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

PROJECT No.: 30109-6345
Progress report year: *2 of 3 (maximum of 3 year funding cycle)*
Title: CLUB WHEAT BREEDING

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Executive summary: In 2014, the USDA-ARS filled the field research technician position and we plan to fill the ARS technician position in 2015 or early 2016. We managed 7 field testing locations ourselves and four others in collaboration with the WSU Winter Breeding program, the WSU Cereal Variety Testing Program, OSU-CBARC and the OSU Wheat Breeding program and University of Idaho. We evaluated over 3000 plots and several thousand head row plots in three states. We are focusing club wheat development on two major goals: 1) Development of a replacement club wheat for Bruehl with excellent resistance to snow mold, eyespot, stripe rust, sprouting and good emergence and winter hardiness and 2) Development of early maturing club wheat for the high rainfall region with excellent resistance to eyespot, cephalosporium stripe, stripe rust, aluminum toxicity and good straw strength, high yield, and good test weight. Based on the 2014 WSU Cereal Variety Trials, the best performing club wheats in the > 20 in. precipitation region were Bruehl and ARS Crescent. ARS Crescent, ARS Chrystal, and ARS 010262-1C were highly competitive with the best soft white common cultivars in the 16-20 in. rainfall zone while ARS010262-1C and 4J071366-1 performed will in the 12-16 inch region and under 12 inch region. For 2015, we entered eight breeding lines into the Washington State Extension Trials. 4J071366-1, and ARS20060123-31C for all zones; ARS010669-2C, ARS010263-10-3C and ARS20060126-35C for ithe wet locations; ARS010679-1C, ARS040335-9C and ARS06135-9C for the dry locations. We did not enter any soft white wheats into the trials. These club breeding lines are all products of crossing with soft wheats from the Eastern US as additional sources of resistance to rusts, Hessian Fly and BYDV. In addition, six breeding lines were entered into the Western regional trials. We are reselecting ARS010262-1C for club head type. We have added an additional head row purification and selection step to the breeding program in order to provide Washington Foundation Seed with quality Breeder seed.

We have greatly expanded our use of genotyping and and are in the process of genotyping all our the entries in 2014 and 2015 yield trials using the genotyping by sequencing (GBS) procedure in the USDA Western Small Grains Genotyping laboratory so that we can implement genomic selection for cold tolerance and disease resistance in 2015. In conjunction with Arron Carter and Yukiko Naruoka, we have identified markers associated with the club wheat gene and with the durable stripe rust resistance currently present in the club wheat germplasm. We are confirming these markers in segregating DH popualtions and in a large PNW-adapted panel. Marker assisted selection using KASP and SSR markers was used to select for resistance to Preharvest sprouting, BYDV, eyespot, and stripe rust. We are developing new KASP markers when possible because they have proved to be quite efficient.

We evaluated several hundred doubled haploid lines in disease nurseries and unreplicated trials and have advanced several to our Elite replicaited trials. Early generation quality testing was performed on all early generation selections in order to continue to maintain and improve club wheat milling quality. Coleotpile testing and winter hardiness testing was run on all breeding lines. All breeding lines were selected for resistance to stripe rust, eyespot, cephalosporioum stripe, and Fusarium in inoculated nurseries.

We updated all of our computers, and purchased a new small tractor for spraying to replace our two old tractors, both of which were at least 30 years old. We planted our yield trials at Pullman using the WSU no-till plot drill with cross-slot openers in order to select under conditions that are similar to common farm practice. This proved to be a challenge in the fall of 2014 due to the lack of rain and hard soil but as of Dec. 21, the stands were adequate. It is critically important to select under farming practices that are similar to current production practice.

We are considering 4J071366-1 as a release for the dryer rainfall zone. This line was developed in conjunction with the WSU winter wheat program.

Impact
Club wheat acreage represents a small but significant part of the total WA wheat market. The excellent disease resistance of the club wheats is a built-in premium for growers because the reduced need for fungicides. Because of their disease resistance, club wheat cultivars have been used to incorporate stripe rust resistance and eyespot resistance into other wheat classes. The combination of excellent end use quality, disease resistance, and cold tolerance of new club wheat cultivars allows growers to make planting decisions based on market demands and to maximize choice in marketing strategy.

Project 6345 Communications:

Presentations:

a. "Club Wheat for Dry Cropping Regions", Lind Field Day-WSU Agricultural Experiment Station, Lind WA, June 12, 2013.
b. Report of Progress: Washington Grains Commission Research Review, "Club Wheat Breeding", Pullman WA, Feb. 2014.
c. Plot and field day tours speaking to approximately 15-30 growers and industry representatives per tour during June, 2014: Harrington WA.

Refereed manuscripts with applications to this project.

Case AJ, Naruoka Y, Chen X, Garland-Campbell KA, Zemetra RS, Carter, A.H. 2014. Mapping Stripe Rust Resistance in a BrundageXCoda Winter Wheat Recombinant Inbred Line Population. PLoS ONE 9(3): e91758. doi: 10.1371/journal.pone.0091758

Martinez, S.A., Schramm, E.C.,Harris, T.J., Kidwell, K.K.,Garland-Campbell, K., Steber, C.M., 2014. Registration of Zak Soft White Spring Wheat Germplasm with Enhanced Response to ABA and Increased Seed Dormancy. J. Plant Reg. 8:217-220.

Guy, S.O., Wysocki,D.J., Schillinger, W.F., Chastain,T.G., Karow,R.S., Garland-Campbell,K., Burke,I.C., 2014. Camelina: Adaptation and Performance of Genotypes. Field Crops Research 115:224-232.

Graybosch, R.; Bockelman, H. E; Garland-Campbell, K. A; Garvin, D. F; Regassa, T; 2014. Wheat. pp 459-488 In Specht, J., and Carver, B., (Eds).Yield Gains in Major US Field Crops. American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc.

WGC project number: **3019-6345**
WGC project title: **Club wheat breeding**
Project PI(s): **Kimberly Garland-Campbell and Arron Carter**
Project initiation date: **7/1/13**
Project year: **Year 2**

Objective	Deliverable	Progress	Timeline	Communication
Objective 1. Conduct crossing program to improve resistance to stripe and leaf rust, cold tolerance, strawbreaker foot rot, Cephalosporium stripe and Fusarium crown rot. Also to identify and improve resistance to cereal cyst and lesion nematodes, and barley yellow dwarf virus.	New populations with novel combinations of important genes.	Best by Best crossing blocks from 2012, 2013 and 2014 are being advanced in the greenhouse. The 2015 Best by Best crossing block has been plantey. DNA has been extracted from all parents and most have been genotyped to better predict good cross combinations.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.
Objective 2.. Develop doubled haploid and backcross populations and conduct early generation selection in disease and cold tolerance screening systems in the WSU plant growth facility.	Several hundred doubled haploids developed. Backcross popualtions using germplasm resources from outside of PNW developed.	Doubled haploid lines were evalauted at Central Ferry, Spillman, or Lind, depending on the breeding objectives for the population. Selections are in yield trials. 20 F1 populations have been designated for DH production given to the WSU DH lab with the goal of obtaining an average of 50 lines per F1 population.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.
Objective 3. Analyze information from the two training panels of adapted winter wheat that we have genotyped to develop genomic selection prediction equations. Conduct marker assisted selection and recombine the best selections to reduce breeding cycle time.	Prediction equations for club wheat quality and agronomic performance. New breeding lines identified using marker assisted selection.	All germplaslm in replicated testing has been through marker assisted selection for at least one trait. Genomic data for advanced breeding lines has been obtained and is currently being analyzed.	By end of 2nd year and ongoing.	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.

Objective 4. Plant, manage, evalaute, and harest early generation un-replicated nurseries at Pullman WA, Pendleton OR, Lind WA as space and time permit. Evaluate resistance to multiple diseases in inoculated disease screening nurseries.	Advanced breeding lines with resistance to multiple diseases and acceptable agronomic characteristics entered into replicated trials.	Unreplicated yield trials were planted, comprising germplasm selected from inoculated disease nurseries. These nurseries were planted at Pendleton, Lind, Harrington and Spillman.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.
Objective 5. Evaluate end use quality on 1500 F4 and F5 head row selections.	Breeding lines entering into unreplicated and replicated trials have been screened for quality characteristics.	Micro quality testing has been started for 2014 crop year. We are working with C. Steber and D. Engle to screen germplasm for low falling number.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.
Objective 6. Conduct laboratory, greenhouse and growth chamber evaluations of stripe rust resistance and coleoptile length. Evaluate cold tolerance in growth chamber trials	Identify germplasm with superior stripe rust resistance, coleoptile length and cold tolerance.	Seedling trials for stripe rust resistance are currently underway at the Wheat Plant Growth Facility. Coleoptile screening is underway at the Agronomy seedhouse. Cold tolerance screening was done on the 2014 yield plots and used for selection.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.
Objective 7. Plant, manage, evalaute and harvest advanced replicated nurseries at multi-location trials for club and soft white wheat in Eastern Washington, NE Oregon and North Idaho.	New club wheat cultivars with superior perfromance. New germplasm of other wheat classess possesing superior stripe rust resistance and quality derived from club wheat cultivars.	Recent releases include ARS-Amber and ARS-Selbu soft white winter wheats, ARS-Crescent and ARS-Chrystal club wheat. New breeding lines have been entered into regional and state variety performance trials.	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.