MANITOBA CROP ALLIANCE

The Focal Point

Winter 2024 Edition

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MESSAGE FROM THE CHAIR

Robert Misko *— Roblin, Manitoba*

Welcome to another edition of Manitoba Crop Alliance's (MCA) annual research magazine, *The Focal Point*.

This edition is focused mainly on the completion of the latest round of Canadian research cluster programs supported by MCA.

We participate in cluster programs because at the end of the day, they help us achieve our strategic plan. Our vision is to ensure our investments will make every Manitoba farmer member more productive and sustainable.

It is our hope that the funding we provide into these clusters and the projects within are achieving that vision.

For every levy dollar we collect, we maximize these resources into meaningful, independent research, valuable knowledge and targeted advocacy.

If we dig a little deeper, variety development, for example, is a key tool to ensure profitability, as it unlocks field potential and addresses agronomic constraints for you, our farmer members.

Through investment in cluster programs, we gain a lot of knowledge from national discussions that benefit crop production in Manitoba, and they provide opportunities to leverage your farmer dollars further.

All of the staff, directors and crop committee delegates at MCA hope you enjoy this edition of *The Focal Point*, and that you can use this information to make productive and sustainable decisions on your farm.

Sincerely,

Robert Misko
MCA Chair

MANITOBA CROP ALLIANCE

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CUSTOM CROPS

Barley breeding programs strive to meet the changing needs of farmers

In simple terms, a genome refers to the entire genetic composition of an organism. When we compare barley to some other plants, its genome is relatively large and complex. In 2006, the International Barley Genome Sequencing Consortium was formed with the goal to develop and assemble a reference genome. A reference genome is a genetic database – a representation of the barley genome that can be used by scientists to compare DNA sequences found in their research. It took several years, but the first assembly was in 2012, and only in 2017 was a highly connected reference genome sequence reported. This was version one.

"Now, we are at version three of the barley genome," says Ana Badea, research scientist in barley breeding and genetics with Agriculture and Agri-Food Canada's (AAFC) Brandon Research and Development Centre (RDC). "And for Canadian malting barley, the first reference genome was released in 2021."

Although the genome sequence of barley was published relatively recently, this has allowed researchers to study the genetic makeup of barley more closely. Genomics play a crucial role in understanding the genetic information of barley and its complex traits.

Aaron Beattie, barley breeder and associate professor at the University of Saskatchewan's Crop Development Centre (CDC), explains genomics as the study of a species genome. This includes not only the composition in terms of the sequence of the genome, but also how different genes interact with one another and control traits of interest.

"Genomics not only attempts to understand the genome, but it also entails the tools that go along with it, helping us to understand or utilize what we already understand of a genome," he says.

"(Variety development) allows us to take those advances, whether in disease resistance or improvements in abiotic stress, and put them into a package for farmers."

Modern breeding tools have improved barley breeding efforts. Both Badea and Beattie have implemented and validated the use of various breeding tools in their breeding programs to make them more efficient.

Double haploid (DH) production has helped Badea at the Brandon RDC speed up the process of releasing varieties by one to two years.

DH production leads to complete plant homozygosity in a single generation. Homozygosity refers to the state of having two identical forms of a particular gene, one inherited from each parent. Without DH production, it would take many years of self-pollination to produce the same outcome.

"We also use this method for genetic mapping, which allows us to screen for biotic and abiotic stresses," Badea says. "It helps significantly with genetic mapping studies."

Genetic mapping allows scientists to link a trait of interest to a particular gene or genes and determine where that gene lies within the plant's genetic makeup. This can help with future marker-assisted selection.

Both Beattie and Badea utilize marker-assisted selection in their work. Molecular markers are short sequences of DNA within a gene that can be used to select plants based on the genes they have.

Beattie says through marker-assisted selection, they can select for certain traits that are important to farmers or end users in a lab situation, saving them time and money.

"We can incorporate these traits without necessarily having to grow something in a disease nursery if it's a disease trait, for example, or measure something in the quality lab if it's a malt quality trait," he says.

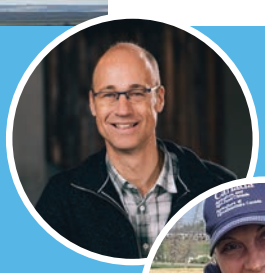
In Brandon, there is a dedicated lab where analyses are completed on several traits with a focus on disease and quality. "This helps us increase the limited resources we have for the field to be more targeted and efficient," says Badea. "We know the material has a high chance of giving us what we need to have that resistance, tolerance or quality we are aiming for."

But breeding is not easy, she emphasizes. "We have all sorts of complex and complicated traits where multiple genes are in charge of that particular trait. For that, genomic selection is the answer."

PHOTO: TONE AG CONSULTING

Lead Researchers:

Aaron Beattie and Ana Badea



Aaron Beattie is the barley breeder and associate professor at the Crop Development Centre at the University of Saskatchewan. His breeding program focuses primarily on two-row malting barley, but also devotes effort towards feed, food and forage barley. Beattie is chair of the barley agronomy evaluation team within the Prairie Grain Development Committee and is a former board member at the Canadian Malting Barley Technical Centre and the Barley Council of Canada.

Ana Badea is a research scientist in barley breeding and genetics with Agriculture and Agri-Food Canada's Brandon Research and Development Centre. She is a board member on the Prairie Grain Development Committee, the Canadian Malting Barley Technical Centre and Plant Breeders' Rights Advisory Committee. Badea is an affiliate with the Canadian Centre for Agri-Food in Health and Medicine as well as a member of the U.S. Barley Crop Germplasm Committee and the International Barley Consortium. She is an adjunct professor with Brandon University and University of Manitoba, as well as an associate editor for two scientific journals.

In genomic selection, molecular markers covering the entire genome are used. "The information from these markers is paired with information from screening in the field, disease nurseries or quality lab, and our biologist analyzes these numbers to develop predictions," she says.

These predictions are used to determine the plants with the highest chance of carrying the traits of interest.

As breeders continue their work, they must incorporate traits that meet the evolving needs of farmers and end users.

"That basically means we have more on our plate over time," Beattie says. Another important aspect for breeders is continuous dialogue. "Dialogue between breeders and farmers and end users is important, so the varieties we are developing are suitable for farms," Badea says. "It's a very competitive market, so we need to work together."

In 1995, Western Grains Research Foundation started funding this breeding program and in recent years it was passed over to the Canadian Barley Research Coalition.

Some support for both breeding programs was part of the National Barley Cluster funded from 2018-23 under the federal government's CAP AgriScience Program on behalf of Canadian barley industry funders. The overall goals of the research are to ensure barley production remains competitive with other major crops in Canada and to improve the quality traits of Canadian barley to satisfy the diverse and evolving needs of customers. Research areas within the cluster include variety development, agronomic productivity, disease resistance, quality and performance, and sustainability.

"This funding is very important because it provides stability to maintain our research," Badea says. "Along with a core agreement, which allows us to maintain skilled staff, this project helps us to develop new, improved varieties that hopefully suit farmers' needs."

Over the lifetime of the project, both breeding programs have been quite successful at producing and registering new varieties in different barley classes.

FROM THE SASKATCHEWAN BREEDING PROGRAM:

Malting variety

CDC Churchill: Three-to-four per cent higher yielding than AAC Synergy with similar lodging resistance, this is one of the highest-yielding malting varieties in the market. It has moderate resistance to net-form and spot-form net blotch, stem rust and surface smuts, along with intermediate resistance to spot blotch. The strong yield increase is paired with a very good malting quality profile, this variety will have a nice fit with not only craft brewers but also some of the larger brewers.

Feed/forage varieties

CDC Durango: This feed variety is seven per cent higher yielding than the current most grown feed barley, CDC Austenson. In comparison, CDC Durango has an improvement in lodging resistance, maturity is one day later, grain protein is 0.5 per cent higher and it maintains the good physical grain quality that CDC Austenson was known for.

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FB21106: This is a new feed line supported for registration in 2023. It shows a six per cent yield increase over CDC Austenson, with maturity being about one day earlier and similar lodging resistance. Physical grain quality is excellent, with improved kernel weight and plumpness over CDC Austenson, even under dry conditions.

CDC Renegade: This forage variety shows a 15 per cent improvement in grain yield and a five per cent forage yield improvement over CDC Cowboy or CDC Maverick. It has shorter stature compared to CDC Maverick, with similar lodging resistance.

Hulless barley

While only a small percentage of acres are grown to food barley in Western Canada, there is a small and dedicated industry that sells into Asia. Beattie's program released a couple different types in this class.

CDC Valdres and HB20349: Two varieties were released with agronomic improvements in yield, better lodging resistance and good disease package improvement. The main selling feature to end users of these varieties is grain beta-glucan content, which was increased in both varieties. Beta-glucan normally sits around four per cent in most barley, but reaches nine to 11 per cent in these varieties.

Canada is unique in producing hulless barley for malt production. Two varieties were supported for registration at the end of the project in 2023. Both new varieties show an increase in the amount of extract produced, which to a brewer translates into more alcohol production per unit of malt, and both also saw big improvements in terms of lower protein content and lower beta-glucan content. From a maltsters point of view, these varieties look like they have some real potential.

HB20351 shows a 15 per cent yield increase over CDC Clear along with shorter stature and earlier maturity. It has moderate resistance to spot-form net blotch, spot blotch, stem rust and surface smuts, along with intermediate resistance to net-form net blotch and Fusarium head blight (FHB).

HB21355 shows a 10 per cent yield increase over CDC Clear along with shorter stature and earlier maturity. It has moderate resistance to spot blotch, the surface smuts and FHB, along with intermediate resistance to both forms of net blotch and stem rust.

ON YOUR FARM

New varieties show strong potential

Feed barley

AAC Lariat: Compared with CDC Austenson, this variety is four per cent higher yielding, has shorter straw and has demonstrated good standability, with a slightly better lodging score. AAC Lariat carries an average to above average combination of disease resistance, including resistance to stem rust, surface smuts and net-form net blotch, moderate resistance to spot-form net blotch, intermediate resistance to spot blotch and moderate susceptibility to FHB.

AAC Stockton: Compared with CDC Austenson, this variety is three per cent higher yielding, with good standability, high kernel weight and plumpness, and good grain protein content. It carries a good combination of disease resistance, including resistance to stem rust, loose smut and surface smuts, moderate resistance to FHB and intermediate resistance to net-form net blotch, spot-form net blotch and spot blotch.

Both varieties will offer good production choices for farmers, but AAC Stockton, especially, will be helpful in areas where FHB is a problem. Based on communication with the license holders, AAC Lariat will likely be available starting spring 2024 and AAC Stockton will follow in 2026.

TR20273: This is another promising variety that demonstrated excellent standability, early maturity (1.3 days earlier than CDC Austenson) and a good combination of disease resistance, including improved stem rust resistance (resistance to Ug99 variants of stem rust and all known races in North America).

"This variety is a great example of how important modern breeding tools are. Ug99 is not present in North America, so we cannot test it in the field here," Badea explains. "By using marker-assisted selection combined with field testing in the late generation in Kenya, this elite breeding line was supported for registration. Hopefully, we won't need it, but we have it in case we do."

All these new varieties show strong potential to replace current varieties through better yields, improved quality traits and better disease packages.

Since 1995, farmer members have funded 40 per cent of barley breeding research and development in Western Canada. Because of your investments in barley research, the yield potential for western Canadian barley varieties has grown 12 per cent since 2004 and continues to grow.

FROM THE AAFC-BRANDON PROGRAM:

Malting variety

AAC Prairie: This variety has a good combination of agronomic traits, disease resistance and promising malting quality. It is five per cent higher yielding than AAC Metcalfe and two per cent higher yielding than CDC Copeland. It has shorter and stronger straw, with better lodging resistance compared to current varieties; moderate resistance to surface-borne smuts, stem rust and net-form net blotch; and intermediate resistance to FHB and spot blotch. It has a combination of malting quality traits that are desired by end users, including high enzyme, high malt extract, high diastatic power and lower beta-glucan.

Based on communication with the license holder, this variety might be available to farmers in 2024.

MCA INVESTMENT OVER FIVE YEARS:
$59,090

CO-FUNDERS:

Agriculture and Agri-Food Canada · Alberta Grains · CBRC Canadian Barley Research Coalition · SaskBarley Development Commission · WGRF Advancing Agriculture through Research

MADE FOR MANITOBA

New Canadian-adapted confection sunflower hybrid coming soon to a farm near you

Ninety per cent of Canadian sunflower production is located here in Manitoba and the top variety grown, 6946 DMR, has been on the market for more than 30 years. A lot can change in 30 years, especially in the world of agriculture, highlighting the need for modern sunflower varieties.

Thanks to a project that began with the National Sunflower Association of Canada and carried over to Manitoba Crop Alliance (MCA) upon amalgamation, a confection sunflower hybrid adapted to our growing conditions is very close to becoming available to Canadian farmers.

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Lead Researcher:

Michael (Mike) Hagen

Michael (Mike) Hagen has 35 years of experience in sunflower breeding and seed production. Hagen began developing confectionary and oilseed sunflower hybrids in 1986. In 2011, Hagen aligned with the National Sunflower Association of Canada to develop a Canadian confection breeding program. Hagen operates under the company of CanSun LLC, located in Fargo, North Dakota.

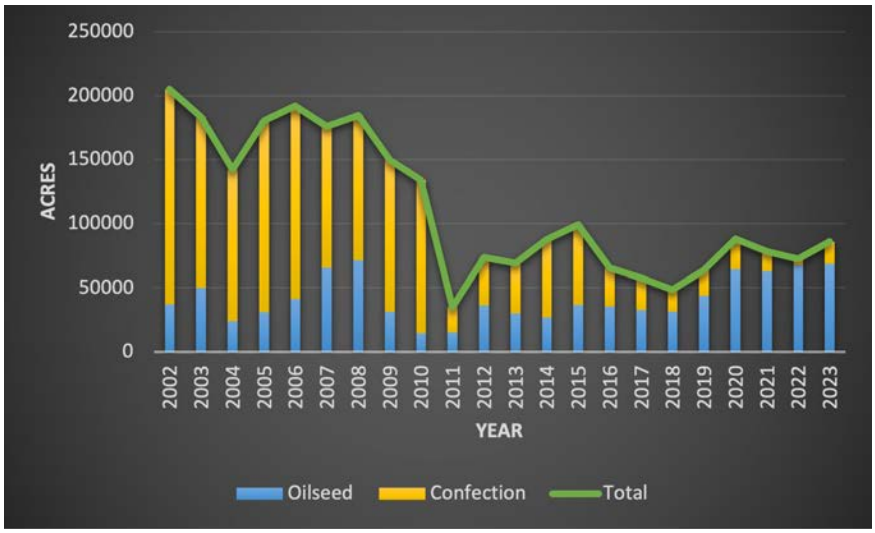

FIGURE 1 | Total acres of sunflowers grown in Manitoba since 2002. *Source: MASC Variety Yield Data Browser.*

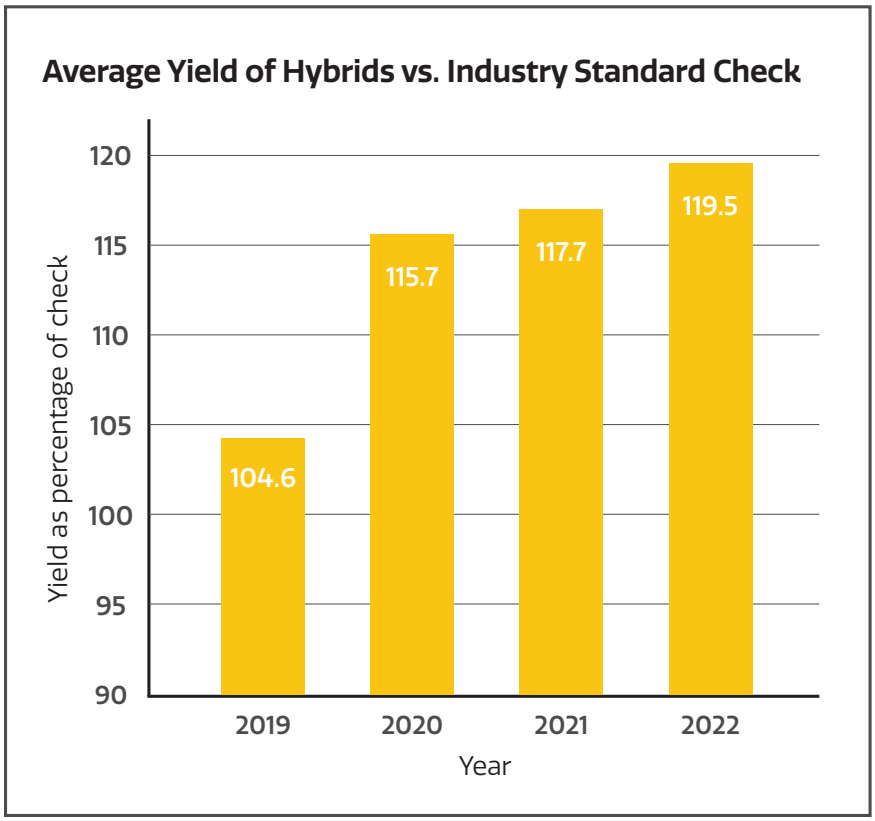

FIGURE 2 | Since 2019, the advanced hybrids have been consistently outperforming the check, and performance has continually increased.

This program was born out of necessity, as there was no breeding in confection sunflowers occurring in Canada. At one point, there were more than 150,000 acres of confection sunflowers being grown ***(Figure 1)***. As time went on and other crops saw advancements in yield and pest management, sunflowers became a less appealing choice for many farmers.

With this breeding program, MCA hopes to bring back confection sunflowers as a stable choice for farmers. Mike Hagen, sunflower breeder at CanSun LLC in Fargo, North Dakota, is the lead breeder on the project and says a lot has gelled in the sunflower breeding program in the last five years.

"Since 2018, we've made some pretty significant advances," Hagen says. "We've seen steady yield increases and we've been able to get good, wide seed (one-half/three-quarters of an inch long), with a good shoulder and a lot of nut meat into all of our advanced hybrids."

The activities of the program include a summer breeding program in North Dakota, a winter nursery in Chile and Canadian testing plots. The winter nursery in South America has doubled the rate of progress.

In Manitoba there are three key trials: a preliminary nursery where roughly 130 new hybrids are tested each year, variety performance trials where advanced hybrids are tested in four different environments for performance against commercial hybrids (evaluated for maturity, height, seed size, visual appearance, kernel size, disease susceptibility and yield) and pre-commercial strip trials testing experimental hybrids against the industry standard.

The breeding program uses the most popular commercial hybrids in Canada as checks: 6946 DMR and Panther. Since 2019, the advanced hybrids have been consistently outperforming the checks and that performance continues to improve.

If we look at the average yield of hybrids as percentages ***(Figure 2)*** compared with the industry standard check (6946 DMR), several of our hybrid yields are higher and have consistently increased. Advanced hybrid yields were 104.6 per cent compared with the check in 2019, rising to 115.7 per cent in 2020, 117.7 per cent in 2021 and 119.5 per cent in 2022.

The hybrid's days to maturity must be equal to or shorter than those of current commercial varieties to advance through the Manitoba testing process.

"In the last five years, we've been able

isolate advanced hybrids with early maturity on everything at or earlier than 6946 DMR, which holds 83.1 per cent market share of the 2023 confectionary acres in Manitoba, according to Manitoba Agricultural Services Corporation (MASC)," Hagen says. "Our goal is to land at or earlier than the check in advanced stage testing, and everything is performing at or above."

A challenge earlier on was standability, as Manitoba has a very challenging environment for sunflower hybrids in this regard. "In 2021, we isolated lines that gave us hybrids that remained perfectly straight after a high wind and driving rain," Hagen says. "I was really happy to finally find that. Most of the advanced hybrids in the program are from that material."

ON YOUR FARM

Breeding program extends Canadian sunflower marketing opportunities

In July 2022, there was a major wind and the checks went down, something Hagen says rarely happens. The advanced hybrids stood just as well or better than the checks, which was a huge milestone for the program. Hagen breeds for medium to short plant height, further helping with standability.

To provide a competitive edge in commercial production, the breeding program is 100 per cent tolerant to the herbicide Express. The SU-7 gene is a single dominant gene from DuPont that conveys herbicide tolerance to tribenuron in sunflower and has been fully incorporated into the program.

This is a non-GMO herbicide resistance trait based on genetics from a natural mutation that occurred in a wild sunflower in 1996. It is non-transgenic, meaning the gene came naturally from the sunflower species and was not genetically modified or introduced from another species. This means the gene addition will not limit the marketability of the crop in regions like Europe or Asia, where GMO regulations are stricter.

The breeding program has also emphasized disease resistance. All the preliminary and advanced hybrids in the program contain a gene for downy mildew resistance, with several also containing a gene for rust resistance.

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▲ *EX359239 is one of the hybrids that is being pursued for variety registration.*

PHOTO: MANITOBA CROP ALLIANCE

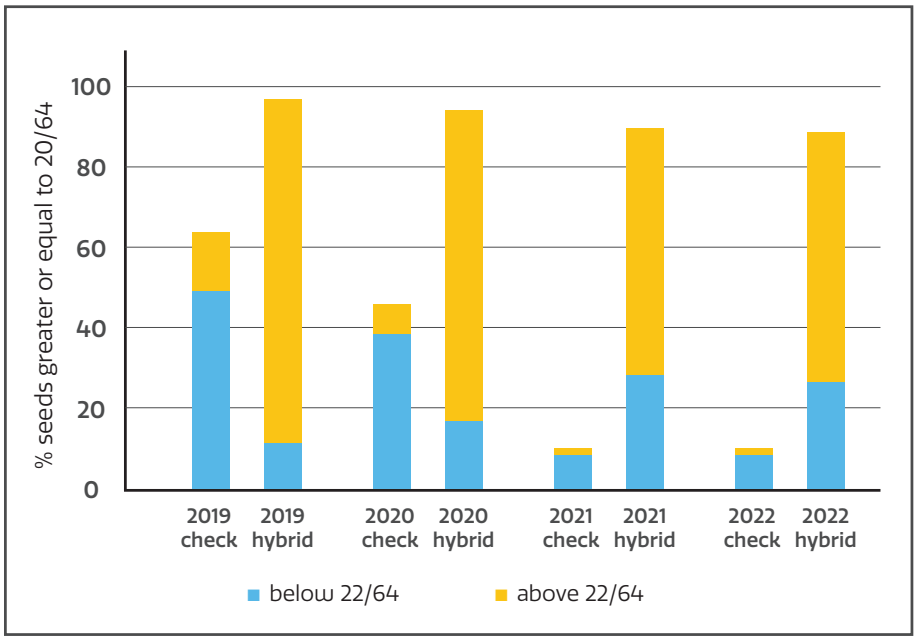

FIGURE 3 | Percentage of seeds equal or greater than 20/64. Further broken down into percentage greater than 22/64, which receives premium prices.

The central objective of the program is to continue incorporating the three resistance genes (herbicide tolerance, rust R12 and R13, and downy mildew PL ARG), but other new disease resistance genes for rust and downy mildew that are made available will also be incorporated. Screening for other common diseases such as sclerotinia will also be a focus. This will further improve sustainability of confection sunflowers.

To compete globally, sunflower farmers in Canada need access to modern varieties adapted to Canadian growing conditions, with desirable traits.

Darcelle Graham, chief operating officer with MCA, says there are two main markets for Canadian sunflowers. "The current variety we grow well in Canada (round seed type) can only be sold in Canada," she says. "To be able to sell in the international marketplace, we must be able to produce a long seed type. However, the current varieties are not adapted to Canadian growing conditions."

Through Hagen's breeding work, they've been able to change the seed type to seeds that are three-quarters to half an inch long (1.9–3.2 cm) with a wide shoulder and dark colouring. These traits are more desirable for both the domestic and international markets. A large percentage of these seeds are in the ideal range for confectionary sunflowers compared with the current market variety.

For confectionary sunflowers, sizing is a big factor in price. Seeds are passed through sieves to determine what percentage are above or below a 20/64 size. Below a 20/64 size ratio will receive a lower price and dockage at the elevator.

Having a seed sizing of above 22/64 is considered very good quality and will receive high prices. On average, 93 per cent of seeds produced by the hybrids in development are larger than 20/64, with 71 per cent larger than 22/64. Meanwhile, on average, only 33 per cent of seeds produced by 6946 DMR are larger than 20/64 and only five per cent are larger than 22/64 ***(Figure 3)***.

From the 130 hybrids tested, 18 hybrids were selected for advanced yield hybrid adaptation screening in the nursery for an additional year. Five elite hybrids were tested in variety performance trials at Elm Creek and Holland, MB, in 2022 and three of these hybrids were pilot-scale tested in 2023 by a commercial seed processor.

Based on in-field testing of flavour profile, one hybrid is preferred over the current commercial confection hybrid.

"We had some fairly significant testing acres this season," Graham says. "At the time of writing this report, a candidate for commercial release is currently in the final stages of field testing to determine if the agronomic characteristics hold up with large-scale production."

The current hybrid data results piqued interest by sunflower processors. If the test data is favourable, MCA will be pursuing the next steps towards variety registration.

This is a major success story, but variety development work must continue. Hagen says he plans to continue working on increasing nut meat percentage and test weight. He's also aiming for darker, shinier seeds.

Higher-yielding hybrids with improved seed types in combination with herbicide tolerance and genetic disease resistance will provide attractive options for Canadian farmers.

"We will continue with this breeding program and focus on variety development to ensure sunflower varieties are adapted to changing environmental conditions and sunflower farmers can remain competitive in global markets," Graham says. ●

PHOTO: KUI LIU

Visit mbcropalliance.ca for sunflower hybrid performance results, or for more information about this research and other MCA projects.

MCA INVESTMENT OVER FIVE YEARS:
$333,898

CO-FUNDERS:

Agriculture and Agri-Food Canada

CANADIAN AGRICULTURAL PARTNERSHIP
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WGRF
Advancing Agriculture through Research

RESILIENT ROTATIONS

Crop rotations are not one-size-fits-all

▲ *Resilient crop rotation at Swift Current, SK, in 2018.*

As a farmer, part of the job is managing your cropping system. Multiple factors affect the performance of that cropping system, including crop types, environmental conditions and various management practices.

While research shows the long-term benefits of diverse cropping systems regarding resiliency against pests and other stresses, some farmers choose short and simple rotations to maximize short-term economic benefits.

Rotations are an important management practice in crop production. They have a critical role in pest management, carbon sequestration and maximizing how efficiently we can use resources such as nutrients and water.

"Achieving sustainable development of cropping systems is a complex challenge," says Kui Liu, research scientist at Agriculture and Agri-Food Canada's (AAFC) Swift Current Research and Development Centre (RDC). "It is critical to develop resilient cropping systems that adopt a holistic approach to address long-term sustainability goals."

Liu is the lead researcher on a five-year rotation study that began in 2018 funded through the Integrated Crop Agronomy Cluster (ICAC): Optimizing systems productivity, resilience, and sustainability in the major Canadian ecozones. Funding has been approved for another five years through ICAC.

Through this study, researchers developed productive and resilient crop rotations with specific objectives to assess their impact on crop productivity, resource use efficiency, pest levels, soil health, carbon footprint, whole-farm economics and system resilience. Assessing the cropping system from different angles provides better understanding of real-world cropping systems.

"The indicators of a rotation's success can vary based on the specific goals of the farm," Liu says. "However, productivity, profitability and environmental impact are the three foundational pillars."

Liu says farmers need to balance short-term benefits and long-term sustainability, and to achieve long-term sustainability, farmers need to prioritize soil health.

"A successful rotation should show resilience to biotic and abiotic stresses, ensuring the stability of cropping systems under various growth environments," he says.

The rotation study was conducted at seven sites across Western Canada, including Beaverlodge, Lacombe and Lethbridge in Alberta; Melfort, Scott and Swift Current in Saskatchewan; and Carman in Manitoba. It tested six cropping systems:

- Conventional cropping system: a typical wheat-based rotation in the geographic region.
- Oilseed or pulse crop intensified cropping system: oilseed intensified rotation in the northern Prairies or pulse crop intensified in the southern Prairies.
- Diversified cropping system: diversified the crops included in the rotation.
- Market-driven cropping system: crops selected each year based on commodity prices.
- High risk and potentially high reward cropping system: introduced crops less commonly grown in the geographic region.

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Lead Researcher:

Kui Liu

Kui Liu is a research scientist at Agriculture and Agri-Food Canada's Swift Current Research and Development Centre. As an agronomist, Liu is interested in developing management practices that improve yield, resource use efficiency, environmental sustainability and resilience of cropping systems.

- Soil-health enhanced cropping system: include crops to increase nitrogen fixation and soil organic matter and reduced nitrogen fertilizer.

Liu emphasizes that to ensure a fair evaluation of system performance and provide solid recommendations for the most effective cropping system, it is essential to extend the study over a longer term.

The first rotation cycle in a rotation study is typically considered a transition period. The true effects of rotations may not immediately show up or could be masked by the influence of previous rotation history.

"Certain system indicators, such as soil health, often require more than five years to demonstrate noticeable changes," he says.

More environmental scenarios are needed to determine how stable the cropping systems are under different growing conditions. "With more time we can assess the true cropping system effects," he says.

Based on the first four years of the study, in the Red River Valley region in Manitoba the most effective cropping system (based on a variety of indicators) was a rotation incorporating corn.

"Among all seven study sites across the Prairies, Carman has the best natural resources, such as growing degree days, precipitation and soil fertility, which favours the performance of corn-inclusive cropping systems," Liu says. "Under such favourable growth conditions, the focus can be on maximizing crop yields rather than prioritizing yield stability."

In the southern Prairies (Swift Current and Lethbridge) where water shortage is the main limiting factor, diversified rotations involving pulse crops performed better, since pulse crops can adapt to this semi-arid region.

In northern Prairie regions (Melfort, Lacombe, Beaverlodge) where a short-growing season is the main limiting factor, diversified rotations featuring canola proved to be more successful overall.

It is evident that cropping systems are region specific. There is no single cropping system that can fit all Western Canada. By selecting crops that are best suited to local conditions and have high yield potential, farmers can maximize their success.

"It is very important for farmers to carefully consider the limitations and resources available in their local area when planning crop rotations, ensuring a region-specific approach for optimal results," Liu says.

PHOTO: KUI LIU

ON YOUR FARM

Systems approach to rotations required now more than ever

At the Carman site, the high-risk rotation had the best economic returns based on the results from the first four years of study. There are much smaller risks in this region, even for the high-risk rotations, compared with the other study sites, due to more favourable growing conditions. Coincidentally, the high-risk rotations are also highly diversified at Carman (four different crops in four years).

"If the short-term economic benefits heavily rely on high frequency of canola like the market-driven system at the Melfort or Lacombe sites, this raises concerns regarding disease outbreaks and potential degradation of soil health," Liu says.

This is another reason why a longer-term study is needed to show the benefits and drawbacks of different cropping systems in each region.

"Crop rotation studies provide valuable insights into the specific benefits and interactions of different crop sequences, allowing farmers and agronomists to make informed decisions," says Ashley Ammeter, whole farm specialist with Manitoba Crop Alliance. "The bulk of the interesting results we can really sink our teeth into will be five years from now or even longer."

There are a few findings from the first rotation cycle worth noting. The key factor affecting yield performance is precipitation ***(Figure 1)***.

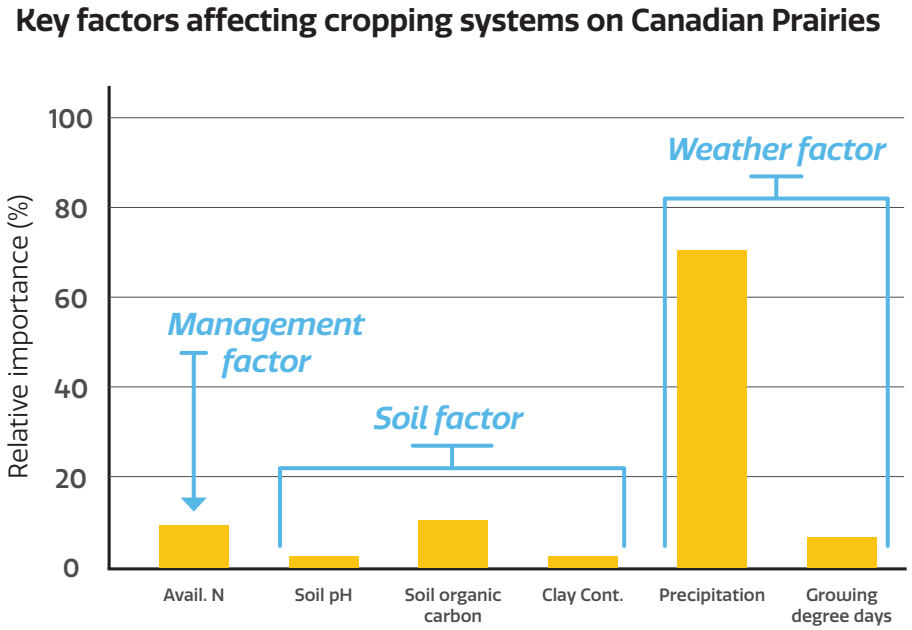
"Due to the difference in precipitation among study sites, there is no single cropping system suitable for all study regions," Liu says. "Site-specific rotation is needed and selecting crops best fitting local conditions is key."

The diversified crop rotation (three or four crops, including pulses) showed good performance overall. "The diversified rotation produced decent yields, economic return and improved nitrogen-use efficiency, as well as lower greenhouse gas (GHG) emissions," Liu says.

The market-driven systems performed better than others in terms of yield and economic returns, which surprised Liu. It's worth noting that these are outcomes from the first four years and results may change over time due to the risks associated with the market-driven system. It is also important to remember that productivity and profitability are only two of several system indicators that should be considered.

"The market-driven system requires higher nitrogen inputs, resulting in lower nitrogen-use efficiency and higher carbon footprint," Liu says. "These results suggest multiple indicators should be considered

▲ *Resilient crop rotation at Melfort, SK, in 2022.*



■ **FIGURE 1** | Precipitation is the most important factor affecting cropping systems. The development of site-specific cropping systems is necessary to optimize overall performance. Future research is needed to develop management practices to mitigate drought effects. *Source: Kui Liu.*

when optimizing cropping systems."

The true cropping system effects need to be addressed and Liu says it is too early to make recommendations for the best cropping systems. "It typically takes two to three rotation cycles to reveal the true effects of a cropping system."

Although precipitation is the key factor affecting cropping systems, it is essential to acknowledge that the performance of these systems is influenced by multiple factors and that the first cycle or experimental period experienced relatively dry weather conditions. "If we had encountered higher levels of rainfall during the study period, the key factors influencing cropping systems might have differed," Liu says.

Cropping systems are an intensively managed agro-ecosystem, featuring lots of complicated interactions. Farmers need more information to maximize ecosystem services and achieve long-term sustainability goals, Liu says.

"This rotation study is unique since we adopt a systems approach," he adds. "We have fully phased rotations at all sites (all crops in rotations are grown in every single year), allowing all crops to be exposed to the same weather conditions. The fully phased study enables us to better understand the resilience at the cropping system level."

In addition to the measurements determined in the first rotation cycle, Liu says they plan to incorporate GHG components, enhance soil health assessment, evaluate system resilience, and explore the complex relationships among soil, crops and weather in the next rotation cycle.

"By conducting a second rotation cycle, we can gain a more accurate understanding of the true effects of different cropping systems, which is essential to be able to recommend optimum cropping systems for each region," he says.

These results will provide science-based knowledge that will enable farmers to optimize their cropping systems.

It's important to acknowledge that cropping systems are dynamic. They are continually evolving to adapt to changing conditions. With support from farmers, researchers can help address the challenges they face in a timely manner.

"Farmers are innovators, and they know how to farm their land better than anyone else," Liu says. "Their support and feedback allow us as researchers to conduct complex, multi-site and multi-year studies and build a multi-disciplinary team to study rotations using a systems approach."

In conclusion, Liu emphasizes that a systems approach to exploring the ecosystem services of cropping systems is required now more than ever, and that cropping systems should be viewed as a long-term investment.

"We recommend farmers balance short-tern economic benefits with long-term sustainability goals when planning crop rotations," he says. ●

MCA INVESTMENT OVER FIVE YEARS: $26,833

CO-FUNDERS:

Alberta Grains · Alberta Pulse Growers · Integrated Crop Agronomy Cluster · SaskCanola · Sask Wheat Development Commission · WGRF Advancing Agriculture through Research

NEW KIDS ON THE BLOCK

Exploring corn and soybean potential in Western Canada

▲ *Field trials north of Brandon, MB.*

Manitoba has seen a significant shift in crops over the last 15 to 20 years. In particular, soybeans have become one of the key crops grown in the province while corn acreage has continued to grow.

Ramona Mohr, a research scientist at Agriculture and Agri-Food Canada's (AAFC) Brandon Research and Development Centre (RDC), has witnessed this shift firsthand during her career and seen the new avenues for research it has necessitated.

"As we began seeing new varieties of soybean and corn developed that were better adapted to Manitoba conditions and as acreage expanded, it led to questions about how best to manage these crops in non-traditional growing areas," she says.

"With better adapted varieties, together with the prospect of a warming climate, the question became: was there potential for expansion of these crops not just in Manitoba, but further west and north into Western Canada? And, if so, how best would these crops fit into existing rotations?"

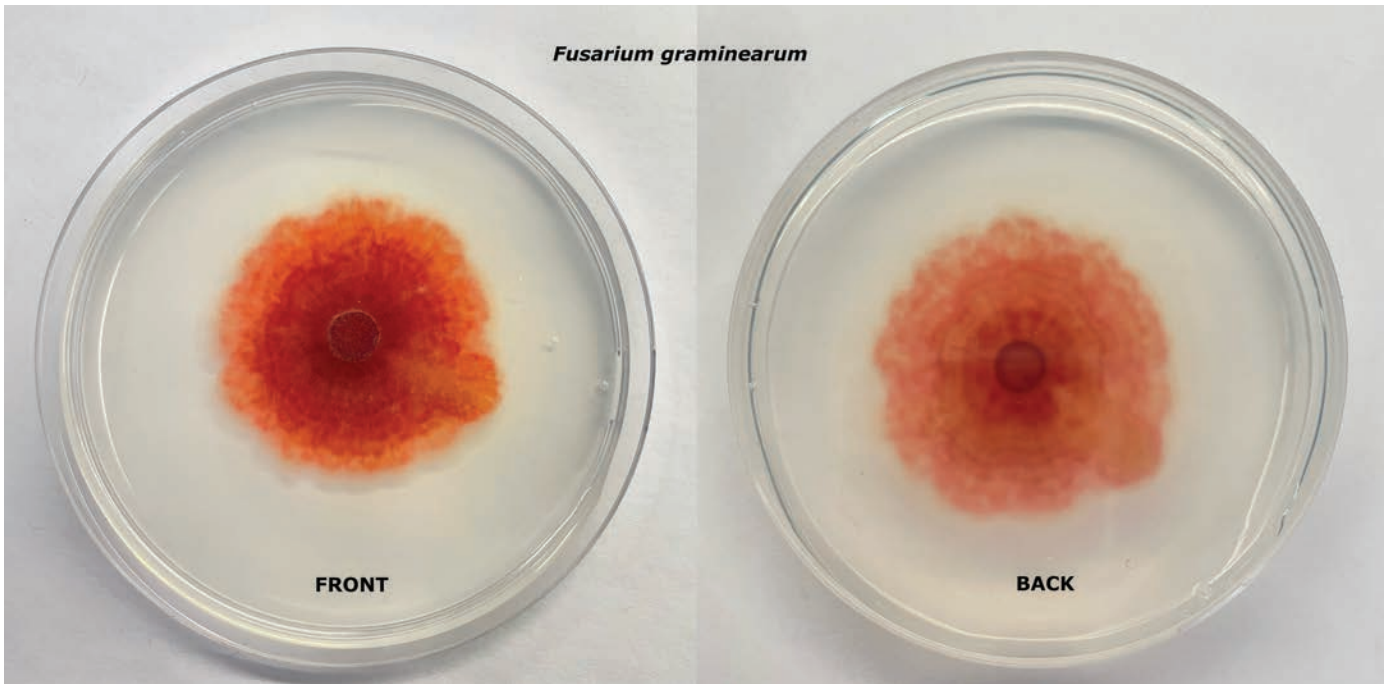
Significant research exists on corn and soybean rotations in the U.S., but little information was available regarding the performance of these crops in rotations in Western Canada.

This was the motivation behind a

Lead Researcher:

Ramona Mohr

Ramona Mohr is a research scientist (agronomy) at Agriculture and Agri-Food Canada's Brandon Research and Development Centre. Since 1998, Mohr has led and collaborated on research focused on developing crop management strategies to support the economic and environmental viability of farming systems in Western Canada.



▲ *Colony of Fusarium graminearum, one of the fungal pathogens causing root rot. This sample was isolated from diseased soybean root tissue.*

PHOTO: AAFC–BRANDON

PHOTOS: YONG MIN KIM, BRANDON RESEARCH AND DEVELOPMENT CENTRE.

five-year study initiated in 2018 and funded under the Integrated Crop Agronomy Cluster (ICAC): Economic and agronomic performance of emerging cropping systems for Western Canada. With continuing support under ICAC, this study is slated to continue for an additional five years through the 2027 growing season.

This study brought together a team of researchers from five AAFC research centres and three western Canadian universities to investigate the effects of a range of crop rotations on yield and quality, disease, weed pressure, soil health, nutrient cycling, mycorrhizal colonization, profitability and economic risk, and to assess the weather-related risks and opportunities of growing corn and soybean in Western Canada.

The rotation study sites were located at AAFC centres at Brandon, Indian Head and Lethbridge, as well as at the University of Saskatchewan in Saskatoon. In 2018, field experiments were set up at the sites to establish the necessary stubble for the rotation study. In 2019, the rotation study began and seven crop rotations were established:

- Wheat-canola
- Soybean-corn
- Soybean-wheat-canola
- Corn-wheat-canola

▲ *Soybean roots with root rot symptoms collected from the Brandon soybean-corn rotation in 2023. Root rot severity is low on the three roots on the left, and higher for the three on the right.*

- Corn-soybean-wheat
- Corn-soybean-canola
- Corn-soybean-wheat-canola

Mohr says they were deliberate when they set out the rotation treatments. "We're not testing rotations that are extreme, we're testing rotations that we think farmers would potentially use."

One of the challenges with rotational studies is they require years, sometimes even decades, to cycle through rotations enough to obtain accurate data. Because effects of crop rotation often accumulate slowly over time, how a rotation performs after one or two rotation cycles will not necessarily reflect its performance in the long term. The fall of 2022 was the first year that all rotations had completed one full cycle. There are some results from this first five-year period, but it is challenging to know how much emphasis should be put on them.

There were a few early trends observed during the first five years of the study that captured the attention of the scientists and will continue to be monitored as the study continues.

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CROP YIELD AND QUALITY

Mohr says they have seen some effects of rotation on yield and quality in select years and sites. To date, there isn't one specific rotation that has consistently outperformed the rest. This is not surprising, she says, as they are just getting these rotations established.

In terms of yield and quality, there aren't any strong trends so far. The researchers are occasionally seeing some differences that they will continue to monitor.

DISEASE INCIDENCE AND SEVERITY

Yong Min Kim at AAFC's Brandon RDC looked at root rot severity over the course of the study (from 2018 to 2022). He did find a trend of lower root rot severity in corn with the three-year rotation (corn-wheat-canola).

In soybeans, he found the same trend of lower root rot severity in the four-year rotation (soybean-wheat-canola-corn) when compared with less diverse rotations.

There seems to be a trend: the more diverse rotations are showing lower root rot severity. The question is whether these trends will continue in the long term.

WEED ABUNDANCE AND COMMUNITY STRUCTURE

Rob Gulden at the University of Manitoba assessed weed communities during the first five years of the study. The composition of the weed community was dependent on the inherent weed community present at each location.

Findings to date show the switch towards corn- and soybean-dominated rotations resulted in a shift in the types of weeds present in the middle of the growing season, with the greatest difference generally observed between the wheat-canola and the corn-soybean rotations.

Gulden and his team will continue to monitor these trends over time.

SOIL FACTORS

One reason researchers were interested in including soybean in the rotation is because it is able to fix its own nitrogen (N). Reducing the need for N fertilizer not only provides economic benefits by reducing input costs, but also environmental benefits. The longer-term effects of growing soybean in rotation on fertilizer N inputs will continue to be monitored over the course of the study.

Effects of rotation on mycorrhizae were also assessed. Mycorrhizae are naturally occurring soil fungi that assist some plants to increase their uptake of phosphorous. The roots of mycorrhizal crops have close associations with the fungi, which act as an extension of the plant root system and allow increased nutrient uptake.

The rotations in the study include wheat, soybean, corn and canola. These crops are all mycorrhizal, except for canola. Terry McGonigle at Brandon University is looking at the impact of canola preceding corn, because the non-mycorrhizal canola can be expected to delay the formation of mycorrhiza in the corn to follow.

To date, canola did reduce mycorrhiza in the corn for some sites in some years. However, at other sites, the mycorrhiza was reduced for all treatments during dry years. It is possible that drought or other soil conditions might override the impact of growing canola before corn for some situations in Western Canada. More data will be collected to explore this effect.

PROFITABILITY AND ECONOMIC RISK

Mohammad Khakbazan at the Brandon RDC conducted economic and risk analysis during the initial phase of the study and will continue these analyses over the next five years.

The longer-term goal will be to use this data together with historic data for Manitoba to develop an economic calculator that will compare different rotation practices with respect to gross revenue, cost, net return, energy balance and carbon footprint. The calculator will allow farmers to input specific data from their own farms to compare with study results and generate information on the relative performance of different rotations.

ON YOUR FARM

Important to understand how rotations perform over more time

WEATHER-RELATED RISK AND OPPORTUNITIES

Weather is an important part of this research. Yield potential, economic returns and production risk are all related to how these crops perform under different environmental conditions.

Mohr says the extremes in weather they saw over the last five years were interesting.

"We had very dry conditions over several years at our Saskatchewan sites, for example, whereas in Manitoba we had some of the best soybean and corn yields we've ever had since growing them as part of our research program."

At the same time as those dry conditions in Saskatchewan, the Manitoba trial site had near- to above-normal growing season rainfall amounts. They also ran into cold fall conditions. In 2019, for example, the corn didn't mature in Saskatchewan and snow and cold weather delayed corn and soybean harvest.

Mohr says that over the first five years of the study, they got a feel for the kind of extreme conditions farmers are dealing with and a closer look at the implications for crops such as corn and soybean that are not generally grown in these regions, especially further west.

"From a research standpoint, we generally like to have perfect conditions for crop growth," she says.

"But in the case of this study, the challenging weather conditions really helped us understand some of the potential risks and benefits of growing soybean and corn in Western Canada, and it allowed us to test these crops in regions where they are not traditionally grown."

From a farmer's perspective, there are a lot of factors to consider when bringing new crops into the mix. If you've not grown these crops before, what seeding or harvest management practices are going to work best under your conditions? How do you fit that new crop into your rotation and how

PHOTO: AAFC-BRANDON

▲ *Field trials north of Brandon, MB.*

does it affect your rotation overall? How does that new crop affect the next crop and vice versa?

These are some of the questions this research is aiming to solve. "If we can understand some of those risks in a research setting, as opposed to a farmer taking them on, and look more holistically at how these rotations perform over time, we can provide that information to farmers," Mohr says.

It's not just a matter of looking at yield and quality, it's also a matter of how rotations impact diseases, weed populations and soil quality.

Rotations are a cornerstone of our cropping systems. Because rotations can affect everything from pest pressure, soil quality and productivity, to economics and the environmental sustainability of our cropping systems, it is important to understand how rotations perform both in the short and long term.

Changes often occur slowly over time. "In rotation studies, we often see changes in the plant-soil system accrue over time, which means that sometimes, the rotations that perform well in the short term may not be the rotations that in the long term are the most productive or sustainable," Mohr says.

She adds this is why it is important this work continues, so they gain a better understanding of how the rotations perform and are confident that the recommendations they generate for farmers are going to be appropriate both in the short and long term. ●

MCA INVESTMENT OVER FIVE YEARS:
$63,040

CO-FUNDERS:

Agriculture and Agri-Food Canada

MANITOBA Pulse Soybean GROWERS

WGRF
Advancing Agriculture through Research

NO SILVER BULLET IN BREEDING

Variety development takes time, but the results speak for themselves

ON YOUR FARM

Continuing to embrace new tools and technology in breeding

Think about the spring when you plant your crop. After you plant those seeds, a lot is left to chance. Whether it's drought, excessive moisture or pressure from disease, the growing season is unpredictable.

In order for plants to thrive in various climates and fend off disease, seeds need strong genetics. From the crosses a breeder makes today, it will take at least 10 years before a variety reaches a farmer's field. Continuous variety development is critical to ensure that farmers have access to varieties that respond to the challenges they will be facing in the next 10 to 20 years.

Since 1995, farmers, including members of Manitoba Crop Alliance (MCA), have funded 46 per cent of wheat breeding research and development in Western Canada. In this time, varieties have come a long way.

In 2003, one of the widely grown varieties of spring wheat was AC Barrie. This variety was a big improvement in its time. It had an intermediate level of resistance to Fusarium head blight (FHB) and was grown on many acres for many years in Western Canada.

As breeding responded to FHB and other challenges on the Prairies at the time, Carberry was released with moderate resistance for FHB. It was a little bit shorter in height, stronger strawed and higher yielding.

Then AAC Brandon ***(Table 1)*** was recommended for registration in 2012, with seed becoming available in 2015. It had moderate resistance to FHB with higher productivity. Richard Cuthbert, a wheat breeder at Agriculture and Agri-Food Canada's (AAFC) Swift Current Research and Development Centre (RDC) recalls seeing AAC Brandon being five to eight per cent higher yielding than Carberry, and Carberry had already been much higher yielding than AC Barrie.

"Last year I was talking with a seed company manager whose comment was breeding is magic. You do the same, and you get more," he says.

"I've thought about that a lot. A farmer does the same work in the field, but they are able to produce much more. Yes, we took 10 to 20 years or a couple of breeding cycles to get here, but we can see the fruits of that labour – it's tangible."

Although breeding might feel like magic, Cuthbert says the perfect variety remains elusive. Every variety has its drawbacks.

"Often, varieties have something we're trying to improve upon," he says. "An issue with AAC Brandon, for example, has been sprouting, and with Carberry, some farmers may have said that it threshed too easily and could shatter a bit."

Some of the new spring wheat varieties that are coming out of the Swift Current breeding program are being supported for entry into the Canada Western Red Spring (CWRS) market class. The commercialization partners have projected commercial availability over the next three to five years.

BW5089 ***(Table 2)*** is a high-yielding, awned, semidwarf variety. Grain yield is five per cent higher than AAC Brandon with similar protein. It is a short-stature plant type (similar to AAC Viewfield) with stronger straw. This variety has resistance to all priority-one diseases (FHB; leaf, stem and stripe rusts; common bunt) as well as loose smut. It also shows improvements in protein content, milling yield and gluten strength.

BW5090 is a high-yielding, awned, semidwarf variety. Grain yield is six per cent higher than AAC Brandon with 0.3 per cent less protein. It is also a short-stature plant type (similar to AAC Viewfield) with stronger straw. This variety has resistance to all priority-one diseases, as well as loose smut. It shows low deoxynivalenol (DON) accumulation in the grain harvested from FHB nurseries and features improvements to grain quality traits important to international markets.

BW5095 is a high-yielding, awned, semidwarf variety. Grain yield is nine per cent higher than AAC Brandon with a similar plant type and larger kernel weight. This variety possesses the Sm1 gene, making it tolerant to orange wheat blossom midge. It also has resistance to all priority-one diseases, as well as loose smut, and features improvements to grain quality traits important to international markets.

Varieties like AAC Brandon have had a wide uptake across the Prairies, as they've been able to respond well in good years and maintain yields during heat and drought stress.

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Lead Researchers:

Curt McCartney and Richard Cuthbert

In 2020, Curt McCartney joined the Department of Plant Science at the University of Manitoba as an associate professor in cereal crop breeding and genetics. McCartney's program will address production issues important to Manitoba farmers, such as Fusarium head blight, lodging resistance and grain yield.

In 2011, Richard Cuthbert joined the wheat breeding team at the Swift Current Research and Development Centre. Cuthbert's research and breeding focuses on developing field-ready varieties that reduce business risk for Canadian farmers and the wheat industry. Since 2011, the Swift Current wheat breeding team has released and commercialized 26 bread wheat varieties with many seeded to about 80 per cent of the insured CWRS acreage in Western Canada.

◀ *Photo taken August 2022 at the Indian Head Research Farm, Seed Increase Unit of AAFC. Pictured are the pre-breeder rows that are grown to combine into the breeder seed, which is provided to the licensing seed company and seed growers to start the variety commercially.*

PHOTO: RICHARD CUTHBERT

"When challenges like FHB are present in a year like 2016, for example, these varieties performed very well across a range of environments," Cuthbert says.

In terms of winter wheat, CDC Falcon ***(Table 3)*** was the top variety in Manitoba in 2013. It was moved from the Canada Western Red Winter (CWRW) class to the Canada Western General Purpose (CWGP) class the following year due to low protein.

Since CDC Falcon, there has been a 15 to 20 per cent yield gain in varieties like AAC Wildfire and AAC Coldfront, both recently released from AAFC's Lethbridge RDC. AAC Wildfire is now the predominant variety across the Prairies, including in Manitoba.

A notable trait of the recent winter wheat varieties from the Lethbridge RDC is improved winter hardiness when compared to previous varieties.

Curt McCartney, associate professor at the University of Manitoba, says resistance to the rust diseases and FHB has also improved among winter wheat varieties. CDC Falcon was susceptible to FHB, whereas almost all the new varieties are either rated moderately resistant or intermediate resistant to FHB.

"The total winter wheat package is better now than it was before through improved winter hardiness, resistance to diseases, as well as yield advantages," he says.

Two winter wheat varieties McCartney says farmers in Manitoba should be watching for are AAC Coldfront and AAC Vortex ***(Table 4)***.

AAC Coldfront is eight to 15 per cent higher yielding than CDC Bueto, Emerson, Moats and AAC Elevate, with comparable protein. It is short to moderate in height with excellent lodging resistance, medium to late maturity and good winter survival. It is resistant to stem, leaf and stripe rust, has intermediate resistance to FHB and is susceptible to common bunt.

AAC Vortex is seven per cent higher yielding than CDC Bueto and 10 per cent higher yielding than Emerson, with higher protein than all checks (except Emerson). It has medium maturity and height, and its winter survival and lodging resistance are equal to the best checks. It is resistant to stem, leaf and strip rust, moderately resistant to FHB and susceptible to common bunt.

"In general, the FHB resistance, as well as the leaf and stem rust resistances, have improved," McCartney says. "These are the top-three diseases Manitoba farmers are facing."

Newer varieties are combining more beneficial traits together than in the past. "Ten or 20 years ago you'd have improvements in one trait, but there'd still be some other issues," he says. "Now, a lot of the beneficial traits have been brought together."

McCartney says there is a general yield gain across the board in all wheat classes

Spring Wheat (CWRS)

VARIETY		CARBERRY	AAC BRANDON
		Top variety 2013*	*Top variety* 2023*
Year of commercial release		2012	2015
Yield (bu/ac)		70	74
Protein (%)		14.7	14.4
Maturity (days)		101	101
Height (cm)		81	81
Resistance Level	Lodging	Very Good	Very Good
	Sprouting	Fair	Poor
	Loose Smut	Moderately Resistant	Moderately Resistant
	Common Bunt	Resistant	Susceptible
	Leaf Spots	Moderately Susceptible	Intermediate
	Stem Rust	Moderately Resistant	Resistant
	Leaf Rust	Resistant	Resistant
	Stripe Rust	Moderately Resistant	Moderately Resistant
	FHB	Moderately Resistant	Moderately Resistant

TABLE 1 | Carberry was the top variety in 2013, and AAC Brandon was available in 2015 and was the top variety in 2023. **Top variety by acres, Manitoba Agricultural Services Corporation (MASC). Sources: Data from Manitoba Crop Variety Evaluation Trials (MCVET)/2024 edition of Seed Manitoba.*

VARIETY		BW5089	BW5090 *(AAC Westking)*	BW5095
Yield (bu/ac)		75	78	80
Protein (%)		14.3	14.0	13.5
Maturity (days)		101	101	102
Height (cm)		79	78	83
Resistance Level	Lodging	Very Good	Very Good	Good
	Sprouting	-	-	-
	Loose Smut	-	-	-
	Common Bunt	Moderately Resistant	Resistant	Moderately Resistant
	Leaf Spots	-	-	-
	Stem Rust	Moderately Resistant	Moderately Resistant	Resistant
	Leaf Rust	Resistant	Resistant	Resistant
	Stripe Rust	Intermediate	Intermediate	Intermediate
	FHB	Moderately Resistant	Moderately Resistant	Moderately Resistant

TABLE 2 | Some of the new spring wheat varieties coming out of the Swift Current breeding program. The commercialization partners have projected commercial availability over the next three to five years . *Source: Data from Manitoba Crop Variety Evaluation Trials (MCVET)/2024 edition of Seed Manitoba.*

Winter Wheat

VARIETY		CDC FALCON[1]	AAC WILDFIRE
		Top variety 2013*	*Top variety* 2023*
Year of commercial release		2000	2018
Yield (bu/ac)		79	89
Protein (%)		11.8	11.7
Height (cm)		75	85
Relative Maturity		Early	Late
Relative Winter Hardiness		Fair	Very Good
Resistance Level	Lodging	Very Good	Good
	Common Bunt	Susceptible	Moderately Resistant
	Stem Rust	Moderately Resistant	Susceptible
	Leaf Rust	Moderately Resistant	Intermediate
	Stripe Rust	Susceptible	Resistant
	FHB	Susceptible	Moderately Resistant

TABLE 3 | CDC Falcon was the top winter wheat variety in 2013, while AAC Wildfire was the top variety in 2023 *[1]CDC Falcon moved from Canada Western Red Winter (CWRW) class to Canada Western Special Purpose (CWSP) class in 2014. *Top variety by acres, Manitoba Agricultural Services Corporation (MASC). Sources: Data from Manitoba Crop Variety Evaluation Trials (MCVET)/2024 edition of Seed Manitoba.*

VARIETY		AAC COLDFRONT	AAC VORTEX
Yield (bu/ac)		92	87
Protein (%)		11.8	12.3
Height (cm)		82	83
Relative Maturity		Medium	Medium
Relative Winter Hardiness		Very Good	Very Good
Resistance Level	Lodging	Very Good	Very Good
	Common Bunt	Susceptible	Susceptible
	Stem Rust	Resistant	Resistant
	Leaf Rust	Resistant	Resistant
	Stripe Rust	Resistant	Resistant
	FHB	Intermediate	Moderately Resistant

TABLE 4 | Two varieties recently released from AAFC's Lethbridge RDC. *Source: Data from Manitoba Crop Variety Evaluation Trials (MCVET)/2024 edition of Seed Manitoba.*

(Figure 1). Because of farmer-member investments, the yield potential for CWRS wheat varieties grew almost 20 per cent from 2004-2021.

Wheat breeding has made significant advancements as breeders adapt modern genetics and genomics tools to supplement traditional breeding techniques.

"We typically have thousands to over 10,000 lines in the program. With modern DNA fingerprinting methods, we can look at every line and get a very good idea of the genetic makeup of that line and the parental lines," Cuthbert says. "Then we use statistical models, paired with the data we collect in the field on grain yield and protein, disease resistance traits and end-use quality traits, to predict the lines that will be improvements and the lines that will be very poor."

This helps discard the lines that are unlikely to represent improvements to those traits of interest, allowing them to make better use of field resources. "The genotyping (DNA analysis) of each line is $20 to $30 and growing a yield plot in the field is about $50 per plot and often an experimental line is grown in many plots at many locations," Cuthbert says. "It's a no brainer."

In Brandon, they are using DNA markers to select for genes of interest and looking into using markers for genomic selection. Genomic selection pairs DNA markers covering the entire genome with information from the field or lab to predict which plants have the highest chance of carrying traits of interest, such as improved grain yield, protein content, FHB resistance, winter hardiness, etc. Similar to Swift Current, this will enable them to only evaluate the lines with the most potential in replicated yield nurseries.

Last summer, they started looking at drones and using multispectral and LiDAR cameras to collect trait data. These cameras are flown over breeding plots and take photographs to collect data that in the past would have been collected by walking individual plots and recording with a pencil and paper.

A graduate student in the program flew a drone with a LiDAR camera, which shoots a laser from the drone down to the plots. When the laser hits the foliage, it bounces back up to the camera and measures the time it takes. This is how they measure plant height.

A trait of focus moving forward for winter wheat is winter hardiness. It is a tough trait to accurately measure – the only way is to repeatedly test breeding lines in field trials. With modern agriculture tools such as drones and digital image analysis, there are opportunities to collect more accurate data to assesses winter hardiness and select better varieties.

When McCartney joined the University of Manitoba in 2020, his vision was to shift the focus of the breeding program

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Mean grain yield — Western Bread Wheat Cooperative tests 1979–2022

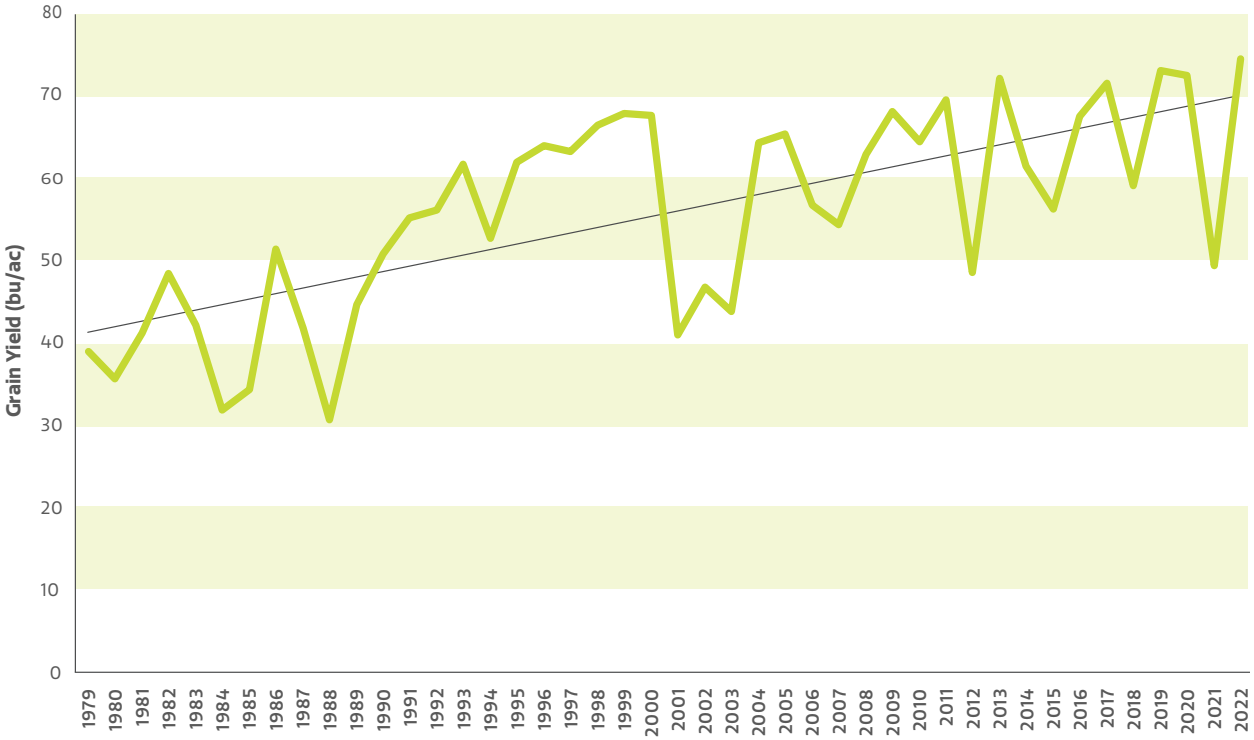

FIGURE 1 | Average red spring wheat yields, 1979 to 2022, based on plot trials across Western Canada performed to test varieties prior to registration. Data includes varieties that reached commercialization and those that did not. Lower yields in the early 2000s are due to drought and the incorporation of genetics that provided FHB resistance but negatively impacted yield. In recent years, researchers noted that even in poor years, such as the severe drought faced in 2021, yields are improved. A yield increase of 1.3 per cent per year has been observed, with 2022 being the highest yielding year to date. *Source: Richard Cuthbert, Swift Current RDC.*

to milling-class varieties. With the signing of the previous core agreement, they were able to add grain quality testing to the program.

Monica Malalgoda of the University of Manitoba's Department of Food and Human Nutritional Sciences performs quality testing on the breeding program's material. McCartney says this collaboration has really changed the program and is playing a huge role in its future success.

"The lines we are entering now into registration trials have a real shot at becoming varieties because they have the grain quality that's needed for the milling class," he says. "Now it's the assessment over different trial locations across the Prairies and repeated testing to make sure they have the grain yield needed as well."

Both breeding programs are embracing new tools and technology, with the hopes of capturing data faster and more accurately.

Breeding is an expensive and long-term endeavour, and core funding is critical. Breeders need to make crosses and perform DNA analysis, as well as test their lines in disease nurseries and yield plots across a wide range of environments.

"AAC Brandon, AAC Wheatland, AAC Starbuck, BW5090 and BW5095: all these varieties have come from core funding," Cuthbert says. "That work has been done over the last 20 to 30 years."

Looking forward, he says, we need to maintain tools like these and continue to incorporate new tools like genomic selection. "There is no silver bullet in breeding. A range of approaches based on the objectives are needed."

These varieties (among others) have come from various projects within the Canadian National Wheat Cluster, which ran from 2018 to 2023. The next Canadian National Wheat Cluster will run from 2023 to 2028. For more information, visit wheatresearch.ca.

MCA INVESTMENT OVER FIVE YEARS:
$1,032,533

CO-FUNDERS:

Agriculture and Agri-Food Canada

Alberta Grains

CWRC Canadian Wheat Research Coalition

SaskBarley Development Commission

WGRF Advancing Agriculture through Research

DOWN BUT NOT OUT

Acres are down, but research is underway to make flax more resilient and profitable for farmers

In Manitoba, flax is grown mainly for human consumption and oil production, but it is also used in livestock feed and industrial applications. Flax is shallow rooted, leaving moisture at greater depths for following crops. It has low insect pressure and low disease pressure, aside from pasmo, a flax-specific disease.

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Flaxseed is a versatile ingredient high in omega-3 fatty acids, fibre and lignans. These components act as antioxidants and are not commonly found in many foods, providing several health benefits.

In addition to its numerous health benefits and its role as a valuable oilseed in a crop rotation, flax is an important crop to the Canadian economy. In Manitoba, farmers plant an average of 66,252 acres of flax each year, and the crop is valued at $28,457,932 (reference the flax crop profile available at **mbcropalliance.ca** for more statistics).

This year, flax acres fell nearly 40 per cent in Manitoba compared with the previous year, according to Manitoba Agricultural Services Corporation (MASC). The decline could be linked to a few explanations: the lack of genetic improvements to address yield, disease management, pest management or heat stress tolerance; slow progress on varietal improvements; and limited research into the effectiveness of different treatments or flax straw utilization.

This lack of advancements means flax is being left behind. Recognizing the importance of flax for Manitoba farmers, Manitoba Crop Alliance (MCA) has heavily invested in research projects aiming to improve the crop and make it more resilient for farmers.

Bunyamin Tar'an is a professor at the University of Saskatchewan and

the Ministry of Agriculture Strategic Research Program chair in chickpea and flax breeding and genetics. He leads the flax breeding program at the university, Canada's only remaining public flax breeding program.

In various written reports, he suggests Canadian seeded area and production of flax is expected to increase during the coming decades, not only due to the collective interest in the health benefits of omega-3 fatty acids for human and animal consumption, but also the demand for industry oil uses.

"The growth in flax production will depend on the availability of varieties with high yield potential, improved weed management options, improved disease resistance and tolerance to abiotic stresses, all with acceptable seed nutritional quality," Tar'an says.

Work is currently underway to develop methods for fast, efficient and accurate breeding. The goal moving forward is to focus on agronomic traits to improve flax's ability to compete in current environmental conditions. MCA provides funding to the breeding program and has invested in several projects led by Tar'an.

The goal of the *Accelerated Breeding Strategy for Flax Improvement* project is to improve the breeding program's capacity to develop varieties in a timely and responsive manner.

Tar'an and fellow researchers are studying the optimal conditions required for accelerated flax growth for seed production and reduced germination time. They are evaluating and implementing tools like speed breeding to generate pre-registration lines through marker-assisted selection and selecting based on phenotypes (i.e., a plant's observable traits).

Another project led by Tar'an, *Integrated approaches for genetic improvement of flax*, is looking at developing the genetic background and breeding lines with tolerance to different mode of action herbicides, improved heat stress tolerance and lower seed cadmium content, while maintaining the seed quality important for food uses.

This project is also looking at high-yielding properties adapted to Canadian growing conditions, with improved resistance to pasmo disease. Pasmo is the primary disease of concern in flax and is quite prevalent, mainly in wet years. Researchers are doing this through accelerated plant growth and genome selection. The team is working to develop and integrate a genomic selection protocol to increase the rate of performance improvement achieved through breeding in flax..

"Future varieties will be more resilient to adverse climatic conditions, such as high temperature, and will make flax more competitive with other commodities in Canadian agriculture," Tar'an says.

MCA funds the annual Flax Co-op trials, where the objective is to expand and evaluate the pre-registration co-op variety trials in conjunction with the post-registration Manitoba Crop Variety Evaluation Trials (MCVET) for flax. These trials test the suitability of varieties pre-registration to Manitoba conditions and help breeders choose which varieties they would like to put forward for registration.

In addition to breeding and variety trials, and recognizing that little information was available about the efficacy of currently registered seed treatments in flax in Manitoba, MCA initiated research trials with the Manitoba Agriculture Diversification Centres.

These trials are designed to test the effectiveness of seed treatments against soil borne diseases in brown and yellow flax types, and evaluate the relationship between seed treatment, germination, emergence and yield.

"Flax is an important production choice for farmers, and while acres have taken a decline, we are committed to working with researchers and organizations to do the research to make the advancements in order to make flax a viable competitor in rotations," says Madison Kostal, research program manager for special crops at MCA.

Another area MCA's flax crop committee has identified as a major research priority is flax straw utilization. Flax straw is incredibly tough and difficult to manage and seed into if left on the field, but there is little to no industry for selling this byproduct. Many farmers end up burning the straw to get rid of it, which can impact soil health and the environment..

Another opportunity has been utilizing flax straw for other industries. For example, Prairie Clean Energy in Regina, SK, has begun to create pellets to be burned as a fuel source like coal. The issue with this can sometimes be supply chain or transportation. Bales are bulky and cumbersome to transport, and with a lower sale value, it can't always be justified for farmers to transport them long distances to the plant.

MCA has also seen some of these ventures start out with good intentions but fail to thrive due to a lack of consideration of the farmer side of supply. Recently, MCA has had some interactions and participated in the creation of projects for flax straw utilization.

"We are engaging with researchers who are beginning to look into flax straw utilization and develop a potential new use for this bioproduct," Kostal says. "We are excited to be able to participate in the conception of these products to help ensure that this industry works for everyone."

Flax farmers have had to overcome quite a few hurdles to continue to produce this crop. Despite this, there are many farmers who see the benefits of continuing to include this crop in their rotations. With the key investments MCA has made over the last couple years, many of these issues should begin to improve and make flax a strong choice for farmers in their rotations.

For more information on flax research or other MCA funded research, visit mbcropalliance.ca/research.

MCA TOTAL INVESTMENT:
$92,329

LIFETIME VALUE:
$527,920

CO-FUNDERS:

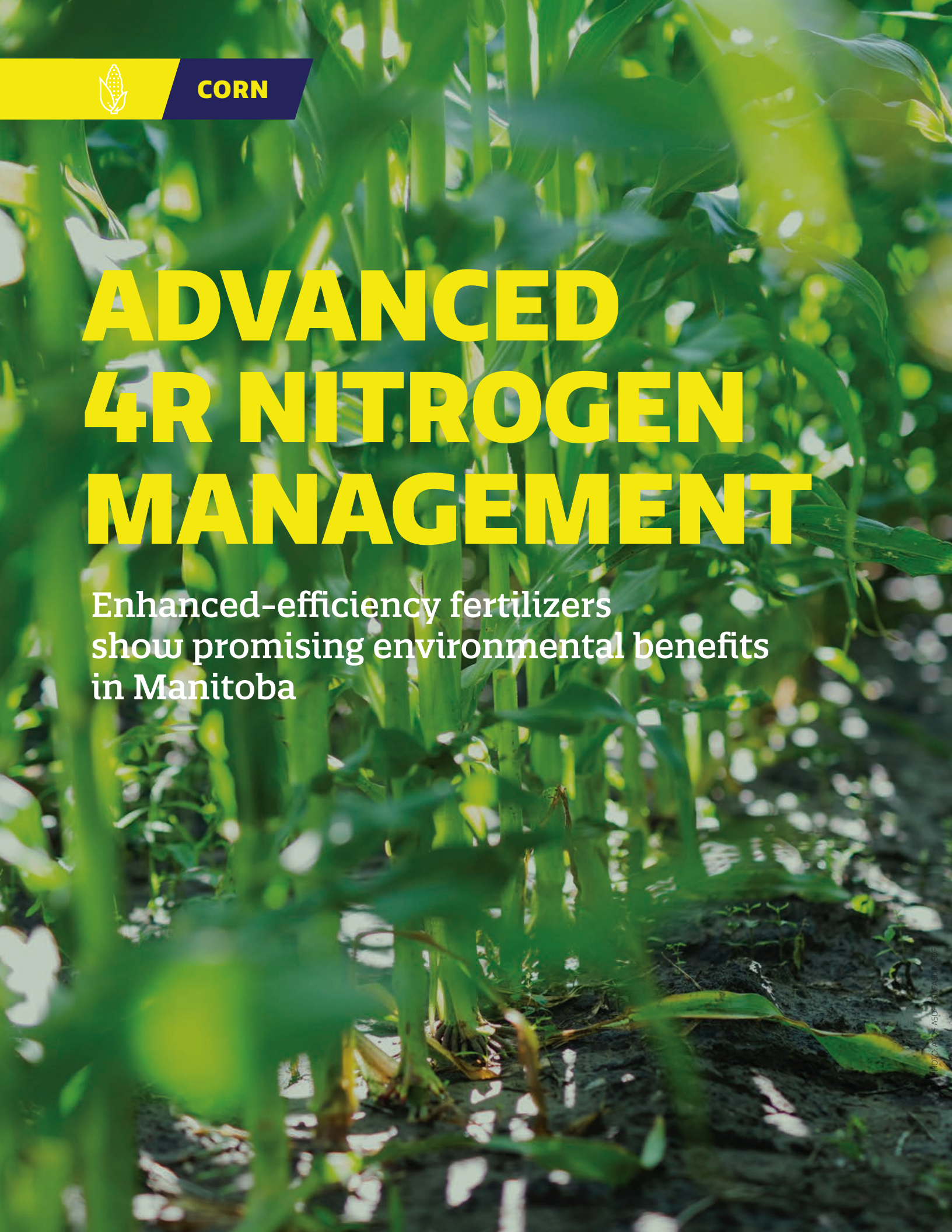
SaskFlax

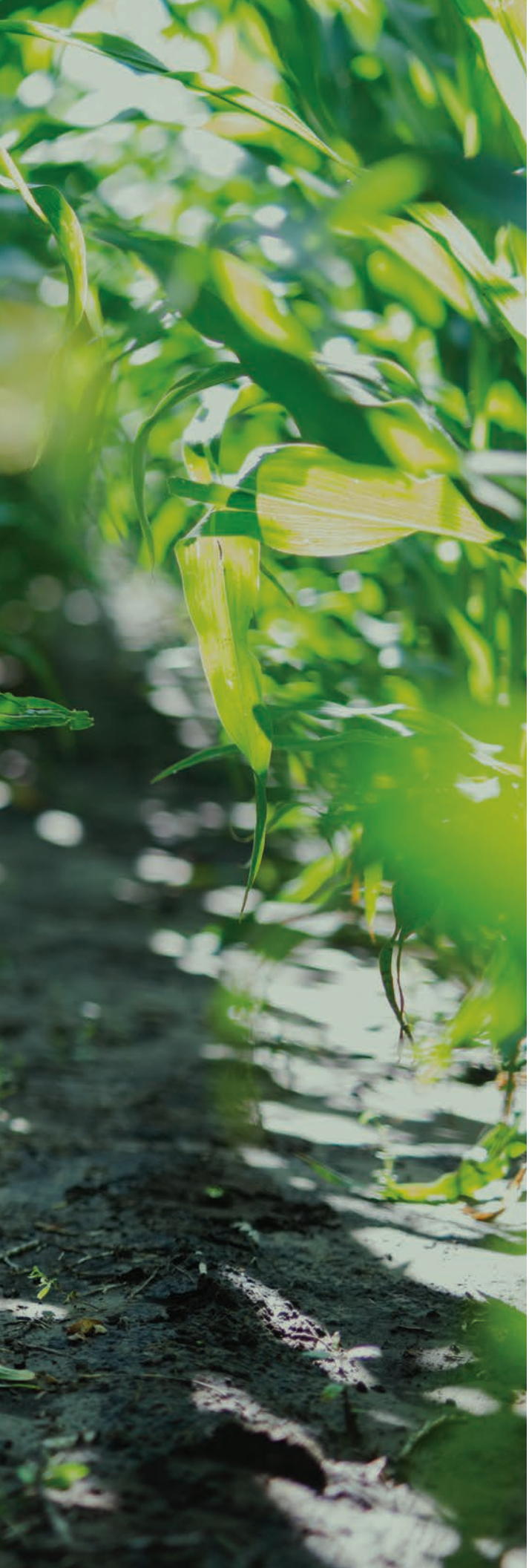
WGRF
Advancing Agriculture through Research

CORN

ADVANCED 4R NITROGEN MANAGEMENT

Enhanced-efficiency fertilizers show promising environmental benefits in Manitoba





Nitrogen management under 4R principles involves using the right source of nitrogen, at the right rate, at the right time and in the right place. Advanced 4R nitrogen management goes beyond the basic principles of 4R and uses advanced technologies, techniques and tools to further improve nitrogen management.

A project led by Mario Tenuta and funded under the Canadian Field Crop Research Alliance (CFCRA) examined the performance of different nitrogen management strategies in grain corn from both an agronomic and environmental perspective.

The research began in 2018 and was conducted across sites in Quebec, Ontario and Manitoba for three years. Four enhanced-efficiency fertilizers (EEFs) ***(Figure 1)***, including ESN, SuperU, Agrotain and Agrotain Plus were compared to urea fertilizer or liquid urea ammonium nitrate (UAN) fertilizer. The study also looked at two different nitrogen application timings: application at planting and split application (applying some at planting and some in season at the four- to six-leaf stage).

They found no yield difference when nitrogen was applied only at planting versus split applied, but with split applications they saw a reduction in nitrous oxide emissions.

Delaying split nitrogen applications after V4 did not improve corn yields in Manitoba compared to earlier split nitrogen applications. Ontario and Quebec, however, did see a more positive response to nitrogen application from V8 to V12, likely due to regional differences in climate.

continues on next page ▶

Lead Researcher:

Mario Tenuta

Mario Tenuta is the Industrial Research Chair in 4R Nutrient Stewardship and professor of applied soil ecology at the University of Manitoba. His training includes a B.Sc. in botany and physical geography, an M.Sc. in soil science, a PhD in plant sciences and post-doctoral research in nematology.

◀ *While there was a very small increase in yield, the use of enhanced-efficiency fertilizers made a significant reduction in nitrous oxide losses.*

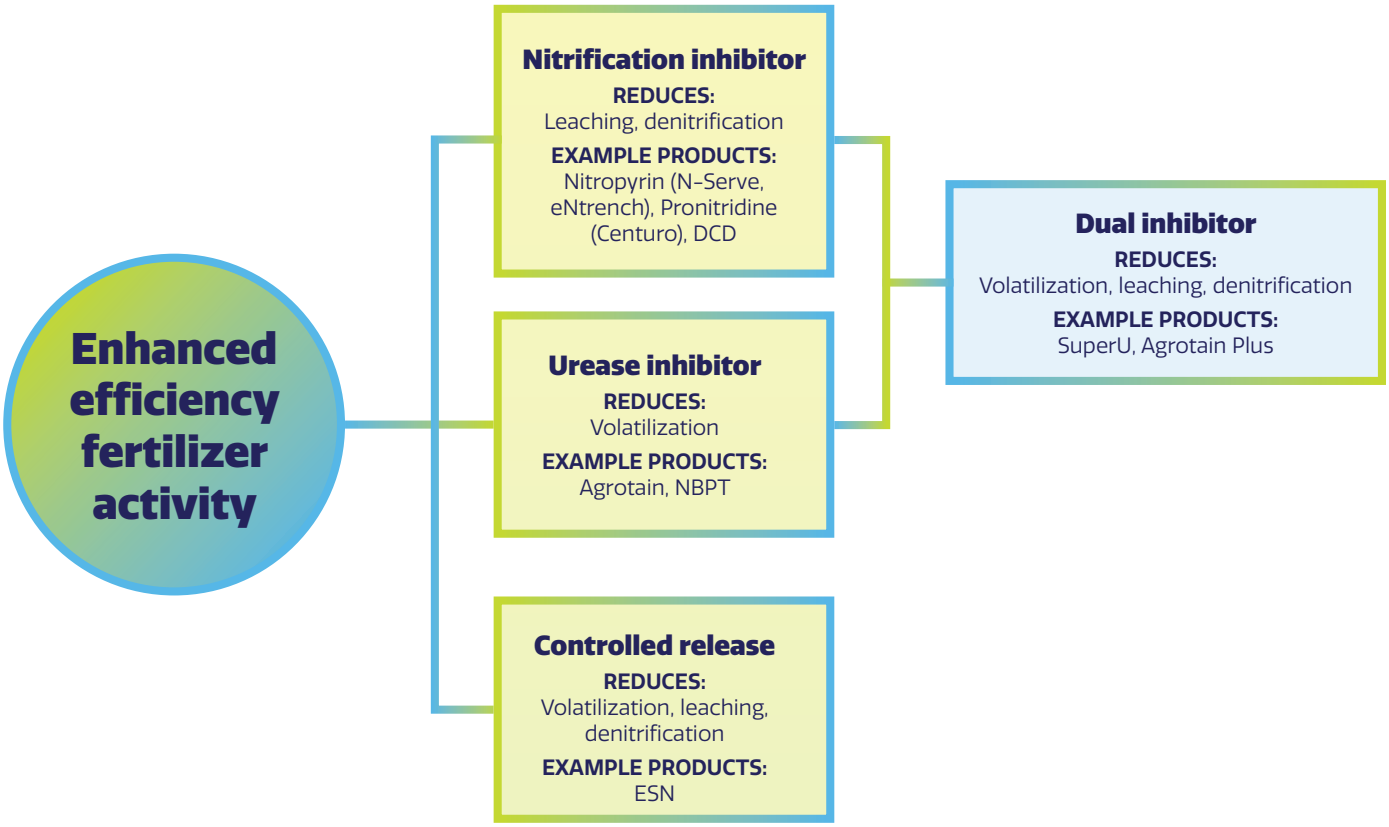


FIGURE 1 | Enhanced-efficiency fertilizer types.

In addition to split applications, the researchers also studied the impact of EEFs on yield. Overall, they found there was a one to two per cent yield increase with EEF use, including controlled release products like ESN, SuperU and, for split applications, Agrotain and Agrotain Plus.

Tenuta says the yield results in Manitoba are fairly typical for 4R projects. "We don't see 15-20 per cent yield increases. Typically, we see more in the zero to five per cent range. Yield differences are subtle."

It is important to note that the research was conducted over a dry number of years and Tenuta says yields were moisture limited. He explains that in terms of yield benefits, it's a bit challenging, but on the environmental side, there are obvious benefits to the 4R practices examined.

"Inhibitors reduce emissions. For example, if we used inhibitors with the UAN dribbled on the surface, the Agrotain reduced the ammonia loss (via volatilization) and the Agrotain Plus reduced nitrous oxide emission losses (via denitrification)," Tenuta says ***(Figure 2)***.

For nitrous oxide, he thinks if they had had more moisture, they would have seen greater differences between the inhibitor practices and controlled release products, as well as greater nitrous oxide reduction for the split application.

"You're producing more nitrous oxide under wetter conditions. Therefore, you have more opportunity to reduce the emissions with better practices," he says. "The practices that improve the nitrogen availability likely would have yielded more."

While there was a very small increase in yield, the use of EEFs made a significant reduction in nitrous oxide losses. From an environmental standpoint, the emission reductions can be significant.

In Canada, there is a commitment to reduce emissions by 30 per cent from soils. These findings are quite promising to support that commitment.

"We know farmers are sometimes concerned that practices that will reduce emissions will reduce yield, but that's not the case," Tenuta says. "It's really optimistic we're able to achieve the reduction in greenhouse gases (nitrous oxide), and we're able to do that without losing yield."

The results for nitrous oxide emissions are better for Manitoba than Ontario and Quebec. Likely due to wetter growing season conditions in Eastern Canada, the reduction in nitrous oxide emissions was less significant and less consistent from year to year when compared with Manitoba. Tenuta thinks it comes down to the amount of rainfall that occurs, particularly in June.

"If we delay our nitrogen into the growing season, the soil is generally drier and we see less nitrous oxide emissions than at springtime planting," he says.

As a part of the project, the researchers utilized drones and hand sensors to analyze the corn canopy

in trial sites on farmers' fields. They specifically examined the greenness and health of the canopy using two indices: Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge, or red edge for short.

"These analyses can tell us if the canopy of the crop is nitrogen starved or not," Tenuta explains. "We were able to fly the drone at varying times, such as before and after addition of the split nitrogen application. We found we can easily spot our treatments and how much nitrogen we added in based on the canopy."

Based on data collected over this study, the team has been able to develop an algorithm that can be used to predict how much nitrogen needs to be added to corn for an in-season application.

Tenuta says they need to develop this idea of canopy sensing further as a tool, as it holds a lot of promise for directing farmers' nitrogen applications.

One thing Tenuta says is missing from the study is manipulation of nitrogen management based on how the crop is growing and varying the rate of the split application. For farmers, that's one thing that a split application can do: they can adjust their nitrogen rate depending on how the season has gone. This is something the researchers want to look at in the future.

For grain corn production in Manitoba, Tenuta and his team have been analyzing the data from the study to determine what it takes to recover costs of the inhibitor and controlled release products.

He says a farmer needs to pull off an extra three or four bushels of grain corn to pay for the products. "If you are not confident you will get the yield increase, another option is to take advantage of some of the programs available," he adds.

The On Farm Climate Action Fund (OFCAF) program delivers non-repayable, cost-shared funding of up to $75,000 per farmer over two years. "A farmer wouldn't really notice a drop in profits if their yields didn't increase and they tapped into the programs out there," Tenuta says.

The other thing Tenuta and fellow researchers involved in the project are asking farmers to think about is with less nitrogen loss in the form of ammonia and nitrous oxide with these products, can you consider reducing your nitrogen rates?

"Consider reducing your nitrogen (rate) to offset the cost difference of these products," he says. "We're losing less nitrogen, so the expectation is that the same amount of nitrogen is available to the crop."

Farmers interested in testing out EEFs or split nitrogen application on their farms can consider doing a test to compare the effects on their farm. "Try performing your own trial based on our past Research on the Farm protocols looking at various nitrogen practices or get in touch to participate in a future Research on the Farm trial," says Ashley Ammeter, whole farm specialist at Manitoba Crop Alliance (MCA). ●

For more information about this project and other MCA-funded research, visit mbcropalliance.ca.

FIGURE 2 | Nitrogen Loss Risk Factors.

VOLATILIZATION RISK FACTORS[1]	DENITRIFICATION RISK FACTORS[2]	LEACHING RISK FACTORS[2]
Surface broadcast application	Surface broadcast application	Surface broadcast application
N source (urea greatest risk, UAN lower risk)	N source (forms containing N in nitrate form are higher risk)	N source (forms containing N in nitrate form are higher risk)
Coarse/sandy soil textures	Fine/clay soil textures	Coarse/sandy soil textures
Moist soil, followed by rapid drying	Low soil oxygen (moist/ saturated soil, very compacted soil)	Heavy rain or snowmelt
Warm soil temperature	Warm soil temperature (particularly fall application of N to warm soil)	Warm soil temperature (particularly fall application of N to warm soil)
Windy conditions		
High soil pH (>7.5)		
High lime (carbonate) content at soil surface		
Low organic matter content in soil		
High amounts of crop residue on surface		

[1]Adapted from: https://www.gov.mb.ca/agriculture/crops/seasonal-reports/pubs/volatilization-surface-applied-urea.pdf
[2]Adapted from: https://www.gov.mb.ca/agriculture/crops/soil-fertility/wet-soils-influence-soil-fertility.html

MCA INVESTMENT OVER FIVE YEARS:
$448,362

CO-FUNDERS:

Agriculture and Agri-Food Canada

CFCRA Canadian Field Crop Research Alliance | ARCCC Alliance de recherche sur les cultures commerciales du Canada

Grain Farmers of Ontario

MANITOBA CROP ALLIANCE

MCA RESEARCH
by the numbers

114 **Active research projects** *(as of July 31, 2023)*

76	30	2	4	2
Barley & Wheat	Whole Farm	Flax	Corn	Sunflower

Lifetime value of 114 current projects:
$128,914,822
Total MCA contribution:
$11,446,006

50+ active partners to co-fund research

54 In 2022–23, MCA contributed ***54 per cent*** of annual expenses to research and production.

MCA leveraging rate in 2022–2023:

For every farmer member → **$1**

MCA leveraged to → **$11**

MCA total investment in research and production in **2022–23** fiscal year:
$3,317,180

Research and production budget for **2023–24** fiscal year:
$5,304,841

Since 2020, a total of

220

ROTF trial locations have been planted covering wheat, barley, sunflower, corn and flax.

2023 Research on the Farm

- 11 protocols
- 3 Barley, 5 Wheat, 1 Corn, 1 Sunflower, 1 Flax
- 65 trial locations

Scientific Research & Experimental Development (SR&ED) Tax Credit

Farmer members who contributed check-off dollars to Manitoba Crop Alliance (MCA) ***are eligible to claim a federal tax*** through the Scientific Research and Experimental Development (SR&ED) program.

32.03%

In the 2022–23 tax year, 32.03 per cent of the MCA check-off was eligible to earn an investment tax credit.

Variety Performance Trials

MANITOBA CORN COMMITTEE:

12
locations

365
Total number of ***corn hybrids*** (grain & silage) have been tested since 2020.

SUNFLOWER VARIETY PERFORMANCE:

5
locations

42
Total number of ***sunflower hybrids*** (confection & oil) have been tested since 2020.

MANITOBA
CROP
ALLIANCE

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Manitoba Crop Alliance

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