CBRC
Canadian Barley Research Coalition

NATIONAL BARLEY RESEARCH STRATEGY

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1. EXECUTIVE SUMMARY

Research supports innovation and productivity enhancements that keep the barley industry strong. Funding for barley research is low compared to canola and wheat, making efficient investment critical for barley to remain a competitive cropping option. The National Barley Research Strategy will serve as a resource for barley funders, researchers and government; supporting the industry through key advances in research.

The objectives of the National Barley Research Strategy are to:

- Identify and quantify the research areas of the highest importance to the barley industry,
- Enhance communication and collaboration between scientists and barley research funders,
- Increase research funding efficiency by avoiding unnecessary duplication and investing in critically important work with the highest returns,
- Influence government and other funding organizations' investment in barley research, and
- Refine and enhance research targets developed under the Getting to Growth plan.

The National Barley Research Strategy identified seven key barley research themes: 1) increased yield, 2) improved lodging resistance, 3) reduced impacts of barley pests, 4) harvest and post-harvest management, 5) end use applications/opportunities, 6) sustainability and 7) knowledge translation and transfer (KTT). Each research theme is discussed and research priorities were identified to support and advance the industry. Finally, quantifiable research targets were developed around the research themes to measure the impact of the industry's research investments.

Appendix A includes a list of active Canadian barley research projects up to December 31, 2020. This information that will enhance collaboration between funders, reduce unnecessary duplication, and identify gaps in research investment.

Appendix B is a current list of Canadian researchers with ongoing projects on barley or with expertise that applies to barley. The updated list allows funders to communicate with scientists on barley related information and opportunities for funding. It also facilitates collaboration between scientists looking for specific expertise for project development.

Other appendices included in the National Barley Research Strategy include:

- Appendix C – Canadian Barley Research Funders
- Appendix D - Research Funding Opportunities
- Appendix F – Producer Research Survey Results

The National Barley Research Strategy is a dynamic document that will be updated as required. The Canadian Barley Research Coalition supports this ongoing work and serves as the voice for Canadian barley research.

2. BACKGROUND

Faced with the challenges of decreasing seeded acreage, and profitability, the barley industry collaborated on the development of the Western Canadian Barley Action Plan "Getting to Growth". The "Getting to Growth" plan was released to increase industry-wide collaboration and guide strategic investment in the sector to position the barley industry for profitability, growth and continued production of high-quality grain.

The objectives of the "Getting to Growth" plan included:

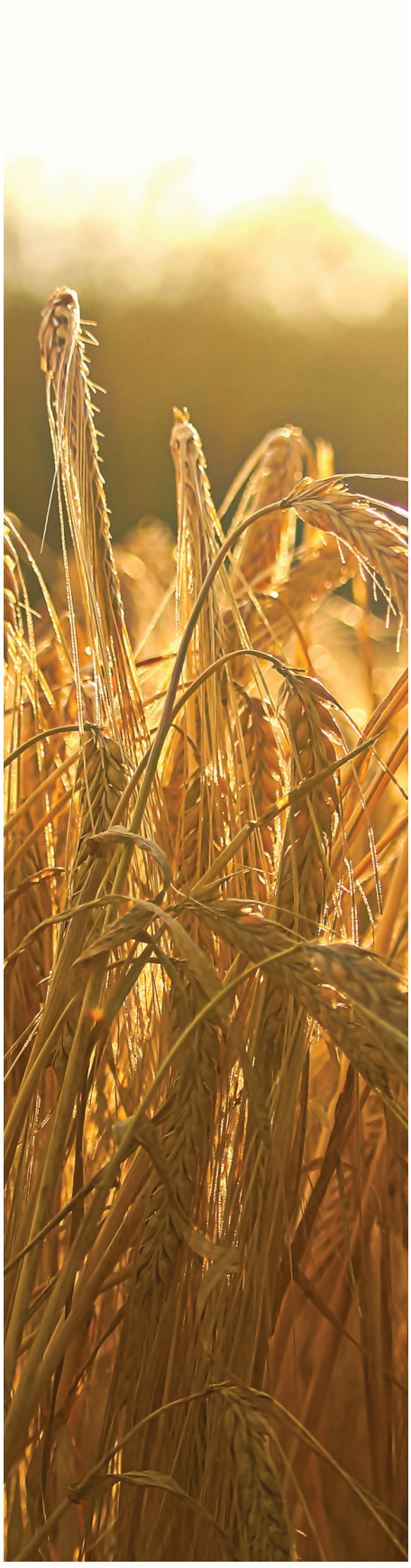
- Supply: increase western Canadian barley production to secure the world's supply of its highest quality barley
- Demand: Maintain high-value markets and grow new opportunities
- Acceptance: Realize supply and demand goals through an integrated variety acceptance strategy

The Canadian Barley Roundtable was established to further the goals and objectives of the "Getting to Growth" Canadian Barley Action Plan and to move forward with determining a sustainable value chain approach to achieving greater coordination and collaboration in the barley sector.

Recommendations from the Canadian Barley Industry Roundtable included the following:

- Establish a national process, with the Brewing and Malting Barley Research Institute (BMBRI) as the facilitator, to identify the research priorities for barley in the malt, feed, food, and industrial use sectors.
- Develop and maintain a catalogue of barley-relevant research being conducted in Canada (Barley Council of Canada (BCC)).
- Enhance and formalize the already emerging process for variety acceptance that identifies market needs, establishes priorities and communicates results. (Canadian Malt Barley Technical Centre (CMBTC)).
- CMBTC to continue to be the market development technical support for malting barley while adding feed barley.
- Strengthen BCC's leadership role as an advocate and unifying voice of Canada's barley value chain to serve as the national point of contact, to collaborate with other national commodity groups, and to facilitate coordination and alignment of all barley-related organizations toward common goals.

Recommendations #1 and #2 were directed towards barley research with the Brewing and Malting Barley Research Institute, and the Barley Council of Canada, taking the lead role on behalf of the barley industry.



Objectives of the National Barley Research Strategy

The National Barley Research Strategy will serve as a valuable resource for researchers, producer funders, industry funders, and the government leading to efficiencies and higher returns on investment in research. Continued investment in research supports innovation and productivity enhancements that keep the barley industry strong. Objectives of the National Barley Research Strategy are as follows:

- Identify and quantify the research areas of the highest importance to the barley industry
- Enhance communication and collaboration between scientists and barley research funders
- Increase research funding efficiency by avoiding unnecessary duplication and investing in critically important work with the highest returns
- Influence government, and other funding organizations, investment in barley research
- Refine and enhance research targets developed under the Getting to Growth plan

A Canadian researcher highlights the need for focused investment on research priority issues and collaboration among funders: "I often cannot get adequate matching funding for barley research (relative to wheat) for agronomic trials, because they simply do not have the cash resources to leverage relative to other crops. For example, if I can get $100,000 from the Wheat Commissions for research then I can leverage it 50:50 and complete a $200,000 study with a number of locations in diverse growing environments. With barley, if I can only get $10,000 for research then I can leverage that 50:50 giving me $20,000 which is likely only one research location."

Process for the National Barley Research Strategy

The development of the National Barley Research Strategy involved numerous steps including an online research priority survey, extensive in-person and group consultations (see Section 11: Contributors to the National Barley Research Strategy), and feedback from research funders and organizations.

The online producer research priority survey was distributed in early 2020 by the Alberta Barley Commission (ABC), Atlantic Grains Council (AGC), Barley Council of Canada (BCC), Manitoba Crop Alliance (MCA) (formally Manitoba Wheat and Barley Growers Association), Producteurs de Grains du Quebec (PGQ), and the Saskatchewan Barley Development Commission (SBDC). In the survey, producers identified the greatest issues they face when growing barley. The survey was completed by 134 producers with representation from producers in Alberta (49%), Saskatchewan (34%), Manitoba (4%), Quebec (7%), and the Maritime Provinces (5%). Top research themes were identified from the survey, comments provided and stakeholder feedback. The top research themes identified included increased yield, improved lodging resistance, reduced impact of barley pests, harvest and post-harvest management, end use applications/opportunities, sustainability and knowledge translation and transfer.

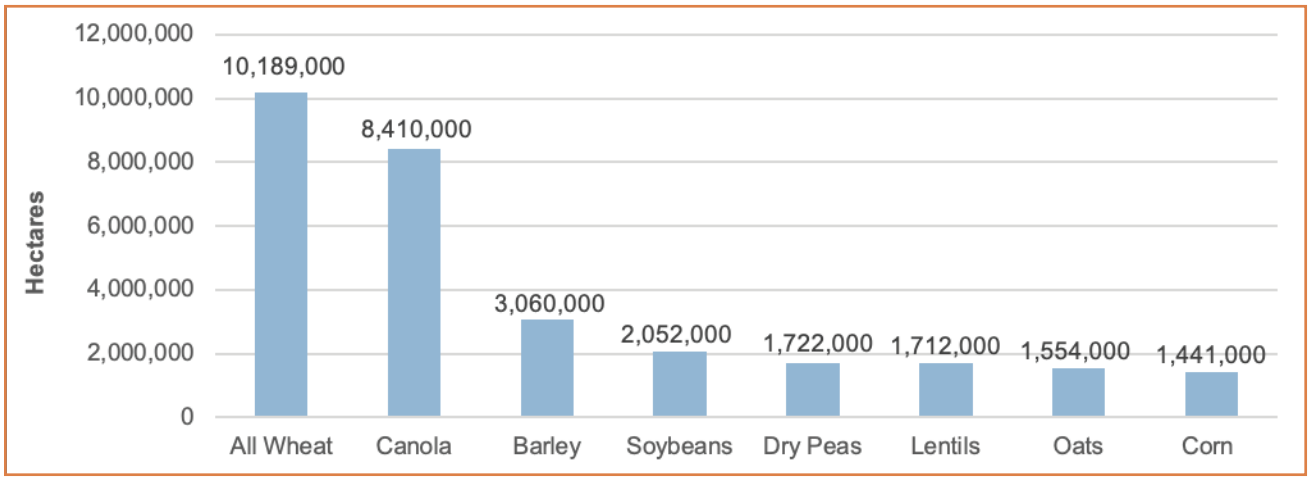
In conjunction with the research priority setting exercise, the current investment in barley research by producers and industry funders was compiled and analyzed. Currently, there are numerous barley research funders including ABC, Alberta Beef Producers (ABP), AGC, Beef Cattle Research Council (BCRC), Brewing and Malting Barley Research Institute (BMBRI), Grain Farmers of Ontario (GFO), SBDC, Saskatchewan Cattleman's Association (SCA), MCA, PGQ, Western Grains Research Foundation (WGRF), provincial and federal governments, and numerous independent companies. Each funder lists their research investment independently on their website. The industry does not currently have a "one-stop-shop" with a list of on-going barley research in Canada. The lack of a complete inventory of current research makes it difficult to be efficient with research investments which is so critical given limited dollars available.

It is important to note that the National Barley Research Strategy is a dynamic document that will be updated periodically. It contains the highest priorities identified through the process but is not all-inclusive and some research areas may not be included.

3. BARLEY INDUSTRY OVERVIEW

Barley is currently Canada's third-largest crop by seeded area (Figure 1), after wheat and canola. Barley continues to be a valued addition to crop rotations and is crucial for weed management, disease control and soil fertility. Barley is also grown by producers for its end use versatility, comparatively lower seed cost, earlier maturity and low heat unit requirements compared to other cropping options.

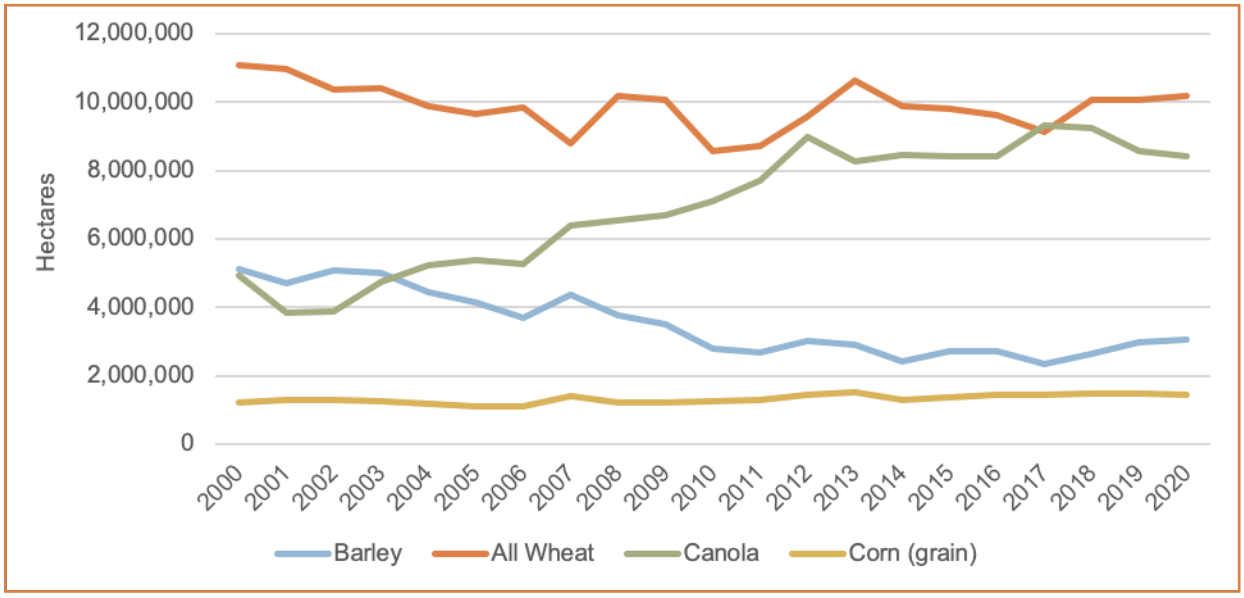
Figure 1. Canadian Barley Seeded Area (2020-21)



Source: (Stats Can, n.d.)

Since 2000, barley seeded area has declined steadily from a high of 5.1 million hectares to a low of 2.3 million hectares in 2017. The greatest loss of acres occurred between 2000 and 2010, during which time canola gained seeded area in western Canada. Since 2010 barley seeded area has stabilized and in recent years there has been a notable increase. Over 95% of Canadian barley is grown in western Canada.

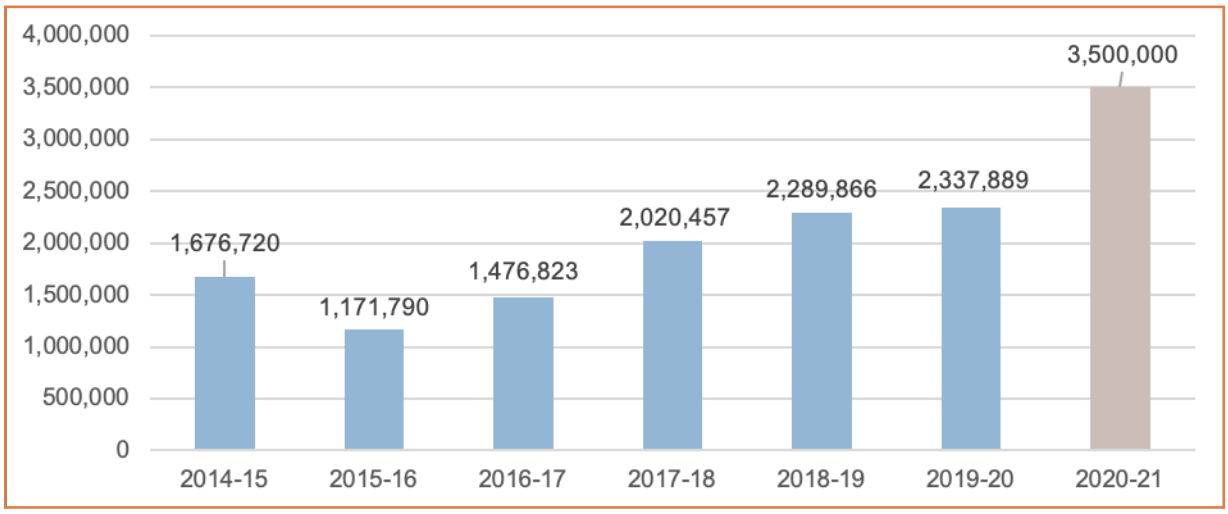
Figure 2. Change in Seeded Area by Crop in Canada



Source: (Stats Can, n.d.)

Barley production in Canada is important for many value-added domestic industries and also supplies our high value export markets. Exports include processed malt, malting barley, feed barley and food barley. In 2019-20, China, Japan, the USA and Mexico were Canada's largest export markets for barley.

Figure 3. Annual (Aug-Jul) Canadian Barley Exports (tonnes)



*Source: (Stats Can, n.d.) *2020-21 barley exports are an estimate*

4. BARLEY RESEARCH CONSIDERATIONS

Advances in research take many years and require committed funding over decades to come to fruition. The barley industry needs to identify the research that will lead to ongoing innovation and competitiveness and to understand the challenges in meeting these goals. Current issues and trends in Canada that may impact barley research outcomes into the future include:

- Historically, agriculture research in Canada has received significant support from provincial and federal governments. Research is considered a non-essential government service and the government deficits, and changes in research priorities, may impact the levels of funding for agriculture research into the future.
- In Canada, barley breeding by private companies is limited due to the lower economic return on investment, and therefore, continued investment by government is required to continue the advances in new varieties.
- Agriculture and Agri-food Canada (AAFC) has signaled it wants to move away from funding variety development (specifically registration trials) and will move these resources to upstream research.
- The Canadian Agriculture Partnership (CAP) Program has indicated the next Cluster (2023-2028) will reduce the federal government contribution ratio to projects related to new variety development.
- Variety Use Agreements (VUA) have been put in place on select new crop varieties to demonstrate how royalties on farm-saved seed could work. In the future value creation may expand to add additional funding to breeding organizations.
- The low turnover rate of new malt barley varieties decreases the return on investment for breeding malting barley.
- Canadian barley research capacity is low compared to other crops due to the lower availability of research funds.
- Uncertain international regulatory environments, and non-tariff trade barriers, may impact both domestic and export acceptability of valid farming practices and products.
- Consumers will continue to want increased transparency with regards to breeding tools, crop management practices, and technology; and it will drive the demand for certain products.
- The incorporation of the Canadian Barley Research Coalition (CBRC) will provide one voice for barley research in Canada and drive efficiencies in funding, coordination and communication.

5. CURRENT RESEARCH INVESTMENT

The inventory of active barley research projects is a key component of the National Barley Research Strategy. It provides information on the type of research supported, gaps in funding for issues of importance, and includes a list of the scientists working on barley.

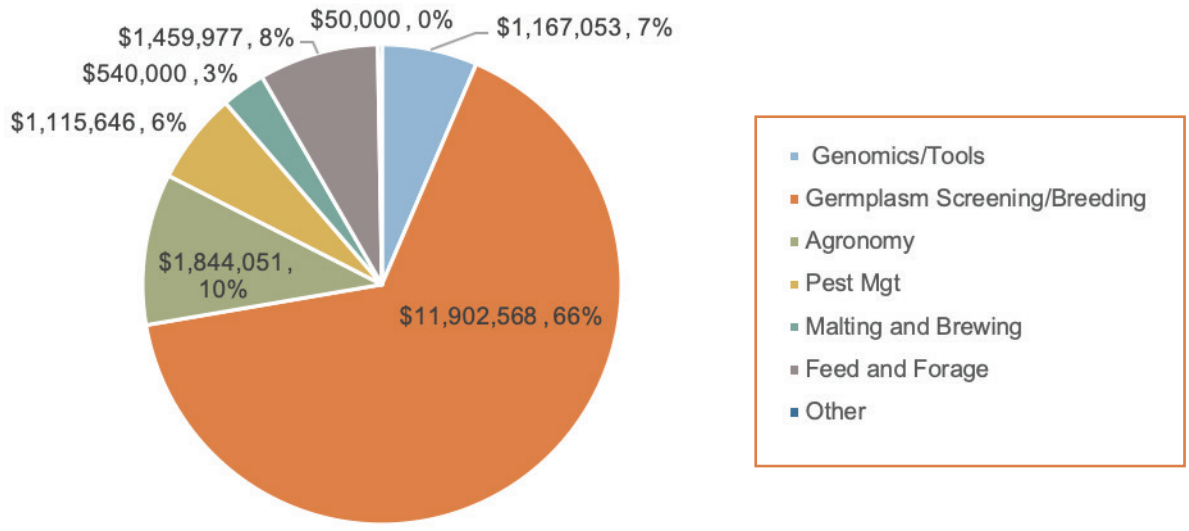
Appendix A includes barley projects supported by the following barley funders: Alberta Barley Commission (ABC), Alberta Beef Producers (ABP), Atlantic Grains Council (AGC), Beef Cattle Research Council (BCRC), Brewing and Malting Barley Research Institute (BMBRI), Grain Farmers of Ontario (GFO), Manitoba Crop Alliance (MCA) formally Manitoba Wheat and Barley Growers Association, Producteurs de Grains du Québec (PGQ), Saskatchewan Barley Development Commission (SBDC), Saskatchewan Cattlemen's Association (SCA) and the Western Grains Research Foundation (WGRF). In this document, the above funders are referred to as the Barley Industry Research Funders. Appendix A does not include research projects/programs that do not receive funding from the Barley Industry Research Funders.

The analysis of the inventory of active barley projects in Appendix A used the following assumptions:

- Active projects only
- Barley specific projects include government contributions
- A multi-crop project value is the total funding value of the project divided by the number of crops
- Whole farm research that has funding from the Barley Industry Research Funders is valued at the contribution from the Barley Industry Research Funders
- Non-crop-specific research, that includes funding from a Barley Industry Research Funder(s) and provides direct value to the barley industry, is valued at its full funding level

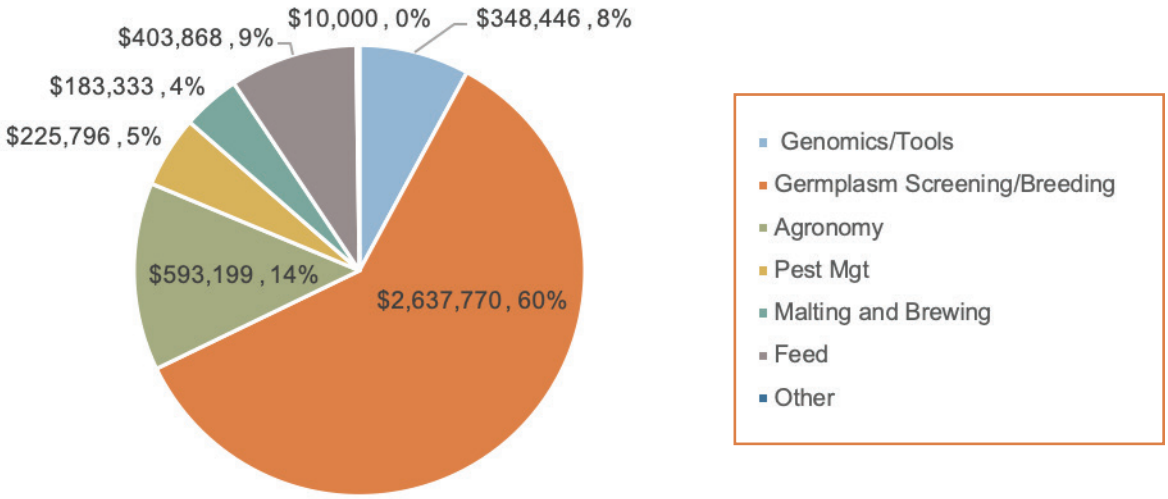
As of December 31, 2020, Barley Industry Research Funders supported 47 barley research projects with a total value of $18.1 million. Funding for barley research was invested in breeding/ germplasm screening (66%), agronomy (10%), feed and forage end use (8%), genomics/research tool development (7%), pest management (6%), malting and brewing end use (3%) and other (<1%). The "other" category has one project directed to identifying the barriers and costs of regulatory delays for agriculture innovation (Figure 4).

Figure 4: Total Funding per Research Category (Total $18.1 M)



The total research funding shows the commitment to a research category over the full duration of the project. Many of the breeding projects are longer-term than other categories of research and therefore have a greater total value. Figure 5 compares the annual commitment per research category, providing a more accurate allocation of yearly funding.

Figure 5: Average Annual Funding per Research Category (Total $4.4 M)



Figures 6 and 7 show the number of projects per research category and the average value of the projects. Germplasm screening/breeding projects are supported in the greatest numbers (14 projects) and have the highest average value per project (~$850,000/project) than other research categories.

Figure 6: Number of Projects per Research Category (Total 47)

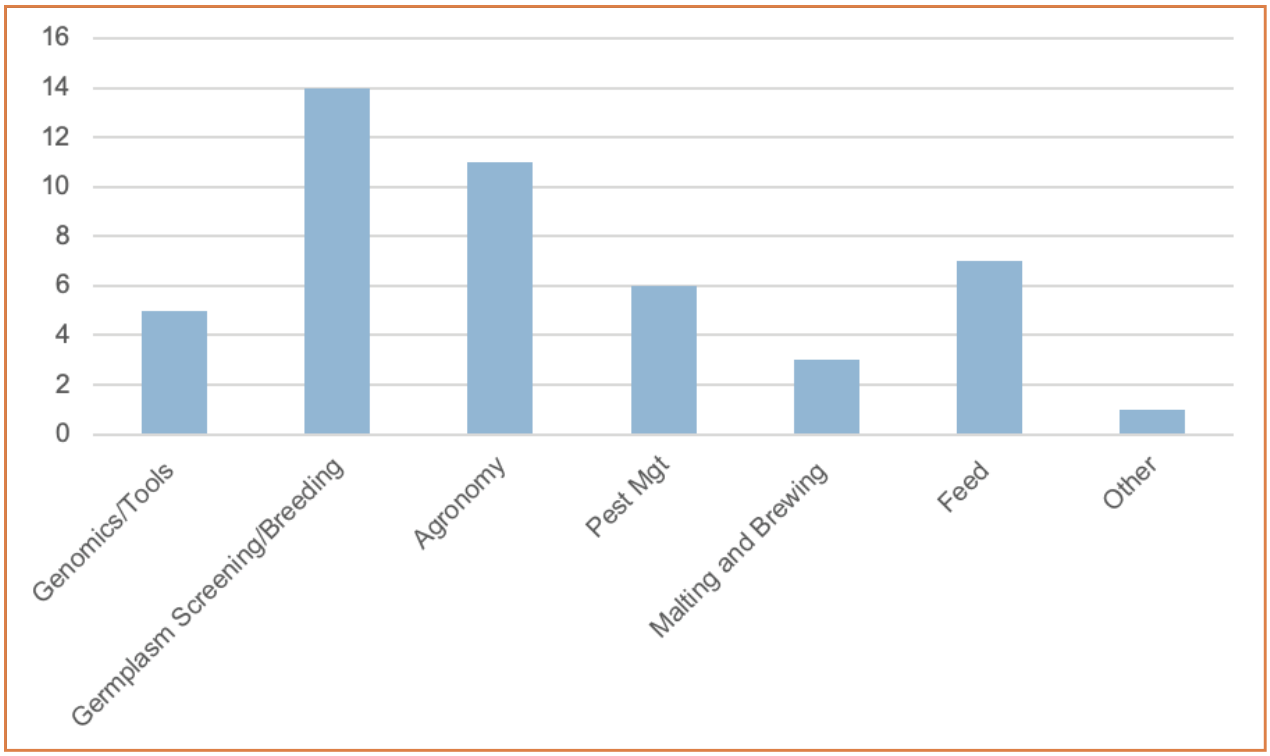
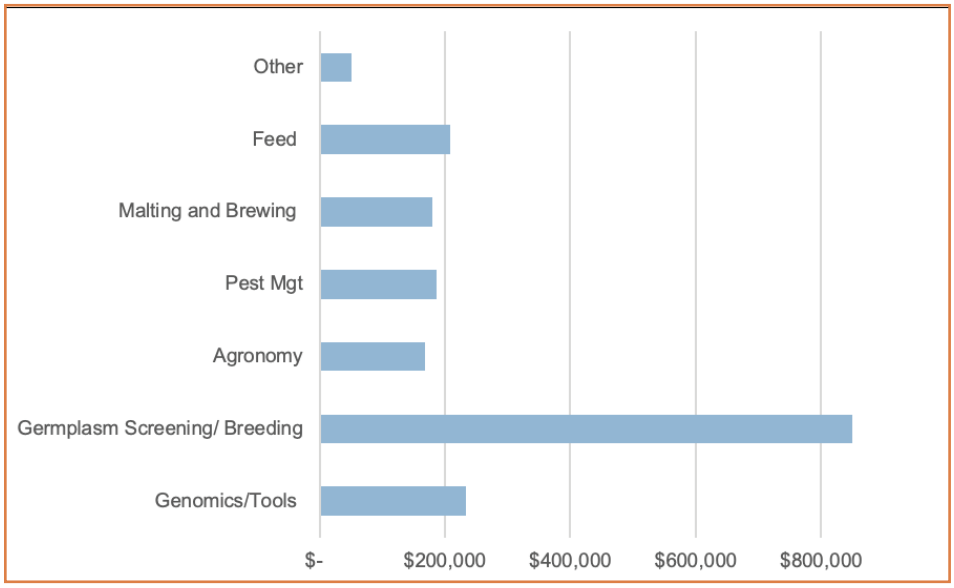


Figure 7: Average Value of Projects per Research Category



Canada has three public research organizations, and 4.5 full-time equivalent (FTE) barley breeders, located across Lacombe, Alberta, Saskatoon, Saskatchewan, Brandon, Manitoba, and Ottawa, Ontario (Table 1). For comparison, the USA has five public barley breeding programs with a total of 10 FTE barley breeders for 2,857,000 acres or 1,156,187 ha, which is approximately 40% of the seeded area in Canada (National Agriculture Statistics Service, 2019).

Table 1: Approximate Public Breeder Resources in Canada (% FTE)

	2R General Purpose	6R General Purpose	2R Malting	2R Hulless Food	Total
Agriculture and Agri-food Canada-Brandon, MB			0.90	0.10	1
Agriculture and Agri-food Canada-Ottawa, ON	0.60	0.20	0.18	0.02	1
Crop Development Centre - University of Saskatchewan	0.10		0.35	0.05	0.5
Field Crop Development Centre/ Olds College	0.75	0.25	1.00		2
Total Breeder(s)	1.45	0.45	2.45	0.15	4.5

The bulk of the research directed to barley new variety development is funded under the Core Breeding Agreements and the National Barley Cluster. Funding for variety development requires a long-term commitment and is a significant proportion of the investment in barley research.

If we compare the Core Breeding Agreements signed in 2020 for wheat and barley, the Core Wheat Breeding Agreements totaled $32.2 million over five years as compared to the barley investment of $4.3 million. Wheat has a seven times greater investment than barley under the Core Agreements, but only three times the seeded area. This discrepancy in investment between wheat and barley is important as these crops often compete as the cereal option in farmer's rotations.

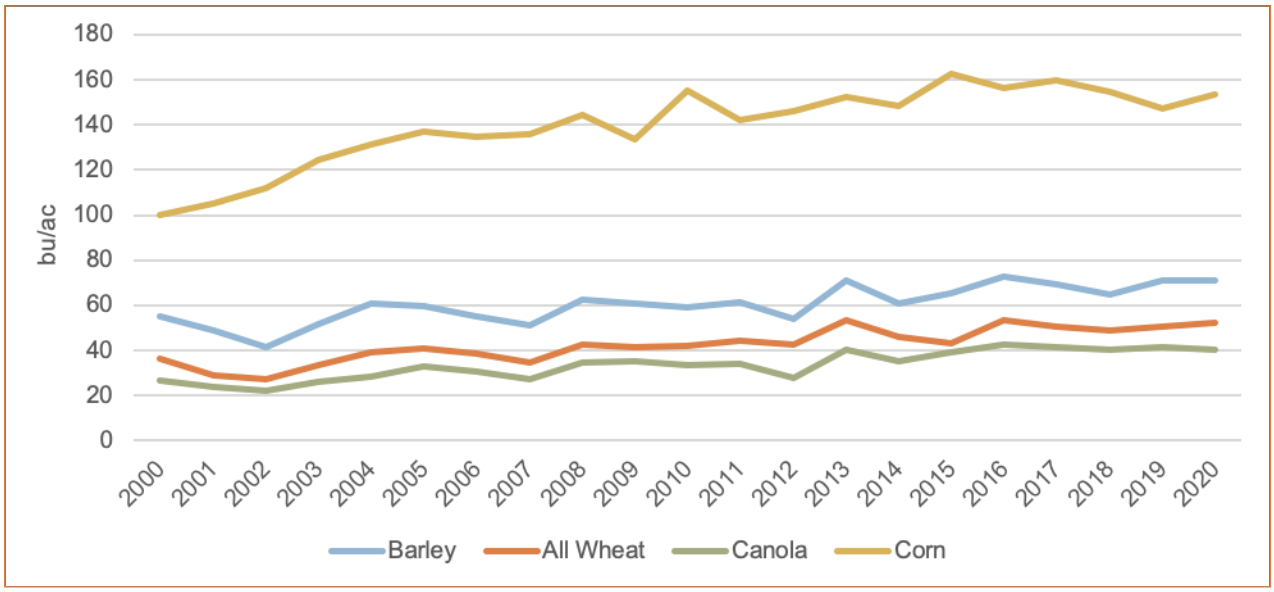
6. BARLEY RESEARCH THEMES

Research is critically important to support the long-term competitiveness and sustainability of the barley industry. The following research themes were developed through on-line surveys and consultation with key stakeholders (see Section 11: Contributors to the National Barley Research Strategy). Research themes include: 1) maximizing yield potential, 2) improving lodging resistance, 3) reducing the impact of barley pests, 4) harvest and post- harvest management, 5) sustainability, 6) end use applications/opportunities and 7) knowledge translation and transfer (KTT).

THEME 1: YIELD

Increasing the production of barley per unit area of land is key to maintaining barley's place in the cropping rotation. Crop yields are a result of genetics, environment, and management, and the gap between current yields and potential yields can be narrowed through research. In 2020, Canadian average barley yields were 72.5 bu/ac. The Barley 180 project determined that 140 bu/ac barley crops were realistically attainable using all production inputs – seed, variety selection, plant densities, seeding dates, fertilizer, growth regulators, fungicides, pesticides and management (The Western Producer, 2019). Closing the yield gap, while maximizing profitability for the farmer, is a very high priority for barley improvement.

Figure 8. Average Barley Yield 2000-2020



Source: AAFC Area, Yield and Production of Canadian Principal Field Crops (Agriculture and Agri-Food Canada, 2000 - 2020)

Figure 8 shows the change in barley yield over time as compared to wheat, canola and corn. Further analysis in Table 2 (below) quantifies the percentage change in average annual yield over five-years from 2000-04 to 2016-20. This data indicates that barley has kept pace with the percentage increase in yield over time with corn but has fallen behind wheat and canola. Some of the canola yield advancements can be attributed to the use of hybrids and genetic engineering/gene editing technologies; therefore, wheat serves as a better comparison for barley. The increase in average yield between 2000-04 and 2016-20 for wheat was 54% as compared to 36% for barley.

Table 2. Change in Average Barley Yield

	Avg Yield 2000-04 (bu/ac)	Avg Yield 2016-20 (bu/ac)	Increase in Avg Yield (2000-04 to 2015-20)
Barley	51.5	69.8	36%
All Wheat	33.1	51.0	54%
Canola	25.3	41.1	62%
Corn	114.6	154.4	35%

Source: AAFC Area, Yield and Production of Canadian Principal Field Crops (Agriculture and Agri-Food Canada, 2000 - 2020)

In the 2020 Alberta Provincial Seed Guide, the average yield of the malting barley and general purpose (GP) barley class is 6.3 % and 5.2% greater than AC Metcalfe, respectively. Both classes of barley, malting and general purpose, have one variety each with an average yield 14% greater than AC Metcalfe (Claymore (GP) and CDC Churchill (malting)).

Breeding higher-yielding barley varieties is a challenging task as it is a combination of several interrelated traits. For example, yield and grain protein concentration are often negatively correlated, making it easier to achieve yield gains on the craft-type malting profile due to their low protein content compared to the high enzyme varieties in demand from the adjunct brewers. General purpose barley often requires higher protein levels for feed, impacting the ability to make significant gains in yield over current malting barley varieties. Longer maturity and higher grain yield positively correlate with the potential to exploit an extended growing season. Increased lodging is also often experienced with higher grain yields. Therefore, it is important to note that breeding higher yields must take into account many factors.

Summary of Current Investment: Improvements to yield and yield stability benefit from investment in all production research (lodging resistance, pest management, sustainability, and harvest management). Research investment in barley production projects makes up 88% of the portfolio, with the majority dedicated to breeding and germplasm screening research projects. Breeding and germplasm screening projects are valued at $11.2 million while agronomy project funding is valued at $1.8 million. Agronomy is a valuable tool that can be used to close the yield gap and it may be important to build capacity in this research area.

Photo courtesy of Dr. Ana Badea – AAFC Brandon Research Station

THEME 2: LODGING

Lodging resistance is a high priority for growers due to its significant impact on yield, grain quality and harvestability. Physiologists believe that lodging can be prevented with the right genetics and crop management. There are two main types of lodging, stem and root, both of which can cause significant yield loss, particularly under increased fertility regimes.

The ability of new barley varieties to withstand lodging is rated during registration trials and reported yearly in the Western Canadian provincial seed guides and shown in Table 3. Breeders have made significant advances in lodging resistance in the new barley varieties developed over the last ten years. In 2010, the Saskatchewan Seed Guide had five barley varieties with a rating of 'Very Good' (VG), while in 2020 there were nine varieties rated VG, an 80% increase.

Table 3: Varietal Lodging Resistance of Varieties in Western Canada 2020

Barley Varieties Rated 'Very Good' (VG)	Total VG (#)	Total VG (%)	Total VG Malting Barley (%)	Total VG General Purpose (%)
Alberta	5	11.3%	2.3%	9.0%
Saskatchewan	9	25.0%	8.3%	16.7%
Manitoba	3	8.1%	0.0%	8.1%

Source: (Saskatchewan Government, 2020), (Alberta Seed Guide, 2020), (Seed Manitoba, 2020)

Eastern Canada uses a 0-9 rating scale for lodging, with nine being undesirable. The mean of the lodging scores were 1.4 for Ontario (2019), 1.9 for Quebec (3-year average) and 1.7 for the Atlantic Provinces (3-year average).

In addition to varietal resistance, research directed to crop management practices also results in reduced lodging. Practices including adjusting the timing and amount of nitrogen applications, evaluating the balance of nitrogen (N), phosphorus (P) and potassium (K) in the soil, the use of plant growth regulators, and efficient drainage are all effective in minimizing lodging (Dahiya, 2017).

Summary of Current Investment: All barley breeding programs in Canada focus on lodging as a key trait for improvement. Currently, lodging resistance in cultivar development is only assessed if there is a differential in the field. Diagnostic tools are not available to quantitatively measure the lodging resistance of new barley lines under development. In addition to the investment in breeding for lodging resistance, there are two active research projects dedicated to 1) screening barley germplasm to identify key genes responsible for lodging and 2) phenotyping Canadian germplasm to evaluate the correlation between lodging and root architecture.

Currently, there are four agronomic projects related to increasing barley profitability that include an evaluation of lodging resistance under varying management regimes.

THEME 3: BARLEY PESTS

Reducing the impact of disease, insects and weed pressure on barley can lead to higher yields and improved quality. Barley diseases that currently produce the greatest economic impact in Canada are included in Table 4 with Fusarium head blight (FHB), net form net blotch and spot blotch at the top of the list. In Eastern Canada scald and powdery mildew are also of concern. Other diseases to watch as emerging threats are listed in Table 5. It is generally accepted that a minimum variety rating of moderately resistant (MR) is required to adequately control disease under favourable weather conditions for disease development.

FHB is a complex disease and remains a serious threat to small grain cereal production quantity and quality in Canada. FHB in barley differs from wheat in that it commonly is found with a diversity of Fusarium species. FHB epidemics in barley across Canada were recorded in 2010, 2013 and 2015. Of particular interest are recent results from molecular surveillance studies that have shown a continuous increase in the 3ADON chemotype compared to the 15ADON in the prairies, as the 3ADON Fusarium isolates are more aggressive and produce more DON than the 15ADON types (Fernando, 2020).

The impact of insect pests on barley is variable and depends on the year. Insects of concern for barley are generally similar to those on wheat and include grasshoppers, cutworms, aphids, wireworms, wheat stem sawfly (barley is less affected than wheat), and the cereal leaf beetle. The majority of research on the economic thresholds for damage due to these insect pests has been done on wheat and may or may not translate to barley. There are two notable pests unique to barley: barley thrips and Haanchen barley mealybug. An economic threshold and chemical control are available for barley thrips, but neither is available for Haanchen barley mealybug, which is only sporadically detected in western Canada. Herbicide resistant weeds are also a key issue for producers. According to the producer survey, wild oats are becoming an increasing problem for barley growers.

Table 4: Barley Pests

	Variety Resistance* (All Classes)	Economic Impact *1 =No Impact* *5 =Extreme Impact*	Ease of Breeding and Testing *1 =Possible* *5 =Very Difficult*	Control through Crop Management *1 =Complete* *5 =Not Possible*	Research Investment *1 =Adequate* *5 =Necessary*	Comments
Spotted Net Blotch	R (16%) MR (65%)	3	2	2	2 to 3	Increasing prevalence
Netted Net Blotch	R (2%) MR (8%)	4	2	2	2 to 3	Good ability to adapt and become less sensitive to select fungicides
Scald	R (4%) MR (12%)	3	2	2	2 to 3	Regional concern i.e., western Prairie region. Highly adaptation and quickly evolves virulence to resistance genes.
Stem Rust	MR (60%)	2	1	2	2 to 3	Regional concerns (particularly Manitoba and southeastern Sask). Resistance is largely dependent on a single major gene (Rpg1).
Surface-Borne Smuts	R (22%) MR (6%)	1	2	1	2	Good resistance in varieties
Ergot	Not tested; likely all susceptible.	2	4	3	None at this time	Toxic alkaloids produced by the fungus in the grain are the biggest issue.
Fusarium Head Blight	MR (18% Hulled; 100% hulless)	4	4	4 (favorable weather for disease development)	3 to 4	High regional importance in Eastern Canada, Manitoba and Saskatchewan. Emerging issue in Alberta. Quality issues are associated with the production of mycotoxins.
Spot Blotch	R (3%) MR (26%)	4	2	2	2 to 3	Historically found in the eastern Prairie region; now found across the prairies. Causal agent associated with common root rot.
Weeds	N/A	2	N/A	4	3	Wild oats are of increasing concern for barley producers.
Insects	N/A	2 to 4	4	2	2 to 3	Variable impact depending on the year.

**Source: Sask/Alberta Seed Guides 2019*

Table 5. Emerging Disease Threats (or threats that currently have limited impact)

Ratings: 1 to 5 with 5 being extreme, very difficult, not possible and necessary, respectively.

	Variety Resistance* (All Classes)	Economic Impact *1 =No Impact* *5 =Extreme Impact*	Ease of Breeding and Testing *1 =Possible* *5 =Very Difficult*	Control through Crop Management *1 =Complete* *5 =Not Possible*	Research Investment *1 =Adequate* *5 =Necessary*	Comments
Ramularia leaf spot (RLS)	No information available	1 (currently)	4?	3 to 4	3?	Currently RLS is a limited issue, but globally it has increased in importance. Triazoles and SDHI fungicides are not effective. Monitoring is required.
Common root rot	MR (26%)	3	4	3	3 to 4	Challenging disease to screen. AAFC Saskatoon had a program prior to 1995.
Stripe rust	Some resistance available	1	2	2	3 to 4	Six row barley is also more susceptible to stripe rust than two row. Risk will also depend on what happens in the Pacific Northwest.
Loose smut	Some resistance available	1 (currently)	3	2	3 to 4	Priority 2 disease that may become more of an issue if breeding efforts are reduced on this disease. Seed husbandry and seed treatments may not provide full control causing increased prevalence.
Bacterial leaf spots	No information available	1 to 2	?	4 to 5	3 to 4	Limited options for chemical control and germplasm resistance. Heat treatment of seed has been used to mitigate seed-borne issues.
Bacterial leaf streak	No information available	1 to 2	?	4 to 5	3 to 4	New disease that has recently been reported in western Canada. The best practice to control BLS so far is using clean, disease-free seed.

**Source: Sask/Alberta Seed Guides 2019*

Summary of Current Investment: The Prairie Pest Monitoring Network (PPMN) is an effective network established in 1997 that includes researchers from across the Prairie provinces. The PPMN monitors insect populations in field crops and correlates the data with climate, weather, agronomic practices and natural enemies, to forecast insect infestations. Current support for the PPMN comes from WGRF, Saskatchewan Canola Development Commission, Manitoba Canola Growers, Alberta Wheat Commission, Saskatchewan Pulse Growers, Saskatchewan Flax Development Commission and AAFC. In Eastern Canada, there is no formal coordinated disease surveillance or monitoring.

The Prairie Crop Disease Monitoring Network (PCDMN) has recently been established and focuses on providing timely information about crop diseases on the Prairies and highlighting effective disease management approaches. Current support for the PCDMN is received under the Integrated Crop Agronomy Cluster from WGRF, Saskatchewan Canola, Alberta Wheat Commission, Saskatchewan Pulse Growers, Saskatchewan Wheat Development Commission, Alberta Pulse Growers, Manitoba Crop Alliance and AAFC. In Eastern Canada, there is currently no formal coordinated disease surveillance or monitoring for disease management.

Barley pest management projects total 7% of the funding or $226,000 annually. Approximately half of the projects investigate Fusarium head blight (FHB) population structure, disease biosensors, and the development of an interactive prairie-wide FHB/DON risk map. Other pest management projects focus more broadly on pathogen variation and surveillance, and beneficial insects for Prairie crops.

It is important to note that the pest management research category (and funding of $226,000 annually) does not include breeding and germplasm screening projects and is thus an underestimate of the dollars dedicated to this area of research. All breeding programs commit a significant portion of their time and funding to develop disease resistant cultivars.

THEME 4: HARVEST AND POST-HARVEST MANAGEMENT

Barley acres are continuously expanding into marginal areas of western Canada, where the need for short-season varieties is important. Breeders search for lines with medium to early maturity to fit the short-season zones. However, the correlation between early maturity and reduced yield makes the early maturing variety less desirable for growers, especially where full-season varieties are currently grown.

The timing and harvesting method used for barley depends on the intended end use for the crop and the conditions at harvest. Barley can be straight cut or swathed for silage, green feed, high-moisture hay, feed grain or malt grain end use. The quality of the harvested barley depends on many factors. In the producer research survey, growers identified pre-harvest sprouting, early maturity, reduced tillering for uniform dry down, head retention and shattering as the top harvest issues.

Preservation of grain quality during storage directly impacts producer profitability. Research directed to maintaining high quality grain, and reducing the incidence of insects and disease, is important to the industry.

Summary of Current Investment: Breeders are searching for earlier maturity without a reduction in yield in their breeding programs. There is currently no dedicated funding from the Barley Industry Research Funders, outside of the breeding commitment for early maturity, dedicated to harvest management projects.

THEME 5: END USE APPLICATIONS/OPPORTUNITIES

Barley is developed for specific end use quality requirements for malt, food or general purpose (feed and forage). In 2020, 53.7% of the barley varieties planted in western Canada were malting barley, 38.5% were general purpose and 2.4% were food barley varieties (Canadian Grain Commission, 2020). Barley can either be two-row or six-row and hulled or hulless. In Canada two-row barley dominates acreage with over 2.7 million hectares seeded in 2019 and only about 202,000 hectares of this acreage sown to six-row barley (King, Breeding Six-Row Feed & Forage Barleys, 2020).

i. Feed and Forage Barley (General Purpose)

Barley is the primary feed grain in western Canada; however, producers have many other feed options, including corn, wheat, triticale, rye, and by-product feeds. Cattle consume the majority of barley by almost 10-fold over either poultry or swine. Other markets, such as the pet food industry, also use barley as a healthy grain additive.

General purpose barley can be either two-row or six-row and hulled or hulless. Two-row barley has fewer kernels than six-row, which results in plumper kernels, especially under dry conditions. Plump kernels have a higher percentage of starch, with lower fibre and protein, leading to improved feed efficiency. The use of hulless feed barley in Canada is limited due to difficulty segregating hulless from hulled varieties, a lack of premiums for hulless, and the lower yields. However, hulless feed barley does have higher digestibility, higher protein and energy content, and lower fibre than hulled barley (Alberta Barley, 2015), making it attractive for livestock feed and pet food.

Demand for barley feed grain is primarily dictated by price due to the fact that the assessment of its quality is limited and it generally contains different barley varieties and a range of quality.

Forage barley is consumed by livestock through swath grazing or after harvesting for greenfeed or silage. Producers have more choice over the barley varieties selected for forage as compared to barley grain for feed.

Summary of Current Investment: Research investment in general purpose barley is primarily directed to the breeding of new feed and forage varieties. There are 1.9 breeder full-time equivalents (FTE) dedicated to breeding general purpose barley in the public breeding organizations in Canada or approximately 42% of the barley breeder resources. The University of Saskatchewan Crop Development Centre dedicates 10% of a FTE breeder, AAFC Ottawa provides 80% of a FTE breeder, and the Field Crop Development Centre has 1 FTE breeder. General purpose barley breeder resources are split approximately 24% six-row and 76% two-row for general purpose barley. At this time, the implications of the transfer of the Field Crop Development Centre (FCDC) to Olds College in Alberta are unknown and leaves uncertainty around the Canadian resources directed to breeding varieties of feed and forage barley. Agronomic research specifically focused on improving feed and forage barley yields and quality is currently limited, with only one project dedicated to this research area.

The active barley research directed to feed and forage end use quality includes seven projects with a total value of $1,459,000. The projects include support for a technician to perform research related to barley grain for livestock, projects related to ergot and mycotoxins, research on the gut health implications of feeding barley grain to swine, and understanding fibre requirements for cattle.

ii. Malting Barley

Western Canada has ideal growing conditions for malting barley, which has resulted in a reputation for very high quality. Each year a quarter of all barley grown in Canada is selected for malt, with the remainder used for feed. Canada uses about 350,000 tonnes of malt domestically while exporting approximately 800,000 tonnes of processed malt and one million tonnes of malting barley annually (personal communication with CMBTC).

Barley used for malting and brewing is primarily two-row hulled barley, with the hulls being used as a filter bed to separate the wort from the grain residue in the brewing process.

The use of hulless varieties for malting and brewing is intriguing due to their higher extracts; however, processing concerns, and the need for a change in brewing equipment, limit the use of hulless barley in the industry today.

Summary of Current Investment: The research investment in malting barley is primarily focused on breeding new varieties. There are 2.45 full-time equivalents (FTE) in public breeding organizations dedicated to developing malting barley varieties, or 54% of the Canadian public breeder time. Malting barley breeder FTEs include the University of Saskatchewan Crop Development Centre at 35% FTE, AAFC Brandon at 90% FTE, AAFC Ottawa at 18% FTE and one FTE at the Field Crop Development Centre (FCDC). Barley Industry Research Funders currently have $5.8 million invested in malting barley variety development.

Malting and brewing end use projects are a small proportion of the portfolio, with three projects directed to understanding the flavour profiles of barley cultivars, exploring issues related to premature yeast flocculation and malt microbial communities. Malting and brewing end use research is valued at $540,000.

iii. Food Barley

Barley is an ancient cereal grain that continues to be a food staple in many parts of the world. In North America, there is renewed interest in barley for its nutritional qualities: it is high in β-glucan soluble fibre, an excellent source of insoluble fibre, tocotrienols, phenolic compounds, lignans, and a good source of many essential vitamins and minerals. In 2012 Health Canada awarded barley with an official health claim linking the consumption of barley beta-glucan to a reduction in blood cholesterol. Food barley also appeals to consumers from a whole food perspective, as it is locally grown and there are no genetically modified varieties.

Despite its high nutritional value, the growth in demand for food barley has faced challenges and has not kept pace with other similar healthy grains. Some of the challenges facing barley for food are a lack of consumer awareness of barley, limited product availability, lack of knowledge on how to prepare and use barley, and the consumer trend for gluten-free options.

Barley used for food is generally hulless two-row barley. In recent years, numerous food barley varieties have been developed and registered. However, due to the lack of producers growing hulless food barley, some processors do use hulled barley in their products. Barley for food can have altered starch characteristics, ranging from waxy to high amylose, making it acceptable for diverse product applications. A competitive advantage of food barley is that the β-glucan is located throughout the endosperm and not removed during hulling, as in other grains such as oats.

Summary of Current Investment: Breeder resources dedicated to the development of food barley varieties are minimal. They include a 10% breeder full-time equivalent (FTE) at AAFC Brandon, 18% FTE at AAFC Ottawa, and 5% breeder FTE at the University of Saskatchewan Crop Development Centre. Food barley research outside of breeding is not currently supported by the Barley Industry Research Funders. The GoBarley Platform, led by the Barley Council of Canada, was a recent initiative directed to growing food barley demand and production.

iv. Industrial Uses for Barley

Industrial applications for barley include bioethanol, paper and wood composites, cosmetics, packaging material, natural emulsifiers, and pharmaceuticals. The economics of using barley for industrial purposes are enhanced through the isolation of high value co-products to make the application of these technologies feasible.

The use of barley grain to produce bioethanol is an established and well researched application. In a study by Bressler et al (Bressler, 2009), barley was compared to corn and wheat as a feedstock for bioethanol production. In this study, barley produced higher ethanol concentrations than wheat, but lower than corn. However, several important components were found to survive fermentation and were concentrated in the barley dried distiller grain with solubles (DDGS), including phenolics, sterols, tocopherols and tocotrienols. If these high value bi-products from fermentation are isolated and sold as high value products themselves, the economics of using barley for ethanol is on par with other grains. Barley DDGS also produced the highest in vitro energy digestibility as compared to corn and wheat. Significant research has been done to improve the ability of bioethanol plants to utilize hulled barley varieties, as well as improving fermentation of the lignocellulosic biomass (hulls or straw).

Prairie Green Renewable Energy (Prairie Green Renewable Energy, 2016) is a proposed state-of-the-art dry mill ethanol plant and animal feed production facility slated to be built in Clavet, Saskatchewan. The facility would be Canada's largest ethanol plant and intends to use primarily peas and barley as their feedstock to produce an estimated 150 million litres of biofuel and 228,000 tonnes of high protein livestock feed annually. As of November 2019, the $325 million facility was still on track to be built (The Western Producer, 2019). No further information has been posted on their website.

Photo: Prairie Green Renewable Energy, 2016

Summary of Current Investment: There is currently no research investment from the Barley Industry Research Funders in industrial barley end use projects.

THEME 6: SUSTAINABILITY

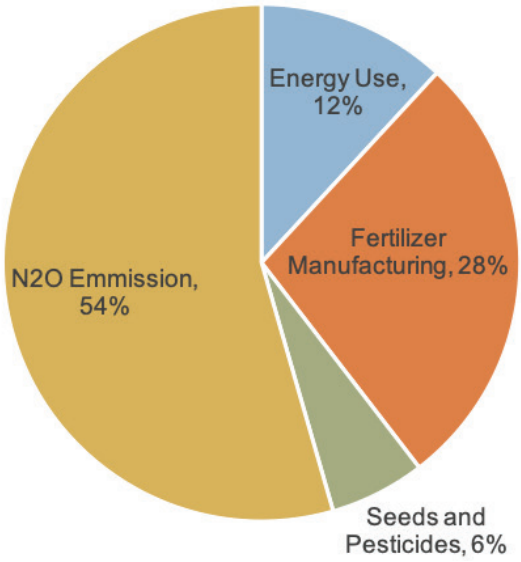
The Canadian government has recently set ambitious targets for both economic growth and combating climate change and identified the agri-food sector as a key element to both. In February 2017, the second set of recommendations from the Advisory Council on Economic Growth (Government of Canada, 2017) proposed actions to move Canada up in the global rankings from the 5th to the 2nd largest agricultural exporter and from 11th to 5th in food exports. These increases would require increasing Canada's agriculture and food product exports by $11 billion and $19 billion respectively by 2027. Investing in the food processing value chain, increasing productivity, and expanding trade were identified as important focus areas to achieve the needed economic growth.

On April 22, 2021, at a virtual Climate Summit of world leaders, Canada announced its intention to reduce greenhouse gas (GHG) emissions by 40% to 45% below 2005 levels by 2030; an increase from its original commitment to a 30% reduction under United Nations Paris Agreement reached in December 2015 (United Nations, n.d.). Like these ambitious emission targets, policy actions have become increasingly common tools that government and industry sectors are using to stimulate innovation, drive investment, and develop strategies for growth.

Sustainability in Canadian agriculture is inherently a positive story. A large stock of natural resources (arable land, freshwater, coastlines, etc.), low occupation density of livestock and people, supportive environmental and labour regulations, access to capital and inputs, and a robust research network are just some of our natural advantages. However, it's generally accepted across the agricultural industry that sustainability is a journey of continuous improvement towards increasingly environmentally sound, socially responsible and economically viable production practices. For example, best management practices (BMPs) for water stewardship, improved energy efficiency, and effective input use continue to evolve both for general application and with regional specificity to address the breadth and variability of Canada's agricultural landscape. There may be a significant difference in the choice of BMPs for barley production across Canada due to regionally suited production practices, soil conditions, and climate.

A benchmark value is needed from which to measure improvement and set a reasonable sustainability target. For example, barley is a relatively low-input crop and a relatively low contributor to GHG emissions compared to more intensively managed crops. According to one 2017 study prepared for the Canadian Roundtable for Sustainable Crops ((S&T)2 Consultants, 2017), the average net GHG emissions of barley produced across Canada is 196 kilograms carbon dioxide equivalents per tonne (kg CO2eq/tonne). Results ranged from 57 to 1,300 kg CO2eq/tonne across the country, and about 60% of production occurs in regions with below-average emissions. Barley production was reported as a net carbon sink for the country, meaning regions were gaining soil carbon due to reduced tillage practices and reduced area under summerfallow. However, soil carbon was lost in regions where perennial crops were transitioned into annual cropland. The majority of GHG emissions from barley are nitrous oxide (N_2O) emissions from the decomposition of fertilizer, crop residues, and soil nitrogen mineralization. The remainder was attributed to direct energy use, fertilizer manufacturing, and the production of seeds and pesticides (Figure 9).

Figure 9: Distribution of GHG emissions for Barley Production in Canada



Source: "Carbon Footprint for Canadian Barley", (S&T)2

Based on this data, it's clear that where barley production can contribute most to the federal government's goals of reduced GHG emissions is by focusing on reducing N2O emissions from the decomposition of fertilizer and crop residues. This aligns with the identified grower priorities around improving barley's nitrogen use efficiency (NUE) by increasing the portion of nitrogen (N) taken up by the plant. Supporting breeding activities for enhanced NUE is challenging and requires dedicated long-term funding to make advances. Improvements in N management have been achieved, but there is an opportunity for further gains in this area. Agronomic research could identify best management practices (BMPs) for fertilizer application, such as optimal rates and timing to reduce synthetic N in the soil and plant residue. However, environmentally driven BMPs must also be evaluated by considering yield, lodging and cost to growers if they are to adopt them.

New variety development is the cornerstone of sustainable barley production and the greatest tool for the industry to adapt to climate change. Though expensive long-term activities, breeding programs directly address how to produce more with fewer inputs. The variety development priorities identified herein overlap with the general goals of sustainable agriculture through the research themes of maximizing yield potential, improving lodging resistance, reducing the impact of barley pests, harvest management, and end use applications.

Improving genetic yield potential and ensuring access to variable germplasm adapted to a range of weather conditions, from drought to flooding, is necessary to mitigate the long-term impacts of climate change and ensure barley remains a competitive crop to grow in rotation. Improving Canada's pool of barley germplasm by improving specific traits such as lodging resistance, disease resistance, and earlier maturity will support barley production into marginal land, promote the judicial use of chemical applications for plant growth and pest protection, and improve the efficiency of harvest. Improvements in disease resistance and quality traits for one or more markets could reduce waste, protect animal and human health, and encourage sales in existing and new markets to maintain and grow barley's economic sustainability.

As climate change continues, generally warmer weather and changes to precipitation creating wetter or drier conditions will influence the type, amount and spread of agricultural pests, from diseases to weeds to insects. Continued investment to identify and develop effective in-field pest management practices, in addition to genetic advancements in disease resistance, will ensure that effective integrated pest management (IPM) strategies remain an industry standard. IPM may reduce herbicide and pesticide use, limiting the need for chemicals applied to the environment and producers' input costs. Forecasting technology for pests and weather may also improve the efficacy of chemical inputs to reduce further both the amount of product needed and the associated cost of application.

Agronomic BMPs are a shorter-term approach for advancing sustainable production and end use quality. The barley carbon footprint example above showed that optimal fertilizer rates, placing and timing could reduce synthetic N in the soil and plant residue to reduce GHG emissions. This work also showed that barley production improved soil carbon when grown under no-till and reduced summerfallow practices. The recent return to more soil cultivating is of concern as it reduces soil carbon and contributes to GHG emissions. Continuing education with growers to understand their approach and investigate alternatives to tillage could be beneficial.

With a broad and diverse landscape, most agricultural sustainability practices will look different across the country. Not all practices will be as impactful across large areas as reducing tillage for improving soil carbon or strong rotations to improve biodiversity. Targeted management strategies for barley can increase both its environmental and economic sustainability. Regional BMPs evaluate and recommend the most effective variety choice, seeding rate, chemical applications and harvest practices to limit inputs and maximize yield in a production area while also improving barley's selectability for key market traits such as feed grain energy, biomass yield, beta-glucan content or pre-harvest sprouting. Investing in agronomic trials across multiple locations can identify the best regional expression of genetic and economic potential.

Improved varieties and better management practices will advance barley's sustainability story. However, it's generally accepted that both the domestic and global demand for sustainable and low-emission products, indicated by government policies like Canada's Barton Report and commitment to GHG emission reductions, outpaces historical growth rates for improvement in agriculture. So, continued research and development, innovation and technology have a critical role in increasing productivity while improving sustainability. For barley, this could include new genomic tools and resources to accelerate variety development, precision application technologies, robotic surveillance, measurement and diagnostic tools, or processing methods. Multi-use crop research, such as developing high-value co-products, could expand Canadian barley into new and emerging markets, increasing economic profitability. This innovation may counter some of the less desirable impacts, such as input costs and reduced profit margins, of government climate change policy, like the carbon tax.

Summary of Current Investment: The barley inventory does not currently include any projects specifically identified or categorized as sustainability research. However, as discussed, the goals of many areas of research closely align with the goals of sustainability.

THEME 7: KNOWLEDGE TRANSLATION AND TRANSFER (KTT)

Effective knowledge translation and transfer (KTT) is essential to realizing the full return on investment for research. KTT plays a role in the adoption of new varieties by farmers, communicates best management practices, enables producers to make informed decisions (i.e. input requirements), and facilitates the sharing of research results in the science community.

With the decrease in extension specialists in the government and universities, research dissemination has increasingly become the responsibility of the producer commissions, industry organizations, and scientists. However, individual researchers have remained committed to sharing their results with stakeholders, peers and producers through publications, conferences, field days and collaborations on industry communications and events.

The pandemic has facilitated the growth of virtual and digital communication. Webinars, podcasts and social media communication have become commonplace and are an effective way to reach a broader audience and reduce travel costs. The pandemic has been challenging for face-to-face KTT but may have enhanced forms of communication that will remain.

KTT is a priority for the industry and recognized as vital to the competitiveness of the barley. Many organizations have hired extension and communication staff, a KTT component has become a standard requirement for successful research funding requests, and numerous print, audio and visual communications tools are being utilized to reach diverse audiences.

Summary of Current Investment: The CAP National Barley Research Cluster has a dedicated KTT activity that provides approximate $160,000 in communications support to its research activities. This includes the development of research magazines, videos and digital website and social media content targeting Canadian producers and other industry stakeholders. It is common for individual project funding to also require a KTT component in the workplan. The amount of funding dedicated to KTT is difficult to quantify and challenging to measure the impact.

7. BARLEY RESEARCH PRIORITIES

PRODUCTION RESEARCH

The research opportunities listed below support and advance the research themes identified in section 6. The research priorities are not listed in order of importance, nor are they all-inclusive, but have been identified as the highest priorities, or providing the greatest economic gains, to the industry. The "Production Research" applies to all classes of barley.

Variety Development

- Develop superior barley varieties (two-row malt, two and six-row general purpose, two-row food barley) that exceed the criteria for support for registration in Canada in at least one category.
- Introduce superior germplasm and introgression of these traits into local/adapted germplasm with a high emphasis on yield and improved lodging resistance.
- Access to reliable long-term multi-site testing over a range of environments (minimum of 9-10 sites required in western Canada and six sites in eastern Canada for advanced barley line evaluation).
- Improve tolerance to low soil temps and frost damage in early spring.
- Understand the correlation and relationship between key barley traits (i.e., disease and maturity).

Pest Management

- Validate disease forecasting and risk assessment technologies in barley to enhance the quality and timeliness of decision-making for producers.
- Monitor the incidence and severity of barley pests (disease and insects) and better understand changes in virulence and the development of chemical resistance.
- Investigate agronomic and management strategies to manage biotic risk with an emphasis on Fusarium head blight.

Agronomy

- Agronomic evaluation of newly developed Canadian cultivars for different geographic regions.
- Optimize nitrogen fertilization to maximize yield, without lodging, for new varieties.
- Evaluate the efficacy of fungicides on barley under diverse environmental conditions and geographic regions to predict an effective yield response.
- Evaluate plant growth regulators, single mode of action or tank mixes, to determine efficacy and impact on quality.
- Investigate optimal seeding rates for new varieties to increase uniformity and reduce tillering for straight cutting and disease management.
- Understand effective rotations to maximize yield and reduce the soil-seedbank for weeds, pathogen and insect loads, and disease.

Innovative Technology/Diagnostics

- Development and application of genomic resources related to Canadian barley lines.
- Breeding strategies to reduce the breeding cycle time.
- Development of tools for quantitative assessment of key barley traits in the field.
- Development and application of research related to precision ag, robotics, artificial intelligence, drones, and understanding the soil microbiome.

FEED AND FORAGE BARLEY RESEARCH

Variety Development

- Breeding and development of feed and forage barley varieties (hulled and hulless); focusing on yield, disease resistance (leaf disease, FHB, ergot), and standability.
- Increased plump and consistency of kernel size (barley feed grain).
- Response to different processing conditions (barley feed grain).
- Smooth awns (barley forage).
- Wider harvest window to allow producers flexibility in harvest management (barley forage).
- Improved fibre digestibility (barley forage).
- Response of barley varieties to forage conservation methods (i.e., ensiling, green feed, pit vs round bale silage, etc.).

Agronomy

- Identify cost-effective agronomic strategies to increase feed grain energy yield or biomass yield per acre.
- Crop management practices to reduce pests.
- Investigate forage barley as part of a complex cropping system, including in mixtures, blends, intercrops, with livestock and cover crops, to order to identify optimal systems.
- Storage, or other crop management practices, to reduce microbial and fungal contamination, specifically deoxynivalenol (DON), ochratoxin A and ergot.

Innovative Technology/Diagnostics

- Prediction models to rapidly and concisely determine the feed value of blended (variable quality and plump) barley grain.
- Technology to refine and improve barley processing to increase the consistency of starch availability.
- Methods to characterize starch availability to support ration formulation strategies.
- Technologies to inactivate, bind or mitigate the effects of ergot and other mycotoxins.
- Establish animal health benefits of including barley in livestock feed rations.

MALTING BARLEY RESEARCH

Variety Development

- Breeding two-row malting barley varieties to meet the diverse quality profiles of the malting and brewing industry (i.e., adjunct, all malt and distilling)
- Increased fine extract allowing the brewer to use less malt to produce the same amount of beer.
- Balanced modification resulting in low beta-glucan without an excessive breakdown of protein fractions.
- Resistance to pre-harvest sprouting without prolonged dormancy in the malthouse.
- Development of varieties that require a shorter process time in the malthouse.
- Thin, bright hulls that adhere tightly during harvesting, cleaning and malting.
- Low β-glucan content (i.e., maximum 150 mg/L for European style and maximum 100 mg/L for North American style).
- Low/no glycosidic nitrile (GN).
- Flavour stability (i.e., Loxless or other technology).
- Unique flavor profiles.

Agronomy

- Investigate agronomic and management factors that will improve the likelihood of selection for malting barley (for a full list of the quality requirements see BMBRI Quality Factors for Malting Barley).
- Harvestability and selectability without the use of pre-harvest herbicides.

Innovative Technology/Diagnostics

- Measurement of propensity for pre-harvest sprouting.
- Germination viability prediction tests.
- Measurement technique for fermentability.
- Technology to reduce levels of deoxynivalenol (DON).
- Physical treatment of grain for enhanced processing.
- Further understanding of β-glucanse activity.

For a full description of the Canadian malting barley research priorities, please use the following link BMBRI Strategic Goals and Targets for Malting Barley Breeding and Research.

FOOD BARLEY RESEARCH— FUNDING IS LIMITED

Variety Development

- Breeding two-row hulless food barley with higher yield, plump kernels, higher protein (currently 13% to 14%) and fiber (soluble β-glucan and insoluble arabinoxylans), whiter kernels (food barley can also be colored) and good threshability.

Agronomy

- Crop management practices to maximize β-glucan and reduce pre-harvest sprouting, staining, microbial contaminants, deoxynivalenol (DON) and alkaloids.
- Improved germination of hulless barley in the field.

Processing

- Inexpensive processing methods to reduce the levels of microbial contamination, DON, and alkaloids in barley products.
- Inexpensive and effective grain treatment methods to improve stability and efficacy of barley functional components (β-glucans and other fibres, tocols, etc.).
- Innovative extraction and processing for healthy barley products from milling fractionations, including soluble and insoluble fibre (β-glucan and arabinoxylans), antioxidants such as phenolics and lignans, secondary metabolites, tocotrienols, etc.
- Technologies aimed at reducing the rancidity of food barley products.

Products

- Pre-processed food products with no, or reduced, cooking times (i.e. breakfast cereals, health bars, concentrated β-glucan powder, snack foods, etc.).
- Improved palatability of barley food products.
- Evidence on the human health benefits of consuming barley.
- Sprouted barley grain products and isolation of functional food bi-products.
- Innovation and development of malted barley food products.

INDUSTRIAL BARLEY RESEARCH— FUNDING IS LIMITED

- Innovative extraction of high value plant products from pearling, wastewater from the malting process, and co-products from barley DDGS.
- Development of high value barley products as natural health products for the nutraceutical/pharmaceutical industry.

8. BARLEY RESEARCH TARGETS 2030

Yield

- 5-7% greater than AAC Synergy (malt)
- 8-10% greater than CDC Austenson (feed)
- Average 85 bu/ac (2026-30)

Lodging

- Increase the number of varieties with a lodging rating of "Very Good" or equivalent by 25% as compared to 2020 ratings

Pests

- Increase the number of varieties with a moderately resistant (MR) rating for FHB resistance or equivalent by 25% as compared to 2020 ratings

End Use Application

- More than 100,000 tonnes of barley used in innovative areas

Sustainability

- Sustainability targets for barley to be developed by the industry by 2022

Knowledge Translation and Transfer

- Update the Research Strategy annually
- Annual meeting of the Canadian Barley Research Coalition
- Maintain the average seeded area of barley from 2016-2020

9. APPENDICES

A. CANADIAN BARLEY RESEARCH INVENTORY (ACTIVE)

Appendix A contains a list of active barley research projects up to December 31, 2020 and includes research specific to barley, whole farm research and multi-crop research that includes barley in the study.

B. CANADIAN BARLEY RESEARCHERS

Appendix B is a list of Canadian researchers, their contact information and expertise, working on barley and/or with expertise or technology applicable to barley.

C. CANADIAN BARLEY RESEARCH FUNDERS

Appendix C is a list of organizations that fund barley research, including research manager contact information.

D. RESEARCH FUNDING OPPORTUNITIES

Appendix D provides a list of funding opportunities for barley researchers including an overview of the program and timelines.

E. PRODUCER RESEARCH SURVEY RESULTS

Appendix E includes a summary of the producer survey results.

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