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

Project #: 5195

Progress Report Year: *1 of 3*

Title: Use of biotechnology for wheat improvement

Investigator/Cooperators: **AH Carter,** KG Campbell, M Pumphrey, D See

Executive summary: In 2021 we continued our effort to advance breeding lines as quickly and efficiently as possibly by employing both molecular marker analysis and doubled-haploid technology. The traits of focus for marker-assisted selection are foot rot resistance, stripe rust resistance, herbicide tolerance, and end-use quality. All these traits are already in established breeding lines and have very good markers to track them. Additional traits include aluminum tolerance, SBWMV, dwarfing genes, low PPO, Fusarium head blight, Hessian fly, and nematode resistance. While we have established some breeding lines with these traits, we are working to increase the number of lines carrying these traits, using markers to track their presence. Thousands of data points were collected on multiple populations to confirm presence of traits of interest. All lines which go through marker testing are then transferred to field testing to confirm the expected phenotype is expressing. Markers were also used to screen all advanced breeding lines to identify presence of known genes. This information, along with field data, was used for selection and advancement purposes as well as for selecting lines which should be cross-hybridized to create future populations. Our genomic selection efforts are proceeding and we have completed our sixth year of phenotypic evaluations in the field and genotyping. Data is being used to validate selection models for multiple traits through the efforts of graduate students funded on various other competitive grant funding. Results have identified the best models to use for specific traits, as well as how to build multi-trait models. In the greenhouse, we made approximately 650 crosses consisting mainly of soft white and hard red germplasm. In 2020 we started a large crossing block to incorporate new traits of interest, mainly herbicide resistance and pest resistance traits. These lines have been advanced in the breeding program, with some of them returning to the crossing block for back-crossing. We planted ~2,000 DH plants in the field in 2021 for evaluation. Our screening process continues to be adjusted to improve efficiency as new techniques and traits come into the program for screening.

Impact: This project covers all market classes and rainfall zones in the state of Washington, with about 70% of the effort on soft white crosses. This work will improve end-use quality, genetic resistance to abiotic and biotic stress, and agronomic adaptability and stability of released cultivars. All cultivars released (Otto, Puma, Jasper, Sequoia, Devote, Stingray CL+, Scorpio, Purl, Piranha CL+, Sockeye CL+) have benefited through this project by incorporation of disease, herbicide resistance, and end-use quality genes. Released lines have gained popularity and are growing in demand due to the gene combinations they were selected for. The breeding program has become more efficient in the selection process, and more focus is placed on field evaluations since known genes are already confirmed to be present in the breeding lines. Continued success will be measured by increases in acreage of these lines as well as enhanced cultivar release through DH production, marker-assisted, and genomic selection.

WGC project number: 5195
WGC project title: Use of biotechnology for wheat improvement
Project PI(s): AH Carter
Project initiation date: July 1, 2009
Project year: 1 of 3

Objective	Deliverable	Progress	Timeline	Communication
Marker-assisted selection				Results are presented through annual progress reports, the research review, field tours, and grower meetings
	Foot rot resistant lines	In 2021, all lines under field testing were screened for both Pch1 and Pch2 markers. This information was used to assist selection of lines for further testing under the field program. As more lines are selected for advancement and recycled in the breeding program for new cross-hybridizations, fewer populations will be segregating for this trait.	Each year new crosses are made to Pch1 and Pch2 containing lines. These are subsequently developed, screened, and advanced to state-wide yield trials. At any given time, lines are in every stage of development	In 2021 we communicated results of this project through the following venues: 21 peer-reviewed publications; 1 virtual field day recordings; 4 field day abstracts; various field days and grower interactions; 8 poster presentations; 1 popular press interviews; 1 podcasts; 2 grower meeting presentations; and 4 seed dealer presentations;
	Stripe rust resistant lines	In 2021, all lines under field testing were screened for six stripe rust resistance markers to identify presence of genes useful in the PNW. New populations segregating for resistance to Yr5 and Yr15 were screened and selected for advancement.	Each year new crosses are made to stripe rust resistant lines. These are subsequently developed, screened, and advanced to state-wide yield trials. At any given time, lines are in every stage of development	
	End-use quality lines	In 2021, populations that were selected for combinations of the GBSS genes (waxy) and the glutenin genes were selected in field testing. All breeding lines are screened for the presence of low PPO genes, and populations were advanced of lines containing none of the PPO genes to field testing.	Each year new crosses are made to lines containing unique end-use quality genes. These are subsequently developed, screened, and advanced to state-wide yield trials. At any given time, lines are in every stage of development	
	Reduced height lines	In 2021, all breeding lines in field trials were screened to identify which dwarfing gene they carry in order to aid in selection and crossing decisions. Selection is then made on which genes are present rather than incorporating new genes as they already exist in our breeding program. All lines are field tested for emergence potential.	Each year, we verify presence of dwarfing genes in all material to assist with selection of lines with enhanced emergence potential.	

	Genomic selection	With the assistance of graduate students, we continue to build genomic prediction models for traits of interest. Lines from the 2015-2021 breeding program have been genotyped and used for model building. We have begun incorporating high-throughput phenotyping measurements in these selection models, which has improved selection accuracy and efficiency.	Each year we will continue to phenotype the training panel, add more lines to the training panel (and genotype them), and refine the prediction model. Validation of results is proceeding.	Results are presented through annual progress reports, the research review, field tours, and grower meetings. Eight manuscripts have been published on this research.
Genotyping advanced breeding lines	Provide useful information regarding genetic diversity and gene profiles to better estimate crossing potential	In 2021, the advanced germplasm was screened with DNA markers for about 25 markers of interest. This information was used to enhance selection of field tested material, as well as assist in parent cross-combinations to develop populations with desired traits of interest.	This is done annually	Results are presented through annual progress reports, with the outcomes of this research being realized in new cultivars
Greenhouse				Results are presented through annual progress reports, with the outcomes of this research being realized in new cultivars
	Hybridization and propagation	In 2021 we made approximately 750 crosses which were targeted for herbicide resistance, low rainfall and high rainfall production. About 80% of these are in soft white backgrounds, and the remaining in hard red backgrounds. Crosses were advanced to the F2 stage. We also made about 100 crosses for trait introgression to continue to build germplasm for traits which are important to PNW growers.	This is done annually, with the number of crosses/populations varying	
	Single-seed descent	In 2020 we began developing more SSD populations to better standardize the production of lines from our crossing program. We are fine-tuning the protocols to maximize the number of lines which can be tested, and are looking forward to seeing how this new process assists the breeding program.	This is done annually, with the number of crosses/populations varying	
	Doubled haploid	In 2021 our DH production focused on increasing seed quantities of 2020 produced lines. The goal is to have all lines produced go into 4-row observation trials at both Pullman and Lind.	This is done annually, with the number of crosses/populations varying	

	Trait Introgression	We made crosses to germplasm containing resistance/tolerance to snow mold, stripe rust, end use quality, foot rot resistance, preharvest sprouting, Al tolerance, Ceph Stripe, SBWMV, vernalization duration, low PPO, Fusarium head blight, imazamox, the CoAxium system, and other herbicides (in coordination with Dr. Burke). Herbicide tolerant lines are screened in the greenhouse for tolerance, as well as with markers, before going into field trials. We now have markers for many of these traits, and can efficiently screen for their presence. After advancement, all populations are transferred to the field program to undergo further testing.	This is done annually, with the number of crosses/populations varying	
Trait assessment				Results are presented through annual progress reports, with the outcomes of this research being realized in new cultivars
	Coleoptile length	Lines are screened and selected for coleoptile length.	Screening and selection will continue in 2022. Superior lines were planted in the field and crossed back into the breeding program.	
	Herbicide Tolerance	We now have a strong pipeline of germplasm tolerant to imazamox, and continue to develop and screen populations. We have many soft white lines using the CoAXium system under field evaluation, and continue to make crosses for this trait. We have expanded to select for both hard and soft germplasm, and work with all three tolerance genes. In collaboration with Dr. Burke, we have new sources of herbicide tolerance which are being tested under both greenhouse and field conditions for tolerance.	Screening and selection will continue in 2022. Superior lines were planted in the field and crossed back into the breeding program.	
	Cold Tolerance	All advanced breeding lines are screened for cold tolerance through the USDA funded WGC grant.	Screening and selection will continue in 2022. Superior lines were planted in the field and crossed back into the breeding program.	

	Stripe rust	Because many sources of resistance in our germplasm are uncharacterized, we have begun developing genomic selection models to use for selection in our breeding populations. We have started the development of more populations to identify more of the genes which are contributing to resistance in our germplasm. These are being advanced in the greenhouse to create recombinant inbred lines.	Screening and selection will continue in 2022 after limited 2021 screening due to limited disease pressure. Superior lines were planted in the field and crossed back into the breeding program.	

Do not use a font size less than 10 point. Let the template break over pages if necessary. The formatting will be retained when saved as a pdf file.