CANADIAN FIELD CROPS RESEARCH ALLIANCE / ALLIANCE DE RECHERCHE SUR LES CULTURES COMMERCIALES DU CANADA

Research Priorities
Summary Report

Summary of Input Provided

Joint Industry-Researcher Summit

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The views expressed and compiled in this report are those of the parties expressing them and are not necessarily held by or endorsed by Agriculture and Agri-Food Canada nor the Canadian Field Crops Research Alliance.

GLOSSARY OF ACRONYMS USED

AAFC	Agriculture and Agri-Food Canada
BCC	Barley Council of Canada
BMP	best management practice
CÉROM	Centre de recherche sur les grains
CFCRA	Canadian Field Crops Research Alliance
CHU	Centigrade heating unit
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats (see footnote p. 38)
CWB	Canadian Wheat Board
FHB	fusarium head blight
FSSC	Food Safety System Certification
GDP	gross domestic oroduct
GHG	greenhouse gas
GMO	genetically modified organism
HQP	Highly qualified personnel
ISO	International Organization for Standardization
KT	knowledge transfer
MIAC	Malting Industry Association of Canada
MTA	material transfer agreement
N	nitrogen
NYSE	New York Stock Exchange
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
PDF	post-doctoral fellow
PNW	Pacific NorthWest
RFOs	raffinose family oligosaccharides
SCN	soybean cyst nematode
SDS	sudden death syndrome
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
UAV	unmanned aerial vehicle (aka drone)

President's Introduction

The research summit which convened in Gatineau on November 1st and 2nd was a unique opportunity for industry representatives and researchers to engage together on vitally important subject matter. The purpose was to debate and set research priorities for barley, corn, oats and soybeans, looking forward well into the next decade. This meeting was held to focus on the impact which industry and researchers can have by working together on common goals.

The priority-setting theme was how to maximize the value derived from the research. "Value" is not only measured in economic terms through such metrics as:

- market share, profitability and investment levels

but also in intangible terms such as:

- the development and enhancement of research talent and research capacity which together form an innovative ecosystem to enable the research discoveries to be effectively applied for the benefit of Canadian farmers and consumers.

An important component of "Value" is advancing public policy goals related to:

- public trust and climate change mitigation. Specific metrics for this kind of societal value include more efficient use of nutrients and greenhouse gas emission reductions.

We believe that the meeting accomplished the goals that CFCRA set in enabling thorough and constructive dialogue. From the input received, appropriate research priorities have been defined well into the next decade for our sector. The priorities which were set from this session are summarized in the "Executive Summary" which follows.

On behalf of CFCRA, I express our gratitude to all those researchers and industry representatives who participated in this session and for the valuable and thoughtful input we received.

Jeff Reid, President

1. Executive Summary

CFCRA developed an open and transparent process for obtaining input from industry and researchers, in the context of government's planning for the Next Policy Framework, in order to set its forward-looking research priorities.

- In August, 2016, CFCRA members used their annual meeting to develop industry's working list of research priorities (Appendix D).
- In September, 2016, CFCRA sought input from the research community by undertaking a structured survey (Appendix A).
- The results of input from these two sources were brought together and presented to the research summit on November 1, 2016. Both industry and researchers were represented and had further opportunity to debate, develop and refine the preliminary work.
- CFCRA members met after the summit by conference calls to use the input received to finalize the research priorities which are set out in the following paragraphs.

In consultation with the Western Grains Research Foundation, CFCRA has agreed that the focus of the CFCRA cluster will be on plant genetics and crop-specific agronomy, and that a separate cluster will be proposed for cross-commodity agronomic issues. Accordingly, the priorities identified below reflect the revised scope of the CFCRA cluster on genetics and crop-specific agronomy. As there was valuable input provided at the summit related to research issues in agronomy, the sections of this report which follow include that input, which has been provided to those responsible for developing the priorities for the proposed new cross-commodity agronomy cluster.

1.1 Barley Priorities (eastern-Canadian scope)

- Increase yields of new barley varieties by **≥1.5%** per year until 2023. Yield increase to be measured relative to 2016 provincial checks, to be named in the proposal. New varieties must also have good standability. Given the limited genetic variability of Fusarium head blight (FHB) resistance in 6-row barley, a focus will be on 2-row barley variety development
- Incorporate durable disease resistance into new varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. In order of priority, key diseases include: FHB, powdery mildew, scald, and net/spot blotch. Given the limited genetic variability of FHB resistance in 6-row barley, a focus will be on 2-row barley variety development
- Develop effective management strategies for FHB
- Develop varieties with consistent quality parameters for feed and food uses. Quality parameters to be set by the applicant and must be clear in the proposal
- Evaluate existing malt barley varieties for agronomic and market suitability in eastern Canada

- In order to rapidly respond to changing pathogen profiles and set timely objectives for research, develop a coordinated survey system for identifying current and emerging barley pathogens to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm

1.2 Corn Priorities (Canada-wide scope)

- Develop new short season, cold-tolerant inbreds targeting **1800-2000 CHU**, while building high yield relative to lowest consistent known varieties
- Develop new inbreds with resistance to diseases. In order of priority, key diseases in **western Canada** include: *Fusarium/Gibberella*, Goss's wilt, northern corn leaf blight (NCLB), rust, smut, and eye spot. In order of priority, key diseases in **eastern Canada** include: *Fusarium/Gibberella*, NCLB, nematodes, rust, gray leaf spot, smut, eye spot, and Goss's wilt. New inbreds must have good standability
- In order to rapidly respond to changing pathogen profiles and set timely objectives for research, develop a coordinated survey system for identifying current and emerging corn pathogens to improve management strategies, screen inbreds, and identify and validate new sources of resistant germplasm
- Optimize corn nitrogen use efficiency and management
- Agronomy with emphasis on nitrogen timing and efficiency, and on population density as influenced by pH (particular priority for Atlantic Canada)

1.3 Oat Priorities (Canada-wide scope)

- Increase yields of new varieties by **≥1.5%** per year until 2023, while maintaining quality and desired agronomic characteristics. Yield increase to be measured relative to 2016 provincial checks, to be named in the proposal
- Incorporate durable disease resistance into new varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. Key diseases include: oat crown rust, yellow dwarf mosaic virus, and Septoria leaf blotch
- Develop varieties with consistent quality parameters for milling. Quality parameters to be set by the applicant and must be clear in the proposal
- In order to rapidly respond to changing pathogen profiles and set timely objectives for research, develop a coordinated survey system for current and emerging oat pathogens across Canada to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm

- Plan and conduct strategic genotype/phenotype testing of appropriate germplasm to provide a shared baseline for genomic selection, particularly selection for yield in defined target environments
- Increase stability, predictability and reliability of β-glucan levels in milling oat varieties across environments, targeting minimum β-glucan levels of **5.0%**. β-glucan levels of ≥6.5% are not being targeted, as this is secondary to yield and other traits. Both genetic and agronomic combined solutions are appropriate approaches
- Develop fungicide and nitrogen recommendations for high yield, improved standability, and consistent quality across multiple environments and identify optimum seeding rates for high yielding oat management systems
- Develop methods of cultivation and drying without the use of desiccants in the field

1.4 Soybean Priorities (Canada-wide scope)

- Increase yields of new conventional, speciality food-grade, and herbicide tolerant varieties by **≥2%** per year until 2023, with a lower emphasis placed on herbicide tolerant varieties. Yield increase to be measured relative to 2016 provincial checks, to be named in the proposal
- Identify and validate new sources of resistance to key diseases and pests. In order of priority, key diseases and pests for **eastern Canada** include: soybean cyst nematode (SCN), sudden death syndrome (SDS), *Phytophthora*, root rot complexes, white mould and soybean aphid. In order of priority, key diseases and pests for **western Canada** include: *Phytophthora*, root rot complexes, white mould, SCN, and SDS, soybean aphid
- Incorporate durable disease resistance into new conventional, specialty food-grade, and herbicide tolerant varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. A lower emphasis will be placed on herbicide tolerant varieties. Key diseases and pests are listed in order of priority, and by geography, in the second soybean priority bullet point
- Develop earlier maturing (00 and 000) conventional and specialty food-grade varieties with good yield, cold and moisture stress tolerance, and suitability for short and very short season regions of Canada
- Develop earlier maturing (00 and 000) herbicide tolerant varieties with good yield, cold and moisture stress tolerance, and suitability for short and very short season regions of Canada
- Increase and stabilize minimum soybean protein levels above **40%** (dry matter basis) in new conventional, specialty food-grade, and herbicide tolerant soybean varieties by 2023. This is particularly important for western Canadian soybeans that typically have lower protein
- Identify and validate early maturity genes useful to breeders to improve yield and protein quality

- Evaluate the impact of cool nights on yield
- Improve tolerance to iron deficiency chlorosis/saline soils, excess moisture, and mid-season drought (particular priority for western Canada)
- Improve conventional and specialty food-grade soybean quality for well-defined end use markets. Applicant to indicate target end use market in proposal
- In order to rapidly respond to changing pathogen profiles and set timely objectives for research, expand coordinated surveys for current and emerging soybean pathogens (particularly root rot pathogens) and insect pests across Canada and use this information to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm
- Develop effective management strategies for soybean diseases and insect pests. Key diseases and pests are listed in order of priority, and by geography, in the second soybean priority bullet point
- Improve integrated weed management strategies (with an emphasis on herbicide-resistant weeds) for herbicide-tolerant and non-herbicide tolerant systems in both conventional tillage and minimum/no-till production systems
- Identify ideal nutrient management strategies for soybeans in western Canada and Atlantic Canada (i.e., inoculant recommendations; requirements and management of N, P, K, and S (4R management); rotational fertilization)
- Improve soybean crop establishment and early season growth in no-till production systems (especially in western Canada)
- Investigate factors controlling pod height in soybean to reduce harvest losses and complications
- Investigate impact of soybean on overall crop rotation (N-credit benefits, economics, where do soybeans fit best in crop rotations); effect of short soybean rotations; and impact of soybean on soil biology (particular priority in western Canada)
- Determine how soybeans can be used in rotation to facilitate low-GHG emission cropping systems (i.e., through reduced N fertilizer, reduce tillage, etc.) (particular priority in western Canada)

2. Gap Analysis

Following a presentation by the project manager for CFCRA, Dr. Josh Cowan, in which Josh summarized the preliminary determination of priorities from industry (Appendix A) and from the research community, participants were asked to identify gaps. Since the word "priorities" is the focus of the work, it is helpful to consider its meaning.

A priority is defined as "something which is more important than other things and that needs to be done or dealt with first." In a world in which resources are limited and constrained, prioritization is essential to ensuring that the things which have the greatest importance – and, by implication, the greatest impact - are addressed first.

Although participants were mostly in commodity-based teams, they were asked to consider the needs of the cluster from as broad a standpoint as possible. Therefore, while their input is summarized under the commodity or topic with which they were associated, it is not necessarily limited to that commodity or topic.

2.1 Barley

- In Atlantic Canada, wireworms are an issue in rotational crops
- Dry down aids need to be improved for barley
- The rate of adoption of new malting barley cultivars needs to be accelerated so that gains in yield are available to farmers sooner; a possible approach is developing better prediction of malting barley quality for new varieties to gain faster uptake by maltsters

2.2 Corn

- Crop modelling which targets population environments
- Anticipating the emergence of novel research ideas (example: the serendipitous discovery that enabled the conversion of rapeseed to canola)
- Defining and documenting "sustainability" in order to satisfy the requirements and expectations for sustainability of end-use markets – providing greater clarity around what 'sustainability' and 'conservation agriculture' mean
- Concern that there are too many priorities, especially in listing disease risks, and a need to determine which diseases should be the focus of research

2.3 Oats

- Continuing evaluation of new cultivars needs to be undertaken after they have been registered to determine their success in terms of agronomic performance (such as yield) and quality relative to end use requirements – post-registration trials could accommodate that kind of performance evaluation

- There is no pre-breeding or germplasm development for seeking out more resistant genes for specific traits which is an important need

2.4 Soybean[1]

- What is the right target for achieving higher yields that enable both profitability and sustainability (for example, lower input costs); in western Canada? To what extent should the focus be on raising protein content rather than on raising yield in order to overcome the discounts growers face for their protein levels? In answering these questions and setting priorities, the decision-makers need to look at the economic implications vis-à-vis the market and end-users as well as the local growing environment.
- Advanced phenotyping requires tools for a high throughput process – good land-based monitoring systems are needed to supplement such technologies as UAV; a concern is that the amount of data that can be generated can be massive and that data require vast processing capacity for effective analysis; collaboration related to phenotyping in different environments is crucial to meeting requirements of different areas
- There needs to be emphasis on conveying the research results to growers so that the learning can be transferred to the farm effectively and in a timely way
- Understanding the interaction of the interface among soil fertility, soil health, root health and plant health and their corresponding impact on quality is a gap that needs more attention
- Soybean mosaic virus needs to be added to the list of priority diseases
- Mapping pathogen strains must be a priority in order to ensure that the strain for which resistance is sought in the lab is the same as the one showing up in the field
- More east-west collaboration is needed to identify unique regional issues such as iron deficiency chlorosis which arises in the west but not in Ontario and Quebec
- Seed quality needs to consider negative traits as well as positive ones – for example, heavy metal accumulation, phytates and anti-nutritionals
- Weed management resistance issues in the context of total management approaches
- Risk assessment of weeds, insects, diseases and new pests needs to be done systematically by considering the economic impact (for example, chemical management tools being under threat or a new race of disease breaking out)

[1] There were three tables for soybeans and only one for each of the other commodities and topics which explains why there are more gaps identified for this commodity. There is no implied order of ranking in the listing of input received since the order in which tables presented, and therefore in which their input is listed, was arbitrary.

2.5 Nutrient Management and Management of Weeds, Insects and Diseases

- Nitrogen needs to be emphasized as the key priority for corn in particular – there are gaps that need to be addressed
- Phosphorus also needs to be emphasized as a key priority; it is the cause of environmental regulatory pressure; as it is an essential input, there is a need to better understand factors such as its movement
- Understanding soybean protein formation in order to consistently raise protein levels especially in western Canada – understanding better how inoculants can unleash the genetics is a research opportunity
- There has been a resurgence in the use of broadcast fertilizer leading to the need for better management recommendations
- A fifth "R" – rotation – could be added to the four Rs because crop rotation diversity can have impacts on nutrient use, on carbon emissions, and on pest management
- Variable rate opportunities in which technology capacity exceeds the understanding of how it can be effectively used

2.6 Agronomy

- There needs to be a cropping systems approach which is resilient, adaptable and sustainable
- More consideration needs to be given to the position related to the role of the use of transgenic tools and transgenic outcomes in order to understand the regulator's intentions, the funders' level of agreement and the public trust implications
- There is a lot of pressure on long-standing tools that have been available such as chemical interventions and increasing resistance as a result of adaptability of the pest/disease/weed complex, thereby giving rise to a role for new chemical and non-chemical options and other management approaches
- More consideration needs to be given to probabilities for making real, tangible progress on specific pest/disease/weed risks over the research funding cycle in order to determine which specific challenges should be given priority

3. Industry Panel

3.1 Eric DeBlieck

Eric's experience and current role are primarily concerned with oats and therefore his presentation focused on that commodity.

Oat production can be viewed as a three-legged stool that has to work for:

- Consumers – the nutritional aspects must provide consumers what they are looking for related to low fat levels (low oil content) and high β-glucan levels (heart health claim)
- Millers – must provide acceptable yield performance
- Farmers – must work agronomically

Research must target all three components because all three must work.

Nutrition

- B-glucan levels in the range of 5% to 6% can be achieved and are affected by the genetic potential but other factors including agronomic practices and environmental conditions can contribute

Milling

- High test weight, easy hull removal, high groat yield and high milling yield are among important criteria for millers

Agronomy

- How can the agronomic package be made most successful for farmers? To what extent does region and territory impact the outcome?

Shattering resistance is one of the attributes that companies are looking at more closely as oat shattering reduces milling yield.

Lodging in oats is another issue as a strong plant that stands will enable more dry down to occur in the field and facilitate one pass harvesting with the combine.

Increasing yields must be achieved without lengthening maturity. Shortening maturity would be a complementary goal to achieve while increasing yield.

The traditional oat market for use in breakfast cereals is not a growing category. Therefore where can future growth occur as a result of more value for oats? Increasing nutritional functionality may be one of the keys to expand the market for oats – elevated protein and β-glucan levels.

3.2 Phil de Kemp

Phil's experience and current role are related to barley with an emphasis on malting applications.

1% of the Canadian barley crop ends up in food uses and 25% is used for malting purposes. The balance is feed barley.

Barley currently has its own cluster for western barley which was well funded under Growing Forward 2 with $8 million approximately from Agriculture and Agri-Food Canada.

The biggest issue is the disease pressure from Fusarium head blight.

Variety development has been a challenge because malting customers are reluctant to try new varieties on account of the risk of altering their recipe. Barley is grown without the use of certified seed which tends to lower the interest of seed companies in the crop. Varietal testing of new varieties is progressing both in the domestic market and with China. Barley is an important rotation crop but it needs to be profitable for growers. Barley has declined in eastern Canada over the past fifty years. The craft brewing industry's development has created renewed interest in locally grown barley. Craft brewers use about three times as much barley per unit of output. Health Canada has approved a health claim for barley as a factor in contributing to lower levels of cholesterol. The food market is a small market but it is a high value one.

3.3 Kevin Hachler

Kevin's experience and current role relates to corn for use by Ingredion. Ingredion operates two wet milling corn plants in Ontario in London and Cardinal that are designed to grind #2 yellow dent corn.

Challenges relate to quality issues. Corn that is higher in fines and foreign material can be an issue. The levels of mycotoxin can be a very serious issue in some years as it affects the marketability of co-products for livestock feed applications.

Ingredion is not likely to develop a unique market in Ontario for corn varieties that demonstrate improved milling attributes or better starch extractability but is keen to see improvements in these areas and no diminution as a result of genetic enhancement.

An evolving challenge relates to the efficiency of the marketplace. The current trading system allows growers to sell corn into multiple markets and, in turn, Ingredion can source from multiple markets. Traits that could affect the efficiency are releases that do not have proper approvals in key markets. One example is provided by high energy corn designed for ethanol processes. Its presence can be very negative in wet milling processes used by Ingredion. Caution needs to be exercised in releasing corn with new traits that could have unintended consequences in processes and thereby disrupt market efficiency.

From a consumer perspective, there is increasing interest in products that are sustainable with clean labels and which are non-GMO. Ingredion has launched a non-GMO program in eastern Ontario and welcomes research to support growers disposed to meet such market requirements. Many of Ingredion's customers need assurance that the products they source are produced using sustainable practices and which are non-GMO.

3.4 Clint Munro

Clint Munro has experience with soybeans for crushing markets.

Soybeans have three major value components: oil (C$1,000), meal (C$450) and hulls (C$180). Because oil is an important part of the total value composition for soybeans, the oil level needs to be maintained while other attributes are developed.

Smaller and variable size soybeans are more difficult to crack and that condition, in turn, reduces the oil yield. Oil yield is a measure of how much of the oil can be extracted versus how much remains in the meal. Smaller size seeds are also tougher to dehull, resulting in more hull fragments remaining in the meal, a condition which in turn reduces its protein content, causing it to be sold at a lower market value as a result of being lower quality. To the extent that plant breeding can contribute to more uniform and larger seeds, it has great value to producers and the industry.

The shorter season varieties have enabled western Canadian soybeans to be developed as a commercial crop for export. They sell at a lower price than Pacific NorthWest (PNW) soybeans to Asian markets – this discounting is partly due to a perception of less protein although the quality is comparable. The target is 34.5% protein. Achieving higher protein levels will be important to positioning western soybeans for better value recovery.

Different labs tend to produce different protein reading levels for the same sample which can cause problems for exports.

Enhanced nutritional energy meal is desired by the market and can be achieved by displacing the level of raffinose family oligosaccharides (RFOs) with constituents that have greater nutritional benefit since neither poultry nor swine enzyme systems are able to digest RFOs. There could be opportunities for identity-preserving soybeans with such special traits.

US Soybean Value Task Force[2] in the US is concerned about declining protein levels in the US from 34.5% at present to a projected 33.7% in 2030. Moving to a constituent price that is correlated to protein level may contribute to addressing this issue.

3.5 Todd Ross

Todd's experience is greatest with non-GMO, identity-preserved soybeans.

[2] The report is available at http://unitedsoybean.org/wp-content/uploads/Value-Task-Force-2015-Report-2.12.16.pdf

What factors deter producers from growing non-GMO identity preserved soybeans for Asian markets? A major trend in production is towards larger farms with fewer people involved in the enterprise. As scale increases, farmers look for solutions that are simple, repeatable, achievable and profitable. Producers need solutions that offer long term competitive advantage.

How do farmers increase their competitive advantage? They can grow either top-line revenue through increased premiums and yields or competitive advantage can come from cost reductions.

Sustainability is important to farmers. They want to know what inputs they are applying and what the consequences will be to their land base and what the impact will be to their customers.

The majority of Asian customers for non-GMO, identity preserved soybeans from Canada are smaller scale enterprises making specialty soy-derived food products and are not large, high volume crushers. Customers want many of the same characteristics as the farmers: simplicity, repeatability, efficiency in processing (example: splitting off hulls easily) and sustainability, including traceability and trackability. It is important to sell the process to customers which creates assurances in respect of origin. Brand managers at companies, not procurement staff, are the drivers for this kind of traceability assurance.

What are the export market segments? Identity preserved soybeans are the highest value market. Colour can be very important as an indication of quality. The Southeast Asian market is about 16.5 M tonnes with Canada's market share at 650,000 tonnes. Growth potential for Canada is large. The premium offered by this market requires extremely efficient systems to compete with the US.

The Europeans are also seeking non-GMO, traceable soybeans. Size is the single biggest issue because it contributes to process efficiency. Protein level is an important need from customers. Cutting soak times for customers increases efficiency. Customers ask what can be done to help with their needs – higher oil content, better sugars. As this market segment is health conscious, the attributes that benefit health will continue to be very important.

Natto soybeans are a niche grown for sprouting. There is an unfulfilled market overseas.

Seed purity is an important attribute which customers are continually seeking for. There is a discrepancy between the level of purity that the market can deliver and what customers are seeking.

3.6 Panelists – Participants Interaction

Following the presentations from each of the five panelists in sequence, participants were able to pose questions.

- The rotation sequence of crops can have a bearing on their agronomic performance and therefore each crop cannot be considered strictly in isolation from the others

- While uniformity in seed weight and seed size is desirable in order to achieve efficient processing, there are no specifications as to what is acceptable for soybeans; there is variability in what is acceptable to customers from year to year depending on crop characteristics
- Colouration of oats is not as important in food oats as it is in feed oats for race horses – hull colour does not generally matter unless it is indicative of low quality. Discolour generally stays in the hull and does not impact the groat – as long as the groat is clean and bright, the hull colour is not particularly important
- What is the meaning of sustainability? There is no set definition for the concept of sustainability and it will vary from customer to customer. In those parts of Ontario where there is high concern over phosphorus runoff, different cropping strategies like strip tilling are being managed at the farm level. There are many positive initiatives which can be leveraged as much as possible to have an industry-wide, whole farm approach.

4. Commodity Case Studies Analysis

4.1 Enhancing barley yields and FHB resistance

Given the expectation that investment in breeding programs will lead to varieties that offer higher yields without sacrificing vital traits related to agronomy and quality, please consider the following priority and targets when answering the questions listed below:

"Increase barley yields of new varieties by at least **1.5% per year** above 2016 provincial checks by 2023 while incorporating **moderate to high resistance** to Fusarium head blight (FHB) and desired agronomic characteristics"

Question to be discussed and answered	Contributions from participants (E)
Is this target sufficiently challenging yet attainable across Canada? If not, why not? If not, please recommend a revised target (the new target should be *Specific*, *Measurable*, *Achievable*, *Relevant*, and *Time-based*).	Participants assessed that this target is definitely very challenging. The lack of genetic diversity was identified as a major gap in identifying material to develop FHB resistance in barley – there will be a need to look for sources of resistance. The simultaneous selection of high yield and FHB resistance may overlay an additional challenge. Two row barley appears to have more resistance than six

Question to be discussed and answered	Contributions from participants (E)
	row barley in Ontario conditions.
Recommend an effective way to accurately measure the level of success in achieving this target (or a modified target) in the future.	Improvements need to be compared to appropriate checks. Several commercial varieties have positive morphological traits that could be proposed as the check varieties for the baseline. DON levels would be an important measurement criterion, i.e. the extent of toxins that FHB produces.
What innovative research approaches and complementary research capacity and expertise needs to be leveraged or developed across Canada to achieve this target by 2023 (or a revised target date)? Does this capacity currently exist or is new capacity required? Identify your top 2 recommendations for highest impact.	Major recommendations: • Collaborate with other global breeding programs that also are seeking sources of resistance to FHB to learn what else has been found in order to incorporate sources of resistance in Canadian breeding programs. • In searching for sources of resistance, it would involve looking at related species, in addition to the barley gene pool. • Some breeding programs for wheat have been able to use genomic selection to support identifying genetic markers for FHB resistance but it requires developing training models, a multi-year task. It is not realistic to expect major progress on FHB resistance in five years – it is a longer term task than five years.

4.2 Enhancing oat yields

Given the expectation that investment in breeding programs will lead to varieties that offer higher yields without sacrificing vital traits related to agronomy and quality, please consider the following priority and targets when answering the questions listed below:

"Increase oat yields of new varieties by at least **1.5% per year** above 2016 provincial checks by 2023 while stabilizing β-glucan levels within the range of **5.0-6.5%,** building disease resistance, and maintaining agronomic advantages"

Question to be discussed and answered	Contributions from participants (A)
Is this target sufficiently challenging yet attainable across Canada? If not, why not? If not, please recommend a revised target (the new target should be *Specific*, *Measurable*, *Achievable*, *Relevant*, and *Time-based*).	The consensus was that a realistic target was a yield increase of 1% per year by 2023 for western Canadian oat growing regions, and 1.5% per year for central and eastern Canada. The revised target is to achieve a minimum of 4.75% β-glucan levels. Yield then becomes the more important target when this minimum is reached.
Recommend an effective way to accurately measure the level of success in achieving this target (or a modified target) in the future.	The issue of measurement is a major challenge because one has to define what the 'current checks' are. For example, there is one variety now that is 10.6% better than the current checks. There needs to be a linear progression of yield with a lot of moving parts for other traits.
What innovative research approaches and complementary research capacity and expertise needs to be leveraged or developed across Canada to achieve this target by 2023 (or a revised target date)? Does this capacity currently exist or is new capacity required? Identify your top 2 recommendations for highest impact.	Selection from future crosses and acceleration of the assessment of the crosses will be important to increasing yield. The use of winter nurseries in New Zealand will be an important asset in future breeding work as it enables crosses to be selected faster. How will more efficient selections be made from the cross material? There is confidence in genetic selection tools for β-glucan levels which needs to extended to select for yield in early generations. Reliable phenotyping is critical to developing the training model development for genomic selection for yield. More sources will be needed to drive this development.

4.3 Enhancing inbred corn yields with improved agronomic attributes adapted for western Canada

Given the expectation that investment in breeding programs will lead to varieties that offer higher yields without sacrificing vital traits related to agronomy and quality, please consider the following priority and targets when answering the questions listed below:

"Develop new short season inbreds for western Canada, targeting **1800-2000 CHU**, yield increases **>2% per year** relative to consistent checks, and improve disease resistance, early season vigour, improved drought and flooding tolerance, and consistent stalk strength by 2023"

Question to be discussed and answered	Contributions from participants (F)
Is this target sufficiently challenging yet attainable across Canada? If not, why not? If not, please recommend a revised target for yield and heat units (the new target should be *Specific*, *Measurable*, *Achievable*, *Relevant*, and *Time-based*). In what year is it realistic to expect these targets to be attained?	The target proposed is too challenging for 2023. An inbred with all of the proposed traits as a package could not be attained by 2023 and more would likely require until 2028. Individually the traits could be developed in that time frame but not bundled together.
Recommend an effective way to accurately measure the level of success in achieving this target (or a modified target) in the future.	One of the challenges is determining what to use as the check variety to measure yield gains. It is difficult to provide a comparison for this level of heat units. Commercial firms are looking for inbreds that provide yields at least at a level of 95% of popular varieties.
What innovative research approaches and complementary research capacity and expertise needs to be leveraged or developed across Canada to achieve this target by 2023 (or a revised target date)? Does this capacity currently exist or is new capacity required? Identify your top 2 recommendations for highest impact.	There need to be more sites in Saskatchewan and Alberta with proper equipment (corn planters and combines) where earlier varieties can be evaluated. To achieve the required equipment, there needs to be improved relationships with provincial and federal research stations. How could inbreds be improved more quickly in their drought resistance and moisture retention traits? Through the use of phenomics. Some progress might also be able to come through genetic modification brought by the commercial partner and not from the inbred itself. Double haploids provide a way to speed up the breeding process.

4.4 Enhancing soybean yields for conventional varieties

Given the expectation that investment in breeding programs will lead to varieties that offer higher yields without sacrificing vital traits related to agronomy and quality, please consider the following priority and targets when answering the questions listed below:

"Increase soybean yields of new conventional varieties by at least **2% per year** above 2016 provincial checks by 2023 while building disease resistance and ensuring quality and desired agronomic characteristics"

Question to be discussed and answered	Contributions from participants (B), (C)
Is this target sufficiently challenging yet attainable across Canada? If not, why not? If not, please recommend a revised target (the new target should be *Specific*, *Measurable*, *Achievable*, *Relevant*, and *Time-based*).	The current yield gain is in the range of 1% and so doubling this rate is not a realistic goal. There are other goals such as early maturity, seed size, protein levels, etc. Revised objective: Maintain 1% yield gain while enhancing value-added traits Yield advances may be able to be achieved at a 2% level in Manitoba and Saskatchewan in the short term. In southwestern Ontario, increasing yield is more challenging than areas relatively new to growing soybeans, in part due to the presence of soybean cyst nematode (SCN) in the soil.
Recommend an effective way to accurately measure the level of success in achieving this target (or a modified target) in the future.	Plants per acre, seedling pods per plant, seed size There is no longer merit testing in the varietal registration process for new soybean varieties. The available commercial varieties can be viewed as the check within a specific maturity range (+/- 2 days of maturity of the candidate variety). Alternatively only varieties released within the last three years would be considered for the check for yield and seed quality purposes. This approach was preferred.
What innovative research approaches and complementary research capacity and expertise needs to be leveraged or developed across Canada to achieve this target by 2023 (or a revised target	• Increased genetic diversity is needed to obtain a larger selection for breeding using genetic and genomics tools (Example: resistance for SCN needs to be expanded); improvements have been limited by continually crossing traditional elite lines

Question to be discussed and answered	Contributions from participants (B), (C)
date)? Does this capacity currently exist or is new capacity required? Identify your top 2 recommendations for highest impact.	together without introducing new material • Have clear selection targets such as minimizing inputs and building pest resistance • Because markers are only as good as the phenotyping, more testing needs to be done in different environments to expand the range of data • Maintain breeding collaboration as it itself contributes to better yield outcomes than any one breeder working alone • There is a strong negative correlation between yield and protein – by selecting for such things as number of seedling pods per plant, number of seeds per pod or seed size it might be possible to break this negative relationship • For example, work on selecting for higher levels of protein and then work on yield increases, in a step by step approach • How much are different yield components part of the yield determination (seeds per pod, pods per node)? Consider the response of the plants to diseases and pests and to abiotic stress factors (cold and drought) as this analysis will help achieve the yield target gains.

4.5 Enhancing soybean yields for short season varieties

Given the expectation that investment in breeding programs will lead to varieties that offer higher yields without sacrificing vital traits related to agronomy and quality, please consider the following priority and targets when answering the questions in listed below:

"Push the boundaries of short and very short season soybean varieties for western Canada, increasing yield by at least **2% per year** above 2016 provincial checks and raising **protein levels above 40%** (dry matter basis) by 2023 while building in stable disease resistance and ensuring desired agronomic characteristics"

Question to be discussed and answered	Contributions from participants
Is this target sufficiently challenging yet attainable across Canada? If not, why not? If not, please recommend a revised target (the new target should be *Specific*, *Measurable*, *Achievable*, *Relevant*, and *Time-based*). How soon in the future can the 40% protein (dry matter basis) be attained?	This is a very challenging target and may not be realistic given the historical achievement of 1%. In order to focus on yield, there needs to be a significant expansion, in the order of 5X, of yield trials from 6 to 8 sites per year to 30 to 50 sites. Yield testing needs to be expanded. There are other factors that contribute to yield, besides breeding, including agronomic management, rotation, and tillage systems. The task is also to increase protein and protein and yield are negatively correlated. There are various QTLs and marker tools that are available and which need to be assessed to determine how they can help breeders. There is a need for better monitoring protein outcomes and better understanding of environment-induced effects.
Recommend an effective way to accurately measure the level of success in achieving this target (or a modified target) in the future.	It is relatively straightforward to measure yield outcomes and protein levels in yield trials and commercial farms but the results are best analyzed over a five year trend rather than a single year snapshot.
What innovative research approaches and complementary research capacity and expertise needs to be leveraged or developed across Canada to achieve this target by 2023 (or a revised target date)? Does this capacity currently exist or is new capacity required? Identify your top 2 recommendations for highest impact.	Achieving these goals needs more investment and more people resources. For example, two more plant breeders and five more technicians could be required to accelerate varietal development for western Canada in particular. Another important step would be an enhanced agronomic network of collaborators. Marker assisted selection is already in use and could be expanded to improve protein levels and yield. High throughout phenotyping would be a boost to the research targets. Another recommendation is to conduct a survey of growers to learn from their experience. Genetic diversity is important – accessing more diversity from programs around the world including accessing wild germplasm needs to be done.

4.6 Improving nitrogen management in multiple feed crops

Given the important role of nitrogen management in field crops and its complexities from both the crop productivity and environmental loss perspectives, please consider the following priority when answering the questions listed below:

Question to be discussed and answered	Contributions from participants (G)
Identify 1-2 SMART (Specific, Measurable, Achievable, Relevant, Time-based) targets for N management work in barley, corn, oat, and soybean that would move the bar forward for growers (either choose a specific crop to address or develop somewhat crop-independent targets) What time-frames are needed to enable the targets you have identified to be attained?	The recommended priority is to optimize the economic return from and minimize the losses of nitrogen for an acre of corn. Other crops do not provide the same opportunity and the nutrient relationships are not as well understood. A timeline of five years would be necessary for the implementation to determine what factors are most relevant to study, based on their impact. It will require ten years or more to get the trajectory data to determine to what extent improvements in nitrogen use efficiency have occurred as a result of changes in practice.
Recommend an effective way to accurately measure the level of success in achieving the targets you have identified in the future.	Agronomic use efficiency – yield per lb. of nitrogen added. Producers can undertake this measure themselves using established databases. The current value is about 1 bushel per lb. of nitrogen. The goal is to increase that yield.
What innovative approaches, agronomic research tools, and complementary research capacity/expertise (i.e., collaborations) could be leveraged across Canada to more efficiently generate and synthesize agronomic data to improve nitrogen management recommendations and mitigate environmental losses? Does this entire capacity already exist or is new capacity	To the four Rs (right source, right rate, right time, right place) could be added a fifth – right rotation – and a precision approach based on zoning needs to be followed. How could this be implemented? Provincial databases would allow the existing trajectory to be established and it could be mined for impacts that affect nitrogen use efficiency using multi-variable analyses. There is good, detailed data for western Canada from which baseline practices can be established. There needs to be a determination of which of the

required? Identify your top 2 recommendations for highest impact.	practices have the best opportunity to impact yield and that research will require field trials as well as extensive data analysis. There needs to be outreach to farmers in order to obtain uptake of the best, recommended practices.

4.7 Coordinated disease, insect pest and weed surveys

Given the important role of pathology, entomology, and weed science in developing robust cropping systems with a strong backbone of variety development, please consider the following priority and targets when answering the questions listed below:

"Implement efficient, coordinated surveys for important current and emerging field crop pathogens, insect pests, and weeds (i.e., herbicide resistant weeds) across Canada by 2019 and use the information to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm"

Question to be discussed and answered	Contributions from participants (H)
Is the coordinated survey network target attainable across Canada? If not, why not? If not, please recommend a revised SMART target *(Specific, Measurable, Achievable, Relevant, Time-based).* What time-frame is needed to enable the target you have recommended to be attained?	Yes, this survey network can be established and by 2019 it is realistic to have identified the collaborating partners necessary to make it work but it will not be fully functional. There is an excellent western Canadian weed survey available that could serve as a template for approaches and classification methods related to how to build such a network that is more comprehensive.
Recommend an effective way to accurately measure the level of success in achieving this target.	One of the key measures will be to assess how many researchers and to what extent the data compiled through the survey is being used. Molecular tools are important to correctly identify the strains of pathogens present. Many different samples will be required to get a comprehensive survey.
What innovative approaches and complementary research	A centralized data management system will be essential to the survey. AAFC would be the best body to host the

Question to be discussed and answered	Contributions from participants (H)
capacity/expertise (i.e., collaborations) could be leveraged across Canada to develop an *efficient, coordinated* and *useful* pathogen, insect pest and weed survey network across Canada? Does this capacity already exist or is new capacity required? Identify your top 2 recommendations for highest impact.	system in view of its national mandate and it already does surveys and analyses. It will require leadership to standardize the approaches and bring it all together. There is a significant amount of investment and resources required to implement this kind of survey. Focus on economically significant pests

5. Research Outcomes Case Studies Analysis

5.1 Enhancing knowledge transfer results

Recognizing that every research project will have a unique and specific target audience/end user, each project requires a customized approach for translating research results to end users. The effectiveness with which that knowledge transfer (KT) is done may affect both the extent and speed with which the research results are adopted, and, therefore, the return on the research investment. Given that a researcher is primarily focused on research, there can often be barriers or obstacles that prevent successful and effective KT of research results to the specific target audience/end user. The questions are designed to open discussion around and lead to solutions for enhancing KT.

Obstacles and solutions for effective research communication

	Components of effective KT:	Considering each KT component, which do you find most difficult? Why? What barriers/obstacles prevent you from effective KT?	What resources or tools would you need to overcome the barriers or obstacles identified?
1	Identifying **the right audiences** (end users, enablers, influencers)	The level of knowledge of the audience and the context of the information are very important in order to develop audience specific recommendations. By discussing results with collaborators, it is possible to discover new applications and new audiences to receive the results.	Resources to provide staff time r to develop technology transfer material is essential and needs to built into proposals. Networks of experts (including non-academics) can be brought together to decide how to best convey the information. There is a need for credibility with the audience. There is a need for access to audiences.
2	Developing **the right message** to convey	There is a need for unified and consistent messaging that utilizes professional networks.	Cooperation and commitment from partners such as commodity groups, governments and universities
3	Releasing the message at **the right time**	Planning is needed to ensure that the message is available at the right time	No incentives are provided for technology transfer and this

	Components of effective KT:	Considering each KT component, which do you find most difficult? Why? What barriers/obstacles prevent you from effective KT?	What resources or tools would you need to overcome the barriers or obstacles identified?
		of year – there are critical times when it is needed.	needs to be revised so that it is recognized in performance reviews.
4	Identifying and accessing **the right communication venue/medium**	There are institutional barriers that sometimes limit technology transfer such as extensive approvals for participation, for travel, and for extension and media documents. It is also important to understand how the targeted end user accesses information and to ensure that there are sufficient skills and time to create the messages using whatever media are determined to be most appropriate.	Ensure that the responsibility is clearly set out in proposals with a champion identified for the KT outcome. Consider needs for translation into both official languages. Technology transfer friendly policies are needed at research institutions.

Recommendations for tools, resources and results from knowledge transfer activities

- Effective communication staff are needed and are essential to enabling communication to occur – this critical resource is often a serious gap
- Statistics are often missing from messaging and their omission detracts from the level of credibility – sample sizes, for example, need to be large enough to establish confidence
- The CFCRA website could be used for information dissemination as well as *Top Crop Manager* featuring a regular column showcasing CFCRA research successes
- A YouTube channel like Real Agriculture could be considered and social media such as a Twitter account could be used to retweet
- Media training for scientists should be provided to develop the communications skill capabilities of researchers

5.2 Proactively addressing environmental and climate change risks

Addressing climate change is an important priority of government. Facets of this issue include:

- the need to reduce greenhouse gas (GHG) emissions
- managing greater weather volatility, including temperature and precipitation extremes

- managing new and/or adapting pest, disease and weed pressures
- market impacts on price and delivery logistics (example: putting a value on carbon)
- regulatory impacts arising from public trust issues affecting tools available to farmers
- other (can be chosen by the table)

Research priorities and targets need to consider expectations of government and society.

Climate change targets using SMART (Specific, Measurable, Achievable, Relevant, Time-based) criteria

- New pests and/or adapting pest, disease and weed pressures – (i) maintain and improve surveys and make the results accessible to more users; (ii) forecast emerging problems; (iii) set a risk level and undertake a risk assessment in order to select priorities before triggering research − *a specific example is provided by soybean cyst nematode (SCN), a new pest in Manitoba in which research could be undertaken over the next five years to (i) develop a quantification tool (ii) calibrate to egg and cyst counts (iii) work across multiple soil types and then as a next step identify HG[3] types.*
- Managing greater weather volatility – in the context of planting breeding programs, (i) look for reliable, repeatable tests for abiotic stress (flooding and drought stress; cold and heat stress); (ii) with reliable tests develop markers to apply in plant breeding programs; (iii) screening tools could include two approaches (a) a controlled environment phytotron used to develop tests for specific stresses and (b) a retrospective look at variety performance to capture stress responses observed in the field either in trials or at farm locations

Recommendations related to innovative approaches, tools and research capacity and expertise required

- With respect to new and adapting pest, disease and weed pressures (risk factors), the management recommendation is to (i) increase or maintain the diversity of cultivars within an agricultural region (ii) ensure diversity in pesticide treatments and (iii) encourage diversity in agronomic practices. A key part of the solution requires breeding and the introduction of new germplasm. It is necessary to understand the best agronomic practices that work for that germplasm; to use genomics to incorporate resistance into the germplasm; and to use innovative molecular monitoring to identify, track and predict the risk factors. There is also opportunity for more take-up of integrated pest management tools that have been tested. *A means for measuring success would be achieving yield stability in the affected area over time.*

3 HG typing is a classification system used to differentiate soybean cyst nematode (*Heterodera glycines*) isolates that vary in their ability to develop and reproduce on an established set of soybean lines that differ in their resistance to SCN

- For weather volatility, the same tools outlined above for pests/weeds/diseases would work well to get to the same answers. Another approach for managing weather volatility is poly-cropping (several crops in one field).

5.3 The potential for using 'Big Data'

Big Data is a term for data sets that are so large or complex that traditional data processing applications are inadequate to deal with them. In the field crops sector, Big Data arises from several possible sources:

- Genomics data for both the crop and non-crop organisms
- Environmental variables such as soil temperature, moisture, wind speed with extensive point source sensor measurements
- Agronomic variables including yield levels monitored to specific field blocks

Setting targets for effective utilization of Big Data and its bearing on tackling specific research priorities

- One impact from collecting and modelling Big Data is obtaining better definition and resolution of the research targets – examples: (i) isolating specific strains of pathogens in a soil environment from genomic data and (ii) understanding and modelling patterns in crops
- Genomic data is the most easily integrated of the three major sources of data on account of the degree of its standardization; environmental data largely offers the same benefit of standardization; but agronomic data does not have the same level of standardization in the manner of measuring and recording data, making integration far more difficult to achieve
- Examples of targets: (i) Big Data could be used for selection of optimal parent lines within breeding programs for best combinations (ii) genomics selection integrated with agronomic data and (iii) crop modelling

Recommendations for resources and expertise to effectively utilize Big Data in addressing research priorities

- Excellent curators are needed to manage the data in the design and organization of a large database so that it is reliable and accessible
- A mandate is required to ensure (i) quality of data (ii) organization of the data in a standard format (iii) financial investment is made in data collection and organization (iv) research data is shared and contributed to the database
- Can existing global databases be used to which Canadian data is added or does a uniquely Canadian database need to be established? A recommendation is to answer this question.
- Development of genomic prediction models from the database is needed

- Bioinformatics expertise, next generation crop physiology, phenomics and better analytical tools that use machine learning are resources that are needed to use Big Data

Two recommendations in order to make strides in the utilization of Big Data are:

- Invest in technology to process, analyze and organize Big Data
- Invest in people and experts in data science

5.4 Measuring return on research investment

As governments are increasingly fiscally constrained, there is more focus on ensuring that government investments in research generate returns. "Returns" on research investment include both a monetary aspect, in terms of gains that are obtained or losses that are mitigated, as well as a non-monetary aspect, in terms of such intangibles as improved environmental conditions, the development of highly qualified personnel (HQP) with skills and expert knowledge of the sector, and the provision of a safe and secure food supply for Canada's population. It is challenging to objectively measure such returns and document that they occurred for a number of reasons including:

- Isolating the impact of the research investment from other factors that may have altered conditions in the sector (for example, there may not be a 'control group')
- The length of time over which the returns are realized – it may be years after the research project ends
- The degree of subjectivity inherent in non-monetary returns

Setting targets to measure return on investment

- Monetary factors that positively affect the return to the grower include increased yield; increased return per hectare; reduced input costs; increased nutrient and water use efficiency; opportunities to realize premiums offered by the market – *a specific measure is the percentage increase in yield as measured against a reference check within a time limit; other measures could be the market share attained by a new variety; the extent to which new, improved germplasm has been incorporated into varietal releases; new markets opened by crop innovations from the research; and new disease resistance levels achieved*
- Monetary factors that positively affect the whole sector include new technology applications, patents and risk management tools – *a variable to measure could be long term overall economic health of the sector*
- Non-monetary factors that positively affect the whole sector include the training of HQP (students and post-docs) that bring their skills to bear for the sector
- Public good intangibles include KT of research outcomes (for example, leading to improved management practices) and more sustainable production systems (for example, better environmental health, reduced run-off and reduced pesticide residues) – *a longer term measure*

could relate to the reduction of phosphorus run-off which, in turn, could be indicated by the reduced frequency and severity of fish kills over a time period (recognizing it may be difficult to isolate one factor from the field crops sector as responsible)

Recommendations for resources and expertise to effectively measure return on investment

- An agricultural economist could provide a macro-analysis of the research investment
- An environmental biologist could assess the extent to which a specific agronomic practice has had a positive impact
- Following careers of undergraduate students, graduate students and post-docs after they leave university – what kind of jobs have they found, what kind of collaborations and networks have emerged with their engagement, to what extent are companies and growers “buying in” to their ongoing work
- Estimating the extent to which farmers are using new products and practices that have come from the research – agencies like Statistics Canada or Provincial Crop Insurance plans could track the uptake of technologies

6. Stretch Questions

Participants were asked to provide individual responses to a series of 'stretch' questions. They have been called 'stretch questions' because they were designed to force thinking outside the box about the future priorities of field crops research.

6.1 What is the best opportunity for achieving cross-commodity efficiencies in CFCRA-funded research?

Cropping systems approach in understanding crop rotational impacts

- Cross-commodity efficiency could be enhanced by a cropping systems approach to research on a number of factors including: pest suppression, weed resistance, soil health, plant health and crop nutrition, use of cover crops, nutrient efficiency (phosphorus and nitrogen). For example, there is evidence that increased rotation reduces pest pressure on any single crop.
- Cross-commodity research efforts are essential for optimizing the outcomes of studies of the impact of crop rotation on resiliency, yield and quality.
- Better understanding of climate change adaptation issues such as pest movement, pest invasion or biotype shifts
- A whole cropping systems approach is necessary to achieve optimization.
- Better understanding the relationship between crop agronomy and crop genetics across multiple crops – a molecular marker, for example, may be common to more than one breeding program

Gains from collaboration – sharing resources and sharing learning and insights

- Collaboration across disciplines including pathology, agronomy, entomology, etc.
- Establishing sites for multi-commodity yield trials to enable collaboration across commodities and to obtain synergies among breeders (one example given was spring cereals testing in both Ottawa and Guelph)
- More collaboration on diseases common to more than one crop – (one example given was Fusarium affecting multiple cereal crops)
- Equipment resources and technical expertise are common to more than one crop and could be shared and utilized more effectively − genomic molecular facilities and other genomics tools were cited as examples where progress could be made
- Strategic phenotyping with public databases and curators – planning and learning from each other

- Standardization and training related to phenotyping, genotyping, analysis and reporting procedures for genomics-assisted breeding
- More sharing of results across commodities and virtual or physical forums to discuss them – a common website for use by researchers in the cluster was envisaged

6.2 What is the best opportunity for achieving efficiencies in commodity needs across geographies including provincial boundaries?

Better utilization of resources

- Better coordinate and utilize provincial and federal funding and breeding programs − openly share molecular and phenotypic data and exchange germplasm across different provinces as well as crop knowledge gained in one region with regions where the crop is less well known (the example given was sharing soybean knowledge with western Canada)
- Be more open to collaboration outside Canada in order to avoid duplicating effort within Canada already being done internationally
- Develop strategic analytical tools to identify agro-ecological challenges for trialing on a national scale for commodities
- Use multiple sites in multiple provinces to perform field trials to evaluate breeding lines – fewer field staff overall would be needed while a wider range of test site results would be obtained; the sites could be chosen to best understand the relationship between genetics and the environment
- Use the same resources to provide services at multiple sites
- Be more open to sharing technology platforms and using molecular genomics tools more efficiently

More standardization of practices

- Standardize data collection methods to accurately determine advancements and future needs − ensure consistency in the experimental and sampling methods (SCN soil sampling, DNA sampling, etc.)
- Create technicians' working groups to regularly confer in order to identify synergies, process efficiencies and to share learning
- Adopt similar language in the presentation of proposals in the context of contributions to national priorities
- Think in terms of zones with similar soil and climate and avoid duplicating testing for the same zone
- Think in terms of common research goals (themes and objectives) rather than specific crops

- Give highest priority to research that spans regions and provinces (comparing protein levels in common soybean varieties in order to analyze the factors responsible for zone differences was given as an example)
- Take a consistent research approach where there are common environmental or regulatory issues– common protocols, data collection methods, etc.–as well as when there are common issues such as pathology and quality
- Wider adoption of research results, related both to new varieties and to new practices, across Canada

Strategic specialization

- Recognize different strengths in different provinces and use the strengths of each province strategically for the best outcomes for all

6.3 What have you learned from other competitive granting processes for research projects in this sector that will help achieve these priorities? *(Consider both the reasons given for declining research project proposals you may have experienced as well as learning from proposals that were approved and undertaken).*

SMART[4] objectives aligned with cluster, program and policy goals

- Clear, well-defined, understandable and achievable objectives and milestones forming a realistic workplan
- Outcomes that can be simply defined and quantified in order to measure the impact of the research
- Demonstration of a strong return on investment – clear articulation of the value proposition arising from the proposed research
- Alignment of the project with the defined priorities of the cluster and the program (granting organization) – make sure that the call for proposals has been read carefully and that the key words are clearly addressed, specify how the project addresses or is consistent with stated government policy objectives related to public trust, climate change, export development, etc.

Competent and collaborative team

- Strong research team with positive track records bringing multi-disciplinary skills – it is necessary to indicate how a diverse team will work together to create value so that the whole is greater than the sum of the parts
- Collaboration among researchers to achieve efficiencies in use of resources and leverage available expertise – collaboration leads to more unified messaging

[4] SMART: Specific, Measurable, Achievable, Relevant, Time-bound

Positive differentiation

- Identification of what gaps in knowledge or technology are being addressed, by what method and for whose benefit – identify what stands to be improved and what is incremental to existing body of knowledge
- Show how the deliverables are best achieved through the cluster approach on account of (i) engaging multi-disciplinary expertise and (ii) the ability to extend scope across more than one region in order to address national objectives
- Innovative so that there is not a knee jerk reaction that this is the 'same old' research

6.4 What is one high impact outcome that you believe this national research investment can achieve? Please be specific.

Why public funding is essential

- Smaller commodities (oats being an example) especially need public and industry joint funding for success – the private sector alone is not a sufficient source; governments' funding match helps to leverage and attract industry funds
- The diverse nature of this cluster will capitalize on the opportunity to address challenges for emerging crops with limited resources through effective collaboration
- Because of our relatively small scale market size in Canada and the corresponding lack of value capture by private firms, federal funding is essential to augment the investment by the private sector in order to realize an impressive return on investment in the range of 20:1

Benefits for Canada in general

- Using an innovative approach to reach meaningful targets while training the next generation of scientists
- A high impact outcome is greater control of Fusarium head blight which offers many benefits: (i) food safety for consumers and feed safety for livestock producers (ii) environmental benefits by reducing the use of fungicide crop protection materials (iii) sustainable production practices and (iv) better access to and value recovery from domestic and international markets
- Building national teams to solve issues with cutting edge science and thereby ensuring a growing contribution to Canada's GDP from our sector of agriculture
- Enhanced cooperation among a range of target crops to improve, adapt and innovate while gaining public trust and being sustainable
- More formal and more solid linkages between breeding efforts and agronomic management practices across crops and regions
- Up-to-date agronomic package for several crops across Canada

Benefits for farmers in particular

- Rapidly and efficiently provide tools to producers for the establishment of economically promising crops across Canada, soybeans being an example
- Great potential to increase acreage and yields to diversify the crop mix in western Canada and expand emerging crops in Atlantic Canada
- A high impact outcome would be satisfying our stakeholders – getting their questions answered and providing solutions for their needs
- Because we compete internationally in markets for these commodities, it is important (i) to gain worldwide recognition in the science community for our unified cluster approach and leadership in collaborative research and scientific advances and (ii) to position our producers to be globally competitive – a specific export opportunity is high-value food grade soybeans for Asian markets
- A high impact outcome would be achieving higher levels of productivity/yield which, in turn, implies more income for the grain sector including farmers – this outcome, in turn, requires research to effectively address climate effects
- Really good new crop cultivars – high yielding varieties that offer disease resistance, lodging resistance and high quality and which therefore form the basis for a robust, sustainable and environmentally friendly production system
- Enable producers to manage climate change challenges (new disease pressures are an example) through robust adaptation strategies that enable stable production and farm incomes during climate volatility – this outcome, in turn, will improve Canada's rural economy, lower greenhouse gas emissions and improve the competitiveness of Canadian farmers
- Profitable crops for farmers in Canada that contribute to increasing farm incomes, more diversity in rotations from a suite of profitable crop choices, and less requirement for government support payments

6.5 What do you anticipate will be "the next big thing" in our sector?

Western Canada opportunities

- Expansion of new crops in western Canada – increased corn and soybeans across the prairies
- Big increase in area and growth of market for soybeans as a result of utilizing sustainable and environmentally responsible production practices
- Crops perfected for all conditions with improved cold and frost tolerance for northern and western regions

Addressing the environment and climate change

- Designing new models for sustainable cropping systems which are carbon neutral based on environmentally friendly and economically viable crop rotations and best management practices
- Preparing for the "new agriculture" based on environmental considerations (GHG emissions, climate change, eutrophication) and increased public scrutiny
- New technologies and knowledge to reduce GHG emissions, attack abiotic stress, and mitigate climate change while remaining competitive with other export nations
- Predicting and modelling for pest complex changes and extended growing seasons (shift in heat units, zones) in order to be prepared for impacts and benefit from them to the extent possible

Use of genomics tools

- Genomics selection tools for new varieties especially in the smaller crops
- Integration of the various "omics" tools – genomics, transcriptomics, proteomics, metabolomics and phenomics – to become routine in breeding efforts; a priority will be integration of genomics with phenomics in high throughput applications that require big data analysis
- Creating and developing genomic tools that can be used by breeders for the development of new cultivars across Canada

CRISPR[5] technology in particular

- CRISPR technology will allow solutions to both biotic and abiotic stress problems; biotic stresses arise from diseases and pests whereas abiotic stresses stem from climate change
- CRISPR technology, as a tool for genome editing, is seen as an alternative to transgenic organisms
- CRISPR technology can be used to develop specific crop traits and improve crop yields and quality

Nutrient efficiency

- Higher nutrient efficiency built into crops made an intense focus of breeding efforts

[5] CRISPR" (pronounced "crisper") stands for Clustered Regularly Interspaced Short Palindromic Repeats, which are the hallmark of a bacterial defense system which forms the basis for the popular CRISPR-Cas9 genome editing technology. In the field of genome engineering, the term "CRISPR" is often used loosely to refer to the entire CRISPR-Cas9 system, which can be programmed to target specific stretches of genetic code and to edit DNA at precise locations. These tools allow researchers to permanently modify genes in living cells and organisms and, in the future, may make it possible to correct mutations at precise locations in the human genome to treat genetic causes of disease. Source: https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/questions-and-answers-about-crispr

Site specific management

- Landscape specific crop management of nutrients, pests and cultivar selection; this approach to production management requires tools that will maximize yields and which is based on variable rate application technologies aligned with field and zone variability mapping

Health claims

- Increasing use of health claims in marketing to consumers, which are real and validated, in order to benefit society
- High β-glucan barley

Eradication of Fusarium head blight

- A permanent solution to FHB and other diseases

6.6 Why can't the private sector fund these research priorities on its own? Why is it appropriate and necessary for public funds to be used as well?

Global commercial profit opportunities are not highest in small market circumstances

- The cluster targets the environments of growing regions in Canada without a rigorous test of immediate profit potential that a commercial investor would apply
- Public funds to share in the risk of development for small markets leverages more industry funds and leads to a bigger pool of research investment overall while, at the same time, building a public-private partnership towards common outcomes
- Self-pollinated, smaller crops have a key value in rotations and may be able to be grown on marginal land – their development would not be a priority for private companies and would not fall within their mandate but the investment offers benefit to Canada and Canadian farmers
- A lot of research done by the cluster is in the 'pre-competitive' space – this role for the cluster avoids duplication of research work while allowing all stakeholders, including private firms, to use the results
- There is an acquisition risk that Canadian companies will be taken over by large global firms, which already dominate global genetics for many crops, and that their focus will shift away from Canada – public investment and public research capacity mitigates this risk

Public funds allow for a systems approach

- Systems approaches are more difficult to fund with private funds; public funds enable better research in such areas as crop rotation impacts to be conducted using a systems approach
- Public funds build research collaborations across institutions more than private sector investment

Benefits of public-private joint research investment

- Public-private partnership to invest in solutions to issues is a better approach than regulatory intervention and tends to ensure greater alignment between public and private goals
- Private matching of public funding provides an assurance that the funding is being spent on relevant and appropriate needs

Public funds allow for more open dissemination of results

- Privately funded research belongs to the private firm providing the funding which limits the extent to which the results may be shared and transferred for broad benefit
- There is more independence in the research and reporting

Public funds enable investment in public good outcomes

- The environment is a common public good in which there is an important role for government to invest in order to protect it; it is less likely to receive investment solely from the private sector because the short term returns are lacking
- There is "sovereignty of public interest" enabled by public funding that private funding does not provide
- Food and feed self-sufficiency is a national security issue not addressed by the mandate of private firms but essential for government
- An important positive contribution can be made to Canada's balance of agricultural trade by public investment as well as stabilizing and strengthening rural economies and thereby lowering costs that governments may otherwise incur

Public funds allow for a longer term research focus

- Private firms have short term interests and goals where their return on investment is realized in a short time frame and therefore may neglect long term 'big' issues that have real importance and/or higher risk

Appendix A – Initial CFCRA working list of research priorities developed in August, 2016

Barley Priorities (eastern-Canadian scope)

- Develop 2- and 6-row varieties with a focus on yield, disease resistance (particularly Fusarium head blight), standability, and quality:
    - Increase yields of new varieties by **≥1.5%** per year above 2016 provincial checks by 2023
    - Incorporate durable disease resistance into new varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. Key diseases include Fusarium head blight (FHB), powdery mildew, scald, and net/spot blotch
    - Develop varieties with consistent quality parameters for malting
- Develop effective management strategies for FHB
- Develop coordinated surveys for current and emerging barley pathogens to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm
- Improve N management recommendations

Corn Priorities (Canada-wide scope)

- Develop new short season inbreds targeting **1800-2000 CHU**, with improved yield, early season vigour, drought tolerance, water tolerance, improved lignin production for consistent stalk strength
- Develop new inbreds with higher yield and resistance to diseases (i.e., northern corn leaf blight, *Fusarium/Gibberella*, rust, smut, eye spot, Goss's wilt); good standability
- Develop coordinated surveys for current and emerging corn pathogens to improve management strategies, screen inbreds, and identify and validate new sources of resistant germplasm
- Pest management strategies, including economic potential from fungicides
- Optimize corn nitrogen use efficiency
- Agronomy with emphasis on nutrient timing and efficiency, and on population density as influenced by pH

Oat Priorities (Canada-wide scope)

- Develop varieties with a focus on yield, disease resistance, and milling quality:

  - Increase yields of new varieties by **≥1.5%**, per year above 2016 provincial checks by 2023 while maintaining quality and desired agronomic characteristics
  - Incorporate durable disease resistance into new varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. Key diseases include: oat crown rust, Septoria leaf blotch, and yellow dwarf mosaic virus
  - Develop varieties with consistent quality parameters for milling
- Develop coordinated surveys for current and emerging oat pathogens across Canada to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm
- Increase stability, predictability and reliability of β-glucan levels in varieties across environments, targeting β-glucan levels of **5.0-6.5%**
- Develop fungicide and nitrogen recommendations for high yield and consistent quality across multiple environments and identify optimum seeding rates for high yielding oat management systems
- Identify mechanisms to improve standability under oat management systems using N fertilizer or N from previous crops in rotation
- Identify effective tools for wild oat control
- Develop methods of cultivation and drying without the use of desiccants in the field

Soybean Priorities (Canada-wide scope)

- Develop conventional food-grade and herbicide-tolerant varieties with a focus on yield, disease resistance, and end use quality:
  - Increase yields of new varieties by **≥2%**, per year above 2016 provincial checks by 2023
  - Incorporate durable disease resistance into new varieties, breeding against current and emerging pathogen profiles in a variety's adapted region. Key diseases and pests include: soybean cyst nematode (SCN), sudden death syndrome (SDS), *Phytophthora*, root rot complexes, white mould, soybean aphid, etc.
    - Identify and validate new sources of resistance to key diseases and pests
  - Push the boundaries of short and very short season varieties with good yield, cold and moisture stress tolerance, harvestability, and suitability for short and very short season regions of Canada
    - Increase and stabilize minimum soybean protein levels above **40%** (dry matter basis) in new western Canadian soybean varieties by 2021.
    - Identify *and* validate early maturity genes useful to improve yield and quality

        - Explore the effect of cool nights on sensitivity of varieties, and evaluate and identify risks associated with planting different heat unit cultivars
        - Improve tolerance to iron deficiency chlorosis/saline soils and mid-season drought (particular priority for western Canada)
    - Improve conventional food-grade soybean quality for end use markets
- Improve soybean seed quality for each specific market's demand (i.e., high oleic oils, higher protein)
- Expand coordinated surveys for current and emerging soybean pathogens and insect pests across Canada and use this information to improve management strategies, screen varieties, and identify and validate new sources of resistant germplasm
- Develop effective management strategies for soybean diseases and insect pests. Key diseases and insect pests include: SCN, SDS, *Phytophthora*, root rot complexes, white mould, soybean aphid, etc.
- Improve integrated weed management strategies for herbicide-tolerant and non-herbicide tolerant systems in both conventional tillage and minimum/no-till production systems
    - Monitor spread of herbicide-resistant weeds and develop integrated weed management systems for their control
    - Impact of new herbicide tolerant (HT) systems on re-cropping options; new herbicide-tolerant options and how they best fit into production systems; control of RR volunteer canola and buckwheat, particularly in western Canada, but also to address new crop systems in the east
- Identify ideal nutrient management strategies for soybeans in western Canada and Atlantic Canada (i.e., inoculant recommendations; requirements and management of N, P, K, and S; risks and management of iron deficiency chlorosis in western Canada)
- Improve soybean crop establishment and early season growth in no-till production systems (especially in western Canada)
- Investigate factors controlling pod height in soybean to reduce harvest losses and complications
- Optimum planting time, rate and depth studies (particular priority in Atlantic Canada)
- Impact of soybean on overall crop rotation (N-credit benefits, economics, where do soybeans fit best in crop rotations); effect of short soybean rotations (S-S); and impact of soybean on soil biology (particular priority in western Canada)
- Determine how soybeans can be used in rotation to facilitate low-GHG emission cropping systems (i.e., through reduced N fertilizer, reduce tillage, etc.)
- Identify cropping systems resilient to climate change (i.e., excess moisture, rainfall, drought, heat, frost)

Appendix B – Survey of Researchers

The following template was sent to researchers. Responses are summarized in Appendix C.

2016 Research Strategy Survey

NAME:

1: Please describe your research interests related to our sector with your highest priority interests (and which crop(s) they address) listed first (point form, 250 words)

2: What do you perceive is the highest research need of our sector (by crop, if relevant)? (150 words)

3: Why do you regard this need (answered in Part 2) as the most important? (150 words)

4: What is the greatest challenge which you face in achieving specific measurable research targets for our sector? (150 words)

5: In undertaking a research project, what approaches to research have allowed you to best achieve specific measurable research targets?
(Maximum 3: 100 words each)

	Description of approach	How this approach impacts success
1		
2		
3		

6: What are the top three characteristics of a successful collaboration and how do you achieve them?
(Maximum 3: 100 words each)

	Description of what is needed for a successful collaboration	How do you meet this need?
1		
2		
3		

7: What HQP concerns/limitations do you see/foresee when undertaking research for our sector in your area(s) of research interest? How would you suggest these concerns/limitations be addressed? (point form, 150 words)

8: In your area of research, as elaborated in Part 1, what do you regard as the three most effective ways to measure the results of your work? (Maximum 3-100 words each)

Method of measuring the results of the research which I undertake (please be specific)		Is the cost of measuring the result worth the benefit which it provides? (please elaborate)	
1		**1**	
2		**2**	
3		**3**	

9: In your area of research, what have you found to be the three most effective ways to transfer the value from your research to Canadian farmers and/or other stakeholders in Canada? (Maximum 3: 100 words each)

Method of measuring the results of the research which I undertake (please be specific)		Is the cost of measuring the result worth the benefit which it provides? (please elaborate)	
1		**1**	

2	
3	

2	
3	

10: What research project, within your sphere of knowledge, do you believe offers the best return on investment, that CFCRA could fund in the next five to seven years? Why? (250 words)

I am giving my consent to CFCRA's using the information and answers in this response in developing its materials for the November 1 and 2 event on the understanding that it will be done without attribution to me personally but aggregated with other responses received. (please initial)

Appendix C – Summary of Researcher Responses

The following summary of researcher responses was provided by Dr. Josh Cowan in the first address on the first day of the Research Summit.

Survey Results: Top Research Needs

- Generally lined up well with CFCRA draft priorities, but less specific

- Revealed need for development and integration of innovative tools (high-throughput phenotyping/genotyping/bioinformatics/site-specific management/CRISPR)

  "*We are making great progress in developing genomic tools that greatly facilitate the genetic characterization of breeding materials, but phenotyping has not progressed as rapidly and is often the main impediment to fully profiting from advances in genomics*" – Survey respondent

- Emphasized the need for a *climate change* perspective
- Also suggested exploring grain components beneficial to human health (and how processing might affect these benefits)

Survey Results: Greatest challenge in achieving research targets

- Time (to build networks, develop methods, meet objectives - research takes time)
- Acquiring, building and retaining technical expertise
- Unstable financial resources (need 3+ years of funding)
  - Aversion to funding risky, novel research
- Lack of intentional funding for equipment renewal
- Inadequate tools available (i.e., phenotyping limiting use of genomic tools; tools not validated or non-existent)
  - Lack of Fusarium-head-blight-resistant germplasm for six-row barley)
- Industry research target expectations can be difficult to achieve and they don't always pan out (i.e., developing one variety with all of the desired features)
- Administration burdens

Survey Results: Best practices to achieve specific research targets

- **Clear planning from the start:** Well-defined problems, realistic and achievable goals, clear objectives, *industry engagement*
- **Engaging complementary expertise/collaborations**
  - Skilled HQP training and retention of expertise
- Stable financial resources, and equipment/field/lab resources
- Incorporate validated research tools into a research program (i.e., markers, tests, etc.) - improves efficiency and solves new challenges
- Explore several approaches to solving a problem, at the same time

- Knowledge transfer – getting results to the target audience

Survey Results: Characteristics for a successful collaboration

- **Frequent, timely communication**
    - Face-to-face meetings are very important
    - Clear goals and objectives from the start (and openness to input from outside the team)
    - Willingness to discuss results/issues along the way
- **Functional multi-faceted team** (complementary expertise)
- **Complementary personalities** (mutual respect; not a forced collaboration; all team members fully committed to project goals)
    - Strong, humble leadership (i.e., clear direction; egos left at the door)
- All collaborators mutually benefit (i.e., recognition)
- Funding (including collaborative funders; money for face-to-face meetings, etc.)
- Minimal administrative barriers across collaborating institutions
- Built over time (when addressing enduring priorities; not just one-off priorities)

Survey Results: HQP concerns and limitations foreseen in the sector

- Attracting good students/PDFs for research programs
    - Solutions: scholarships/better stipends; provide work experience; improve connection to jobs after graduation; facilitate hiring from a global workforce
- Retaining skilled labour (technicians/field staff)
    - Solutions: long-term positions (not short contracts); decent wages for field staff
- Replacing a retiring workforce (scientists and technicians)
    - Solutions: mentorship overlap (trains new expertise, especially when hiring pool is small); new positions need to be long term
- *Specific gaps identified:* cereal chemistry, soy food and processing quality, nematology, bioinformatics

Survey Results: Effective ways to measure impact of research

- **Quality publications** in good journals ("quality over quantity")
- **Commercial interest** (variety licenses, germplasm MTAs, patents)
- **Adoption by end user** (growers, scientists, industry members)
- **Extent of communication of results** to end users (KT)

- **Economic and environmental benefits**
- Training of HQP (even better if they land a job in the sector)
- Number of outputs developed (i.e., varieties)
- Success in achieving initial deliverables
- *Invitations* to share info with end users (i.e., grower field day talks)
- If subsequent phases of a research thread are funded (value to funders)

Survey Results: Effective ways to transfer value to stakeholders

- **Tours/meetings with ag industry** (farmers and other end users)
    - Face-to-face, two-way communication
- **Equip "industry"** to communicate to farmers (equip the equippers)
- **Agricultural farm media** (newsletters, magazines, online articles…)
- **Releasing lines/patents** to companies that can market them
- **Scientific publications**
- Scientific conference posters and presentations
- Directly contributing tools/resources to advance other research programs (i.e., sharing germplasm, sharing screening tools)
- Incorporating results into education curriculums (i.e., Ag in the Classroom)

Survey Results: What research offers best return on investment?

- **Variety development** for high yield, disease resistance, adaptability, and good quality for end users (direct impact on farmers - # of bushels/acre)
    - Integrating collaborative approaches (i.e., integrating quality and molecular marker work)
- **Adoption of new technologies/approaches** to solve research questions
    - i.e., phenomics, genomics, CRISPR, large scale phenotyping, molecular markers, bioinformatics
- **Effective monitoring methods** for current and emerging pests, pathogens, weeds
    - i.e., molecular ID tools, mapping
- **Developing BMPs** for corn and soy production in new short-season environments
- Reducing reliance on chemical controls for diseases/pests/weeds
- Exploring new and emerging market opportunities
- Long-term cropping system studies to explore implications
- Exploring ways to mitigate nitrous oxide emissions

Appendix D – Biographies for Panel Presenters

Eric DeBlieck – Crop Specialist, Grain Millers, Inc.

Eric DeBlieck is an agronomist with Grain Millers, a wholegrain ingredient manufacturer. Eric has been focusing on oat production since the spring of 2013. This focus has allowed him to learn all aspects of production, grain quality, and what makes a great food ingredient. He uses this knowledge to work with producers and researchers to develop and apply methods to grow quality ingredients. Eric currently lives in the Minneapolis area but spends most of his time on the road.

Phil de Kemp - Executive director of the Barley Council of Canada (BCC) and president of the Malting Industry Association of Canada (MIAC)

Phil de Kemp has over 30 years of experience in strengthening Canada's domestic and international trade relationships and commercial opportunities for malt and barley. He was raised on a corn and soybean farm in eastern Canada and began his career working for Cargill Limited in various grain merchandizing roles across Canada. He is a former employee of Agriculture Canada and served as the senior policy advisor to the Canadian Federal Minister of State for grains and oilseeds and the Canadian Wheat Board. In the early 1990s, he became the executive director of the Canadian National Flour Millers Association. De Kemp joined MIAC as president in 1996, and also became the executive director of the BCC in the early 2015.

Kevin Hachler – Manager of Commodity Purchasing, Canada – Ingredion Incorporated

As Manager of Commodity Purchasing, Canada, Kevin oversees the sourcing of corn for Ingredion's Canadian locations. Ingredion is a global, NYSE listed ingredient solution company. Ingredion's Canadian operations include commercial corn wet-milling facilities in London, Ontario and in Cardinal, Ontario. These facilities support Canadian agriculture by producing an assortment of starches and sweeteners derived from locally sourced corn. In his current role, Kevin is responsible for securing corn that meets Ingredion's specifications and enables compliance with FSSC 22000 and ISO 9001 food safety and quality standards. Kevin is involved in a project to initiate a non-GMO corn program for the Cardinal facility. While Ingredion supports both GMO and non-GMO customer needs, this program is a consumer-driven initiative that responds to growing awareness of non-GMO food products.

Clint Munro – Independent

Clint was raised on a grain farm in Western Australia, where he completed a Bachelor of Business (Agriculture) at Curtin University. He started his career with James Richardson International, working at a grain elevator in Alberta, and then as a canola trader exporting to Asia markets based in Winnipeg. In addition, he was involved in the initial production and exports of high oleic canola, which required identity preservation through to the destination market in Japan. Working for Gardner Smith based in Sydney, Australia, he managed the trading and logistics for three canola processing plants. During the past 9 years, Clint has worked for Bunge in various roles. Based in the White Plains New York global head office he exported soybean oil from South America. Based in Canada he has managed the trading and merchandising teams purchasing canola and soybeans, and marketing the meal to livestock markets across North America. In addition, he coordinated the certification of sustainability programs to supply key food and biodiesel customers. Within industry associations Clint has held the positions of director of the Canadian Oilseed Processors Association, director Australian Oilseed Federation, and treasurer of Soy Canada.

Todd Ross – Grain Merchant, South West Ag Partners

Todd grew up on a family farm in Palmerston, Ontario and graduated from Brock University with a Honours Degree in Business Administration. Embarking on a career in agriculture almost 20 years ago Todd worked in various marketing and management roles gaining expertise in domestic and offshore trading of Ontario's agricultural production in most modes of transportation. Over the past 5 years Todd has been active in the western Canadian marketplace, he carried the role of Director of Risk Management at Parrish and Heimbecker during the transition from the CWB managed market to a free and diverse open market. He then transitioned into a position as the General Manager of the successful start-up of a western Canadian focused joint venture between Lansing Trade Group and Olam which focused on the direct procurement of grain and lentils from the Prairie producer for marketing to customers around the world.

Appendix E – List of Participants

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