UNITED STATES DEPARTMENT OF AGRICULTURE
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CEREAL CROPS RESEARCH UNIT

MISSISSIPPI VALLEY REGIONAL SPRING BARLEY NURSERY
2013 Crop

Preliminary Quality Report

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Detailed Data:

Aberdeen, ID
Crookston, MN
Morris, MN

Appendix:
Methods
Criteria for Quality Score

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 – 2013 Crop

The Mississippi Valley Uniform Regional Barley Nursery (MVBN) is an annual, cooperative effort among the 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.larrl.ars.usda.gov/research/publications/publications.htm?seq_no_115=303358 . In this report, the malting quality of 2013 MVBN lines received from Aberdeen, Idaho, Crookston, Minnesota, and Morris, Minnesota 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 commercial malting facilities for 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" for 6-rowed and 2-rowed, adjunct barleys developed by the American Malting Barley Association (AMBA) These are listed in Appendix B. (The overall quality scores do not, necessarily, reflect the needs of craft brewers using 2-rowed barleys for all malt brewing).

Statistical analyses were performed on the quality data using SAS 9.2 software and the station mean values for fourteen quality factors, and an overall quality score, 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. (This was also true with the 2012 MVBN crop). These barleys did not differ significantly in average "Plumpness" (6/64" screen) from those of Morris, but were significantly more plump than those from Crookston. As typically occurs, the Aberdeen samples were significantly brighter (Agtron Colorimeter), on average, than those from the Minnesota locations. The Malt Extract % average was significantly higher than for either Crookston or Morris, even though the barley protein average of 13.1% was significantly higher than that of Morris, but not significantly different from Crookston. The wort color average was intermediate at this location – significantly higher than that of Crookston, but lower than that of Morris. Although the Aberdeen Diastatic Power average did not differ significantly from that of Crookston, these barleys lagged both the Crookston and Morris averages for the α-Amylase parameter – though its average of 66.7°DU was still above the ideal α-Amylase criterion for adjunct brewing of greater than 50.0°DU. MVBN barleys grown at this location were highest in average β-Glucan content (316ppm) and Viscosity (1.54cP). However, the average overall quality score was greater than that of Crookston and not significantly different from that of Morris.

The barleys from Crookston, MN (Table 4) were notable for their relatively low average kernel weight (35.0mg), and low average % plumpness (92.0%) -- both significantly lower than either Aberdeen or Morris. Also, these parameters likely may have contributed to the 78.8% Malt Extract average being significantly lower than that of Morris (79.2%) or Aberdeen (80.2%). The average barley surface coloration was lowest at this location; this is likely due to environmental factors (humidity/microbrial load) at this site. Even though the average barley protein from this location was high (13.3%, not significantly different from Aberdeen), Soluble Protein %, S/T, and FAN were the lowest averages of any location, indicating slow protein modification in these barleys. The Crookston barleys had the lowest average overall quality score.

The MVBN malts from barleys grown at Morris, MN (Table 5) generated the highest average Wort Color (3.23°), even though their barley surface coloration (Agtron) average was intermediate – significantly higher than that of Crookston, but lower than Aberdeen's average. This location was also notable for having the lowest Diastatic Power and β-Glucan averages ($p < 0.05$).

The top performing line across locations in the 2013 MVBN was M152. Its overall quality average of 62.7 was significantly higher than any other line. It had a high average Diastatic Power (DP) of 191° and low average viscosity of 1.47cP. None of its other parameters were remarkable, and its average β-Glucan of 166ppm could be considered high. M156 was another high overall performer with a quality score average of 62.0, which did not differ significantly from that of M152. Its average DP (167°) was lower than M152, but so was β-Glucan at 131ppm. M150 averaged 59.0 for overall quality, and had a low Turbidity average of 6.3° Hach. Other top overall performers included M155, M157, 2ND27705, SR440, and SR452. (SR440 had also been a top average scorer in the 2012 MVBN results). M155 and M157 had similar malt quality profiles, except that M157 had a significantly higher β-Glucan average. SR440 and SR452 also shared similar quality profiles, but with SR440 yielding a significantly higher Malt Extract average at 80.5%. 2ND27705 differed from the other high performing lines in its significantly lower DP average of 137°, which wasn't surprising, as it is a 2-rowed barley.

Relatively low overall malting quality performers for the 2013 MVBN included 2ND28065, 2ND29990, 6B10-4988, and 6B104515. The most negative attribute for 2ND28065 was an average β-Glucan content of 286ppm. 2ND29990 also had relatively high average β-Glucan, and very high average Turbidity: 35.7°Hach. The main negative issues for 6B10-4988 were relatively high β-Glucan (294ppm) and Viscosity (1.55cP) averages, and 6B10-4515 was hampered by low Malt Extract (77.8%) and S/T (41.6) averages.

Other divergent averages include high kernel weight for Pinnacle (44.2mg) and 2ND28131 (43.8mg), 2ND28071 with an average 6/64" plumpness score of 97.8%, M155 with the lowest Agtron average of 39.0, and 2ND29990 with an average wort color of 3.35°. The variety Robust had the highest average barley protein (dry basis) of 13.8%, and 2ND29990 generated the lowest Soluble Protein average of 4.29% -- its Kolbach Index and FAN were also lowest at 39.4 and 191ppm, respectively. Not surprisingly, the variety Tradition had the highest DP average at 205°. Conversely, 2ND28131, a 2-rowed barley, yielded the

lowest DP average of 99°. The lowest and highest β-Glucan average values in the 2013 MVBN were yielded by ND25652 (85ppm) and 2ND28071 (373ppm), respectively. Robust and Lacey did not differ significantly on the Turbidity metric, yielding averages of 4.9 and 5.5°Hach – the lowest, and best in this year's MVBN.

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MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2013 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	**37.3** a	**94.4** a	**70.8** a	**80.2** a	**2.74** b	**13.1** a	**5.55** a	**44.1** b	**162** a	**66.7** b	**316** a	**249** a	**1.54** a	**13.8** a	**55.1** a
Crookston, MN	**35.0** c	**92.0** b	**45.2** c	**78.8** c	**2.43** c	**13.3** a	**5.10** b	**39.7** c	**167** a	**72.1** a	**182** b	**223** b	**1.49** b	**13.2** a	**50.2** b
Morris, MN	**36.0** b	**95.3** a	**60.3** b	**79.2** b	**3.23** a	**11.7** b	**5.43** a	**48.0** a	**147** b	**72.8** a	**125** c	**250** a	**1.50** b	**15.8** a	**56.7** a

* 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, M150, ND25652, SR440, M151,ND26891, ND27177, ND28993, 2ND28065, 2ND28131, M152, M155, M156 M157, ND28554, ND28555, 2ND27705, 2ND28071, 2ND29990, 6B10-4515, 6B10-4528, 6B10-4635, 6B10-4748, 6B10-4905, 6B10-4988, SR451, SR452

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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	33.1 jklm	90.5 fghi	54.3 def	78.5 fghi	2.43 ghi	13.4 ab	5.48 bcdef	43.4 bcdefg	174 bcde	72.9 bcdefg	149 defgh	253 defgh	1.48 abcd	8.7 de	51.7 abc
ROBUST	34.8 hijk	94.0 abcdefg	54.7 cdef	78.9 defghi	2.13 i	13.8 a	5.51 bcdef	42.2 defg	175 bcde	59.9 klm	216 bcdefgh	247 efghij	1.48 abcd	4.9 e	51.7 abc
LEGACY	33.3 jklm	92.6 cdefgh	65.3 ab	79.5 bcdefg	2.50 efghi	13.1 abcd	5.83 abc	47.0 abcde	178 bcde	80.0 b	213 bcdefgh	260 bcde	1.48 abcd	5.5 e	55.7 abc
LACEY	35.5 efghi	94.6 abcdef	59.0 bcde	79.1 cdefghi	2.47 fghi	13.3 ab	5.41 bcdefgh	42.6 cdefg	177 bcde	70.7 cdefgh	113 gh	234 efghijkl	1.46 d	11.2 de	54.3 abc
TRADITION	34.4 hijkl	95.0 abcde	62.0 abcde	79.0 defghi	3.13 abcd	13.0 abcd	5.14 cdefgh	40.8 fg	205 a	74 bcdef	182 cdefgh	230 ghijklm	1.52 abcd	25.0 abc	54.0 abc
PINNACLE	44.2 a	97.5 ab	57.3 bcde	80.2 abcd	2.53 efghi	11.6 e	4.74 ghi	41.2 defg	111 jk	58.4 lm	353 ab	200 no	1.55 ab	12.0 de	51.3 abc
2ND25276	41.7 b	96.3 abcd	48.3 f	80.7 ab	2.87 abcdefgh	11.5 e	4.95 efghi	45.2 bcdefg	118 ijk	76.4 bc	306 abcd	215 klmno	1.52 abcd	13.1 cde	54.7 abc
M150	32.2 m	89.1 hi	55.0 cdef	79.0 defghi	2.37 hi	12.9 abcd	5.32 bcdefgh	42.7 cdefg	181 abc	74 bcdef	186 cdefgh	234 efghijkl	1.47 cd	6.3 e	59.0 abc
ND25652	34.8 hijk	95.2 abcde	58.5 bcde	78.5 ghi	2.85 abcdefgh	13.1 abcd	5.54 bcdef	43.4 bcdefg	199 ab	76.6 bc	85 h	239 efghijk	1.51 abcd	15.0 bcde	45.5 bc
SR440	32.9 klm	90.0 ghi	54.3 def	80.5 abc	3.03 abcdef	12.1 cde	5.69 abcde	49.1 ab	164 def	90.4 a	96 gh	279 abcd	1.48 abcd	8.7 de	57.0 abc
M151	33.4 jklm	90.8 efghi	62.0 abcde	79.6 bcdefg	2.77 bcdefgh	12.9 abcd	5.44 bcdefg	43.4 bcdefg	159 defg	74.2 bcde	205 bcdefgh	252 efghi	1.47 cd	9.0 de	56.3 abc
ND26891	35.1 fghij	94.3 abcdefg	62.0 abcde	78.8 defghi	3.27 abc	12.8 abcd	5.47 bcdefg	44.2 bcdefg	163 defg	66.6 efghijk	180 cdefgh	228 hijklm	1.52 abcd	27.0 ab	54.7 abc
ND27177	35.7 efghi	95.8 abcd	60.7 abcde	79.1 cdefghi	3.07 abcde	13.1 abc	5.64 bcde	44.0 bcdefg	192 abc	73.4 bcdefg	236 abcdefgh	253 defgh	1.55 ab	16.4 bcde	58.3 abc
ND28993	34.2 hijkl	94.5 abcdef	57.0 bcde	78.6 fghi	2.70 cdefgh	12.5 bcde	5.42 bcdefgh	45.7 bcdef	153 efgh	66.3 fghijk	217 bcdefgh	248 efghij	1.55 ab	17.4 bcde	54.0 abc
2ND28065	38.2 cd	90.4 fghi	58.7 bcde	79.8 bcdefg	2.13 i	12.4 bcde	4.89 fghi	41.3 defg	109 jk	56.6 m	286 abcdef	205 mno	1.52 abcd	9.0 de	43.0 c
2ND28131	43.8 a	97.1 abc	55.7 cdef	81.4 a	3.3 ab	11.6 e	4.69 hi	42.2 defg	99 k	67.3 efghijk	332 abc	205 mno	1.55 abc	36.7 a	53.3 abc
M152	34.7 hijk	93.5 abcdefg	62.0 abcde	79.4 bcdefgh	3.13 abcd	12.4 bcde	5.44 bcdefg	46.1 abcdef	167 cde	64.5 hijkl	131 fgh	245 efghij	1.46 d	18.1 bcde	62.7 a
M155	33.1 jklm	88.1 i	39.0 g	79.5 bcdefg	2.67 defghi	13.3 ab	5.61 bcdef	43.9 bcdefg	171 cde	76.5 bc	148 defgh	257 cdefg	1.49 abcd	8.8 de	57.0 abc
M156	32.5 lm	94.0 abcdefg	59.7 bcde	79.2 cdefghi	2.77 bcdefgh	12.7 bcd	5.40 bcdefgh	44.1 bcdefg	191 abc	75.2 bcd	166 defgh	234 efghijkl	1.47 d	13.3 cde	62.0 ab
M157	34.9 ghijk	92.2 defgh	63.3 abc	79.7 bcdefg	2.63 defghi	12.7 abcd	5.71 abcd	47.1 abcd	154 defg	70.8 cdefgh	246 abcdefg	256 cdefgh	1.53 abcd	9.3 de	58.3 abc
ND28554	37.2 de	96.7 abcd	58.3 bcde	79.3 bcdefgh	2.97 abcdefg	12.8 abcd	5.45 bcdefg	43.7 bcdefg	157 defg	69.7 cdefghi	193 cdefgh	247 efghij	1.51 abcd	17.3 bcde	54.0 abc
ND28555	36.0 efgh	96.1 abcd	60.0 abcde	79.2 cdefghi	2.90 abcdefgh	12.9 abcd	5.43 bcdefg	44.1 bcdefg	157 defg	70.2 cdefgh	212 bcdefgh	243 efghijk	1.52 abcd	16.3 bcde	51.7 abc
2ND27705	39.3 c	92.6 cdefgh	68.3 a	80.0 bcdef	2.83 abcdefgh	11.7 e	4.96 efghi	43.8 bcdefg	137 ghi	76.3 bc	142 efgh	232 fghijklm	1.48 bcd	9.3 de	57.0 abc
2ND28071	41.4 b	97.8 a	53.7 ef	79.9 bcdefg	3.20 abcd	12.0 de	4.69 hi	40.4 fg	129 hij	57.3 m	373 a	208 lmno	1.53 abcd	25.7 abc	51.0 abc
2ND29990	43.5 a	94.8 abcdef	64.7 ab	80.1 bcde	3.35 a	11.6 e	4.29 i	39.4 g	129 hij	62.3 ijklm	218 bcdefg	191 o	1.52 abcd	35.7 a	48.0 abc
6B10-4515	34.2 hijkl	95.4 abcd	58.0 bcde	77.8 i	2.83 abcdefgh	13.7 ab	5.22 cdefgh	41.6 defg	170 cde	70.9 cdefgh	133 fgh	236 efghijk	1.52 abcd	16.0 bcde	49.3 abc
6B10-4528	34.5 hijkl	94.5 abcdef	58.0 bcde	78.8 efghi	2.47 fghi	12.4 bcde	4.88 fghi	41.0 efg	139 fghi	67.7 defghij	114 gh	222 jklmn	1.50 abcd	9.5 de	52.7 abc
6B10-4635	36.8 defg	94.2 abcdefg	54.7 cdef	79.1 cdefghi	3.00 abcdefg	12.8 abcd	5.61 bcdef	45.3 bcdefg	157 defg	75.9 bc	295 abcde	283 ab	1.55 a	10.6 de	54.7 abc
6B10-4748	37.0 def	97.3 ab	58.0 bcde	79.7 bcdefg	2.77 bcdefgh	13.2 abc	6.04 ab	48.4 abc	168 cde	68.0 defghij	166 defgh	259 bcdef	1.50 abcd	11.9 de	56.3 abc
6B10-4905	33.8 ijklm	90.5 fghi	65.7 ab	79.3 bcdefgh	3.03 abcdef	12.5 bcde	5.05 defgh	41.8 defg	170 cde	61.0 jklm	285 abcdef	224 ijklmn	1.52 abcd	20.5 bcd	52.0 abc
6B10-4988	35.0 ghij	96.0 abcd	60.7 abcde	78.0 hi	2.43 ghi	13.4 ab	5.51 bcdef	42.2 defg	174 bcde	65.8 ghijk	294 abcde	241 efghijk	1.55 abc	7.1 de	48.3 abc
SR451	34.4 hijkl	93.2 bcdefgh	64.7 ab	79.9 bcdefg	2.90 abcdefgh	12.9 abcd	6.36 a	51.5 a	159 defg	80.0 b	200 bcdefgh	283 ab	1.48 bcd	9.0 de	54.0 abc
SR452	33.9 ijklm	93.8 abcdefg	63.0 abcd	79.2 cdefghi	2.87 abcdefgh	13.2 ab	5.96 ab	46.2 abcdef	164 def	80.5 b	102 gh	292 a	1.47 cd	7.8 de	57.0 abc

* 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; Crookston, MN; Morris, MN

2013 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.	Turbid. (Hach)	Quality Score	Overall Rank
5492	Morex	6	34.9	94.5	72	79.4	2.4	1	14.4	5.84	43.1	179	67.7	266	269	1.53	9.6	49	28
5493	Robust	6	36.2	94.4	72	79.5	2.0	1	14.8	5.65	40.7	176	55.0	358	251	1.55	5.1	48	30
5494	Legacy	6	34.8	94.7	75	80.3	2.5	1	13.4	6.12	48.0	186	78.5	335	282	1.55	5.6	51	23
5495	Lacey	6	37.7	95.8	68	79.8	2.3	1	14.2	5.80	42.4	180	70.7	206	264	1.51	6.7	49	28
5496	Tradition	6	34.7	94.2	77	80.2	3.2	2	12.2	4.99	41.0	193	68.6	319	241	1.57	24.0	53	19
5497	Pinnacle	2	45.1	98.3	70	80.4	2.2	1	12.0	4.88	41.4	126	58.7	478	217	1.57	8.5	60	9
5498	2ND25276	2	42.9	97.6	*49	81.1	2.5	1	12.1	4.76	41.2	117	69.6	433	211	1.52	7.3	60	9
5499	M150	6	32.9	85.7	69	79.2	2.3	1	13.6	5.29	41.3	181	72.6	292	248	1.51	5.3	53	19
5501	AC Metcalfe	2	37.4	89.2	72	80.8	2.6	1	12.5	5.24	43.2	174	82.5	84	253	1.47	6.6	60	9
5503	SR440	6	32.8	87.3	65	81.3	2.8	1	12.1	5.37	46.7	165	85.5	169	281	1.48	6.3	66	1
5504	M151	6	34.6	91.0	74	79.9	2.8	1	13.2	5.51	42.6	165	69.7	346	264	1.53	10.4	63	2
5505	ND26891	6	37.0	96.0	71	80.2	3.4	2	12.5	5.34	43.9	150	64.2	304	231	1.57	34.0	62	6
5506	ND27177	6	38.5	97.5	70	80.0	3.3	1	12.8	5.61	45.0	172	68.5	540	263	1.65	22.0	63	2
5507	ND28993	6	34.1	92.5	69	79.5	2.8	1	13.2	5.30	41.6	181	67.4	260	245	1.55	12.3	58	13
5508	2ND28065	2	39.0	91.7	67	79.8	2.0	1	12.9	4.88	39.4	121	52.9	379	208	1.53	9.0	52	22
5509	2ND28131	2	45.2	97.5	63	82.5	3.8	2	11.9	4.39	40.1	106	62.5	449	208	1.56	50.0	55	16
5510	M152	6	36.4	95.2	73	79.9	3.2	1	12.8	5.68	45.3	180	61.2	242	258	1.51	18.8	63	2
5511	M155	6	33.9	87.1	56	80.1	2.8	1	13.9	5.64	42.3	172	71.5	242	269	1.50	8.2	58	13
5512	M156	6	33.5	95.2	69	80.3	2.7	1	13.2	5.43	44.3	194	69.8	293	245	1.52	14.4	63	2
5513	M157	6	36.1	92.9	77	80.1	2.6	1	13.1	5.85	46.7	165	67.7	362	262	1.58	9.1	59	12
5514	ND28554	6	39.6	98.0	67	79.5	3.0	1	14.1	6.03	43.1	149	66.4	397	266	1.55	15.5	46	31
5515	ND28555	6	37.9	97.7	70	80.2	3.0	1	13.6	5.98	45.2	156	65.6	395	263	1.57	15.3	54	17
5516	2ND27705	2	40.1	94.8	81	81.0	2.8	1	11.8	4.99	42.8	144	67.4	201	238	1.47	8.7	62	6
5517	2ND28071	2	42.0	97.4	66	80.6	2.7	2	12.7	4.56	37.4	151	58.0	367	196	1.53	25.0	53	19
5518	2ND29990	2	44.8	92.9	77	80.2	3.4	2	12.3	4.33	37.7	148	59.3	162	200	1.48	32.0	50	27
5519	6B10-4515	6	35.3	95.8	74	78.0	2.5	1	14.4	5.73	42.6	179	66.6	241	253	1.50	9.2	43	33
5520	6B10-4528	6	35.7	94.7	72	79.0	2.3	1	13.4	5.19	39.7	146	60.5	190	225	1.51	7.4	51	23
5521	6B10-4635	6	39.0	97.5	67	79.9	3.0	1	13.5	6.11	46.3	154	70.3	473	293	1.57	7.9	56	15
5522	6B10-4748	6	39.3	98.5	71	80.7	2.9	1	13.8	7.45	*56.5	169	64.8	291	281	1.52	14.3	46	31
5523	6B10-4905	6	34.3	91.0	82	80.8	3.0	2	12.4	5.25	44.5	172	59.0	365	235	1.57	20.0	62	6

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)		Turbid. (Hach)	Quality Score	Overall Rank
5524	6B10-4988	6	35.1	94.9	75	78.4	2.2	1	13.7	5.99	45.0	184	61.1	**383**	235	1.59	5.9	51	23
5525	SR451	6	34.8	93.8	82	81.9	2.7	1	12.4	**7.39**	*63.3	144	77.0	**201**	285	1.50	6.6	51	23
5526	SR452	6	34.2	94.2	75	81.6	2.7	1	12.9	**6.10**	**48.8**	166	74.5	167	285	1.51	8.3	54	17
5500	LACEY MALT CHECK		33.1	88.6	46	78.3	2.7	1	13.1	5.51	43.7	174	71.6	41	282	1.42	7.7	67	
5502	HARRINGTON MALT CHECK		39.9	96.3	71	81.2	2.1	1	11.7	4.48	40.2	131	75.8	135	213	1.52	6.3	51	
Minima			32.8	85.7	56	78.0	2.0		11.8	4.33	37.4	106	52.9	84	196				
Maxima			45.2	98.5	82	82.5	3.8		14.8	7.45	48.8	194	85.5	540	293				
Means			37.3	94.2	72	80.2	2.7		13.1	5.54	43.0	162	67.1	309	249				
Standard Deviations			3.5	3.3	6	0.9	0.4		0.8	0.69	2.8	22	7.4	106	26				
Coefficients of Variation			9.5	3.5	8	1.2	15.3		6.1	12.50	6.5	14	11.0	34	11				

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			26.7	84.2	55	77.4	1.5		10.7	3.46	34.7	96	45.0	-10	170				
Pos Std Dev			47.8	104.2	88	83.0	4.0		15.5	7.61	51.4	228	89.2	628	329				

2013 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)	Visc. Relative	Turbidity (Hach)	FAN (ppm)	Quality Score	Overall Rank
5399	MOREX	6	31.4	85.8	32	77.6	2.1	1	14.1	5.29	38.9	186	75.5	111	1.46	4.2	234	44	27
5400	ROBUST	6	33.7	92.2	34	78.3	1.9	1	14.1	5.26	38.8	176	60.6	212	1.46	3.8	230	45	23
5401	LEGACY	6	32.0	89.0	53	78.7	2.1	1	13.8	5.56	42.6	180	82.2	194	1.46	4.3	249	55	10
5402	LACEY	6	33.4	92.5	48	78.7	2.0	1	14.1	5.16	38.5	190	72.9	94	1.45	9.2	217	48	20
5403	TRADITION	6	34.1	93.7	49	78.1	3.2	2	13.9	4.91	35.8	208	71.5	170	1.52	40.0	209	42	30
5404	PINNACLE	2	44.4	97.0	41	80.2	1.9	1	11.9	4.28	36.5	107	52.8	412	1.54	5.6	175	43	29
5405	2ND25276	2	40.9	95.3	41	80.6	2.3	1	11.9	4.81	41.7	127	83.7	223	1.48	6.1	208	59	5
5406	M150	6	31.3	90.3	45	78.7	2.0	1	13.1	5.30	41.6	185	74.1	199	1.46	4.3	227	54	11
5407	ND25652	2	34.5	93.3	52	78.4	2.3	1	13.2	5.05	38.8	207	74.8	66	1.50	12.3	216	49	18
5408	SR440	2	32.7	88.8	44	80.1	2.6	1	13.0	5.79	45.3	176	94.4	48	1.44	5.2	277	51	13
5409	M151	6	32.6	88.9	46	78.4	2.4	1	14.2	5.64	40.8	170	79.2	179	1.45	5.9	258	45	23
5410	ND26891	6	33.6	90.6	50	78.4	2.8	2	13.4	4.98	38.7	174	67.8	141	1.51	30.0	198	51	13
5411	ND27177	6	34.0	93.3	46	78.7	2.5	1	13.7	5.22	39.3	210	73.7	90	1.51	16.0	228	57	8
5412	ND28993	6	35.5	97.4	40	79.0	2.6	1	13.1	5.35	43.6	184	72.7	64	1.50	13.9	227	70	1
5413	2ND28065	2	36.0	83.7	48	79.1	1.6	1	13.1	4.41	34.6	109	56.7	285	1.49	4.0	185	32	32
5414	2ND28131	2	43.6	97.0	42	81.3	2.8	2	11.7	4.57	39.7	105	69.7	325	1.49	28.0	194	54	11
5415	M152	6	33.7	92.2	48	79.0	2.7	1	13.2	5.49	44.3	171	67.5	102	1.45	13.4	246	70	1
5416	M155	6	32.9	88.5	*24	78.9	2.1	1	14.1	5.50	40.9	177	79.7	125	1.46	5.2	251	48	20
5417	M156	6	30.8	91.3	43	78.5	2.3	1	12.9	5.23	41.3	200	82.1	136	1.45	6.7	226	57	8
5418	M157	6	33.2	90.2	46	78.9	2.5	1	13.6	5.71	44.0	149	71.4	269	1.54	9.7	262	51	13
5419	ND28554	6	36.7	95.8	47	79.4	2.9	2	12.8	5.14	41.0	170	68.6	113	1.50	25.0	220	60	3
5420	ND28555	6	35.2	95.0	48	78.3	2.8	2	13.5	5.11	38.6	171	69.7	173	1.52	25.0	214	45	23
5421	2ND27705	2	38.9	91.3	60	79.3	2.2	1	12.2	4.61	39.3	137	77.7	172	1.47	4.8	203	49	18
5422	2ND28071	2	41.5	97.9	36	80.1	3.1	2	12.2	4.53	37.6	111	46.5	*545	1.53	29.0	188	45	23
5423	2ND29990	2	41.2	94.1	55	80.1	3.3	2	12.2	4.04	35.2	134	65.5	286	1.53	40.0	169	44	27
5424	6B10-4515	6	32.9	94.1	43	77.6	2.2	1	13.6	4.87	36.9	183	72.2	84	1.47	9.9	210	46	22
5425	6B10-4528	6	33.2	92.2	46	78.2	1.9	1	12.8	4.46	36.7	147	67.8	79	1.47	4.8	193	50	16
5426	6B10-4635	6	34.3	89.1	46	78.0	2.3	1	13.5	5.44	41.5	195	82.4	117	1.49	4.8	267	59	5
5427	6B10-4748	6	36.0	96.9	46	78.9	2.1	1	13.4	5.26	41.5	174	67.8	155	1.48	7.7	232	58	7
5429	6B10-4905	6	31.8	83.7	54	77.6	3.0	2	13.6	4.71	34.8	179	59.7	347	1.53	31.0	192	32	32

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)	Visc. Relative	Turbidity (Hach)	FAN (ppm)	Quality Score	Overall Rank
5430	6B10-4988	6	34.0	94.8	45	**77.2**	2.1	1	**14.3**	4.98	**35.7**	182	71.9	**197**	1.52	4.8	211	34	31
5431	SR451	6	33.0	89.4	46	78.9	2.8	1	13.5	5.63	42.5	171	80.7	**250**	1.49	13.3	265	60	3
5432	SR452	6	31.3	89.9	47	**75.7**	2.7	1	13.8	5.91	43.2	168	86.1	40	1.45	8.0	277	50	16
5428	LACEY MALT CHECK	6	32.5	89.7	45	79.3	2.5	1	13.0	5.79	45.7	185	85.4	36	1.43	5.3	276	66	
Minima			30.8	83.7	32	75.7	1.6		11.7	4.04	34.6	105	46.5	40	1.44	3.8	169		
Maxima			44.4	97.9	60	81.3	3.3		14.3	5.91	45.3	210	94.4	412	1.54	40.0	277		
Means			35.0	92.0	46	78.8	2.4		13.3	5.10	39.7	167	72.1	171	1.49	13.2	223		
Standard Deviations			3.6	3.7	6	1.1	0.4		0.7	0.46	2.9	30	9.8	92	0.03	11.1	29		
Coefficients of Variation			10.3	4.0	13	1.4	17.3		5.5	9.05	7.4	18	13.6	54	2.05	83.7	13		
Neg Std Dev			24.2	80.8	29	75.6	1.2		11.1	3.71	30.9	78	42.7	-106	1.40	-20.0	136		
Pos Std Dev			45.8	103.1	63	81.9	3.7		15.4	6.48	48.5	256	101.5	447	1.58	46.4	310		

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 Kevin Smith, U. of MN

13 MVBN -- Morris, MN
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)	Visc. Relative	Hach Turbidity (NTU)	FAN (ppm)	Quality Score	Overall Rank
5433	MOREX	6	32.9	91.2	59	78.6	2.8	1	11.7	5.32	48.1	156	75.5	71	1.46	12.2	256	62	9
5434	ROBUST	6	34.6	95.5	58	78.8	2.5	1	12.5	5.61	47.1	174	64.2	79	1.44	5.9	261	62	9
5435	LEGACY	6	33.1	94.2	68	79.5	2.9	1	12.0	5.80	50.5	167	79.4	109	1.44	6.5	250	61	12
5436	LACEY	6	35.4	95.4	61	78.8	3.1	2	11.7	5.26	46.9	161	68.5	39	1.43	17.6	221	66	3
5437	TRADITION	6	34.3	97.2	57	78.8	3.0	1	12.9	5.51	45.6	213	80.6	57	1.48	11.1	241	67	2
5438	PINNACLE	2	43.2	97.2	61	80.1	3.5	2	11.0	5.05	45.8	101	63.6	171	1.54	22.0	208	51	24
5439	2ND25276	2	41.2	96.0	55	80.3	3.8	2	10.5	5.28	52.6	110	76.0	262	1.57	26.0	227	45	30
5440	M150	6	32.3	91.3	51	79.1	2.8	1	12.1	5.36	45.3	176	75.3	66	1.45	9.2	226	70	1
5441	ND25652	2	35.0	97.0	65	78.5	3.4	2	13.0	6.02	48.0	191	78.3	104	1.52	17.6	262	42	32
5442	SR440	2	33.3	93.8	54	80.1	3.7	1	11.3	5.91	*55.2	151	91.3	72	1.53	14.6	280	53	23
5443	M151	6	32.9	92.6	66	80.4	3.1	1	11.2	5.18	46.9	141	73.8	89	1.44	10.8	233	61	12
5444	ND26891	6	34.8	96.3	62	77.9	3.6	2	12.6	6.08	50.0	164	67.7	96	1.49	16.9	255	51	24
5445	ND27177	6	34.7	96.6	66	78.5	3.4	1	12.9	6.08	47.6	195	77.9	78	1.49	11.2	267	55	20
5446	ND28993	6	33.0	93.6	62	77.3	n.d.	3	11.3	5.60	51.8	93	58.9	328	1.60	26.0	273	34	33
5447	2ND28065	2	39.6	95.7	61	80.6	2.8	1	11.3	5.38	49.8	97	60.2	193	1.54	13.9	222	45	30
5448	2ND28131	2	42.5	96.7	62	80.4	n.d.	3	11.1	5.11	46.9	86	69.6	223	1.59	32.0	214	51	24
5449	M152	6	34.0	93.0	65	79.2	3.5	2	11.3	5.15	48.6	151	64.9	49	1.43	22.0	231	55	20
5450	M155	6	32.5	88.8	*37	79.4	3.1	1	12.0	5.69	48.4	164	78.3	78	1.50	13.1	250	65	6
5451	M156	6	33.2	95.6	67	78.7	3.3	2	12.0	5.54	46.8	179	73.7	69	1.44	18.8	232	66	3
5452	M157	6	35.4	93.4	67	80.2	2.8	1	11.5	5.58	50.5	149	73.3	108	1.46	9.1	245	65	6
5453	ND28554	6	35.3	96.2	61	79.0	3.0	1	11.4	5.17	47.1	152	74.1	70	1.48	11.5	254	56	18
5454	ND28555	6	35.0	95.6	62	79.0	2.9	1	11.5	5.20	48.4	143	75.2	69	1.46	8.5	251	56	18
5455	2ND27705	2	38.9	91.6	64	79.6	3.5	1	11.0	5.28	49.2	131	83.8	53	1.49	14.4	254	59	15
5456	2ND28071	2	40.7	98.2	59	79.0	3.8	2	11.2	4.98	46.1	125	67.3	207	1.53	23.0	240	55	20
5457	2ND29990	2	44.5	97.3	62	79.9	n.d.	3	10.2	4.50	45.3	105	62.0	208	1.56	35.0	203	50	28
5458	6B10-4515	6	34.5	96.2	57	77.8	3.8	2	11.8	5.05	45.4	148	74.0	74	1.59	29.0	246	59	15
5459	6B10-4528	6	34.6	96.6	56	79.1	3.2	2	11.0	4.98	46.7	125	74.9	73	1.52	16.2	249	57	17
5461	6B10-4635	6	37.2	96.1	51	79.3	3.7	2	11.3	5.29	48.1	121	75.1	296	1.60	19.1	288	49	29
5462	6B10-4748	6	35.8	96.6	57	79.5	3.3	1	12.3	5.41	47.1	160	71.4	51	1.49	13.7	264	65	6
5463	6B10-4905	6	35.3	96.9	61	79.5	3.1	1	11.6	5.19	46.1	158	64.3	144	1.46	10.5	245	62	9

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)	Visc. Relative	Hach Turbidity (NTU)	FAN (ppm)	Quality Score	Overall Rank
5464	6B10-4988	6	36.0	98.2	62	78.4	**3.0**	1	12.3	5.55	45.9	155	64.4	**303**	1.53	10.6	277	60	14
5465	SR451	6	35.5	96.3	66	78.9	**3.2**	1	12.7	**6.05**	**48.8**	163	82.2	150	1.44	7.0	300	51	24
5466	SR452	6	36.1	97.4	67	80.2	**3.2**	1	12.9	5.87	46.6	158	80.9	100	1.45	7.0	313	66	3
5460	HARRINGTON MALT CHECK	2	40.1	96.8	72	82.2	2.1	1	11.3	4.79	43.5	135	94.3	47	1.47	4.3	228	69	
Minima			32.3	88.8	51	77.3	2.5		10.2	4.50	45.3	86	58.9	39	1.43	5.9	203		
Maxima			44.5	98.2	68	80.6	3.8		13.0	6.08	52.6	213	91.3	328	1.60	35.0	313		
Means			36.0	95.3	61	79.2	3.2		11.7	5.43	47.8	147	72.7	126	1.50	15.8	250		
Standard Deviations			3.2	2.2	5	0.8	0.4		0.7	0.37	1.9	30	7.4	82	0.05	7.6	25		
Coefficients of Variation			9.0	2.4	8	1.0	11.1		6.1	6.84	4.0	21	10.2	65	3.51	47.7	10		

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 Kevin Smith, U. of MN

Neg Std Dev		26.2	88.5	47	76.8	2.2		9.6	4.31	42.1	56	50.4	-120	1.34	-6.8	174		
Pos Std Dev		45.7	102.0	75	81.6	4.3		13.9	6.54	53.4	238	95.1	371	1.66	38.5	325		

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.

American Malting Barley Association, Inc.

MALTING BARLEY BREEDING GUIDELINES
IDEAL COMMERCIAL MALT CRITERIA

	Six-Row	Adjunct Two-Row	All Malt Two-Row
Barley Factors			
Plump Kernels (on 6/64)	> 80%	> 90%	> 90%
Thin Kernels (thru 5/64)	< 3%	< 3%	< 3%
Germination (4ml 72 hr. GE)	> 98%	> 98%	> 98%
Protein	≤ 13.0%	≤ 13.0%	≤ 12.0%
Skinned & Broken Kernels	< 5%	< 5%	< 5%
Malt Factors			
Total Protein	≤ 12.8%	≤ 12.8%	≤ 11.8%
on 7/64 screen	> 60%	> 70%	> 75%
Measures of Malt Modification			
Beta-Glucan (ppm)	< 120	< 100	< 100
F/C Difference	< 1.2	< 1.2	< 1.2
Soluble/Total Protein*	42-47%	40-47%	38-45%
Turbidity (NTU)	< 10	< 10	< 10
Viscosity (absolute cp)	< 1.50	< 1.50	< 1.50
Congress Wort			
Soluble Protein*****	5.2-5.7%	4.8-5.6%	< 5.3%
Extract (FG db)	> 79.0%	> 81.0%	> 81.0%
Color (°ASBC)	1.8-2.5	1.6-2.5	1.6-2.8
FAN	> 210	> 210	140-190
Malt Enzymes			
Diastatic Power (°ASBC)*****	> 150	> 120	110-150
Alpha Amylase (DU)*****	> 50	> 50	40-70

General Comments

Barley should mature rapidly, break dormancy quickly without pregermination and germinate uniformly.

The hull should be thin, bright and adhere tightly during harvesting, cleaning and malting.

Malted barley should exhibit a well-balanced, modification in a conventional malting schedule with four day germination.

Malted barley must provide desired beer flavor.

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