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Western REGIONAL SPRING BARLEY NURSERY
2012 Crop

Preliminary Quality Report

C. H. Martens and *Staff

Detailed Data:

Aberdeen, ID
Conrad, MT
Fairfield, MT
Idaho Falls, ID

Appendix:
Methods
Criteria for Quality Score

Samples were malted and analyzed by the Cereal Crops Research Unit, Madison, WI

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Western Regional Spring Barley Nursery – 2012 Crop

The Western Regional Spring Barley Nursery (WRSBN) is an annual agronomic project coordinated by Dr. Charles Erickson of the USDA-ARS National Small Grains Germplasm Research Facility, Aberdeen, ID. Cereal Crops Research Unit, in Madison, Wisconsin, received WRSBN selections from the 2012 crop, grown at experimental stations in Aberdeen, ID, Conrad, MT, Fairfield, MT, and Idaho Falls, ID. Table 1 is an entry list, with parentages for the 2012 WRSBN, supplied by Dr. Erickson. Each location grew 31 selections – 16 of them new for the 2012 crop. These samples were tested for barley characteristics, malted, and analyzed for malt quality.

The maltings were performed in Joe White (JW) micro-malters, under conditions that should generate malts having modification levels similar to those produced industrially. Detailed descriptions of the malting conditions and analytical methods employed are listed in Appendix A. The criteria and value assignments used to calculate quality scores are based upon the "Ideal Commercial Malt Criteria" developed by the American Malting Barley Association (AMBA). These are listed in Appendix B.

SAS 9.3 statistical software was used to compare performances at the four locations and between the selections; mean values for fourteen quality factors are listed across the four WRSBN stations (Table 2), and across all lines (Table 4). Table 3 shows the location means for the quality factors across all lines, with the three Food barleys excluded. Individual station data are reported in Tables 5 through 8. Evaluations of data from individual locations and overall performance of each line, derived mostly from Tables 2 and 4, are presented, as well.

The barley submissions from Aberdeen, ID were relatively large, with an average kernel weight of 40.6mg/kernel – second highest of the locations – and quite plump, with an average of 94.1%, as measured by 6/64" slotted screen. However, they averaged the lowest kernel brightness ($p < 0.05$), of any of the locations. Malts made from samples from this location yielded the highest Fine Grind Extract average of the locations (81.2%, dry basis), except for those from Conrad, MT, from which they did not differ significantly (81.1%). This was likely due to their second lowest average barley protein percent, coupled with the high kernel size and plumpness averages. The malts from these Aberdeen submissions also yielded the highest Wort Color average ($p < 0.05$). Their Kohlbach Index average fell into the ideal range for 2-rowed barleys: 45.6. This was a moderate location for amylolytic measures, with the Diastatic Power average of 123° significantly lower than that of Fairfield, Mt (158°), and not significantly different from the Idaho Falls, ID average (132°); none of the location α-Amylase averages differed significantly ($p < 0.05$). The average Free Amino Nitrogen (FAN) content of worts produced from these malts was significantly higher than any other location (189ppm). The Aberdeen samples produced the highest overall quality score average of any location -- an impressive 50.6.

Conrad, MT barleys had the lowest average kernel weight in the nursery: 36.1mg/kernel. This was significantly lower than those of the three other locations. Conrad's average plumpness was significantly lower than that of Fairfield, but did not differ significantly from either Aberdeen or Idaho Falls. The Kernel Brightness (Agtron) average was significantly higher than that of any other location in the WRSBN. Interestingly, however, the malts from these barleys developed the second highest

average Wort Color – only lower than that of the Aberdeen malts. Even with the low average Kernel Weight, these barleys were in the top tier for average Malt Extract Percent (81.1%, dry basis), and here again, low barley proteins may have played a role; the Conrad average Barley Protein value was significantly lower than that of any other location; the 10.7% average was less than the ideal range for 2-rowed barley. The Wort Protein average was significantly lower than for the three other locations, yet the S/T ratio averaged the highest of the locations in the nursery. These findings likely can be traced back to the low Barley Protein average mentioned above. In addition, because of this, it is not surprising that the Conrad location Diastatic Power average was significantly lower than the other three locations' averages. The 92° average paled in comparison with the 158° average of Fairfield. However, the α-Amylase parameter did not mirror the DP results, as the average for this location did not differ significantly from any other location. Again, likely as a result of the low barley proteins, the average FAN value was the lowest of any in the WRSBN ($p < 0.05$), at 165ppm.

Barleys from Fairfield, MT showed the highest average Kernel Weight of any location at 41.6mg/kernel, and their Plumpness average was high, as well, at 95.5% -- not significantly different from that of Aberdeen, but higher than those of Conrad and Idaho Falls. Even so, the average Malt Extract Percent from this location of 78.6% was in the lowest tier with Idaho Falls. This was the converse of the Conrad results; the Fairfield barleys had the highest Barley Protein % average at 14.6%, which is well above the ideal range, and this contributed to its lower Malt Extract average. Soluble Protein levels also may have been impacted, as this location showed the highest average. Wort colors were relatively low, with the average not differing significantly from that of Idaho Falls, but significantly lower than that of Aberdeen or Conrad, and the S/T index average was the lowest in the nursery, due to such a high denominator. The thousands of barleys we receive annually demonstrate a moderate correlation between Barley Protein and DP ($r = 0.63$) and a weaker correlation with α-Amylase ($r = 0.25$). The Fairfield location data adhered to these trends. Its DP average at 158.0° was significantly higher than those of the three other locations, yet none of the location α-Amylase averages differed significantly. Also of note, the Fairfield malts averaged the lowest Viscosity (not significantly different from Aberdeen), and these malts had the lowest overall Quality Score of the locations at 36.6 (not significantly different from Conrad).

The Idaho Falls barleys had a significantly lower average Kernel Weight, at 38.7mg/kernel, than Fairfield or Aberdeen, but it was significantly higher than that of Conrad. Average Plumpness at 91.6%, was also relatively low, though not significantly different from that of Conrad. These barleys paired with those of Fairfield in averaging significantly lower Malt Extract % than the barleys from Aberdeen or Conrad. However, these malts also aligned with those from Fairfield in yielding the lowest average Wort Color (1.64) – not significantly different from Fairfield. The Idaho Falls DP average was relatively high at 132°, but not significantly different from that of the Aberdeen barleys. The Beta-Glucan levels at this location averaged significantly higher than all of the three other locations, and it had a high average Relative Viscosity, as well, at 2.14. Please note that the Beta-Glucan and Viscosity averages were raised by the presence of Food barleys in the 2012 WRSBN. When the Food barleys were removed from the statistics, the Idaho Falls Beta-Glucan and Viscosity averaged dropped to 231ppm and 1.51m respectively. For this reason, a second table (Table 3) showing means across all lines, except the Food

barleys, was included for the 2012 WRSBN data. Finally, the Idaho Falls Turbidity average, at 8.9 Hach units, was significantly lower than those of the three other locations.

The top performing line across locations was the variety, CDC Kindersley. The mash extract made from this malted barley had very low average Relative Viscosity (1.41), the lowest average Beta-Glucan level (55ppm), relatively high Diastatic Power/ α-Amylase – 172°/54.5DU, and low Turbidity (5.5 Hach units). It's Malt Extract of 80.7 % was respectable, but others were higher. Its malts from Conrad and Aberdeen did yield high Malt Extract levels. (CDC Kindersley also had a high average overall quality score in the 2011 WRSBN). 2Ab07-X031098-31 shared a similar profile, but with a higher Malt Extract average of 81.8%. (Its Conrad malt yielded an 84.1% Malt Extract). 2B09-3944, also shared this pattern, except that its malt yielded lower Soluble Protein and S/T levels than the former two varieties. This was despite the fact it had a higher average Barley Protein. 2Ab07X04M219-46 had a good Malt Extract average, but lower averages for Soluble Protein, S/T, and amylolytic enzyme levels; these all were likely affected by its lower Barley Protein average, which was over one percent lower than any of the previously mentioned high performing lines. 2B09-3998 performed in a manner similar to 2B09-3944, except with lower average DP, and higher average Beta-Glucan levels.

The 2013 WRSBN barleys which exhibited the lowest overall malting quality were, not surprisingly, Feed or Food barleys. These included Steptoe, 05WA-316.99, UT6R2120-14, 2Ab09-X06F58HL-21, 2Ab09-X06F058HL-30, and Baronesse. Steptoe's Malt Extract averaged 82.7%, but none of its other malting quality parameters could be considered good. UT6R2120-14 surprised with an average DP of 131°, but its α-Amylase was only 38.9DU. The two Food barleys, 2Ab09-X06F58HL-21 and 2Ab09-X06F058HL-30, demonstrated that profile, but little malting quality. They had Beta-Glucan and Relative Viscosity averages of 2904ppm, 3059ppm, 10.21, and 9.96, respectively. Their hull-less characteristics raised their Malt Extract Percentages, which saved them from having the lowest numerical overall quality score averages. Again, those levels buttress their intended Food usage, but also indicate a definite lack of malting quality.

*We wish to thank the American Malting Barley Association (AMBA) for supporting this project. This report could not have been produced without the commitment and excellent technical work of our staff: Jordon Geurts, USDA-ARS Biological Science Technician; Keith Gilchrist, USDA-ARS Physical Science Technician; Michael Marinac, USDA-ARS Physical Science Technician; and Andrew Standish, U. of Wisconsin Research Specialist (AMBA-funded).

Table 1. 2012 Western Regional Spring Barley Nursery Entries

Seed Source	Entry No.		Entry	Parentage	Type	Grade	Years Tested	Cooperator
WSU	1		Steptoe	CI 15229	6 row	feed		Check, Ulrich, Wood
WPB	2		Baronesse	PI 568246	2 row	feed		Check, Clark, Cook
USDA-ARS	3		Harrington		2 row	malting		Check, Erickson
USDA-ARS	4		AC Metcalfe		2 row	malting		Check, Erickson, Beattie
BARI	5	*	2B09-3408		2 row	malting	0	Selmer
BARI	6	*	2B09-3944		2 row	malting	0	Selmer
BARI	7	*	2B09-3998		2 row	malting	0	Selmer
BARI	8	*	2B09-4049		2 row	malting	0	Selmer
USDA-ARS	9		01Ab9663	93Ab375//92Ab5189/M83	6 row	malting	2	HU
USDA-ARS	10		2Ab04-X01084-27	98Ab11993/Garnet	2 row	malting	2	HU
USDA-ARS	11	*	2Ab07-X031098-31	2B97-4004/Newdale	2 row	malting	0	HU
USDA-ARS	12	*	2Ab09-X06F058HL-21	02HR-4590/CDC Fibar	2 row	hulless, Food	0	HU
USDA-ARS	13	*	2Ab07-X04M219-46	95SR316A/2B97-4004	2 row	malting	0	HU
USDA-ARS	14	*	2Ab09-X06F058HL-30	02HR-4590/CDC Fibar	2 row	hulless, Food	0	HU
USDA-ARS	15	*	2Ab07-X04M281-32	2B97-4004/Newdale	2 row	malting	0	HU
USDA-ARS	16	*	2Ab09-X06F058HL-195	02HR-4590/CDC Fibar	2 row	hulless, Food	0	HU
USDA-ARS	17	*	08ID1549	Spaulding/Clearwater	2 row	hulless, feed	0	Bregitzer
USDA-ARS	18	*	08ID2661	04lpa-10/Tetonia	2 row	feed	0	Bregitzer
MSU	19	*	MT061035		2 row	feed	0	Blake
MSU	20	*	MT070158		2 row	feed	0	Blake
MSU	21	*	MT070159		2 row	feed	0	Blake
MSU	22	*	MT080279		2 row	feed	0	Blake
NDSU	23		2ND25276	ND20802/3/ND1922//ND19929/ND20177	2 row	malting	2	Horsley
NDSU	24		2ND26333	ND22032-2/ND21972	2 row	malting	1	Horsley
USU	25		UT04B2041-42	Goldeneye/Columbia	6 row	feed	5	Hole
USU	26		UT6R2120-14		6 row	feed	1	Hole
WSU	27		05WA-316.K	Baronesse/PB1-95-2R-522	2 row	feed	2	Murphy, Wood
WSU	28		05WA-316.99	Baronesse/PB1-95-2R-522	2 row	feed	2	Murphy, Wood
WSU	29	*	07WA-614.4	Bob/Baronesse//85Ab2323/3/WA 10497-97	2 row	feed	0	Murphy, Wood
WSU	30	*	07WA-682.1	WA 10701-99/ AC Metcalfe	2 row	malting	0	Murphy, Wood
WSU	31		2004NZ151	00NZ304xCellar	2 row	feed	1	von Wettstein
WSU	32		2004NZ163	00NZ304x85Ab2323	2 row	feed	1	von Wettstein
WSU	33	*	2008NZ003	Tradition*01NZ706 F4 Bulk	6 row	malting	0	von Wettstein
WSU	34	*	2008NZ004	Tradition*01NZ706 F4 Bulk	6 row	malting	0	von Wettstein
WSU	35	*	2008NZ013	Tradition*01NZ706 F4 Bulk	6 row	malting	0	von Wettstein
USASK	36		CDC Kindersley	SM00490/BM9647D-64	2 row	malting	1	Beattie

* new entries

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Table 2 - Station Means* of Barley and Malt Quality Factors for 31 Varieties or Selections*/

LOCATION	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Viscosity (Relative)	Turbidity (HACH)	Quality Score
Aberdeen, ID	**40.6 b**	**94.1 ab**	**60.0 d**	**81.2 a**	**2.0 a**	**11.7 c**	**5.11 b**	**45.6 b**	**123 b**	**69.2 a**	**277 b**	**189 a**	**1.52 b**	**17.6 a**	**50.6 a**
Conrad, MT	**36.1 d**	**92.6 bc**	**86.8 a**	**81.1 a**	**1.9 b**	**10.3 d**	**4.78 c**	**47.1 a**	**92 c**	**68.6 a**	**323 b**	**165 c**	**2.29 a**	**16.7 a**	**39.3 bc**
Farifield, MT	**41.6 a**	**95.5 a**	**72.0 c**	**78.6 b**	**1.7 c**	**14.6 a**	**5.47 a**	**38.5 d**	**158 a**	**68.4 a**	**254 b**	**176 b**	**1.51 b**	**14.7 a**	**36.6 c**
Idaho Falls, ID	**38.7 c**	**91.6 c**	**75.8 b**	**78.9 b**	**1.6 c**	**13.3 b**	**5.24 b**	**41.3 c**	**132 b**	**67.7 a**	**499 a**	**181 b**	**2.14 a**	**8.9 b**	**40.0 b**

* Within each column, means followed by the same letter are not significantly different (alpha < 0.05), according to Duncan's Multiple Range Test

**Steptoe, Baronesse, Harrington, AC Metcalfe, 2B09-3408, 2B09-3944, 2B09-3998, 2B09-4049, 01Ab9663, 2Ab04-X01084-27, 2Ab07-X031098-31, 2Ab09-X06F058HL-21, 2Ab07-X04M219-46, 2Ab09-X06F058HL-30, 2Ab07-X04M281-32, 2Ab09-X06F058HL-195, 08ID1549, 08ID2661, MT061035, MT070158, MT070159, MT080279, 2ND25276, 2ND26333, UT04B2041-42, UT6R2120-14, 05WA-316.K, 05WA-316.99, 07WA-614.4, 07WA-682.1

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Table 3 - Station Means* of Barley and Malt Quality Factors for 31 Varieties or Selections -- Without Food Barleys**

LOCATION	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Viscosity (Relative)	Turbidity (HACH)	Quality Score
Aberdeen, ID	**40.6 b**	**94.1 b**	**60.0 d**	**81.2 a**	**2.0 a**	**11.7 c**	**5.11 b**	**45.6 b**	**123 c**	**69.2 a**	**277 a**	**189 a**	**1.52 a**	**17.6 a**	**50.6 a**
Conrad, MT	**36.1 d**	**93.1 b**	**89.1 a**	**81.1 a**	**1.9 b**	**10.0 d**	**4.72 c**	**48.3 a**	**95 d**	**71.0 a**	**128 c**	**169 b**	**1.47 b**	**16.0 a**	**40.5 b**
Farifield, MT	**41.9 a**	**95.9 a**	**73.9 c**	**78.6 b**	**1.7 c**	**14.4 a**	**5.44 a**	**38.7 d**	**161 a**	**69.5 a**	**260 b**	**174 b**	**1.51 a**	**15.0 a**	**36.9 c**
Idaho Falls, ID	**38.7 c**	**91.5 c**	**77.9 b**	**78.9 b**	**1.7 c**	**13.0 b**	**5.34 a**	**42.7 c**	**138 b**	**70.2 a**	**231 b**	**187 a**	**1.51 a**	**8.8 b**	**42.1 b**

* Within each column, means followed by the same letter are not significantly different (alpha < 0.05), according to Duncan's Multiple Range Test

**Steptoe, Baronesse, Harrington, AC Metcalfe, 2B09-3408, 2B09-3944, 2B09-3998, 2B09-4049, 01Ab9663, 2Ab04-X01084-27, 2Ab07-X031098-31, 2Ab07-X04M219-46, 2Ab07-X04M281-32, 08ID1549, 08ID2661, MT061035, MT070158, MT070159, MT080279, 2ND25276, 2ND26333, UT04B2041-42, UT6R2120-14, 05WA-316.K, 05WA-316.99, 07WA-614.4, 07WA-682.1

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Table 4 - Varietal Means* of Barley and Malt Quality Factors for Four Stations**

Variety or Selection	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Viscosity (Relative)	Turbidity (HACH)	Quality Score
Steptoe	**40.0 bcdefgh**	**94.4 abcd**	**82.7 abc**	**74.8 m**	***** n.d.**	**11.1 hi**	**3.85 mn**	**36.5 jkl**	**67 qr**	**35.3 p**	**740 c**	**117 n**	**1.71 c**	**43.3 a**	16.7 m
Baronesse	**39.4 defghij**	**94.4 abcd**	**84.0 ab**	**77.2 jkl**	**2.1 b**	**12.2 efgh**	**4.09 lmn**	**35.9 kl**	**104 klmnop**	**48.4 lm**	**161 d**	**117 n**	**1.51 c**	**29.2 bcde**	26.0 ijklm
Harrington	**38.2 fghijklmn**	**93.7 abcde**	**75.3 defghi**	**80.6 bcde**	**1.6 cdefg**	**12.8 cdefg**	**5.59 bcd**	**45.7 cdefg**	**145 bcdefg**	**82.0 bcd**	**146 d**	**203 bcde**	**1.47 c**	**5.8 fg**	47.5 abc
AC Metcalfe	**36.5 lmno**	**90.6 cdefg**	**78.3 bcdefghi**	**79.6 defg**	**1.8 bcde**	**13.8 c**	**6.03 b**	**46.1 cdef**	**185 a**	**96.7 a**	**66 d**	**221 b**	**1.44 c**	**5.6 fg**	46.5 abcd
2B09-3408	**38.5 efghijklmn**	**93.0 abcdef**	**75.8 cdefghi**	**79.7 defg**	**1.6 cdefg**	**12.1 efgh**	**4.92 efghij**	**42.8 efghi**	**160 abcdef**	**83.1 bcd**	**102 d**	**170 ghij**	**1.45 c**	**4.9 g**	48.0 abc
2B09-3944	**39.0 defghijkl**	**94.6 abcd**	**72.0 hi**	**80.5 bcde**	**1.7 bcdef**	**12.6 cdefg**	**5.14 cdefg**	**43.2 efghi**	**166 abcd**	**79.0 de**	**100 d**	**182 defgh**	**1.46 c**	**6.3 fg**	50.3 ab
2B09-3998	**43.2 a**	**95.9 abc**	**74.3 defghi**	**80.4 bcdef**	**1.8 bcdef**	**12.5 defg**	**5.21 cdefg**	**43.4 efghi**	**141 bcdefghi**	**86.1 bc**	**190 d**	**185 cdefgh**	**1.49 c**	**6.8 fg**	49.8 ab
2B09-4049	**36.5 lmno**	**92.7 abcdef**	**71.8 i**	**79.7 defg**	**1.8 bcde**	**12.6 cdefg**	**5.16 cdefg**	**43.8 defgh**	**146 bcdefg**	**86.6 b**	**126 d**	**185 cdefgh**	**1.47 c**	**7.1 fg**	45.5 abcde
01Ab9663	**39.2 defghijk**	**94.5 abcd**	**79.5 bcdefg**	**81.5 bc**	**2.0 bc**	**10.6 i**	**5.38 cdef**	**52.3 ab**	**142 bcdefgh**	**71.8 fg**	**174 d**	**201 bcdef**	**1.50 c**	**7.1 fg**	47.5 abc
2Ab04-X01084-27	**38.6 defghijklm**	**93.1 abcdef**	**72.5 ghi**	**80.2 bcdef**	**1.7 bcdef**	**12.6 cdefg**	**5.23 cdefg**	**44.0 defgh**	**142 cdefgh**	**80.8 bcde**	**104 d**	**189 cdefg**	**1.49 c**	**4.9 g**	48.3 ab
2Ab07-X031098-31	**40.0 bcdefgh**	**94.5 abcd**	**73.3 efghi**	**81.8 b**	**1.7 bcdef**	**12.3 defgh**	**5.60 bcd**	**47.9 cd**	**160 abcdef**	**82.4 bcd**	**60 d**	**211 bc**	**1.45 c**	**5.0 g**	51.8 ab
2Ab09-X06F058HL-21	**37.4 ijklmn**	**88.3 fg**	**59.7 j**	**80.5 bcde**	**1.1 h**	**13.5 cd**	**4.16 klmn**	**32.6 lm**	**64 qr**	**43.8 mno**	**2904 a**	**113 n**	**10.21 a**	**21.0 cdef**	24.5 jklm
2Ab07-X04M219-46	**36.0 no**	**88.5 efg**	**80.5 bcde**	**81.5 bc**	**1.8 bcdef**	**11.2 hi**	**4.95 efghi**	**45.4 cdefg**	**128 efghijkl**	**68.7 fgh**	**77 d**	**177 efghi**	**1.47 c**	**7.7 fg**	50.0 ab
2Ab09-X06F058HL-30	**39.9 bcdefghi**	**93.3 abcdef**	**51.7 k**	**80.4 bcdef**	**1.3 efgh**	**15.2 b**	**4.36 jklm**	**29.5 m**	**63 qr**	**41.2 nop**	**3059 a**	**119 n**	**9.96 a**	**18.7 defg**	26.0 ijklm
2Ab07-X04M281-32	**36.5 lmno**	**86.2 g**	**74.5 defghi**	**81.0 bcd**	**1.9 bcd**	**11.7 ghi**	**5.47 cde**	**49.0 bc**	**135 cdefghij**	**94.4 a**	**73 d**	**208 bcd**	**1.44 c**	**7.8 fg**	46.3 abcd
2Ab09-X06F058HL-195	**36.0 mno**	**89.1 defg**	**54.3 jk**	**79.5 defgh**	**1.2 gh**	**16.8 a**	**4.78 fghij**	**29.4 m**	**56 r**	**36.7 op**	**1972 b**	**144 klm**	**7.52 b**	**9.97 fg**	18.3 lm
08ID1549	**38.3 fghijklmn**	**79.5 h**	**57.7 jk**	**86.6 a**	**1.4 efgh**	**12.8 cdefg**	**5.00 defgh**	**41.4 ghi**	**96 klmnopq**	**59.5 ij**	**150 d**	**161 hijk**	**1.59 c**	**3.3 g**	37.3 cdefgh
08ID2661	**40.5 bcdefg**	**90.4 cdefg**	**88.7 a**	**78.7 fghij**	**1.6 bcdef**	**12.3 defgh**	**4.83 fghij**	**40.7 hij**	**85 opqr**	**50.8 kl**	**404 cd**	**161 hijk**	**1.60 c**	**7.2 fg**	35.3 efghi
MT061035	**39.4 defghij**	**95.2 abc**	**81.0 bcd**	**77.5 jkl**	**2.0 bc**	**11.7 ghi**	**3.97 lmn**	**36.0 kl**	**95 klmnopq**	**48.8 lm**	**210 cd**	**113 n**	**1.52 c**	**33.5 abc**	27.0 ijkl
MT070158	**42.1 abc**	**96.4 ab**	**76.8 bcdefghi**	**80.1 bcdef**	**1.7 bcdef**	**12.5 defg**	**5.09 cdefg**	**42.3 fghi**	**112 ghijklmnop**	**63.7 hi**	**296 cd**	**176 efghi**	**1.52 c**	**42.7 ab**	42.5 abcdefg
MT070159	**41.2 abcd**	**96.4 ab**	**77.3 bcdefghi**	**80.5 bcde**	**1.6 cdefg**	**12.2 efgh**	**4.98 efghi**	**43.2 efghi**	**106 ijklmnop**	**66.9 gh**	**244 cd**	**175 fghi**	**1.52 c**	**45.0 a**	42.3 bcdefg
MT080279	**40.5 bcdefg**	**95.1 abc**	**75.0 defghi**	**80.5 bcde**	**1.8 bcde**	**11.8 fghi**	**5.07 cdefg**	**45.2 cdefg**	**109 hijklmnop**	**71.4 fg**	**198 d**	**172 ghij**	**1.49 c**	**32.0 abcd**	43.8 abcdef
2ND25276	**42.4 ab**	**97.5 a**	**73.0 fghi**	**81.1 bcd**	**1.7 bcdef**	**11.6 ghi**	**5.31 cdefg**	**47.3 cde**	**122 ghijklmn**	**78.4 de**	**173 d**	**181 efghi**	**1.47 c**	**7.1 fg**	47.8 abc
2ND26333	**43.1 a**	**97.8 a**	**73.0 fghi**	**80.0 cdefg**	**1.7 bcdef**	**13.0 cdef**	**5.28 cdefg**	**42.4 fghi**	**126 fghijklm**	**74.5 ef**	**250 cd**	**181 efghi**	**1.49 c**	**7.8 fg**	47.0 abc
UT04B2041-42	**34.2 o**	**92.4 abcdef**	**80.0 bcdef**	**78.0 hijk**	**1.6 bcdef**	**11.6 ghi**	**3.98 lmn**	**36.4 jkl**	**82 pqr**	**50.3 klm**	**377 cd**	**127 mn**	**1.53 c**	**14.7 fg**	29.3 hijk
UT6R2120-14	**37.5 hijklmn**	**92.8 abcdef**	**79.7 bcdefg**	**77.1 kl**	**1.4 defgh**	**12.2 efgh**	**3.75 n**	**32.6 lm**	**131 defghijk**	**38.9 op**	**348 cd**	**107 n**	**1.54 c**	**8.57 fg**	23.3 klm
05WA-316.K	**40.8 abcdef**	**95.1 abc**	**79.3 bcdefgh**	**77.8 ijk**	**1.4 defgh**	**12.5 defg**	**4.41 ijklm**	**37.1 jk**	**109 hijklmnop**	**46.8 lmn**	**266 cd**	**130 lmn**	**1.51 c**	**7.7 fg**	34.0 fghij
05WA-316.99	**41.1 abcde**	**94.3 abcd**	**77.3 bcdefghi**	**76.1 lm**	**1.6 cdefg**	**12.7 cdefg**	**4.20 klmn**	**35.0 kl**	**88 nopqr**	**41.2 nop**	**323 cd**	**119 n**	**1.52 c**	**29.2 bcde**	23.0 klm
07WA-614.4	**39.6 cdefghi**	**93.1 abcdef**	**80.3 bcdef**	**79.7 defg**	**1.4 defgh**	**12.2 efgh**	**5.11 cdefg**	**43.2 efghi**	**142 bcdefgh**	**81.9 bcd**	**229 cd**	**180 efghi**	**1.49 c**	**5.6f g**	46.7 abc
07WA-682.1	**42.4 ab**	**97.0 ab**	**81.5 bcd**	**81.0 bcde**	**1.6 cdefg**	**11.9 efgh**	**5.26 cdefg**	**46.3 cdef**	**118 ghijklmno**	**71.6 fg**	**163 d**	**187 cdefgh**	**1.46 c**	**5.3 g**	48.3 ab
2004NZ151	**40.0 bcdefgh**	**96.3 ab**	**74.3 defghi**	**79.3 efghi**	**1.9 bcd**	**12.0 efgh**	**4.45 hijkl**	**38.9 ijk**	**94 lmnopq**	**55.4 jk**	**274 cd**	**147 jklm**	**1.50 c**	**13.7 fg**	36.0 defgh
2004NZ163	**39.5 cdefghij**	**91.8 bcdef**	**73.3 efghi**	**78.4 ghijk**	**1.6 cdefg**	**12.7 cdefg**	**4.71 ghijk**	**39.0 ijk**	**91 mnopq**	**50.3 klm**	**264 cd**	**154 ijkl**	**1.48 c**	**7.8 fg**	32.7 ghijk
2008NZ003	**37.9 ghijklmn**	**94.7 abc**	**78.0 bcdefghi**	**80.1 bcdef**	**2.8 a**	**13.2 cde**	**6.80 a**	**52.4 ab**	**167 abc**	**79.3 cde**	**364 cd**	**260 a**	**1.57 c**	**16.2 efg**	42.0 bcdefg
2008NZ004	**37.0 jklmn**	**94.2 abcd**	**77.5 bcdefghi**	**80.2 bcdef**	**2.7 a**	**13.0 cde**	**6.75 a**	**53.8 a**	**162 abcde**	**78.8 de**	**341 cd**	**263 a**	**1.56 c**	**15.3 efg**	46.3 abcd
2008NZ013	**36.6 lmno**	**93.3 abcdef**	**77.3 bcdefghi**	**80.2 bcdef**	**2.8 a**	**13.0 cdef**	**6.83 a**	**53.3 a**	**159 abcdef**	**78.7 de**	**372 cd**	**258 a**	**1.55 c**	**14.5 fg**	43.3 abcdef
CDC Kindersley	**38.6 defghijklmn**	**96.2 ab**	**75.8 cdefghi**	**80.7 bcde**	**1.7 bcdef**	**12.3 defgh**	**5.66 bc**	**47.1 cde**	**172 ab**	**83.2 bcd**	**55 d**	**193 cdefg**	**1.41 c**	**5.5 fg**	53.3 a

* Within each column, means followed by the same letter are not significantly different (alpha=0.05), according to Duncan's Multiple Range Test.

**Aberdeen, ID; Conrad, MT; Fairfield, MT; Idaho Falls, ID

***n.d.: Sample's clarity reported as hazy, hence the wort color was not defined.

Western Regional Spring Barley Nursery (WRSBN) - Aberdeen, ID
Table 5

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Turbid (Hach)	Rel. Viscos.	Quality Score	Overall Rank
5588	Harrington	2	39.1	91.0	59	80.8	1.8	1	12.7	5.32	45.4	129	74.3	180	198	9.5	1.48	57	9
5589	AC Metcalfe	2	38.6	89.6	60	80.5	2.0	1	13.2	5.50	42.3	158	83.6	123	203	8.0	1.47	53	13
5590	2B09-3408	2	41.7	94.6	61	80.9	1.8	1	11.9	4.85	42.4	152	75.6	207	172	7.2	1.49	54	12
5591	2B09-3944	2	39.3	93.6	56	80.7	1.9	1	12.4	4.92	41.3	156	68.8	164	179	8.6	1.48	52	15
5592	2B09-3998	2	44.7	94.2	63	80.8	2.2	1	11.9	4.85	43.2	121	73.6	333	174	12.9	1.54	55	11
5593	2B09-4049	2	38.5	94.0	54	80.3	2.2	1	11.9	5.00	45.0	121	78.2	125	188	10.8	1.48	58	6
5594	01Ab9663	2	39.4	94.9	63	83.2	2.1	1	9.6	4.72	52.5	116	68.9	271	179	8.3	1.55	42	25
5595	2Ab04-X01084-27	2	39.0	91.7	53	80.2	2.0	1	12.3	5.05	42.5	125	78.7	149	187	6.3	1.50	58	6
5596	2Ab07-X031098-31	2	42.5	94.6	56	82.5	2.0	1	11.7	5.51	48.1	151	75.1	99	210	7.1	1.47	65	1
5597	2Ab07-X04M219-46	2	39.1	91.2	61	82.2	2.1	1	11.5	5.02	45.4	136	65.3	114	178	10.7	1.49	58	6
5598	2Ab07-X04M281-32	2	38.4	87.7	54	81.5	2.1	1	11.7	5.32	47.6	140	86.0	114	204	10.7	1.46	56	10
5599	MT061035	2	39.7	95.3	62	79.0	n.d.	3	11.2	3.89	37.9	80	47.6	313	117	34.0	1.56	25	26
5600	MT070158	2	44.5	97.3	60	81.1	n.d.	3	11.7	4.85	43.1	104	60.4	325	174	65.0	1.54	53	13
5602	MT070159	2	43.2	96.6	60	81.5	n.d.	3	10.8	4.75	44.9	99	61.6	272	180	70.0	1.53	44	23
5604	MT080279	2	39.2	86.8	60	80.8	n.d.	3	11.2	4.86	43.8	102	59.5	309	171	45.0	1.55	45	21
5605	2ND25276	2	42.4	97.2	60	81.9	1.7	1	10.7	5.03	47.2	119	71.1	275	179	7.9	1.49	45	21
5606	2ND26333	2	46.8	98.6	57	80.1	1.7	1	12.6	4.93	39.8	121	65.3	425	175	7.3	1.53	50	17
5607	07WA-682.1	2	43.5	96.7	64	82.2	1.8	1	10.9	4.97	47.1	101	65.1	240	182	7.8	1.49	48	18
5608	2008NZ003	6	39.0	96.0	64	80.9	2.8	1	11.8	5.86	50.2	114	63.8	678	229	20.0	1.69	47	19
5609	2008NZ004	6	36.8	94.2	64	82.0	2.5	1	11.5	5.85	53.7	109	63.8	617	241	12.7	1.64	47	19
5610	2008NZ013	6	37.4	95.5	62	81.8	2.4	2	12.0	6.29	52.5	115	64.8	663	253	12.7	1.63	43	24
5611	CDC Kindersley	2	40.4	97.9	67	81.9	1.7	1	11.2	5.15	47.4	142	72.3	92	179	5.4	1.44	59	5
5612	2Ab08-X04M278-35	2	43.3	95.9	58	82.6	2.1	1	11.9	5.70	49.0	137	66.1	81	217	10.3	1.47	61	2
5613	2Ab08-X05M006-24	2	42.1	93.6	54	80.7	1.8	1	12.6	5.44	43.5	134	73.3	269	203	5.5	1.47	60	4
5614	2Ab09-X05M049-2	2	42.7	95.7	67	81.7	1.7	1	12.5	5.17	43.2	132	71.9	163	187	5.2	1.48	61	2
5615	2Ab08-X05M010-10	2	40.7	96.6	64	81.8	1.6	1	10.8	4.82	45.5	129	75.3	160	180	5.5	1.48	52	15

Table 5

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Turbid (Hach)	Rel. Viscos.	Quality Score	Overall Rank
5601	HARRINGTON MALT CHECK		38.9	97.0	74	81.9	1.5	1	12.0	5.16	46.3	133	80.3	131	190	1.51	5.9	54	
5603	LACEY MALT CHECK		34.5	88.4	51	79.5	n.d.	3	12.7	5.75	45.8	138	62.0	192	212	1.54	54.0	54	
Maxima			46.8	98.6	67	83.2	2.8		13.2	6.29	53.7	158	86.0	678	253				
Means			40.8	94.3	60	81.3	2.0		11.7	5.14	45.6	125	69.6	260	190				
Standard Deviations			2.5	3.0	4	0.9	0.3		0.8	0.47	3.9	19	8.2	170	26				
Coefficients of Variation			6.2	3.2	7	1.1	15.7		6.7	9.20	8.5	16	11.8	65	14				
Neg Std Dev			33.3	85.3	48	78.5	1.1		9.4	3.72	33.9	67	45.0	-250	111				
Pos Std Dev			48.4	103.3	72	84.1	2.9		14.0	6.56	57.2	183	94.2	770	269				

Malt Check Data are Excluded from Rank Sorting and Statistics

Table Data Flagged by an Asterisk Exceed the Mean by +/- 3 Standard Deviations and are Excluded from Statistics

For Wort Clarity - 1 = clear, 2 = slightly hazy, 3 = hazy; Wort Colors were not determined (n.d.) on hazy samples

Samples Submitted by Dr. Gongshe Hu, USDA-ARS, Aberdeen, ID

WRSBN, Conrad, MT
Table 6

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Relative Viscos	Turbidity (Hach)	Quality Score	Overall Rank
5392	Steptoe	6	38.7	95.0	95	**75.7**	n.d.	3	**9.8**	**3.79**	**40.5**	**59**	**36.8**	*627	**118**	1.73	51.0	15	36
5393	Baronesse	2	**35.3**	93.5	93	79.3	n.d.	3	**8.9**	**3.79**	44.2	**69**	48.6	76	**109**	1.49	43.0	30	30
5394	Harrington	2	**34.5**	95.5	90	82.7	1.4	1	**9.9**	5.06	**52.3**	103	86.5	85	188	1.46	4.3	50	6
5395	AC Metcalfe	2	**34.4**	90.6	97	82.1	1.8	1	**10.4**	5.39	**54.0**	124	98.6	39	202	1.43	5.2	55	1
5396	2B09-3408	2	**34.4**	91.6	91	80.8	1.5	1	**9.5**	4.40	**48.1**	118	88.0	45	**149**	1.43	5.4	44	12
5397	2B09-3944	2	**36.0**	93.2	86	82.2	1.9	1	**10.1**	5.01	**51.8**	115	82.9	53	183	1.44	8.4	50	6
5398	2B09-3998	2	38.0	93.1	87	81.9	1.6	1	**10.5**	5.01	**49.1**	118	98.9	101	184	1.47	5.7	48	8
5399	2B09-4049	2	**33.7**	93.6	90	81.4	1.6	1	**9.9**	4.70	**50.8**	**96**	85.4	38	**176**	1.43	6.3	43	14
5400	01Ab9663	6	39.0	96.4	92	82.8	1.9	1	**9.0**	4.86	**54.6**	**104**	70.3	114	**190**	1.50	9.2	44	12
5401	2Ab04-X01084-27	2	**35.0**	94.8	86	81.5	1.5	1	**9.9**	4.62	**49.2**	**96**	78.2	38	**175**	1.46	4.4	43	14
5402	2Ab07-X031098-31	2	**35.9**	93.8	85	84.1	1.7	1	**9.4**	5.26	**55.9**	106	84.5	27	214	1.43	5.3	52	4
5403	2Ab09-X06F058HL-21	2	**35.2**	**82.8**	63	81.5	n.d.	3	11.8	4.18	**36.8**	**62**	44.7	*2284	**111**	10.62	34.0	27	32
5404	2Ab07-X04M219-46	2	**32.6**	87.0	95	82.4	1.6	1	**9.2**	4.37	**47.7**	**93**	71.6	39	**161**	1.44	6.1	37	22
5405	2Ab09-X06F058HL-30	2	**37.6**	92.5	62	81.2	n.d.	3	13.5	4.44	**33.2**	**67**	43.0	*2502	**121**	10.47	25.0	31	29
5406	2Ab07-X04M281-32	2	**34.8**	91.3	89	82.8	1.7	1	**9.3**	4.79	**52.9**	**92**	100.9	36	182	1.40	4.8	46	10
5407	2Ab09-X06F058HL-195	2	**34.1**	86.3	62	81.3	n.d.	3	13.4	4.06	**31.7**	**53**	**38.8**	*2594	**110**	12.87	16.0	21	34
5408	08ID1549	2	**36.0**	*72.4	69	*89.0	1.5	1	**10.0**	4.71	**49.7**	**67**	61.0	105	**160**	1.55	3.2	34	26
5410	08ID2661	2	**35.6**	87.0	98	79.8	1.8	1	**10.3**	4.41	44.9	**72**	55.1	**229**	**157**	1.65	8.2	36	24
5412	MT061035	2	**35.9**	94.6	96	78.7	n.d.	3	**9.1**	**3.76**	42.1	**70**	49.9	87	**111**	1.48	44.0	30	30
5413	MT070158	2	39.3	97.9	89	82.2	n.d.	3	**9.9**	4.65	46.4	**91**	67.0	**180**	**164**	1.48	52.0	41	18
5414	MT070159	2	38.4	97.7	88	81.7	n.d.	3	**10.3**	4.43	45.7	**86**	70.2	**164**	**161**	1.47	41.0	41	18
5415	MT080279	2	**36.3**	97.8	95	81.6	n.d.	3	**9.5**	4.65	**49.8**	**89**	77.9	89	**164**	1.44	55.0	41	18
5416	2ND25276	2	38.1	96.1	93	82.5	1.8	1	**9.4**	4.88	**52.6**	**88**	81.2	84	**177**	1.44	6.1	45	11
5417	2ND26333	2	40.2	98.6	80	81.8	1.7	1	11.7	5.35	**47.3**	120	83.7	150	186	1.44	4.8	55	1
5418	UT04B2041-42	6	31.1	91.1	92	78.6	2.1	2	**10.0**	**3.86**	**40.5**	**75**	55.4	149	**125**	1.47	23.0	32	28
5419	UT6R2120-14	6	35.1	91.6	91	77.8	1.6	2	**10.3**	**3.62**	**36.9**	**114**	**38.7**	149	**105**	1.46	8.9	23	33
5420	05WA-316.K	2	38.4	96.5	90	80.0	1.8	1	**9.2**	4.07	43.9	**73**	43.7	**182**	**127**	1.49	10.2	33	27
5421	05WA-316.99	2	38.5	93.8	87	**77.8**	n.d.	3	**10.1**	**3.91**	40.4	**65**	**39.0**	**195**	**110**	1.49	37.0	17	35
5422	07WA-614.4	2	**37.4**	94.5	91	81.7	1.5	1	**10.2**	4.64	44.8	117	81.4	139	**178**	1.46	5.0	48	8
5423	07WA-682.1	2	**37.7**	96.0	96	80.8	1.7	1	**10.3**	4.89	**49.9**	**95**	69.6	86	187	1.42	5.2	43	14

Table 6

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Relative Viscos	Turbidity (Hach)	Quality Score	Overall Rank
5424	2004NZ151	2	**37.3**	97.0	77	81.0	2.2	1	**9.9**	4.18	44.2	**63**	53.3	**204**	**151**	1.49	14.9	37	22
5425	2004NZ163	2	**37.6**	94.8	80	80.6	1.8	1	**10.1**	4.51	46.3	**66**	50.0	**191**	**166**	1.47	7.0	35	25
5426	2008NZ003	6	33.8	91.0	91	79.4	3.0	1	**11.5**	**6.29**	**56.2**	**118**	85.1	**193**	250	1.47	11.0	39	21
5427	2008NZ004	6	34.2	90.2	85	79.0	**3.0**	1	11.7	**6.26**	**54.1**	123	84.7	135	247	1.47	12.9	51	5
5428	2008NZ013	6	33.4	88.2	90	79.4	**3.1**	1	**11.3**	**6.34**	**55.9**	**113**	83.1	160	242	1.47	11.9	42	17
5429	CDC Kindersley	2	**36.0**	96.0	85	81.7	1.9	1	**10.7**	5.31	**50.5**	124	82.3	42	192	1.39	5.8	55	1
5409	HARRINGTON MALT CHECK	2	39.4	96.4	75	82.7	1.6	1	11.5	5.38	47.9	137	97.1	71	213	1.45	5.4	62	
5411	LACEY MALT CHECK	6	33.6	91.3	54	79.5	2.7	2	13.0	5.75	45.9	129	59.8	149	210	1.49	30.0	58	
Minima			31.1	82.8	62	75.7	1.4		8.9	3.62	31.7	53	36.8	27	105				
Maxima			40.2	98.6	98	84.1	3.1		13.5	6.34	56.2	124	100.9	229	250				
Means			36.1	93.2	87	80.8	1.9		10.3	4.68	47.1	92	68.6	113	165				
Standard Deviations			2.1	3.7	10	1.8	0.5		1.1	0.69	6.3	22	19.4	61	39				
Coefficients of Variation			5.8	4.0	11	2.2	24.6		10.6	14.66	13.4	24	28.3	54	24				
Neg Std Dev			29.8	82.1	58	75.6	0.5		7.0	2.62	28.1	24	10.3	-70	47				
Pos Std Dev			42.4	104.2	115	86.1	3.3		13.5	6.74	66.1	159	126.9	295	283				

Malt Check Data are Excluded from Rank Sorting and Statistics
Table Data Flagged by an Asterisk Exceed the Mean by +/- 3 Standard Deviations and are Excluded from Statistics
For Wort Clarity - 1 = clear, 2 = slightly hazy, 3 = hazy; Wort Colors were not determined (n.d.) on hazy samples

Samples Submitted by BARI

WRSBN Fairfield, MT
Table 7

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	Relative Viscos	Turbidity (Hach)	FAN (ppm)	Quality Score	Overall Rank
5354	Steptoe	6	42.3	97.2	77	**74.7**	n.d.	3	12.2	**3.95**	**33.8**	**69**	**34.1**	*790	1.73	46.0	**114**	20	33
5355	Baronesse	2	44.1	97.9	77	**76.1**	n.d.	3	**14.5**	4.22	**29.3**	134	47.5	**206**	1.52	26.0	**114**	24	30
5356	Harrington	2	41.4	96.9	73	79.5	1.5	1	**14.9**	**6.09**	42.3	188	87.4	**185**	1.47	5.3	210	42	8
5357	AC Metcalfe	2	**37.7**	93.9	77	**77.7**	1.7	1	**16.6**	**6.77**	42.2	245	104.0	63	1.42	5.3	236	38	14
5358	2B09-3408	2	41.6	97.4	76	79.1	1.4	1	**14.1**	5.29	**39.5**	199	87.6	79	1.44	4.5	**178**	43	7
5359	2B09-3944	2	42.3	97.6	72	79.1	1.4	1	**14.8**	5.23	**36.2**	210	85.4	101	1.45	4.7	**174**	40	13
5360	2B09-3998	2	46.1	98.6	72	79.2	1.6	1	**14.3**	5.66	40.8	163	84.2	**151**	1.47	5.8	189	41	10
5361	2B09-4049	2	38.7	97.8	63	78.6	1.7	1	**14.7**	5.35	**37.0**	186	91.1	**305**	1.52	7.5	**176**	34	23
5362	01Ab9663	6	39.8	93.9	76	78.6	1.7	1	12.6	**6.05**	**48.8**	196	76.2	78	1.44	7.1	207	55	1
5363	2Ab04-X01084-27	2	43.9	98.1	72	81.3	1.6	1	**13.6**	5.58	43.2	168	79.8	**155**	1.51	6.1	193	53	3
5364	2Ab07-X031098-31	2	41.7	96.5	79	79.6	1.4	1	**14.6**	5.32	**38.9**	191	82.1	77	1.47	4.2	**178**	46	5
5365	2Ab09-X06F058HL-21	2	38.1	90.6	60	**77.1**	1.4	1	**17.5**	4.22	**24.8**	**57**	**34.8**	*3737	6.52	9.0	**137**	12	34
5366	2Ab07-X04M219-46	2	**37.3**	89.8	86	78.0	1.6	1	**15.3**	5.48	**37.7**	174	68.0	118	1.44	7.4	214	38	14
5367	2Ab09-X06F058HL-30	2	39.3	91.1	46	**75.8**	1.5	2	*18.8	4.28	**23.2**	**71**	**39.5**	*3842	6.43	22.0	**136**	11	35
5368	2Ab07-X04M281-32	2	38.9	89.8	81	**78.0**	1.7	1	**15.0**	6.00	40.9	182	87.8	139	1.42	5.8	255	37	17
5369	2Ab09-X06F058HL-195	2	**37.6**	91.5	46	**72.4**	**1.0**	1	*19.9	4.06	**21.1**	**59**	**33.4**	*1656	6.26	8.9	**112**	10	36
5370	08ID1549	2	39.7	*79.9	48	84.5	1.3	1	**15.1**	5.29	**35.1**	120	55.3	**201**	1.59	3.4	**155**	35	20
5371	08ID2661	2	44.8	95.8	84	78.3	1.5	1	**13.9**	5.05	**36.6**	101	49.1	**461**	1.59	7.1	**155**	31	25
5372	MT061035	2	43.0	98.0	80	**75.8**	n.d.	3	**14.5**	4.08	**28.6**	127	47.7	**280**	1.55	35.0	**102**	24	30
5373	MT070158	2	45.3	98.5	77	78.7	n.d.	3	**14.9**	5.54	**38.5**	142	64.7	**362**	1.53	42.0	**173**	35	20
5374	MT070159	2	44.1	98.1	80	79.2	n.d.	3	**14.5**	5.25	**37.5**	129	64.2	**356**	1.55	62.0	**164**	35	20
5375	MT080279	2	43.5	98.4	77	78.6	2.0	2	**14.5**	5.22	**36.6**	132	73.3	**243**	1.51	23.0	**163**	36	19
5376	2ND25276	2	45.5	99.0	66	80.8	1.7	1	12.8	5.59	44.7	137	80.1	**205**	1.49	10.2	**170**	55	1
5378	2ND26333	2	45.4	98.2	68	78.7	1.5	1	**14.5**	5.52	**39.2**	154	81.3	**150**	1.46	5.7	**169**	37	17
5380	UT04B2041-42	6	36.4	93.3	73	78.0	**1.4**	1	12.3	**4.05**	**34.6**	**86**	48.4	**453**	1.56	12.5	**123**	30	26
5381	UT6R2120-14	6	40.2	94.9	71	**77.1**	**1.4**	1	13.6	**3.79**	**29.1**	138	**38.4**	**494**	1.60	10.4	**103**	21	32
5382	05WA-316.K	2	43.9	97.7	73	**76.8**	**1.2**	1	**15.6**	4.76	**31.9**	152	51.6	**313**	1.51	6.1	**131**	33	24
5383	05WA-316.99	2	44.5	97.5	68	**75.3**	n.d.	3	**15.1**	4.51	**30.4**	119	44.5	**324**	1.51	32.0	**122**	25	29
5384	07WA-614.4	2	42.7	95.5	74	78.2	1.5	1	**14.1**	5.51	40.1	172	85.0	**290**	1.49	6.9	**176**	42	8
5385	07WA-682.1	2	46.2	98.8	81	80.3	1.4	1	**13.9**	5.54	40.3	147	75.3	**215**	1.48	4.5	184	48	4

Table7

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	Turbidity (Hach)	FAN (ppm)	FAN (ppm)	Quality Score	Overall Rank
5386	2004NZ151	2	42.5	97.4	70	**77.3**	1.9	2	**14.8**	4.66	**32.8**	119	55.1	**362**	1.51	19.4	**137**	29	27
5387	2004NZ163	2	40.9	95.3	71	**76.1**	1.6	1	**15.4**	4.84	**32.4**	117	49.3	**338**	1.48	9.2	**143**	26	28
5388	2008NZ003	6	40.3	96.8	72	80.1	*3.0	1	**15.2**	**7.99**	**52.6**	237	83.3	**246**	1.52	16.0	292	41	10
5389	2008NZ004	6	38.9	96.3	74	79.9	*2.7	1	**15.1**	**7.85**	**54.4**	239	80.8	**248**	1.53	15.5	292	41	10
5390	2008NZ013	6	38.3	93.2	75	79.0	*2.6	1	**15.8**	**7.82**	**50.6**	245	82.4	**261**	1.51	14.2	276	38	14
5391	CDC Kindersley	2	41.9	97.9	74	78.9	1.8	1	**15.1**	**6.39**	42.4	222	86.5	54	1.41	7.5	206	46	5
5377	HARRINGTON MALT CHECK	2	40.1	96.5	77	82.3	1.7	1	11.5	5.49	50.5	135	98.5	80	1.48	5.4	188	62	
5379	LACEY MALT CHECK	6	33.7	89.8	55	80.0	2.3	2	13.0	5.80	45.5	128	65.5	162	1.53	26.0	185	53	
Minima			36.4	89.8	46	72.4	1.0		12.2	3.79	21.1	57	33.4	54	1.41	3.4	102		
Maxima			46.2	99.0	86	84.5	2.0		17.5	7.99	54.4	245	104.0	54	6.52	3.4	292		
Means			41.6	96.0	72	78.2	1.5		14.6	5.36	37.4	153	67.2	54	1.91	3.4	174		
Standard Deviations			2.8	2.7	9	2.1	0.2		1.1	1.06	7.6	52	19.9	54	1.37	3.4	50		
Coefficients of Variation			6.7	2.9	13	2.7	13.7		7.5	19.77	20.3	34	29.6	100	71.86	3.4	29		
Neg Std Dev			33.2	87.8	44	71.9	0.9		11.3	2.18	14.6	-3	7.6	-107			23		
Pos Std Dev			50.0	104.2	100	84.6	2.1		17.9	8.53	60.3	310	126.8	214			325		

Malt Check Data are Excluded from Rank Sorting and Statistics
Table Data Flagged by an Asterisk Exceed the Mean by +/- 3 Standard Deviations and are Excluded from Statistics
For Wort Clarity - 1 = clear, 2 = slightly hazy, 3 = hazy; Wort Colors were not determined (n.d.) on hazy samples

Samples Submitted by

2012 WRSBN, Idaho Falls, ID
Table 8

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Relative Viscos	Turbidity (Hach)	Quality Score	Overall Rank
5316	Steptoe	6	39.0	90.9	76	**74.1**	n.d.	3	**11.3**	**3.80**	**35.1**	**74**	**35.1**	*802	**119**	1.67	33.0	15	35
5317	Baronesse	2	38.9	91.8	82	**76.2**	2.1	2	13.3	4.26	**34.2**	110	49.2	**201**	**127**	1.51	18.5	24	32
5318	Harrington	2	**37.8**	91.3	79	79.2	1.5	1	**13.8**	5.90	42.9	158	79.7	133	216	1.46	3.9	41	19
5319	AC Metcalfe	2	**35.2**	88.2	79	78.2	1.8	1	**14.9**	**6.47**	45.8	211	100.7	38	244	1.42	3.8	40	22
5320	2B09-3408	2	**36.3**	88.1	75	**78.0**	1.5	1	12.9	5.13	41.1	169	81.0	76	182	1.44	2.6	51	7
5321	2B09-3944	2	38.4	93.8	74	79.8	1.6	1	13.0	5.38	43.6	184	78.9	81	190	1.45	3.3	59	1
5322	2B09-3998	2	44.1	97.7	75	79.6	1.6	1	13.4	5.33	40.4	162	87.5	**173**	191	1.49	2.8	55	2
5323	2B09-4049	2	**35.1**	85.5	80	78.5	1.6	1	**13.9**	5.57	42.3	182	91.5	36	199	1.43	3.6	47	12
5324	01Ab9663	6	38.5	92.6	87	81.5	2.1	1	**11.2**	5.88	**53.1**	150	71.7	**233**	227	1.52	3.8	49	10
5325	2Ab04-X01084-27	2	**36.6**	87.6	79	**77.6**	1.7	1	**14.5**	5.67	40.9	179	86.6	74	201	1.47	2.8	39	23
5326	2Ab07-X031098-31	2	40.0	93.0	73	80.8	1.8	1	**13.5**	**6.29**	**48.6**	193	87.7	36	242	1.43	3.3	44	16
5327	2Ab09-X06F058HL-21	2	38.8	91.5	56	79.5	**1.1**	2	**15.2**	4.13	**28.4**	**65**	42.8	*3524	**115**	9.79	7.9	22	33
5328	2Ab07-X04M219-46	2	**34.9**	85.9	80	79.8	1.6	1	13.0	5.47	43.2	155	69.2	79	192	1.49	6.4	55	2
5329	2Ab09-X06F058HL-30	2	42.7	96.3	*47	79.5	1.3	2	**16.9**	4.28	**25.7**	**58**	**39.4**	*3615	**117**	9.45	12.3	21	34
5330	2Ab07-X04M281-32	2	**33.7**	*75.9	74	78.8	1.8	1	**14.0**	**6.30**	46.6	174	96.4	68	238	1.45	7.9	37	25
5331	2Ab09-X06F058HL-195	2	**36.4**	89.5	55	**77.2**	**0.7**	1	**17.1**	4.08	**24.3**	**57**	**38.0**	*3226	**108**	8.25	10.0	8	36
5332	08ID1549	2	39.3	86.2	56	*86.3	1.3	1	13.4	4.99	**39.5**	101	62.1	144	**168**	1.62	3.4	43	17
5333	08ID2661	2	41.0	88.4	84	78.1	1.6	1	12.8	5.04	40.5	**83**	48.2	**523**	**171**	1.56	6.2	39	23
5334	MT061035	2	39.0	92.9	86	**76.6**	2.0	2	12.0	4.16	**35.2**	104	50.0	**161**	**122**	1.50	21.0	29	28
5335	MT070158	2	39.1	92.0	81	78.2	1.7	1	**13.6**	5.33	41.0	109	62.8	**315**	194	1.52	11.6	41	19
5336	MT070159	2	38.9	93.2	81	79.5	1.6	1	13.0	5.49	44.8	110	71.4	**182**	193	1.50	6.8	49	10
5337	MT080279	2	42.9	97.3	68	81.0	1.6	1	11.8	5.54	**50.5**	112	74.8	**151**	190	1.47	5.1	53	5
5338	2ND25276	2	43.4	97.8	73	79.1	1.5	1	**13.6**	5.74	44.6	142	81.0	126	196	1.46	4.2	46	13
5339	2ND26333	2	39.8	95.6	87	79.3	1.7	1	13.1	5.30	43.2	109	67.6	**276**	192	1.52	13.3	46	13
5340	UT04B2041-42	6	35.2	92.9	75	**77.3**	**1.4**	1	12.4	**4.04**	**34.2**	**84**	47.1	**530**	**133**	1.56	8.6	26	30

Table 8

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Relative Viscos	Turbidity (Hach)	Quality Score	Overall Rank
5341	UT6R2120-14	6	37.3	91.9	77	**76.4**	**1.3**	1	12.6	**3.84**	**31.9**	140	**39.7**	**400**	**112**	1.57	6.4	26	30
5342	05WA-316.K	2	40.1	91.2	75	**76.6**	1.3	1	12.7	4.41	**35.6**	101	45.1	**302**	**133**	1.52	6.9	36	27
5343	05WA-316.99	2	40.3	91.5	77	**75.2**	1.6	2	13.0	4.18	**34.1**	**80**	40.2	**450**	**124**	1.56	18.7	27	29
5344	07WA-614.4	2	38.8	89.3	76	79.3	1.3	1	12.3	5.17	44.8	138	79.3	**259**	185	1.51	5.0	50	8
5346	07WA-682.1	2	42.0	96.6	85	80.6	1.4	1	12.5	5.65	**47.9**	128	76.3	109	196	1.45	3.6	54	4
5348	2004NZ151	2	40.3	94.4	76	79.5	1.6	1	11.4	4.51	**39.8**	**100**	57.9	**255**	**154**	1.50	6.8	42	18
5349	2004NZ163	2	40.1	85.4	69	78.4	1.4	1	12.5	4.78	**38.4**	**91**	51.5	**264**	**154**	1.50	7.2	37	25
5350	2008NZ003	6	38.3	95.1	85	79.8	2.4	1	**14.1**	**7.03**	**50.7**	198	84.9	**340**	268	1.58	17.6	41	19
5351	2008NZ004	6	38.1	95.9	87	79.7	2.5	1	13.8	**7.02**	**52.9**	177	85.7	**363**	270	1.59	19.9	46	13
5352	2008NZ013	6	37.3	96.1	82	80.4	*2.9	2	12.9	**6.84**	**54.1**	163	84.3	**403**	262	1.59	19.0	50	8
5353	CDC Kindersley	2	**36.0**	92.9	77	80.4	1.5	1	12.3	5.78	**48.2**	199	91.7	30	196	1.41	3.2	53	5
5345	HARRINGTON MALT CHECK	2	40.3	97.2	75	82.7	1.4	1	11.6	5.58	51.6	151	94.7	55	202	1.47	4.5	64	
5347	LACEY MALT CHECK	6	33.3	90.3	53	79.8	2.0	1	13.0	6.13	48.7	135	64.9	103	222	1.49	13.6	55	
Minima			33.7	85.4	55	74.1	0.7		11.2	3.80	24.3	57	35.1	30	108				
Maxima			44.1	97.8	87	81.5	2.5		17.1	7.03	54.1	211	100.7	530	270				
Means			38.7	92.0	77	78.7	1.6		13.3	5.24	41.3	132	67.7	213	181				
Standard Deviations			2.5	3.6	8	1.7	0.3		1.3	0.90	7.4	45	19.5	145	47				
Coefficients of Variation			6.5	3.9	11	2.1	21.5		9.8	17.23	17.9	34	28.8	68	26				
Neg Std Dev			31.2	81.2	52	73.6	0.6		9.4	2.53	19.1	-2	9.2	-222	41				
Pos Std Dev			46.2	102.8	101	83.7	2.6		17.2	7.95	63.5	266	126.2	648	322				

Malt Check Data are Excluded from Rank Sorting and Statistics
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For Wort Clarity - 1 = clear, 2 = slightly hazy, 3 = hazy; Wort Colors were not determined (n.d.) on hazy samples

Samples Submitted by BARI

Appendix A: METHODS

Cleaning All samples were cleaned on a Carter Dockage Tester and only grain between 5 and 7/64" was used.

Barley Mill Ground barley was prepared with a Labconco Burr mill that was adjusted so that only 35% of the grist remained on a 525 µm sieve after 3 min of shaking and tapping.

Kernel Weight The number of kernels in a 20 g aliquot of each sample was counted electronically and the '1000 kernel weight' was calculated.

Plumpness Samples were sized on a Eureka-Niagra Barley Grader and the percentage of the seeds retained on a 6/64" screen was determined.

Barley Color The brightness of the grains was measured using an Agtron M45-D analyzer.

Barley Moisture Content (Barley 5B) Five g of ground sample was dried for 3 h at 104°C. The percentage of weight loss that occurred during this drying was calculated.

Barley Protein Content Total nitrogen values were obtained using an automated Dumas combustion procedure with a LECO FP-528 analyzer. Nitrogen values were converted to protein percentages by multiplication by 6.25.

Malting Conditions 170 g (db) aliquots of barley were processed in Joe White micro-malters. Samples were hydrated to 47% moisture via a 32 h steep at 19°C: 8 h wet, 8 h air, 5 h wet, 5 h air, 2 h wet, 2 h air, 2 h wet. (Larger barleys, > 42 mg/kernel, received a continuous, wet pre-steep (16°C) of between 1 and 3 h). The samples were germinated for 48 h (18°C), 24 h (17°C), and 24 h (16°C), with moisture adjustment to 47% at 0, 24, and 48 h. The samples received 4 full turns every 2 h. The germinated grain was kilned for 24h as follows: 49°C, 10 h; 54°C, 4 h; 60°C, 3 h; 68°C, 2 h; and 85°C, 3 h, with 30 min. ramps between stages. All stages received 40% total flow, with 0% recirculation for stages 1-3, 50% for stage 4, and 75% for stage 5.

Malt Mill Fine-grind malts were prepared with a Miag laboratory cone mill that was adjusted so that 10% of the grist remained on a 525 µm sieve after 3 min of shaking, with tapping. Malts to be used for moisture, protein and amylolytic activity analyses were ground in a Labconco Burr mill (see Barley Mill).

Malt Moisture Content Determined by Malt 3 (Methods of Analysis of the ASBC, 8th ed, 1992) See Barley Moisture Content.

Malt Protein Content See Barley Protein Content.

Malt Extract Samples were extracted using the Malt-4 procedure (Methods of Analysis of the ASBC, 8th ed, 1992), except that all weights and volumes specified for the method were halved. The specific gravity of the filtrate was measured with an Anton Parr DMA5000 density meter. The density data were used to calculate the amount of soluble material present in the filtrate, and thus the percentage that was extracted from the malt.

Wort Color was determined on a Skalar SAN plus analyzer by measuring the absorbance at 430nm and dividing by a factor determined by collaborative testing.

Wort Clarity was assessed by visual inspection.

β-Glucan Levels were determined on a Skalar SAN plus analyzer by using the Wort-18 fluorescence flow injection analysis method with calcofluor as the fluorescent agent (Methods of Analysis of the ASBC, 8th ed, 1992).

Free Amino Nitrogen Levels were determined on a Skalar SAN plus analyzer using an automated version of the Wort-12 protocol (Methods of Analysis of the ASBC, 8th ed, 1992).

Soluble (Wort) Protein Levels were determined on a Skalar SAN plus analyzer using the Wort-17 UV-spectrophotometric method (Methods of Analysis of the ASBC, 8th ed, 1992).

S/T Ratio was calculated as Soluble Protein / Total Malt Protein

Diastatic Power Values were determined on a Skalar SAN plus analyzer by the automated ferricyanide procedure Malt-6C (Methods of Analysis of the ASBC, 8th ed, 1992).

α-Amylase activities were measured on a Skalar SAN plus analyzer by heating the extract to 73°C to inactivate any β-amylase present. The remaining (α-amylase) activity was measured as described for Diastatic Power Values.

Viscosities were measured on an Anton Paar AMVn rolling ball viscometer. Relative viscosities were reported: flow time of mash extract over the flow time of distilled water.

Turbidities were determined in Nephelometric Turbidity Units (NTU) on a Hach Model 18900 Ratio Turbidimeter.

Quality Scores were calculated by using a modification of the method of Clancy and Ullrich (Cereal Chem. 65:428-430, 1988). The criteria used to quantify individual quality factors are listed in Table A1.

Overall Rank Values were ordered from low to high based on their Quality Scores. A rank of '1' was assigned to the sample with the best quality score.

Appendix B

Quality Score Parameters for 2- and 6-rowed barleys

	2-rowed		6-rowed	
Quality parameter	condition	score	condition	score
Kernel Weight	> 42.0	5	> 32.0	5
(mg)	40.1–42.0	4	30.1–32.0	4
	38.1–40.0	2	28.1–30.0	2
	≤ 38.0	0	≤ 28.0	0
on 6/64 "	≥ 90.0	5	≥ 80.0	5
(%)	85.0–89.9	3	73.0–79.9	3
	< 85.0	0	< 73.0	0
Malt Extract	≥ 81.0	10	≥ 79.0	10
(% db)	79.4–81.0	7	78.2–78.9	7
	78.0–79.4	4	77.7–78.2	4
	< 78.0	0	< 77.7	0
Wort Clarity				
3=hazy	= 3	0	= 3	0
2=slightly hazy	= 2	1	= 2	1
1=clear	= 1	2	= 1	2
Barley Protein	≥ 13.5	0	≥ 14.0	0
(% db)	13.0–13.5	5	13.5–13.9	5
	11.0–13.0	10	11.5–13.5	10
	≤ 11.0	5	≤ 11.5	5
Wort Protein	> 6.0	0	> 6.0	0
(% db)	5.6–6.0	3	5.7–6.0	3
	4.4–5.6	7	5.2–5.7	7
	4.0–4.4	3	4.8–5.2	3
	< 4.0	0	< 4.8	0
S/T (Soluble/Total	> 47	0	> 47	0
Protein, % db)	40–47	5	42–47	5
	< 40	0	< 42	0
DP (Diastatic	> 120	7	> 140	7
Power, ° ASBC)	100–120	4	120–140	4
	< 100	0	< 120	0
Alpha-amylase	> 45	7	> 45	7
(20° DU)	40–45	4	40–45	4
Beta-glucan	< 100	7	< 120	7
(ppm)	100–150	3	120 – 170	3
	> 150	0	> 170	0
Free Amino Nitrogen	> 190	5	> 200	5
FAN (ppm)	180–190	3	190 – 200	3
	< 180	0	< 190	0