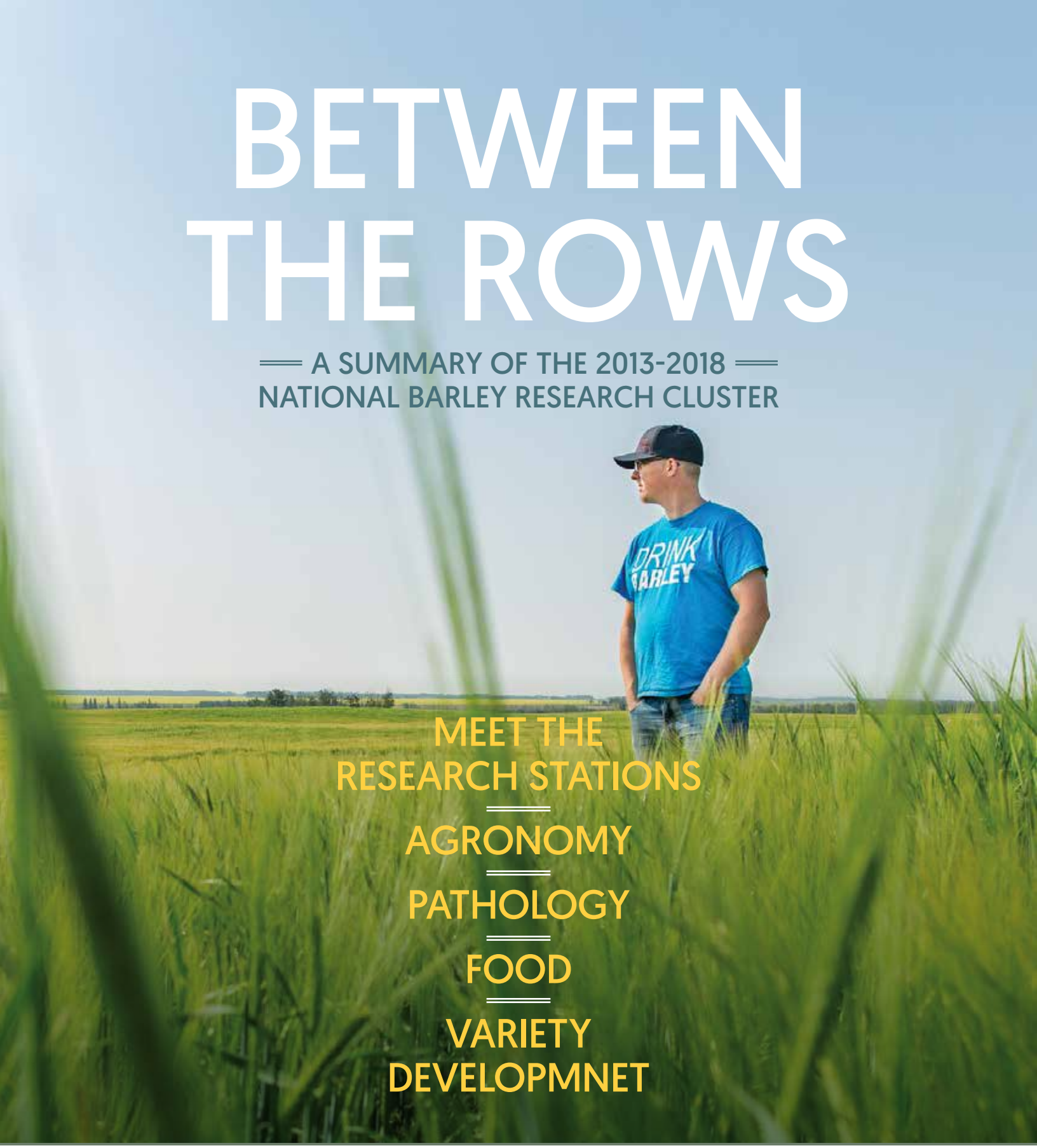
BETWEEN THE ROWS

A SUMMARY OF THE 2013-2018 NATIONAL BARLEY RESEARCH CLUSTER



MEET THE RESEARCH STATIONS

AGRONOMY

PATHOLOGY

FOOD

VARIETY DEVELOPMNET

Growing Forward 2 | Atlantic Grains Council | Western Grains Research Foundation | Brewing and Malting Barley Research Institute | Alberta Barley | Canada

MEET THE RESEARCH STATIONS

Field Crop Development Centre Lacombe (FCDC)

Enhancing selection for malting quality in two-rowed and hulless barley at FCDC

Patricia Juskiw- *Principal Investigator*

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Feed and malting barley: Linking enzymes to disease resistance

Dr. Jennifer Zantinge - *Principal Investigator*

Lacombe Research and Development Centre

Effect of rate and timing of a pre-harvest glyphosate application on seed germination, yield and quality of malting barley

Effect of plant growth regulator (PGR) application on yield and quality of malting barley

Quality and yield response of malting barley varieties to increasing nitrogen rates

Effect of seeding rate on β-glucan levels of hull-less barley varieties across various soil and climatic zones in western Canada

Dr. John O'Donovan/Dr. Breanne Tideman - *Principal Investigators*

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Identification and development of barley germplasm and varieties with resistance to multiple diseases

Development of alternative, sustainable, reduced input strategies for crop and pest management and their impact on silage quality and feed value

Assessment of pathogen variation for scald, net blotch, stripe rust and common root rot/spot blotch pathogens in response to geographic location, host genotype, host growth stage, and specific host tissues

The impact of seed treatments and foliar fungicides and their interaction with variety resistance and plant growth regulators on barley productivity and quality

Impact of microbial communities on malt properties in commercial malting

Dr. Kelly Turkington - *Principal Investigator*

Crop Development Centre Saskatoon

Breeding two-row feed and malting barley varieties

Breeding hulless malting and food barley varieties

Association mapping for agronomic traits in two-row barley (malting)

Scald resistance gene mapping and breeding

Development and commercialization of SNP marker technology for rapid identification of malting barley varieties

Dr.Aaron Beattie - *Principal Investigator*

Brandon Research and Development Centre

Breeding two-row malting barley cultivars for western Canada at Agriculture and Agri-Food Canada's Brandon Research Centre

Breeding two-row feed barley cultivars for western Canada at Agriculture and Agri-Food Canada's Brandon Research Centre

Breeding six-row malting barley cultivars for western Canada at Agriculture and Agri-Food Canada's Brandon Research Centre

Breeding two-row hulless food barley cultivars for western Canada at Agriculture and Agri-Food Canada's Brandon Research Centre

Breeding dual purpose forage/feed barley for western Canada at Agriculture and Agri-Food Canada's Brandon Research Centre

Developing barley germplasm with improved resistance to Fusarium head blight for western Canada

Dr. Bill Legge/Dr. Ana Badea - *Principal Investigator*

Morden Research and Development Centre

The Effect of Barley Beta-Glucan on Human Glycemic Response: A Meta-Analysis

Optimization of Primary Processing Protocols to Improve Wholegrain Barley Product Nutrition, Safety and Flavour

Dr. Nancy Ames - *Principal Investigator*

Ottawa Research and Development Centre

Improving malting barley production in eastern Canada, cultivar and germplasm development

Dr. Alek Choo/Dr. Raja Khanal - *Principal Investigator*

Charlottetown Research and Development Centre

Improving malting barley production in eastern Canada, through disease resistance to FHB and foliar diseases

Martin/Adam Foster - *Principal Investigator*

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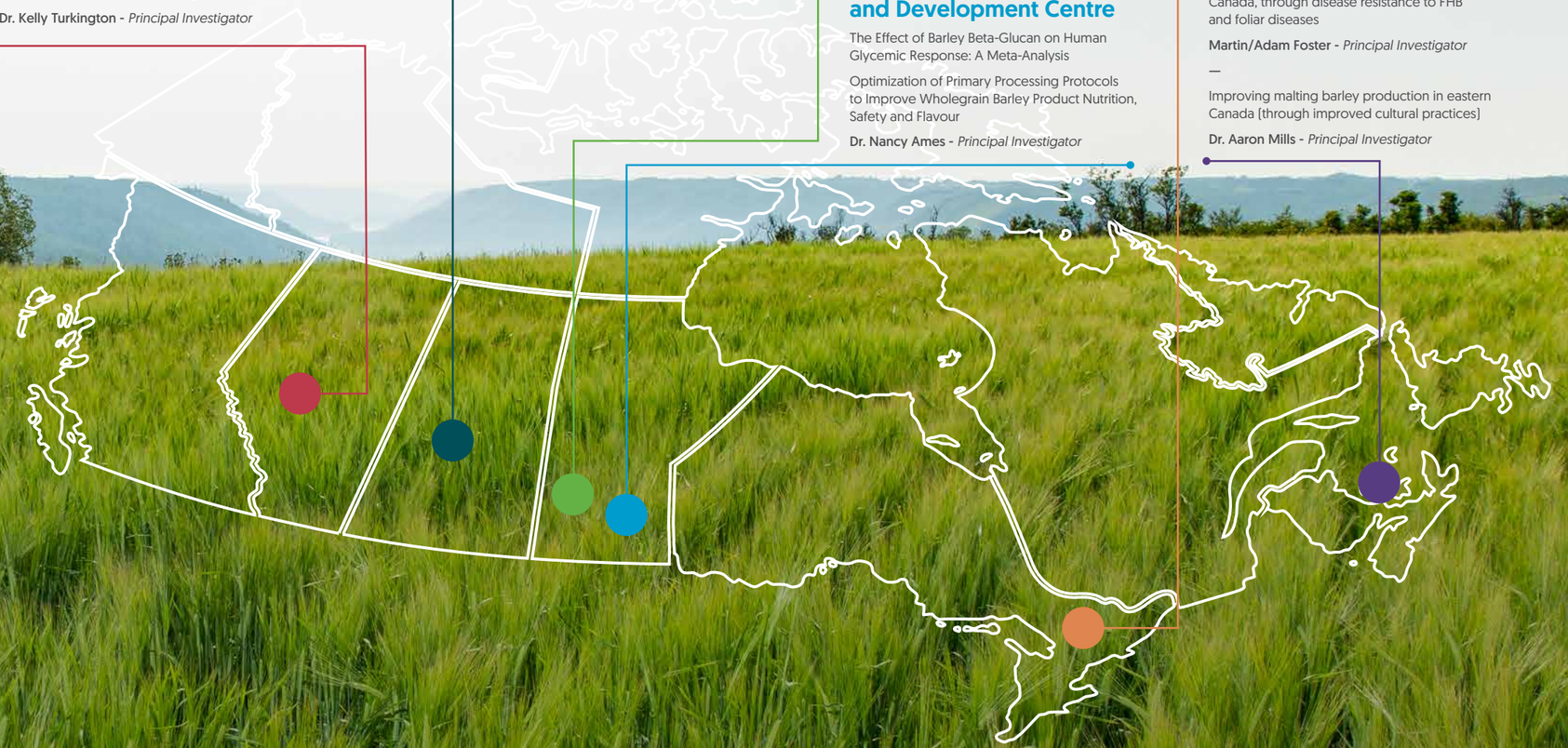
Improving malting barley production in eastern Canada (through improved cultural practices)

Dr. Aaron Mills - *Principal Investigator*



In 2013, Agriculture and Agri-Food Canada (AAFC) announced an $8 million-dollar investment in the barley industry to fund Barley Research Cluster projects via the AgriInnovation Program (AIP) under Growing Forward 2, a federal, provincial, territorial initiative, aimed at increasing agri-sector competitiveness and sustainability.

This investment leveraged an additional $3 million from Alberta Barley, the Atlantic Grains Council, the Brewing and Malting Barley Research Institute, Rahr Malting and the Western Grains Research Foundation. Funds were administered by Alberta Barley.

Barley Cluster funding covered 28 projects that met industry priorities for feed, food and malt barley. These projects were specifically directed at the development of more competitive agronomic packages for farmers, disease prevention and management, breeding high performing varieties and strengthening end-use characteristics.

In *Between the Rows*, you'll find an overview of some of the major highlights, success stories and new varieties that came as a result of this important funding initiative.

Learn more about these, and other projects funded under the 2013 Barley Cluster by visiting **www.albertabarley.com.**

AGRONOMY

WESTERN CANADIAN BARLEY PRODUCERS HAVE A LARGE VARIETY OF AGRONOMIC PRACTICES AND PRODUCTS AT THEIR DISPOSAL TO HELP THEM GROW BETTER CROPS.

BUT IT CAN BE OVERWHELMING TO DECIDE WHICH TOOL TO USE WHEN, AND WHEN TO NOT USE THEM AT ALL, ESPECIALLY AS BEST PRACTICES ARE CONSTANTLY BEING REVIEWED, UPDATED AND REFINED.

FOR THIS REASON, ONE OF THE MAIN FOCUSES OF BARLEY RESEARCH IN THE RECENTLY COMPLETED GROWING FORWARD 2 PROGRAM WAS HELPING PRODUCERS DETERMINE THE BEST AGRONOMIC PRACTICES FOR GROWING BARLEY ON THEIR FARMS.

AND THE RESULTS ARE IN ...

PRE-HARVEST GLYPHOSATE

One of the biggest industry concerns related to barley production in recent years has been surrounding the use of glyphosate as a pre-harvest desiccant.

Although many industry members require that malting barley not be treated with glyphosate (members of the Brewing and Malting Research Institute ban it completely for malting barley) producers still have questions about the product.

This is why one project, led by Agriculture and Agri-Food Canada (AAFC) Research Scientist Dr. John O'Donovan, specifically aimed to test the effects of pre-harvest glyphosate on barley crops.

"The objective of the study was to address the feasibility and risk of using pre-harvest glyphosate on malting barley," says AAFC Research Scientist Dr. Hiroshi Kubota, who took over O'Donovan's role following his retirement last year.

To test the effects, the research team applied glyphosate at high and low rates to two malting barley varieties at the soft dough, hard dough and maturity stage.

An unexpected issue arose from the testing: the researchers found that the typical method of measuring grain maturity (using fingernail dents) was not a consistent indicator of grain maturity and moisture.

"If grains on the main stem are at the hard dough stage, that doesn't mean all crops are mature and have less than 30% moisture," Kubota says. "If we apply when grain moisture is above 30%, the glyphosate will be translocated from the leaves or stems to the grain, so that leads to higher residue content in grain."

Overall the results of the tests showed that when glyphosate was applied at the correct rate and time (based on the label), MRLs were almost always below acceptable levels. However, overall, the lack of accurate maturity testing and uneven maturity in-field increase the risk of non-compliant MRLs, Kubota says.

"According to our study, the typical method of measuring maturity is not necessarily a good indicator of barley moisture content. This variability in moisture may have led to some of the concerns around consistent impacts with glyphosate applications."

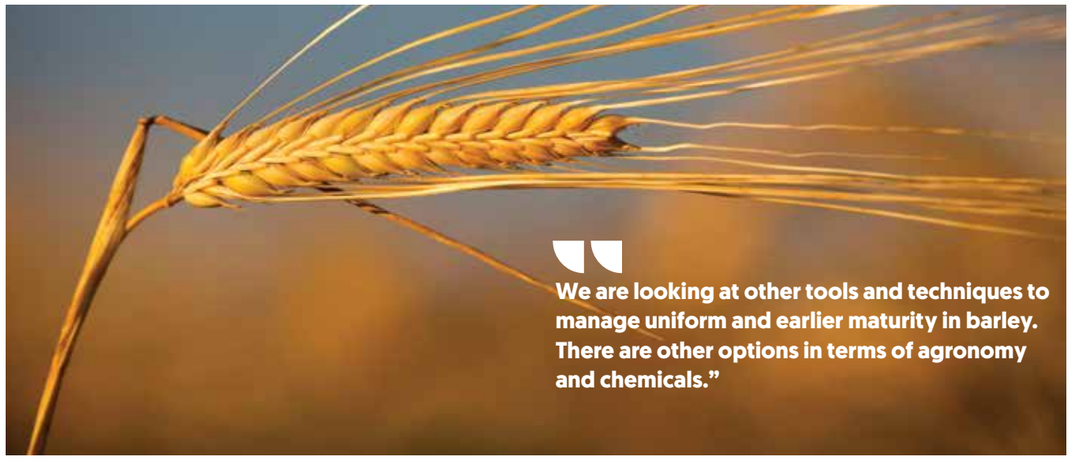
Additionally, the variation in maturity that researchers found between the main stems and tillers is highly concerning, particularly in terms of residues, Kubota says.

And while the research team is still waiting for final results from the quality analysis being done by the Canadian Grain Commission, Kubota says that for now, the use of glyphosate as a crop desiccant on malting barley is not ideal and not recommended.

He encourages producers to make their own, informed choices around crop products, and to always talk with their grain buyer before making final decisions around product use.

Kubota also hopes to be able to offer more information on acceptable alternatives to glyphosate in the near future.

"We are looking at other tools and techniques to manage uniform and earlier maturity in barley. There are other options in terms of agronomy and chemicals."



NITROGEN

Another agronomic tool at producers' disposal is nitrogen, although there are questions around the cost benefit involved.

Generally speaking, increasing nitrogen rates can help increase yields, but it can also increase protein content, which leads to a decrease in the chance of malt acceptance as malting barley should contain not more than 12.5% protein.

This is why another project led by O'Donovan aimed to delve deeper into the effects of increased nitrogen rates on malting barley crops, in order to weigh the pros and cons.

In order to do this, the research team tested the response of five different varieties to increased nitrogen levels (0, 25, 50, and 100kg ha^{-1}).

They found that overall, although general trends were the same, the responses depended a great deal on the variety being used.

For example, AAC Synergy showed high grain yield with relatively lower protein even under high nitrogen conditions.

"It appears to be a good fit for malting barley producers," Kubota says.

However, the team also found that increased nitrogen also increased lodging and days to maturity, regardless of variety.

"At higher nitrogen rates we found it took an additional two days to get mature compared to the other control check," Kubota says. "Two days may not be critical for some parts of Alberta, but it is for those in the north."

The general conclusion of the research was the risks of increasing nitrogen rates outweigh the benefits, unless you are using specific varieties, Kubota says.

"If producers want to raise their nitrogen rate our suggestion would be selecting varieties which have good nitrogen response, which means high grain yield with lower protein even under certain conditions."

Based on the research, AAC Synergy is a good choice for producing higher quality malt and increasing acceptability rates, Kubota says.

However, he cautions that AAC Synergy also has medium susceptibility to some of the diseases of concern for Western Canada, including FHB, a major threat for malt barley.

"Producers need to have a good plan for disease management if they plan to use AAC Synergy," he says.

PLANT GROWTH REGULATORS

Another study led by O'Donovan looked at the benefits of using plant growth regulators (PGRs) on barley crops to increase yield and reduce lodging.

Specifically, the study measured the effects of chlormequat, trinexapac and ethephon in five Western Canadian locations over three years.

The results were not that promising, showing that the benefits that PGRs offer are limited and inconsistent.

For example, while trinexapac and ethephon were successful at reducing height, they also had adverse effects on days to maturity, percent plumpness and kernel weight. Trinexapac's ability to increase yield was inconsistent between locations and years, while chlormequat did not show an ability to reduce lodging.

The conclusion was that PGRs do not offer enough proven benefits, and pose too many risks, to be recommended for western Canadian malting barley producers at this point.

IMPROVING CULTURAL PRACTICES

Another study, led by Dr. Aaron Mills, looked at general ways to improve cultural practices for producing malting barley.

Although the research was done in eastern Canada, the results are applicable nationally, says Mills, a Research Scientist at the Agriculture and Agri-Food Canada (AAFC) Charlottetown Research and Development Centre.

Specifically the project looked at how to best achieve malt quality through seeding rates, nitrogen application and variety selection.

One noteworthy conclusion was the importance of fertility levels. Higher fertility levels led to higher yield, thousand-kernel-weight and test weight, Mills says.

"We found that malting quality, particularly protein levels, was increased at higher fertility levels," he says. "Ideal fertility was anywhere between 60 to 80 kilograms of nitrogen per hectare, which shows that producers in the east may have to give up some yield in order to hit quality."

Another noteworthy outcome was the effect of the previous grown crop on subsequent malting barley crops.

"There was some indication that previous crop affected malt quality, which is different from what has been shown to happen out west," Mills says.

While the east coast tends to have more diverse rotations than Western Canada – commonly including soybean, potato, buckwheat and brown mustard – there could be opportunities to share knowledge in the future.

"As these crops move out west, producers will have a better idea how to manage them in a rotation with malt barley."

SEEDING RATES ON BETA GLUCAN CONTENT

Another study looked at how producers could optimize their beta-glucan rates for the food market.

The study was conducted using two hull-less varieties, which were seeded at three seeding rates and were treated with low and high nitrogen rates.

Results showed that increased nitrogen rates and lower seeding rates provided higher beta-glucan content, but they also had negative effects on the crops, including increased lodging risk, increased days to maturity and decreased kernel weight.

"The takeaway message of this study was that optimizing beta-glucan content cannot be achieved by following agronomic recommendations for malting barley," Kubota says.

"It is important to weigh the gain in beta-glucan content against some of these risks, based on where a producer is located and the environmental conditions that are likely to have an effect on the barley."

Therefore the overall results were inconclusive at this point, he says.

PATHOLOGY

ONE OF THE TOP ISSUES FOR WESTERN CANADIAN BARLEY PRODUCERS HAS LONG BEEN HOW TO BETTER PREVENT AND MANAGE DISEASE IN THEIR CROPS.

BUT TODAY, WITH INCREASING THREATS OF FUSARIUM HEAD BLIGHT (FHB) DAMAGE TO CROPS AND CROP ROTATIONS BECOMING TIGHTER, THE ISSUE HAS BECOME MORE IMPORTANT THAN EVER.

THIS IS WHY SEVERAL OF THE RESEARCH PROJECTS IN THE RECENTLY COMPLETED GROWING FORWARD 2 (GF2) PROGRAM AIMED TO EXPLORE DISEASE MANAGEMENT FOR BARLEY CROPS, WITH THE GOAL OF BEING ABLE TO PROVIDE PRODUCERS WITH BETTER INFORMATION TO USE ON THEIR FARMS.

FUNGICIDE APPLICATIONS

Over the last 10-15 years, one of the common tools producers considered for leaf disease management was early fungicide applications, typically at the time of herbicide application.

"The thought was that putting fungicide on at that stage can help to reduce disease risk later on," says Agriculture and Agri-food Canada (AAFC) Research Scientist| Dr. Kelly Turkington.

However, previous AAFC-funded research demonstrated that a fungicide application at herbicide timing had limited benefit, while applications around the flag leaf stage and later provided much greater and more consistent benefits.

Producers are also becoming increasing interested in head emergence fungicide application as a way to control FHB, says Turkington, who works out of the AAFC Research and Development Centre in Lacombe.

To address this, Turkington led a research project, as part of GF2, that looked at how to optimize the use of fungicide treatments through timing and aimed to measure the difference between flag leaf and head emergence applications in terms of managing leaf spot diseases and FHB.

"The results showed that the most important factor in terms of managing leaf disease in season is either fungicide application at flag leaf emergence or head emergence," he says. "The level of disease control and the yield response we saw was very similar between those two stages."

There was also a small benefit observed from dual applications, Turkington says, but it likely wasn't economical.

The takeaway advice for producers is that they can delay their fungicide application until after head emergence, which will help with leaf disease control and can also help limit FHB development and suppress deoxynivalenol (DON) production in the crop, Turkington says.

A late application also offers benefits for grain size.

"You can probably delay your fungicide application until head emergence without necessarily impacting productivity, but an earlier application at or prior to flag leaf emergence may also be needed if there is significant leaf disease development as the crop enters the stem elongation stage."

The research also looked at the interaction between fungicide applications and disease resistance in the varieties.

"With really resistant varieties you had limited or no yield response versus a substantial yield response with susceptible varieties," he says, adding that added input costs associated with fungicide application can be avoided when the variety has a very effective leaf disease resistance package.

SEED TREATMENT

Producers are also becoming increasingly concerned about early season leaf disease development.

Seed treatments are one option to help manage this issue. As part of the GF2 barley cluster project on fungicide timings, Turkington looked at the potential role of seed treatments for leaf disease management.

"Our idea was that a seed treatment could help producers avoid any pre-anthesis fungicide timing so they could instead focus entirely on targeting the crop after head emergence, which would top up leaf disease control and suppress the development of FHB and DON."

Turkington was inspired by previous research he had done in the late 1990s which showed that seed treatments provided some protection against early season leaf disease developments at the two-to-three leaf stage. More recently, he visited Australia where they were using non-triazole-based seed treatments for early season leaf disease management. Both these factors sparked his interest in evaluating seed treatments for managing leaf diseases.

"Seed treatments may allow for early- to mid-season disease management under moderate to high risk conditions, resulting in only needing one in-crop fungicide application at head emergence," he says.

However, he cautions that other GF2-funded research has shown shifts in fungicide sensitivity for some barley leaf disease pathogens.

"Thus we want to make sure these fungicides remain effective for as long as possible. One aspect to that is managing their use – don't use them if you don't need to and limit the number of in-crop applications to a minimum."

Overall, the research results showed some small benefits to seed treatments in terms of disease management.

“There was some indication of reduced leaf disease development later on in the growing season, at the early dough stage when we would typically assess disease,” he says.

There were also some minor benefits in terms of yield.

“We saw a small increases in yield which could also be due to better stand establishment,” he says. “It may or may not be economic, depending on the seed treatment you’re using and the cost.”

Some of the newer seed treatments being used in Australia and now being introduced in Canada are not triazole-based and thus one strategy may be to use those products as a seed treatment and then use your triazoles as your key fusarium product later on, Turkington says.

Overall, the takeaway message is that producers should consider using seed treatments as part of an overall disease management strategy, especially as some newer products are becoming available in Western Canada. Moreover, in-crop application should be the main focus when using fungicides for leaf disease management.

THE IMPORTANCE OF GOOD VARIETIES

One of the most important takeaways from all this and previous research is the importance of using a holistic approach for disease management, and not relying too heavily on any one tool.

Choosing resistant varieties is always the best mode of protection, Turkington says.

“From a producer’s point of view, it provides peace of mind. You can use the genetic capacity that been bred into the variety to manage risk for you.”

Turkington says the progress that has been made in breeding disease-resistant barley varieties in recent decades is commendable.

“If you look at the progression from the 80s and varieties like Harrington and two-row feed and malt, we have seen significant improvements in leaf disease resistance and multiple other issues.”

When choosing new varieties, pay attention to resistance ratings, Turkington says.

He was also part of a GF2-funded project that had him and colleague Kequan Xi, who works for Alberta Agriculture and Forestry in Lacombe, evaluating levels of resistance to barley leaf diseases in breeding lines and cooperative variety trial entries, and also looking at potential sources of resistance.

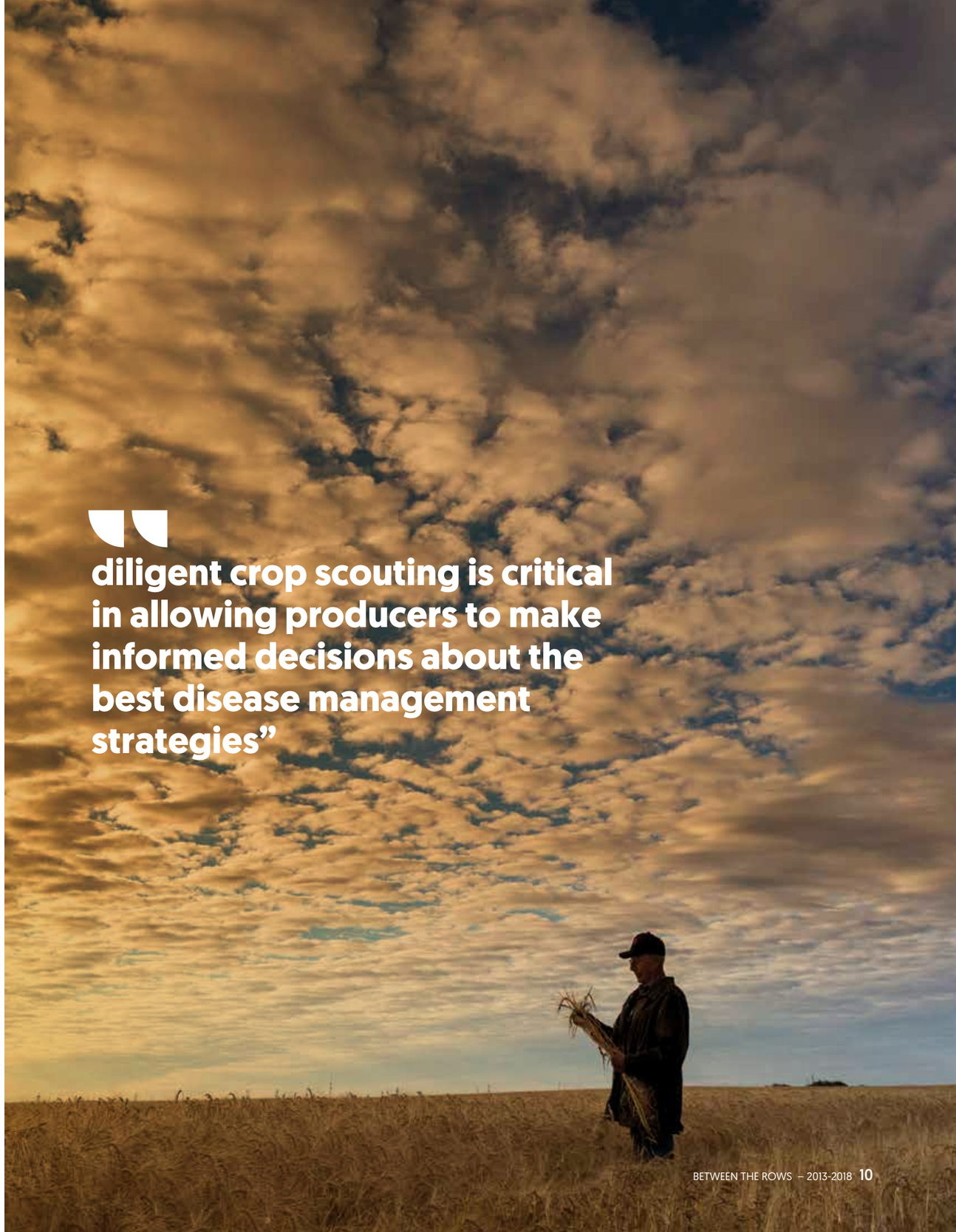
These screening trials were initially focused on evaluating scald resistance in the field, but have expanded to cover the spot and net forms of net blotch. Turkington and Xi also monitored new and current varieties, as well as known sources of resistance, for changes in virulence in the scald and net blotch pathogens.

“We wanted to make sure that varieties that are listed as resistant maintain that rating. If we see a shift in reaction we can change the rating. This ensures producers have the latest information in terms of how resistant that variety is.”

Another important tool in disease management is crop rotation, Turkington says. Although it may not necessarily fit into producers’ cropping plans, leaving at least two years between barley crops is recommended to help reduce disease risk.

Finally, diligent crop scouting is critical in allowing producers to make informed decisions about the best disease management strategies, Turkington says.

It’s always important to look at what the crop is telling you. I can’t emphasize that enough. Especially in high-risk situations like barley on barley or barley every second year.”



FOOD

WE KNOW THAT BARLEY IS A VERSATILE AND HEALTHY INGREDIENT FOR HUMAN FOODS.

HEALTH CANADA HAS EVEN APPROVED A HEALTH CLAIM LINKING BARLEY AND CHOLESTEROL REDUCTION.

SO WHY DON'T WE SEE IT IN MORE OF THE FOOD THAT WE EAT?

"Despite proven health benefits, several barriers still exist to increasing consumption of barley," says Dr. Nancy Ames, an Agriculture and Agri-Food Canada Research Scientist who works out of the Morden Research and Development Centre.

One of the biggest hurdles is that barley is not a commonly used ingredient by food manufacturers, as they don't have access to a consistent, reliable supply of barley and there is a lack of knowledge around best practices for processing the grain to ensure a safe and consistent tasting final product.

As a result, consumers are not seeing barley as an ingredient in mainstream food products, Ames says.

"With the few products readily available such as flour or pearled or pot barley, many consumers may not be knowledgeable about how to incorporate these products into everyday foods or how much they need to eat to obtain health benefits."

Ames recently wrapped up research, as part of the Growing Forward 2 barley cluster, which aimed to help address these problems and in turn grow demand for barley as an ingredient in commercial food products.

Specifically the research aimed to identify additional health effects of barley that would be of interest to the consumer, including its potential to lower glycemic response, and also how different processing treatments can help improve the nutrition, safety and flavour of barley in processed foods.

OUTCOMES

Overall the results of Ames' research re-iterated the fact that barley offers health benefits to humans, specifically helping lower postprandial glycemic response, which is increasingly important for a North American population facing surging rates of diabetes and pre-diabetes.

The research also identified ways to improve future studies in this area

"Overall, this study advanced our knowledge of additional health benefits of consuming barley and could provide support to pursuing a future health claim for barley beta-glucan and glycemic control," Ames says.

The research also made significant progress in understanding best practices around using barley as an ingredient in processed foods.

For example, researchers learned the many benefits of heat treating the grain before it's used in processed foods.

"Our study demonstrated that heat treating barley grain using micronization, roasting or moist heat conditioning was an effective way to reduce standard plate count and yeast and mold counts in whole grain barley compared to untreated barley," Ames says.

The results further showed that using heat treatments in primary barley processing improved safety particularly when whole grain barley was to be used in food applications where no other heating steps such as cooking were required.

The research also generated data showing that heat treatments could have a positive effect on the kernel and flour colour of barley, as well as the fractionation properties during milling and pasting characteristics, Ames says.

"This will help predict the functionality of heat treated whole grain barley products in food systems."

Further research done with heat treatments on flaked end products suggested there could also be opportunities to use genotype selection and heat processing conditions to improve the quality of barley flakes.

Ames is currently involved in the next stage of the research, which will aim to support another health claim for barley around lowering glycemic response and will continue to look at processing opportunities for barley. Ames says another important piece of future work will be communicating the benefits of barley to consumers.

But for now, the knowledge gained from the recently completed research provides valuable and critical knowledge for food processors as the barley industry builds a case to get more of the crop into processed foods, Ames says.

The knowledge gained can be utilized to develop optimized primary processing protocols that can be implemented by barley millers and processors to improve product quality and consumer demand, thus supporting the expansion of food barley markets for Canadian farmers."

VARIETY DEVELOPMENT

AS WE WRAP UP ANOTHER PHASE OF GROWING FORWARD 2 (GF2) BARLEY BREEDING RESEARCH IN WESTERN CANADA, BREEDERS ARE OPTIMISTIC ABOUT THE PROGRESS THAT HAS BEEN MADE.

NOT ONLY HAVE NEW VARIETIES MADE ADVANCES IN TERMS OF AGRONOMIC TRAITS, THEY ARE ALSO CONSTANTLY EVOLVING TO KEEP UP WITH CHANGING DEMANDS OF END USERS, SAYS DR. AARON BEATTIE, BARLEY BREEDER WITH THE UNIVERSITY OF SASKATCHEWAN'S CROP DEVELOPMENT CENTRE (CDC).

PROGRAM OVERVIEW

"The varieties that we put out in this last phase of research made improvements on a number of different traits that were needed or are relevant to the barley industry," he says.

One of his main focuses in breeding two-row malting barley in recent years has been meeting the needs of maltsters and brewers, for both the adjunct and craft (or low adjunct) industries.

The challenge is that both industries have different demands, Beattie says.

While adjunct brewers look for varieties with high enzymes, such as CDC Metcalfe, craft brewers favour low-enzyme varieties such as CDC Copeland.

There are also newer quality characteristics that are appealing to all brewers, such as the LOXless trait (LOX is a fatty acid that causes oxidation with negative flavor effects on beer) and low levels of dimethyl sulphide (DMS) and its precursor DMSP, which cause an unappealing taste in the beer.

It's also important that varieties that come out of the program are well-adapted for all of Western Canada."

Beattie's program is looking at ways to produce varieties with improvements to traits such as these ones.

"These are newer traits so we are still in the early days but both these traits really impact brewers."

Since Canadian malting varieties in the past have traditionally been developed with the adjunct industry in mind, breeders are also looking at other novel ways to incorporate new traits for the growing craft beer industry, says Dr. Ana Badea, who works in the Agriculture and Agri-Food Canada barley breeding program out of Brandon, Manitoba.

The program she is leading recently wrapped up a phase of research breeding two-row malting varieties for Western Canada and has recently started exchanging active breeding material with European barley breeding programs. This material is being evaluated for malting characteristics specifically for the craft industry.

"We will use the ones that have good malting qualities and decent agronomics as parents in crosses, in the hopes of bringing these malting profiles into Canadian barley," she says.

On top of end-use characteristics, agronomic traits remains a top priority as well when it comes to breeding barley, Beattie says, as a main objective is always to keep the crop competitive.

"We are still pushing yield pretty hard and we are also paying attention to straw strength to go along with yield increases. We know we can't have high yielding varieties that fall over, so straw strength is important."

Another focus is maintaining maturity, he says.

"It's really important to not let these varieties drift too far towards late maturity."

Badea's program in Manitoba also focuses heavily on disease resistance, as the research centre she works out of is home to three barley disease nurseries, including one for fusarium head blight (FHB) led by James Tucker.

The Brandon barley team closely follows the disease guidelines established by the Prairie Recommending Committee for Oat and Barley, which advises which diseases are the most urgent for Western Canadian producers. Currently they are focused on breeding resistance to FHB and leaf diseases such as spot blotch and net blotch, as well as stem rust, scald and smut.

It's also important that varieties that come out of the program are well-adapted for all of Western Canada, Badea says.

"Consistency across locations is very important. This is why the most advanced lines in the program are tested at various locations across Western Canada."

The breeding team also does exchange testing with barley programs in Alberta and Saskatchewan.

"We gather information on how our advanced lines are doing in those locations and only those that have consistent performance will be entered into co-op registration trials."

On top of Badea and Beattie's breeding programs during the last phase of barley breeding research, the Government of Alberta's Field Crop Development Centre (FCDC) in Lacombe also led research aiming to strengthen the breeding process for two-rowed and hulless barley. Beattie also just completed breeding research focused on hulless varieties, targeting the food industry.

NEW TOOLS AND TECHNOLOGY IN BREEDING

Dr. Patricia Juskiw led the FCDC project aiming to use new breeding tools to improve the process of selecting traits for new two-row and hulless barley varieties.

The project relied on two advanced technologies to achieve their goal of developing improved varietie in less time.

One of these technologies was Near-Infrared Spectroscopy (NIRS), which Juskiw and her colleague Lori Oatway used to predict and measure quality traits in developing lines.

NIRS technology works by testing materials' reactions to light.

"When you scan anything with light it either absorbs or reflects it," Juskiw says. "This is how we can tell what things are composed of. Everything reflects or absorbs light differently."

From the reaction, scientists can predict the contents of the material.

"We then use math to try to figure out what is most important about the spectral pattern we are receiving and then develop calibration from that. It's very complex and mathematical," Juskiw says.

Using NIRS, the team was able to develop tests for malting functions in barley, which overall helped increase the effectiveness of selection and release of new varieties.

The second technology the team used was genetic markers and breeding nurseries to develop disease resistance.

Scald is a big concern for Alberta and is also a challenging disease to breed resistance to, Juskiw says.

Through this research however, the team was able to find markers for three resistant genes that could be used to create pyramid genes in new lines.

"If we can get those all together it gives us more durable resistance," Juskiw says.

The team was also working on developing and maintaining resistance to other major barley diseases for western Canada.

Although stem rust and loose smut are not as big of a concern in Alberta right now, it's important to maintain the resistance levels that already exist to these diseases in new varieties, Juskiw says.

Advanced breeding tools are improving the process of selecting traits for new two-row and hulless barley varieties.

SUCCESS STORIES

Malting varieties

- CDC Fraser. This high yielding variety has good straw strength, good standability and a great disease package, with either moderate resistance or resistance to leaf diseases and also to fusarium head blight (FHB). It also has a malting profile that is a bit more like Metcalfe, says Beattie, with higher enzymes, but also has some of the new characteristics that are appealing to brewers, such as a low DMSP content.

  "Amongst the varieties we have now, it has the lowest amount of DMSP. That should be attractive to brewers wanting to try that out."

  CDC Fraser has also been malted (by Canada Malt) and all feedback has been positive so far, Beattie says.

- CDC Goldstar. This variety is high yielding with much better lodging resistance than predecessors CDC Polarstar and CDC Platinumstar. It also has the LOXless trait.

  However, because the variety was created in collaboration with Sapporo (Sapporo owns the patent for the LOXless trait), the variety resides within a closed loop system.

  "This is likely a small acreage variety due to the closed loop system," Beattie says.

- CDC Copper. This variety has a high yield potential and good straw strength (similar to CDC Fraser). However, its real claim to fame is that is has excellent scald resistance, Beattie says.

  "Scald is more prevalent in the western prairies, especially Alberta, so some of the producers there might find it has a nice fit for them and it also performs well against other leaf diseases."

- TR15155. The newest variety to be released by CDC, this one is most noteworthy for its end-use characteristics for craft brewers, Beattie says.

  "It has low enzyme activity, even lower than Copeland," Beattie says. "This was our first attempt to target a variety for the craft brewers."

  TR15155 also outyielded all feed lines in trials.

- Lowe. This variety came from the FCDC breeding program and although it contains two genes for scald resistance, its real claim to fame is that it has the best fusarium resistance of any Western Canadian malting barley variety and has consistently low DON accumulation, Juskiw says.

  "It consistently has 50% less DON than AC Metcalfe, rating similar to the most resistance lines in the nurseries."

  Lowe is also appealing to the maltsters, with low beta-glucan, low protein and high extract.

  "This variety has potential to replace CDC Copeland," Juskiw says. "I hope it has a long life."

- AAC Connect. This new variety is widely adapted to western Canada, has good agronomic traits and a desirable malting quality profile. It is also high yielding, with 11% higher grain yield than AC Metcalfe and 5% higher than CDC Copeland. It also has a good overall disease package, most notably as moderately resistant to FHB, with a 24% lower deoxynivalenol (DON) accumulation than AC Metcalfe (tested over 12 site-years in FHB nurseries in Manitoba).

  "This is a very important trait," Badea says.

  In a very short time AAC Connect already made its way on the Canadian Malting Barley Technical Centre (CMBTC) Recommended Malting Barley Varieties list. Generally, CMBTC recommendations follow farmer availability so in 2018, Canadian farmers and the industry had one more choice for malting barley.

- AAC Goldman. Another promising new variety, this one also has an improved yield and disease package over previous varieties, most notable with 35% less DON accumulation than AC Metcalfe.

  AAC Goldman also offers good malting quality. Although it's still early in the process, Badea says that the variety has been through rigorous testing and has shown early indication that it could be a good fit for the craft industry, in terms of protein, enzymes, and sensory attributes such as aromas and flavours.

  "It's quite exciting because we had it tested for more than 35 sensory attributes and this is the first time we have this type of data," Badea says

Hulless varieties

- CDC Ascent. This is the sole release to come from the CDC's hulless breeding program. With a high beta glucan content (around 7%), and higher yields than hulless varieties before it, CDC Ascent was designed to replace older hulless varieties such as CDC Rattan.

  "This is a big step up for hulless varieties," Beattie says.

BARLEY CLUSTER NEW VARIETIES LISTING

NAME	TYPE	BREEDING INSTITUTION	REGISTRATION YEAR	LICENSEE	CHARACTERISTICS
AAC Connect	2-row malt	AAFC- Brandon	2016	Canterra Seeds	• yields 111% of AC Metcalfe and 105% of CDC Copeland • widely adapted to western Canada • short, strong straw • malt quality similar to AC Metcalfe, with higher malt extract and friability • moderate resistance to FHB with lower DON accumulation
CDC Ascent	2-row hull less	CDC	2016	Secan	• very good threshability = to CDC McGwire • yields 111% of McGwire • higher β-glucan content ≤ CDC Rattan • low DON accumulation
CDC Goldstar	2-Row malt	CDC	2017	Canterra Seeds	• yields 110% of AC Metcalfe • straw strength > checks • test weight and kernel weight > malting checks • a LOXless variety
AAC Goldman	2-Row malt	AAFC- Brandon	2018	La Coop fédérée	• yields 110% of AC Metcalfe and 105% of CDC Copeland • widely adapted to western Canada • lower malt beta-glucan content and viscosity than AC Metcalfe • moderate resistance to FHB with lower DON

NEW VARIETIES LISTING CONT'D

NAME	TYPE	BREEDING INSTITUTION	REGISTRATION YEAR	LICENSEE	CHARACTERISTICS
CDC Copper	2-Row malt	CDC	2018	FP Genetics	• yields 116% of Metcalfe • kernel weight > AC Metcalfe and CDC Copeland • resistant to scald, net block and stem rust
Lowe	2-Row malt	Alberta Agriculture	2016	SeCan	• <50% DON accumulation of Metcalfe • yields 112% of AC Metcalfe and 106% of CDC Copeland • lodging scores < check • Low protein, low DP line suitable for all malt craft brewing
CDC Fraser	2-Row malt	CDC	2016	Secan	• yields 114% of AC Metcalfe • straw strength > checks and Zena • kernel weight > checks • suitable for adjunct brewers
TR15155	2-row malt	CDC	2018	N/A	• well suited for all-malt and low adjunct brewers • yields 112% of CDC Copeland • shorter than Champion with similar lodging resistance of CDC Austenson

CONCLUSION

OVERALL BEATTIE SAYS HE IS QUITE PLEASED WITH THE OUTCOME OF THIS LAST PHASE OF RESEARCH, WHICH WILL FUEL NEW AND IMPROVED VARIETIES IN THE NEXT PROGRAM, WHICH BEGINS THIS YEAR.

"All breeding efforts continue to build over time," he says. "Many of those varieties have already become parents for the next round of better performing varieties."

Juskiw is also looking forward to the next round of breeding work.

"Breeding is not about the one you just released but about the next one you're going to release. The varieties are all your little babies and once they're out in the world they're like adults – they have to look after themselves. It's the new ones coming along that you have to nurture and promote."

She says there are currently several new lines in the FCDC breeding program that have lots of potential for the next few rounds of breeding.

"Our program has matured over the last twenty years. All the support we have received from the Growing Forward 2 Barley Cluster has made it possible to select for traits using markers and getting gene combinations we would not have been able to otherwise get."