6344-Wheat Research Progress Report

Project #: 3019-6344

Title: Club Wheat Breeding

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Progress Report Year: 2008

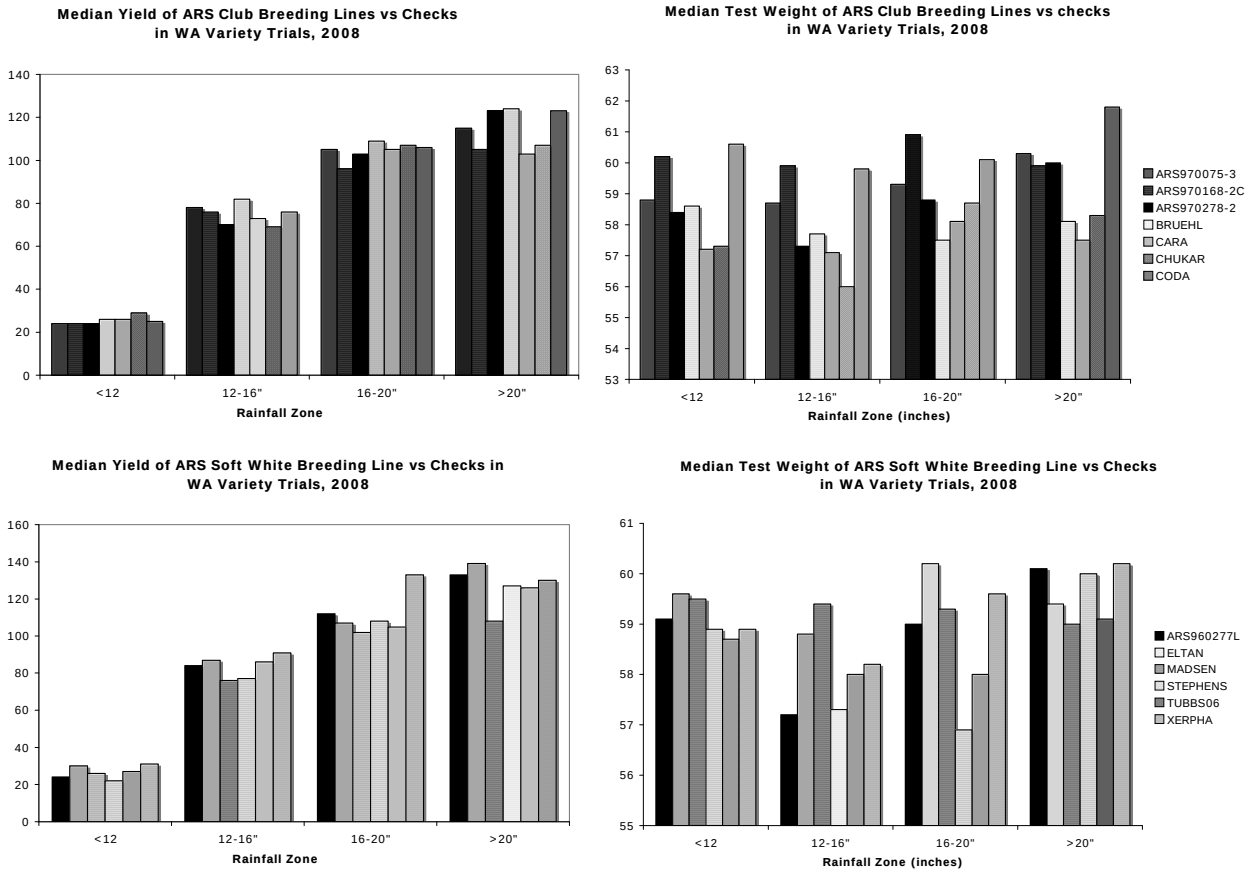
Accomplishments and Results:
For 2008, four breeding lines were entered into the Washington State Cereal Variety trials (top four entries in Table 1).

Table 1. USDA-ARS Wheat Breeding Entries in WA Variety Testing Soft Winter Wheat Nursery, 2008

Name	Class	Pedigree	First year in trial
ARS970278-2	Club	TRES//Madsen sib/TRES/5/Ten/Jub*2//Bno/3/YR/4/Hyak	2007
ARS970075-3C	Club	WA7665/Rulo//Brimstone/Moro	2008
ARS970168-2C	Club	Dusty//Madsen sib/Dusty///Brimstone/Moro,	2008
ARS960277L	SWW	Eltan/96REA11///WA7665//Madsen/Tyee.	2008
ARS97071-3C	Club	CODA//Brimstone/Moro	2009
ARS0170-2L	SWW	Dusty//MDN sib/Dusty///TRES/VPM	2009

Median yields and test weights for those four breeding lines compared to checks in the 2008 trials are included in Figures. 1-4. Medians were calculated rather than averages in order to reduce the effects of extreme values.

Yields of the three club breeding lines are competitive with current club wheat checks but test weights are higher in all rainfall zones, especially for ARS970075-3C and ARS970168-2C. Yields and test weight of the soft white winter wheat breeding lines, ARS960277L was competitive with newer checks Tubbs06 and Xerpha. Both ARS97007503 and ARS960277L performed well under snow mold at St. Andrews and may carry some resistance. Both lines performed well across rainfall zones in Washington State. The drop in test weight for ARS970277L in the 11-16 in. rainfall zone was due to extremely low test weight at Anatone. Both have good end use quality as summarized in Table 2.



Figures 1-4. Breeding lines are shaded darker than checks.

For the 2009 trials, three lines were repeated; ARS970278-2 was dropped due to lack of consistency across location years. The two new breeding lines that were entered are a club, ARS97071-3C and a SWW, ARS0170-2L. Both have been competitive for yields in ARS trials (data from 18 location years is summarized in Table 2) and possess excellent end use quality characteristics. All breeding lines that have graduated from the ARS Elite nurseries carry good resistance to stripe rust and strawbreaker foot rot.

Table 2 is a large table full of data that has been included because, in addition to providing details of specific ARS breeding lines, it illustrates the current state of the elite material in the breeding program. Several of the lines are performing in the same LSD group and have competitive yield performance with newer soft white wheat cultivars. Quality has been emphasized early in the breeding program so that all lines in ARS elite nurseries meet club and soft white wheat quality standards for milling and baking performance. Disease resistance has been a major focus and all lines in elite nurseries have excellent straw strength. We expect to release a new club within the next two years and possibly a soft white, depending on market demand.

Table 2: Peforrmance of ARS Breeding Lines vs Checks in ARS Trials in WA, ID and OR in 2007 and 2008 (18 location-yea in Descending Order by Yield

Name	Yield (bu/ac)	Test Weight (lb/bu)	Height (in)	Heading Date (from Jar 1)	Flour Protein (%)	Flour Ash (%)	Flour Yield (%)	Break Flour Yield (%)	Single Kernel Hardness (%)	Kernel Weight (g/1000 seeds)	Viscosity	Mill Score (%)	Cookie Diameter (cm)	Cake Volume (cc)
ARS970170-2L	79	58.9	32	152	8.5	0.41	71	46	36	35	-	86	9.4	1213
X970108-2C	78	56.5	32	151	9.0	0.36	74	51	30	32	37	92	9.8	1298
XERPHA	77	59.1	33	152	-	-	-	-	-	-	-	-	-	-
ARS970163-4C	77	58.7	31	155	8.9	0.33	74	50	35	32	-	95	9.7	1340
ARS970184-1C	76	58.9	31	149	8.5	0.34	71	47	37	31	50	90	9.7	1205
ARS970075-3C	76	58.5	31	151	9.4	0.35	72	49	30	34	70	90	9.5	1285
X970042-2C	76	57.3	32	151	8.8	0.36	75	54	24	31	44	94	10.0	1380
TUBBS	75	58.3	33	149	8.6	0.39	70	43	41	39	-	86	9.1	1198
ARS960277L	75	58.2	31	151	8.4	0.37	73	50	29	36	-	91	9.5	1253
X970170L	74	59.1	31	152	8.1	0.37	70	48	32	30	-	87	9.6	1310
ARS970071-3C	74	58.7	33	150	9.3	0.32	72	47	40	34	138	92	9.5	1235
BRUNDAGE96	74	58.6	30	149	9.6	0.40	71	48	22	33	-	86	9.7	1298
CHUKAR	73	57.0	31	154	8.8	0.38	72	50	42	29	53	89	9.8	1290
BRUEHL	73	57.3	34	154	-	-	-	-	-	-	-	-	-	-
X960538C	73	57.0	29	153	8.5	0.36	73	49	33	31	40	91	9.7	1258
X970161-2L	73	60.2	32	151	7.7	0.38	73	46	37	36	-	89	9.6	1258
X960011C	73	57.6	31	155	8.7	0.40	72	49	44	29	51	88	9.7	1293
X970161-3L	73	60.0	32	151	8.6	0.38	71	46	33	36	-	88	9.5	1235
ARS970108-1C	72	56.1	31	151	9.5	0.39	73	51	31	31	42	90	9.7	1270
X970005-2C	72	58.0	30	154	10.1	0.38	73	50	29	29	46	90	9.7	1298
X970042-1C	72	58.3	31	151	9.0	0.35	75	52	28	33	40	94	9.8	1308
ARS970042C	72	57.8	31	151	9.2	0.36	76	53	17	33	43	95	9.7	1295
ELTAN	72	59.4	32	153	10.0	0.38	69	46	33	32	-	85	9.5	1208
X96698t699C	72	57.6	31	154	8.4	0.35	72	50	43	30	47	90	9.9	1303
X970163-3C	71	58.8	30	152	8.4	0.39	72	49	38	32	38	88	9.7	1298
CODA	71	59.8	33	152	10.0	0.35	73	47	53	31	59	92	9.3	1208
X970185-1C	71	57.4	30	152	8.6	0.35	73	48	40	33	54	92	9.5	1235
ARS970168-2C	71	60.5	31	151	9.5	0.34	73	49	36	31	76	92	9.5	1248
CARA	71	57.3	29	153	9.6	0.38	74	50	42	28	57	91	9.7	1240
X970048C	71	58.3	30	150	9.4	0.37	72	49	38	29	45	90	9.6	1213
ARS970071-1C	71	60.1	31	149	9.3	0.34	72	49	42	31	100	92	9.6	1258
X96316t317-2C	71	58.3	32	151	8.8	0.36	73	49	44	31	64	92	9.6	1275
X970167-1-L	71	58.2	29	149	8.1	0.35	72	48	29	33	-	90	9.4	1315
X96312t313C	71	57.5	32	155	9.7	0.36	75	49	45	29	78	93	9.6	1185
X970048-1C	71	55.5	26	150	8.2	0.36	72	48	38	29	41	90	9.6	1243
ARS970175-1L	71	57.8	32	149	8.8	0.33	74	46	38	41	-	94	9.4	1203
X9602044-2C	71	58.8	27	150	9.0	0.33	71	48	32	33	82	90	9.4	1300
X970027-1C	71	58.8	30	152	9.3	0.38	71	48	36	31	63	88	9.7	1275
X96495t496-1C	70	58.5	31	155	9.8	0.38	72	49	30	31	62	88	9.8	1283
ARS970278-2C	70	58.6	32	149	8.7	0.38	70	47	42	30	73	87	9.5	1273
STEPHENS	70	58.5	31	147	-	-	-	-	-	-	-	-	-	-
ARS970175-3C	69	58.7	29	150	9.1	0.36	73	46	45	33	59	91	9.6	1185
X96316t317-1C	69	58.1	30	152	9.1	0.35	73	48	46	31	84	92	9.6	1243
FINCH	69	59.6	31	153	8.5	0.41	71	49	39	31	-	86	9.6	1270
X970038-2C	68	58.5	32	151	9.6	0.35	76	52	32	32	60	96	9.8	1248
ARS970175-4C	68	56.7	30	153	9.1	0.37	75	50	28	31	61	93	9.8	1285
X96347t348C	67	58.8	31	154	8.8	0.37	73	47	54	29	56	90	9.6	1205
LSD (5%)	4	0.8	1	1	0.8	0.02	1	1	7	2	17	2	0.2	49

Lines with **BOLD** font have also been included in WA state Variety Trials
Lines ending in C are Club, those ending in L are Soft White Winter
Desired values for Yield, Test Weight, Flour Yield, Break Flour, Single Kernel Weight, Mill Score, Cookie Diameter, and Cake Volume are high.
Desired values for Flour Protein, Flour Askh, Sinle Kernel Hardness, and Viscosity are low.
Viscosity was only determined on club wheats. Some named lines were not included as quality checks.

Additional results by Objective:

1: Conduct crossing program to improve resistance to stripe and leaf rust, cold tolerance, Cephalosporium stripe and Fusarium crown rot, resistance to cereal cyst and lesion nematodes and to maintain resistance to strawbreaker foot rot.

Approximately 300 crosses were made to incorporate new sources of resistance to stripe rust, Fusarium crown rot, and pathogenic nematoes into spring and winter breeding lines.. We initiated a hard white wheat breeding program in 2006 and made additional crosses and backcrosses for that germplasm.

Objective 2: Conduct marker assisted selection for winter survival, resistance to stripe rust, strawbreaker foot rot, Fusarium crown rot, barley yellow dwarf virus, cyst and lesion nematodes, and resistance to preharvest sprouting.

Marker assisted selection for foot rot has been conducted on a routine basis in our laboratory since 1989. We are now in the sixth year of development of our marker assisted populations. Head rows were selected at Spillman in 2008 and advanced to disease evaluation nurseries at Spillman. This additional year of head row selection was necessary because of the low stripe rust disease incidence at Spillman Farm in 2008.

Table 3. Field Plots and Headrow plots, USDA-ARS Wheat Breeding 2008

Location	Farm	Winter Wheat plots	Winter Wheat Head Row's	Spring Wheat plots	Spring Wheat Head Rows
Pullman, WA	WSU-Spillman Research Farm	2392	40,450	176	5907
Genesee, ID	Univ. of Idaho Kambitsch Research Farm	312			
Farmington, WA	Richard Pfaff Farm	120			
Harrington, WA	Kramer Farms	280			
Lind, WA	WSU-Dryland Research Station	660			
St. Andrews, WA	L. Tannenberg Farm	72			
Central Ferry, WA	USDA-ARS Research Farm	320	1000	100	
Pendleton, OR	OSU CBARC	1267			
Moro,OR	OSU Sherman County Ag Experiment Station	846			
Lexington, OR	Chris Rausch	120			
Hemiston, OR	Madison Farms	120			
TOTAL		6509	41,450	276	5907

Objectives 3: Plant, manage, evaluate and harvest early generation un-replicated nurseries, and 6. 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.

We evaluated over 54,142 wheat plots in 11 locations in WA, ID, and OR in 2008, similar to previous years (Table 3). We continued to increase our spring wheat breeding effort, specifically to introgress new sources of disease resistance into spring wheat. The primary disease screening nurseries (for resistance to Cephalosporium stripe, Strawbreaker Foot Rot, Stripe Rust and Fusarium crown rot were located at Pullman WA. The Oregon locations are managed by Jerron Chatelain who is employed by OSU at the Columbia Basin Agricultural Research Center.

Objective 4: Evaluate end use quality.
Traits evaluated:

Early generation nurseries were evaluated for micro-milling parameters, microsedimentation (a measure of protein strength), polyphenol oxidase activity and single kernel hardness. Our first hard wheat nurseries were evaluated using these methods and have been advanced to unreplicated yield plots in 2009.

Objective 5: Conduct laboratory, greenhouse and growth chamber evaluations.

Survival in artificial freezing tests was evaluated for all the entries in the Elite replicated nurseries (see report for project 5344). We are using the new mist chambers and growth chambers at the WSU wheat plant growth facility to evaluate both seedling and adult plant resistance to stripe rust during the winter. We are conducting an inheritance trial to determine the number and location of genes for resistance to stripe rust in Chukar. These results will be used for marker assisted selection of resistance gene combinations.

Purification of selected lines in all F_7 preliminary yield nurseries was conducted by snapping 40 heads and planting head rows in 2006. Those head rows were evaluated for stripe rust and lodging resistance in the presence of foot rot in an inoculated nursery at Spillman in 2007. This purification step results in higher quality breeder seed and another round of disease evaluation.

Objective 7: Conduct management research in collaboration with other scientists as needed. Several years ago, R.E. Allan conducted research using near isogenic lines of SWW and club wheat that differed only for the club gene. The club gene was associated with reduced seed size and fewer tillers than soft white winter wheats. Higher yields in club wheat come about because the club gene also results in more seeds per head. In the breeding program we rate and select for increased tillering as well as for increased seed size but the club gene is working against us. Because of concern that planting based on plant population may result in less than optimal tillers per square foot fot club and other low tillering wheats,, we have initiated trials comparing high and low tillering club and SWW wheats with large and small seeds at three seeding rates. These trials were planted at Harrington, Spillman, Farmington, and Pendleton in the fall of 2008. Early attempts to rate emergence have been hindered by the dry fall.

Presentations:

Invited speaker: Garland Campbell, K., 2008. New strategies in wheat breeding. Wheat CAPs project. Washington State Farm Forum, February 2008. Spokane WA. Customers: Growers, approx. 50. Impact/outcome: Grower education about molecular marker assisted selection strategies in wheat breeding to combat root and leaf diseases.

Speaker: Garland Campbell, K., 2008. Club wheat breeding. Washington Grain Alliance Wheat Review. February 2008. Pullman WA. Customers: Growers, approx. 50. Impact/outcome: Grower education about progress in breeding new club wheat cultivars for the Pacific Northwest using marker assisted selected integrated with field based breeding.

Speaker: Garland Campbell. K., 2008. New strategies for wheat breeding. All Russian Institution of Biological Plant Protection. Krasnodar Russia. May 2008. Customers: Scientists from Institute. Approx. 30. Impact/outcome: Exchange of ideas for wheat improvement and use of marker assisted selection, especially for breeding for rust resistance.

Field day: Garland-Campbell, K.., 2008. Club wheat breeding in the Pacific Northwest. Field Day for the Columbia Basin Agricultural Research Center., Pendleton OR, June 10, 2008. Customers: Growers, Scientists, administrators in Oregon. Approx. 100. Impact/outcome: Education about new cultivars, use of marker assisted selection in breeding for root diseases, and needs for future work. Information collected about grower needs.

Field day: Garland-Campbell, K.., 2008. Club wheat breeding in the Pacific Northwest. Field Day for the Sherman County Research Station, Moro OR, June 11, 2008. Customers: Growers, Scientists, administrators in Oregon. Approx. 75. Impact/outcome: Education about new cultivars, use of marker assisted selection in breeding for root diseases, and needs for future work. Information collected about grower needs.

Speaker: Garland-Campbell, K.., 2008. USDA-ARS wheat breeding: New strategies in wheat breeding. Overseas Variety Trial Meeting, Moscow ID and Pullman WA, June 10-13, 2008. Customers: Invited cereal scientists, buyers, exporters, grain quality specialists from US. Approx. 75. Impact/outcome: Discussion of Club wheat characteristics, use of marker assisted selection to improve grain quality in wheat breeding programs, and strategies for continued improvement. Information exchange between scientists and buyers and end–users.

Also attended and spoke at WA Variety Testing Plot Tours at: Connell, Almira, Fairfield, and Colton.

Publications.

Baley, G.J., K.G.Campbell, J.Yenish, K.K.Kidwell, T.C.Paulitz (submitted) Influence of Glyphosate, Crop Volunteer and Root Pathogens on Glyphosate-Resistant Wheat under Controlled Environment Conditions. Pest Management Science (In Press).

Carter, A, D. See, K. Kidwell and K. Campbell. 2008. Marker development and marker-assisted selection for improved disease resistance and end use quality in Pacific Northwest wheat. p. 32. *In* Burns, J. (ed), "2008 Dryland Field Day Abstracts: Highlights of Research Progress". Cooperative Extension, Washington State University, Dept. of Crop and Soil Sciences, Technical Report 08-1.

Carter, A.H., X.M. Chen, K.G. Campbell, K.K. Kidwell. 2008. Molecular mapping and identification of a QTL for high-temperature, adult-plant resistance to stripe rust

(*Puccinia striiformis* f. sp. *tritici*) in the spring wheat cultivar Louise (*Triticum aestivum* L.). ASA-CSSA-SSSA Annual Meetings. October 5-9, 2008. Houston TX.

Morris CF, Li S, Bettge AD, King GE, Garland- Campbell K, Gill KS. 2008. Arabinoxylan Content of Hard Winter and Spring Wheats of the U.S. Pacific Northwest. P-240. Proceedings of the International Wheat Genetics Symposium. August 24-29, 2008, Brisbane, Gld. Australia.

Santra, D.K. X.M. Chen, M. Santra, K.G. Campbell, K. K. Kidwell. 2008. Identification and mapping QTL for high-temperature adult-plant resistance to stripe rust in winter wheat (Triticum aestivum L.) cultivar 'Stephens'. Theor Appl Genet (doi:10.1007/s00122-008-0820-5) Online first.

Zemetra RS[1], Hansen JL[1], Koehler T[1], Chen J[1], Riera-Lizarazu O[2], Leonard J[2], Quincke M[2], Peterson CJ[2], Mundt C[2], Campbell KG[3], Chen X. 2008. Creation of a Multiple-Use Recombinant Inbred Line Population for the Development of Molecular Markers in Soft White Winter Wheat. P276. Proceedings of the International Wheat Genetics Symposium. August 24-29, 2008. Brisbane, Gld. Australia. http://www.fcconventions.com.au/IWGS/program.html#abstracts