

Washington Grain Commission
Wheat and Barley Research Annual Progress Reports and Final Reports

PROJECT #: 30109-3157

Progress report year: 2 of 3

Title: Evaluation and Selection for Cold Tolerance in Wheat

Cooperators: K. Garland Campbell, K. Sanguinet, A.H. Carter

Executive summary:

In 2020, in spite of the slow down due to the pandemic, we rated 924 breeding lines and cultivars from public winter wheat breeding and variety testing programs for survival. This compared well with 2019 when we tested 936 lines. Breeders used this information for selection of new experimental lines. We have evaluated the Washington Extension Winter Wheat Trials every year since 2001. The survival results for the top varieties grown according to the Washington Grain Commission Variety Survey are below (next page). We observed association between our testing results and the winter injury that occurred in WA in April of 2020.

We conducted a genome-wide association study of wheat from the WSU winter wheat and ARS winter wheat programs and a doubled haploid population of Cara/Xerpha. We also did a preliminary QTL analysis on a population derived from the very cold tolerant Canadian cultivar, Norstar, in collaboration with Dr. Debbie Laudencia of USDA-ARS in Albany CA. We previously identified allelic variation at the Vrn and CBF genes on the group 5 chromosomes that impacts vernalization requirement and cold tolerance. We have now identified QTL for cold tolerance on chromosomes 1A, 2A, 4A, 5B, 7A, and 7B in more than one population. These results will be used in genomic selection models to improve freezing tolerance in PNW wheat.

We analyzed gene expression data for epigenetic effects of exposure to cold in the cultivar Norstar. One version of Norstar was induced to flower with the usual vernalization (exposure to cold) and the other was induced to flower only with longer daylengths. We identified 19 genes with expression differences and are following up on this research in year 3.

Impact

- The data from these cold tolerance trials was published in the seed buyers guide so that farmers can select winter wheat varieties that are less sensitive to winter kill.
- Our results from screening the regional nurseries, and screening breeding lines has been used by winter wheat breeders to select for resistance to winter injury.
- Varieties released from the WSU winter wheat breeding program have consistently excellent cold tolerance and this tolerance has been maintained because of testing using the procedures developed by this project.
- Because of the high correlation between our artificial screening trial and winter survival in the field, we can incorporate better cold tolerance into our early generation breeding lines.
- We have identified molecular markers that are being used by breeders to select for winter survival.

**Freeze Survival Of Top Acreage Winter Varieties in
WSU Cereal Variety Testing program, 2016-2020.**

Ranking Based On 2020 Variety Acreage Survey

	Percent Survival	95% LCL	95% UCL			Percent Survival	95% LCL	95% UCL
Soft White Wheat					Club Wheat			
UI Magic CL+	27%	9%	44%		ARS Crescent	65%	47%	82%
Curiosity CL+	80%	63%	98%		Bruehl	54%	37%	72%
Norwest Duet	54%	37%	72%		Pritchett	56%	38%	73%
Otto	58%	43%	73%					
Norwest Tandem	52%	32%	72%		Hard Winter Wheat			
M-press	33%	13%	53%		LCS Jet	40%	23%	58%
Mela CL+	67%	49%	84%		Keldin	64%	47%	82%
Eltan	73%	62%	84%		SY Clearstone CL2	70%	52%	87%
Resilience CL+	44%	26%	62%		LCS Rocket	14%	0%	31%
Puma	50%	32%	67%		WB 4303	75%	55%	95%
SY Dayton	26%	9%	44%					
PNW Hailey	65%	41%	90%		Checks			
LCS Art deco	26%	8%	43%		Norstar	86%	75%	97%
Jasper	32%	14%	49%		Stephens	39%	28%	50%
LCS Hulk	68%	51%	86%					
SY Assure	28%	8%	48%					
LCS Drive	23%	3%	43%					
WB 1604	42%	24%	60%					
LCS Sonic	51%	33%	68%					
Bobtail	28%	8%	49%					
SY Raptor	4%	0%	29%					
SY Ovation	17%	0%	37%					
Rosalyn	23%	5%	41%					
UI Castle CL+	30%	12%	48%					
Madsen	29%	9%	49%					

Freeze Tests were conducted under controlled conditions in the WSU Plant Growth Facility between 2016 And 2020.

These were severe survival trials. Field survival is likely to be greater, but the survival rankings from our freezing tests have correlated with field survival over multiple years.

The precision of Confidence Intervals varies because some lines have been tested more than others.

WGC project number: 3019-3157
WGC project title: Evaluation And Selection For Cold Tolerance In Wheat
Project PI(s): Kimberly Garland-Campbell, Karen Sanguinet and Arron Carter.
Project initiation date: 7/1/19
Project year: Year 2

Objective	Deliverable	Progress	Timeline	Communication
1. Evaluate Washington winter wheat variety trials and the hard spring wheat trials.	Ratings for freezing tolerance for commonly grown and new winter wheat cultivars and hard spring cultivars and breeding lines.	The Washington Cereal Variety Trial Winter wheat nurseries were evaluated for cold tolerance in artificial screening trials.	June 2019 - June 2022.	Presentation at grower meetings, Wheat commission meetings, Wheat Life and Research Review. Published on WSU small grains Web-site
2. Evaluate cold tolerance of new breeding lines in US regional nurseries in order to identify germplasm to use in crossing for better winter survival.	Ratings for freezing tolerance for advanced wheat germplasm from the US that can be used as new sources of cold tolerance for the PNW.	The Western Regional Winter wheat nurseries was evaluated for freezing tolerance in artificial screening trials.	June 2019 - June 2022.	Email results to regional nursery cooperators and publish on regional nursery web sites.
3. Evaluate cold tolerance of advanced breeding lines contributed by regional winter wheat breeding programs, including the WSU and USDA-ARS wheat breeding programs.	Ratings for breeding lines contributed by regional wheat breeders that will facilitate their selection decisions.	We evaluated freezing tolerance for 748 breeding lines from the Wsu Winter wheat and the USDA club wheat breeding programs and reported the data to the breeders. These data were used for selection.	June 2019 - June 2022.	Presentation at Research Review. Peer reviewed publications. Direct communication with wheat breeders.
4. Evaluate cold tolerance of F3-F5 (early generation) wheat populations that are segregating for cold tolerance and select resistant progeny.	Selections made for cold tolerance in early populations.	This was not accomplished due to less testing during the pandemic but we did release Castella club wheat in 2019, which was selected using this strategy.	June 2019 - June 2022.	Presentation at Research Review. Peer reviewed publications. Direct communication with wheat breeders.
5. Identify genes controlling cold hardiness in winter wheat.	New molecular markers and genomic selection indices for cold tolerance in PNW winter wheat and Hard red spring wheat.	We analyzed several mapping populations and identified or confirmed consistent QTLs for markers on the group 1, 4, 5, and 7 chromosomes that are being used for marker assisted selection for cold tolerance.	June 2019 - June 2022.	Presentation at Research Review. Peer reviewed publications. Direct communication with wheat breeders.

Impact:

Hessian fly resistance in the inland Northwest is valued from \$45 to \$104 per acre based on a study led by Dick Smiley at Oregon State University. Applying these values, a very conservative Washington state-wide loss estimate without resistant varieties is over \$10,000,000 per year, not including lower-level losses to winter wheat crops. Hessian fly infestations are widespread through the state every year and sampling with pheromone traps produces hundreds to thousands of flies at all locations sampled.

Hessian fly is largely controlled through genetic resistance maintained by expert screening of germplasm and by farmer adoption of resistant varieties. Typical insect pest management regimens for Hessian fly rely on prevention measures. From 2016-2018, we've seen heavy infestations at more sites, with heavier pressure than has been seen in over ten years or more. While newly released WSU varieties Glee, Alum, Chet, Seahawk, Tekoa, and Ryan are Hessian fly resistant due to the Hessian fly screening program funded by Washington growers, this work not only needs to continue, but the insect can and does adapt to resistant varieties. Therefore, additional research on Hessian fly population genetics and Hessian fly virulence is critical for successful management now and in the future.

No measurable impact has yet been shown in this project in the most recent funding cycle as we are setting up the foundational work for Hessian fly screening at WSU as we show in our output and outcomes table below.

Outputs and Outcomes:

A. Progress:

Objective	Deliverable	Progress
1: Comprehensive review of PNW Hessian fly biology	Published literature review of updated Hessian Fly biology; new extension bulletin published.	Literature has been reviewed; manuscript will be written in summer 2021; Visual key to identification of HF and look-alikes drafted
2: Field collections of HF; screen against varieties in greenhouse	MS grad student; HF screening at UI and at WSU (new).	HF screening at WSU in place. Screening has started and will continue using HF pupae collected in summer 2020 and from Univ of Idaho HF colonies.

C. Timeline:

Objective	Timeline
1: Comprehensive review of PNW Hessian fly biology	Summer 2021 with extension bulletin submitted to peer review by March 1, 2020
2: Field collections of HF; screen against varieties in greenhouse	Jan-June HF screening at WSU and UI; Wheat Life article after August 2021

D. Communication: