UNITED STATES DEPARTMENT OF AGRICULTURE
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CEREAL CROPS RESEARCH UNIT

MISSISSIPPI VALLEY REGIONAL SPRING BARLEY NURSERY
2012 Crop

Preliminary Quality Report

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Detailed Data:

Aberdeen, ID
Crookston, MN
Fargo, ND

Appendix:
Methods
Criteria for Quality Score

This is a joint progress report of cooperative investigations being conducted in the Agricultural Research Service of the U.S. Department of Agriculture and State Agricultural Experiment Stations. It contains preliminary data that have not been sufficiently confirmed to justify general release; interpretations may be modified with additional experimentation. Confirmed results will be published through established channels. The report is primarily a tool available to cooperators and their official staffs and for those persons who are interested in the development of improved barleys.

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

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Malting Quality of the Mississippi Valley Uniform Regional Barley Nursery – 2012 Crop

The Mississippi Valley Uniform Regional Barley Nursery (MVBN) is an annual, cooperative effort among ARS and several US and Canadian breeding programs to compare advanced lines grown under different environmental conditions. Dr. Michael Edwards (USDA ARS Cereal Crops Research, Fargo, ND) coordinates the program and reports agronomic and disease data on these submissions: http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=292143. In this report, the malting quality of 2012 MVBN lines received from Aberdeen, Idaho, Crookston, Minnesota, and Fargo, North Dakota are evaluated.

The barleys were characterized and then malted in Joe White (JW) micro-malters, under conditions that should generate malts having modification levels similar to those produced by industrial breweries. Subsequently, they were analyzed for quality using the Methods of the American Society of Brewing Chemists (ASBC). (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 were based upon the "Ideal Commercial Malt Criteria" developed by the American Malting Barley Association (AMBA). These are listed in Appendix B.

Statistical analyses were performed on the quality data using SAS 9.2 software and the station mean values for fourteen quality factors are listed across all lines (Table 1) and varietal means across the 3 stations (Table 2). Individual station data are reported in Tables 3 through 5. These statistics allowed evaluation of data from individual locations and overall performance of each line.

The Aberdeen, Idaho barley submissions (Table 3) had a significantly higher average kernel weight, than either of the other locations. However, average "Plumpness" (6/64" screen) did not differ significantly from Crookston, but was higher than Fargo. These factors contributed to a significantly higher average Malt Extract score for Aberdeen barleys relative to the other locations, and, as expected, the average kernel brightness (Agtron colorimeter) was significantly higher for these samples, than those from the two Midwestern locations. In addition, the Aberdeen barleys averaged significantly lower dry basis protein (12.3%) than Crookston (13.6%) or Fargo (14.4%), which also contributed to the Malt Extract result. Other factors influenced by this were the average Soluble Protein, Diastatic Power, Alpha-Amylase and Free Amino Nitrogen (FAN) values generated from these malted barleys. All were significantly lower relative to those from Crookston and Fargo. It should also be noted that malts made from the Aberdeen barleys exhibited the highest average Beta-Glucan and Viscosity scores. Their average Turbidity levels did not differ significantly from those of Crookston, but were higher, significantly, than those from Fargo.

The barley samples received from Crookston, Minnesota (Table 4) had an average kernel weight (35.4mg) intermediate to the other two locations – significantly higher than Fargo (32.9mg), but lower than Aberdeen (36.3mg). The Crookston barleys did not differ

significantly in Plumpness from those of Aberdeen. Despite this, and likely due to the lower Barley Protein and higher Kernel Weight size averages for the Aberdeen barleys, the Crookston submissions averaged significantly lower Malt Extract. They showed the lowest average Kernel brightness, which increased progressively for the more western locations, with the highest average Agtron value from Aberdeen, ID. This trend was not reflected in the average Wort Color generated for samples from each location; none were significantly different. Even though the barley protein average was significantly less than that of Fargo, the Crookston barleys generated an average Diastatic Power not significantly different from Fargo's average. The Alpha-amylase and FAN averages were statistically intermediate to those of Fargo (higher), and Aberdeen (lower), respectively.

The MVBN barleys grown at Fargo (Table 5) had the lowest average Kernel Weight and Plumpness scores of any location. Nevertheless, their Malt Extract average was not significantly different than that for Crookston. This location yielded the highest average barley protein, and this carried through to the Soluble Protein, Alpha-amylase, and FAN averages for the Fargo barleys, which were significantly higher than those of all other locations; the Diastatic Power average was higher than that of Aberdeen, but not significantly different from that of Crookston. These barleys displayed the lowest average Turbidity and Viscosity of the locations. Yet, due to this location's high barley and soluble protein averages, the malts made from Fargo submissions averaged the lowest Overall Quality Score (44.2), which was significantly lower than Crookston (50.2), which was significantly lower than Aberdeen (55.3).

The top performing line across locations was ND25652. This was true even though it was not grown at, and submitted from Aberdeen, the location which produced the highest overall quality average. It was well-rounded across the quality parameters, and didn't excel in any one area, other than very low Beta-Glucan levels – the lowest average of any line in the MVBN. (ND25652 was also a top performer among the 2011 MVBN barleys). Not surprisingly, the established malting variety Lacey yielded an excellent overall malting quality score across locations; its malts had low Beta-Glucan levels at all 3 locations and good Malt Extract scores at 2 of 3 locations; its Malt Extract average was in the top third, across locations; and it had the 6th lowest average viscosity in the nursery. Other excellent performers, across locations, included M154, ND27177, ND27245, 6B09-4235, 6B08-3210, SR440, and M145, all of which had higher average overall quality scores than Tradition. Though M145 had the lowest average kernel brightness (44) in the MVBN, its malts, when mashed/extracted, didn't show excessive average wort color, and had low turbidity and extremely low viscosity. Another negative was that its mash extract had excessive soluble protein at 2 of 3 locations, with the malt produced from its lower protein Aberdeen barley, the only one yielding less than 6.00% soluble protein, in the mash extract. ND27177 exhibited very good Malt Extract for a 6-rowed barley: 79.7%. Its malts showed a very high average Diastatic Power of 199, and FAN of 229ppm, however its average viscosity and turbidity were the 2nd and 5th highest in the nursery, respectively. As with ND25652, ND27245 received a high score for overall quality, without standing out in any of the parameters. 6B09-4235 had the second highest kernel brightness (Agtron) average and third lowest Beta-Glucan average

(81ppm) of all samples, while 6B08-3210 had an excellent Malt Extract average (80.1%) -- for a 6-rowed barley -- and the second lowest barley protein average in the nursery. SR440 also exhibited a low barley protein average across locations, which helped its mean Malt Extract reach 80.3%. Interestingly, even with the lower barley protein, it developed a high FAN average, and the sixth highest Soluble Protein (6.27%); the latter moved it to the highest Kolbach Index average of these barleys. Protein modification was vigorous with this barley. SR440 also yielded the second highest Alpha-amylase average. Finally, M145 overcame a greater than ideal Beta-Glucan level to achieve a very good overall Quality Score, with solid Diastatic Power and FAN averages. Another negative aspect of M145 was that it displayed the lowest barley color (Agtron) score in the nursery.

The 2012 MVBN submissions which displayed the lowest overall Quality scores were 2ND26333 and 2ND27440. In the case of 2ND26333, even though it had a very large kernel weight average and good plumpness, it yielded the third lowest Malt Extract average of 77.7%, likely due to its second highest Barley Protein % average. Even with the high Barley Protein score, its Soluble Protein average was mid-pack at 5.95%, which contributed to the second lowest S/T average – 41.4. (It also was not grown at Aberdeen, ID, where grain protein averages were lowest, and average overall quality the highest). 2ND27440 had the lowest S/T average at 40.0. Clearly, protein modification was very slow with these two barleys, relative to the others. 2ND26333 did produce a good (2-rowed) Diastatic Power average of 154°, however 2ND27440 performed poorly with an average DP of 105°-- the lowest in the nursery -- and its Alpha-amylase average of 62.7DU was the second lowest. It had the lowest FAN, second highest Beta-Glucan, and third highest Turbidity averages for this set of barleys, while 2ND26333 achieved good FAN, DP, Alpha-amylase, Turbidity, and Viscosity averages. However, its Beta-Glucan average was 150ppm.

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MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2012 Crop

Table 1 - Station Means* of Barley and Malt Quality Factors for 34 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	**36.3** a	**90.9** a	**70.4** a	**80.3** a	**1.87** a	**12.3** c	**5.43** c	**47.2** a	**141** b	**68.6** c	**209** a	**204** c	**1.50** a	**8.4** a	**55.3** a
Crookston, MN	**35.4** b	**91.0** a	**48.0** c	**78.7** b	**1.95** a	**13.6** b	**5.90** b	**44.4** c	**187** a	**77.6** b	**139** b	**223** b	**1.48** b	**8.2** a	**50.2** b
Fargo, ND	**32.9** c	**84.2** b	**54.4** b	**78.8** b	**1.88** a	**14.4** a	**6.40** a	**45.8** b	**187** a	**82.9** a	**166** b	**253** a	**1.44** c	**5.6** b	**44.2** c

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

** Morex, Robust, Legacy, Lacey, Tradition, Pinnacle, 2ND25276, M145, 2ND26333, M150, ND23898, ND25652, ND27245, 2ND27421, 2ND27440, SR440, M148, M151, M153, M154, ND26891, ND27177, ND28993, 2ND28065, 2ND28131, 6B08-3210, 6B09-3531, 6B09-3580, 6B09-3655, 6B09-4021, 6B09-4235, SR446, SR447, SR448

MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2012 Crop

Table 2 - Varietal Means* of Barley and Malt Quality Factors for Three 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
Morex	**31.5** ij	**81.6** g	**55.0** bcde	**78.2** efghi	**1.87** abcde	**14.6** abc	**6.23** abcdefg	**44.8** ghijkl	**209** abc	**82.7** cdefg	**118** efgh	**236** cdefgh	**1.44** ij	**5.7** c	**49.7** abcd
Robust	**32.5** ghij	**85.4** bcdefg	**53.3** cdef	**78.8** bcdefgh	**1.70** def	**14.1** abcde	**6.08** bcdefghi	**44.5** ghijklm	**196** abcdef	**65.6** mno	**205** bcde	**220** defghijk	**1.46** cdefghi	**4.5** c	**46.3** abcd
Legacy	**31.4** j	**82.3** fg	**59.0** abcd	**78.9** abcdefgh	**1.97** abcde	**13.8** abcdefg	**6.48** abcd	**48.5** bcde	**202** abcd	**91.0** b	**201** bcdef	**244** bcdefg	**1.45** efghij	**4.2** c	**45.3** abcde
Lacey	**33.6** fghij	**88.9** abcdefg	**59.0** abcd	**79.8** abcd	**1.77** bcdef	**13.4** bcdefghi	**5.98** cdefghij	**46.6** efghij	**181** abcdefg	**76.6** fghij	**121** efgh	**219** defghijkl	**1.45** fghij	**5.4** c	**57.3** ab
Tradition	**33.3** fghij	**87.4** abcdefg	**64.0** ab	**78.6** cdefgh	**1.97** abcde	**13.6** bcdefghi	**5.74** fghijklm	**43.7** ijklm	**213** ab	**78.1** efghi	**152** efgh	**214** fghijkl	**1.48** bcdefg	**12.9** bc	**52.7** abcd
Pinnacle	**42.0** ab	**92.4** abcde	**56.5** abcde	**80.5** a	**1.80** bcdef	**12.6** ghi	**5.19** lm	**43.4** jklm	**117** h	**62.8** no	**302** abc	**182** lm	**1.49** bcde	**9.5** bc	**42.0** cde
2ND25276	**40.3** bc	**94.1** ab	**50.0** def	**80.3** a	**1.90** abcde	**12.2** i	**5.44** ijklm	**45.5** efghijk	**116** h	**78.8** defgh	**281** abcd	**192** jklm	**1.49** bcde	**6.6** c	**52.3** abcd
M145	**33.2** fghij	**87.5** abcdefg	**44.0** f	**79.1** abcefdg	**1.83** abcdef	**13.3** cdefghi	**6.25** abcdef	**47.3** defgh	**181** abcdefg	**68.0** klmno	**172** defgh	**238** cdefgh	**1.44** hij	**5.2** c	**53.0** abcd
2ND26333	**37.2** de	**87.6** abcdefg	**48.5** ef	**77.7** ghi	**1.75** cdef	**14.8** ab	**5.95** defghij	**41.4** mn	**154** g	**98.3** a	**150** efgh	**213** ghijkl	**1.42** j	**4.4** c	**33.0** e
M150	**31.7** ij	**83.8** defg	**55.0** bcde	**78.7** bcdefgh	**1.80** bcdef	**14.1** abcde	**6.03** cdefghi	**45.0** fghijkl	**187** abcdefg	**76.6** fghij	**209** bcde	**218** defghijkl	**1.46** cdefghi	**4.7** c	**49.7** abcd
ND23898	**31.2** j	**80.9** g	**55.5** abcde	**78.4** defghi	**1.75** cdef	**14.3** abcd	**6.10** abcdefgh	**43.2** klm	**210** abc	**85.7** bcde	**77** gh	**232** cdefghi	**1.45** efghij	**6.1** c	**50.0** abcd
ND25652	**31.5** j	**82.7** fg	**59.5** abcd	**78.4** defghi	**1.75** cdef	**13.5** bcdefghi	**5.96** defghij	**46.1** efghijk	**215** a	**84.4** bcdef	**52** h	**227** cdefghij	**1.45** fghij	**5.0** c	**59.0** a
ND27245	**33.3** fghij	**91.5** abcdef	**64.3** ab	**79.4** abcdef	**1.60** ef	**13.0** defghi	**5.74** fghijklm	**46.3** efghijk	**179** abcdefg	**72.3** hijklm	**121** efgh	**206** hijklm	**1.46** defghi	**4.8** c	**56.3** ab
2ND27421	**43.8** a	**95.5** a	**48.7** ef	**79.7** abcd	**1.97** abcde	**13.2** cdefghi	**5.34** jklm	**42.0** lmn	**179** abcdefg	**67.4** lmno	**366** a	**188** klm	**1.53** a	**8.4** bc	**51.0** abcd
2ND27440	**41.4** ab	**93.8** ab	**55.7** abcde	**79.8** abcd	**1.93** abcde	**13.4** bcdefghi	**5.16** m	**40.0** n	**105** h	**62.7** o	**332** a	**176** m	**1.50** abcd	**13.1** bc	**41.0** de
SR440	**32.0** hij	**82.2** fg	**53.3** cdef	**80.3** a	**2.07** abcd	**12.6** fghi	**6.27** abcdef	**51.7** a	**167** defg	**91.9** ab	**117** efgh	**251** bcdef	**1.44** ghij	**5.2** c	**53.3** abcd
M148	**33.6** fghij	**87.4** abcdefg	**58.0** abcde	**79.2** abcdef	**2.07** abcd	**13.7** abcdefgh	**6.61** abc	**50.3** abcd	**173** cdefg	**78.0** efghi	**286** abcd	**275** ab	**1.49** bcdef	**4.3** c	**44.0** bcde
M151	**32.7** ghij	**83.3** efg	**54.7** bcde	**79.6** abcdef	**1.97** abcde	**13.4** bcdefghi	**6.22** abcdefg	**48.2** bcdef	**160** fg	**75.2** ghijkl	**186** cdefg	**258** abc	**1.46** cdefghi	**5.2** c	**51.0** abcd
M153	**32.9** ghij	**85.7** bcdefg	**65.3** a	**78.7** bcdefgh	**2.03** abcd	**14.2** abcd	**6.25** abcdef	**46.3** efghijk	**206** abc	**74.0** hijkl	**161** efgh	**252** bcde	**1.46** cdefghi	**7.9** c	**46.3** abcd
M154	**34.8** efghi	**94.1** ab	**59.0** abcd	**79.3** abcdef	**1.87** abcde	**13.5** bcdefghi	**5.82** efghijkl	**45.0** fghijkl	**162** efg	**73.8** hijkl	**194** bcdefg	**226** cdefghij	**1.47** cdefghi	**9.9** bc	**56.7** ab
ND26891	**34.0** efghij	**88.9** abcdefg	**61.7** abc	**79.2** abcdef	**2.13** abc	**13.0** defghi	**5.73** fghijklm	**46.2** efghijk	**158** fg	**69.4** jklmno	**118** efgh	**210** ghijklm	**1.50** abc	**16.7** ab	**42.0** cde
ND27177	**33.7** fghij	**90.9** abcdef	**63.0** abc	**79.7** abcde	**2.07** abcd	**13.2** defghi	**5.75** fghijklm	**46.0** efghijk	**199** abcde	**75.7** ghijk	**124** efgh	**229** cdefghij	**1.51** ab	**12.4** bc	**56.7** ab
ND28993	**33.4** fghij	**92.7** abcd	**58.3** abcde	**78.9** abcdefgh	**2.10** abcd	**13.3** cdefghi	**6.06** cdefghi	**48.9** efghi	**171** cdefg	**74.7** ghijkl	**124** efgh	**237** cdefgh	**1.50** abc	**8.1** c	**51.7** abcd
2ND28065	**38.5** cd	**91.0** abcdef	**54.7** bcde	**80.3** a	**1.47** f	**12.8** efghi	**5.25** klm	**41.9** lmn	**115** h	**61.8** o	**212** bcde	**196** ijklm	**1.47** cdefghi	**4.1** c	**45.7** abcde
2ND28131	**41.9** ab	**93.2** abc	**50.0** def	**80.3** a	**1.95** abcde	**12.7** fghi	**5.16** m	**41.5** mn	**115** h	**71.4** hijklm	**308** ab	**198** ijklm	**1.49** bcde	**21.4** a	**49.3** abcd
6B08-3210	**34.1** efghij	**88.0** abcdefg	**62.0** abc	**80.1** abc	**1.83** abcdef	**12.5** hi	**5.74** fghijklm	**47.8** cdefg	**157** fg	**70.4** ijklmn	**208** bcde	**224** cdefghijk	**1.49** bcdef	**7.3** c	**54.7** abcd
6B09-3531	**32.9** ghij	**89.3** abcdefg	**55.7** abcde	**79.1** abcdefg	**2.23** a	**13.6** bcdefgh	**6.73** a	**50.6** abc	**175** bcdefg	**91.0** b	**126** efgh	**289** a	**1.49** bcdef	**5.7** c	**48.3** abcd
6B09-3580	**34.2** efghij	**86.2** abcdefg	**58.7** abcde	**78.1** fghi	**1.87** abcde	**13.6** bcdefghi	**5.59** ghijklm	**43.5** jklm	**175** bcdefg	**78.7** defgh	**141** efgh	**229** cdefghi	**1.47** cdefghi	**5.2** c	**45.3** abcde
6B09-3655	**35.8** defg	**93.1** abc	**57.7** abcde	**77.5** hi	**1.90** abcde	**13.9** abcdef	**5.85** defghijk	**43.5** jklm	**191** abcdefg	**75.3** ghijkl	**101** efgh	**221** cdefghijk	**1.48** bcdefghi	**5.9** c	**48.0** abcd
6B09-4021	**36.3** def	**95.2** a	**56.0** abcde	**77.1** i	**1.83** abcdef	**14.9** a	**5.96** defghij	**41.8** lmn	**196** abcdef	**72.7** hijklm	**106** efgh	**230** cdefghi	**1.48** bcdefghi	**6.7** c	**48.0** abcd
6B09-4235	**35.5** defg	**92.4** abcde	**64.7** ab	**78.7** bcdefgh	**1.77** bcdef	**13.0** defghi	**5.48** hijklm	**44.2** ijklm	**172** cdefg	**75.0** ghijkl	**81** fgh	**215** efghijkl	**1.48** bcdefgh	**5.7** c	**55.0** abc
SR446	**34.4** efghij	**87.0** abcdefg	**62.0** abc	**80.2** ab	**1.90** abcde	**13.3** cdefghi	**6.45** abcde	**50.6** abc	**175** bcdefg	**86.2** bcd	**113** efgh	**255** bcd	**1.47** bcdefghi	**4.2** c	**49.0** abcd
SR447	**31.1** j	**83.9** cdefg	**62.3** abc	**80.2** ab	**1.93** abcde	**13.4** bcdefghi	**6.01** cdefghi	**47.6** cdefg	**152** g	**78.5** efghi	**107** efgh	**233** cdefghi	**1.48** bcdefgh	**5.9** c	**50.7** abcd
SR448	**35.1** efgh	**88.9** abcdefg	**59.7** abcd	**79.9** abcd	**2.17** ab	**13.8** abcdefgh	**6.70** ab	**51.1** ab	**205** abcd	**87.5** bc	**93** efgh	**275** ab	**1.48** bcdefgh	**6.0** c	**52.3** abcd

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

** Crookston, MN; Fargo, ND; Aberdeen, ID

Mississippi Valley Barley Nursery (MVBN) - Aberdeen, ID
Table 3

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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5546	MOREX	6	31.4	75.9	63	78.8	1.8	1	13.0	5.48	45.4	165	68.0	166	208	1.46	6.0	60	9
5547	ROBUST	6	32.6	84.1	65	79.5	1.6	1	13.3	5.56	44.6	161	56.5	233	200	1.49	4.5	61	3
5548	LEGACY	6	30.0	75.5	69	79.4	1.9	1	13.0	5.98	48.1	172	85.4	203	224	1.47	3.6	51	21
5549	LACEY	6	33.3	91.1	78	81.0	1.6	1	12.4	5.59	49.0	150	70.1	130	203	1.48	3.6	61	3
5550	TRADITION	6	35.7	94.4	78	80.2	1.8	1	12.6	5.48	45.7	167	72.4	217	208	1.53	6.8	63	1
5551	PINNACLE	6	46.5	98.0	66	81.6	1.8	1	11.9	5.19	45.4	115	56.2	240	187	1.51	7.4	47	29
5552	2ND25276	6	42.0	97.4	58	81.4	2.0	1	11.5	5.33	47.3	115	71.7	260	188	1.50	9.4	46	30
5553	M145	6	32.3	82.8	59	79.7	1.8	1	11.7	5.74	49.7	151	62.7	157	219	1.45	4.2	57	15
5554	6Ab07-X020029-45	6	31.2	74.2	72	79.3	1.8	1	10.2	4.53	47.4	109	59.9	364	173	1.56	5.5	31	38
5555	M150	6	32.2	80.6	71	79.5	1.6	1	12.7	5.34	45.3	159	67.9	299	193	1.51	3.8	61	3
5556	6Ab07-X04M172-29	6	36.4	95.3	69	82.0	2.5	2	9.4	4.89	54.4	71	66.0	184	187	1.51	15.9	36	34
5557	04Ab034-62	6	37.1	97.3	76	80.9	1.9	1	11.4	5.17	47.0	134	66.8	392	196	1.61	11.4	44	31
5558	ND27245	6	34.7	95.0	75	80.5	1.6	1	12.3	5.41	47.6	150	63.2	158	190	1.50	5.4	56	17
5559	2ND27421	6	46.5	98.3	56	80.7	2.0	1	12.8	5.43	46.1	167	61.6	258	195	1.53	7.9	61	3
5560	2ND27440	6	44.7	97.9	66	81.3	1.7	1	13.0	5.23	42.9	99	58.7	225	185	1.49	8.2	51	21
5561	SR440	6	32.3	85.8	62	80.7	2.2	1	11.6	5.66	51.3	124	81.3	217	228	1.48	7.3	55	19
5562	M148	6	33.4	88.6	65	79.8	1.9	1	12.5	5.86	50.8	140	71.6	343	234	1.51	4.3	51	21
5563	M151	6	32.3	77.7	70	79.3	1.9	1	12.5	5.64	48.6	142	66.3	282	221	1.50	5.7	56	17
5564	M153	6	33.4	85.2	82	79.4	1.9	1	12.8	5.77	48.2	179	66.6	190	221	1.50	7.0	54	20
5565	M154	6	36.1	97.2	76	80.4	1.8	1	12.3	5.29	46.4	144	68.1	248	195	1.51	8.8	61	3
5566	ND26891	6	36.7	96.6	78	81.2	2.4	2	10.6	4.87	50.4	96	60.8	203	172	1.56	21.0	36	34
5567	ND27177	6	35.4	96.6	77	80.8	2.5	2	11.8	5.16	47.4	140	65.0	226	194	1.58	23.0	51	21
5568	ND28993	6	35.0	95.8	76	80.0	2.0	1	12.2	5.48	48.1	151	68.8	171	204	1.53	8.3	58	12
5570	2ND28065	6	39.2	90.9	64	80.0	1.6	1	12.8	5.23	42.6	112	56.6	207	183	1.47	6.1	51	21
5572	2ND28131	6	42.7	93.9	53	80.4	n.d.	2	12.1	5.19	44.5	110	65.7	286	192	1.48	37.0	49	28
5573	6B08-3210	6	34.8	88.9	72	80.1	1.9	1	12.6	5.60	47.2	146	66.8	266	206	1.52	9.9	58	12
5574	6B09-3531	6	34.8	93.1	70	80.3	2.1	1	12.0	5.90	51.0	134	81.5	227	242	1.54	6.8	51	21
5575	6B09-3580	6	36.9	93.6	75	79.9	1.8	1	11.4	5.07	46.5	131	70.3	257	202	1.52	6.0	51	21
5576	6B09-3655	6	37.4	96.0	72	79.2	2.0	1	12.0	5.26	45.7	140	65.1	185	203	1.51	6.6	60	9
5577	6B09-4021	6	36.7	98.2	73	78.8	1.8	1	13.3	5.42	44.1	140	62.5	187	205	1.50	6.2	60	9

Table 3

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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5578	6B09-4235	6	37.7	97.1	81	80.1	1.8	1	11.5	4.94	46.1	128	66.1	122	192	1.51	6.2	57	15
5579	SR446	6	41.4	96.6	76	82.5	1.6	1	11.8	5.42	**50.1**	133	87.8	88	207	1.50	4.6	62	2
5580	SR447	6	31.1	81.8	76	80.7	1.8	1	11.7	5.14	**47.1**	143	75.7	104	194	1.49	7.0	58	12
5581	SR448	6	35.9	91.7	79	81.0	1.8	1	12.2	5.63	**49.7**	178	85.0	122	231	1.50	5.9	61	3
5582	01Ab9663	6	39.8	94.1	70	82.7	2.1	1	**10.3**	5.04	**52.6**	125	70.4	**320**	198	1.56	8.5	44	31
5583	6Ab07-X031057-33	6	33.2	83.3	57	79.8	2.1	1	**10.5**	4.97	**50.5**	**116**	71.9	**247**	202	1.48	7.4	42	33
5584	6Ab07-X020049-13	6	32.8	**68.5**	63	78.4	2.0	1	**10.1**	**4.29**	44.8	**107**	56.9	**348**	**163**	1.54	10.1	31	38
5585	6Ab07-X020030-37	6	34.2	78.8	72	78.9	2.0	1	**10.0**	**4.22**	45.1	**98**	55.3	**502**	**167**	1.62	12.2	34	36
5586	6Ab07-X04M238-13	6	32.0	**65.0**	72	78.1	1.9	1	**9.8**	**4.27**	45.1	**108**	55.5	**291**	**160**	1.52	9.7	27	40
5587	6Ab07-X020047-9	6	33.6	91.6	78	79.4	n.d.	3	**10.0**	**4.50**	**48.6**	**61**	58.6	**430**	**182**	1.58	7.0	32	37
5569	HARRINGTON MALT CHECK		39.1	96.2	75	82.6	1.5	1	11.6	5.11	46.0	131	83.2	117	191	1.52	4.3	61	
5571	LACEY MALT CHECK		34.8	89.5	51	79.6	2.7	2	13.2	5.82	46.2	128	60.6	185	207	1.53	32.0	55	
Minima			30.0	65.0	53	78.1	1.6		9.4	4.22	42.6	61	55.3	88	160	1.45	3.6		
Maxima			46.5	98.3	82	82.7	2.5		13.3	5.98	54.4	179	87.8	502	242	1.62	37.0		
Means			35.9	89.1	70	80.2	1.9		11.8	5.25	47.5	133	67.2	239	199	1.51	8.7		
Standard Deviations			4.2	9.0	7	1.1	0.2		1.1	0.44	2.6	27	8.4	89	19	0.04	6.2		
Coefficients of Variation			11.6	10.1	10	1.3	11.8		9.0	8.36	5.5	21	12.5	37	10	2.48	71.2		

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

Neg Std Dev			23.4	62.2	48	77.0	1.2		8.6	3.94	39.6	51	42.0	-27	142	1.4	-9.84		
Pos Std Dev			48.4	116.0	92	83.4	2.6		15.0	6.57	55.4	215	92.4	504	256	1.6	27.15		

2012 Mississippi Valley Barley Nursery (MVBN) - Crookston, MN

Table 4

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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5624	MOREX	6	32.4	87.7	42	77.8	1.8	1	**15.0**	**6.42**	44.5	244	92.3	61	244	1.44	4.6	47	20
5625	ROBUST	6	33.5	89.6	41	78.3	1.7	1	**14.5**	**6.06**	**41.7**	222	69.8	151	216	1.46	4.6	41	27
5626	LEGACY	6	33.4	91.1	47	78.6	1.8	1	13.6	**6.14**	46.3	223	87.0	**193**	230	1.47	3.7	48	18
5627	LACEY	6	35.7	92.9	44	79.8	1.8	1	13.4	5.77	45.0	196	76.9	101	215	1.46	5.9	66	4
5628	TRADITION	6	34.2	88.9	54	77.9	2.1	2	14.0	5.83	42.2	243	79.0	98	220	1.49	17.1	54	11
5629	2ND25276	2	40.1	91.5	43	79.6	1.9	1	12.9	5.42	43.8	130	82.8	**213**	190	1.49	5.1	57	9
5630	M145	6	35.0	93.1	40	79.2	1.9	1	13.3	**6.19**	46.5	192	67.8	141	242	1.46	6.4	59	6
5631	2ND26333	2	**37.5**	**84.5**	50	**76.9**	1.8	1	**15.1**	5.77	**38.5**	166	93.9	79	210	1.42	4.9	31	33
5632	M150	6	32.1	90.5	42	78.1	2.0	1	**14.2**	**6.05**	43.4	201	77.3	162	222	1.47	5.2	43	24
5633	ND23898	6	33.2	86.1	52	78.5	1.8	1	13.9	**6.08**	44.3	215	79.8	64	233	1.48	6.2	55	10
5634	ND25652	6	32.8	88.6	47	78.2	1.7	1	13.7	5.93	45.5	242	77.9	37	225	1.48	4.5	58	7
5635	ND27245	6	34.7	95.5	57	79.6	1.6	1	12.4	5.38	44.9	172	68.8	81	198	1.47	5.1	68	1
5636	2ND27421	2	*44.8	96.0	43	79.6	2.1	1	12.9	4.93	**39.1**	176	63.8	*467	**171**	*1.60	12.6	50	16
5637	2ND27440	2	40.8	93.2	55	79.9	2.4	2	12.7	4.96	**39.8**	**100**	60.2	**325**	**167**	1.51	23.0	41	27
5638	SR440	6	33.4	89.1	43	80.7	2.0	1	12.7	**6.39**	**52.3**	180	98.7	54	263	1.45	3.7	58	7
5639	M148	6	34.1	86.9	55	78.1	2.0	1	13.8	**6.69**	**48.6**	200	83.4	**229**	262	1.48	4.1	40	31
5640	M151	6	33.9	89.4	43	79.4	2.1	1	13.5	**6.29**	46.8	168	79.2	136	249	1.47	5.7	54	11
5641	M153	6	33.5	89.2	52	78.6	2.2	1	**14.2**	**6.09**	44.6	209	75.3	**172**	233	1.48	11.5	43	24
5642	M154	6	35.7	95.4	50	78.5	2.1	1	13.0	5.50	43.9	162	73.0	**179**	202	1.47	17.3	60	5
5643	ND26891	6	31.7	81.9	52	**76.8**	2.2	2	**14.2**	5.81	**41.4**	205	69.7	51	196	1.48	23.0	37	32
5644	ND27177	6	34.5	91.9	53	78.9	1.9	1	13.4	5.63	43.7	211	78.7	62	213	1.50	9.9	67	2
5645	ND28993	6	34.0	94.8	47	78.0	2.2	1	13.6	**6.12**	45.6	178	77.9	77	227	1.51	10.1	52	15
5646	2ND28065	2	39.0	90.9	50	80.3	1.4	1	11.8	4.83	41.1	**98**	59.0	**251**	**179**	1.50	3.5	45	21
5647	2ND28131	2	41.6	92.6	46	79.4	2.2	2	12.5	4.80	**39.0**	112	68.7	*393	**174**	1.53	23.0	42	26
5648	6B08-3210	6	36.3	93.8	57	80.6	1.9	1	**11.3**	5.36	**48.5**	143	72.2	**190**	205	1.50	8.1	53	13
5649	6B09-3531	6	33.5	92.6	45	78.3	2.1	1	13.8	**6.87**	**50.0**	203	96.8	53	281	1.49	5.1	50	16
5650	6B09-3580	6	34.2	87.4	45	**76.9**	1.8	1	**14.3**	5.62	**41.3**	200	84.0	109	220	1.47	5.0	45	21
5651	6B09-3655	6	36.9	95.6	45	**76.3**	1.7	1	**15.0**	5.91	**41.3**	221	80.2	58	215	1.48	4.5	41	27

Table 4

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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5652	6B09-4021	6	38.0	96.5	44	**76.4**	1.7	1	**15.5**	5.80	**38.2**	227	72.2	71	225	1.49	6.4	41	27
5654	6B09-4235	6	36.7	93.7	57	78.5	1.7	1	12.7	5.54	44.7	184	72.4	69	222	1.49	4.8	67	2
5656	SR446	6	33.2	91.2	47	79.3	2.2	1	**14.3**	**6.91**	**50.2**	182	80.0	122	267	1.47	3.6	44	23
5657	SR447	6	32.9	89.6	51	80.1	2.1	1	**14.3**	**6.30**	46.4	156	76.3	71	241	1.49	5.6	53	13
5658	SR448	6	36.3	90.9	44	79.4	2.6	1	**14.5**	**7.21**	**51.3**	209	86.2	64	291	1.48	5.7	48	18
5653	HARRINGTON MALT CHECK	2	39.3	96.6	74	82.1	1.4	1	11.2	5.12	46.9	135	77.7	160	196	1.54	4.4	60	
5655	LACEY MALT CHECK	6	33.8	89.4	53	79.8	n.d.	3	13.3	5.71	45.8	132	56.4	220	205	1.55	43.0	54	
Minima			31.7	81.9	40	76.3	1.4		11.3	4.80	38.2	98	59.0	37	167	1.42	3.5		
Maxima			41.6	96.5	57	80.7	2.6		15.5	7.21	52.3	244	98.7	325	291	1.53	23.0		
Means			35.2	91.0	48	78.7	2.0		13.6	5.90	44.4	187	77.6	120	223	1.48	8.2		
Standard Deviations			2.6	3.4	5	1.2	0.3		1.0	0.58	3.7	38	9.5	71	30	0.02	5.9		
Coefficients of Variation			7.3	3.8	11	1.5	13.1		7.0	9.89	8.3	21	12.3	59	14	1.40	72.3		
Neg Std Dev			27.5	80.7	33	75.2	1.2		10.8	4.15	33.3	71	49.0	-92	132	1.42	-9.5		
Pos Std Dev			42.8	101.3	63	82.2	2.7		16.5	7.65	55.4	302	106.2	333	313	1.54	25.9		

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. Kevin Smith, U. of MN

2012 MVBN - Fargo
Table 5

Lab No.	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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5430	Morex	6	30.6	81.3	60	78.0	2.0	1	**15.7**	**6.78**	44.5	217	87.8	128	257	1.41	6.6	42	20
5431	Robust	6	31.4	82.6	54	78.5	1.8	1	**14.5**	**6.61**	**47.1**	204	70.6	**232**	243	1.43	4.4	37	30
5432	Legacy	6	30.7	80.3	61	78.8	2.2	1	**14.9**	**7.31**	**51.2**	210	100.7	**208**	278	1.42	5.3	37	30
5433	Lacey	6	31.8	82.6	55	78.7	1.9	1	**14.5**	**6.57**	45.9	197	82.9	133	238	1.40	6.8	45	10
5434	Tradition	6	29.9	78.9	60	77.8	2.0	1	**14.1**	5.90	43.3	228	82.9	140	213	1.43	14.7	41	23
5435	Pinnacle	2	**37.4**	86.8	47	79.3	1.8	1	13.2	5.18	41.4	118	69.4	**364**	**177**	1.47	11.6	37	30
5436	2ND25276	2	38.9	93.5	49	80.0	1.8	1	12.3	5.56	45.5	104	81.8	**371**	197	1.48	5.3	54	3
5437	M145	6	32.4	86.6	*33	78.3	1.8	1	**14.9**	**6.83**	45.8	201	73.6	**219**	253	1.41	4.9	43	16
5438	2ND26333	2	**36.8**	90.6	47	78.4	1.7	1	**14.4**	**6.13**	44.2	142	102.7	**221**	216	1.41	3.9	35	33
5439	M150	6	30.8	80.2	52	78.4	1.8	1	**15.4**	**6.69**	46.3	202	84.5	165	239	1.41	5.0	45	10
5440	ND23898	6	29.1	75.6	59	78.3	1.7	1	**14.6**	**6.11**	42.1	204	91.5	90	230	1.42	5.9	45	10
5442	ND25652	6	30.1	76.7	*72	78.6	1.8	1	13.3	5.99	46.6	187	90.8	66	229	1.41	5.4	60	1
5444	ND27245	6	30.4	83.9	61	78.2	1.6	1	**14.3**	**6.44**	46.5	214	84.8	125	230	1.40	4.0	45	10
5445	2ND27421	2	40.2	92.3	47	78.9	1.8	1	**14.0**	5.66	40.9	195	76.7	**372**	197	1.47	4.8	42	20
5446	2ND27440	2	38.6	90.2	46	78.3	1.7	1	**14.5**	5.29	**37.4**	116	69.1	**445**	**176**	1.49	8.2	31	34
5447	SR440	6	30.3	**71.7**	55	79.5	2.0	1	13.6	**6.75**	**51.5**	196	95.6	79	262	1.40	4.6	47	9
5448	M148	6	33.3	86.8	54	79.7	2.3	1	**14.7**	**7.29**	**51.6**	180	79.0	**286**	329	1.47	4.5	41	23
5449	M151	6	31.8	82.8	51	80.0	1.9	1	**14.2**	**6.74**	**49.2**	169	80.1	140	303	1.42	4.1	43	16
5450	M153	6	31.8	82.8	62	78.2	2.0	1	**15.6**	**6.88**	46.0	229	80.1	121	302	1.41	5.2	42	20
5451	M154	6	32.6	89.8	51	79.1	1.7	1	**15.1**	**6.66**	44.7	180	80.3	155	280	1.42	3.5	49	7
5452	ND26891	6	33.5	88.3	55	79.7	1.8	1	**14.3**	**6.51**	46.9	173	77.6	100	262	1.46	6.1	53	4
5453	ND27177	6	31.2	84.3	59	79.4	1.8	1	**14.4**	**6.45**	47.0	245	83.3	85	279	1.45	4.3	52	6
5454	ND28993	6	31.3	87.6	52	78.8	2.1	1	**14.2**	**6.58**	46.9	184	77.4	125	279	1.46	5.8	45	10
5455	2ND28065	2	**37.2**	91.2	50	80.6	1.4	1	**13.9**	5.68	41.9	134	69.8	**179**	226	1.43	2.6	41	23
5456	2ND28131	2	41.4	93.0	51	81.2	1.7	1	13.4	5.49	41.0	123	79.7	**244**	227	1.46	4.2	57	2
5457	6B08-3210	6	31.3	81.3	57	79.7	1.7	1	13.5	**6.25**	**47.6**	183	72.1	168	260	1.44	4.0	53	4
5458	6B09-3531	6	30.3	82.2	52	78.6	*2.5	1	**15.0**	**7.41**	**50.8**	187	94.6	97	345	1.43	5.2	44	15
5459	6B09-3580	6	31.5	77.7	56	**77.5**	2.0	1	**15.0**	**6.08**	42.8	193	81.7	58	266	1.41	4.6	40	29
5460	6B09-3655	6	33.1	87.7	56	**77.0**	2.0	1	**14.8**	**6.39**	43.4	212	80.6	60	245	1.44	6.5	43	16
5461	6B09-4021	6	34.1	90.9	51	**76.1**	2.0	1	**16.0**	**6.66**	43.0	220	83.4	60	260	1.44	7.5	43	16

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)	Rel. Visco	Turbidity (Hach)	Quality Score	Overall Rank
5462	6B09-4235	6	32.1	86.5	56	**77.4**	1.8	1	**14.9**	5.96	**41.8**	204	86.5	52	231	1.44	6.1	41	23
5463	SR446	6	28.7	73.1	63	78.7	1.9	1	13.8	**7.01**	**51.5**	209	90.9	129	290	1.44	4.5	41	23
5464	SR447	6	29.4	80.3	60	79.7	1.9	1	**14.3**	**6.60**	**49.3**	158	83.5	145	263	1.46	5.0	41	23
5465	SR448	6	33.2	84.0	56	79.3	2.1	1	**14.7**	**7.26**	**52.3**	227	91.2	94	304	1.46	6.3	48	8
5441	HARRINGTON MALT CHECK	2	39.0	96.8	74	82.4	1.5	1	11.9	5.34	48.3	138	88.0	94	192	1.46	3.5	62	
5443	LACEY MALT CHECK	6	33.5	89.9	52	79.8	2.3	2	13.1	5.85	46.8	135	63.6	156	204	1.48	22.0	58	
Minima			28.7	71.7	46	76.1	1.4		12.3	5.18	37.4	104	69.1	52	176	1.40	2.6		
Maxima			41.4	93.5	63	81.2	2.3		16.0	7.41	52.3	245	102.7	445	345	1.49	14.7		
Means			32.9	84.2	55	78.8	1.9		14.4	6.40	45.8	187	82.9	166	253	1.44	5.6		
Standard Deviations			3.3	5.6	5	1.0	0.2		0.8	0.58	3.7	35	8.5	101	39	0.02	2.3		
Coefficients of Variation			10.1	6.7	9	1.3	9.4		5.4	9.06	8.0	19	10.2	61	16	1.70	40.2		

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. Richard Horsley, N.D.S.U.

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