties throughout the period of study.

5.2 Returns to Investments in Agronomic Improvement

About $17.8 million or 48% of the AG investments were directed to a broad range of activities directed to more general agronomic improvement, including pre-breeding innovation, commercialization and adoption, farm management and market use. The distribution of funds and the number of projects by each category year by year reflect the AG's response to the shifting agricultural landscape. The data shows a pivot towards certain research areas as new challenges emerge and priorities shift. Ultimately a significant share of the funds goes to wages and salaries for both highly skilled researchers, but also for the training of new workers. Those investments have a much longer payback period and are likely widely diffused in the sector in Canada and globally.

Assigning specific values to these are complicated. First, we explore the range of investments, identifying wherever there are known quantitative estimates of the impact. We conclude with a simulation applying a base rate of improvement in agronomics to the two crops and then simulate the impact of different rates.

5.2.1 Investments in and around grains research, commercialisation, and marketing

AG has made several noteworthy investments in a range of venues that one could reasonably categorize as pre-breeding.

- Early on in 2013, AG joined with other groups to fund several core agreements, clusters, and chairs, generating significant research capacity and new platforms designed to support and facilitate long-term research. This has supported a host of research efforts, including the $19.2 million varietal development program assessed in Section 5.1.
- AG has also invested heavily in crop establishment and growth, with over 80 projects, reflecting a strategic long-term approach to enhancing agricultural foundations. Significant investments have been directed towards breeding programs that focus on Fusarium Head Blight (FHB) resistance and reduced DON (deoxynivalenol) accumulation. Such efforts are very important in developing wheat varieties that meet high-quality standards and exhibit enhanced disease resistance.

- Precision agriculture and the integration of technology represent a forward-looking investment by AG. These projects, which involve genetic research and plant physiology, aim to optimize crop development, and respond to specific environmental stresses.

AG has contributed both directly and indirectly to more efficient and effective commercialization and adoption of new varieties. Value creation in producer resources, agronomic research and crop resilience can be quantified in numerous manners and are often interrelated. Producer resources, those aimed at promoting best practices, tangentially drive the adoption of new varieties.

Yield gain in barley and wheat has been relatively slower than for corn, soybeans, and canola, among other competitive crops. Many factors undoubtedly influence rates of change. One driving factor is the use of bin-run seed. Data detailing the pedigreed seed market acreage shares in Manitoba were obtained from MASC (Alberta and Saskatchewan do not have comparable data). On average, pedigreed seed was planted on 2.65% of the seeded acres of hard red spring wheat and 2.79% of barley acres in the study period. In many years, the top pedigreed variety did not comprise even 1% of the total market share, which is clear drag on uptake and use of new higher yielding varieties.

There are several ways we can assess whether better farm-level advice helps keep the sector competitive. A significant number of new varieties never get used by farmers. We noted above that only 50% of registered barley varieties and 88% of wheats registered appear in any of the prairie seed guides. That is a relatively high product failure rate. The positive news for AG is that those new varieties supported by Alberta Grains have a much higher success rate. Of all the varieties developed using AG funds, 86% of barley and 100% of wheat varieties registered are presented for sale in the seed guides.

The next consideration is whether these varieties are adopted and used. Table 24 offers one glimpse of the behaviour of western Canadian farmers during 2011-22.

Table 24: Varietal adoption behaviours of western Canadian farmers, 2011-22

Year	Varietal Registrations	Number Varieties Adopted	Average Lag (Years)	Varieties Unused
2011	10	9	2.44	1
2012	8	4	1.33	4
2013	5	3	1	2
2014	8	2	3.5	6
2015	4	1	0	3
2016	8	5	0.8	3
2017	5	3	1.33	2
2018	7	2	1.5	5
2019	6	3	1.33	3
2020	9	3	1.33	6
2021	9	2	1.5	7
2022	11	2	.5	9
2011-14	***31***	***18***	***2.11***	***42%***
2015-22	***59***	***21***	***1.09***	***64%***

These results suggest farmers have gotten more selective in the post-2015 period, adopting less than one-third of new varieties released and commercialized in this period, compared with almost 60% before. Moreover, the average lag for adoption has dropped from 2.1 years to 1.1 years, implying that investments to hasten the pace of varietal adoption have positively impacted value creation at the farm level. Our modelling assumed that adoption would occur on average three years after the research investment. If this change in adoption is generalized, it may take up to a year out of that lag, which all other things holding constant, should help to bump up the rate of return on all plant breeding for barley and wheat.

AG has also invested in a range of projects that should help farms more effectively and efficiently adopt and use new varieties. The range of projects includes:

- The 'pest management and disease control strategies' category, with around 40 projects is a need-driven response to emergent agricultural challenges.
- Work on the management of herbicide resistance issue, a growing concern for modern agriculture, contributing to the development of long-term, sustainable weed control strategies.
- The development of diagnostic tools and pathogen monitoring systems has been another focus, showcasing a proactive stance on crop health management. Such diagnostic capabilities are crucial for early detection and effective response to crop diseases, thereby maintaining crop yield and quality.

While we have no specific evidence of the impacts of these projects, we know from other research that farmers are applying genetics, machinery, chemicals, and farm management models to improve the resilience of farms. A set of recent studies suggest western Canadian farmers, especially in Alberta and Manitoba, have significantly reduced their environmental footprint. Lika et al. (2024) showed that farmers have reduced their Environmental Impact Quotients by refining their uses of genetics, chemicals, and rotation. For example, the impact of in-crop herbicides applied in Saskatchewan between 2016-2019 is 65% lower than those applied between 1991-1994. Awada, Nagy and Phillips (2021) modelled the long-term change in greenhouse gas (GHG) emissions from farms across the prairies, showing that the crop sector was a net GHG sink between 2013 and 2016 in Alberta and between 2006 and 2016 in Saskatchewan. Bamber, Turner and Pelletier (2022) undertook a life cycle analysis that revealed that with current production systems, wheat now sequesters about 0.103 kg CO_2/kg, which makes it the most sustainable producer among the leading producing and exporting countries. This improvement in soil and crop management is having a positive effect on risk management in the sector. Drought and other climatic stressors have increased in recent years but yields and productivity have held up much more than in previous periods with poor growing conditions.

The last focused area for AG is research on market use of grains. They have signalled that at least some of their funds have been directed to work on bioactive compound development and application, which has implications for both crop protection and human health. We are not able to model or estimate these effects, but anything that increases the value to the supply chain or end users will bump up returns to everyone.

One factor that most evaluations ignore is the impact of the investments on the long-term development of skilled and motivated workers (what many in the research industry call highly

qualified personnel or HQP). Most evaluations treat wages and scholarships as costs and ignore the potential returns from the improvement in human capital. We think it is important to consider the residual value in the skilled and trained individuals who are supported through research. The general rule of thumb among labour economists is that every year of additional education brings a return of about 9-10% in returns annually.

Recent Statistics Canada data suggests that while the returns diminish with further education, they remain substantial and positive for advanced degrees. Data from 2015 shows that adding a Masters adds 4-8% to predicated median wages relative to an undergraduate and another 10-15% for a Ph.D. (Table 25). In total, Ph.D. graduates in biological sciences earn around 18-20% more than those who leave university with a bachelor's degree.

Table 25: Difference in predicted median earnings between types of university degrees, STEM fields, women and men aged 30 to 59 working full-year, full-time, 2015

	Percent Difference in Predicted Median Earnings					
	Master's degree vs BSc		Doctorate vs master's degree		Doctorate vs BSc	
	Men	Women	Men	Women	Men	Women
All STEM programs	1.3 **	5.8 **	7.0 **	4.4 **	8.4 **	10.5 **
Biological sciences	4.1 **	7.8 **	14.5 **	9.9 **	19.2 **	18.4 **
Computer and information science	6.4 **	0.1	13.8 **	13.2 **	21.1 **	13.3 *

*****Statistically different from zero ($p < 0.05$); ****** statistically different from zero ($p < 0.01$)
Source**:** Statistics Canada, Census of Population, 2016.

Beyond that, education also offers social benefits that are distributed about the economy and society and not captured by the graduate. Some assert the social returns are equal to or greater than private returns. Even on a narrow estimate of social return, one can anticipate an additional 6-8% benefit that will accrue to the industry and economy (Table 26).

Table 26: Estimates of social rates of return to education, 1999-2000, OECD countries, (%)

	Upper Secondary		**Tertiary**	
	Men	**Women**	**Men**	**Women**
Canada	-	-	6.8	7.9
Denmark	9.3	8.7	6.3	4.3
France	9.6	10.6	13.2	13.1
Germany	10.2	6.0	6.5	6.9
Italy	8.4	-	9.7	-
Japan	5.0	6.4	6.7	5.7
Netherlands	6.2	7.8	10.0	6.3
Sweden	5.2	-	7.5	5.7
U.K.	12.9	-	15.2	13.6
U.S.	13.2	9.6	13.7	12.3

Source: Blöndal, Field and Gïrouard (2002)

Looking at Alberta Grains investments specifically, we can identify that they have generated significant human capital. Our analysis indicates that a substantial portion of the funding is dedicated to fostering expertise within the field. While it was not possible to find HQP data on all the funded projects for the period of interest, an extrapolation based on available figures suggests an average investment that can be applied across the broader portfolio of initiatives.

To assess the economic impact of Alberta Grains' investment in this regard, we begin by deducting 20% from Alberta Grains' total outlay of $37 million. This deduction, accounting for imports, materials, and machines, leaves us with approximately $30 million, which is presumed to be directed towards HQP, including chairs.

One approach to estimating the impact of these outlays is to use external benchmark data on full-time equivalent (FTE) contributions (Scott et al. 2005) to gauge the involvement of HQP in Alberta Grains-funded projects. External research indicates that similar projects in the domain of wheat and barley breeding typically involve around 15 FTEs, with an estimated annual investment of $375,000 per FTE. This includes materials and other costs. To ensure our estimates reflect the actual scale of funding from AG, we adjusted this figure downward to $150,000 per FTE. Assuming there is about $29M to allocate, this would generate about 200 FTE of employment. Professional scientists generally generate some incremental private returns for each additional year of experience but none of the social returns we find for education.

Another way is to consider the costs of different researchers and evidence from grants on how they are used. We simulated the number of research scientist, post docs, Ph.D. studentships and Masters' students that could be supported by $29,000,000. For this analysis, we assume professional scientists cost $110,000 per year (including 20% benefits) and work for two years on average on a grant. Post docs cost $90,000 per year and stay one year on average. Ph.Ds. take three years and cost $90,000 in total and master's candidates cost $75,000 and take two years.

Looking at projects that disclosed HQP plans, we see they fund a few chairs, no post docs, a dozen or so Ph.D. and Master's each and a projected ~150 professional scientists (some of whom may be post docs). Extrapolating this, we anticipate half these funds going to leading scientists who, as noted, generate only modest incremental private returns but few if any social returns. We anticipate the rest of the funds could support up to 145 post docs, Ph.Ds. and Masters, leading to more than 300 student years of further training. Applying the ratios above, one might anticipate those graduates would realize 10-20% private returns on those investments and a further 5% of social return. In aggregate that could add about $1.9M of new private return (higher wages) for the graduates and a further $600,000 in social return spread across the industry and society.

5.2.2 IRR and ROI for AG agronomic research investments

Using the assumption that agronomics and varietal development comprise total yield gain in a 1:1 ratio, economic returns were calculated for agronomic research investments. Given that AG leveraged about $4.30 for every $1 it invested in agronomic research, we applied a direct attribution factor of 0.15 to the anticipated spill-in, with a similar 0.2 spill-in adjustment. The returns and initial investments associated with agronomic advancement attributed to AG is contained in Table 27. From these figures, an IRR of 2.09% arises.

Table 27: IRR on pre-and-post variety breeding activities research investment, current $

Year	Estimated Returns	AG investment in agronomics, current $	Net benefit
2013	$0	$1,847,933	-$1,847,933
2014	$0	$1,311,315	-$1,311,315
2015	$2,515,954	$865,000	$1,650,954
2016	$2,391,659	$1,290,100	$1,101,559
2017	$2,127,585	$511,500	$1,616,085
2018	$2,445,755	$1,928,179	$517,576
2019	$2,482,701	$3,538,322	-$1,055,621
2020	$2,380,547	$2,947,801	-$567,254
2021	$2,303,685	$2,888,160	-$584,475
2022	$2,456,166	$681,729	$1,774,437
2023	$2,171,407	-	$2,171,407
2024	$2,200,291	-	$2,200,291
2025	$2,188,028	-	$2,188,028
2026	$2,159,423	-	$2,159,423
2027	$2,127,448	-	$2,127,448
2012-22	***$19,104,052***	***$17,810,039***	***$1,294,013***
2012-27	***$29,950,648***	***$17,810,039***	***$12,140,609***

Deflating both returns and costs to the base year of 2022 provides the figures detailed in Table 28. Considering investments from 2013-22 and returns from 2015-27 a return on investment of 59.75% was calculated for agronomic research investments.

Table 28: Return on investment in pre-and-post variety breeding activities

Year	Returns	AG investment in agronomics, 2022$	Net Benefit
2013	$0	$2,292,721	-$2,292,721
2014	$0	$1,589,473	-$1,589,473
2015	$3,002,332	$1,032,220	$1,970,112
2016	$2,827,020	$1,524,941	$1,302,079
2017	$2,479,703	$596,154	$1,883,549
2018	$2,804,765	$2,211,214	$593,550
2019	$2,795,834	$3,984,597	-$1,188,763
2020	$2,630,438	$3,257,239	-$626,801
2021	$2,453,339	$3,075,783	-$622,444
2022	$2,456,166	$681,729	$1,774,437
2023	$2,154,173	-	$2,154,173
2024	$2,140,361	-	$2,140,361
2025	$2,085,822	-	$2,085,823
2026	$2,016,268	-	$2,016,268
2027	$1,946,430	-	$1,946,430
2012-22	***$21,449,597***	***$20,246,070***	***$1,203,528***
2012-27	***$31,792,652***	***$20,246,070***	***$11,546,582***

5.2.3 Sensitivity analysis

Within the agronomic impact assessment, all acres cropped to wheat and barley across the prairies from 2015 to 2027 were analyzed at the same attribution rate. As a result, the sensitivity analysis contained in Table 29 and Table 30 modify the attribution rate and spill-in rate.

Table 29: Impact of different attribution and spill-out rates on agronomic development IRR

Attribution rate	**Spill-in rate**				
	10%	**15%**	**20% (BASE)**	**25%**	**30%**
5%	-7.04%	-5.07%	-3.64%	-2.51%	-1.57%
10%	-3.64%	-1.57%	-0.07%	1.11%	2.09%
15% (BASE)	-1.57%	0.55%	**2.09%**	3.31%	4.32%
20%	-0.07%	2.09%	3.67%	4.91%	5.95%
25%	1.11%	3.31%	4.91%	6.18%	7.22%

The internal rates of the return were estimated at 2.09% in our base case and ranged from a low of -7.0% with the lowest feasible attribution and spill-in rates to as high as 7.2% with the highest attribution and spill-in rates.

Table 30: Impact of different attribution and spill-out rates on agronomic development ROI

Attribution rate	**Spill-in rate**				
	10%	**15%**	**20% (BASE)**	**25%**	**30%**
5%	-73%	-60%	-47%	-33%	-20%
10%	-47%	-20%	7%	33%	60%
15% (BASE)	-20%	20%	**60%**	100%	140%
20%	7%	60%	113%	166%	220%
25%	33%	100%	166%	233%	299%

Similar to the IRR analysis, ROI varies broadly from -73% to 299% dependent on the attribution and spill-in rates selected. The value in the base case is 60%.

5.3 Macroeconomic Effects

As revealed in our analysis, AG's research efforts deliver value in terms of immediate research outlays, benefits from new varieties and benefits from better agronomics. Each has a somewhat different impact on the economy.

First, investment in basic and agronomic research is assumed to be a straight influx of capital, so no import leakages are applied. The following Type II multipliers were used for research efforts distributed over the prairie provinces using the professional, scientific and technical services sector. We are using Type II multipliers – the ratio of the total multiplier to the direct multiplier. This shows the total impact of all direct, indirect, and induced effects of the activity (Table 31).

Table 31: Type II Economic Multipliers for Agri-food Research for Canada, 2020

$1 million of direct economic impact on GDP at basic prices for Professional, Scientific and Technical Services (Source: Statistics Canada,15F0046XDB)			
Type II multipliers	Impact in province	Total impact all provinces	Portion of impact outside province
AB research	1.62	1.92	16%
SK research	1.48	1.80	18%
MB research	1.53	1.88	19%

Second, all new crop production is deemed to be exported, and therefore is assessed in the grains and other crop products, live animals, and other farm products category. No import leakages are assessed. The sector-specific Type II multipliers in Table 32.

Table 32: Type II Economic Multipliers for Crop and Livestock Exports for Canada, 2020

$1 million of direct economic impact on GDP at basic prices and Jobs (FTE) (Source: Statistics Canada,15F0046XDB)			
Type II multipliers	**Impact in province**	**Total impact all provinces**	**Portion of impact outside province**
AB research	1.83	2.21	17%
SK research	1.44	1.89	16%
MB research	1.63	2.27	28%

Table 33 shows the overall impact of all the activities supported by their research and the related changes in farm productivity. Overall, GDP increases by about $95 million in Alberta.

Table 33: Macroeconomic impact of Alberta Grains activity by activity and location, $ millions

	Direct Impacts	**Indirect & Induced Impacts**	**Total Impacts**
ALBERTA			
AGC research investments	18.5	11.5	30.0
Contribution of new varieties in AB	21.2	17.6	38.8
Contribution of agronomic research in AB	14.2	11.8	26.0
Total GDP impact in Alberta	***53.9***	***40.9***	***94.8***
REST OF CANADA			
AGC research investments	18.5	22.6	41.0
Contribution of new varieties	82.7	108.1	190.8
Contribution of agronomic research	15.8	24.5	40.3
Total GDP impact in rest of Canada	***117.0***	***155.2***	***272.2***

6. Conclusions and Recommendations

6.1 Summary of Findings

In the period of study Alberta Grains dedicated $37 million towards research efforts aimed at bettering the economic prosperity of the wheat and barley sectors in Alberta. Of this, $19.4 million was directed to plant breeding efforts and $17.8 million went to agronomic development and other projects. Through the evaluation of advancements in yield and agronomics, returns to these investments were calculated using return on investment and internal rate of return as the primary methods of measurement.

Considering plant breeding investments, the internal rates of the return were estimated at 8.5% in our base case and ranged from a low of 4.9% with the lowest feasible attribution and spill-out rates to as high as 10.6% with the highest attribution and spill-out rates. Return on investment in the base case scenario is $3.78 per dollar invested, which varies considerably under the variety of scenarios and sensitivity analyses conducted, ranging from a low of 139% to as high as 617%.

Alberta Grains' investments in agronomics fostered an estimated $12,140,609 in net returns from 2015-27. This translates to an IRR of 2.1% and an ROI of 60% in the base case scenario. Subsequent sensitivity analysis values ranged from a low of -7.0% with the lowest feasible attribution and spill-in rates to as high as 7.2% with the highest attribution and spill-in rates.

These findings further show that much of the value created by AG is realized in Saskatchewan and Manitoba as they also adopt and use the new varieties coming from AG sponsored research. However, it is important to remember that research is not performed in a vacuum. That is, benefits from research spill across provincial borders in both directions as funding from organizations distributed across the prairies will benefit Albertan wheat and barley producers as well. Given that AG investments represent only a portion of Alberta's investment portfolio – and a smaller portion of total prairie investments – we found that more value spills into Alberta than spills out.

Relative to the other studies discussed in Section 2 of this report, our findings appear conservative regarding returns to plant breeding and agronomic research. While our results fall at the lower end of the studies reported, this is almost certainly due to the decision to attribute only value created by AG in the analysis. We did not count 'leveraged' funding as there is no evidence that it would not otherwise have been spent. As such, our results are expected to be better aligned with the actual return on investment and internal rate of return achieved through research investments. Another factor contributing to more modest results is that Alberta Grains has only been operating for a short period of time. Even though we forecast returns five years beyond the investment period, there likely will be benefits flowing much beyond that.

6.2 Strategic Recommendations

Based on the findings presented in the research report and taking into account the Alberta Grains Research Priorities Update Survey 2023-24 distributed to the membership base in Fall 2023, the

following strategic recommendations are proposed to guide future research and investment directions for Alberta Grains:

1. Strategic alignment with emerging agricultural challenges: while continuing investment in cutting-edge technologies and sustainable farming practices, Alberta Grains should ensure its research priorities are dynamically aligned with the evolving challenges and opportunities within the agricultural sector. This involves utilizing the results from the 'Research Priorities Update Survey' to align research funding with the most pressing challenges and opportunities identified by farming community. Alignment would ensure that investments directly contribute to making the wheat and barley more profitable cropping options.

2. Development of a comprehensive impact assessment framework: to overcome challenges related to monitoring the progress, outcomes, and tangible benefits of funded research projects, Alberta Grains should develop a robust, transparent, and continuous tracking and evaluation framework. This framework would facilitate real-time analysis and adjustments to research strategies, ensuring that investments are yielding the desired impacts and that course corrections can be made promptly. Additionally, by quantifying the impact of research initiatives more effectively, Alberta Grains can better articulate the return on investment to its members and stakeholders.

3. Strengthening collaborations and leveraging partnerships: recognizing that the benefits of Alberta Grains' investments extend beyond provincial borders – and that Alberta also benefits from investments made by other prairie provinces – Alberta Grains should continue to foster interprovincial collaborations. These partnerships can amplify research impacts, facilitate learning, and enhance the overall resilience and competitiveness of the prairie provinces' grain sectors.

4. Enhanced communication and engagement with membership base: Alberta Grains should maintain and enhance engagement strategies, such as the recent survey to update research priorities and the organization's proactive efforts to gather input from its membership base. Regular, transparent communication about research progress, outcomes, and the tangible benefits of investments can strengthen member trust and support while refining the feedback mechanisms will ensure it captures and addresses the evolving needs and challenges of the farming community.

5. Adaptive policy advocacy for supportive research environment: while the organization is already engaged in policy advocacy, there is an opportunity to adapt and intensify these efforts based on evolving research priorities and industry needs. This entails not just advocating for regulatory environments that are supportive of innovative agricultural research and the commercialization of new varieties but also engaging in dialogues with policymakers to ensure that the agricultural research agenda is responsive to technological advancements and market demands.

6. Enhance support mechanisms for the adoption and commercialization of research findings: this involves not just the development of new varieties and technologies but works proactively to ensure that farmers and industry stakeholders have the resources, information,

and incentives to adopt these innovations. Tailored extension services, demonstration projects, and economic incentives could facilitate faster and wider adoption of research outcomes. Faster and more complete adoption of new varieties is core to sustaining innovation, productivity and profit in the industry.

With the strategic investments in research and development, Alberta Grains significantly influences the wheat and barley production in Alberta and beyond. By adopting a forward-looking approach that emphasizes high-return research areas, enhances real-time tracking and adjustments, strengthens collaborations, and commits to environmental sustainability, Alberta Grains can ensure the continued success and resilience of its membership base.

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