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CANADIAN SOYBEAN INDUSTRY RESEARCH AND INNOVATION STRATEGY WORKSHOP

February 5, 2020
Mississauga, ON
Meeting Notes

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SYNTHESIS
Agri-Food Network

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Soy Canada facilitated a workshop for the Canadian soybean value chain and research community on February 5, 2020. The purpose of the workshop was as follows:

- Develop a shared understanding of soybean research and innovation needs and current programs/projects across Canada
- Develop and gain agreement on soybean research objectives/priorities and an overall innovation strategy
- Determine the "best approach" for the industry to collectively position itself for success and to have a co-ordinated approach for future research funding programs/agreements

Synthesis Agri-Food Network conducted an on-line survey, facilitated the February 5 workshop and prepared this report.

Current Context for Canada's Soybean Industry

Soybeans are a major field crop in Canada, generating $3.05 B in farm cash receipts in 2018 and an estimated $12.7B in total economic output (2017 data). For six consecutive years (2013-2018), soybeans ranked as Canada's third most valuable crop, following canola and wheat. In 2020 Soy Canada facilitated a research priority workshop to update the research priorities and innovation needs of the soybean value chain, considering the changes that have occurred since the last priority-setting process in 2016.

This current context section outlines some of the current trends in the soybean sector that are influencing research and innovation needs. Key production values are listed in Table A; these figures demonstrate that the soybean industry generating strong economic performance for Canada's agri-food sector.

Table A: Key Statistics for the Canadian Soybean Industry in 2019

Production	**Soybean Farms**	**31, 520 (2016 Census; number of farms growing soybeans)**
	Seeded Area	2.31 million Ha*, 5.71 million Ac**
	Yield	2,650 (Kg/Ha), 39.6 (Bu/acre) ***
	Total Production	6,045,100 MT ****
	Farm Cash Receipts	$3,055,079,000 (2018)
Processing	Total Soybean Crushing	1,906,224 MT
	Soybean Meal Produced	1,478,358 MT
	Soybean Oil Produced	360,258 MT
Exports	Exports of Soybeans (Volume)	3,953,705 MT
	Exports of Soybeans (Value)	$1,996,590,416

All statistics are based on 2019 data unless otherwise stated and were obtained from Statistics Canada, Agriculture and Agri-Food Canada, and the Canadian Oilseed Processors Association.
* Ha – Hectares
** Ac – Acres
*** Bu – Bushels (27.22 kg)
**** MT – metric tonnes

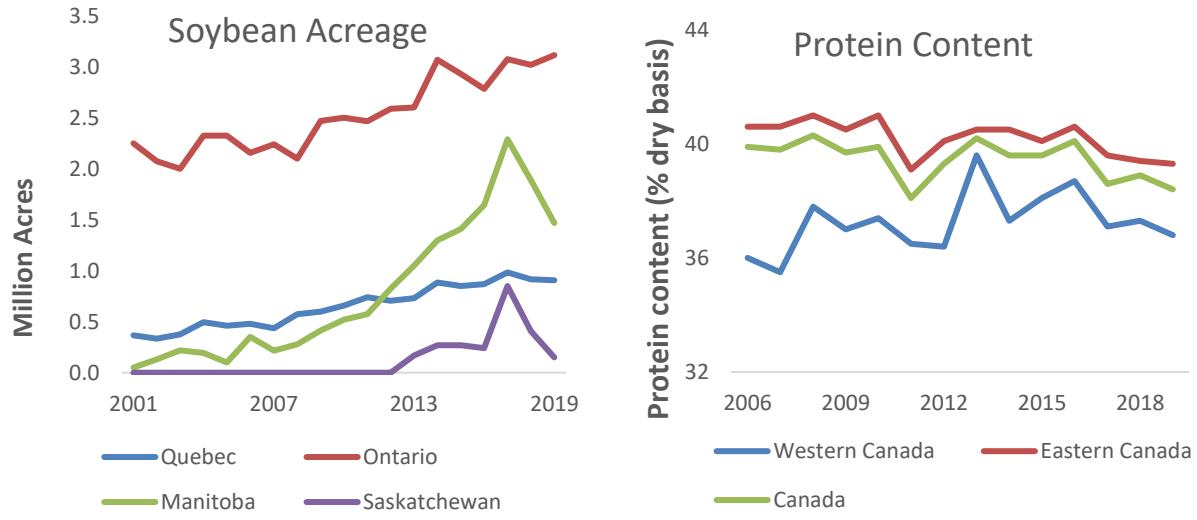
Production Overview

Soybean acreage has been relatively stable in Eastern Canada for the past decade, while acreage in Western Canada rose dramatically between 2007-2017. Since then, Western Canadian acres have fallen sharply and the projected acres planted nationally in 2020 is expected to be 5.6 million acres[1], down from a high of 7.2 million acres in 2017. A major factor

[1] Source: AAFC Planting Intentions 2020

driving this reduction in western Canada was three successive years (2017, 2018, and 2019) of low moisture during the critical pod fill period. Figure 1A shows historic soybean acreage by province.
The value of soybeans in world markets is driven by protein content and production in Western Canada has struggled with consistent and reliable protein content of soybeans, as shown in Figure 1B. Discounting of low protein soybeans (i.e. less than 40%) has become a disincentive for Western producers to continue to integrate soybeans as a reliable and profitable crop in their production systems.

Figure 1: Soybean Production Trends A. Soybean acreage by province 2001-2019 **B.** Protein content of Canadian soybeans, by production area, from 2006-2018 Sources: Stats Canada and Canadian Grain Commission, Quality of Canadian Soybean, Oil-Seed Type 2019

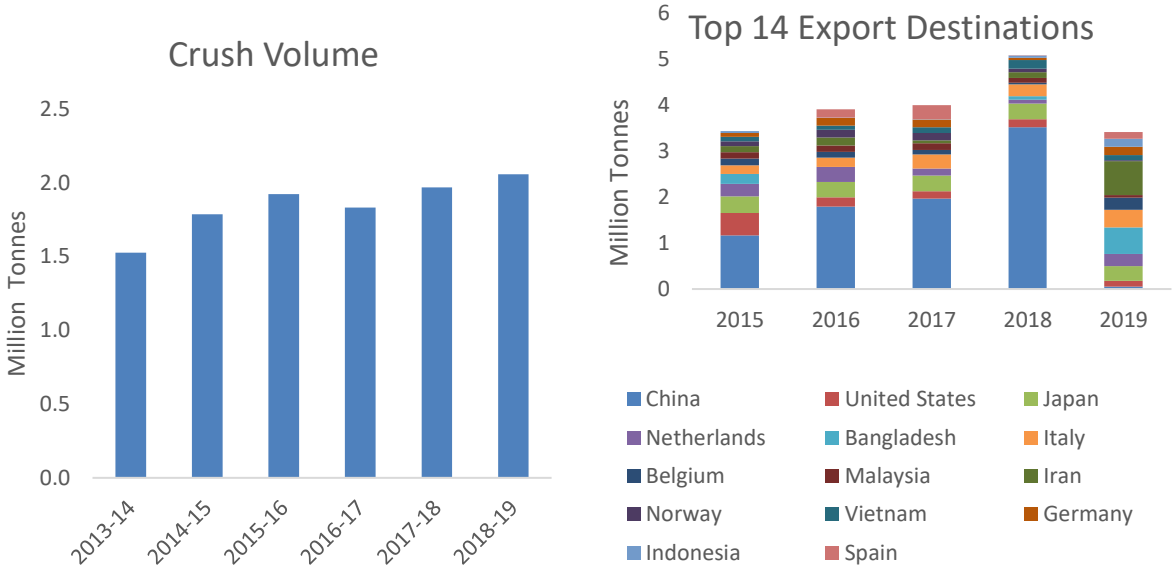


Market Overview

Crush volumes in Canada have remained stable over the last few years, as shown in Figure 2A. Approximately 25% of soybeans are crushed domestically, while the remainder are exported.

Trade issues and market access have experienced increased volatility since 2017 and have impacted Canada's soybean exports, particularly with the virtual cessation of soybean exports to China in 2019 (a 98.4% drop in exports in 2019 compared to 2018 levels), as shown in Figure 2B.

Figure 2: Market overview of Canadian soybeans**. A.** Volume of Canadian soybeans crushed domestically (2013/14 – 2018/19) **B.** Top 14 Destinations of Canadian Soybeans (2015 – 2019) Sources: StatsCan; Canadian International Merchandise Trade (*CIMT*)



Soybean Research in Canada

Each year in Canada, millions of dollars are spent on soybean research in both the public and private sectors. This overview provides a summary of the main sources of funding for soybean research and active areas of soybean research in Canada.

Publically Funded Research

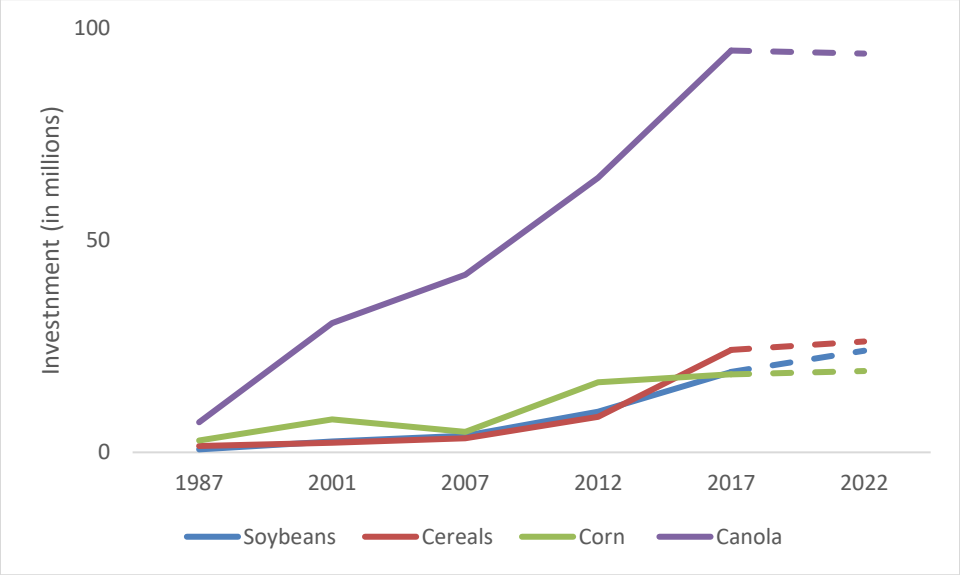
At the federal level, the main source of soybean research funding is AAFC's Canadian Agricultural Partnership **(CAP)** program. This program provides funding through a variety of mechanisms, including federal programs as well as provincial programs. An example of a federal CAP program is the AgriInnovation program for industry-led research and development. Currently, soybean research is funded through the Agri-Science Cluster Program via a $5.4 million investment in the Soybean Cluster, with a focus on root diseases, breeding short-season non-GMO varieties, and improving protein content, led by the Canadian Field Crop Research Alliance (CFCRA). In addition, in 2018 the Agri-Science Projects program provided $3.7 million to the Eastern Canada Oilseeds Development Alliance (ECODA) for research projects in a variety of oilseeds, including soybeans. The Natural Sciences and Engineering Research Council of Canada (NSERC) also funds basic and industry-led research relevant to the soybean value chain, including over $1.4 million to various research projects and collaborations in 2018-2019.

Genome Canada is a not-for-profit organization funded by the federal government. Although soybeans have received large-scale Genome Canada funding in the past (e.g. SoyaGen), there are currently no soybean research projects funded by Genome Canada.

Provincial governments are also actively funding soybean research both through CAP federal-provincial programs and through independent programs. Industry associations that fund soybean research include: the Atlantic Grains Council, Grain Farmers of Ontario, Les Producteurs de grains du Québec, Manitoba Pulse and Soybean Growers, Saskatchewan Pulse Growers and Western Grains Research Foundation.

In Canada, private sector investment in soybean research and breeding grew to $18,986,000 in 2017, and is expected to increase to 23,983,000 in 2022. In 2017, 1,242 people were employed by private sector plant breeding & research programs (all crops) and private companies also contribute to publicly funded programs.

Figure 3: Private Sector Innovation Investment in Canada's Seed Sector (1987 – 2017, projected 2022)



Source: Canadian Seed Trade Association – Snapshot of Private Innovation Investment in Canada's Seed Sector

Research Strategy Opportunities for Canadian Soybeans

GxExM (Genetics x Environment x Management)

In the past decade, soybeans have been the fastest expanding crop in Canada. This expansion has highlighted the role of soybeans as a profitable and highly marketable component of crop production systems which offers environmental benefits for soil health and entire cropping systems.

The expansion into new growing areas has come with new crop management and processing challenges. These challenges may require a new lens for linking breeding and agronomic research to manage environmental variability, using new precision technologies to uncover GxExM relationships.

In established growing regions, most of the focus has been on GxE interactions and this subsequent breeding research has driven progress in soybean yield and quality. In newer growing regions, research incorporating GxExM relationships may provide rapid progress in management solutions for grower challenges. Precision technologies will facilitate the integration of data from several sources to uncover best practices (e.g. genomics, field sensors, imagery, weather data).

Cropping Systems Approach

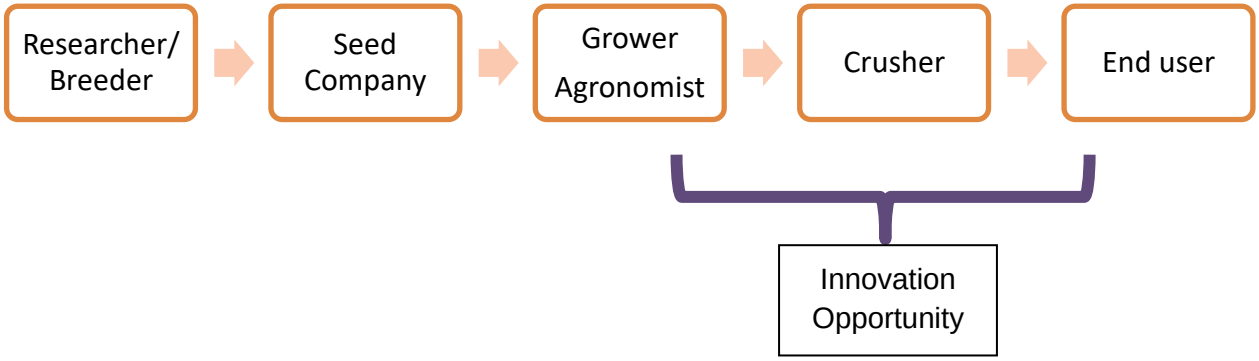
The pace of change in agriculture has never been faster, and there are new pressures and challenges every day for growers:

- Public trust and global regulatory shifts are impacting the availability of agricultural technologies for growers, including crop protection products and genetic technologies (like biotechnology).
- End users are also increasingly asking for sustainability metrics.
- Climate change is increasing unpredictable and extreme weather events

In order to manage cropping systems for sustainability and resilience, a systems approach is required to develop solutions that harness the power of agronomic management and genetic progress. As examples, research is needed to determine the impact of long-term soil health management practices on pest pressures to identify an integrated approach; crop management best practices should be viewed in a multi-year lens considering impacts of previous and subsequent crops.

Value Chain Innovation

Currently, much of the funded research in Canada is co-funded by grower groups and is targeted at genomics, plant breeding and agronomic advancements. While variety development is a fundamental element of Canada's soybean research strategy, this type of research is long-term and for most traits progress is incremental.
There is an apparent gap in research and innovation along the value chain in downstream processes. Post-harvest and processing innovations typically require shorter research cycles and may provide solutions to some of the challenges in the soybean industry. Adopting an innovation mindset along the value chain and engagement/investment from value chain participants may foster new solutions to current challenges.



Soybean Innovation Framework

A framework was developed at the 2016 workshop as a way to organize national soybean research priorities. The 2020 workshop was an opportunity to refine this framework and develop more specific targets and research goals. The following innovation goals and research themes and priorities reflect the current context of the Canadian soybean industry, including both crush and food grade production.

SOYBEAN INNOVATION GOALS

The four goals listed below are the overarching goals which drive research and innovation for the Canadian soybean industry. These goals will enhance the sustainability of the industry, for the benefit of the soybean value chain, the environment and the economic development of Canada's agri-food industry.

A. Increase soybean yield potential (yield, net return/acre, adaptation to new areas) while meeting/maintaining quality attributes required by end users (e.g. protein).

B. Protect yield and quality from pests and stresses (drought, climate change) using both traditional tools and innovative systems approaches. (e.g. incorporation of soil health management practices to reduce weed, disease and insect pest pressures.)

C. Improving quality to meet customer needs and ensure access to markets.
    a. Market-driven soybean quality research from upstream variety development through to production, post-harvest and processing for the benefit of the soybean value chain, including crush and food-grade soybeans, with particular focus on protein levels.

D. Enhance Cropping System Sustainability using a systems approach to develop resilient production systems with soybeans in rotation.

SOYBEAN RESEARCH AND KNOWLEDGE TRANSFER THEMES

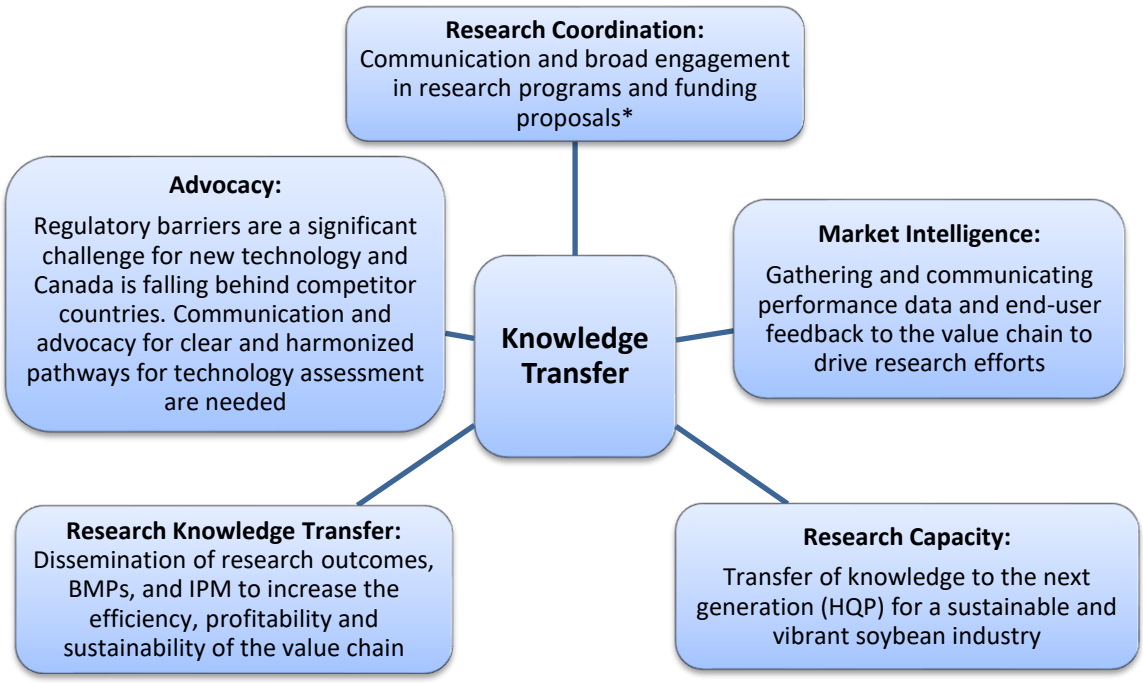
Pursuit of the 4 soybean innovation goals will require engagement and coordination across the value chain, from upstream research to end-use customers. In the 2016 workshop, there were 5 research themes identified to enable progress towards the innovation goals. In addition, below the 5 research themes, the cross-cutting theme of knowledge transfer encompasses a wide variety of key activities, from the development of highly qualified personnel (HQP) to market intelligence.

Research Themes and Focus Areas	Link to Innovation Goals*			
	A	**B**	**C**	**D**
1. Basic research (Genetics / Genomics) • Utilize new tools and knowledge to increase plant breeding efficiency and progress • Advance crop adaptation to mitigate the impacts of stresses such as climate change and plant pests	✓	✓	✓	✓
2. Plant Pests (Pathology / Entomology / Weed Mgmt.) • Developing genetic and agronomic controls to mitigate the impact of weeds, pests and disease.		✓		✓
3. Plant Breeding • Developing germplasm/varieties with enhanced yield, defensive traits and quality, in particular protein level. • Support the breeding of varieties for expanding regions, such as Western Canada as well as Northern Ontario and Quebec.	✓	✓	✓	✓
4. Agronomy • Improving adaptation of soybeans in a sustainable crop production system (address specific regional needs) • Develop regionally-relevant agronomic BMPs to maximize soybean yield and quality	✓	✓	✓	✓
5. Quality – Crusher / Food Grade / New Uses • **Crusher -** Meeting customer needs for soybean meal and oil quality • **Food Grade -** Meeting customer needs for food attributes in high value soy food markets • **New uses -** Adding value to soybeans with new feed and food uses and markets (e.g. silage, green feed)			✓	

*__A__: Yield; __B__: Pests and Stresses; __C__: Quality; __D__: Sustainability

CROSS-CUTTING THEME: KNOWLEDGE TRANSFER

Throughout the workshop, several priorities were discussed that can be grouped under the cross-cutting theme of knowledge transfer (KT). In addition to the traditional transfer of research results and best practices to growers, KT can play an important role in connecting the whole value chain to the priorities and outcomes that matter the most. The following diagram illustrates important KT activities that can move the soybean industry towards its innovation goals.[2]



*The coordination of research was also highlighted in the pre-meeting survey. Several respondents requested more face-to-face meetings, via an annual soybean research meeting and/or meeting between researchers and industry. See survey results in Appendix C for further details.

[2] Abbreviations used in diagram: BMPs: Best Management Practices; IPM: Integrated Pest Management; HQP: Highly Qualified Personnel

Research Priorities

In 2016, a set of research priorities were developed to address short-term and long-term needs in each of the 5 theme areas. In the 2020 workshop, participants were asked to update these specific priorities, based on the current context. Compared to the 2016 list of priorities, these 2020 priorities are much more focused on the current significant production challenges for established markets and less focused on new markets or specialty uses.

1. Basic research (Genetics / Genomics)

Genetics and genomics are core research activities to address research challenges in several areas. The following research priority topics were emphasized by workshop participants for each of the focus areas in this theme.

Focus Areas:

- Utilize new tools and knowledge to increase plant breeding efficiency and progress
  - Implementation of marker-assisted and genomic prediction and selection
  - Linking genes to traits
  - Utilize new tools (e.g. AI for breeding solutions) to enhance breeding efficiency
  - Integration of genomics, breeding and physiology to enhance trait selection
- Advance crop adaptation to mitigate the impacts of stresses such as climate change and plant pests
  - High-yielding soybean varieties with high protein levels are a research priority for all growing areas
  - Biotic and abiotic stresses are also a priority target for genetics and genomics, including sclerotinia, drought tolerance and other abiotic stress

2. Plant Pest Research Priorities (Pathology / Entomology/ Weed Mgmt.)

Focus Area:

Developing genetic and agronomic controls to mitigate the impact of weeds, pests and disease.

- Key diseases mentioned include Soybean Cyst Nematode (SCN), Sudden Death Syndrome (SDS), sclerotinia, and Phytophthora rots

- Weed control / management was mentioned as a key challenge for both Eastern and Western Canada, particularly with the development of herbicide-resistant (HR) weeds
- New disease control strategies, including new chemistry and new genetic resources
- Pest monitoring / surveillance is a key priority to track intensity and population shifts such as: genetic changes, pest changes, climate change effects, and for the development of models and decision support tools
- The development of new pest monitoring tools, including molecular, visual, culture and digital technologies can increase the efficiency and accuracy of pest surveillance.
- Integrated pest management, by taking a systems approach to identifying new practices that decrease pest pressure (e.g. rotation, tillage, fertility practices and their impact on disease, insect or weed management)
- Innovative approaches to pest management challenges were also highlighted as a research priority (e.g. bioinoculants, biostimulants)

3. Plant Breeding

Plant breeding in soybeans is conducted by both the public and private sectors. Seed companies have significant breeding programs investments across Canada in both GM and non-GM. The public breeding organizations are also active and tend to focus on germplasm development, early maturity, niche markets (such as food grade soybeans) and new uses.

Focus Area:

- Developing germplasm/varieties with enhanced yield, defensive traits and quality
    - High protein levels for Western Canada varieties is a high research priority with the potential for strong impact
    - Development of capacity and new tools for phenotyping/phenomics to increase accuracy and speed of decisions
    - Germplasm development with new genetic sources, novel disease resistance genes, and genetic diversity
    - Development and utilization of predictive breeding tools to increase the efficiency of breeding progress, including:
        - High-powered statistical tools
        - High throughput genotyping / phenotyping
        - Advanced analytical tools (e.g. incorporating weather data)

- Support the breeding of varieties for expanding soybean seed markets in regions such as Western Canada as well as Northern Ontario and Quebec

In addition to high protein, these regions in particular require research in the following areas:

- Early maturity for Western Canada and Northern Ontario/Quebec – focus on fast emergence, germination and seedling in cool and wet soils
- Focus on abiotic stress (e.g. drought stress)
- Elucidating and managing the protein x environment interaction

4. Agronomy

Agronomy research and knowledge transfer have regional differences between Western and Eastern Canada due to the level of experience with growing soybeans and unique climate, soils and crop rotational diversity. Soybeans are well established in Eastern Canada and while there is some room to expand the crop to new Northern areas, the agronomy needs are mainly related to specific management challenges such as weed management. In Western Canada there is a wide range of grower experience and thus a need for agronomy research to understand how to establish and manage soybeans in various soil zones and early maturity areas. The following is a summary of agronomy research needs.

Focus Area:

- Improving adaptation of soybean in a sustainable crop production system
  - Explore the development of precision agriculture options for agronomic issues, such as weed management
  - Link agronomic management to breeding programs, including G x E x M interactions
  - Develop a systems approach to design stable/resilient cropping systems (e.g. soil health management including the incorporation of cover crops; rotational diversity considering economic and best fit with previous crop, etc.)
  - Develop methods to mitigate the impact of climate change on soybean production (e.g. protocols for early/late planting, harvest management techniques or desiccants to permit early harvesting, etc.)

- Develop regionally-relevant agronomic BMPs to maximize soybean yield and quality
  - For Western Canada, priorities include:
    - Seed establishment in cool soils
    - Soil fertility requirements, including inoculants, nitrogen, phosphorus and potassium, and iron chlorosis in some areas
    - Land preparation, including zero-tillage and residue management
    - Row spacing and plant populations
  - For Eastern Canada,

- Weed management, including herbicide resistant weeds
- Site-specific nutrient management (including phosphorus)
- Soil management, including boron, low pH, and nitrogen and sulfur interactions in Atlantic Canada

5. Quality – Crusher / Food Grade / New Uses

Quality research encompasses several ends uses, with food and feed as the largest markets. The workshop participants indicated that research priorities related to soybean quality should be market-driven, responding to high potential opportunities.

Focus Areas:

- **Crusher -** Meeting customer needs for soybean meal and oil quality, with emphasis on the requirements of meal end-users
    - The main focus for crusher quality is increasing protein levels in Western Canada
    - Increasing bean size to avoid high fibre meal is also a priority for breeding and agronomics, while recognizing that the development of bean size is highly dependent on the environment (e.g. moisture). Downstream innovation (e.g. grain handling or processing innovation) may also be explored as fibre management options.
    - Other research priorities could include specialty soymeal with targeted amino acids or modified fatty acid profiles to improve oil stability, depending on market factors (e.g. price of synthetic amino acids)

- **Food Grade -** Meeting customer needs for food attributes in high value soy food markets
    - Soybean annual quality assessments for food grade soy (e.g. research at AAFC's Harrow Research and Development Centre) are an important activity for the development and promotion of Canada's food grade soy industry
    - Quantify organoleptic characteristic (e.g. mouth feel, flavour, aroma) to better target customer needs
    - New uses as a plant-based protein for food product development, including working with other emerging protein crops (e.g. peas, oats)
    - Nutrition and digestibility research, based on market needs and consumer pull

- **New uses -** Adding value to soybeans with new/alternate feed and food uses and markets (e.g. silage, green feed)
    - Particularly for Western Canada, research into alternate feed and food uses may provide new markets for soybeans
    - There is interest in exploring opportunities in the EU market for biofuels

Appendix A: Agenda for the February 5th Workshop

Canadian Soybean Industry - Research and Innovation Strategy Workshop
February 5th, 2020,
Alt Hotel - 6080 Viscount Road, Mississauga, ON

Purpose:

The purpose of this workshop and process is as follows:

- Develop a shared understanding of soybean production opportunities and research needs
- Update soybean research objectives/priorities based on future needs
- Develop an industry profile and approach that would best support sector participants collectively in the pursuit of success in research and innovation
- Generate a co-ordinated advocacy plan for the active pursuit of soybean research and innovation prioritization and funding

9:00 am Arrival, Coffee and Networking

9:30 am Welcome and Introduction

- Welcome, purpose & intent

9:40 pm Overview of Current Situation

- Review current state of soybean production in Canada
- Review pre-meeting survey results

10:00 am Research Progress Update

- Summary of research priorities and progress since 2016
  - Atlantic Canada - Aaron Mills, AAFC-AAC
  - Quebec - Francois Belzile, Laval University
  - Ontario - Josh Cowan, GFO
  - Manitoba - Daryl Domitruk, MPSG
  - Saskatchewan - Dave Greenshields, SPG

11:00 am Seed Sector Perspective

- Nadia Krasheninnik, Corteva Agrisciences

11:30 am Producer Needs Presentations

- Farmer needs – Eastern Canada
  - Quebec - Salah Zoghlami, PGQ
  - Ontario - Horst Bohner, OMAFRA
- Farmer needs – Western Canada
  - Manitoba - Ernie Sirski, MPSG
  - Saskatchewan/Alb - Glenda Clezy, FCL

1:00pm **Customer Needs Presentations**

- Crusher perspective
  - Rolf Mantei, Canadian Oilseed Processors Association
- Food Grade perspectives
  - Marc Ham, Prograin

1:30 pm **Future Directions - Research Priorities Group Discussion**

- Where do we want to be in the future?
- Review previous research strategy goals to build upon
- What are the priorities in each theme area?

2:30 pm **Funder Perspectives on Future Opportunities**

- Filippo Miglior, Ontario Genomics
- Michèle Marcotte, AAFC-AAC

3:15 pm **Break**

3:30 pm **Getting the Message Out**

- Pre-meeting survey results
- What are the key messages about soybean research investment?
- Develop a strategy to co-ordinate messaging about soybean research

4:30 pm **Wrap-up and Next Steps**

- What is the path forward for the industry to move ahead with research priorities and strategy?

5:00 pm **Adjourn meeting**

Appendix B: List of Registered Attendees

Bahram	Samanfar	AAFC-AAC
Istvan	Rajcan	University of Guelph
Matthew	Czerwinski	Grain Farmers of Ontario
Salah	Zoghlami	Producteurs de grains du Québec
Josh	Cowan	Grain Farmers of Ontario
Colin	Richardson	Snobelen Farms Ltd.
Patrick	Ham	Prograin Inc.
Lai	Wei	Soybean Research Institute, Heilongjiang Academy of Agricultural Sciences
Jason	McNaughton	Hensall Co-op
Malcolm	Morrison	AAFC-AAC
Elroy	Cober	AAFC-AAC
Frédéric	Marsolais	AAFC-AAC
Ketema	Daba	University of Saskatchewan
Aaron	Mills	AAFC; Atlantic Grains Council
Dave	Greenshields	Saskatchewan Pulse Growers
Patrick	Ham	Prograin Inc
Dan	Wright	Syngenta Canada
Willie	Vanderpol	SeCan
Brad	Garlough	Syngenta Canada
Ning	Wang	Canadian Grain Commission
Edward	Cavalier	Huron Commodities
Weiwei	Wang	Harbin Fenghong Agricultural Ltd.
Paul	Cornwell	Hensall Co-op
Ben	Hodgins	Hensall Co-op
Milad	Eskandari	University of Guelph
Michèle	Marcotte	AAFC-AAC
Horst	Bohner	Ontario Ministry of Agriculture, Food and Rural Affairs
Dave	Harwood	Corteva AgriScience
Jeffrey	James	Broadgrain
Glenda	Clezy	Federated Co-operatives Limited
Ernie	Sirski	Manitoba Pulse & Soybean Growers
Daryl	Domitruk	Manitoba Pulse & Soybean Growers
Filippo	Miglior	Ontario Genomics
Rolf	Mantei	Canadian Oilseed Processors Association
Nadia	Krasheninnik	Corteva AgriScience
Martin	Vanderloo	Huron Commodities
Kangfu	Yu	AAFC-AAC
Emma	Coffin	SOY Canada
Ron	Davidson	SOY Canada
Rob	Hannam	Synthesis Agri-Food Network
Carol	Hannam	Synthesis Agri-Food Network

Appendix C: Meeting Notes – Summary of Presentations

1. Current Snapshot of Research Across Canada:

Area	Current Research
Atlantic Canada	<u>Agronomy:</u> Seeding rate Boron, low pH strategies Fungicide efficacy Nitrogen and Sulfur interactions
Quebec	<u>Genomics:</u> -DNA sequencing of 102 Canadian soybean varieties -Genotyping on a fee-for-service basis ($25/line) -Genomic-assisted prediction -DNA marker for improved resistance to white mould (Sclerotinia) <u>Earliness genes/breeding</u> : -Genetic fingerprinting of known genes controlling maturity -Discovery of novel maturity genes -Characterization of how different “maturity packages” perform throughout Canada -New markers for resistance to *Phytophthora sojae* and SCN -DNA marker lab for supporting breeding <u>Phytophothora:</u> -Diagnostic kit to identify the “race” (pathotype) of *P. sojae* so growers select varieties with the “right” resistance gene (RpsX) -Identifying new genes conferring horizontal resistance to *P. sojae* <u>SCN:</u> -Sequencing of the SCN genome, mapping SCN populations in Quebec -Interactions between *P. sojae* and SCN -Adaptation of SCN populations to resistance genes -Characterizing the microbiome of cysts -Projected impact of climate change on SCN <u>Other</u>: Nutraceuticals; Agronomy; Nodulation
Ontario	Agronomy & production: • Long-term cropping systems approach - Effects of tillage, cover crops, crop rotation, N fertilization on productivity & soil health Linking soil biodiversity & soil health • Cover crop termination strategies • Characterization of soil compaction • P management tools for farmers based on P monitoring data • Long-term strategic management of P & K • Impact of organic amendments on P & soil health

	• Optimizing crop management decisions in early and late-planted soybean and corn • Advancing soybean harvest for earlier wheat seeding using various desiccants Pest Management • Integrated weed management: glyphosate & multiple-resistant weeds; Canada fleabane; Glyphosate resistant waterhemp; Emerging weed management challenges • Disease management: SCN Coalition; SDS management; New & emerging diseases; Soil suppressiveness against SDS/SCN Quality • Targeting neurodegeneration to maintain brain health with soybean-derived functional foods • Improving soybean storage protein content • End use quality evaluations for non-GM soybeans Breeding and Genetics • Novel soybean genes involved in host-pathogen interaction between soybean & SCN • Genetic dissection of SCN resistance • Breeding strategies for organic soybean
Canadian Field Crop Research Alliance (CFCRA) Soybean Cluster Research	Activity 2: Short season food type soybean breeding Activity 3: Meeting the soybean protein meal standard in Western Canada Activity 4: Supporting western and northern expansion of soybeans in Canada Activity 5: Northern latitude soybean – physiology of yield formation and beating the cold Activity 6: Breeding for Soybean Cyst Nematode (SCN) resistance using marker assisted selection Activity 7: Breeding of high yielding resistance & value-added soybean using elite and exotic germplasm Activity 8: Breeding food grade soybean varieties or germplasm for high yield, better quality or pest resistance Activity 9: Strategies for effective and durable management of Phytophthora and root rot complexes of soybean Activity 10: A new method for precise and reproducible phenotyping of Phythophthora sojae isolates in soybean Activity 11: Ultra early herbicide tolerant soybean
Manitoba	Agronomy Pest Management: Fusarium diagnostics & epidemiology Phytophthora rapid diagnostics & epidemiology Cultural practices, ecology, herbicide resistance Herbicide performance and resistance Surveillance

	Insects and Nematodes Incidence, ecology SCN surveillance, ecology Biological N-fixation, microbial ecology Soil health management Harvest Management & Storage Quality Protein chemistry Animal nutrition Soy product development and testing
Saskatchewan	Fertility and N fixation Developing nitrogen and phosphorus management recommendations in SK Nutrient content and release from SK soybeans Iron chelates for iron chlorosis in SK Biological N fixation in short season soybeans in SK Weeds Management of RR canola in RR soybeans in SK Towards a robust strategy for long-term weed management Diseases Advancing soybean root disease management Phenotyping *Phytophthora sojae* isolates in soybean Genetic improvement improving yield and disease resistance Short season conventional soybean breeding Very short season herbicide tolerant soybean varieties Physiology & adaptation Western and Northern expansion of soybean in Canada Northern latitude soybean – physiology of yield formation Meeting the soybean protein meal standard in W. Canada Best management practices Moisture management effects on SK soybean Diversifying organic cropping options for the brown soil zone with intercropping

2. Producer Challenges and Research Needs

Challenges	Research Needs
Atlantic Canada	
Low pH soils in PEI (required to control potato scab) Low heat units available; challenge to harvest beans before “instant winter” Low organic matter in soils (2.5-3% on average). Shallow soils in PEI Sulfur deficiency Disease	New Brunswick and Prince Edward Island Higher yielding low heat unit varieties Better pH adaptability Nova Scotia White mould resistance Pod and stem blight Nodulation failure Drought tolerance
Quebec	
Stagnant yields over the last few years More restrictions around pesticide use Disease pressure Expanding growing regions into regions where canola is grown Climate change	High-yielding varieties that meet the quality standards of users/ buyers Prevent negative impact of pests and pathogens, specifically white mould, Phytophthora root rot, Soybean cyst nematode (SCN) through genetic resistance and agronomic practices Surveillance for emerging resistance to pest management traits Develop weed, insect and disease management options that reduce the requirement for pesticides Climate change and resilience Crop management research, including efficient fertilization, crop rotation Development of forecast tools and economic thresholds for pest management
Ontario	
Inconsistent yields - gain has been through genetics, not management Weather - wet springs and falls lead to bigger and faster equipment = more compaction Reduced organic matter and soil nutrient levels White mould (especially in eastern Ontario) Soybean cyst nematode and root rots	Better white mould tolerant varieties More short season SCN varieties Additional practical soil health solutions (increases resilience to drought and excess water) More agronomic trials for fertilizer recommendations and novel yield enhancing products (e.g., bio-stimulants, new inoculants, seed treatments, etc.) New approaches to winter wheat establishment

Herbicide resistant weeds, including Canada fleabane, waterhemp, and potential for Palmer amaranth	
Manitoba	
Soybeans must compete with a diverse set of crops for a place in rotations. Soybeans have not performed well in drought conditions. Soybeans appear to have positive impacts on other crops in rotation, but they still need to be profitable under drought conditions.	Yield stability under drought Reduced uncertainty re: protein discount Cost-effective pest control – detection, resistance, management options (e.g. Phytophthora root rot) Market diversification: develop conventional soybean supply chain and local crushing Improve and clarify what growers can expect from public plant breeding and genetics research.
Saskatchewan	
Soybeans have many positive attributes for Western Canada, such as good standability, non-host for Aphanomyces, limited disease and insect pressure (for now), and good global marketing options. Low protein, particularly as growing regions expand north is a major challenge for Western Canada. Sclerotinia is the only disease pressure for now Low pod height impacts harvestability Economic weed control options	New uses – chop for green feed if can't get harvest off? Understand and manage the GxE interaction for protein content Need to increase yields and pod fill under dry conditions Varieties optimized for maturity and yield considering day length Agronomic research topics including: Fertility / nodulation (inoculant) Rotation (stubble, soil temp) Pod height BMPs for seeding Weed management (volunteer canola, kochia) Disease (sclerotinia) Insects (spider mites, thistle caterpillar, Pea leaf weevil)

Seed Sector Perspective

Nadia Krasheninnik, Corteva Agriscience

- Corteva uses precision breeding for all crosses and only make crosses with high prediction values. The next frontier of seed breeding advancement is phenotyping - using high throughput field sensors and tools. For example, maturity prediction used to take five weeks of manual work. Using drones, it now takes 10 minutes per week to obtain pictures and an algorithm predicts maturity. Drones can also be used to more precisely and repeatedly screen conditions such as iron chlorosis.

- Soybeans have received a lot of interest from Western Canada growers in the last 15 years and Corteva is committed to developing varieties for Western Canada. Intensive breeding efforts will be able to deliver high protein varieties for Saskatchewan and Alberta.

- There is a negative correlation between yield and protein, but protein is still the key factor that dictates the value of soybeans. Soybean protein levels have been dropping globally in several countries, so this is not just a Western Canada problem. Overtime, breeders have been so focussed on yield, varieties are getting closer to the edge of not meeting quality requirements. Through a USB collaboration, there were high protein varieties with acceptable yield developed but there is no grower incentive to produce them, so the project was stopped.

- In a commercial breeding program, advancement decisions are made very quickly and if breeders do not have oil and protein data available rapidly, these characteristics are not considered in variety development. Breeders need tools to rapidly identify oil and protein contents.

Customer Perspectives

Crusher Perspective, Rolf Mantei, Canadian Oilseed Processors Association

In Canada, 25% of soybean production is processed domestically by a variety of crushers. Using 2018 data, 75% of soymeal crushed in Canada is used domestically and 25% is exported. The largest soymeal export countries in 2018 were the US (51%), Ireland (34%) and the UK (10%). In 2018, 55% of soy oil was used domestically, while 45% is exported to the US.

Crushers receive a variable commodity and they need to process it into specific products to meet end-user quality requirements. Their current challenges include:

- Protein Content - low soybean protein levels can result in selling meal below Trading Rule levels and increased customer claims
- Seed Moisture - higher moisture levels in incoming beans affect storage stability and results in increased processing costs
- Oil Content - lower oil yields per tonne (such as in the 2019 crop) impacts the profitability of crushing
- Small Bean Size - small soybean size can make cracking and dehulling more difficult and usually result in increased meal fibre. Variable bean sizes also reduce crushing efficiency

Future crusher challenges include:

- Chlorophyll level increases will reduce stability and increase processing costs
- Synthetic amino acid addition threatens traditional soybean meal markets

Research priorities from the crusher perspective include:

- Increase seed protein content to at least 40%
- Maintain balance between oil content & protein
- Maintain consistency in bean size across all growing regions, particularly with Western beans
- Minimize risk of harvesting damaged/immature beans in order to avoid chlorophyll in the beans

Food Grade, Marc Ham, Prograin

Food grade production requires close communication with customers in order to meet their processing needs, as food trends and soy food products change based on consumer demand. For example, in 2020, the current trend is for high sugar content (e.g. above 7.3%) in order to satisfy the fermentation market in the EU and soymilk markets in Asia.

There are at least 80 varieties of food grade soybeans available in Canada, so there is a lot diversity in bean size, protein level, and other quality traits (e.g. sugar). The current average life cycle of a food-grade variety for Prograin is 6 years, as producers seek higher-yielding varieties.

Current production challenges are diseases such as Phytophthora, and white mould, as well as pests such as SCN. Agronomic management of these diseases and pests is critical in order to provide short-term disease control options. New chemistry or genetic resources to manage diseases and pests are needed to remain competitive, but these solutions are long-term research needs.

Food labelling laws are creating new markets for Canadian food grade soybeans. For example, Taiwanese processors were buying mainly GMO soy for soymilk, until that country introduced food labelling laws, which opened up a new market for non-GMO soybeans.

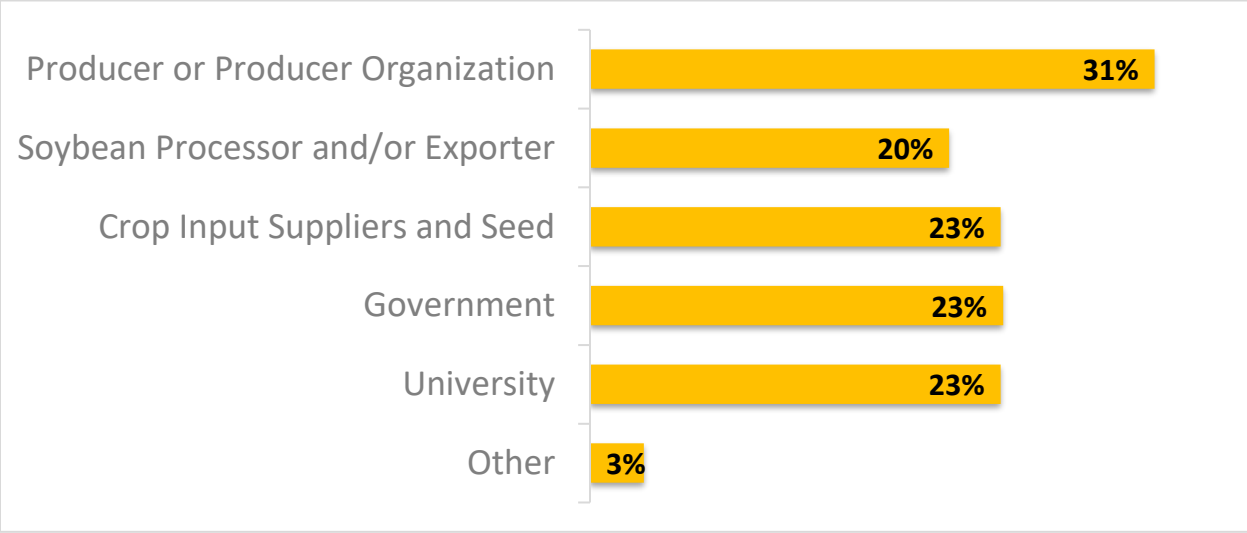
There are other similar examples throughout Asia, in countries where soy foods (e.g. tofu, natto, tempeh) are daily dietary staples. Canadian food grade exporters have an obligation to supply consistent volumes and consistent quality to their end users.

In order to increase the supply of food grade soybeans, exporters are looking to western Canada, particularly with their transportation advantages to Asian markets. Other emerging areas for food grade soy increases are PEI as well as Northern and Western parts of Quebec.

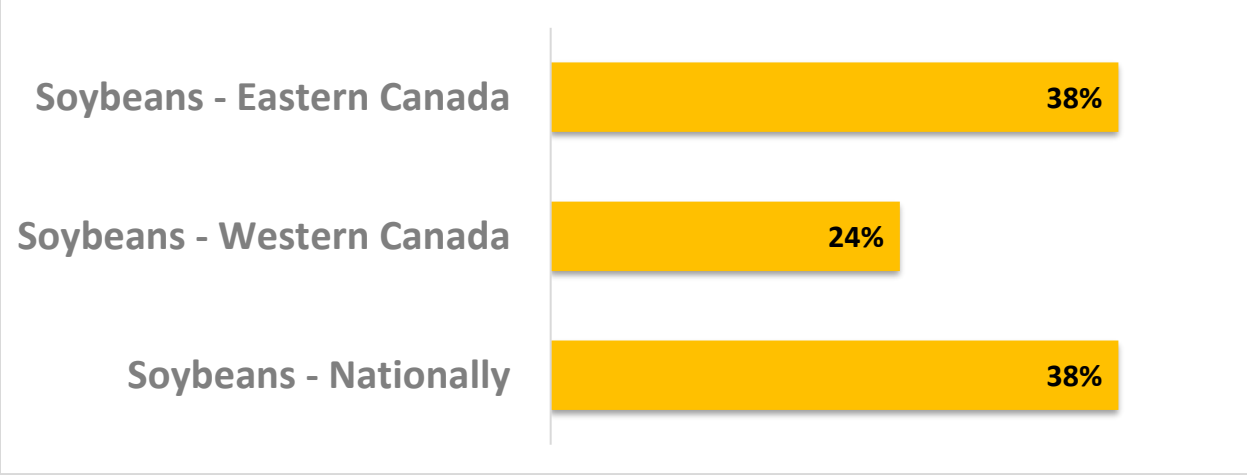
Appendix D: Pre-Meeting Online Survey Results Summary

Canadian Soybean Industry
Soybean Research and Innovation Workshop
Pre-Survey Results
January 2020

1.Please select in the stakeholder group you represent (35 responses).



2. Which perspective do you represent at this workshop?



3. **Since the last soybean research priority workshop in 2016, what changes have taken place that may impact soybean research priorities?**

- Western Canada low protein content*******
- Western Canada production volatility ******
    - drought, protein, pest pressure, market access
- R&D - new tools, genomics, precision ag*****
- Pests and diseases****
    - SCN
    - herbicide resistance weeds
    - SDS
- Competitiveness/economics of soybean production ****

decreased govt research funding ***	climate change **
technology acceptance **	Carbon tax *
Market access**	sustainability tracking, auditing *
soil productivity awareness **	drought/cold tolerance *
gap in agronomy research for W Canada **	Trade instability *
value creation introduced (GoC) **	

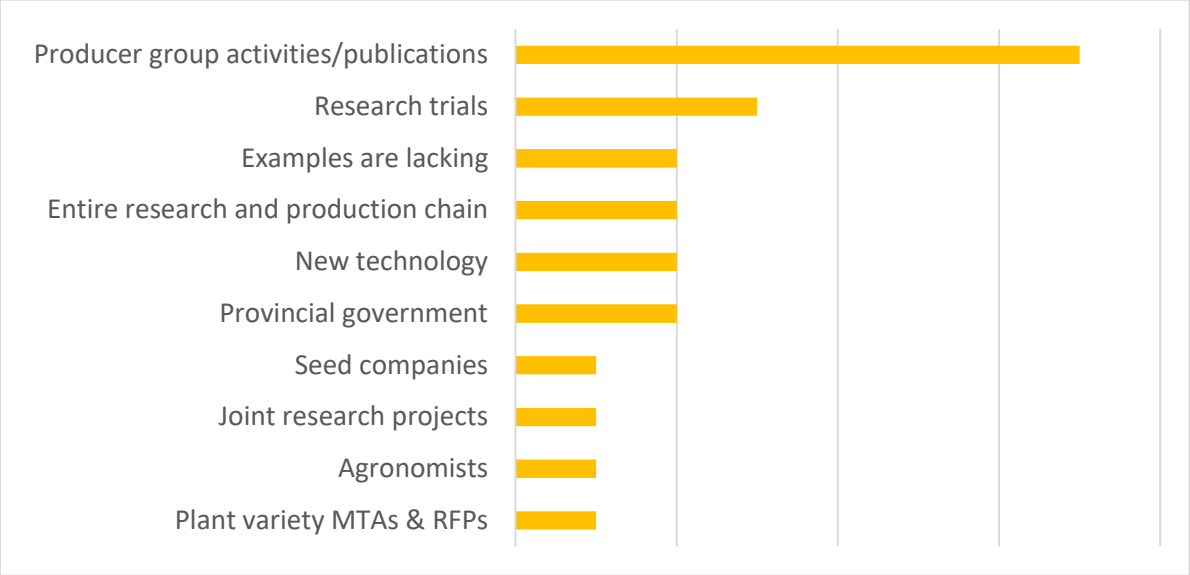
4. **Rank the research themes from 2016 in terms of progress and importance:**

5. **From your perspective, what are examples of successful co-ordination of soybean research across organizations/provinces?**

CFCRA *******
SoyaGen *****
Public/private partnerships** (e.g. Cėrėla/UofG; SeCan/UofG)
MPSG/SPG/WGRF in GF2/CAP
Government trials and extension
North Central Soybean Research Program (NCSRP)
Ontario Soybean and Canola Committee
Herbicide resistant weed testing on prairie-wide scale

6. From your perspective, where is there room for improvement in the coordination of soybean research in Canada?

7. From your perspective, what are examples of successful knowledge transfer/communication between soybean research and industry (e.g. exporters, producers, agronomists, etc.)?



8. From your perspective, where is there room for improvement in information transfer between soybean research and industry in Canada? What are the gaps that need to be addressed?

- annual soybean research meeting***
- centralization of information and outreach
- meeting of researchers and industry every few years
- dedicated tech transfer meeting for soybeans
- more defined roles for everyone - university researchers, industry groups, producer groups, governments, etc.
- improved awareness of KT initiatives (like the Crop Protection Network)
- national coordination in agronomy
- more training for agronomists

9. From your perspective, what can be done to improve collective advocacy in support of public sector funding of soybean research?