

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

PROJECT No.: 30109-6345

Progress report year: 3 of 3 (maximum of 3 year funding cycle)

Title: CLUB WHEAT BREEDING

Researchers: K. Garland Campbell, A.H. Carter,

Cooperator: M. Pumphrey,

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Executive summary: A new club wheat cultivar, Pritchett, was released in 2015, named after John Pritchett a valued and long serving technician for the USDA-ARS club wheat breeding program. Pritchett was jointly developed by the USDA-ARS and WSU winter wheat breeding programs and has significantly better grain yield and grain test weight over multiple locations in <15 inch annual precipitation environments than Bruehl, the cultivar that it is targeted to replace. Pritchett has better milling quality, producing larger diameter cookies and greater volume sponge cake than Bruehl. Pritchett has highly effective adult plant resistance to stripe rust (*Puccinia striiformis* f. sp. *tritici*) based on a combination of multiple loci for resistance to that disease. Pritchett has moderate resistance to Cephalosporium stripe disease, similar to Bruehl. Pritchett carries the *Pch1* gene for resistance to eyespot, is moderately susceptible to that disease, but more resistant than Bruehl. Pritchett has excellent emergence from deep sowing with coleoptile lengths averaging 95cm and carries the *Rht-B1b* allele for reduced plant height. Fifteen samples of Pritchett from the 2014 and 2015 crop years have been graded by FGIS and 13 of them were graded as white club with the other two graded as western white. Pritchett was released because of its superior agronomic productivity in the targeted region, and superior end use quality combined with resistance to multiple diseases and abiotic stress.

The USDA-ARS Wheat breeding program managed field testing locations at Central Ferry, Lind, Harrington, Pullman, and Farmington WA and at Pendleton OR and Genesee ID. We also evaluated breeding lines at Walla Walla, St. Andrews, Mansfield, Ritzville, Kahlotus, WA and Corvallis OR in collaboration with the WSU Winter Breeding program, the WSU Cereal Variety Testing Program, OSU-CBARC, the OSU Wheat Breeding program, the University of Idaho and Syngenta. We focused 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. Pritchett meets goal number 1 and several new breeding lines have potential to meet goal number 2.

The club wheat ARS Crescent is a complement to Pritchett in the higher rainfall regions. In the 2015 WSU Cereal Variety Trials, ARS Crescent was the best performing wheat in the >20 in. precipitation region and this cultivar has achieved stable high performance across rainfall zones over multiple years. In addition, club wheat breeding lines have been highly competitive with soft white wheat cultivars in multiple rainfall zones during the past three harvest seasons. The club breeding line ARS010263-10-3C was a top performer in the 16-20in precipitation zone.

The breeding lines ARS20060123-31C, ARS06135-9C, and ARS010679-1C were in among the top performers in the 12-16in rainfall zone and ARS06135-9C and ARS20060123-31C were also highly competitive in the <12 inch rainfall zone.

For 2016, we entered ARS20060123-31C and ARS06135-9C into the WA State Extension <16 in rainfall zone trials and we entered ARS20060123-31C and ARS06136-49C into the >16 in rainfall trials. We also entered ARS20060123-31C and ARS06136-49C into the Oregon Winter Elite Yield Trial. We also entered five breeding lines, ARS010679-1C, ARS06132-45C, ARS06135-9C, ARS20040150-2-0-2 and ARS20060194-0-10L into the Western Regional Soft Winter Wheat Trial. These club breeding lines are all products of crossing with soft wheat from the Eastern US as additional sources of resistance to rusts, Hessian Fly and BYDV. 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 in a timely manner.

We have greatly expanded our use of genotyping and are in the process of genotyping all our the entries in 2014 -2016 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 2016. 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. Marker assisted selection using KASP and SSR markers was used to select for resistance to Preharvest sprouting, BYDV, eyespot, stripe rust and dough strength.

We evaluated several hundred doubled haploid lines in disease nurseries and unreplicated trials and have advanced several to our Elite replicated trials. Early generation quality testing using the Micro-mill and solvent retention capacity tests was performed on all early generation selections in order to continue to maintain and improve club wheat milling quality. Coleoptile testing and survival from freezing was assayed on all breeding lines. All breeding lines were selected for resistance to stripe rust, eyespot, cephalosporium stripe, and Fusarium in inoculated nurseries.

Impact

Club wheat acreage represents a small but significant part of the total WA wheat market. The excellent disease resistance of the club wheat 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. The club wheat breeding program works collaboratively with several other WGC funded projects including the Winter and spring wheat breeding projects, the disease resistance and quality projects, and the drought and preharvest sprouting projects to integrate their results and methods into production of quality cultivars for PNW growers.

D. Communication

Presentations:

- a. "Club Wheat for Dry Cropping Regions", Lind Field Day-WSU Agricultural Experiment Station, Lind WA, June 13, 2013.
- b. "USDA-ARS Club Wheat Breeding", Spillman Farm Field Day – WSU Dept. of Crops and Soil Sci., Pullman WA., July 11, 2013.
- c. Report of Progress: Washington Grains Commission Research Review, "Club Wheat Breeding", Pullman WA, Feb. 2013.
- d. Invited by Coordinating Committee, Plant Breeding Academy, Univ. of California at Davis, CA. to lecture on "Breeding Self-Pollinated Crops". Sept 16, 2013.
- e. Plot and field day tours speaking to approximately 15-30 growers and industry representatives per tour during May, June and July, 2013: Connell WA, Harrington WA, St. Andrews WA.
- f. "Club Wheat for Dry Cropping Regions", Lind Field Day-WSU Agricultural Experiment Station, Lind WA, June 12, 2014.
- g. Report of Progress: Washington Grains Commission Research Review, "Club Wheat Breeding", Pullman WA, Feb. 2014.
- h. Plot and field day tours speaking to approximately 15-30 growers and industry representatives per tour during June, 2014: Harrington WA. St. Andrews WA.
- i. "Club Wheat for Dry Cropping Regions", Lind Field Day-WSU Agricultural Experiment Station, Lind WA, June 11, 2015.
- j. Report of Progress: Washington Grains Commission Research Review, "Club Wheat Breeding", Pullman WA, Feb. 2015.
- k. Invited by Coordinating Committee, Plant Breeding Academy, Univ. of California at Davis, CA. to lecture on "Breeding Self-Pollinated Crops". Sept 16, 2015.
- l. Plot and field day tours speaking to approximately 15-30 growers and industry representatives per tour during June, 2015: Harrington WA, Reardan WA, Ritzville WA.
- m. "Breeding Wheat for Functionality and Grading" Invited talk to American Association of Cereal Chemists International, Minneapolis MN, Oct. 19, 2015.
- n. Breeding Wheat for End use Quality" Invited talk to Advanced Plant Breeding Class, Colorado State Univ. Ft. Collins, CO, Nov 20, 2015.

Refereed manuscripts with applications to this project.

- Christopher**, M. D., S. Liu**, M. D. Hall**, D. S. Marshall, M. O. Fountain, J. W. Johnson, E. A. Milus, K. A. Garland-Campbell, X. Chen, and C. A. Griffey. 2012. Identification and mapping of adult-plant stripe rust resistance in soft red winter wheat cultivar USG 3555. *Plant Breeding*. Doi:10.1111/pbr.12015.
- Christopher, M.D., Liu, S., Hall, M.D., Marshall, D.S., Fountain, M.O., Johnson, J.W., Milus, E.A., Garland-Campbell, K.A., Chen, X., Griffey, C.A., 2013. Identification and Mapping of Adult Plant Stripe Rust Resistance in Soft Red Winter Wheat VA00W-38. *Crop Science*. 52:871-879.
- 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.
- Garland Campbell, K., Thompson, Y.M., Guy, S.O., McIntosh, M., Glaz, B., 2015. *Is, or is not, the two great ends of Fate?*: Errors in Agronomic Research. *Agron. J.* 107: 718-729.
- Piaskowski, J.L., Brown, D., Garland Campbell, K. 2016 NIR Calibration of Soluble Stem Carbohydrates for Predicting Drought Tolerance in Spring Wheat. *Agron J.* 108:285-293. doi:10.2134/agronj2015.0173

Popular Press:

Campbell, K., 2015. "Welcome to the Club" *WheatLife* 58:53-55.

WGC project number: 3019-6345
WGC project title: Club wheat breeding
Project PI(s): Kimberly Garland-Campbell, Arron Carter, Mike Pumphrey
Project initiation date: 7/1/13
Project year: Year 3

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,-2015 are being advanced in the greenhouse. DNA has been extracted from all parents and breeding lines for 2014-2015 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 populations using germplasm resources from outside of PNW developed.	Doubled haploid lines were evaluated at Central Ferry, Spillman, or Lind, depending on the breeding objectives for the population. Additional DH populations are being	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.	Marker assisted selection using KASP and SSR markers was used to select for resistance to Preharvest sprouting, BYDV, eyespot, stripe rust and dough strength. Genomic data for advanced breeding lines has been obtained and is	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, evaluate, and harvest 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.	The USDA-ARS Wheat breeding program managed field testing locations at 13 locations in WA, ID and OR in collaboration with the WSU Winter Breeding program, the WSU Cereal Variety Testing Program, OSU-CBARC, the OSU Wheat Breeding program, the University of Idaho and	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.	Early generation quality testing conducted every year.	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, evaluate 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 performance. New germplasm of other wheat classes possessing superior stripe rust resistance and quality derived from club wheat cultivars.	A new club wheat cultivar, Pritchett, was released in 2015, and was jointly developed by the USDA-ARS and WSU winter wheat breeding programs	Sept 2013-August 2015	Presentation at grower meetings, Wheat commission meetings, field days, plot tours, Wheat Life and Research Review.