



CFCRA
CANADIAN FIELD CROP
RESEARCH ALLIANCE

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ALLIANCE DE RECHERCHE SUR LES
CULTURES COMMERCIALES DU CANADA

Climate-smart cropping systems with corn, oat, and soybean for a sustainable Canadian field crop sector

Interim Research Highlights 2023-2025





Introduction

Since April 2023, the Canadian Field Crop Research Alliance (CFCRA) has been managing a \$10.5 million AgriScience Cluster under the *Sustainable Canadian Agricultural Partnership (SCAP)* AgriScience Program.

The Cluster, entitled “Climate-smart cropping systems with corn, oat, and soybean for a sustainable Canadian field crop sector” (often referred to as the Cropping Systems Cluster), combines innovative research on soybean, corn, and oat that will support diverse crop rotations to reduce greenhouse gas (GHG) emissions, improve resiliency, and grow the economic stability of the Canadian grain sector.

CFCRA Cropping Systems Cluster

The research activities of the Cropping Systems Cluster will improve farm income stability, crop resilience, expand efforts in value-added production, and decrease GHG emissions by addressing barriers in the implementation of diverse crop rotations.

Together, the set research activities in the Cropping Systems Cluster are foundational to implementing corn, oat, and soybean in rotation, together, and with other field crops, to create sustainable economic growth in the field crop sector.

Specifically, the research activities of the Cropping Systems Cluster will:

- Explore cover crop and 4R nitrogen management strategies in corn production
- Advance soybean production for short season environments in Canada through yield enhancement, increases in soybean protein content, and improvements to abiotic stress tolerance (e.g. drought tolerance)
- Develop oat varieties with improved traits for eastern and western Canada
- Improve soybean resistance to *Sclerotinia* stem rot (white mold)
- Develop corn germplasm with improved resistance to key diseases, including *Gibberella* ear rot, Goss’s wilt, and tar spot.

This report summarizes the interim research highlights for the five activities of the Cropping Systems Cluster through the first three field seasons (2023-2025).



About the Canadian Field Crop Research Alliance

The CFCRA is a not-for-profit entity founded in 2010 with an interest in advancing the economic and sustainable capacity of field crops in Canada, particularly soybean, corn, wheat, barley and oat. The CFCRA is comprised of provincial producer organizations and industry partners, including: Atlantic Grains Council; Producteurs de grains du Québec; Grain Farmers of Ontario; Manitoba Crop Alliance; Manitoba Pulse & Soybean Growers; Saskatchewan Pulse Growers; Prairie Oat Growers Association; SeCan; and FP Genetics.

For more information on the CFCRA, please visit: www.fieldcropresearch.ca



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Activities 1, 2, and 3 are non-research Cluster administration activities





Activity 4

Title: Cover Crops and 4R Strategies to Mitigate GHG Emissions

Researchers: Craig Drury, Agriculture & Agri-Food Canada (AAFC); Lori Phillips (AAFC); David Pelster (AAFC); Claudia Wagner-Riddle (University of Guelph); John Lauzon (University of Guelph); Joann Whalen (McGill); Mario Tenuta (University of Manitoba); Ike Agomoh (AAFC); Ward Smith (AAFC); Aaron Delaporte (University of Guelph); Alfons Weersink (University of Guelph)

Background

Reducing greenhouse gas (GHG) emissions while maintaining productivity is a major challenge for field crop systems in Canada, where nitrogen fertilization and annual cropping have contributed to rising nitrous oxide (N₂O) emissions and declining soil organic carbon. Agriculture accounts for a significant share of GHG emissions, and N₂O from agricultural soils has increased in recent decades due to higher fertilizer use and intensified cropping. Corn production, especially in key regions such as Ontario, Quebec, Manitoba, and the Maritimes, is particularly important because of its high nitrogen requirements and expanding acreage, making it a priority crop for GHG emission mitigation strategies.

This research activity evaluates integrated soil and nutrient management practices designed to both reduce nitrogen losses and rebuild soil carbon, focusing on cover cropping and advanced 4R nutrient stewardship approaches. Across six research sites representing major corn-growing environments in Canada, researchers are testing combinations of fall-seeded cover crops, conservation or no-tillage systems, and injected fertilizer with urease and nitrification inhibitors. Measurements include seasonal GHG fluxes, crop nitrogen uptake, yields, soil carbon stocks, and microbial processes driving nitrogen cycling. The data will be used to refine and scale predictive models to estimate regional impacts of these practices.

By identifying management systems that simultaneously enhance soil health, improve nitrogen efficiency, and lower emissions, the project will provide practical, science-based recommendations for producers, with potential benefits extending to roughly half of Canada's corn, soybean, and pulse acreage. Ultimately, the research will support climate targets, strengthen farm profitability, and advance sustainable intensification of Canadian cropping systems.





The objectives of this activity are to:

1. Determine the impact of cover crops and combined urease & nitrification inhibitors under no-tillage and conservation tillage treatments from 6 sites across four provinces on growing-season N_2O & CO_2 emissions over 4 years, and on agronomic parameters (e.g. nitrogen uptake and corn yields) over 5 years.
2. Increase carbon sequestration and active carbon fractions using cover crop and inhibitor treatments.
3. Model the 24 site-years of data using the Canada DeNitrification-DeComposition (Canada DNDC) model and scale up to the provincial level (MB, ON, PQ, NB) to understand integrated agronomic and environmental impacts.
4. Evaluate how the microbially-mediated carbon and nitrogen cycling processes that underpin soil health are altered by combined cover crop and inhibitor treatments.

Overall, this activity aims to:

Provide producers with information on yield, soil health, and environmental benefits of growing cover crops, using inhibitors, and adopting different tillage practices in corn-based rotations.

Interim Research Results (2023-2025)

Through two complete field seasons (2023 and 2024), field data show mixed results regarding practices. With analysis ongoing from the 2025 field season, and field studies continuing in 2026 and 2027, the three remaining years of field data will be critical in determining effects over time and space and drawing robust conclusions and determining the impact of cover crops, inhibitors, and tillage practices on N_2O and CO_2 emissions and agronomic parameters.





Activity 5

Title: Reducing GHG Emissions by Lengthening Short-Season Crop Rotations with Soybean

Researchers: Elroy Cober (AAFC); Tanya Copley (CÉROM); Tom Warkentin (University of Saskatchewan); Louise O'Donoghue (CÉROM - retired)

Background

Expanding soybean production into short-season regions represents a major opportunity to strengthen cropping systems in Canada, particularly across Western Canada where cereal and oilseed crops dominate rotations. Estimates from Soy Canada suggest up to 1.62 million additional hectares could be integrated into cropping systems in provinces such as Manitoba, Saskatchewan, and Alberta, improving rotation diversity while reducing nitrogen fertilizer use and associated GHG emissions.

However, expansion is currently limited by the lack of early-maturing soybean varieties that combine high yield, strong protein content, and tolerance to short-term moisture stress conditions frequently encountered in these environments.

Even brief dry periods of two weeks or more, especially during flowering or seed fill, can sharply reduce productivity because soybean nitrogen fixation is highly sensitive to moisture stress. Since the crop obtains over half of its nitrogen through symbiotic fixation, disruptions can cascade into reduced growth, lower yields, and diminished seed quality.

This research activity aims to overcome these barriers by developing high-yielding early soybean varieties alongside genomic tools and breeding germplasm that accelerate selection for drought tolerance, protein content, and nitrogen fixation stability. Through multi-environment testing and collaborative breeding, the research will deliver regionally adapted varieties that support broader soybean adoption, enhance farm profitability, and enable climate-smart crop rotations that lower agricultural emissions.





The objectives of this activity are to:

1. Quantify and model the effect of moisture stress on nitrogen fixation, seed protein content, and seed yield in Western versus Eastern Canada. Increase carbon sequestration and active carbon fractions using cover crop and inhibitor treatments.
2. Generate a list of quantitative trait loci (QTL) and underlying genes for the identified QTLs from a soybean Multiparent Advanced Generation Inter-Cross (MAGIC) population for the effect of moisture stress on nitrogen fixation, seed protein, and seed yield. QTL or allele-specific markers for target genes will be developed for marker-assisted selection in soybean breeding programs.
3. Develop a test to determine the presence of the prolonged nitrogen fixation (PNF) trait in soybean lines. The effect of this PNF trait on seed yield and protein will be examined under differing moisture regimes and environments.
4. Incorporate traits for resilience and adaptation into new varieties of soybean higher yielding, early maturity soybean lines with yield 7.5% higher than provincial check varieties with seed protein greater than 40% in relevant locations.

Overall, this activity aims to:

- Identify new moisture stress tolerance and seed protein content genetics
- Prolong nitrogen fixation during moisture stress to increase yield and protein
- Develop improved MG 00 and MG 000 non-GM soybean varieties
- Understand moisture stress impacts on protein in irrigated versus dryland conditions





Interim Research Results (2023-2025)

Soybean Variety Development Results

CDC Cedar, an early maturity, non-GMO food grade soybean variety was released by the University of Saskatchewan Crop Development Centre (CDC) to SeCan for commercialization. Breeder seed of CDC Cedar was multiplied in summer 2024 in New Liskeard, Ontario.

AAC Bozzart, a medium maturity food grade soybean variety developed at AAFC Ottawa Research and Development Centre was licensed to Semcan.

Soybean Protein Agronomy Trial Results

Across five locations (Ottawa, Morden, Melita, Carberry, and Saskatoon), protein agronomy trials were conducted under both irrigated and dryland conditions using eight soybean lines ranging from low to high protein, along with nodulating and non-nodulating isolines.

Seed yield, protein content, nitrogen fixation, and other agronomic traits were measured for each soybean line at all locations.

Through two field seasons (2023 and 2024), drought stress impacts varied considerably by location, with yield losses ranging from as little as 1% in Ottawa to as much as 45% in Saskatoon. Under drought stress, soybean protein levels decreased in dryland conditions relative to irrigated conditions, between 1.3-2.5%, depending on the year. Nitrogen fixation and soil nitrogen availability were also quantified, with irrigation increasing protein yield from nitrogen fixation by 54 kg/ha and total protein yield by up to 355 kg/ha.

Analysis of the 2025 season data (the third year of data) is still underway, and protein agronomy trials are planned to continue in 2026 and 2027. These remaining three years of protein agronomy trials will be critical for determining the effect of moisture stress on nitrogen fixation, seed protein content, and seed yield in western versus eastern Canada.





Activity 6

Title: Climate-smart trait development in oat germplasm for Canada

Researchers: Kirby Nilsen (AAFC), Weikai Yan (AAFC), Wubishet Bekele (AAFC)

Background

Oat is a vital crop in Canada, supporting food, feed, forage, and soil health systems while contributing to both farm profitability and environmental sustainability. Although most production occurs in western Canada, eastern production remains economically significant, in part due to processing demand from facilities such as the PepsiCo plant in Peterborough. With growing global demand, climate pressures, and evolving market expectations, continued development of high-yielding, resilient, and high-quality oat varieties is essential to maintain competitiveness and long-term sector sustainability.

This research activity aims to establish a coordinated national breeding effort led by Agriculture and Agri-Food Canada research centres in Brandon and Ottawa to develop next-generation oat varieties tailored to Canada's three major growing environments. Using advanced genomic selection and marker-assisted breeding, it seeks to combine higher and more stable yields with improved grain quality, durable disease resistance, and climate-smart traits that reduce GHG emissions and production risks. Ultimately, the goal is to deliver resilient, market-ready oat cultivars that strengthen farmer profitability, enhance environmental performance, and support long-term growth and competitiveness across the Canadian oat value chain.

Canada's oat production spans three distinct mega-environments that differ in climate, latitude, and disease pressures, requiring regionally-adapted oat varieties. Mega-environment (ME) 1 includes southern areas of Ontario characterized by lower latitudes and high crown rust pressure; ME2 covers Quebec, the Maritimes, and northern Ontario where cooler conditions and diverse environments influence performance; and ME3 encompasses the Canadian Prairies, marked by shorter growing seasons and different stress factors. This project targets variety development specifically for each of these three regions, ensuring new oat cultivars are optimized for their local production challenges while contributing to a coordinated national breeding strategy.





The objectives of this activity are to:

1. Sustainably increase the productivity of oat in Canada for both western Canada (ME3) and eastern Canada (ME1 and ME2), incorporating climate resilience, while maintaining consistent milling quality, disease resistance, and superior agronomic performance.
2. Enhance resilience to crown and stem rust by incorporating durable resistance into elite varieties.
3. Reduce the environmental impacts of oat production by leveraging genomics-assisted breeding approaches to incorporate climate-smart oat traits for Canada.

Overall, this activity aims to:

- Develop better performing oat varieties that are more competitive in crop rotations.





Interim Research Results (2023-2025)

For ME3 (Canadian Prairie region):

- **AAC Fetch** received support for registration and was licensed to Alliance Seed. AAC Fetch is a high-yielding white hulled milling oat that combines early maturity with resistance to crown rust and stem rust. The stem rust resistance carried by AAC Fetch represents a significant move forward against a disease where limited host resistance options are available to producers. AAC Fetch is expected to have a meaningful impact on the industry with strong agronomic performance and dual rust resistance.
- **OT2152**, the first variety developed using genomic selection (GS) for ME3 received support for registration in 2025 and will be licensed to FP Genetics. To be known as 'AAC Gladys'.

For ME2 (Northern Ontario, Quebec and Maritimes):

- **AAC Savka** was supported for registration by Réseau des Grandes Cultures du Québec (RGCQ) and was licensed to SeCan, outperforming the check mean by 8% in Quebec and 21% in southern Quebec, and showing superior kernel weight and protein content.
- **AAC Dwyer** received full registration support from RGCQ and was licensed to grant Ag Corp – Labonte Seed. Across three years, it outperformed the check mean by 8% in Quebec and 21% in southern Quebec (primarily Zone 1). It also showed superior groat content and lodging resistance compared to check varieties.

For ME1 (Southern Ontario):

- **AAC Hayes** was supported for full registration by the Ontario Cereal Crop Committee (OCCC) and was licensed to SeCan. It showed superior crown rust resistance and yielded 18% higher than AAC Reid. It also has high test weight and β -glucan content.





Activity 7

Title: A pan-Canadian approach to improving soybean *Sclerotinia* stem rot resistance

Researchers: Tanya Copley (CÉROM); Jacqueline Bede (McGill); Valerio Hoyos-Villegas (Michigan State University; previously McGill)

Background

Soybean sclerotinia stem rot (SSR), also known as white mold, is a costly and increasingly challenging soybean disease that threatens yield stability and profitability, particularly as climate conditions shift and soybean acreage expands. In Canada, annual losses from SSR are estimated at roughly \$41 million, including about \$20 million in Ontario alone. SSR-resistant soybean varieties are one of the most effective management tools, but current screening methods can produce inconsistent results because resistance ratings often vary depending on which pathogen isolate is used in testing. This variability can lead to unreliable soybean variety recommendations, increased fungicide use, and higher disease risk across crop rotations.

This research activity aims to strengthen the reliability of resistance breeding by creating a nationally representative panel of pathogen isolates collected from across eastern and western Canadian soybean production regions, including Quebec and other major soybean-growing areas. Researchers will map pathogen diversity, assess virulence, and evaluate commonly used short-season soybean parents against multiple isolates to identify sources of stable resistance. By standardizing nursery screening and improving confidence in resistance ratings, the project seeks to support the delivery of more dependable resistant varieties, reduce inoculum levels and fungicide reliance, and enhance long-term resilience and profitability for soybean producers.





The objectives of this activity are to:

1. Identify and map *S. sclerotiorum* populations across Canada, evaluate their virulence, and develop genomic tools for the assessment of *S. sclerotiorum* isolates to identify a representative multi-isolate *S. sclerotiorum* panel reflecting genetic and virulence diversity from across Canada.
2. Evaluate resistance in commonly used short season soybean parental varieties against a subset of representative isolates and compare to the Québec registration trial isolate NB-5 to identify parents with reliably stable resistance.

Overall, this activity aims to:

- Improve field screening to evaluate soybean resistance to *Sclerotinia* stem rot, also known as white mold.

Interim Research Results (2023-2025)

Through two field seasons (2023 and 2024), 64 Canadian *Sclerotinia* isolates (48 eastern isolates and 15 western Canadian isolates) were sequenced, revealing 4 unique subpopulations of *Sclerotinia* isolates. Sequencing of all isolates identified 16 mutations across 6 virulence genes, and their impact on aggressivity is still being assessed.

Preliminary results show significant isolate x cultivar interactions, and that the severity of infection depends on the isolate.





Activity 8

Title: Corn germplasm development focused on key diseases

Researcher: Aida Kebede (AAFC)

Background

Canada produces over 13 million metric tons of grain corn annually on more than 1.3 million hectares of land, with a farm gate value exceeding \$2 billion. Corn production and productivity are increasingly challenged by frequently occurring and newly emerging diseases, exacerbated by a changing climate. Among the most economically significant diseases are Gibberella ear rot (GER), Goss's wilt, and tar spot. GER is particularly prevalent in southwestern Ontario, where a 2018 epidemic resulted in estimated revenue losses to farmers of over \$200 million. Goss's wilt primarily affects corn production in Manitoba, while tar spot, first detected in Ontario in 2020, is spreading northward with potential to cause substantial yield losses.

Private corn seed companies in Canada, mostly headquartered in the United States, place limited emphasis on some of these regionally significant diseases, leaving Canadian farmers reliant on public sector breeding programs for disease-resistant germplasm. The corn genetics program at AAFC's Ottawa Research and Development Centre is the only public program in Canada developing disease-resistant inbred lines for use in commercial hybrid development.

This activity focuses on developing corn inbred lines resistant to GER, Goss's wilt, and tar spot, while ensuring acceptable agronomic performance. Molecular markers and marker-assisted backcrossing are being used to efficiently transfer resistance traits and validate candidate genes, including those linked to mycotoxin reduction in GER.

Through multi-site field trials, disease nurseries, and annual disease surveys, this activity will generate publicly available, disease-resistant germplasm that private seed companies can incorporate into commercial hybrids. By combining conventional breeding, doubled haploid technology, and molecular tools, the project aims to enhance Canadian corn sector resilience, reduce yield losses, and ensure safe, high-quality grain for farmers, while maintaining competitiveness of Canadian corn in domestic and international markets.





The objectives of this activity are to:

1. Develop multiple disease-resistant corn inbred lines to *Fusarium/Gibberella*, Goss's wilt and tar spot with acceptable agronomic performance and identify molecular markers associated with disease resistance genes.
2. Survey for current and emerging diseases such as tar spot, screen inbred lines, and identify and validate new sources of tar spot resistant germplasm and transfer the trait using marker assisted backcrossing.

Overall, this activity aims to:

- Develop new corn inbreds with resistance to key corn diseases in Canada, including *Gibberella* ear rot, Goss's wilt, and tar spot

Interim Research Results (2023-2025)

Inbred line CO484 was released to the corn industry. CO484 is an early-maturing inbred line with moderate resistance to *Gibberella* ear rot and Goss's wilt. It has the fast kernel drydown trait as well, which makes it ideal to create hybrids for the prairie regions and northern parts of Ontario and Quebec.

Inbred line CO485 was released to the corn industry. CO485 is a dwarf inbred line with moderate resistance to *Gibberella* ear rot. It is extra early maturing and can be used to create short statured corn hybrids which are becoming popular. The extra early maturity of this inbred allows it to be grown in regions with very short growing seasons (2100-2000 CHU).





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