1. **Project title and reporting period.**

   Breeding milling oat varieties with improved agronomic, quality and disease traits for Saskatchewan oat producers
   20180260
   July 1, 2022 – June 30, 2023

2. **Name of the Principal Investigator and contact information.**

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3. **Name of the collaborators and contact information**

   None.

4. **Abstract (Not more than 250 words).** *Describe in lay language the progress towards the project objectives over the last reporting period. Include any key findings and any interim conclusions. Include any deviations from the original methodology.*

   Good progress on the objectives for project 20180260 was made in 2022-23. The 2022 growing season was a significant improvement over the very dry and hot 2021 season. There was adequate soil moisture available for spring seeding which commenced on May 5 and was completed on May 28 with only minimal delays due to rain. Timely rains throughout June and July, combined with warm to hot conditions led to good growth with yields being average to above average. From May 1-August 31 Saskatoon received 1,399 GDD (5°C base) with the 5-year average being 1,348 GDD, and received 135 mm of precipitation with the 30-year average being 216 mm. Overall, plots at Goodale, Preston, Seed Farm, Kernen, Melfort and Codette SK, Lacombe AB, and Ft. Whyte, Portage-la-Prairie and Brandon, MB were uniform and produced good data. The Roblin, MB site had seeding issues which produced high CVs. Harvest began on August 12 and was completed by September 8 with no frost received prior to completion. Good data was produced from almost all sites during the 2022 season and all material moved through the program normally. During the summer 6,676 lines were evaluated at disease nurseries coordinated by the University of Saskatchewan for crown rust, stem rust, smut, fusarium head blight and barley yellow dwarf virus. All nurseries provided good data in 2022. Over the winter a total of 39,988 marker data points were collected on breeding material related to four crown rust resistance genes and one quality trait, and 21,097 analyses were conducted in the quality lab for beta-glucan, total dietary fiber, protein, oil and groat percentage. Forty-eight new crosses were made in 2022. **OT3115**, which was supported for registration in February 2023, was licensed to FP Genetics.

5. Introduction: *Brief project background and rationale.*

Oat is considered a healthy cereal due to a number of nutritional compounds found within the grain, including beta-glucan. Beta-glucan is a soluble fiber that has been shown to lower plasma cholesterol and reduce the risk of heart disease. This has resulted in health claims being established in both Canada and the United States. Oat grain also contains a number of antioxidant compounds, including the polyphenolic avenanthramides, which have anti-inflammatory effects that may protect against coronary heart disease. Oat contains 12-20% protein which is rich in globulins and contains more lysine and threonine than other cereals, and provides a better balance of essential amino acids. Finally, oat is able to be consumed by most people suffering from celiac disease and is thus considered to be gluten-free.

As a result of these desirable attributes, oat remains a significant Canadian crop that has been seeded on an average of 3.7 million acres over the past three years, with Saskatchewan accounting for 50% of these acres. Over the past three years, 50% of the 3.8 million metric tonnes (MT) of oat produced annually in Canada has been exported to the U.S., destined for the food market. In addition to the export of raw oat, oat is critical to the domestic milling industry. Total annual domestic milling in Canada is close to 1,225,000 MT, with Saskatchewan being home to Richardson Milling (Martensville), Grain Millers (Yorkton), Ardent Mills (Saskatoon), and Avena Foods (Regina), or about half of all milling production. Investment in domestic milling capacity continues to be strong, with the announcement in late 2019 of a new Patterson GlobalFoods oat mill near Winnipeg, MB. Combined sales of oat and milled oat products were valued at almost $1.1 billion last year. In addition, farm-gate sales of oat represent an estimated value of $700 million to growers.

Saskatchewan currently holds a strong position in supplying the North American oat market due to the steady decline in U.S. oat acres since the 1980s and our proximity to the main US oat distribution hub in Minneapolis, MN. In addition to the long-term, stable U.S. export market, two other markets hold promise to increase demand for Canadian oat. Firstly, Mexico has become the second largest importer of Canadian oat in recent years, in part due to recent marketing efforts by the Prairie Oat Growers Association (POGA), and the purchase of Canadian Oat Milling (Namo, Alberta) by Grupo Vida. Secondly, POGA is working to gain market access to China for Canadian oat. In 2017 China purchased about 500,000 MT of oat from Australia, up from just 50,000 MT in 2009, and in 2020/21 imports sat at 320,000 MT. Access to the Chinese market, currently valued at $100 million, could become a strong export market for Canadian oat, as it is in barley where China is now the leading importer of Canadian barley (having recently surpassed the U.S.).

To build on Saskatchewan's (and Canada's) position as a supplier of premium quality oat to current U.S. markets (and developing markets in Mexico and China) require developing varieties with improved agronomic, quality and disease resistance (traits that are current breeding targets for the CDC oat breeding program). This will provide value to growers, through improved yield and harvestability which will help oat remain a viable crop within a growers rotation, and to millers/food processors, through higher selectability (i.e. good plumpness and test weight) and better nutritional profile (i.e. higher beta-glucan and protein, lower fat). In addition, the CDC is exploring new traits for incorporation into future Canadian oat varieties that may add value to the crop. For example, the CDC has begun crossing with oat lines which possess very few trichomes (i.e. 'hairs') on the groat. Oat trichomes are known to be irritating and can cause allergic reactions, in addition they form a fine dust when removed from the groat during grain handling, or when groats are dehulled and scoured, which can be hard on equipment. When speaking to several Canadian oat millers about producing a 'hairless' oat groat, there was interest in understanding if this will have benefits to the oat grower and miller in terms of less irritation, and if it will allow more efficient dehulling.

This proposal is part of our effort to maintain the viability and productivity of the CDC oat breeding program which will allow us to build on our past oat variety successes through continued focus on improving agronomics, milling and nutritional quality and disease resistance. We will also expand our efforts to increase protein content and improve stem rust resistance while also incorporating novel traits, like 'hairless' groats, to understand their potential impact and importance to growers and millers.

6. Objectives and the *progress towards meeting each objective*

Objectives (*Please list the original objectives and/or revised objectives if Ministry-approved revisions have been made to original objective. A justification is needed for any deviation from original objectives)*	**Progress (e.g. completed/in progress)**
a) Produce improved milling oat varieties	A total of 245 early generation milling oat populations, and 2,584 advanced milling oat lines were grown and evaluated in 2022 for agronomic performance and reaction to various diseases. Physical grain quality traits were also evaluated. **OT3115** was supported for registration in 2023 and licensed to FP Genetics. Two lines were advanced to 2nd year registration testing and five lines were advanced to 1st year registration testing in 2023.
b) Nutritional quality evaluation	12,857 milling oat samples were collected from 2022 field trials, ground, scanned by NIT or NIR, and evaluated for a combination of traits including beta-glucan, protein and fat. A total of 21,097 analyses were conducted, including 3,041 beta-glucan, and 12,857 protein and fat analyses. This data was used to assist in decisions regarding lines to advance to 2023 trials.
c) Produce 'hairless' groat milling oat lines	No crosses were made in 2022 with the hulless, hairless groat variety VAO-51 to incorporate this trait into elite breeding lines adapted to western Canada. Five lines were advanced to the POYT and 38 lines to the POMP advanced testing generations that were derived from crosses with the VAO-51 parent.

7. Methodology: *Specify project activities undertaken during this reporting period. Include approaches, experimental design, tests, materials, sites, etc. Please note that any significant changes from the original work plan will require written approval from the Ministry.*

<u>Breeding Objectives and Targets</u>

Objectives and targets related to agronomics, physical grain quality, nutritional grain quality and disease resistance desired in future oat varieties are as follows (traits are listed in priority order beneath each general category and targets are expressed relative to current best varieties to provide guidance for future, desired improvements in varieties):

1. Agronomics

Grain Yield: better than CDC Arborg
Lodging resistance: equal to or better than CDC Arborg
Maturity: equal to or earlier than CDC Arborg
Plant height: equal to or shorter than CDC Endure

2. Physical Grain Quality

Groat percentage: equal to or better than CDC Arborg
Test weight: better than CDC Arborg
Plumpness/Thins: equal to or better than CDC Endure
Thousand kernel weight: equal to or better than CDC Endure

White hull: equal to CDC Arborg or CDC Endure
Uniformity (fewer tertiary kernels): equal to CDC Dancer
Hairless: no comparator, using VAO-51

3. Nutritional Grain Quality

Beta-glucan: equal to or higher than CDC Endure
Fat: equal to or lower than CDC Endure
Protein: equal to or higher than Leggett
Total dietary fibre: equal to or greater than Leggett

4. Disease Resistance

Crown rust: equal to or better than CDC Endure (MR)
Stem rust: Intermediate reaction or better
Smut: equal to CDC Endure (R)
Fusarium head blight: MR or better
BYDV: intermediate reaction or better

Strategy

Breeding milling oat varieties will begin with bi-parental or three-way crosses made in the greenhouse (University of Saskatchewan). 40 to 60 crosses will be targeted per year. Parental lines are chosen to maximize the potential to produce progeny containing the desired agronomic, quality and disease trait package indicated above. With respect to the 'hairless' trait, a limited number of crosses with the hairless line VAO-51 will be used to introduce this trait into elite breeding germplasm. Selection for the trait will be based on visual examination of the grain.

Progeny populations will be quickly advanced from the F1-F5 generations using a bulk breeding strategy in combination with single seed descent. Bulk populations will be grown at the Saskatoon Seed Farm during the summer and either as bulk populations in our winter nursery located in Leeston, New Zealand (Southern Seed Technology Ltd.), or as single seed descent populations in the U of S greenhouse. Single F5 plant selections (300-400) from each population will be selected in the field based on maturity, height and disease (if present) and further selected based on physical seed quality and/or molecular markers. In addition, a small number of populations (2 or 3) will be selected based on genomic selection (GS) predictions.

F6 hill populations will be grown in Saskatoon in the summer with approximately 50% of hills culled in the field based on visual traits (e.g. straw strength, height, lodging) and a further 50% culled after threshing of field selected hills based on NIT-predicted seed quality (protein, beta-glucan, fat, groat percentage). Unreplicated F7 microplots (MPs) will be grown in a modified augmented design the following year in Saskatoon with 50% culling in the field and a further 50% culling based on nutritional and physical grain quality. Field selection is based on maturity, height, lodging resistance, leaf diseases (if present) and overall appearance. Nutritional quality traits (i.e. protein, fat) are evaluated using NIT predictions while beta-glucan is evaluated using wet chemistry. Physical grain quality assessed included test weight, plumpness/thins, thousand kernel weight, and groat percentage. Lines are subjected to crown rust evaluation in Guelph, ON.

Selected F8 lines are then grown the following year in two replication randomized complete block design (RCBD) preliminary yield tests (POYTs) grown at the Kernen Crop Research Farm (KCRF), AAFC-Melfort farm and the Goodale Research Farm. No selection is done in the field. Lines are evaluated for yield along with the nutritional and physical grain quality characteristics mentioned for the MPs. All lines are subjected to crown rust evaluation in Guelph, ON and smut evaluation in St. Paul Minnesota.

Advanced F9 lines are then tested for one more year in advanced yield tests (SOYTs) as three replicate RCBD tests grown at 5-6 locations, depending on the trial (KCRF, Goodale, Melfort and Codette, SK, Brandon and Roblin, MB, Lacombe AB). Lines are evaluated as in the PBYTs, except total dietary fibre (TDF) using wet chemistry, barley yellow dwarf virus (BYDV) is evaluated in Champaign, Illinois, adult plant resistance (APR) to crown rust is evaluated in St. Paul, MN and stem rust resistance is screened in Morden, MB.

Selected lines are then advanced for two years of testing in the Western Cooperative Oat Registration Trial grown at 15 sites across Western Canada in three replication RCBD tests. If deemed to have merit by the Prairie Recommending Committee on Oats and Barley (PRCOB), lines are then registered and tendered for sale to producers in Canada.

Germplasm Exchange

The CDC oat breeding program conducts extensive germplasm exchanges with oat breeding programs within Canada and around the world in order to access new genetics that can be incorporated into future varieties targeted for Western Canada. Exchanges currently exist with:

Dr. K. Nilsen (AAFC-Brandon Research and Development Centre, Brandon, MB)
Dr. W. Yan (AAFC-Ottawa Research and Development Centre, Ottawa, ON)
Dr. V. Chabot (Sollio, St-Hyacinthe, QC)
Dr. S. Harrison (Louisiana State University, Baton Rouge, LA)
Dr. A. Ceplitis (Lantmannen, Sweden)
Dr. P. Richter (General Mills)

Molecular Marker-Assisted Selection (MMAS)

Molecular marker-assisted selection (MMAS) is an essential part of the CDC breeding program and is conducted on the F5 space-planted generation and lines at the F6 single seed descent generations. MMAS is conducted using the Taq-Man (ABI) marker system in combination with the ABI StepOnePlus™ Real-Time (RT)-PCR machine. MMAS is conducted for the Pc45, Pc91, Pc94 and APR crown rust resistance genes and the low acid detergent lignin trait.

Nutritional Quality Evaluation

For nutritional quality evaluation, clean whole grain oat samples are analyzed using either an Infratec 1241 Grain Analyser or Infratec Nova (Foss North America, Eden Prairie, MN) to predict grain quality traits such as groat, oil, protein, and hull lignin content. Dehulling oat grain for chemical analysis and determination of groat percentage is accomplished using a Codema Laboratory Oat Huller (Codema, LLC, Maple Grove, MN) on a 50g sample of oat grain. Post-dehulling, whole oat groat samples are analyzed with the NIRS DS2500 Analyser (Foss North America, Eden Prairie, MN) to predict beta-glucan content. Grain quality predictions are developed and monitored/validated in-house using the Foss calibration development software WinISI (version 4.6) and ODIN (version 4.42) application model maker (for use with the Infratec 1241).

Oat samples are prepared for chemical laboratory analysis by grinding 20 g of groats to pass through 0.5 mm screen using a Retsch ZM 200 Ultra Centrifugal Laboratory Mill (ATS Scientific Inc, Burlington, ON). The resulting wholemeal samples are then analyzed for Total Dietary Fibre (TDF), oil, protein and beta-glucan. TDF percentage is measured on samples using Ankom's Automated Dietary Fiber Analyzer (Ankom Technology, Macedon, NY) in accordance to AOAC method 991.43. Oil percentage is quantified by the official method AOCS Am 5-04 using hexane as the solvent in the automated Ankom's XT15 Fat Extractor (Ankom Technology, Macedon, NY). Protein percentage is determined using the AACC 46-30.01 combustion method (%Nx6.25), using a Leco FP-628 Nitrogen Analyzer (Leco Corporation, St. Joseph, MI). Beta-glucan is obtained by extracting samples in a dilute acid with the supernatant being loaded into Thermo Fisher Scientific's Gallery Discrete Photometric Analyzer for quantification using beta-glucan (high MW) test kits purchased also from Thermo Fisher Scientific (Thermo Fisher Scientific, Mississauga, ON).

8. Results and discussion: *Describe research accomplishments during the reporting period under relevant objectives listed under section 6. The results need to be accompanied with tables, graphs and/or other illustrations. Provide discussion necessary to the full understanding of the results. Where applicable, results should be discussed in the context of existing knowledge and relevant literature. Detail any major concerns or project setbacks.*

<u>Crossing and Early Generations</u>

A total of 48 new crosses were made in the greenhouse during the 2022 winter, summer and fall crossing blocks. Sub-categories of crosses included introductions, crown rust resistance, adult plant crown rust resistance, reduced tillering, general and yield. The F1 generation from the winter and summer crossing blocks were sent to the winter nursery in Leeston, New Zealand (Southern Seed Technology, Ltd.) for seed increase over the winter of 2022-23. The F1 generation from the fall crossing block was increased in the greenhouse during the winter of 2022-23.

Thirty-four F2 generation populations were grown as bulk plots in Saskatoon during the summer of 2022. F3 seed harvested from these plots were subsequently sent to our New Zealand winter nursery for generation advancement over the winter of 2022-23. Twenty-four F3 generation populations were grown as bulk plots in Saskatoon during the summer of 2023. F4 seed harvested from these plots were subsequently sent to our New Zealand winter nursery for generation advancement over the winter of 2022-23. Fifty-eight F4 generation populations were grown as bulk plots in Saskatoon during the summer of 2022. F5 seed harvested from these plots were subsequently sent to our New Zealand winter nursery for generation advancement over the winter of 2022-23.

Thirty-one F6 space-planted populations were grown in Saskatoon in the summer of 2022 with 400 single plant selections from each population harvested and further culled based on physical seed quality and/or molecular markers to 200 lines per population.

Twenty-nine F6 hill and F6 single-seed descent (SSD) hill populations were grown in Saskatoon in the summer of 2022. Approximately 50% of hills were culled in the field with a further 50% culled after threshing of field selected hills based on physical seed quality and NIT-based prediction of hull, total fat and protein content.

Sixty-nine F7 hill and F7 SSD hill populations were grown in Saskatoon in the summer of 2022. Approximately 50% of hills were culled in the field with a further 50% culled after threshing of field selected hills based on physical seed quality and NIT-based prediction of hull, total fat and protein content.

<u>Winter Nursery Increases</u>

Over the winter of 2022-23 the following populations were grown for seed increase at the winter nursery located in Irwell, New Zealand (Southern Seed Technology, Pty.):

25 F1 row populations derived from 2022 crosses.
10 F2 bulk increase populations derived from 2022 crosses.
34 F3 bulk increase populations derived from 2021 crosses.
24 F4 bulk increase populations derived from 2020 and 2021 crosses.
58 F5 bulk increase populations derived from 2020 crosses.

<u>Advanced Generations</u>

Preliminary Oat MicroPlots (POMP)

A total of 1,891 lines were evaluated at the POMP stage as un-replicated plots in Saskatoon in the summer of 2022 with 50% culling in the field and a further 50% culling based on chemical and/or physical grain quality. Field selection was based on maturity, height, lodging resistance, leaf diseases (if present) and overall appearance.

Chemical quality traits evaluated included, protein content, oil content and beta-glucan content, depending on the population. Physical grain quality assessed included hull percentage, test weight, plumpness and seed weight. Lines were subjected to appropriate disease evaluation (crown rust at Guelph, ON). 495 lines were advanced to the 2023 Preliminary Oat Yield Trials (POYT).

Preliminary Oat Yield Trials (POYT)

594 lines were tested at the POYT stage in two replication tests grown at the Kernen Crop Research Farm (KCRF), the Goodale Research Farm and either Melfort or Codette, SK (milling lines), or KCRF and Goodale (forage lines). No selection was done in the field. Lines were evaluated for yield along with the chemical and physical grain quality characteristics mentioned for the POMP. Lines were subjected to appropriate disease evaluation (crown rust at Guelph, ON; oat smut at University of Minnesota). Ninety-nine (99) lines were advanced to the 2023 Standard Oat Yield (SOYT) and ENCORE Trials.

Standard Oat Yield (SOYT) and ENCORE Trials

Ninety-nine (99) lines were tested at the SOYT/ENCORE stage in two or three replicate tests grown at 5-6 locations, depending on the trial (Codette, Goodale, KCRF, SK; Lacombe, AB; Brandon, Portage-la-Prairie, Ft. Whyte, Roblin, MB; and Ottawa, ON). Lines were evaluated as in the POYTs. Lines were subjected to appropriate disease evaluation (crown rust at Guelph, ON, Saskatoon, AAFC-Morden and the University of Minnesota; oat smut at the University of Minnesota; stem rust at AAFC-Morden, Saskatoon and Ft. Whyte, FHB at AAFC-Morden, BYDV at the University of Illinois).

Five milling lines were advanced to the 2023 Western Co-operative Oat Registration test (WCORT) (Table 1). General characteristics of the lines are as follows:

OT3125: MR CRR, I SRR, R Smut, >>YLD, shrtr, strg, ok Mat, >TWT, >>TKW, >>PLP, <<THINS, ok MY, Wht, BG=Sum, Fat<Leg, ok Prot

OT3126: I CRR, S SRR, R Smut, >YLD, Tlr, strg, erlr, >TWT, >>TKW, >>PLP, <<THINS, >erMY, Wht, BG>Leg, Fat=Dan, ok Prot

OT3127: I CRR, S SRR, S Smut, >>>YLD, Tlr, strgr, erlr, >TWT, >>TKW, >>PLP, <<THINS, ok MY, Wht, BG=Leg, Fat=Dan, ok Prot

OT3128: Pc94, MR-I SRR, R Smut, >YLD, shrt, strg, erlr, ok TWT, >TKW, >>PLP, <<THINS, ok MY, Wht, BG>Leg, Fat=Dan, <erProt

OT3129: I CRR, S SRR, S Smut, >>>YLD, ok HT, strg, erlr, ok TWT, >TKW, >PLP, ok THINS, <erMY, Wht, BG>Leg, Fat=Dan, >erProt

Table 1. Summary of lines being advanced to the 2022 WCORT.

2023 Coop#	**CDC#**	**Pedigree**	**Type**	**2022 SOYT#**
OT3125	SA200043	OT2119/OT3100	Milling	2022 SOYT#1-7
OT3126	SA200069	OT2119/OT3102	Milling	2022 SOYT#1-16
OT3127	SA200847	CDC Endure/CDC Arborg	Milling	2022 SOYT#2-32
OT3128	SA200898	CDC Endure/OT3098	Milling	2022 SOYT#3-5
OT3129	SA201243	SW141022/CDC Endure	Milling	2022 SOYT#3-21

Cooperative Testing

OT3115 was proposed for, and received, support for registration at the 2023 PGDC meeting. **OT3121** and **OT3123** were advanced for a 2nd year of testing in the 2023 WCORT. All other CDC oat lines were dropped from further testing in the WCORT.

Breeder Seed Production

Advanced Bulk Increases

0.02 acre plots of 2022 WCORT 1st year (**OT3121**-**OT3124**) milling entries were grown. Approximately 250 heads were taken from the 1st year entries for potential Breeder Seed purification. **OT3121** and **OT3123** were threshed and will be used to plant 2023 breeder hills. The others were discarded.

Breeder Hills

Breeder hills are the initial stage of Breeder Seed purification produced for 2nd year cooperative testing lines. In 2022 no breeder hills were produced.

Breeder Long Rows

Breeder long rows are the second stage of Breeder Seed purification produced for lines supported for registration that year.

Breeder long rows were grown for **OT3115** in 2022.

Breeder Seed and Special Increases

0.67 acre Breeder Seed plots of **CDC Arborg**, **CDC Anson** and **CDC Dancer** were grown at KCRF to increase seed stock of this variety.

0.3 acre special increases were grown for no varieties.

Plant Breeders Rights (PBR) Trials

CDC Anson (**OT3112**) completed second year PBR trials in 2022. Grant of PBR is pending.

Variety Registration

No varieties were registered with CFIA in 2022-23.

Miscellaneous Trials

The oat tests listed in Table 2 were planted in 2022 as part of collaborative exchanges or cooperative testing. These tests continue to be a valuable resource for identifying and evaluating oat germplasm that can be used in the CDC crossing block as parents to diversity and improve the genetic base of the CDC oat breeding program. Eight lines grown in these collaborative tests were used in the 2022 crossing block as parents to incorporate traits such as crown rust resistance, beta-glucan and agronomic traits.

Table 2. Collaborative or exchange test grown by the CDC in 2022.

Test	Coordinating Organization	Entries	Reps	Sites
WCORT	AAFC-Brandon (Nilsen)	36	3	1
UMOPN	University of Minnesota (Kianian)	34	3	1
UEOPN	University of Minnesota (Kianian)	25	3	1
ENCORE	AAFC-Ottawa (Yan)	216	2	1
SW Oat	Lantmannen (Ceplitis)	208	1	1
Canterra Oat	Canterra (Badea)	21	3	1
22-ES3403-SKT	Coop Federee (Chabot)	28	3	1
Quaker Area Trial	PepsiCo (Beattie)	21	3	1
SACGC-Oat	CDC/Sask. Ag. and Food (Tetland)	11	3	1
QION	Louisiana State University (Harrison)	119	1	1

Disease Nurseries

6,676 lines were evaluated at nurseries coordinated by the University of Saskatchewan (Saskatoon; Dr. Randy Kutcher) for crown rust (654 lines) and stem rust (1,431), University of Guelph (Guelph, ON; Dr. Duane Falk) for crown rust (2,994 lines), AAFC-Morden for crown rust, stem rust, smut and FHB (Morden, MB; Drs. Tom Fetch, Jim Menzies and Xiben Wang) (109 lines), University of Minnesota (Minneapolis, MN; Dr. Shahryar Kianian) for crown rust (124 lines), University of Minnesota (Minneapolis, MN; Dr. Ruth Dill-Macky) for smut (661 lines), Murphy et al. (Ft. Whyte, MB; Keith Murphy) for crown rust and stem rust (248 lines) and University of Illinois (Urbana, IL; Dr. Juan Arbelaez) for BYDV (260 lines). This information was obtained on lines entered in the WCORT, as well as, the SOYTs, POYTs and POMPs. This data was extremely valuable when making selection decisions.

Molecular Marker-Assisted Selection (MMAS)

A total of 39,988 marker data points was obtained on CDC oat lines harvested from the F5 and F6 space-planted generations, and lines at the F6 and F7 SSD generations. This work was completed in the Crop Molecular Genetics Lab at the University of Saskatchewan. Molecular marker-assisted selection (MMAS) was conducted using the Taq-Man® (ABI) marker system in combination with the ABI StepOnePlus™ Real-Time (RT)-PCR machine. MMAS was conducted for the *Pc91* crown rust resistance gene, the *Pc94* crown rust resistance gene, the *PcKM* (*Pc45*) crown rust resistance gene, the *PcAS* crown rust marker, APR (from MN841801) crown rust resistance and the low acid detergent lignin trait.

Quality Lab

The Grain Quality Lab completed 21,097 analyses over the 2022-23 screening year. Table 3 lists the number of lines tested for each trait at each stage in the breeding program. We continue to develop Near Infrared Reflectance Spectroscopy (NIR) and Near Infrared Transmittance Spectroscopy (NIT) calibration curves predictive of quality traits. These tools can allow us to screen more samples at earlier generations, thus providing us with other selection criteria on which to discard poor lines. To improve the correlation between predicted and actual values, all lines on which wet chemistry analysis is done are also scanned with the NIR (Foss NIRSystem DS2500) and NIT (Foss Infratec 1241 Grain Analyser and Foss NOVA). These data points are added to the database and the prediction is recalibrated. We currently have very good NIT calibration curves for protein, total oil and groat percentage which are used to cull lines at the hill plot and advanced generation stages of the program. We are currently building calibrations curves for beta-glucan.

Good progress is being made as a result of these screening efforts. Of lines entering the 2023 WCORT, one line shows groat percentage similar to, or better than, CDC Endure (**OT3126**) while three lines (**OT3126**, **OT3128**, and **OT3129**) contain beta-glucan equal to or greater than CS Camden. Additionally, three lines show protein content similar to (**OT3126**, **OT3126**, **OT3127**) or higher than Summit (**OT3129**) and four lines (**OT3126-OT3129**) contains total fat at the low levels shown by CDC Morrison.

Table 3. Summary of analyses conducted at the CDC Grain Quality lab in 2022-23.

Oat Field Trial	NIT	NIR	BG	TDF	Moisture	Protein	Oil	ADL	Totals
Validation	17	17	17	17	17	17	17	17	**136**
SOYT/ENCORE	356	356	356	216	324	216	216	32	**2,072**
Exchange Trials	558	558	558	36	-	-	-	-	**1,710**
POYT	1,296	1,296	1,296	207	-	-	-	-	**4,095**
POMP	1,500	1,500	546	-	-	-	-	137	**3,683**
Misc. MP Trials	250	-	250	-	-	-	-	-	**500**
Misc. Yield Trials	46	-	18	-	3	-	-	-	**67**
F6 Hill Trials	2,576	-	-	-	-	-	-	-	**2,576**
F7 Hill Trials	6,029	-	-	-	-	-	-	-	**6,029**
Misc. Hill Trials	229	-	-	-	-	-	-	-	**229**
Totals:	**12,857**	**3,727**	**3,041**	**476**	**344**	**233**	**233**	**186**	**21,097**

ADL=acid detergent lignin content of hulls (wet chemical analysis)
BG=beta-glucan (Gallery Analyzer)
Moisture: measurement of groat moisture to assist with NIR calibration.
Oil= Ankom analysis
Protein=LECO analysis
NIR=near infrared reflectance spectroscopy; building calibration curve to estimate BG.
NIT=near infrared transmittance spectroscopy; estimation of total oil, protein, hull percentage.
TDF: total dietary fiber (Ankom TDF Analyzer)

9. Interim conclusions (If any).

OT3115, was supported for registration in February 2023 and provided to FP Genetics for marketing. **OT3115** is a high β-glucan, low oil and moderate protein oat line that combines good groat percentage, good kernel weight, high plumps and very low thins. It shows very good yield potential, short height, very good lodging resistance and moderate maturity. **OT3115** also demonstrates moderate resistance to crown rust and resistance to smut and BYDV.

10. List any technology transfer activities undertaken in relation to this project: *Include conference presentations, talks, papers published etc.*

Calls/Meetings:

15 meetings/calls with industry/producer groups

Field Tours:

3 (CDC Oat Industry Tour, Richardson Milling Tour, CDC 50th Anniversary Field Tour)

Presentations:

A.D. Beattie, 2022. Update on CDC Oat Breeding and Research Activities, Prairie Oat Growers Association AGM, Saskatoon, SK, November 29, 2022.

Media:

Oat Scoop, Pam Yule, November 2022, pp. 2 “USask Celebrates the CDC’s 50th Year Working for Saskatchewan, the Prairies and the World”

Oat Scoop, Pam Yule, November 2022, pp. 3 “CDC Oat Breeding Program Progress in 2021”

Oat Scoop, Pam Yule, November 2022, pp. 4 “On-going Crown Rust Resistance Project”

Oat Scoop, Pam Yule, November 2022, pp. 5 “Stand at Attention: A Project to Address Oat Lodging”

11. Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

None.

12. Appendices: *Include any additional materials supporting the previous sections, e.g. detailed data tables, maps, graphs, specifications, literature cited, acknowledgments.*

None.