RESEARCH PROJECT TITLE: Identifying Spring Habit Specialty Barley Varieties for Direct-Seeding and Development of Winter Habit Forms

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FINAL REPORT

PROJECT OBJECTIVES:
1. Screen available spring specialty barley varieties and advanced lines for adaptation to direct-seed production in the intermediate and low precipitation zones.
2. Develop winter specialty barley varieties that are adapted to direct seed production in the intermediate and low precipitation areas.

KEY WORDS: Direct-seeding, food barley, spring barley, winter barley

STATEMENT OF PROBLEM: Growers in the dryland PNW are searching for an agronomically suitable and economically profitable alternative crop. Winter and spring barley are potential crops for much of the low and intermediate rainfall areas where fallow is practiced to minimize the potential for barley to contaminate wheat. The dramatic increase in barley prices in the last year has increased grower interest in barley. There is increasing interest in ‘functional foods’ which have specific characteristics that are desired by consumers for their added health, nutrition, or other benefits. One such example is the health claim for barley. The FDA has approved a ‘heart healthy’ claim for barley because the B-glucans in barley have been shown to lower cholesterol. Barley grain is also a potential input for starch-based ethanol production while barley straw is a potential input for cellulosic ethanol production.

ZONE OF INTEREST: Intermediate and low rainfall zones

ABSTRACT OF RESEARCH FINDINGS: The field trials were established in the spring of 2006, 2007, and 2008 at the Pendleton and Moro Stations of the Columbia Basin Agricultural Research Center and harvested in July. Growing conditions were favorable for spring-seeded barley in 2006 at both Moro and Pendleton resulting in high yields at both sites. Yields in 2007 and 2008 were somewhat less than in 2006. Eleven of the 33 varieties were in the top 15 at both sites in 2006 and one, BZ-502-563, was the highest yielding line at both Pendleton and Moro. Eight of the 33 varieties were in the top 15 at both sites in 2007 and three of the top four varieties at both sites were the same. We seeded eight lines in 2008 into both conventional and untilled strips. The hulled lines consistently exhibited greater seedling vigor than hull-less lines and produced as much grain as ‘Baronesse’ and ‘Radiant’, two standard spring varieties. The hull-less lines of spring barley had noticeably greater test weight values than the hulled lines.

The development of winter habit, high β-glucan food barley germplasm was addressed using marker assisted selection (MAS) for two critical genes. Incorporation of the waxy allele at *Wx*, from spring to winter barley, is expected to raise the β-glucan concentration. Combining winter habit alleles at *Vrn-H1* and *Vrn-H2* is expected to maximize low temperature tolerance. Two spring habit donors of the waxy allele were selected and crossed to the winter six-row 'Strider' and the winter two-row 'Luca'. MAS was used to select target genotypes in the BC1F1 and BC1F2 generations. This involved ~ 1300 plants and 3,800 PCR reactions. In the fall of 2007, ~ 1,000 BC1F3 lines were planted in the field for phenotyping and seed increase. Grain β-glucan values equal to, and higher than, the high parent were observed in all crosses. The maximum β-glucan was 6.5%. Selected lines were advanced to preliminary yield trials at three locations (Corvallis and Pendleton, Oregon and Aberdeen, Idaho). Three lines are in elite trials. Abundant and promising germplasm is in the pipeline.

RESULTS AND INTERPRETATION: Objective One. Field trials were successfully established at Pendleton and Moro in the spring of 2006 and 2007; field trials in 2006 were seeded using a conventional drill while trials were seeded in direct seed fields using a no-till drill in 2007. A total of 33 varieties and advanced lines of waxy, high β-glucan spring barley, both hulled and hull-less were collected from breeders at the USDA-Agricultural Research Service (ARS) at Aberdeen, Idaho; Washington State University; University of Idaho and WestBred, LLC. These varieties and advanced lines were seeded in early March at 22 seeds per ft^2; the varieties were arranged in a randomized complete block design with four replications. We seeded 'Baronesse' and 'Camas' spring barley as check varieties. Individual plots were 5 by 20 ft in 2006 and 8 x 30 ft in 2007. In 2008 we established field trials at Pendleton and Moro on both conventional and untilled ground using a split plot design in which tillage was the main plot and varieties with all combinations of hull type and β-glucan concentration were the subplots. We seeded the entire trial area using a no-till drill and individual plots were 8 x 30 ft. Trials were established after fallow at Moro in 2006 and 2007 and after winter wheat in 2008; the previous crop at Pendleton was fallow in 2006 and winter wheat in 2007 and 2008. Fertilizer was applied as needed based on soil test results and weeds were controlled by using the appropriate herbicides. The trials were harvested in late July using a Wintersteiger plot. Grain was weighed to estimate yield and we measured grain protein, test weight, plump kernels, and β-glucan concentration.

2006 Moro

Growing conditions were favorable for spring-seeded barley in 2006 at both Moro and Pendleton. Total precipitation during the crop year (September 1 to August 31) was 18.9 inches at Pendleton and 16.9 inches at Moro. These figures are 15 and 49% greater than the long-term average at Pendleton and Moro, respectively. The distribution of rainfall was especially favorable for spring-seeded crops as April, May, and June precipitation was 45 and 115% greater than normal at Pendleton and Moro, respectively.

The greatest grain yield at Moro was slightly more than 4,000 lbs/acre; 'Camas' and two advanced lines (BZ-502-563 and 02WA-7037.25) produced more than 4,000 lbs of grain/acre in 2006 while 'Baronesse', the most widely planted variety of spring barley, produced 3,895 lbs of grain/acre (Table 1). Data from only the top 15 varieties are shown in the table. Grain protein ranged from 9.6% for 'Camas' to 13.5% for a Washington line (01WA-13860-10) and averaged 12.9%. Test weight ranged from 49 to 62 lbs/bu. Fifteen lines had test weights of 60 lbs/bu or greater. The hulled varieties had lower test weight values than the hull-less varieties. Plump kernels were taken to be kernels that did not pass through a screen with 6/64 inch openings. The plump kernels ranged from a low of 18% (three lines) to a high of 74% plump kernels from the advanced line 03AH2229; unfortunately, 03AH2229 was a low yielding variety at both Moro and Pendleton. There was an average of 39% plump kernels at Moro.

2006 Pendleton
The high yields at Pendleton are due to two factors: (1) the trial was seeded after fallow and (2) the favorable growing conditions in the spring of 2006. Three varieties (BZ-502-563, 'Camas' and 'Salute BZ-598-095') produced more than 5,000 lbs of grain/acre while 'Baronesse' was close behind at 4,980 lbs of grain/acre (Table 2). BZ-502-563 and 'Camas' produced the first and second greatest yields at both Moro and Pendleton, and four of the top five producing varieties were the same at Moro and Pendleton.

Grain protein values were higher at Pendleton, where the average grain protein was 14.4 percent compared to 11.9 percent at Moro. Grain protein at Pendleton ranged from 12.3 percent for 'Salute BZ-598-095' up to 16.9 percent for a Washington line (01WA-13860-5). Test weight ranged from 53 lbs/bu up to 61 lbs/bu. Twenty-one lines had test weights of 60 lbs/bu or greater. The hulled varieties and lines had lower test weight values than the hull-less varieties; the test weight of the hull-less lines was similar to the typical values for test weight of spring wheat grown in Pendleton. The plump kernels ranged from a low of 16% to a high of 87% from the advanced line 'Salute BZ-598-095'. The average of 58% plump kernels at Pendleton compared to only 39% at Moro. High β-glucan concentration is a desired trait for the potential food uses for barley because the β-glucan is the source of the health benefits. 'Camas' and 'Baronesse' had the lowest β-glucan concentration at 3.2 and 3.4%, respectively; the β-glucan concentration in the other lines ranged as high as 7.1% in 03AH2214. Eleven of the 33 varieties were in the top 15 at both sites in 2006 and one, BZ-502-563, was the highest yielding line at both Pendleton and Moro.

2007 Moro
Grain yields in 2007 were somewhat less than in 2006; average yield was 4,395 in 2006 and 2995 in 2007 (Table 3). However, the yield of 'Baronesse', the top yielding variety in 2007 was greater than the top yielding line in 2006. BZ-502-563 was the second-highest yielding variety in 2007 and the top producer in 2006. Grain protein ranged from a low of 11.5% to a high of 14.4% for two low yielding lines. The average protein concentration was 13.6% in 2007 compared to 11.9 in 2006. Test weights were markedly lower in 2007 compared to 2006; the average test weight was 58 lbs/bu in 2006 and 51.2 lbs/bu in 2007. Plump kernels were an average of 23% greater in 2007 than in 2006. β-glucan values averaged 5.3% in 2006 and 5.5% in 2007.

Table 1. Spring barley grain yield, protein, test weight, and percent of plump kernels and β-glucan at Moro, Oregon, 2006.

Variety	Grain yield	Protein	Test wt	Plump	β-glucan
	lb/acre	--%--	lb/bu	% on 6/64	% (w/w)
BZ-502-563	4,160	12.3	54	47	5.0
Camas	4,045	9.6	55	59	3.2
02WA-7037.25	4,015	10.7	56	34	3.4
Salute BZ598-095	3,985	11.5	52	63	5.0
Baronesse	3,895	9.7	51	38	3.4
Yu 501-0039 (HB813)	3,750	12.2	56	28	6.0
03AH2873	3,735	11.9	61	39	4.7
01WA-13860-10	3,645	13.5	59	37	4.6
03AH6482	3,600	11.3	59	57	3.5
02WA-7037.9	3,590	11.4	56	26	3.6
01WA-13860.5	3,570	12.4	59	22	4.6
Meresse-2	3,555	11.8	61	24	5.8
Yu 599-006	3,535	12.5	49	70	5.4
01WA-12501.2	3,485	11.2	60	29	5.5
WA-9820-98	3,470	11.7	59	18	4.0
Average of 33 entries	3,450	11.9	58	39	5.3
LSD (0.05)	480	2.0	3.8	20.5	1.7
CV %	10	8.1	5.4	42	16.6

Table 2. Spring barley grain yield, protein, test weight, and percent of plump kernels and β-glucan at Pendleton, Oregon, 2006.

Variety	Grain yield	Protein	Test wt	Plump	β-glucan
	lb/acre	--%--	lb/bu	% on 6/64	% (w/w)
BZ-502-563	5,180	12.9	53	78	5.3
Camas	5,085	13.0	55	64	3.4
Salute BZ-598-095	5,070	12.3	55	87	5.4
Baronesse	4,980	13.0	53	66	3.5
03AH6482	4,760	13.9	61	70	5.5
03AH6481	4,690	14.5	60	64	5.6
01WA-13860.5	4,675	16.9	60	53	4.7
02WA-7037.9	4,565	14.3	57	42	3.7
01WA-12501.2	4,560	14.9	60	64	6.0
03AH2873	4,555	14.5	61	60	5.8
03AH2854	4,500	14.3	60	47	4.1
03AH2689	4,480	14.0	60	59	6.4
Yu 501-0039 (HB813)	4,465	13.8	59	61	4.8
01WA-10001.4	4,450	14.5	60	39	5.0
01WA-13860-10	4,425	14.3	60	73	5.4
Average of 33 entries	4,395	14.4	59	58	5.3
LSD (0.05)	490	1.1	2.9	*	0.9
CV %	8.0	3.9	4.5	24	8.6

Table 3. Spring barley grain yield, protein, test weight, and percent of plump kernels and β-glucan at Moro, Oregon, 2007.

Variety	Grain yield	Protein	Test wt	Plump	β-glucan
	lb/acre	--%--	lb/bu	% on 6/64	% (w/w)
Baronesse	4,410	12.8	46.8	72	3.4
BZ-502-563	4,040	11.8	46.7	92	5.6
Salute BZ-598-095	3,940	11.5	47.3	87	4.9
02WA-7037.9	3,710	13.0	50.7	61	4.2
Camas	3,695	11.6	48.2	74	3.1
Yu 599-006	3,695	12.0	43.8	89	6.9
02WA-7037.25	3,450	13.0	52.7	57	4.2
01WA-13860.5	3,400	13.6	53.5	57	5.2
WA-9820-98	3,255	12.8	51.6	49	4.3
02WA-7037.10	3,200	13.3	52.3	63	4.5
03AH1170	3,075	13.1	52.7	71	5.2
BZ 598-161(HB811)	3,055	12.6	53.2	50	5.9
03AH6482	3,050	12.8	53.4	76	5.9
01WA-13860.4	3,050	13.5	52.0	63	5.8
03AH2854	2,990	12.8	51.7	51	4.3
Average of 33 entries	2,995	13.6	51.2	63	5.5
LSD (0.05)	430	0.1	1.1	14	0.7
CV %	10.3	6.3	0.1	8.7	8.6

2007 Pendleton

The trial at Pendleton was seeded after winter wheat resulting in somewhat reduced yields in 2007 compared to 2006 (Table 4). There was considerable straw and other residue from the previous wheat crop and this affected the early season vigor and growth of the crop. There was much less residue at Moro. 'Baronesse' was the top yielding variety at Pendleton as well as at Moro in 2007; BZ-502-563, the top yielding variety in 2006, was the second-highest yielding variety in 2007 at both sites. Grain protein values were somewhat less in 2007 compared to 2006 and averaged 13.6%. Test weight values were much lower in 2007 compared to 2006. However, the average plump kernel value was greater in 2007 than in 2006. β-glucan values were slightly higher in 2007 compared to 2006; β-glucan values at were the same at each location each year.

Eight of the 33 varieties were in the top 15 varieties at both sites in 2007 and three ('Baronesse', BZ-502-563, Salute BZ-598-095) were in the top four varieties at both sites.

Table 4. Spring barley grain yield, protein, test weight, and percent of plump kernels and β-glucan at Pendleton, Oregon, 2007.

Variety	Grain yield	Protein	Test wt	Plump	β-glucan
	lb/acre	--%--	lb/bu	% on 6/64	% (w/w)
Baronesse	3345	12.8	46.8	78	3.4
BZ-502-563	3050	11.8	46.7	80	5.6
03AH6481	3030	12.6	51.5	82	5.4
Salute BZ-598-095	2820	11.5	47.3	87	4.9
WA-9820-98	2635	12.8	51.6	31	4.3
BZ 598-161(HB811)	2565	12.6	53.2	68	5.9
01WA-13860-10	2545	13.1	53.4	71	5.6
Camas	2490	11.6	48.2	83	3.1
03AH2616	2475	13.3	52.9	67	5.8
03AH2215	2405	13.7	52.0	70	6.5
03AH6482	2395	12.8	53.4	85	5.9
02WA-7037.25	2390	13.0	52.7	44	4.2
01WA-12501.2	2345	13.1	51.9	68	5.5
Yu 501-0039 (HB813)	2300	12.4	52.8	70	5.6
03AH2689	2300	13.3	52.6	72	6.8
Average of 33 entries	2240	13.6	51.2	67	5.5
LSD (0.05)	635	1.0	1.1	8	0.7
CV %	15	6.3	0.1	8.2	8.6

2008 Results

Observations in 2006 and 2007 suggested that the hull-less lines were less vigorous, especially under direct-seeding, and that this reduced vigor may have lead to reduced yields. In 2008 we set out to directly compare the vigor, yield, and test weight of hulled and hull-less lines under both conventional and direct-seeding conditions. In addition, there were observations by others that suggested the reduced vigor from the hull-less lines might be associated with the high B-glucan concentration of most hull-less lines so we seeded all combinations of hulled and hull-less lines with low and high B-glucan values.

Moro

This trial was established following winter wheat and there was straw and residue on the surface that adversely affected planting; the drill frequently raked piles of residue containing soil and seed in the no-till strips which led to significant gaps in seeding leading to reduced seedling establishment and yield. In contrast, the drill worked much more effectively in the conventional strips.

Overall grain yields were markedly reduced compared to the grain yield in previous years due to the challenges we encountered with seeding, lower than normal rainfall of only 8.7 inches in the 2007-08 crop water year, and re-crop seeding after winter wheat. 'Bear' and 03AH6841, both hull-less lines, emerged very poorly under both conventional and direct-seeding conditions and no grain was harvested from those plots. Early season vigor, grain yield and test weight are shown in Table 5. The trial was plagued by extreme variability in final crop stand; yield data from this trial should be interpreted with caution.

The average vigor rating of the varieties in the conventional tillage strips was 5.6 compared to 4.1 in the untilled strips. The hull-less lines exhibited substantially lower average vigor than the hulled lines; the average vigor rating of the hulled lines was 8.2 compared to 3.1 for the hull-less lines in the conventional tillage strips. The average vigor rating of the hulled lines was 6.5 compared to 1.8 for the hull-less lines in the untilled strips. There was no difference in the average vigor rating of the lines with low or high β-glucan concentration.

Table 5. Vigor, yield, and test weight of eight spring barley varieties at Moro, 2008.

Entry			Vigor		Yield		Test wt.	
	Hull	β-glucan	Conv.	No-till	Conv.	No-till	Conv.	No-till
					Lbs/acre		Lbs/bu	
Baronesse	Yes	Low	9	7	715	415	49.8	49.9
Radiant	Yes	Low	6.7	5	605	575	50.5	48.1
Salute	Yes	High	9	6.5	640	365	49.8	45.3
BZ502-563	Yes	High	8.2	7.5	385	305	47.3	45.6
Merlin	No	Low	4.2	3.0	275	300	49.4	52.3
Bear	No	Low	2.7	1.0	--	--	--	--
WA13860.5	No	High	3	1.7	305	385	52.8	53.7
03AH6841	No	High	2.2	1.5	--	--	--	--

Pendleton

This trial was established following winter wheat; in contrast to the trial at Moro, there was no 'raking' of residue and we anticipated a good stand in both conventional and no-tillage strips. Unfortunately, rainfall soon after seeding caused the soil in the conventional strips to crust and the seedling emergence was erratic in the plots. The soil in the direct-seed strips did not crust and stands were more uniform and thicker. The plots were rated for vigor in late April and there was little difference in vigor of a variety grown in the conventional or no-till strips (Table 5). There was, however, a marked difference in the average vigor of the hulled and hull-less lines; the overall average vigor rating was 9.1 for hulled lines and 3.4 for hull-less lines. The vigor was unaffected by the β-glucan content as the overall vigor rating for the low β-glucan lines was 5.9 compared to 6.6 for the high β-glucan lines.

Yields were lower in 2008 because the total rainfall for 2008 was about 2 inches less than normal and the crop was subject to unseasonably hot weather in mid-May. Yields were unaffected by tillage system with the overall average yield for conventional tillage of 2,200 lbs/acre compared to 2,250 lbs/acre for the no-till average. The average yield of the hulled lines was 2,490 lbs/acre while the average yield of the hull-less lines was only 1,830 lbs/acre. 'Bear' emerged very poorly and there only a few plants (<20) in each plot so we did not harvest grain from those plots. 'Salute' and BZ502-563, hulled high β-glucan lines, were as productive as 'Baronesse' and 'Radiant', the standard feed barley lines in the trial.

Table 6. Vigor, yield, and test weight of eight spring barley varieties at Pendleton, 2008.

Entry			Vigor		Yield		Test wt.	
	Hull	β-glucan	Conv.	No-till	Conv.	No-till	Conv.	No-till
					Lbs/acre		Lbs/bu	
Baronesse	Yes	Low	8.8	9.5	2,640	2,685	49.6	48.3
Radiant	Yes	Low	8.3	8.5	2,325	2,310	47.9	48.0
Salute	Yes	High	9.0	9.5	2,685	2,395	50.0	49.0
BZ502-563	Yes	High	9.3	9.5	2,260	2,610	45.7	47.4
Merlin	No	Low	4.8	4.8	1,840	1,765	57.3	58.1
Bear	No	Low	1.3	1	--	--	--	--
WA13860.5	No	High	4.8	5.7	1,975	2,065	57.2	58.4
03AH6841	No	High	1.7	3.5	1,465	1,880	51.6	52.4
LSD (0.05)			2.3		360		2.4	

Summary of field trials
The highest yielding lines of hulled waxy spring food barley were as productive as the non-waxy standard varieties such as 'Baronesse' with greater β-glucan concentration. The hull-less lines had noticeably less seedling vigor, especially under stressful conditions and tended to yield less than the hulled lines. The hull-less lines of spring barley had greater test weight values than the hulled lines.

Objective Two.
Goal: The goal of this aspect of the project is to rapidly develop winter habit barley varieties with high grain beta glucan content. Incorporation of the waxy (recessive) allele at the Waxy locus is a quick way to maximize grain beta glucan content. All current waxy barley varieties are spring habit. Therefore, our goal was to transfer the waxy gene into adapted winter barley germplasm. We chose the winter six-row (Strider) and the winter two-row (Luca) as recipients for the waxy gene.

Background: We used molecular marker assisted selection (MAS) and backcrossing as our breeding tools. Because we had previously determined that two spring habit waxy varieties (Waxbar and Merlin) have winter (*vrnH1*) alleles at *VrnH1*, this meant that MAS was based on "perfect markers" for alleles at two loci: *VrnH2* and *Wx*. We developed large backcross populations from the crosses of Luca/Merlin//Luca, Luca/Waxbar//Luca, and Strider/Merlin//Strider. We also developed a double cross population from Luca/Waxbar//Luca/Merlin. DNA was extracted from cross progeny grown in the greenhouse and used for polymerase chain reaction (PCR) amplification of *VrnH2* and *Wx* alleles. Progeny with target alleles (homozygotes at *VrnH2* and heterozygotes at *Wx*) were selected in the BC1F1 generation. Selected plants were selfed. The next generation (BC1F2), progeny were again genotyped and homozygotes were selected at *Wx*. The MAS program involved ~ 1300 plants and 3,800 PCR reactions. In the fall of 2007, these BC1F3 lines were planted in the field for phenotyping and seed increase. Although the focus of the project was on MAS for waxy starch type and vernalization sensitivity, we also cast a wider net for non-waxy starch types by including the BC1F2 and unselected lines in our field trials. We have also developed six-row hull-less lines with normal starch using "Doyce" as the donor of the hull-less trait. The adapted parents were Strider and an experimental selection with the pedigree "Maja/Legacy/Maja".

Results: The numbers of lines in field trials last year (in 2007-2008), this year (2008-2009) and forecast for the following year (2009-2010) are shown in Table 7.

Table 7. Numbers of winter food barley lines advanced to field trials.

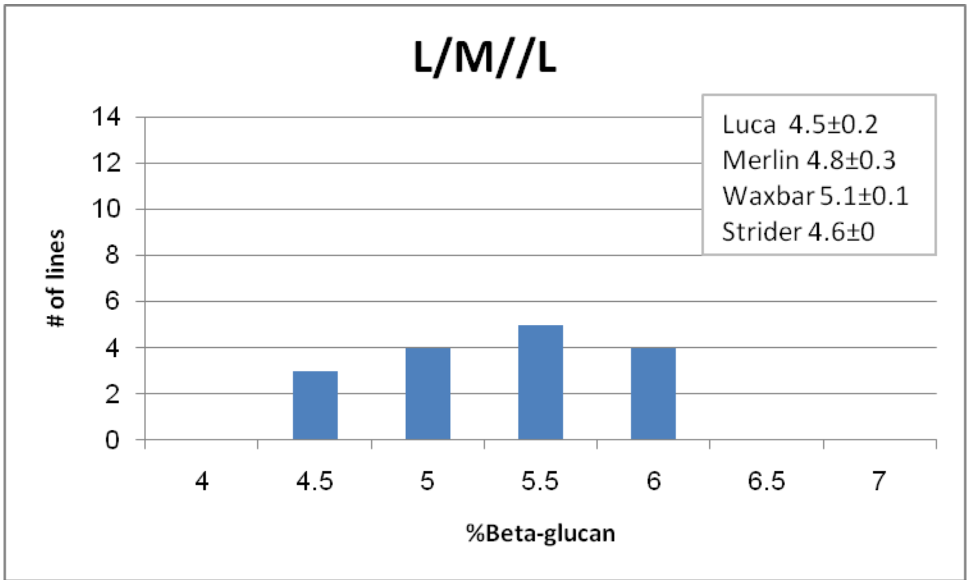
Winter barley crop year	***Crossing block***	***Early generations***	***Head rows***	***Preliminary yield trials***	***Elite yield trials***	***On farm trials***
07-08	0	0	~ 1000	12 (PO)*	0	0
08-09	17	64 F1	129	Fixies:102 (CO & AI) 83 (PO) Segs: 51 (PO)	OR85,86,87 CO,PO,AI,PW	0
09-10	P**	P-F1, P-F2		P***	~ 20	P

*PO = Pendleton, Oregon, CO = Corvallis, Oregon, AI = Aberdeen, Idaho, PW = Pullman, Washington
** Option to re-select among ~350 sister lines of 08_09 PYTs, held in reserve
*** Possible

In order to make selections amongst the products of MAS and to reduce the number of lines going into yield trials to fit available resources, we selected the most phenotypically attractive of each of the three sister lines tracing to each MAS-selected plant. Individual heads and bulk seed were harvested from each of these selected lines. We also harvested individual heads and bulk seed from each of the remaining two sister lines. In some cases, particularly in the 2-row x 6-row population (S/M//S), we harvested only individual heads since the level of phenotypic segregation within the head row was unacceptable. We determined grain β-glucan (using Megazyme kits) and grain protein (using NIR) on each of the selected bulks. Head rows that were fixed for the *Vrn* and *Wx* alleles ("fixies") were the principal targets for selection and were advanced to preliminary yield trials (PYTs) at Corvallis, Pendleton (Oregon) and Aberdeen (Idaho) (Table 5). A subset of selected head rows that were fixed for target *Vrn* alleles but still segregating at the *Wx* locus ("segs") were advanced to a PYT only at Pendleton. For every bulk advanced to a PYT, purification head rows were planted at Corvallis. Grain β-glucan results for the "fixie" lines are shown in Figures 1a – 1d. For all crosses, lines with grain β-glucan values higher than the high parent were advanced to PYTs.

Figure 1. Grain β-glucan values for winter barley germplasm developed by marker assisted selection (MAS) for the allele combination *Vrn-H2VrnH2vrnH1vrnH1wxwx*. The Figures represent phenotypic frequency distributions for head rows derived from the cross of (a) Luca/Merlin//Luca (L/M//L), (b) Luca/Waxbar//Luca (L/W//L), (c) Strider/Merlin//Strider (S/M//S) and (d) Luca/Merlin//Luca/Waxbar (L/M//L/W).

a



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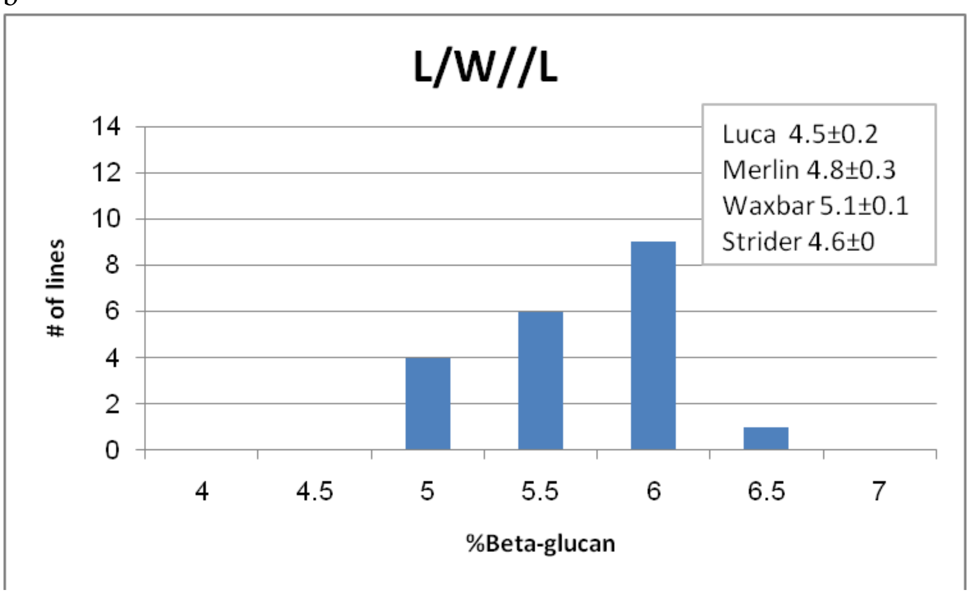

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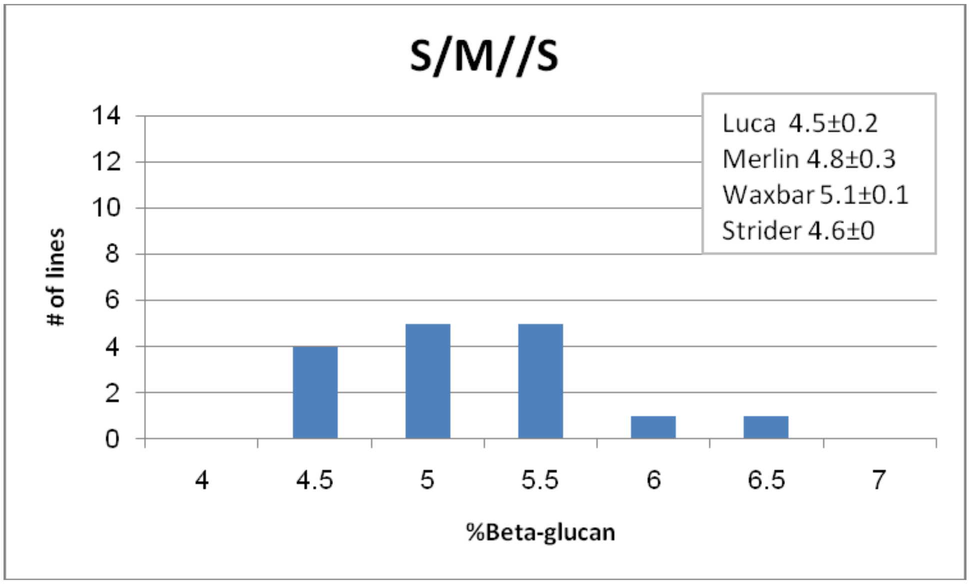

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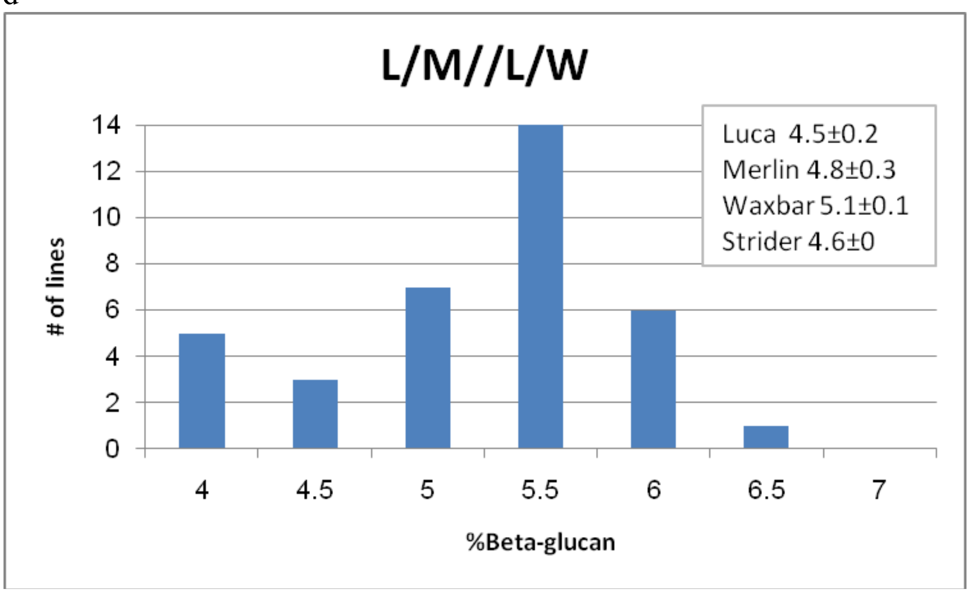

IMPACTS OF RESEARCH: This work has created a novel germplasm base that will increase the likelihood of quick release of winter food barley varieties. The widespread production of food barley is dependent on the development of markets for barley-based foods and this food segment is in its infancy at the current time.

INTERACTION WITH SCIENTISTS CONDUCTING RELATED ACTIVITIES:
Various current and past members of the Dept. of Crop and Soil Science, Oregon State University have contributed to this effort. Dr. Peter Szucs and Ms. Tanya Filichkin were responsible for developing and supervising the molecular marker laboratory work. Ms. Ann Corey was responsible for field trials. Mr. Juan Rey and Ms. Yada Chutimanitsakun participated

in germplasm development and assessment as part of their MS thesis research, but they were not paid with STEEP funds. Dr. Andrew Ross and Ms. Caryn Ong assisted with the grain β-glucan and protein analyses. The 2008 – 2009 trials at Aberdeen, Idaho are grown in cooperation with Dr. Don Obert, USDA/ARS Aberdeen, Idaho.

PUBLICATIONS AND PRESENTATIONS: We presented information on the breeding aspects of this research at the Pendleton Field Day (210 attendees in 2007) and the Sherman Station Field Day (120 attendees in 2007) in 2007. We presented information on the spring variety evaluation at the Pendleton Field Day (175 attendees) and Sherman Station Field Day (110 attendees) in 2008 The preliminary results of the breeding work were presented as examples of marker assisted selection in numerous regional, national and international presentations including:

1. Using genetics to advance breeding. Eucarpia – Cereal Section. Lleida, Spain. Nov,13-17, 2006.
2. Tri-State Barley Research Review. Pacific Northwest Grains Conference. Portland, OR. Dec. 7, 2006.
3. Winter hardiness update. Barley Improvement Conference. San Diego, CA. January 11, 2007.
4. Tapping allelic diversity in barley. Pannonian Biotechnology Association Workshop. Piestany, Slovakia. April 17, 2007.
5. Tapping allelic diversity in barley. Visiting scientist series. Martonvasar Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. April 20, 2007.
6. The Barley Coordinated Agricultural Project (CAP): Alineando Genomica, Genetica y Mejoramiento para el descubrimiento de genes y desarrollo de la cebada. Universidad de la Republica. Montevideo, Uruguay. October 3, 2007.
7. Current and future prospects for marker assisted selection. BioAsia 2007. Bangkok, Thailand. November 5 – 9, 2007.
8. Return to the wild: Prospects for molecular breeding of malting and food barley. Gaterslabian lecture. IPK, Gaterslaben, Germany. June 9, 2008.

Information on the evaluation of spring barley lines was presented at regional and national meetings and publications including:

1. Agronomic performance of food barley and waxy wheat varieties at Pendleton and Moro. 2006 Oregon Wheat Growers League Annual Meeting. Portland, OR.
2. Yield and quality of spring food barley lines. 11th Annual Direct Seed Cropping Systems Conference. Kennewick, WA.
3. Agronomic performance of food barley at Pendleton and Moro. Ore. Agric. Exp. Stn. Spec. Rept. 1074.
4. Yield and quality of spring waxy barley lines at Moro and Pendleton. 2007 PNW Grains Conference. Spokane, WA.
5. Production of dryland barley for human food: quality and agronomic performance. Crop Sci. *In press.*