



Field Crop Development Centre

2019-20 research results

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Executive Summary

The Field Crop Development Centre (FCDC) has been developing enhanced cereal varieties for feed, malt, food, and bio-industrial uses for 47 years. Barley makes up nearly two thirds of the breeding efforts, with triticale and wheat the remaining. The breeding programs are supported by quality, biotechnology, pathology, and biostatistics laboratories and research.

We consider that varieties are the foundation of agriculture; without improved varieties, there is no genetic progress to contribute to the increase in productivity and food security. New varieties are able to substantially decrease the risk of production in changing environmental conditions, while also responding to industry and international markets.

The 2019-20 year was another productive one for the FCDC. Five barley and two triticale varieties were approved for registration in March 2020. From those, two new barley varieties are currently in the licensing process for commercialization.

In 2019 we re-structured the breeding programs to better reflect our efforts. Patricia Juskiw (PhD) continues in charge of the malting barley program, Joseph Nyachiro (PhD) is responsible for feed barley, Yadeta Kabeta (PhD) is working to improve forage barley, and Flavio Capettini (PhD) continues his pre-breeding work in conjunction with providing leadership as Head of Research. We have adjusted the balance between two- and six-row breeding efforts based on the relative market demand of both types. Mazen Aljarrah (MSc) continues in charge of the triticale program. We have discontinued the efforts in wheat and hulless barley.

Feed and forage are the core of our work. Over 50% of barley acres in Canada are planted to malting varieties, but approximately 75% of acres are used for feed or forage. We continue to make large progress in barley and triticale feed and forage. Grain yield continues to increase every year, as well as forage and feed quality. We are releasing two-row barley varieties with yields that exceed market-dominant varieties, and have significantly improved lodging resistance in most of them. In six-row barley we are releasing varieties that have improved Nitrogen Use Efficiency (NUE) in addition to the expected desirable characteristics. We continue offering robust triticale varieties that cover the demand for this cereal, mostly for forage use, with exceptional yield and agronomic type. The feed barley program also focuses on superior agronomic traits such as lodging resistance and early maturity. The forage barley program focusses on high biomass, as well as smooth awns, forage quality with low lignin levels (orange-lemma), overall energy value, and hooded varieties. The malting barley breeding program develops two-row varieties that balance agronomics with malting quality characteristics required by maltsters, brewers, and distillers. Additional characteristics valued by the industry are being researched and rapidly incorporated in the programs, such as non-GN, LOX-less, and *Fusarium* Head Blight (FHB) resistance, among others. Backing all of the breeding efforts is our pre-breeding and germplasm development program, which brings novel genetics and novel traits from around the world to Lacombe to be incorporated into our locally adapted material.

As with barley, the triticale breeding program is focused on feed and forage production. FCDC develops spring triticale types and is releasing winter types from our winter program that was discontinued in 2015. Triticale targets include enhanced forage digestibility with reduced awns for swath-grazing and green forage uses, improved drought tolerance, early maturity, reduced pre-harvest sprouting, and FHB and ergot resistance for feed grain. We work to widen the genetic base of triticale through making wide crosses of spring x winter or wheat, to produce forage type genotypes with higher digestibility and nutrient values. All of our new registered triticale varieties expressed improved levels of resistance to FHB and ergot, complemented with better digestibility.

The wheat breeding program has been working toward developing Canadian Prairie Spring (CPS) and Canadian Northern Hard Red (CNHR) varieties, obtaining lines with multiple disease resistance and attractive yield and agronomics. The wheat breeding program was suspended in early 2020.

The Cereal Quality program supports the breeding programs by analyzing our germplasm for feed, forage, malting and food quality characteristics. Our lab is continually evolving to address changes in the market and new quality targets. The biotechnology lab works to develop genetic tools and genetically characterize and screen germplasm for different traits, improving the selection efficiency in the breeding programs. The plant pathology program assesses the germplasm's genetic resistance to diseases. It also ensures that FCDC's disease priorities remain up to date on potential new and emerging diseases by conducting cereal disease surveys and assessing shifts in race variation in central Alberta and North America. The Biostatistics program ensures breeding trials are validly and efficiently designed, and also supports FCDC's breeding efforts by developing bioinformatics tools for use of genome-wide DNA markers in marker-assisted breeding.

In July 2019 we were proud to receive the Alberta Agriculture and Forestry Teamwork Recognition Award for our high level of collaborative work and engagement in the Field Crop Development Centre Cereal Breeding Program.

Despite the challenging conditions imposed by the COVID-19 pandemic, we continue working hard while managing the contingency practices aimed to avoid the risk in the workplace. We are looking forward to another productive year that will allow us to continue contributing to the foundation of agriculture with enhanced varieties and to the whole cereal value chain.

Varieties

AB BrewNet

'AB Brewnet' is a two-row malting barley marketed by SeedNet Inc. Its grain yield is significantly higher than the dominant commercial varieties like CDC Copeland and AAC Synergy. The malting profile is suitable for the craft and low adjunct brewing industries. AB BrewNet shows

resistance to multiple diseases including *Fusarium* head blight (FHB) and produces 30% less mycotoxin deoxynivalenol (DON) than other commercial varieties.

AB Tofield

'AB Tofield' is a six-row smooth-awned feed and forage barley marketed by SeCan. Its grain yield is 8% higher than present cultivars with a forage yield 3-6% higher. Grain quality is reflected in the high plump seed, test weight and heavy kernels. It has excellent lodging resistance, higher than the dominant cultivars. In addition, it shows multiple disease resistance, including to scald, spot blotch, spot-form net blotch, surface-borne smuts, loose smuts, and stem rust.

AB Wrangler

'AB Wrangler' is a two-row feed and forage barley marketed by Canterra Seeds. It has an overall yield 3% greater than feed checks and matures one day earlier. In the drought of 2018 it yielded 8% higher than the checks in the Black/Grey Soil Zone. It has forage yields similar to forage checks, but the forage quality is significantly superior to current cultivars, with improved fiber digestibility and higher starch. DON levels are 36-46% lower than present feed and forage cultivars.

T267 (to be commercially named)

T267 is a high-yielding spring triticale marketed by SeCan. Its grain yield is 112% of 'AC Ultima'. It has intermediate to moderate resistance to FHB and lower ergot infection rates, both of which are rarely attained in triticale. With strong straw and better lodging resistance than dominant varieties, it is suitable for high moisture areas. It has higher digestibility of fiber complemented with high digestibility.

WT0009 (to be commercially named)

WT0009 is a reduced awn winter triticale suitable for feed and forage uses and is marketed by Corns Brothers Farm. WT0009 has higher grain and forage yield than cultivars and checks. The winter survival, critical for winter crops, is better than all winter triticale and winter wheat checks. It has higher forage protein and other quality characteristics than all winter triticale checks. WT0009 matures a couple of days earlier than dominant cultivars and has exceptional lodging resistance due to its intermediate height.

Research program results

Barley breeding

Feed

The objective of the feed program is to develop two- and six-row feed barley that will increase barley grain production in Alberta. Specific priorities include high grain yield that exceed the current cultivars, better adaptation to the environment, superior agronomic traits such as lodging resistance, early maturity, enhanced grain and biomass characteristics with attractive visual appeal. It needs to have a good combination of resistance to multiple diseases such as scald, net blotch (spot- and net-form), spot blotch, smuts, stem and stripe rusts, and FHB.

Moving forward the feed barley program will prioritize two-row varieties while adjusting the six-row program to market demand.

Achievements:

- TR18645 and TR18647 were supported for registration by the PRCOB in Feb. 2020.
- Pre-registration Cooperative trials:
 - Six-row Coops: Four of 11 first year six-row lines were advanced to second year. One of the four second year lines was put forward for PRCOB approval for registration in Feb 2020.
 - Two row Coops: two lines were advanced to second year with both being put forward and supported for registration by the PRCOB in Feb 2020; three two-row lines were entered into the first year Coop but were not advanced.
- Material:
 - Crosses: 24 two-row and 15 six-row feed/forage crosses were made between advanced and elite two-row varieties.
 - Yield evaluation trials: Six-row: 208 superior feed and forage lines were tested in year 1 to year 3 for yield, agronomic and quality characteristics, at 1 to 10 locations.
- 'Canmore' occupied 5% of the insured acres in 2019 making it the fifth most popular non-malting type in western Canada.
- Project 2018F105R: Determining the critical traits associated with lodging in Canadian barley varieties and elite breeding lines. The second year of this study to understand traits associated with lodging was completed and found that the environment (year and location) has a significant effect on lodging. Varieties differ in lodging resistance depending on the environment. Varieties showed significant differences in cellulose,

- lignin and hemicellulose content. There was a negative correlation between grain yield and lodging, while there was a positive correlation between grain yield and days to anthesis, grain test weight, 1000 kernel weight and percent plump seed. There was no significant correlation between lodging and 1000 kernel weight and percent plump seed.
- Project 2017F050R / AGR-15699: Development of a rapid screening method to assess grain processing responses of barley as a trait for the selection of feed varieties for cattle. We are in the third year of this study to determine how barley grain grown under different conditions responds to processing and feeding, and how to incorporate this knowledge back into the breeding program. We have found that although particle size distribution of processed barley varied between dry and temper rolled barley, its impact on grain processing (GP) and dry matter digestibility (DMD) appeared small between the 2-row and 6-row. As the DMD of ground barley at 6 and 48 hr indicate, respectively, the ruminal digestion rate and potential maximum digestion, the lack of significant differences in DMD at 6 and 48 hr between 2-row and 6-row barley suggest minimal differences in digestion rate and maximum digestibility in the rumen. There were varietal differences in GP and DMD within the two-row types, and within the six-row types. The method (grinding, dry rolling or temper rolling) used for grain processing had much greater impact on DMD than just the barley type (two-row or six-row).

Forage

The primary objective of this research is to develop barley varieties specifically suited to forage production systems, with enhanced fodder quality (energy content, fiber digestibility) and improved whole plant forage yields for silage, greenfeed, or swath grazing. The forage barley varieties we intend to develop also meet other desirable agronomic and disease resistance requirements.

FCDC is changing its breeding strategy to bring varieties that better meet the needs of the forage industry to market. This includes a specific breeding program for forage, focusing on forage yield, quality, and smooth awns, especially in two-row barley. The majority of available varieties have rough awns, which can irritate cattle's mouths. Smooth or hooded awns can avoid that negative effect. We aim to incorporate smooth awns into the majority of forage barley lines by 2024, and are also developing barley with the hooded awn characteristic. We are selecting for improved forage quality by crossing in exotic germplasm with low lignin levels, known as orange lemma mutants, to improve fiber digestibility and overall energy value. Prospective varieties are showing very attractive results.

Achievements:

- TR18647 (FB494), and SR18524 (FB492) were supported for registration by the PRCOB in Feb. 2020.
- Pre-registration Cooperative trials: Two two-row lines were tested in 2019 with one line (FB495) advancing to second year Coop testing; seven two-row lines were entered into first year Coop testing in 2020.
- The first set of lines developed from the orange lemma mutant crosses were evaluated for forage yield and quality in 2019. The forage yield for these lines was lower, but these had higher forage quality as compared to the standard cultivars. The best lines were advanced for further evaluation.
- Dr. Kabeta was appointed coordinator of the Western Cooperative Forage Barley Test by the Barley Agronomic Evaluation Team at the PRCOB meeting in Feb. 2020.
- Material:
 - Crosses: 40 specific 2-row feed/forage crosses were made.
 - Yield evaluation trials: 215 entries were tested between 1 and 10 locations.
- Nitrogen Use Efficiency Project (2016F076R): Improving yield and sustainability of feed and fodder barley through targeted research in nutrient and water use efficiency. Barley varieties with enhanced nitrogen use efficiency (NUE) will provide reduced input costs and potentially more stable yields to producers while also reducing N lost to the environment. Phase 1 of this work began in 2009, with this project continuing the work and additionally assessing the interdependence of water use efficiency (WUE) and NUE. This study revealed a positive relationship between NUE and WUE, which indicates that it may be feasible to breed barley lines that are tolerant to both drought and low nitrogen stresses. Our first variety from this project, SR17519, was supported for registration by the PRCOB in February 2019. The second, SR18524, was supported in February 2020. Several other lines are also coming up through the breeding pipeline. This project has also identified a number of germplasm with superior NUE that will be incorporated into future crosses.

Malt

The objective of this program is to develop varieties of two-row malting barley with good malting quality characteristics that are desired by the market place and will enhance overall economic returns with high yields and good agronomic adaptation. In addition, good disease resistance and tolerance to abiotic stresses such as low nitrogen, water, cold, and other adverse environmental factors are considered.

Achievements:

- AB BrewNet was released and will be marketed by SeedNet. Support for registration of TR17635 passed by the PRCOB in February 2020.
- Lowe has potential as a replacement variety for 'CDC Copeland', with additional malting testing underway. Lowe's resistance to FHB with low DON accumulation is very important to the industry.
- Support for registration of TR14617 has been extended by the PRCOB to March of 2021. It has been identified as a non-glycosidic nitrile producer (non-GN) type. GN is a cyanogenic glycoside precursor of ethyl carbamate, which develops during malting. Ethyl carbamate is an undesirable trace component that remains in spirits or whisky produced from malted grains that contain GN. There are currently no non-GN malting barley varieties commercially available in Canada, while varieties are highly demanded by the industry.
- Pre-registration Cooperative trials: two lines in second year malting Collaborative testing (TR18635 put forward and supported for registration); no second year Coop/first year Collab; five lines entered into first year Coop with three selected to be advanced to second year Coop and first year Collab in 2020.
- Material:
 - Crosses: 32 elite crosses of our most advanced lines with new malting varieties from western Canadian programs; 20 top crosses of F₅s with 'CDC Copper', a high yielding variety with multiple disease resistance (although it lacks FHB resistance); 10 crosses of mutants (low LOX, LOX-less, high Beta-amylase) with elite malting varieties.
 - Yield evaluation trials: 676 entries were tested at 1-10 locations for 1-4 years.
- The malting program is moving to an exclusively marker assisted selection protocol with the support of the Biotechnology lab. Selection using molecular markers will occur 2 generations earlier than the standard program, reducing the time to complete the breeding cycle. This is possible due to the number of malting quality markers FCDC has. The goal is to use at least one marker for each key disease by 2020-21. As well we will continue to screen parents with genetic markers for the presence of favorable genes before making crosses.

Germplasm Development

The main objective of the Germplasm Development program is to identify and use favorable and novel traits and genes that could be advantageous in new barley varieties. We carefully

introgress genes from exotic germplasm into the main breeding programs while avoiding a possible depression in yield or other favorable traits already present in the adapted varieties.

Specifically, this happens through introducing germplasm from successful breeding programs worldwide, testing these germplasm in Alberta, utilizing and maintaining the FCDC gene bank, and executing and coordinating the pre-breeding activities. We continue incorporating germplasm with yield potential, unique lodging resistance, earliness, disease resistance and quality, as well as new traits that respond to changes in the industry. That may include germplasm with orange lemma for improved forage quality, hooded awns, short stature, non-GN, earliness, etc. FCDC is also building a collection of heritage malting barleys that are recognized for flavor such as 'Maris Otter', 'Chevalier', and 'Golden Promise' among others. Next year we are going to test lines derived from crosses with these varieties for those characteristics.

Achievements:

- Many of the lines developed in the program show superior traits that are not present in other varieties in Canada but are accepted worldwide, like lodging, yield, yield stability, and malting quality.
- The lines that prove well adapted to our environment and superior to the checks are advanced to the mainstream multi-location Yield trials, or are used as parents in the mainstream breeding programs.
- Pre-registration Cooperative trials: Two of the lines introduced from France were among the top ranking of the FCDC's 2019 pre-Coop trial and were advanced to the 2020 first year two-row Coop, with the potential of becoming commercial varieties in 2023.
- Material:
 - Introductions: 360 new barley genotypes were introduced from successful breeding programs worldwide, including: ICARDA, Germany, France, UK, United States Department of Agriculture, Plant Gene Resources of Canada.
 - Crosses: Over 200 crosses are made in the entire barley program, 85 of which are specifically for germplasm development.
 - Yield evaluation trials were performed to test the introductions and superior lines developed by the program.

Testing for unique traits with value added potential:

- Non-glycosidic nitrile (non-GN) varieties. There is an emerging market for non-GN malting barley, particularly for the distilling industry. This trait is present in the FCDC germplasm; TR14617 is the first Canadian non-GN variety, released in spring 2020. New enhanced varieties with this trait are being introduced, tested and extensively used in crosses.

- Lipoxygenase-less (LOX-less) varieties. LOX gives side flavors to beer as it ages, as well as shelf life stability. We use barley lines derived from a mutation breeding program carried out in collaboration with Innotech Alberta that are being tested and extensively used in crosses.
- FHB resistance. 150 lines selected from a collection of 1,000 elite FHB-resistant lines from ICARDA introduced two years ago are being tested at AAFC Brandon to confirm their unique resistance. This constitutes a diverse germplasm collection that likely contains genes not available in Canada. These lines are also being tested in FCDC Yield trials as well as used extensively in our crosses.
- Improved flavor. Our program is developing a malting barley flavor program and participating in collaborative projects with CMBTC, BMBRI, AAFC, University of Saskatchewan, and Oregon State University, among others.
- Orange lemma and hooded awns for forage quality (see Forage barley section above).

Triticale breeding

The triticale breeding program aims to develop new spring triticale varieties with higher dry matter and grain yield and lodging resistance, adapted to variable growing conditions in western Canada. Spring and winter triticale types have the potential to be used in multiple systems as annual forages for ruminant animals. In western Canada, triticale varieties with reduced awns have been released specifically to enhance acceptance of triticale for forage. FCDC's breeding program is designed to identify high-performing grain and forage lines from the same populations.

Specifically, the program focusses on enhanced forage digestibility with reduced awns for swath-grazing and green forage uses. Also improved drought tolerance, early maturity, reduced pre-harvest sprouting, and FHB and ergot resistance for feed grain. Generally, acid detergent fiber (ADF) and fiber digestibility have been used as screening criteria for digestibility. We work to widen the genetic base of triticale through making wide crosses (spring x winter) to produce forage type genotypes with higher digestibility and nutrient values.

Achievements:

- In 2021, we plan to register two new dual-purpose spring triticales and two winter triticales, adapted to the western Canadian prairies.
- Pre-registration Cooperative trials:
 - Spring triticale: three lines were in the third year Coop, with one put forward and receiving PRWRT support for registration in February 2020; five lines in the second year Coop, with three advanced to the third year for 2020; seven lines in the first year Coop, with five advanced to the second year Coop in 2020.

- Winter triticale: one line was in the third year Coop, with one put forward and receiving PRWRT support for registration in February 2020; three lines in the second year Coop, with three advanced to the third year in fall 2019; nine lines in the first year Coop, with six advanced to the second year Coop in fall 2019. Three lines were entered into the first year Coop in fall 2019.
- Material:
 - Crosses: 50 crosses were made, with 10% for germplasm development (winter x spring and triticale x wheat).
 - Yield evaluation trials: 442 advanced lines were evaluated for their adaptability in Alberta and in the western prairies.
- All of our new registered triticale varieties express high levels of FHB and ergot resistance, complemented with better digestibility.
- Launched FCDC's first collaboration with University of Manitoba: over 250 spring triticale lines will be evaluated for FHB resistance in Carman, MB.

Wheat breeding

The wheat breeding program is working toward developing varieties to meet the market quality of Canadian Prairie Spring (CPS) and Canadian Northern Hard Red (CNHR) classes. In CWSP class, we are targeting high grain yield and multiple disease resistance. Specific objectives include higher grain yield, drought tolerance, multiple disease resistance, and superior agronomic types including lodging resistance and early maturity, adapted to the Parkland and Peace River region of western Canada.

The wheat breeding program will be suspended in 2020. Material will not be continued in the Coop tests.

Achievements:

- FCDC's wheat breeding program began in 2014 from our previously established elite germplasm collection.
- In addition to superior yields, the lines achieved high level of resistance to all rusts, the main diseases in Alberta, in a very attractive agronomic type.
- Pre-registration Cooperative trials: four new promising lines were advanced to the first year Coop (1 CPS, 1 CNHR and 2 SP). In the SP Coop one line was advanced to the second year and one line to the third year.
- Material:
 - Crosses: In 2019, 105 new wheat crosses were made, targeting CPS, CNHR and CWSP wheat classes.

- Yield evaluation trials: 500 advanced wheat lines were evaluated in multiple locations in western Canada. Grain yield and quality, lodging, rusts and FHB diseases were among data priorities.
- In collaboration with the pathology team at FCDC, the advanced lines in yield trials were successfully evaluated for stripe rust resistance in Lacombe and Olds.
- Leaf and stem rust are still major foliar diseases in Saskatchewan and Manitoba. Through our collaboration with University of Manitoba and Syngenta we screened our wheat germplasm and the advanced yield trials for FHB disease.

Supporting Programs

Quality

The Cereal Quality program supports the breeding programs by analyzing the germplasm for quality characteristics like malt, feed, forage and food. We develop new analysis techniques, and outsource analyses for providing accurate and timely data to support research projects, the registration of new varieties and to validate and expand the NIRS calibrations we use for breeding. We also collaborate with industry partners by sending out samples for additional testing.

We use Near Infrared Reflectance Spectroscopy (NIRS) to screen and analyze samples for our programs. We also support several other research groups developing NIRS calibrations and/or providing quality analysis.

Our lab is continually evolving to address changes in the market and new quality targets.

Achievements:

- In 2019, the lab was able to process over 11,000 entries through NIRS, including lines from Yield trials, Coops, headrows and germplasm introductions.
- 442 samples of spring wheat were analyzed for Falling Number (FN) and protein sedimentation, as well as sending 10 of the advanced spring wheat lines to Leduc Food Processing Center for milling and gluten strength testing.
- 309 malting lines were sent to Canada Malting, Rahr Malting and CMBTC for micro malt analysis. Besides the selection of our malting program, this data supported our submission of over 20 new lines into the Coop testing process.

Current projects:

- Development of a rapid screening method to assess grain processing responses of barley as a trait for the selection of feed varieties for cattle: the quality lab sent 225 samples to Lethbridge for the initial analysis.
- Ongoing collaboration with several outside groups, supporting them with quality analysis for their programs and projects including:
- AAF – Advanced Agronomy Research project through Dr. Sheri Strydhorst (822 samples), CAP Barley Profitability Project through Laurel Thompson at Lakeland College (297 samples), Perennial research project through Erin Day at the University of Alberta (150 samples) and AAF – Biosolid Project through Germar Lohstraeter at Agri-Environmental Innovation (150 samples).
- We are working with private companies for the development of NIRS technology:
 - Canada Malt to evaluate their NIRS instruments for the prediction of DON in commercial barley samples.
 - Rahr Malting to increase their NIRS capabilities in the barley selection lab by developing a calibration that would detect minute traces of glyphosate residue.
- AAF apiculture group: evaluating if NIRS could be used to segregate viable leaf cutter bee cocoons from dead or contaminated cocoons.
- In 2020, we will start a new project with BMBRI on evaluation of barley flavour in current malting varieties, lines from FCDC, and heritage varieties with known flavor attributes. This project will give us more information on the different flavor profiles that we currently have in the market and our program and develop a screening technique for this attribute.

Biotechnology

Our main objective is to identify, develop, validate and apply molecular biology-based technologies to increase selection efficiency of important traits for crop production and end use. This includes applying various genotyping methods to select breeding lines by comparing DNA sequences (genotypes) linked to disease resistance, improved quality and yield.

Our specific priorities include the characterization of potential germplasm through genomics, thereby allowing breeders to better understand genetic resources and how genes are inherited. We work on identifying, validating and applying genetic markers to germplasm to better “see” the genes, for direct utilization within our breeding programs. We also track and characterize cereal pathogens in order to better manage disease and reduce crop losses.

Achievements

- Our biotech program has identified several gene clusters or Quantitative Trait Loci and markers for those genes linked to disease resistance in FCDC barley germplasm. With those markers we screened 6,636 malt barley lines (scald, net blotch, stem rust, and smut) and malt quality.
- Evaluated effectiveness of marker panel for selection, and adjusted as needed due to germplasm introduction into the breeding program and changes in field pathogen races.
- We tested more than 40 new markers linked to disease resistance as well as malt quality, such as beta glucanase, alpha amylase and glycosidic nitrile (GN) production.
- We also screened lines with wet chemistry including a colorimetric GN test. We identified four advanced malt barley lines that did not produce GN, the precursor for the potentially harmful substance known as ethyl carbamate, including the newly registered non-GN line, TR14617.
- We continue to look for new markers, including those linked to pre-harvest sprouting, LOX-less, nitrogen use efficiency and lodging resistance.

Current projects:

2019A021AF: Canadian non-GN malt barley for improved food safety and economic competitiveness. Funding: Canadian Agricultural Partnership and Brewing and Malting Barley Research Institute. 2019 - March 2022. As a proof of concept study, we have developed and applied new genotyping and colorimetric tests to identify non-GN lines that will be used to develop high quality and high yielding non-GN barley varieties for western Canada. All currently available malting barley varieties in Canada produce GN. We discovered non-GN malt breeding lines already in the FCDC breeding program. This includes the malt line TR14617, which has potential as a new dual brewing / distilling non-GN variety.

2019N050AF: Addressing climate change, food safety, and finding new markets through better use of barley genetic resources, in conjunction with the Germplasm program. Funding: Canadian Agricultural Partnership. 2018 - Dec 2021. We are genetically characterizing our germplasm collection to increase their utility for breeding. With that we will be able to mark important genes and then transfer them to elite material. We are in the process of developing a large nested association mapping population (Ab NAM) with two referent lines (AB Lowe and AB Advantage) that can be used by western Canada programs. Populations were created with 10 founding lines with superior qualities that will be targeted for marker development and will be characterized by sequencing and genotyping.

Pathology

Objectives of the pathology program include: a) assessing the genetic resistance of barley, wheat and triticale genotypes to breed varieties that are resistant to various diseases, b) carrying out disease surveys, c) conducting phenotyping and genotyping on cereal pathogens, and d) updating and disseminating information on disease resistance for varieties and potential new and emerging diseases in central Alberta.

Specific priorities include the screening breeding lines for resistance to a number of leaf and smut diseases of barley, wheat and triticale in artificially inoculated field nurseries and greenhouse tests, and in those field tests relying on natural infection across breeding sites. We are assessing shifts in race variation for scald, net blotch and stripe rust pathogens in central Alberta and North America, and surveying cereal diseases to obtain information on disease distribution, prevalence and severity in this region. We are annually updating disease ratings for newly released and existing cereal varieties in Varieties of Cereal and Oilseed Crops for Alberta (Agdex 100-32, Alberta Agriculture and Forestry), and disseminating related information through publications, seminars, field days and other media sources.

Achievements:

Screening barley resistance to various diseases:

Cereal pathology screened or assisted in screening a total of 6,168 plots/lines of barley for resistance to various diseases under the National Barley Cluster project, including:

- 2,864 hills for FCDC breeding programs and 264 hills for the Western Cooperative Variety Registration Test were evaluated for scald resistance at Crop Diversification Centre North (CDCN), Edmonton.
- 1,469 FCDC breeding plots were screened for resistance to multiple diseases across four FCDC breeding sites.
- 51 lines from two-, six-row and hulless Coop trials were evaluated for loose smut reactions.
- Assisted with screening 760 barley lines in the stripe rust nurseries at each site of Mt. Vernon and Pullman in Washington, USA.

Screening nurseries and activities were highly successful again this year; there were adequate differentiations in multiple disease reactions in screening tests. Data from disease ratings were submitted to the FCDC barley breeding programs and the Prairie Recommending Committee for Oat and Barley (PRCOB). Promising resistant lines have been advanced to the Western Coop Tests.

In 2019, 20 barley breeding lines were tested for their resistance to four major soil-borne pathogens *Fusarium avenaceum*, *Cochliobolus sativus*, *Rhizoctonia solani* and *Pythium irregulare* under greenhouse conditions at CDCN, Edmonton. Results showed that all lines were susceptible to the pathogens to certain degrees. Studies of some preventative measures against these pathogens will be needed in the near future.

In 2020, we plan to screen 500 hills for AAFC Brandon and 160 hills for Limagrain for scald resistance at CDCN, in exchange for screening barley for FHB resistance in Brandon and Osler, Saskatoon. Collaboration has been established with the Alberta Plant Health Lab and CDCN, AAF to screen 500 barley lines for resistance to FHB and DON production in CDCN, Edmonton in 2020.

Screening wheat resistance to stripe rust, leaf rust and leaf spot diseases:

Cereal pathology screened or assisted in screening a total of 5,958 plots/lines of wheat for resistance to various diseases, including:

- 1,077 spring wheat plots were evaluated for stripe rust resistance at Lacombe and Olds.
- 569 plots were screened for leaf rust resistance in Lacombe.
- 88 and 84 lines were screened for Septoria and tan spot resistance, respectively, at CDCN.
- 3,200 wheat plots were screened for stripe rust resistance at Lacombe for Syngenta in exchange for screening FCDC barley lines for resistance to FHB at Rosebank, MB.
- Assisted in screening 470 wheat lines for stripe rust resistance at each site of Mt. Vernon and Pullman in Washington, USA.

There were adequate differentiations in multiple disease reactions in screening tests except for the barley stripe rust data in 2019. For 2020, no screening work for wheat disease resistance will be carried out as a result of suspending the wheat breeding program. We will screen approximately 400 FCDC triticale lines for resistance to stripe rust in Lacombe, AB.

Central Alberta disease surveys:

Cereal disease surveys were conducted for central Alberta in 2019 and results were submitted to Can. Plant Dis Survey for publication (Waterman, et al. 2020 in press). Field trials in Lacombe and Olds, AB showed that stripe rust as well as leaf spots caused considerable yield losses in susceptible wheat and barley, and the use of resistant cultivars substantially reduced yield losses (Kumar et al. 2019a). Survey activities for cereal diseases will continue for 2020 with emphasis on barley and triticale.

Northern Alberta disease surveys:

A total of 90 commercial cereal fields in northern Alberta, including 57 spring wheat, 22 barley, 10 oat and one rye crop, were surveyed for the occurrence of disease in early to mid-August 2019. Tan spot and spot blotch were observed on spring wheat at all locations, with disease incidence ranging from 5-100%. Scald and net blotch were found in most of the surveyed barley crops, with average incidence ranging from 5.8-100%. All foliar cereal diseases were observed at much higher incidence and severity than in 2018. Unusually frequent rain showers and thunderstorms occurred during the summer may have promoted higher foliar and root disease development in this region. One rye crop surveyed near Fort Saskatchewan was heavily infected with ergot. Many barley and wheat crops also developed high root rot symptoms as a consequence of frequent rainfall that caused extensive flooding and water accumulation in the low lying areas of most fields. Various *Fusarium* spp. were most frequently isolated from diseased roots and crowns. Other pathogens (i.e. *Bipolaris sorokiniana*, *Rhizoctonia solani*, and *Pythium* spp.) were also isolated from root rot samples.

Variability of the scald pathogen in field tests and identification of scald pathotypes of *Rhynchosporium commune*:

Scald is the most important barley disease in Alberta. Effective/ineffective genotypes were determined from all four FCDC test locations in central Alberta for the 2019 growing season. Lacombe and Edmonton were the two sites with strong Genotype x Environment interactions (GxE), suggesting that screening for scald resistance at both sites is needed to account for the variability of the scald pathotypes between locations. Virulent isolates from the Olds breeding site will be chosen to mix with a check isolate and the mix will be used to inoculate the scald nursery in 2020.

Variability of the stripe rust pathogen and identification of Pst (wheat) and Psh (barley) in Alberta and Washington, USA:

Effective/ineffective wheat and barley genotypes were determined from all test locations in 2019. There were significant GxE interactions in stripe rust severity, suggesting that both locations in the PNW and central Alberta region are needed to screen for resistance. Analysis using differentials and PCR based on 67 isolates from the 2012 to 2014 collection showed that all isolates from wheat were classified to Pst and the majority of isolates from barley were classified to Psh with a few of them being classified to Pst. This suggests that while Pst specializes in wheat only, a small portion of Psh isolates are capable of crossing infection between wheat and barley. Characterization of the stripe rust pathogen will be continued using barley, wheat and triticale for 2020.

Biostatistics

The biostatistics program has continued its two general objectives. The first objective is to provide advice and assistance to ensure valid and efficient designs of breeding and agronomy field trials as well as correct statistical analyses of the data generated from such experiments by FCDC and other AF researchers as well as their partners in other organizations (e.g. U of A and AAFC). The second objective is to support FCDC's breeding efforts by developing bioinformatics tools for use of genome-wide DNA markers in marker-assisted breeding.

The biostatistics program has three specific priorities:

- To continue helping FCDC and other AF researchers to adapt to the new reality that SAS and R software co-exist as the main statistical analysis packages by advising. A great deal of effort has been made to help AF staff and their partners on R coding of the same statistical analysis used by SAS, thereby getting them quick and seamless transition between SAS and R for their research designs and analyses.
- To continue improving and enhancing the two statistical genomics/bioinformatics software packages, Barley Breeding Platform (BBP) and Multiple Trait Genomic Selection System (MTGSS). BBP and MTGSS were developed under the two GF2-funded projects in anticipation of possible transition from classic phenotypic selection to genome-based selection by breeders at FCDC and elsewhere. In particular, bioinformatics modules and functions were updated due to the 2018 release of new wheat genome sequence assembly (RefSeq V1.0) by the International Wheat Genome Sequencing Consortium.
- To secure long-term funding to conduct bioinformatics and computational genomics research in support of FCDC breeding programs.

Achievements:

- Responded to ~85 requests with ~190 hrs spent with FCDC colleagues and other AF staff (including staff from Livestock and Crop Research, Environmental Stewardship, Food Safety, and Animal Health and Assurance) as well as their partners in other organizations (mainly AFNS, University of Alberta) for high-level advice and assistance with research designs and statistical analyses.
- Continued the improvement and enhancement of the user-friendly software packages MTGSS (multiple trait genomic selection system) and BBP (Barley Breeding Platform) for processing and analyzing breeding/genetics data. The improvement and enhancement of these packages are periodically posted to the web site (<http://statgen.ualberta.ca/>).
- New 5-yr funded project: Bioinformatics and computational genomics of resistance to biotrophic and necrotrophic pathogens in cereal plants (April 2019 – March 2024).

Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant.

Contributions and impacts of biostatistics program:

- An important role in networking FCDC with other AF researchers and their partners in other organizations (e.g., UofA and AAFC) through statistical consultation and graduate training/supervision and teaching. The program has been enhanced through conducting NSERC-funded computational genomics research and leveraging UofA computing infrastructure and research resources;
- User-friendly Excel-based software packages, BBP and MTGSS, have enabled FCDC breeders and scientists to easily access and use the package for their complex breeding and research activities in Microsoft Excel environment. These packages are highly expendable as new developments on statistical and bioinformatics analyses of genomic data for marker-based selection can be easily added to the packages.
- An impactful role in helping FCDC breeders and scientists for a smooth transition between SAS and R programming for the same or similar statistical analyses;
- A new 5-yr NSERC-funded project enables the program to conduct bioinformatics and computational genomics research for genome-wide identification of novel candidate genes in cereal crops with resistance to major diseases in western Canada (e.g., rusts, FHB and tan spot). The ultimate goal of the project is to narrow down the long list of potential candidate genes to very few most promising ones for practical use by FCDC breeders and others.

Knowledge transfer

Refereed journal articles

Chang, K.F., G.D. Turnbull, R. Fredua-Agyeman, M. Laribi, F. Capettini, S.F. Hwang, and S.E. Strelkov. 2020. Cereal crop disease surveys in northern Alberta, 2019. *Can. Plant Dis. Surv.* 100: (In press).

Farid, M., R.-C. Yang, B. Kebede, H. Rahman. 2019. Evaluation of Brassica oleracea accessions for resistance to *Plasmodiophora brassicae* and identification of genomic regions associated with resistance. *Genome* 2019, 63(2):91-101. doi.org/10.1139/gen-2019-0098.

- Juskiw, P., L. Oatway, M. Oro, J.M. Nyachiro, Y. Anbessa, K. Xi, T.K. Turkington, S. Lohr, J. Bowness, and F. Capettini. 2019. Registration of 'Lowe', a Two-Rowed Malting Barley with Enhanced Resistance to Fusarium Head Blight. *Journal of Plant Registrations* 13:301-310. doi.org/10.3198/jpr2018.11.0075crc
- Kubota, H., R.-C. Yang, M. Iqbal, D. Spaner. There are Different Pathways to Stable Spring Wheat Grain Yield and Nitrogen Utilization Efficiency in Conventional and Organically-Managed Systems. *Agronomy Journal* 2019, 111:2370-2377. doi.org/10.2134/agronj2018.12.0809.
- Kumar, K., K. Xi, T.K. Turkington, M. Aljarrah, and F. Capettini. 2019. Yield responses in spring wheat and barley cultivars, varying in stripe rust resistance in central Alberta. *Can. J. Plant Pathol.* doi.org/10.1080/07060661.2019.1680443
- Holtz, M.D. 2020. Distribution and frequency of mating types of *Rhynchosporium commune* in central Alberta. *Canadian Journal of Plant Pathology*. (submitted).
- Holtz, M.D., S-F. Hwang, V. Manolii, I. Silva-Strelkov, and S. Strelkov. 2020. Development of molecular markers to identify distinct populations of *Plasmodiophora brassicae*. *European Journal of Plant Pathology*. (submitted).
- Nikzad, A., B. Kebede, J. Pinzon, J. Bhavikkumar, R.-C. Yang, H. Rahman. 2019. Potential of the C Genome of Different Variants of Brassica oleracea for the Improvement of Agronomic and Seed Quality Traits of B. napus Canola. *Crop Science* 2019, 59:2608-2620. doi.org/10.3389/fpls.2019.01691.
- Osman, M., X. He, F. Capettini, J. Helm and P.K. Singh. 2019. Phenotypic Characterization of Canadian Barley Advanced Breeding Lines for Multiple Disease Resistance. *Cereal Research Communications*. 47(3):484-495(2019). DOI: 10.1556/0806.47.2019.19.
- Saleem, A.M., J. Nyachiro, W.M.S. Gomaa, W.Z. Yang, L. Oatway and T.A. McAllister. 2020. Effects of barley type and processing method on rumen fermentation, dry matter disappearance and fermentation characteristics in batch culture. *Journal of Animal and Feed Science Technology*. Submitted March 2020.
- Strydhorst, S.M., R.-C. Yang, K.S. Gill, R. Bowness. 2019. Inter-row stubble seeding and plant growth regulators to improve field pea standability and production. *Canadian Journal of Plant Science* 2019, 99(2):184-198. doi.org/10.1139/cjps-2018-0237.
- Tidemann, B.D., J.T. O'Donovan, M. Izydorczyk, T.K. Turkington, L. Oatway, B. Beres, R. Mohr, W. May, K.N. Harker, E.N. Johnson and H. de Gooijer. 2020. Effects of Plant Growth

Regulator Applications on Malting Barley. Canadian Journal of Plant Science. Submitted March 2020.

Xi, K., T.K. Turkington, P. Juskiw, J. Nyachiro, and F. Capettini. 2019. Field screening is effective for identifying genetic resistance to scald of barley. *Crop Sci.* 59:1479-1493. doi: 10.2135/cropsci2018.09.0536

Oral presentations

Aljarrah, M., F. Capettini, S. Lohr and L. Oatway. 2019. Breeding Triticale for Grain and Forage Yield and Quality: Challenges and Future Prospects. Presented at: 10th International Triticale Symposium. Lethbridge, AB. July 15-18, 2019.

Aljarrah, M., S. Lohr, L. Oatway, and F. Capettini. 2019. Breeding Triticale for Grain and Forage Yield and Quality: Challenges and Future Prospects. Presented at: 1st International Wheat Congress. Saskatoon, SK. July 21-26, 2019.

Capettini, F. 2020. Winter Barley Germplasm Development: the FCDC Experience. Presented at: 9th Canadian Barley Symposium & 24th BMBRI Triennial Meeting. Winnipeg, MB. February 25, 2020. (Invited)

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, J. Tucker, K. Xi, M. Aljarrah, L. Oatway. 2019. Breeding for Fusarium Head Blight in Barley: An Empirical Experience. Presented at: 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. (Invited)

Capettini, F., P. Juskiw, L. Oatway. 2019. Craft malting, fitting Lowe barley into craft production, FCDC program. Presented at: Master Brewers Association conference tour of Red Shed Malting. Penhold, AB. October 30, 2019.

Juskiw, P. 2019. New barley varieties. Presented at: CARA Field Day. Consort, AB. August 2, 2019.

Nyachiro, J. 2019. Cold Stress and Lodging of Barley. Presented at: InnoTech Field Day. Vegreville, AB. July 25, 2019.

Nyachiro, J. 2019. Barley: Lacombe Center's lines at Westlock. Presented at: Cut The Crop 2019, Gateway Research Organization Field Day. Westlock, AB. August 8, 2019.

Oatway, L. 2019. New barley varieties are crucial to your business – never stop improving. Presented at: 3rd annual Alberta Craft Brewers Convention. Edmonton, AB. March 4-6, 2019.

Strydhorst, S., L. Thompson, M. Asif, L. Oatway, N. Blue, and A. Terry. 2019. Sustainable Intensification of Wheat Agronomy with GxExM Principles. Presented at: 1st International Wheat Congress. Saskatoon, SK. July 21-26, 2019.

Tso, H.H., L. Galindo-González, H. Askarian, M.D. Holtz, and S.E. Strelkov. 2019. Molecular discrimination of two virulent pathotypes of *Plasmodiophora brassicae* using RNase H2-dependent PCR. Presented at: The 40th Annual Meeting of the Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019.

K. Xi, T.K. Turkington, K. Kumar, and F. Capettini. 2019. Field evaluation of genetic resistance in barley to single and multiple foliar diseases. Presented at: 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019.

Poster presentations

Aljarrah, M., F. Capettini, S. Lohr and L. Oatway. 2019. Triticale Production and Utilization in Western Canada. Poster session presented at: 10th International Triticale Symposium. Lethbridge, AB. July 15-18, 2019.

Baron, V. and P. Juskiw. 2019. Identifying superior small grain varieties for forage utilization. Poster session presented at: Crop Science Society of America Meeting. San Antonio, USA. November 10 – 13, 2019.

Baron, V. and P. Juskiw. 2019. Superior Small Grain Cereals for Forage Utilization. Poster session presented at: Prairie Cereals Summit. Banff, AB. December 11-12, 2019.

Holtz, M.D., J. Zantinge, and K. Xi. 2019. Population genetics of Albertan barley scald (*Rhynchosporium commune*) as revealed by next generation sequencing. Poster session presented at: 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019.

Holtz, M., S. Xue, P. Juskiw, F. Capettini, and J. Zantinge. Look and you will find: New non-GN malt barley varieties are on the way. Poster session presented at: 9th Canadian Barley Symposium and 24th BMBRI Triennial Meeting. Winnipeg, MB. February 24-25, 2020.

Kabeta, Y., P. Juskiw, and J. Nyachiro. 2019. Breeding for Nitrogen Use Efficiency in Barley. Poster session presented at: 19th Australian Barley Technical Symposium. Perth, Australia. September 9-12, 2020.

- Kumar, K., K. Xi, T.K. Turkington and F. Capettini. 2019. A comparison of stripe rust severity caused by *Puccinia striiformis* between the Pacific Northwest and Central Alberta Regions from 2016-2019. Poster session presented at: 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019.
- Nyachiro, J., L. Capo-chichi, P. Juskiw, Y. Kabeta, K. Xi, R.-C. Yang, L. Oatway, J. Zantinge, and F. Capettini. 2019. Understanding the causes and effects of lodging in barley and approaches to mitigate the risks of lodging in the Canadian Prairies 2018 – 2019. Poster session presented at: Prairie Cereals Summit. Banff, AB. December 11 – 13, 2019.
- Xi, K. and F. Capettini. 2019. Screening for resistance to scald of barley. Poster session presented at: Alberta Public Service Field Day. CDCN, Edmonton, AB. June 11, 2019.
- Yang, R.-C., F. Peng. 2020. Genome-Wide Identification for Candidate Genes with resistance to biotrophic and necrotrophic pathogens in wheat. Poster session presented at: International Plant and Animal Genome Conference 2020 (PAGXXV), San Diego, United States. January 11-15, 2020.
- Yang, W.Z., A. M. Saleem, J. Nyachiro, W.M.S. Gomaa, L. Oatway, P. Juskiw, Y. Kabeta, F. Capettini, R.-C. Yang and T. A. McAllister. Effects of head type and processing method of barley grain on rumen fermentation, dry matter digestibility and fermentation characteristics in batch culture. Poster session presented at: Prairie Cereals Summit. Banff, AB. December 11 – 13, 2019.
- Zantinge J., M.D. Holtz, and K. Xi. 2019. Population genetics of Albertan barley scald (*Rhynchosporium commune*) as revealed by next generation sequencing. Poster session presented at: Prairie Cereal Summit 2019. Banff, AB. December 11-12, 2019.

Conference proceedings

- Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, J. Tucker, K. Xi, M. Aljarrah, L. Oatway. 2019. Breeding for Fusarium Head Blight in Barley: An Empirical Experience. Proceedings of 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. Plant Pathology Society of Alberta.
- Kumar, K., K. Xi, T.K. Turkington and F. Capettini. 2019. Stripe rust severity caused by *Puccinia striiformis* between the Pacific Northwest and Alberta Regions during 2016-2019. Proceedings of 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. Plant Pathology Society of Alberta.

Waterman, S., M. Holtz, T.K. Turkington and K. Xi. 2019. Proceedings of 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. Plant Pathology Society of Alberta.

Xi, K., T.K. Turkington, K. Kumar, and F. Capettini. 2019. Field evaluation of genetic resistance in barley to single and multiple foliar diseases. Proceedings of 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. Plant Pathology Society of Alberta.

Scientific and technical reports

Baron, V. and P. Juskiw. 2019. Integration of Forage Quality for Ruminant Nutrition into Western Canadian Cereal Forage Breeding Programs. Interim report: AAF Strategic Research and Development Program

Government of Alberta. 2020. Varieties of Cereal and Oilseed Crops for Alberta, Agdex 100-32. With input from K. Xi.

Juskiw, P and S. Lajeunesse. 2020. Western Cooperative Forage Barley Test: 2019 Report. Submitted to the Prairie Recommending Committee for Oats and Barley. February 2020.

Kabeta, Y., A. El-Mezawy, J. Nyachiro, P. Juskiw, J. Zantinge, L. Oatway, and F. Capettini. 2019. Final Report: Improving yield and sustainability of feed and fodder barley through targeted research in nutrient and water use efficiency. Project Report to Alberta Innovates and Alberta Barley.

Nyachiro, J., T.A. McAllister and W.Z. Yang. 2019. Report on Project 2017F050R / AGR-15699. Development of a rapid screening method to assess grain processing responses of barley as a trait for the selection of feed varieties for cattle. Project Report to Alberta Beef Producers and Strategic Research. December 2019.

Nyachiro, J. and D. Westling. 2020. Western Cooperative Six-Row Barley Registration Test: 2019 Report. Submitted to the Prairie Recommending Committee for Oats and Barley. February 2020.

Turkington, T.K. and K. Xi. 2020. Annual Performance Report 2019 – 2020, Activity 5 FCDC component. Report to National Barley Cluster.

Turkington, T.K. and K. Xi. 2020. Annual Performance Report 2019 – 2020, Activity 7 FCDC component. Report to National Barley Cluster.

Waterman, S. and K. Xi. 2019. Report to PPSA - 40th Annual Meeting of Plant Pathology Society. November 2019.

Waterman, S., K. Kumar and K. Xi. 2020. Wheat and barley disease survey in central Alberta, 2019. Can. Plant Dis. Surv. 100: (in press)

Xi, K. 2020. Western Cooperative 6-row Barley Test disease reaction report. Submitted to Disease Evaluation Team of Prairie Recommending Committee for Oat and Barley. February 2020.

Xi, K. and S. Waterman. 2020. Annual Performance Report for 2019 – 2020 Activity 5 FCDC component. Report to AgriScience Program – Barley Cluster. Principal Investigator: T. K. Turkington.

Xi, K. and S. Waterman. 2020. Annual Performance Report for 2019 – 2020 Activity 7 FCDC component. Report to AgriScience Program – Barley Cluster. Principal Investigator: T. K. Turkington.

Non-refereed articles

Nyachiro, J. and D. Simbo. 2020. Impact of pre-harvest sprouting damage in Alberta wheat and barley. The Grain Exchange. Winter 2020/Vol. 6:4-5.
https://albertawheat.com/files/the_grain_exchange_newsletter_january_2020.pdf

Tours

Aljarrah, M., and S. Lohr. 2019. Lacombe Field Day. July 24, 2019. FCDC farm. Approximately 150 attendees. Discussed: Advances in spring and winter triticale.

Aljarrah, M., S. Lohr, F. Capettini, Y. Kabeta, L. Oatway, P. Juskiw, J. Nyachiro. International Triticale Symposium tour. July 19, 2019. FCDC Farm site. 20 participants. Discussed: overview of the breeding programs at FCDC.

Capettini, F. 2019. Lacombe Field Day. July 24, 2019. FCDC farm. Approximately 150 attendees. Discussed: Introduction to the Field Crop Development Centre.

Capettini, F. SECOBRA Research (France) - Dr. Stephan Hilbers. July 16, 2019. FCDC farm. Discussed overview of breeding programs at FCDC.

Capettini, F. Buck Seed Company (Argentina) - Dr. Diana Martino. July 26 – 30, 2019. FCDC farm. Discussed overview of breeding programs at FCDC.

Capettini, F. Brazilian Cooperative Tour (Brazil). July 30, 2019. FCDC farm and AAFC farm. Discussed overview of breeding programs at FCDC.

Capettini, F., M. Aljarrah, M. Oro. Canterra Seeds - Collette Prefontaine. August 22, 2019. FCDC farm. Discussed overview of breeding programs at FCDC.

Capettini, F., M. Aljarrah, M. MacNaughton. Limagrain Seeds - Jim Peterson, Jason Reinheimer. August 27, 2019. FCDC farm. Discussed overview of breeding programs at FCDC.

Capettini, F., M. Aljarrah, M. Oro, M. MacNaughton. SeCan - Jim Downey, Trent Whiting. August 15, 2019. FCDC farm. Discussed overview of breeding programs at FCDC.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta. Mastin Seeds - Bob Mastin. August 2019. FCDC farm. Presentation of the new and prospective varieties, experiments.

Capettini, F., P. Juskiw, and L. Oatway. Rahr Malting and distribution representatives. May 8, 2019. FCDC farm and office. Approximately 10 participants. Discussed: breeding new barley varieties and FCDC programs.

Capettini, F., P. Juskiw, and L. Oatway. Rahr Malting and distribution representatives. June 18, 2019. FCDC farm and office. Approximately 10 participants. Discussed: breeding new barley varieties and FCDC programs.

Capettini, F., P. Juskiw, and L. Oatway. Rahr Malting and CMBTC Brewer's Tour. July 25, 2019. FCDC Lacombe. Approximately 30-40 participants. Discussed: FCDC program for malt variety development, quality program, germplasm.

Capettini, F., P. Juskiw, J. Zantinge, L. Oatway. AAFC Lacombe staff facility tour. October 17, 2019. FCDC office, lab space, and growth facility. 5 people. Discussed: highlighted the laboratories and growth facilities of FCDC.

Kabeta, Y. and L. Hunt. 2019. Lacombe Field Day. July 24, 2019. FCDC farm. Approximately 150 attendees. Discussed: Barley for forage production.

Nyachiro, J. and P. Juskiw. Lacombe Field Day. July 24, 2019. FCDC farm. Approximately 150 attendees. Discussed: New barley varieties.

Waterman, S. and K. Xi. 2020. AgQuest. March 4, 2020. Two attendees. Discussed: Gave a demo on the procedures for stripe rust inoculation and spore increase.

Xi, K., K. Kumar and S. Waterman. 2019. Lacombe Field Day. July 24, 2019. FCDC farm. Approximately 150 attendees. Discussed: Disease resistance.

Social media

Alberta Agriculture [@albertaag]. March 10, 2020. #AbAgChat: Field Crop Development Centre cereal breeding team discusses new barley and triticale varieties released this spring. Input from: M. Aljarrah, F. Capettini, P. Juskiw, Y. Kabeta.

Peer review

Capettini, F. Beverages Journal. Original research paper (1).

Capettini, F. Colombian Agronomy Journal. Original research paper (1).

Capettini, F. Crop Breeding and Applied Biotechnology. Original research paper (1).

Capettini, F. The Crop Journal. Original research paper (1).

Holtz, M.D. BMC Plant Biology. Original research paper (1).

Holtz, M.D. European Journal of Plant Pathology. Original research papers (2).

Holtz, M.D. Journal of Plant Pathology. Original research papers (2).

Juskiw, P. Agronomy Journal. Original research paper (1).

Juskiw, P. Canadian Journal of Plant Science. Variety description (1).

Juskiw, P. European Journal of Agronomy. Original research paper (1).

Juskiw, P. Ontario Ministry of Agriculture, Food and Rural Affairs. Funding Proposal (1).

Juskiw, P. Plant and Soil. Original research paper (1).

Nyachiro, J. Canadian Journal of Plant Science. Original research paper (1).

Nyachiro, J. Crop Science. Original research paper (1).

Nyachiro, J. Euphytica. Original research papers (2).

Nyachiro, J. Journal of Plant Registrations. Variety description (1).

Nyachiro, J. McGill University, McDonald Campus. Funding Proposal (1).

Nyachiro, J. Ontario Ministry of Agriculture, Food and Rural Affairs. Funding Proposal (1).

Yang, R.-C. Agronomy Journal. Original research papers (1).

Yang, R.-C. BMC Genetics. Original research papers (2).

Yang, R.-C. Crop Science. Original research papers (2).

Yang, R.-C. International Journal of Molecular Sciences. Original research papers (1).

Media features

Baerg, M. 2019. Triticale is holding its own thanks to Alberta Agriculture and Forestry plant breeder, Mazen Aljarrah. Alberta Seed Guide, Fall 2019. Input from Mazen Aljarrah. <https://www.seed.ab.ca/triticale-is-holding-its-own-thanks-to-alberta-agriculture-and-forestry-plant-breeder-mazen-aljarrah/>

Barker, B. 2020. Wheat and barley responses to stripe rust and fungicides. Canadian Agronomist. <https://canadianagronomist.ca/wheat-and-barley-response-to-stripe-rust-and-fungicides/>. Summary based on K. Kumar, K. Xi, T. K. Turkington, M. Aljarrah, and F. Capettini. 2019. Yield responses in spring wheat and barley cultivars, varying in stripe rust resistance in central Alberta. Can. J. Plant Pathol. doi.org/10.1080/07060661.2019.1680443.

Bergen, R. 2020. Barley Comes up the Backstretch. Canadian Cattlemen. February 3, 2020. Input from F. Capettini.

Bergen, R. 2020. Barley Comes up the Backstretch. Beef Cattle Research Council blog, republished from Canadian Cattlemen. February 10, 2020. <https://www.beefresearch.ca/blog/barley-comes-up-the-backstretch/>. Input from F. Capettini.

Blair, J. 2019. New feed and forage barley lines bring high yields, strong standability. Alberta Farmer Express. March 13, 2020. <https://www.albertafarmexpress.ca/crops/cereals/barley/new-feed-and-forage-barley-lines-bring-high-yields-strong-standability/>. Input from F. Capettini.

Geddes, G. 2019. Beating the bushels-per-acre barrier. Grains West. March 01, 2019. <https://grainswest.com/2019/01/beating-the-bushels-per-acre-barrier/>. Input from F. Capettini.

Kossowan, K. 2019. Barley through the value chain. Video (in production). With input from: F. Capettini, P. Juskiw, L. Oatway.

Mendonsa, K. Celebrating the Lacombe Research Centre with 2019 Field Day. Lacombe Online. July 24, 2019. <https://lacombeonline.com/ag-news-ab/la-field-day>. Input from F. Capettini.

Olafson, K. 2019. Flavio Capettini and the FCDC: Keeping Canadian Barley Competitive. Alberta Barley, Barley Country. May 15, 2019. <https://www.albertabarley.com/flavio-capettini-and-the-fcdc-keeping-canadian-barley-competitive/>. Input from F. Capettini.

Collaboration

Juskiw, P. J. Bowness, and C. Weidner. Integration of Forage Quality for Ruminant Nutrition into Western Canadian Cereal Forage Breeding Programs. With: Alberta Agriculture and Forestry Strategic Research and Development Program, Forage trials for Oat and Barley; Oat Advantage; Crop Development Centre – University of Saskatchewan; AAFC Brandon. April 2019 – March 2020.

Juskiw, P. and S. Lajeunesse. Coordinators. Western Cooperative Forage Barley Test. With: Prairie Recommending Committee for Oat and Barley. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Advanced barley breeding tests. With: Ana Badea, AAFC-Brandon. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Advanced barley breeding tests. With: Aaron Beattie, Crop Development Centre – University of Saskatchewan. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Advanced barley breeding tests. With: James Anderson, Nutrien. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Yield trials. With: Ludovic Capo-Chichi, Alberta Innovates. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Western Cooperative Two Row Barley Registration Test. Prairie Recommending Committee for Oat and Barley. April 2019 – March 2020.

Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Western Cooperative Six Row Barley Registration Test. Prairie Recommending Committee for Oat and Barley. April 2019 – March 2020.

- Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Western Cooperative Hulless Barley Registration Test. Prairie Recommending Committee for Oat and Barley. April 2019 – March 2020.
- Capettini, F., P. Juskiw, J. Nyachiro, Y. Kabeta, L. Oatway, D. Westling, J. Bowness. Western Cooperative Forage Barley Registration Test. Prairie Recommending Committee for Oat and Barley. April 2019 – March 2020.
- Nyachiro, J., P.E. Juskiw, Y. Kabeta, F. Capettini, L. Oatway, R-C. Yang. 2019. Project 2017F050R: Development of a rapid screening method to assess grain processing responses of barley as a train for the selection of feed varieties for cattle. With: T.A. McAllister and W.Z. Yang, AAFC Lethbridge; M. Oba, University of Alberta; M-L. Swift, Hi-Pro Feeds; and M. May. 2018 - 2021.
- Nyachiro, J., P.E. Juskiw, Y. Kabeta, F. Capettini, L. Oatway, R-C. Yang, J. Zantinge, K. Xi. 2019. Project 208F105R: Determining the critical traits associated with lodging in Canadian barley varieties and elite breeding lines. With: L. Capo-Chichi, InnoTech. 2018 – 2021.
- Oatway, L. Advisor/calibration specialist. Evaluation of NIRS for glyphosate residue in barley. With: Kevin Sich, Rahr Malting Co. 2019 – 2020.
- Oatway, L. Advisor/calibration specialist. Advanced agronomy research project. With: Sheri Strydhorst, Alberta Agriculture and Forestry. November 2019.
- Oatway, L. Advisor/calibration specialist. Barley profitability. With: Laurel Thompson, Lakeland College. November 2019.
- Oatway, L. Advisor/calibration specialist. Perennial research project. With: Erin Day, University of Alberta. July – November 2019.
- Oatway, L. Advisor/calibration specialist. Biosolid project. With: Germar Lohstraeter, Agri-Environmental Innovation. February 2020.
- Oatway, L. Advisor/calibration specialist. Evaluation of NIRS for predicting DON in barley samples. With: Canada Malt. September – October 2019.
- Oatway, L. Advisor/calibration specialist. Evaluating NIRS for segregating leaf cutter bee cocoons. With: Alberta Agriculture and Forestry. April –September 2019. Ongoing.
- Xi, K. Co-investigator. Phenotyping barley breeding lines and germplasm for disease resistance (Activity 5). With: T.K. Turkington, AAFC Lacombe Research and Development Centre. April 2018 – March 2023.

- Xi, K. Co-investigator. Barley pathogen variation and surveillance: implications for managing disease via host resistance and fungicides (Activity 7). With: T.K. Turkington, AAFC Lacombe Research and Development Centre. April 2018 – March 2023.
- Xi, K. and F. Capettini. Co-investigators. Phenotyping barley for scald resistance. With: Cameron Stevenson, Crop Diversification Centre, Alberta Agriculture and Forestry. Ongoing from 2016.
- Xi, K. Co-investigator. Screening barley, wheat and triticale for stripe rust resistance in Pullman and Mt. Vernon, the Pacific North West region. With: Xian Ming Chen, Washington State University, USA. 2010 - 2021.
- Yang, R-C. Co-Investigator. Genetics and Improvement of Earliness in Canadian Spring Wheat. Agriculture Funding Consortium. With: Dean Spaner (Principal Investigator), Department of Agricultural, Food and Nutritional Science, University of Alberta. April 2018 – March 2021.
- Yang, R-C. Co-Investigator. Western gall rust resistance in pines: using genomics to discover resistance mechanisms and develop new tools for tree breeding. Natural Sciences and Engineering Research Council of Canada (NSERC) Strategic Partnership Grants for Projects (SPG-P). With: Janice Cooke (Principal Investigator), Department of Biological Sciences, University of Alberta. October 2018 – September 2021.

Alberta Agriculture and Forestry Teamwork Recognition Award

- FCDC Staff. 2019. AAF Teamwork Recognition Award: Field Crop Development Centre Cereal Breeding Program.
- Oatway, L., R.-C. Yang, C. Weidner. 2019. AAF Teamwork Recognition Award: AAF Advanced Agronomy Research Team. With team members: Sheri Strydhorst, Robyne Bowness, Doon Pauly, Jackie Tieulie, Susan Jess, Chelsea Jaeger, Brandi Kelli, Alexander Fedko, Trina Dubitz, Allan Middleton, Pat Pfiffner, Colin Enns, Tabitha MacKinnon, Kabal Gill, Laurel Thompson.

Additional knowledge transfer

- Capettini, F. Member, Plant Breeder. Canadian Seed Growers Association. 2013 - Present
- Capettini, F. Full Voting Member. Barley Quality Evaluation Team of Prairie Recommending Committee for Oat and Barley. 2014 - Present

Capettini, F. Full Voting Member. Barley Agronomy Evaluation Team of Prairie Recommending Committee for Oat and Barley. 2014 - Present

Capettini, F. Member. International Organizing Committee of the International Barley Genetics Symposium. International team of barley experts that organize the IBGS every four years. 2012 – Present.

Holtz, M.D. Chair and Website editor. Website Committee. Canadian Phytopathological Society. 2016-present

Juskiw, P. Reviewer. Fellow's Award review. Crop Science Society of America. 2019.

Kabeta, Y. Full Voting Member. Barley Agronomy Evaluation Team of Prairie Recommending Committee for Oat and Barley. 2009 - Present

Oatway, L. Presenter/classroom resource. Classroom Agriculture Program, AAF. Aspen Heights Elementary School. May 13th, 2019. Changes in Agriculture.

Oatway, L. Presentation/classroom resource. Classroom Agriculture Program, AAF. Clive Elementary School. May 9th, 2019. Changes in Agriculture.

Oatway, L. Presentation/classroom resource. Classroom Agriculture Program, AAF. Normandeu Elementary School. May 8th, 2019. Changes in Agriculture.

Oatway, L. Presentation/classroom resource. Classroom Agriculture Program, AAF. G.W. Smith Elementary School. May 28th, 2019. Changes in Agriculture.

Waterman, S. Secretary. Plant Pathology Society of Alberta. 2019.

Waterman, S., M. Holtz, K. Kumar, and K. Xi. Organizing Committee. 40th annual meeting of Plant Pathology Society of Alberta. Lacombe, AB. November 4-6, 2019. With assistance of N. Rauhala, J. Bussan, and T.K. Turkington.

Xi, K. President. Plant Pathology Society of Alberta. 2019.

K. Xi. Voting member. Disease evaluation team of Prairie Recommending Committee for Oat and Barley. 2005 – present.

K. Xi. Voting member. Disease evaluation team of Prairie Recommending Committee for Wheat, Rye and Triticale. 2005 – present.

Yang, R-C. Reviewer/assessor. Career Assistance Network/Ashton Selig. Telephone conversation and email exchanges. March 17-24, 2020. GoA's occupational profiling of biostatistician for medical and health care professions.

Yang, R.-C. Supervisor/co-supervisor. Two research associates. University of Alberta. 2019-2020.

Yang, R.-C. Supervisor/co-supervisor. Two graduate students. University of Alberta. 2019-2020.

Yang, R.-C. Supervisor/co-supervisor. Eight supervisory committees with 1 completion. University of Alberta. 2019-2020.

Yang, R.-C. Professor. AN SC 384 Principles of Animal Genetics. University of Alberta. September – December 2019.