

AAFC Oat Varieties: What's New, on its Way, and Good for Alberta Producers



BRDC Research Scientist - Sustainable Oat Breeding and Genomics

Dr. Kirby Nilsen

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Short Biography



Kirby Nilsen, PhD

- Research Scientist – Sustainable Oat Breeding and Genomics with AAFC-BRDC, MB since 2020;
- Secretary of the Breeding and Agronomy Team of the PRCOB;
- Coordinator of the Western Cooperative Oat Registration Test (WCORT), and Alberta Regional Variety Trial for Oat



Oat research plots, Brandon

BRDC Oat Breeding Program

Goal: to develop milling oat cultivars, both for conventional and organic production, includes both the rust-prone and rust-free regions of western Canada.



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Breeding Program Objectives

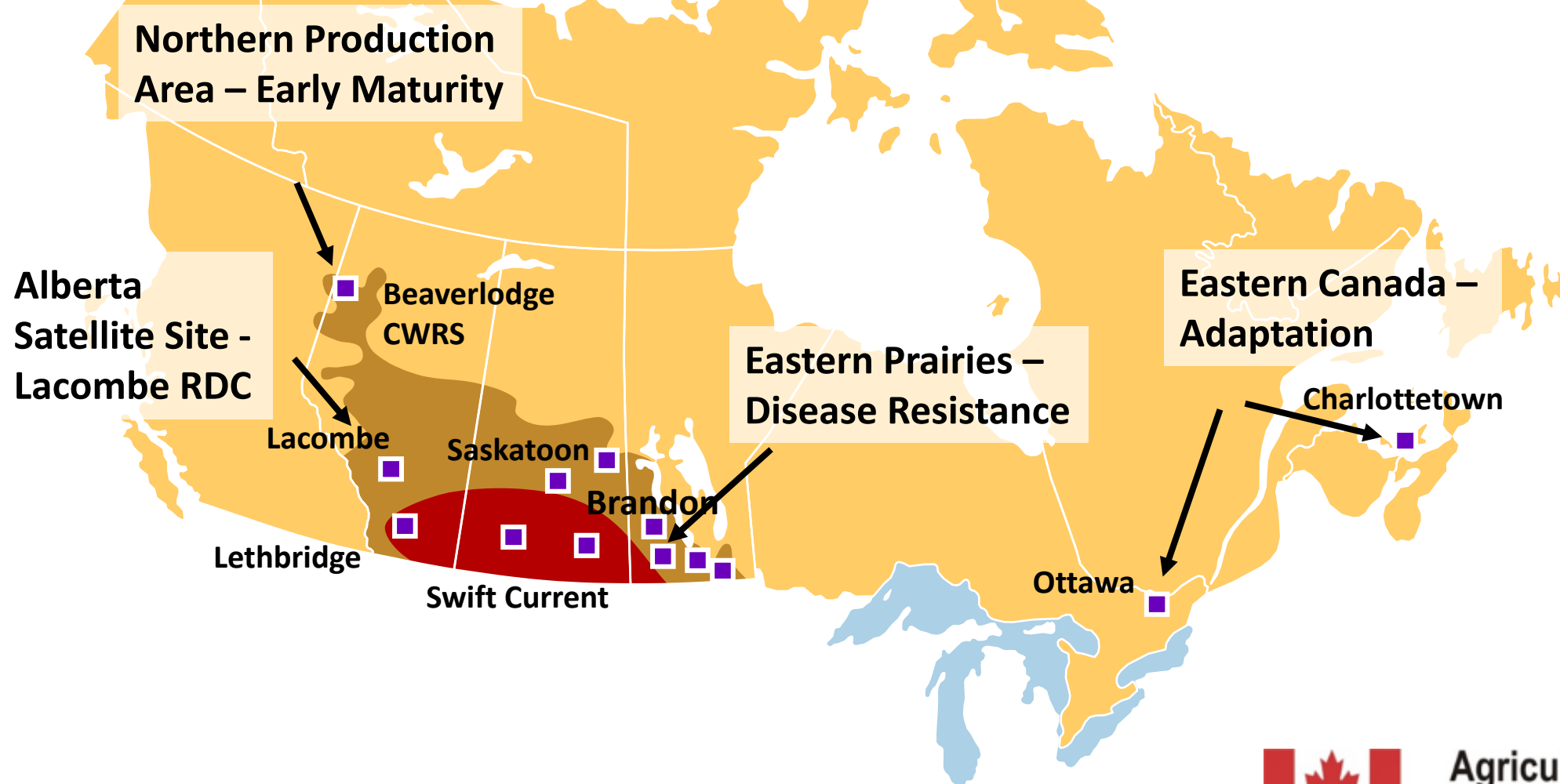
- Agronomics
 - Yield ▲
 - Maturity ▼
 - Height ▼
 - Lodging ▼
 - Test weight, Kernel weight ▲
- Grain quality
 - Groat percentage ▲
 - Beta-glucan ▲
 - Oil ▼
 - Protein ▲
 - Plump/thins ▲/▼
- Disease resistance
 - Crown rust, stem rust, smut, BYDV, FHB ▲



BRDC Oat Yield Plots, Summer 2021



Breeding Oats for Western Canada



Oat breeding at Lacombe-RDC



Left to right: Wes Dyck, Brooke Cottyn, Kirby Nilsen

- Primary Alberta testing location
- Yield testing
- Seed increase
- Seed processing
- ~3000 plots/year



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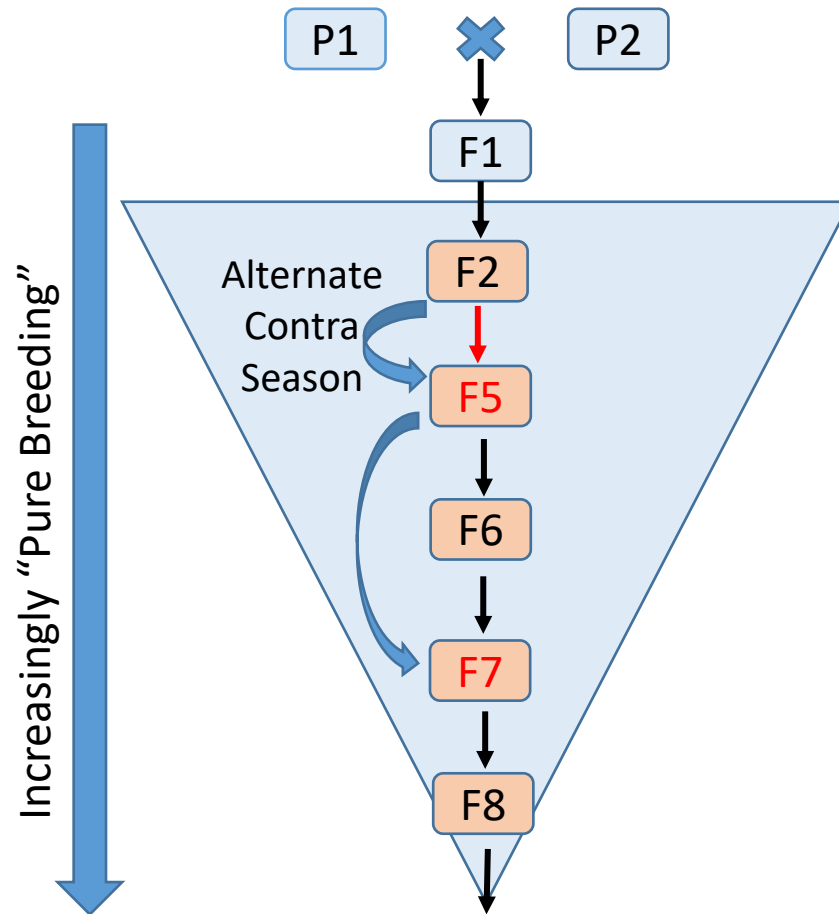
Oat Breeding Pipeline



F2-F6 Hill Nursery



Yield Plots



Parental Selection and Crossing

- Elite | Adapted | Exotic

Early Generation Selection for qualitative traits

- Disease
- Plant type
- Height
- Agronomics

Advanced Generation Selection for quantitative traits

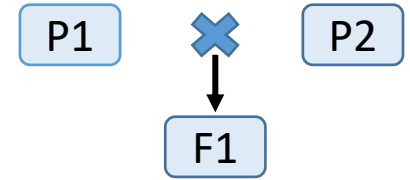
- Grain quality and yield

Pre-registration Tests → 2 year WCORT → Support for Registration (PRCOB)



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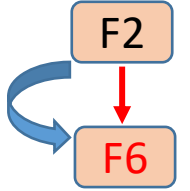
Crossing Oats



- Goal: To create large segregating populations
- Recombination of alleles between parents
- Crossing oat is extremely challenging with a low success rate
- How to select parents?



Speeding Up The Breeding Cycle



- Alternating contra-season/Canadian nurseries allow 2x generations per year at the early generation stages
- Selection in NZ for rust, BYDV, height, lodging

- Palmerston, NZ, 2022



Advanced Generation Yield Testing

- 4+ years of yield testing
 - Preliminary yield test
 - Pre-registration test
 - Registration test (WCORT)
- Multiple locations across western Canada
- **Evaluated for agronomics, disease, quality**



OT8008



OT8010



Grain Quality Testing CQL



De-hulling



Sample Milling



Near-Infrared Spectrometry

- Hull percentage
- Beta-glucan
- Oil
- Protein
- Can also be done on whole grain with higher throughput but lower accuracy



Recent oat varieties from BRDC program

- OT2129 (Supported for registration by PRCOB in 2021)
- AAC Douglas (OT2122)
- AAC Kongsore (OT8006)
- AAC Oravena (OT8003)
- AAC Justice (OT2084)
- Stride (OT2069)
- Summit (OT2046)
- Leggett (OT2021)



What's New: AAC Douglas

OT2122, Oat (J. Mitchell-Fetch, 2019)

Parentage: OT7070/CS Camden

- 1. Good yield combined with early heading and earlier maturity
- 2. Good test weight and thousand kernel weight
- 3. Groat % better than test average and AC Morgan
- 4. Excellent protein and beta-glucan content, and acceptable total dietary fibre, with average oil content
- 5. Resistant to smut and MR to oat crown rust. MR to FHB.
- Licensed to SeCan



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AAC Douglas

Variety	Overall Station Years of Testing	Overall Yield	Yield Category (% CS Camden)		Agronomic Characteristics:					
			Low < 115 (bu/ac)	High ≥ 115 (bu/ac)	Maturity Rating (Days +/- CS Camden)	Test Weight (lb/bu)	TKW (g)	Height (cm)	Resistance to Lodging	Tolerance to Smuts
MILLING										
Varieties tested in the 2021 trials (Yield and agronomic data only directly comparable to CS Camden)										
CS Camden (bu/ac)		126	91	150						
CS Camden ☺	54	100	100	100	100	40	41	99	VG	I
AAC Douglas ☺	21	101	99	102	0	40	41	100	G	R
AC Morgan ☺	20	103	96	106	1	41	43	104	VG	I
CDC Arborg ☺	25	105	XX	105	0	41	41	108	VG	R
CDC Dancer ☺	50	91	92	91	-2	41	38	107	G	R
CDC Endure ☺	27	106	XX	106	0	41	42	105	VG	R

<https://www.seed.ab.ca/variety-trials/cereals/>



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What's On It's Way: OT2129

OT2129, Oat (K.T. Nilsen/J. Mitchell-Fetch,
Brandon)

Parentage: OT3076/OT8004

- Yield: 103% of Summit
- Plant height = Summit, 3.6 cm shorter than CS Camden
- Maturity: 4 days earlier than Summit
- Lodging, TWT and TKW equivalent to CS Camden
- High groat percentage and beta-glucan similar to Summit
- Consistently low scores for oat crown rust, stem rust, BYDV and low DON
- Licensed to FP Genetics



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What's in the Pipeline: OT8011

OT8011, Oat (K.T. Nilsen/J. Mitchell-Fetch, Brandon)

Parentage: OT3046/Newburg

- Organically selected on farm via Participatory Plant Breeding program
- Yield: 107% of Summit (2021)
- Plant height similar to AC Morgan
- Maturity: 2 days earlier than AC Morgan
- Lodging, TWT and TKW equivalent to AC Morgan
- Good groat percentage
- R to Smut, MR to BYDV
- MS-S to crown/stem rust



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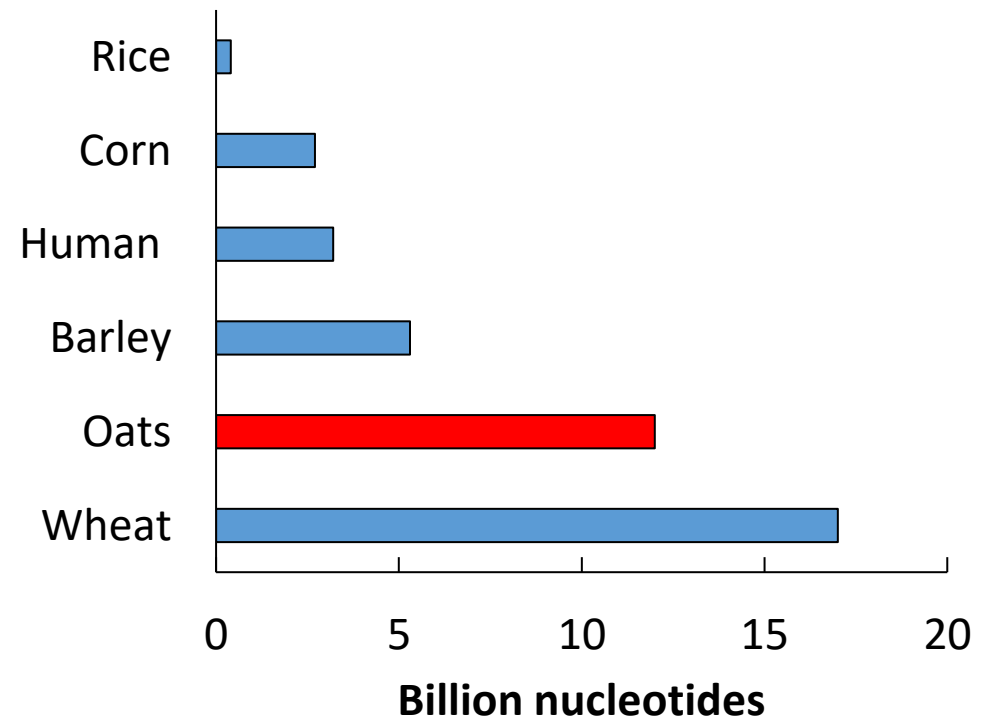
Oat Genomics

- The oat genome is **huge** and complex
- 12 billion nucleotides
- Polyploid
- 100,000 genes

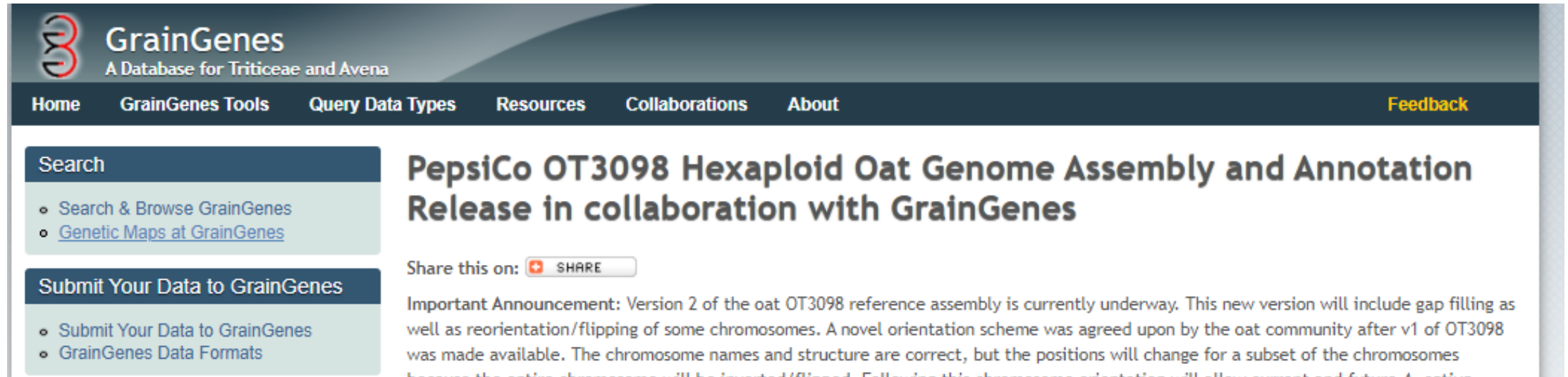


- Agronomics
- Disease resistance
- Grain quality

Comparison of Genome Size



The First Oat Genome is Now Available



GrainGenes
A Database for Triticeae and Avena

Home GrainGenes Tools Query Data Types Resources Collaborations About Feedback


Search

- Search & Browse GrainGenes
- Genetic Maps at GrainGenes

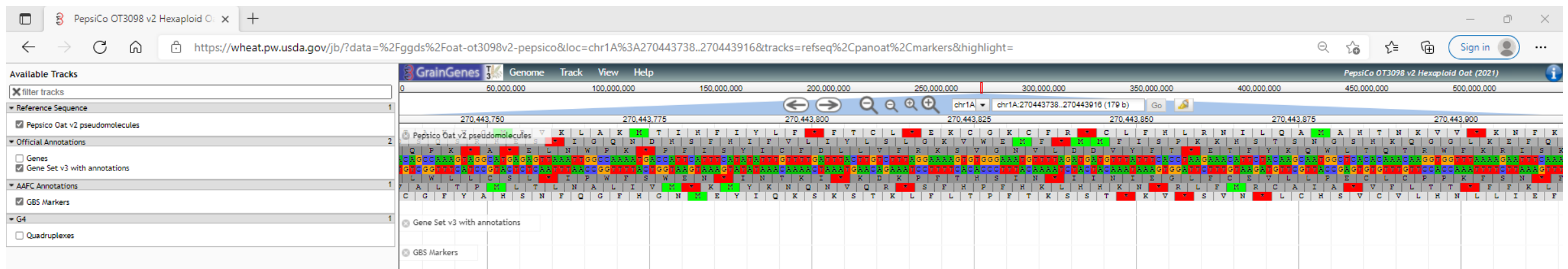
Submit Your Data to GrainGenes

- Submit Your Data to GrainGenes
- GrainGenes Data Formats

PepsiCo OT3098 Hexaploid Oat Genome Assembly and Annotation Release in collaboration with GrainGenes

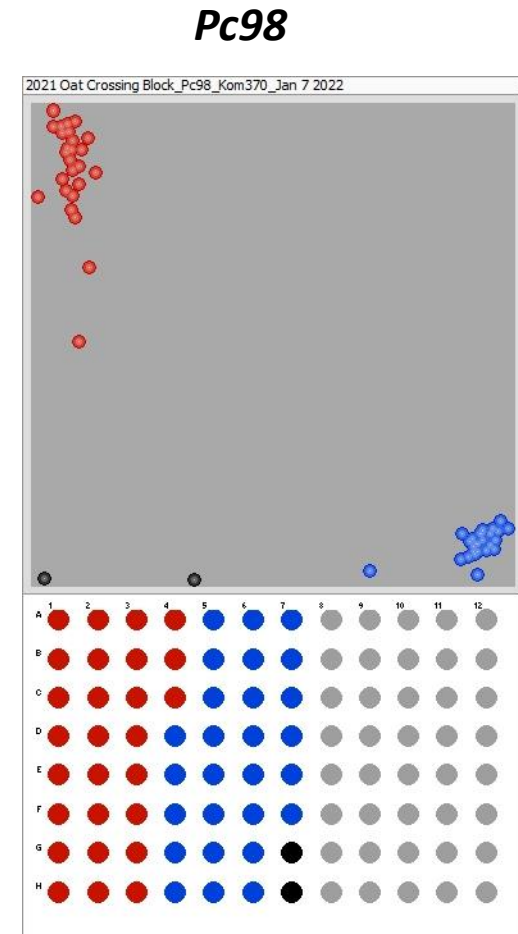
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Important Announcement: Version 2 of the oat OT3098 reference assembly is currently underway. This new version will include gap filling as well as reorientation/flipping of some chromosomes. A novel orientation scheme was agreed upon by the oat community after v1 of OT3098 was made available. The chromosome names and structure are correct, but the positions will change for a subset of the chromosomes because the entire chromosome will be inverted/flipped. Following this chromosome reorientation will allow correct and future 4-way



Marker Assisted-Breeding

- For qualitative traits
- Major genes with large effects (R genes)
- Selection in early generation breeding material
- Marker development pipelines + validation
- Parental screening
- Cost is < 20% of field screening



Chromosomal location of the crown rust resistance gene *Pc98* in cultivated oat (*Avena sativa* L.)
DOI: 10.1007/s00122-020-03535-x



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Genomic Selection for Grain Yield

For quantitative traits:
Controlled by many genes with large environmental effects

Genotype



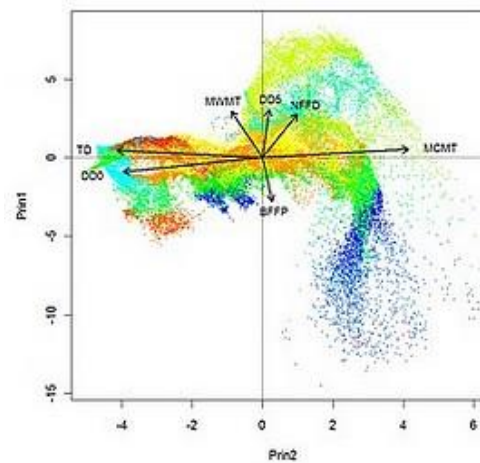
**Early Gen. +
Advanced Gen. Breeding
Lines**

Phenotype



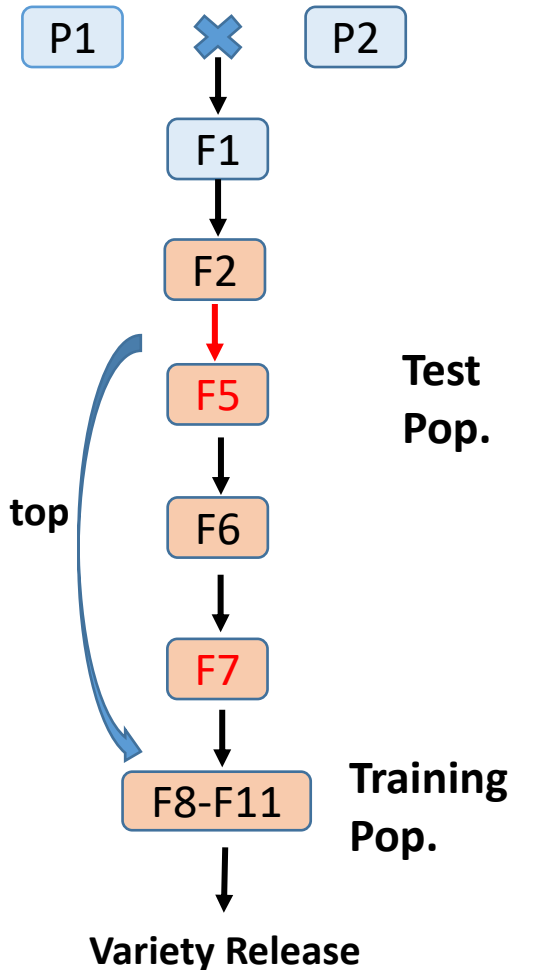
**Training Population
Advanced Gen. Breeding
Lines**

Predictive Models



**Test Population - Early
Gen. Breeding Lines**

Apply GS
**Select lines with top
GEBV (yield)**



Predictive Models



- 1) Sample leaf tissue from test set of nursery lines (F4 generation) + training population
- 2) Extract DNA
- 3) Genotype (GBS)
- 4) Apply GS models and generate predictions
- 5) Grow selected lines in yield plots to validate

GS Validation: 2018 - Present

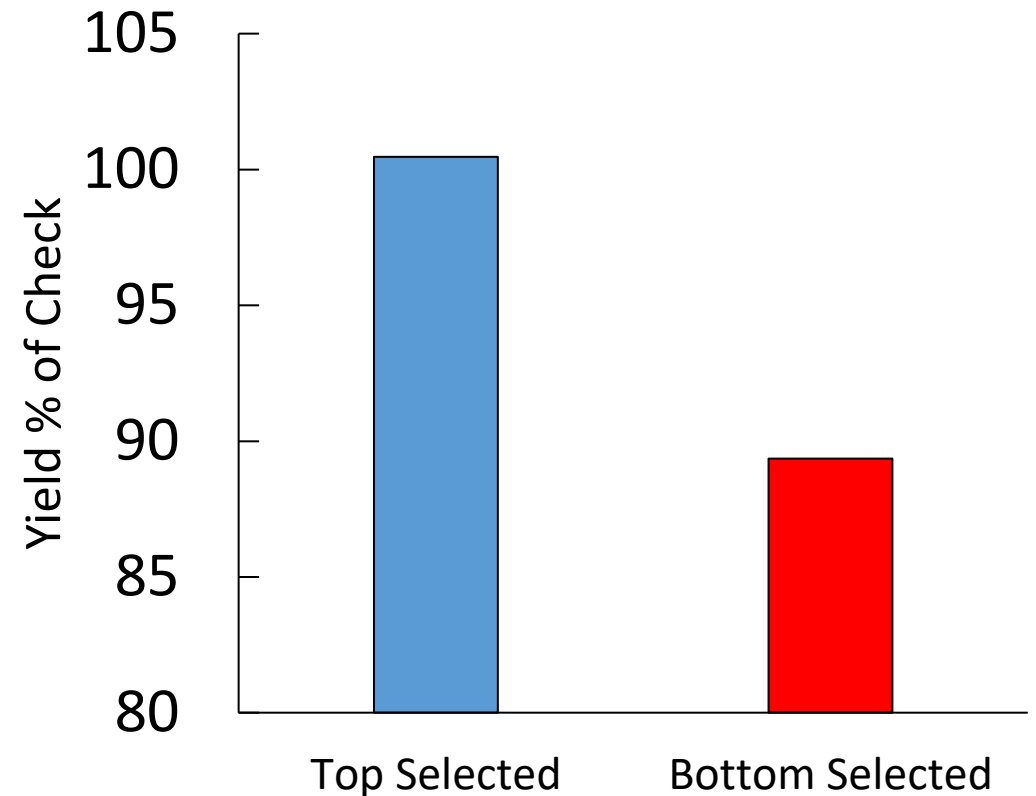
- Grow yield tests containing GS selected lines
- 2 locations: Brandon and Lacombe
- 80 selected entries
 - 60 “top”
 - 20 “bottom”

Collaborators:

Dr. Weikai Yan

Dr. Wubishet Bekele

Dr. Nick Tinker



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Conclusions from GS Pilot Study

- GS was effective in predicting the yield performance of untested lines. However many were deficient in one or more other traits preventing them from becoming a variety. For example:
 - Too tall
 - Late maturing
 - Low groat percentage
 - Low plumps
- Can GS be optimized in a multi-trait selection model?



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Why is Genomics Important?

- Genomics facilitates:
 - Better understanding of germplasm resources and genetic diversity
 - Selection for traits at early and advanced stages of breeding program
 - Complementary, but not replacement for traditional breeding
- Where do we go next:
 - Identification and marker development for more important genes in oat
 - GS for complex traits with emphasis on a multi-trait selection framework
 - GS for selection of superior parents for crossing



Acknowledgements



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- Jennifer Mitchell-Fetch

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Grain Quality

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- Jim Dyck
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- Nick Tinker
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- Charlene Wight
- Curt McCartney
- Ana Badea
- And many more!



AAFC Wheat and Oat Breeding Crew



GRAIN MILLERS



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THANK YOU!

