

UNITED STATES DEPARTMENT OF AGRICULTURE
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MIDWEST AREA
CEREAL CROPS RESEARCH UNIT

**MISSISSIPPI VALLEY REGIONAL SPRING BARLEY NURSERY
2014 Crop**

Preliminary Quality Report

C. H. Martens and *Staff

Detailed Data:

Aberdeen, ID
Crookston, MN
Morris, MN
Osnabrock, 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.

This report includes data furnished by the Agricultural Research Service and by the State Agricultural Experiment Stations. The report is not intended for publication and should not be referred to in literature citations nor quoted in publicity or advertising. Use of the data may be granted for certain purposes upon written request to the agency or agencies involved.

Samples were malted and analyzed by the Cereal Crops Research Unit,
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Malting Quality of the Mississippi Valley Uniform Regional Barley Nursery – 2014 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.larri.ars.usda.gov/research/publications/publications.htm?seq_no_115=303358. In this report, the malting quality of 2014 MVBN lines received from Aberdeen, Idaho, Crookston, Minnesota, Morris, Minnesota, and Osnabrock, 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 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 9.4 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 6. These statistics allowed evaluation of data from individual locations and overall performance of each line.

The Aberdeen, Idaho barley submissions (Table 3) produced malts that were notable for having significantly lower Barley Protein, Soluble Protein, and FAN than the other locations. Their average Kernel Weight was intermediate and not significantly different than Crookston, MN ($p < 0.05$), but higher than Morris and lower than Osnabrock. Even with the low protein averages, their Malt Extract average was third lowest – only higher than that of Morris, MN ($p < 0.05$). Also of note, their average β -Glucan content was significantly lower than the other locations, except Osnabrock ($p < 0.05$).

Those MVBN barleys submitted from Crookston, MN (Table 4) yielded intermediate protein measures – the second highest Barley Protein and Soluble Protein averages. They had the second highest Malt Extract average, only significantly lower ($p < 0.05$) than the Osnabrock average. Their β -Glucan average was higher than that of any other location ($p < 0.05$). The other negatives for barleys from this location were the high Viscosity and Turbidity averages.

Morris, MN (Table 5) produced malts that were unique in showing the lowest average Kernel Weight, % Plump, and Malt Extract averages ($p < 0.05$). That Malt Extract average was not helped by their highest Barley Protein average ($p < 0.05$). However, this latter fact likely bolstered their amylolytic averages: highest average Diastatic Power and α -Amylase ($p < 0.05$). The malts from these barleys tied for lowest average Viscosity (with Osnabrock, ND) at 1.48, and showed the lowest average Turbidity ($p < 0.05$). Other averages from this location were unremarkable with intermediate β -Glucan and FAN averages.

Finally, the Osnabrock MVBN location (Table 6) yielded barleys with the highest Plumpness average ($p < 0.05$) and their subsequent malts showed the highest Malt Extract average of any location ($p < 0.05$). Interestingly their Wort Color average was highest ($p < 0.05$). This is atypical for this location, but may have been affected by pre-harvest growth conditions. Though these barleys' protein average was intermediate, they had the highest S/T average ($p < 0.05$). Other low averages from this location were α -Amylase ($p < 0.05$), and β -Glucan (not significantly different than that of Aberdeen, ID ($p < 0.05$)). Their malts tied for the highest average FAN ($p < 0.05$). Although they showed the lowest average Viscosity (tied with Morris), they yielded relatively high Turbidity, on average, 11.3 NTU.

The top performing barleys across locations in the 2014 MVBN were 2ND25276, Pinnacle, SR460, ND28555, and 2ND30837. 2ND25276 showed excellent Malt Extract % -- tied with Pinnacle for highest in the MVBN ($p < 0.05$). The Pinnacle malt's excellent Malt Extract % was complemented by a very high average Kernel Weight -- highest in the MVBN ($p < 0.05$) -- and Plumpness; its other parameters were unremarkable, but mostly hit desirable specifications. SR460 was notable for a good Malt Extract % average and a very high FAN average. ND28555 exhibited a very high Diastatic Power average. 2ND30837 had the highest average Malt Extract % in the MVBN, and a high Plumpness average. This malt also presented a decent amylolytic enzyme profile, for a 2-rowed barley, and a relatively low β -Glucan average. However its average Turbidity of 33.5NTU was the highest observed in the 2014 MVBN.

Conversely, the varieties and selections showing the relative lowest malting quality average scores in the MVBN were 6B10-4748, 2ND30639, Conrad, and ND29196. That said the averages for these malting barleys were not terrible. A high β -Glucan average was the main detriment for 6B10-4748. 2ND30639 showed relatively high β -Glucan and low S/T averages, albeit with a low Viscosity average of 1.45. The Conrad malts had high Soluble Protein and Kolbach Index averages, but a relatively low β -Glucan average. Their Turbidity average of 14.6 NTU would be rated "slightly hazy" range per visual inspection. ND29196 had a high Barley Protein average, which, on the positive side, supported high Diastatic Power and α -Amylase averages, but likely contributed to a relatively low Malt Extract % average of 79.1%.

The individual quality parameters for the MVBN barleys showed robust distributions among the varieties and selections. Pinnacle and 2ND30724 tied for the highest average Kernel Weight average; Morex had the lowest average for this factor (34.7mg). SR458

yielded the highest Plumpness average of 98.7%. With respect to Barley Color, Legacy's average of 49.8 was highest ($p < 0.05$), while 2ND25276 had the lowest average of 33.3 ($p < 0.05$). 2ND30837 was outstanding with a Malt Extract % average of 82.2%, highest in the MVBN ($p < 0.05$). The malts for 2B05-0811 attained the highest Wort Color average (7.2). Pinnacle and 2ND25276 tied for lowest average Barley Protein at 11.4%; ND29196 had the highest average of 13.9%. With respect to the protein modification measures, M159 had the highest Soluble Protein average (6.49%) and 2ND30724 was lowest at 4.68%. This was mirrored by S/T index, with M159 at 52.6 (highest) and 2ND30724 at 37.1 (lowest). For the FAN parameter, M161 displaced M159 for the highest average at 326 ($p < 0.05$), while 2ND28065 had the lowest average. Not surprisingly, the Tradition malts yielded the top Diastatic Power average of 198, and 2ND28065 was lowest at 106. α -Amylase differed with 2B09-3425 having the highest average of 91.4. The 2ND30724 malts showed the lowest average: 56.1DU. The lowest and highest barley malts for average β -Glucan content were 2B09-3425 and M158, respectively. ND27177 had the highest average Viscosity (1.53) and 2ND30639 was lowest on this factor, with an average of 1.45.

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MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2014 Crop

Table 1 - 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	39.3a	97.9b	42.5a	80.3c	2.7b	12.0c	5.00c	43.3b	140b	68.9b	163c	211c	1.50b	9.5ab	57.3a
Crookston, MN	39.1a	97.3b	41.7a	80.8b	2.9b	12.9b	5.25b	42.6b	141b	69.1b	314a	283a	1.53a	14.0a	54.9a
Morris, MN	38.2b	94.4c	41.9a	79.5d	2.7b	13.4a	5.33b	41.5b	173a	81.3a	200b	258b	1.48c	7.3b	53.1a
Osnabrock, ND	39.7a	99.0a	39.3b	81.2a	4.7a	12.6b	6.17a	51.0a	132b	58.4c	129c	292a	1.48c	11.3ab	53.5a

* 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, ND26891, ND27177, ND27177, 2ND28065, M156, M157, ND28554, ND28555, 2ND27705, M158, N159, M160, M161, ND29196, ND29380, 2ND30639, 2ND28071, 2ND30724, 2ND30837, 6B10-4748, Conrad, 2B05-0811, 2B09-3425, SR458, SR459, SR460

MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2014 Crop

Table 2 - 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
MOREX	34.7 k	94.4 f	40.5 cdef	79.1 m	3.4 bc	13.6 ab	5.38 defghij	41.0 hij	161 bcdef	64.0 defg	185 bcdef	272 defghi	1.50 abcdefgh	8.6 c	50.0 a
ROBUST	37.0 ghijk	97.1 abcde	41.0 cdef	79.2 klm	2.2 c	13.8 ab	5.46 cdefgh	41.0 ghij	179 abc	57.9 f	274 b	266 efghij	1.49 defghij	4.6 c	51.5 a
LEGACY	35.2 jk	96.0 abcdef	49.8 a	79.8 ijklm	2.6 c	13.0 abcde	5.76 bcdef	46.8 bcdefgh	156 bcdefg	75.5 bcd	267 bc	292 abcdefg	1.51 abcdef	11.9 bc	56.5 a
LACEY	37.5 ghij	98.0 abc	40.0 cdefg	79.9 jklm	2.4 c	13.1 abcde	5.45 cdefgh	44.0 cdefghi	170 abcd	69.7 bcdefg	141 defg	249 hijkl	1.46 hij	8.6 c	53.3 a
TRADITION	35.8 ijk	97.0 abcdef	42.8 abcde	79.4 jklm	2.5 c	13.5 abc	5.29 defghij	42.0 fghij	198 a	77.2 bcd	184 bcdef	258 fghijk	1.50 abcdefgh	8.4 c	57.3 a
PINNACLE	46.4 a	98.2 abc	37.3 efg	81.9 abc	2.4 c	11.4 g	4.78 hij	43.9 cdefghi	111 ij	63.1 defg	196 bcdef	220 kl	1.52 abcd	8.1 c	59.3 a
2ND25276	43.8 bc	98.4 ab	33.3 g	81.9 abc	3.0 c	11.4 g	4.95 ghij	45.4 bcdefghi	118 hij	81.1 ab	148 cdefg	231 jkl	1.48 efghij	10.5 bc	59.5 a
ND26891	37.1 ghijk	97.5 abcd	38.0 defg	80.2 hijkl	2.8 c	12.4 cdefg	5.31 defghij	44.8 cdefghi	136 efghij	70.4 bcdefg	226 bcde	236 ijkl	1.52 abc	16.4 bc	54.5 a
ND27177	37.9 ghi	98.1 abc	44.0 abcde	80.2 hijkl	3.0 c	12.6 bcdef	5.35 defghij	44.6 cdefghi	183 abc	71.2 bcdefg	160 bcdefg	255 ghijk	1.53 a	15.7 bc	56.8 a
2ND28065	40.8 def	95.9 bcdef	37.8 efg	81.3 abcde	2.4 c	12.1 defg	4.72 ij	40.6 ij	106 j	59.4 efg	199 bcdef	215 l	1.51 abcdef	8.1 c	56.3 a
M156	35.8 ijk	97.5 abcd	37.8 efg	80.1 ghijkl	2.6 c	13.1 abcde	5.45 cdefgh	44.3 cdefghi	170 abcd	69.0 bcdefg	238 bcd	248 hijkl	1.48 defghij	9.1 bc	57.8 a
M157	36.5 hijk	95.5 cdef	42.8 abcde	80.3 fghijk	4.3 abc	13.1 abcde	5.74 bcdef	46.0 bcdefghi	139 defghij	65.2 cdefg	274 b	288 bcdefg	1.52 ab	10.9 bc	53.8 a
ND28554	38.7 fgh	98.0 abc	42.8 abcde	79.9 ijklm	2.6 c	12.8 abcde	5.25 defghij	42.8 efghi	156 bcdefg	65.6 cdefg	227 bcde	242 ijkl	1.52 ab	18.9 bc	54.5 a
ND28555	39.2 efg	98.2 abc	43.3 abcde	79.9 hijklm	2.8 a	12.9 abcde	5.40 defghi	43.7 defghi	164 bcde	67.4 bcdefg	206 bcdef	249 hijkl	1.51 abcde	10.0 bc	58.8 a
2ND27705	40.8 def	98.0 abc	42.5 bcde	81.8 abcd	3.4 bc	11.5 fg	4.89 hij	44.1 cdefghi	125 ghij	70.3 bcdefg	114 efg	232 jkl	1.46 hij	6.3 c	55.8 a
M158	35.3 ijk	91.8 g	43.7 abcde	79.9 hijklm	2.4 c	13.0 abcde	5.13 fghij	41.9 fghij	142 defghi	66.6 bcdefg	425 a	233 jkl	1.52 abcde	11.7 bc	51.7 a
M159	35.5 ijk	96.7 abcdef	45.0 abcd	80.6 efghi	6.3 ab	13.0 abcde	6.49 a	52.6 a	145 defgh	68.7 bcdefg	253 bcd	322 abc	1.50 abcdef	6.2 c	57.7 a
M160	35.4 ijk	94.4 ef	42.7 bcde	80.0 hijklm	2.9 c	13.0 abcde	5.40 defghi	43.3 defghi	136 efghij	64.2 defg	185 bcdef	262 fghij	1.47 fghij	13.4 bc	53.0 a
M161	36.6 hijk	98.3 ab	45.3 abc	80.4 efghij	5.0 abc	13.1 abcde	6.42 ab	50.8 ab	167 abcde	70.1 bcdefg	211 bcdef	326 a	1.47 fghij	7.0 c	53.7 a
ND29196	35.3 ijk	96.3 abcdef	49.0 ab	79.1 lm	2.7 c	13.9 a	5.86 abcde	44.8 cdefghi	188 ab	73.5 bcde	202 bcdef	286 cdefgh	1.50 abcdefg	6.5 c	49.7 a
ND29380	36.5 hijk	97.5 abcd	41.0 cdef	80.9 defghi	3.4 bc	12.0 efg	5.20 efghij	45.9 bcdefghi	120 hij	65.2 cdefg	258 bcd	265 efghij	1.52 ab	23.9 ab	53.3 a
2ND30639	45.2 ab	98.6 ab	35.3 fg	79.8 ijklm	2.3 c	13.9 a	5.33 defghij	40.2 ij	126 ghij	62.9 defg	236 bcd	262 fghij	1.453 j	3.8 c	47.7 a
2ND30724	46.5 a	98.1 abc	41.0 cdef	80.5 efghij	2.6 c	12.8 abcde	4.68 j	37.1 j	122 hij	56.1 g	209 bcdef	229 jkl	1.49 bcdefghi	9.0 bc	53.3 a
2ND30837	45.9 ab	97.8 abc	34.0 fg	82.2 a	4.5 abc	12.7 bcdef	5.61 cdefg	46.8 bcdefg	128 ghij	64.9 cdefg	153 cdefg	291 abcdefg	1.50 abcdefgh	33.5 a	58.3 a
6B10-4748	40.5 def	97.6 abcd	37.0 efg	79.3 klm	3.4 bc	13.2 abcde	5.36 defghij	43.3 defghi	155 cdefg	68.3 bcdefg	256 bcd	296 abcdef	1.51 abcde	9.1 bc	47.0 a
Conrad	41.3 de	96.7 abcdef	38.0 defg	80.9 cdefgh	3.3 bc	13.3 abcd	6.11 abc	47.4 abcdef	129 fghij	77.4 bcd	106 fg	306 abcd	1.46 ij	14.6 bc	47.7 a
2B05-0811	42.0 cd	97.6 abcd	40.7 cdef	82.1 ab	7.2 a	13.2 abcd	6.40 ab	49.6 abc	111 ij	80.9 ab	165 bcdef	322 abc	1.48 efghij	6.5 c	52.3 a
2B09-3425	40.4 def	95.0 def	46.0 abc	81.2 abcdef	4.4 abc	12.6 bcdef	5.93 abcd	48.7 abcd	146 defgh	91.4 a	51 g	291 abcdefg	1.47 ghij	8.0 c	56.7 a
SR458	41.0 def	98.7 a	39.3 cdefg	81.7 abcd	3.9 bc	13.0 abcde	6.32 ab	50.5 ab	184 abc	79.8 abc	230 bcde	318 abc	1.52 abcde	7.9 c	53.0 a
SR459	40.4 def	98.3 abc	43.7 abcde	80.8 defghi	5.0 abc	13.4 abcd	6.30 ab	48.7 abcd	156 bcdefg	73.0 bcdef	219 bcdef	325 ab	1.51 abcde	7.4 c	51.3 a
SR460	37.5 ghij	96.7 abcdef	45.0 abcd	81.1 bcdefg	4.4 abc	12.6 bcdef	5.78 bcdef	48.0 abcde	138 defghij	70.1 bcdefg	216 bcdef	301 abcde	1.51 abcde	8.1 c	59.0 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; Crookston, MN; Morris, MN; Osabrock, ND

2014 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
5452	Morex	6	37.1	97.3	45	79.5	2.1	1	12.6	4.82	39.5	155	64.1	159	202	1.50	6.7	57	17
5454	Robust	6	38.5	98.1	47	79.2	1.7	1	13.4	4.73	37.0	156	60.9	272	193	1.50	4.0	49	26
5456	Legacy	6	36.4	97.8	53	79.6	2.7	1	12.6	5.16	42.4	155	69.0	267	227	1.50	6.9	59	15
5457	Lacey	6	37.8	97.7	40	80.6	2.3	1	10.9	4.97	47.3	143	65.9	83	210	1.45	5.8	56	18
5458	Tradition	6	37.2	98.5	46	80.4	2.5	1	12.0	4.93	43.9	172	78.6	106	211	1.49	11.5	66	4
5459	Pinnacle	2	47.6	98.5	42	82.0	2.3	1	11.6	4.74	44.8	110	59.3	149	189	1.49	8.4	61	12
5460	2ND25276	2	44.9	98.6	30	81.7	2.7	1	10.9	4.68	46.3	110	80.1	99	188	1.48	11.7	60	13
5461	ND26891	6	38.2	98.2	39	80.4	2.5	1	11.1	5.01	46.0	106	74.3	141	199	1.51	13.4	48	28
5462	ND27177	6	39.2	98.1	39	80.8	3.0	1	11.0	4.84	46.4	137	75.0	300	208	1.56	15.1	51	25
5463	2ND28065	2	40.6	93.5	45	80.4	2.3	1	12.8	4.78	39.8	111	61.1	134	195	1.46	5.9	54	21
5464	M156	6	37.6	98.1	27	80.0	2.3	1	13.0	5.46	44.2	163	76.2	124	226	1.46	6.1	66	4
5465	M157	6	37.8	97.1	42	80.7	4.1	2	12.6	5.46	43.7	141	58.6	171	244	1.55	20.0	62	10
5466	ND28554	6	40.0	99.0	50	79.9	2.6	1	12.5	5.16	42.3	165	68.6	124	207	1.50	12.4	62	10
5467	ND28555	6	40.3	98.7	49	80.5	3.0	1	12.3	5.30	43.9	151	70.4	116	214	1.50	6.1	70	1
5468	2ND27705	2	36.8	98.2	47	81.2	3.7	1	12.1	4.58	39.5	135	68.6	147	186	1.46	9.0	54	21
5469	M158	6	36.4	94.9	49	80.7	2.7	1	12.0	5.28	45.5	133	72.7	267	257	1.50	5.0	60	13
5470	M159	6	35.8	97.7	44	80.2	4.3	1	12.5	5.76	46.1	156	69.2	194	301	1.52	12.8	59	15
5471	M160	6	35.8	94.3	51	80.0	2.7	1	12.8	5.31	44.4	163	79.6	84	269	1.44	4.3	70	1
5472	M161	6	36.6	97.3	47	79.8	4.4	1	12.7	5.48	43.8	172	65.0	155	282	1.51	12.6	66	4
5473	ND29196	6	34.8	97.1	54	79.8	3.0	1	12.6	5.54	47.4	161	81.7	112	276	1.47	5.1	65	8
5474	ND29380	6	37.4	98.7	57	80.5	3.6	2	11.3	4.94	46.3	108	71.3	144	246	1.50	18.4	49	26
5475	2ND30639	2	44.3	97.0	51	79.3	2.7	1	13.7	5.40	42.0	145	68.1	203	263	1.45	5.3	47	29
5476	2ND30724	2	47.4	98.2	37	79.7	3.0	2	12.4	4.48	38.7	135	60.0	194	213	1.51	10.8	54	21
5477	2ND30837	2	45.1	96.8	49	80.4	n.d.	3	13.0	5.14	42.6	143	63.2	212	252	1.49	43.0	53	24
5478	6B10-4748	6	39.2	98.5	39	*77.3	3.6	1	11.2	4.87	45.0	132	71.8	215	273	1.50	9.2	41	31
5479	Conrad	2	41.3	95.8	45	79.8	4.3	1	12.8	5.57	43.5	149	78.4	77	268	1.46	10.7	66	4
5480	2B05-0811	2	41.1	96.5	38	82.1	4.3	1	12.2	5.28	46.5	127	77.6	108	277	1.47	9.0	65	8
5481	2B09-3425	2	42.7	96.8	47	79.8	4.0	1	12.8	5.09	42.9	152	73.3	84	249	1.48	13.2	67	3
5482	SR458	6	40.2	98.8	52	81.6	4.1	1	11.4	5.37	48.6	149	75.6	169	290	1.53	13.8	56	18
5483	SR459	6	37.5	95.5	43	80.8	4.7	1	12.6	5.73	46.0	137	71.1	223	303	1.52	11.1	56	18

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. Viscosity	Turbidity (Hach)	Quality Score	Overall Rank
5484	SR460	6	37.8	98.1	50	81.4	4.0	1	11.1	4.80	45.5	108	69.1	168	258	1.52	16.4	47	29
5453	HARRINGTON MALT CHECK*	2	40.1	95.8	73	82.6	1.9	1	11.4	4.67	42.9	115	85.5	142	194	1.55	4.5	62	
5455	LACEY MALT CHECK	6	32.6	89.1	44	80.2	2.4	1	12.9	5.74	44.8	167	74.5	58	244	1.44	4.5	66	
Minima			34.8	93.5	27	79.2	1.7		10.9	4.48	37.0	106	58.6	77	186				
Maxima			47.6	99.0	57	82.1	4.7		13.7	5.76	48.6	172	81.7	300	303				
Means			39.5	97.4	45	80.4	3.2		12.2	5.12	43.9	141	70.3	161	238				
Standard Deviations			3.4	1.4	7	0.8	0.8		0.8	0.34	2.8	20	6.6	61	36				
Coefficients of Variation			8.7	1.4	15	1.0	26.2		6.4	6.70	6.3	14	9.4	38	15				

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	29.2	93.3	25	78.1	0.7		9.9	4.09	35.6	82	50.4	-21	129
Pos Std Dev	49.7	101.5	65	82.8	5.7		14.6	6.15	52.3	201	90.1	344	347

2014 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
5524	MOREX	6	33.3	*91.0	39	78.4	2.3	1	13.9	5.10	37.8	137	62.6	311	275	1.53	8.2	43	30
5525	ROBUST	6	36.9	96.7	44	79.5	2.2	1	13.4	5.30	41.1	153	51.1	297	286	1.50	4.7	58	10
5526	LEGACY	6	35.5	95.7	49	80.1	2.2	1	12.6	5.24	43.4	146	72.0	406	277	1.53	4.3	63	2
5527	LACEY	6	38.3	98.4	41	79.9	2.6	1	14.2	5.36	39.8	162	60.3	249	285	1.49	13.1	48	27
5528	TRADITION	6	35.5	97.3	43	79.1	2.4	1	14.9	5.28	37.5	193	63.4	405	282	1.55	9.4	48	27
5529	PINNACLE	2	46.9	98.3	35	82.1	2.4	1	11.2	4.55	41.3	97	54.6	284	218	1.59	8.8	56	13
5530	2ND25276	2	44.1	99.2	34	82.4	2.7	1	11.5	4.95	46.2	109	79.1	239	255	1.51	6.4	60	8
5531	ND26891	6	37.2	98.2	40	80.4	3.0	2	12.9	5.32	42.9	146	61.8	310	264	1.55	24.0	62	5
5532	ND27177	6	37.3	98.2	50	80.6	3.0	2	12.5	4.91	41.8	188	65.5	138	265	1.53	27.0	56	13
5533	2ND28065	2	40.8	97.7	32	82.3	2.0	1	11.4	4.50	40.3	84	53.5	397	234	1.55	5.3	55	15
5534	M156	6	35.5	98.2	41	80.3	2.8	2	13.7	5.27	40.7	176	63.9	384	271	1.53	16.5	52	20
5535	M157	6	36.5	97.6	40	80.5	2.6	1	13.8	5.50	42.1	154	68.0	504	310	1.57	7.4	58	10
5536	ND28554	6	39.0	98.5	41	80.2	n.d.	3	12.3	5.05	42.6	135	62.4	367	254	1.59	41.0	54	16
5537	ND28555	6	39.6	97.9	44	80.4	2.9	2	12.9	5.40	42.8	159	61.4	360	273	1.57	19.5	62	5
5538	2ND27705	2	41.5	98.5	40	82.2	2.6	1	11.2	4.80	44.4	118	78.5	120	253	1.47	4.5	62	5
5539	M158	6	36.0	*92.3	45	79.8	3.0	2	12.8	4.85	39.0	124	60.9	519	229	1.57	25.0	50	25
5540	M159	6	35.8	97.6	45	80.7	2.6	1	13.1	5.64	44.6	151	76.2	486	292	1.58	6.2	63	2
5541	M160	6	36.2	*95.4	44	80.0	3.4	2	12.6	4.94	40.7	127	64.2	276	249	1.50	26.0	50	25
5542	M161	6	37.4	98.7	45	80.8	3.5	1	13.2	6.11	48.5	191	80.9	334	330	1.50	4.4	51	22
5543	ND29196	6	35.6	98.3	51	80.0	2.7	1	13.6	5.72	45.3	181	75.2	230	304	1.53	7.0	54	16
5544	ND29380	6	37.2	98.5	38	81.2	3.7	2	11.7	4.94	43.8	109	62.8	407	268	1.58	35.0	51	22
5545	2ND30639	2	45.2	98.8	35	79.2	2.6	1	14.5	5.30	37.4	115	62.4	303	287	1.47	4.9	39	31
5546	2ND30724	2	47.0	98.0	38	80.9	2.9	1	12.5	4.73	37.8	105	52.8	356	258	1.52	8.7	52	20
5547	2ND30837	2	47.0	98.7	32	82.0	n.d.	3	12.3	5.06	41.8	112	60.9	274	278	1.54	70.0	58	10
5548	6B10-4748	6	38.9	97.4	37	81.0	2.8	1	14.1	5.21	38.7	153	65.6	404	313	1.55	9.9	48	27
5549	CONRAD	2	38.2	*93.5	43	81.2	3.9	1	13.1	5.73	45.4	139	92.5	183	328	1.46	3.5	51	22
5550	2B05-0811	2	40.1	96.7	43	82.5	3.8	1	12.4	5.58	46.6	106	93.0	294	334	1.51	6.3	59	9
5551	2B09-3425	2	40.1	95.5	51	81.7	3.6	1	12.0	5.39	46.4	137	98.6	80	282	1.48	7.6	69	1
5552	SR458		41.0	99.3	39	81.8	3.5	1	13.1	5.98	48.1	180	81.2	268	354	1.54	7.8	54	16
5554	SR459		39.8	99.2	46	81.7	3.3	1	12.8	5.77	47.4	162	80.5	307	345	1.53	5.1	54	16
5556	SR460	6	37.8	97.4	47	81.4	3.5	1	12.5	5.40	45.5	147	76.7	251	324	1.52	5.5	63	2

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
5553	HARRINGTON MALT CHECK	2	40.0	96.7	74	82.7	2.5	1	11.3	4.68	41.7	122	76.7	138	255	1.50	4.6	63
5555	LACEY MALT CHECK	6	33.0	87.4	41	79.9	3.2	1	13.7	5.75	44.6	168	74.1	62	328	1.44	9.0	61
Minima			33.3	95.5	32	78.4	2.0		11.2	4.50	37.4	84	51.1	80	218	1.46	3.5	
Maxima			47.0	99.3	51	82.5	3.9		14.9	6.11	48.5	193	98.6	519	354	1.59	70.0	
Means			39.1	97.9	42	80.8	2.9		12.9	5.25	42.6	142	69.1	314	283	1.53	14.0	
Standard Deviations			3.7	1.0	5	1.1	0.5		0.9	0.39	3.2	29	12.1	105	34	0.04	14.3	
Coefficients of Variation			9.4	1.0	12	1.3	17.9		7.2	7.45	7.6	21	17.5	33	12	2.33	102.4	

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

Neg Std Dev	28.1	95.1	26	77.6	1.3	10.1	4.08	32.9	53	32.8	1	181	1.42	-29
Pos Std Dev	50.1	100.8	57	84.0	4.5	15.7	6.43	52.4	230	105.4	628	385	1.64	57

2014 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)	FAN (ppm)	Rel. Visco.	Turbidity (Hach)	Quality Score	Overall Rank
5557	MOREX	6	33.6	92.0	35	78.1	2.9	1	14.7	5.47	38.7	174	65.0	215	301	1.47	6.5	42	28
5558	ROBUST	6	35.7	94.4	40	79.0	2.7	1	14.0	5.55	42.1	211	65.9	219	294	1.46	5.4	53	17
5559	LEGACY	6	33.8	91.5	45	78.7	3.0	1	14.0	5.55	42.4	192	99.3	254	293	1.47	5.2	55	13
5560	LACEY	6	36.0	96.5	39	78.8	2.3	1	14.4	5.57	40.9	195	87.5	143	223	1.45	8.5	48	23
5561	TRADITION	6	34.0	93.0	42	78.0	3.1	1	14.0	5.45	40.8	233	96.8	141	273	1.47	7.1	45	26
5562	PINNACLE	2	43.9	96.6	43	80.7	2.6	1	11.7	4.97	44.4	133	78.6	153	255	1.49	7.8	60	5
5563	2ND25276	2	42.4	96.3	38	81.5	2.7	1	11.5	4.45	39.5	131	97.7	160	213	1.45	9.4	58	9
5564	ND26891	6	36.4	94.4	36	79.2	2.8	1	13.4	5.50	41.9	176	84.8	191	238	1.50	8.2	58	9
5565	ND27177	6	37.5	97.0	45	79.0	2.5	1	13.6	5.34	42.2	218	86.0	119	250	1.49	6.7	62	4
5566	2ND28065	2	41.3	94.2	38	80.5	2.0	1	12.8	4.61	37.9	126	73.5	180	199	1.46	3.8	54	15
5567	M156	6	33.3	94.4	43	79.5	2.4	1	12.8	5.16	43.5	183	85.4	256	229	1.47	5.5	59	7
5568	M157	6	34.3	88.5	47	78.7	2.8	1	13.6	5.51	42.7	165	85.6	251	270	1.49	5.7	55	13
5569	ND28554	6	37.3	95.0	41	78.3	2.6	1	14.1	5.19	38.4	183	79.1	258	234	1.51	10.5	41	31
5570	ND28555	6	37.8	96.8	39	78.5	2.5	1	13.6	5.09	39.2	192	76.4	201	226	1.50	8.3	46	25
5571	2ND27705	2	42.2	95.9	48	80.7	2.4	1	12.3	4.58	38.9	144	88.0	106	213	1.46	3.7	58	9
5572	M158	6	34.3	86.5	44	78.7	2.3	1	13.7	5.21	39.4	163	77.0	*435	224	1.50	5.3	50	21
5573	M159	6	35.8	93.9	48	79.3	2.8	1	13.2	5.60	43.0	186	86.1	205	287	1.47	4.8	63	1
5574	M160	6	34.1	90.4	44	79.4	2.6	1	12.9	5.19	40.4	152	74.3	176	251	1.46	8.2	54	15
5575	M161	6	36.6	97.1	48	79.8	2.7	1	13.3	5.54	44.2	188	81.4	174	287	1.45	4.2	63	1
5576	ND29196	6	34.2	91.6	54	78.0	2.6	1	14.6	5.55	39.0	204	74.1	257	264	1.51	6.6	42	28
5577	ND29380	6	35.4	94.3	44	80.1	3.4	2	11.8	4.89	44.4	128	67.1	150	247	1.50	27.0	58	9
5578	2ND30639	2	44.9	98.0	36	79.5	2.1	1	14.4	4.96	36.7	126	66.3	281	241	1.45	3.6	45	26
5579	2ND30724	2	46.8	97.3	45	79.7	2.5	1	13.1	4.51	35.9	135	58.7	163	205	1.48	9.9	50	21
5580	2ND30837	2	45.2	95.8	36	81.9	3.2	2	13.1	5.36	44.3	144	75.0	113	266	1.46	13.2	60	5
5581	6B10-4748	6	38.6	95.0	35	78.2	3.0	1	15.0	5.62	40.1	194	77.1	240	296	1.49	7.5	42	28
5582	CONRAD	2	40.7	96.7	33	79.6	2.7	1	13.6	5.30	40.0	167	90.9	78	265	1.43	4.3	51	19
5583	2B05-0811	2	45.2	97.0	40	81.1	2.9	1	13.9	5.57	42.0	157	97.1	154	279	1.46	4.9	53	17
5584	2B09-3425	2	39.3	90.8	45	79.2	3.1	1	13.9	5.86	43.1	184	105.8	52	285	1.44	5.7	47	24
5586	SR458	6	38.6	97.3	38	81.2	3.2	1	13.5	6.61	*50.6	218	89.8	292	318	1.51	6.9	51	19
5588	SR459	6	37.9	96.1	46	79.6	3.4	1	13.2	5.92	44.3	194	78.0	276	291	1.51	6.5	59	7

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
5589	SR460	6	35.5	92.7	45	79.9	3.1	1	13.0	5.61	45.5	174	71.8	312	288	1.51	6.0	63	1
5585	IARRINGTON MALT CHEC	2	40.1	96.4	76	82.4	2.1	1	11.8	4.80	44.1	129	83.7	110	238	1.50	4.9	65	
5587	LACEY MALT CHECK	6	33.2	88.5	44	79.7	2.6	1	13.8	5.84	43.5	197	85.3	41	294	1.44	6.1	61	
Minima			33.3	86.5	33	78.0	2.0		11.5	4.45	35.9	126	58.7	52	199				
Maxima			46.8	98.0	54	81.9	3.4		15.0	6.61	45.5	233	105.8	312	318				
Means			38.1	94.4	42	79.5	2.7		13.4	5.33	41.2	173	81.3	192	258				
Standard Deviations			4.0	2.8	5	1.1	0.3		0.9	0.45	2.5	30	11.3	66	32				
Coefficients of Variation			10.5	3.0	12	1.3	12.6		6.4	8.41	6.1	17	13.9	34	12				

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

Neg Std Dev	26.1	86.0	27	76.3	1.7		10.9	3.99	33.6	84	47.4	-6	162
Pos Std Dev	50.2	102.8	57	82.7	3.8		16.0	6.68	48.7	263	115.2	391	354

2014 MVBN Osnabrock, ND

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)	Rel. Visco.	Turbidity (Hach)	Quality Score	Overall Rank
5419	MOREX	6	34.7	*97.2	43	80.2	6.1	1	13.3	6.14	47.8	179	64.1	55	310	1.49	12.8	58	8
5420	ROBUST	6	36.8	99.0	33	79.2	2.2	1	14.4	6.24	43.7	195	53.6	309	290	1.48	4.1	46	27
5422	LEGACY	6	35.2	99.1	52	80.9	n.d.	3	12.4	7.10	59.0	133	61.7	139	369	1.52	*31.0	49	23
5424	LACEY	6	38.0	99.2	40	80.3	2.5	1	12.9	5.91	48.1	180	65.2	90	277	1.46	6.9	61	3
5425	TRADITION	6	36.4	99.3	40	80.2	2.1	1	12.9	5.50	45.9	195	69.9	83	267	1.48	5.7	70	1
5426	PINNACLE	2	47.3	99.2	29	82.9	2.3	1	11.1	4.84	45.2	102	59.8	197	217	1.50	7.3	60	5
5427	2ND25276	2	43.8	99.4	31	82.0	3.9	2	11.8	5.73	49.6	123	67.3	95	268	1.48	14.3	60	5
5428	ND26891	6	36.5	99.3	37	80.6	2.9	2	12.1	5.39	48.2	114	60.5	260	242	1.52	20.0	50	22
5429	ND27177	6	37.6	99.1	42	80.2	3.6	1	13.4	6.31	48.0	188	58.3	84	295	1.53	14.1	58	8
5430	2ND28065	2	40.5	98.1	35	82.1	3.1	2	11.5	4.97	44.5	102	49.6	85	233	1.51	17.5	62	2
5431	M156	6	36.7	99.4	40	80.5	2.7	1	12.7	5.89	48.6	159	50.4	190	265	1.47	8.4	54	16
5432	M157	6	37.2	98.8	42	81.1	7.7	2	12.2	6.50	55.4	94	48.7	170	326	1.48	10.5	40	31
5433	ND28554	6	38.5	99.5	39	81.2	2.7	1	12.1	5.59	47.8	141	52.3	158	271	1.49	11.6	61	3
5434	ND28555	6	39.1	99.3	41	80.3	2.6	1	12.8	5.79	49.0	154	61.2	148	284	1.48	6.1	57	11
5435	2ND27705	2	42.8	99.3	35	82.9	5.0	2	10.5	5.61	53.4	101	46.1	83	277	1.46	7.8	49	23
5436	M158	6	35.7	*96.7	42	81.3	1.9	1	12.2	5.34	47.3	139	61.9	320	245	1.48	4.8	55	14
5437	M159	6	34.8	98.6	42	81.9	*13.5	2	12.6	8.22	*70.3	98	43.9	69	387	1.46	7.6	47	25
5438	M160	6	36.0	*97.4	40	80.7	2.8	1	13.2	6.08	48.7	129	54.0	103	287	1.45	6.0	55	14
5439	M161	6	35.7	99.1	43	80.5	8.8	2	12.8	7.60	59.8	123	48.0	126	362	1.47	12.4	47	25
5440	ND29196	6	36.2	99.0	42	79.3	2.7	1	13.6	6.31	50.0	179	71.1	118	290	1.46	5.8	53	19
5441	ND29380	6	37.0	99.7	41	81.3	3.1	1	12.4	5.78	49.6	122	65.7	218	280	1.49	9.8	51	20
5442	2ND30639	2	45.5	99.0	35	80.8	2.1	1	12.9	5.73	46.5	136	59.9	125	259	1.44	2.9	59	7
5443	2ND30724	2	45.7	99.1	40	80.8	2.5	1	12.8	4.80	37.5	126	56.8	107	225	1.47	8.4	58	8
5444	2ND30837	2	45.6	99.0	34	82.6	5.7	2	12.6	6.42	54.4	128	58.8	73	329	1.49	17.2	57	11
5445	6B10-4748	6	45.1	99.4	37	80.7	4.0	1	12.4	5.73	49.5	141	58.8	165	300	1.50	9.6	57	11
5446	CONRAD	2	45.0	99.2	38	82.0	n.d.	3	13.1	7.31	56.7	82	48.7	56	324	1.48	*36.0	41	29
5447	2B05-0811	2	40.6	99.0	39	82.7	*15.0	1	13.4	8.05	60.3	70	52.6	48	355	1.47	8.2	45	28
5448	2B09-3425	2	41.7	98.8	42	82.7	6.4	1	11.9	6.53	56.5	118	69.7	20	307	1.48	10.6	54	16
5449	SR458	6	43.3	99.5	41	82.1	5.0	1	12.4	6.36	52.9	155	68.3	129	282	1.50	9.1	54	16
5450	SR459	6	43.4	99.5	39	81.1	8.2	1	14.1	7.21	54.3	113	60.4	74	340	1.50	10.7	41	29

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)	Rel. Visco.	Turbidity (Hach)	Quality Score	Overall Rank
5451	SR460	6	39.3	99.4	43	82.0	6.6	1	12.4	6.32	53.1	94	61.7	85	291	1.51	12.7	51	20
5421	HARRINGTON MALT CHECK	2	40.0	96.7	72	82.5	1.9	1	11.7	4.78	43.8	129	70.3	173	236	1.55	5.6	62	
5423	LACEY MALT CHECK	6	32.6	86.6	43	79.8	2.8	1	13.8	6.00	45.2	174	79.4	47	302	1.44	6.5	61	
Minima			34.7	98.1	29	79.2	1.9		10.5	4.80	37.5	70	43.9	20	217	1.44	2.9		
Maxima			47.3	99.7	52	82.9	8.8		14.4	8.22	60.3	195	71.1	320	387	1.53	20.0		
Means			39.7	99.2	39	81.2	4.0		12.6	6.17	50.4	133	58.3	128	292	1.48	9.8		
Standard Deviations			3.9	0.3	4	1.0	2.0		0.8	0.85	5.2	34	7.5	73	42	0.02	4.2		
Coefficients of Variation			9.9	0.3	11	1.2	50.6		6.4	13.85	10.3	25	12.9	57	14	1.44	42.6		

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.

Neg Std Dev	27.9	98.2	26	78.2	-2.1		10.2	3.61	34.9	31	35.7	-91	166	1.42	-3				
Pos Std Dev	51.6	100.1	52	84.2	10.2		15.0	8.74	65.9	234	80.9	347	418	1.55	22				

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.

April, 2014 DRAFT