

UNITED STATES DEPARTMENT OF AGRICULTURE
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MIDWEST AREA
CEREAL CROPS RESEARCH UNIT

**MISSISSIPPI VALLEY REGIONAL SPRING BARLEY NURSERY
2011 Crop**

Preliminary Quality Report

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Detailed Data:

Crookston, MN
Morris, MN
Sidney, MT

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,
Madison, WI

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Mississippi Valley Regional Spring Barley Nursery – 2011 Crop

Barley samples from the 2011 Mississippi Valley Regional Spring Barley Nursery (MVRSBN), grown at experimental stations in Crookston, Minnesota, Morris, Minnesota and Sidney, Montana, were submitted to the USDA-ARS Cereal Crops Research Unit, in Madison, WI, for malting and quality analysis. No MVRSBN samples were received from North Dakota or Aberdeen, Idaho for the 2011 crop.

These samples were malted in Joe White (JW) micro-malters, under conditions that should generate malts having modification levels similar to those produced industrially. Detailed descriptions of the malting conditions and analytical methods employed are listed in Appendix A. The criteria and value assignments used to calculate quality scores are based upon the “Ideal Commercial Malt Criteria” developed by the American Malting Barley Association (AMBA): www.amainc.org/media/AMBA_PDFs/Press_Releases/GUIDELINES.pdf; these are listed in Appendix B.

Mean values for fourteen quality factors are listed across the three MVRSBN stations (Table 1), and across all lines (Table 2). Individual station data are reported in Tables 3 through 5. Evaluations of data from individual locations and overall performance of each line, derived mostly from Tables 1 and 2, are presented, as well.

The barley samples received from Crookston, MN (Table 3) had good to excellent plumpness (on 6/64” screen), with the exception of the Morex barley standard; they were significantly plumper, on average, than either of the other two locations. This location also yielded the largest average kernel weight at 35.0mg. The average barley protein level was intermediate between the other two locations, with most in the optimal 2- and 6-rowed ranges. The malts made from these barleys had mash extracts with the lowest average color of any location, and they were clear, except 2ND24388, which was slightly hazy and significantly higher in color. Crookston showed the lowest protein modification. Average wort protein and FAN were significantly lower than at Morris and Sidney. The 6-rowed barley malts yielded good Malt Extract (%) values, with the exception of 6B08-3428. Conversely, the majority of 2-rowed barley Malt Extract values were less than optimal. The best malts from this location included those from barleys, 6B07-1613, ND25652, M145, and M143. The latter was notable for its excellent Malt Extract and Free Amino Nitrogen (FAN) values.

The MVRSBN barley samples grown at Morris, MN (Table 4) were significantly less plump, smaller in kernel weight, and less bright (Agtron) than the other two locations. In addition, their average protein values were significantly lower. However, even with their relative lack of plumpness and kernel weight, the resultant malts from this location developed Mash Extract values, which were not significantly lower than those from Crookston, and were higher than those from Sidney. These mash extracts had the highest average color of any location, and showed more haziness, including 6B08-3428, which was rated “hazy”. Malt Extract and Beta-glucan levels were similar to those from Crookston, however, these malts showed more protein modification, with significantly higher S/T and FAN averages. The average Diastatic Power was significantly lower than for Crookston and Sidney, and this contributed to a lower overall average quality score. M149, ND25652, and ND23898 were the best performers. (ND25652 had also shown excellence at Crookston). The three showed very similar profiles, but the malts for

ND25652 and ND23898 developed significantly more FAN than M149. The worst malting quality was shown by the 2-rowed SR440, which lacked barley plumpness, had low Malt Extract and Diastatic Power, and developed a slightly hazy mash extract, with high color.

The barleys grown at Sidney, Montana (Table 5) had average plumpness (6/64”) and kernel weights, intermediate to those grown at Morris and Crookston, but had the highest average protein of any location. Not surprisingly, these MVR SBN malts yielded a soluble protein average that was significantly higher than Morris and Crookston. The FAN average, though significantly higher than Crookston, didn’t differ significantly from that of Morris. Beta-Glucan and Viscosity averages were significantly higher than either of the Minnesota locations. ND23898 had the best overall quality score at this location, receiving a top score in every category. 6B07-1613, which had scored very well at Crookston, was another top performer at this location, though it did not receive the maximum for Malt Extract; Robust produced a similar malt, but with lower amyolytic levels, and its barley protein was 1% higher than 6B07-1613. 6B07-1753 also produced a good overall malt at this location. SR432 and SR434 produced malts with the least quality from Sidney.

Although all three locations yielded barley malts with relatively high overall quality scores, malts made from barleys grown at Crookston, MN and Sidney, MT had significantly higher scores, on average, than those grown at Morris, MN. This may have been due partially to the significantly lower average barley kernel size and plumpness from Morris; Morris was lower than Sidney, which was lower than Crookston for both parameters. In addition, the barleys grown at Sidney and Crookston were significantly brighter than those from Morris. Average Malt Extract was lower for Sidney than the other two locations. Not surprisingly, the average barley protein was highest at Sidney, followed by Crookston, and then Morris – all significantly different. The mash extracts made from Morris grown barleys had significantly more color on average than Sidney barleys, which were significantly higher than those from Crookston. Soluble protein mirrored barley protein location averages: Sidney was greater than Morris, which was greater than Crookston. Morris had a significantly higher Kolbach Index than either of the other locations, indicating more vigorous protein modification. Morris showed an average Diastatic Power which was significantly lower than the other two, while the Sidney location had an average Alpha-amylase level which was significantly lower than Crookston and Morris. Beta-glucan levels averaged significantly higher in malts from Sidney (138ppm), than Morris (80ppm) and Crookston (75ppm). Average Free Amino Nitrogen levels were lower at Crookston than Sidney and Morris, and the average Viscosity was significantly lower at Morris than Crookston and Sidney.

Most of the 2011 MVR SBN barleys produced very good malts, across all three locations. ND25652, 6B07-1613, ND23898, M149, and M145 were top performing lines, along with the variety, Robust. In addition, ND27245 and M145 outperformed Tradition and Lacey for average, overall quality score. ND25652 averaged 92.7% plumpness and was relatively bright (average Agtron, 50.7). Its barley protein average was 12.0%, which is the middle of the ideal range. It had high amounts of Diastatic Power, and alpha-amylase content. 6B07-1613 stood out in barley testing, only as the third brightest barley, on average. However, this malt’s average wort protein level was ideal at 5.41%, and it had high DP and alpha amylase averages. ND23898 had an

excellent average S/T of 46.6, with very high DP and α -amylase averages, and a low average Beta-glucan level. M149 had good plumpness, 92.5%, on 6/64" slotted screen, and was relatively bright: average Agtron score of 50.3. It displayed a relatively low S/T ratio for the nursery. Its average DP was the second highest in the MVRSDN, at 182°; however it also had the second highest average B-glucan (the Sidney malt for this line had 290ppm B-Glucan). The malt from M145 exhibited high DP, but the second lowest alpha-amylase content in the nursery. Another strength was its low average, relative viscosity (1.43, third lowest in the nursery). The malt made from Robust was distinguished by its low average viscosity and turbidity.

The worst overall quality score averages were generated by the barleys SR444, SR432, SR440, and SR434. Their mash extracts were high in color, soluble protein, Kolbach Index, and FAN, indicating excessive protein modification relative to the other MVRSDN malts.

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MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2011 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
Crookston, MN	35.0 a	94.4 a	46.9 a	79.7 a	1.9 c	12.0 b	5.29 c	46.0 b	164 a	84.6 a	75 b	217 b	1.46 a	8.4 a	58.1 a
Morris, MN	31.3 b	84.4 c	43.0 b	79.6 a	2.6 a	11.1 c	5.48 b	52.1 a	130 b	86.1 a	80 b	237 a	1.44 b	9.7 a	50.6 b
Sidney, MT	33.8 c	89.7 b	48.3 a	79.0 b	2.2 b	12.7 a	5.64 a	46.1 b	164 a	77.2 b	138 a	232 a	1.47 a	8.6 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, ND22421, 2ND24388, 2ND25276, SR432, M143, M145, ND26249, 2ND26333, 6B07-1753, 6B07-1819, 6B07-1825, SR434, M144, M147, M149, M150, ND23898, ND25652, ND26036, ND27245, 2ND25272, 2ND27421, 2ND27440, 6B07-1613, 6B07-1770, 6B07-3428, SR440, SR444

MISSISSIPPI VALLEY UNIFORM REGIONAL BARLEY NURSERY - 2011 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	30.3 gh	78.8 h	46.0 bcdefg	78.2 hij	2.0 de	12.3 abcdefg	5.42 bcde	45.6 jkl	163 abc	89.1 abcde	75 cde	230 cdefghij	1.44 abcd	6.1 c	56.0 abcde
Robust	32.2 defgh	88.7 abcdefg	46.7 abcdefg	79.1 efghi	1.9 de	12.0 abcdefgh	5.44 bcde	48.0 defghijk	163 abc	70.3 i	89 cde	231 cdefghij	1.43 bcd	5.5 c	60.7 abc
Legacy	31.2 efgh	87.3 abcdefgh	50.0 abcd	79.3 defg	2.3 bcde	11.4 defghi	5.63 abcd	51.3 abc	155 abc	90.1 abcd	78 cde	237 bcdefgh	1.44 abcd	8.2 bc	56.7 abc
Lacey	32.2 defgh	88.4 abcdefg	45.3 bcdefg	79.4 cdefg	2.0 cde	11.8 bcdefghi	5.34 de	47.7 defghijk	155 abc	84.3 abcdefgh	62 de	217 fghijk	1.42 d	7.6 bc	59.3 abc
Tradition	32.0 dfeigh	88.3 abcdefg	51.7 abc	78.9 efghi	1.9 e	12.0 abcdefgh	5.19 defg	44.6 l	181 ab	86.7 abcde	75 cde	222 efghijk	1.45 abcd	7.5 bc	59.3 abc
Pinnacle	38.0 bc	91.9 abcdef	42.0 fgh	81.0 a	2.6 abcde	10.8 i	5.19 def	49.0 bcdefghi	103 g	77.2 defghi	84 cde	210 ghijk	1.47 ab	8.6 bc	47.3 defg
ND22421	34.2 d	94.0 abcd	45.3 bcdefg	78.8 fghi	2.2 bcde	12.0 abcdefgh	5.45 bcde	46.9 efghijkl	146 bcde	81.4 cdefghi	97 bcde	212 ghijk	1.47 abc	9.4 bc	56.0 abcde
2ND24388	39.8 ab	94.3 abcd	33.5 i	80.7 ab	2.9 ab	10.9 hi	4.97 fg	46.8 efghijkl	116 efg	72.5 fghi	119 bcde	195 ijk	1.47 abcd	35.5 a	52.5 bcdef
2ND25276	36.8 c	90.2 abcdefg	42.0 fgh	80.8 ab	2.4 abcde	11.0 ghi	5.38 cde	51.1 abc	120 defg	87.6 abcde	76 cde	218 fghijk	1.44 abcd	8.3 bc	51.3 cdef
SR432	32.6 defgh	93.1 abcd	43.0 efgh	79.4 cdefg	2.5 abcde	11.9 abcdefgh	5.93 abc	52.3 a	154 abc	85.6 abcdefg	89 cde	261 abcd	1.44 abcd	10.1 bc	45.3 efg
M143	31.4 defgh	82.5 fgh	49.0 abcde	79.8 bcdefg	2.2 bcde	12.2 abcdefgh	5.71 abcd	49.6 abcde	149 abcd	80.7 cdefghi	100 bcde	259 abcd	1.44 abcd	7.5 bc	52.7 bcdef
M145	32.0 defgh	86.3 bcdefgh	45.7 bcdefg	79.3 defgh	1.8 e	12.3 abcdefg	5.62 abcd	49.1 bcdefgh	172 abc	71.5 hi	111 bcde	243 bcdefg	1.43 cd	5.2 c	61.3 abc
ND26249	31.7 defgh	91.3 abcdefg	37.3 hi	79.2 efgh	2.3 bcde	11.2 efghi	5.36 de	49.9 abcd	113 fg	75.4 efghi	147 abc	227 defghij	1.46 abcd	10.5 bc	53.3 bcdef
2ND26333	38.3 bc	93.1 abcd	43.0 efgh	80.8 ab	2.3 bcde	11.7 bcdefghi	5.68 abcd	49.6 abcde	120 defg	95.7 ab	59 de	237 bcdefgh	1.45 abcd	6.8 c	51.0 cdef
6B07-1753	30.2 h	85.1 cdefgh	49.7 abcde	80.1 abcde	2.0 de	11.2 fghi	5.35 de	49.6 abcde	158 abc	87.8 abcde	65 de	232 cdefghi	1.45 abcd	6.3 c	55.7 abcde
6B07-1819	31.1 efgh	88.0 abcdefgh	44.7 defg	79.9 abcdef	2.1 cde	11.6 cdefghi	5.46 bcde	49.3 bcdef	163 abc	89.2 abcde	100 bcde	251 bcdef	1.44 abcd	5.3 c	58.0 abcd
6B07-1825	31.8 defgh	89.1 abcdefg	50.3 abcd	79.8 bcdefg	2.0 cde	11.3 efghi	5.00 ef	46.1 hijkl	158 abc	76.5 defghi	106 bcde	214 ghijk	1.46 abcd	10.1 bc	56.7 abcd
SR434	33.2 defg	91.4 abcdefg	45.0 cdefg	78.9 fghi	2.7 abc	12.5 abcde	6.13 a	51.5 ab	151 abcd	85.8 abcdefg	123 abcde	271 ab	1.47 ab	14.3 bc	40.7 g
M144	29.9 h	84.8 defgh	53.0 a	79.2 efgh	2.2 bcde	12.3 abcdefg	5.93 abc	51.2 abc	171 abc	82.7 bcdefghi	85 cde	264 abc	1.45 abcd	5.8 c	51.0 cdef
M147	31.5 defgh	87.5 abcdefgh	46.7 abcdefg	79.1 efghi	1.9 de	13.0 ab	5.68 abcd	46.2 hijkl	173 abc	80.8 cdefghi	88 cde	232 cdefghi	1.44 abcd	5.9 c	60.0 abc
M149	34.2 d	92.5 abcde	50.3 abcd	78.9 efghi	2.2 bcde	12.7 abcd	5.38 cde	45.0 kl	182 a	77.1 defghi	167 ab	217 fghijk	1.48 a	11.7 bc	62.0 abc
M150	30.6 fgh	82.2 gh	44.7 defg	78.8 fghi	2.0 cde	12.8 abc	5.57 acd	45.6 jkl	178 ab	82.5 bcdefghi	134 abcd	225 defghijk	1.44 abcd	5.8 c	55.0 abcde
ND23898	32.2 defgh	92.9 abcde	48.7 abcdef	79.0 efghi	1.9 de	12.8 abc	5.69 abcd	46.6 efghijkl	175 ab	84.4 abcdefgh	68 de	243 bcdefg	1.47 abc	7.1 c	63.3 ab
ND25652	32.4 defgh	92.7 abcde	50.7 abcd	79.3 cdefg	2.2 bcde	12.0 abcdefgh	5.39 bde	48.4 cdefghij	168 abc	86.3 abcdef	67 de	228 cdefghij	1.47 ab	8.8 bc	65.0 a
ND26036	31.1 efgh	91.1 abcdefg	49.0 abcde	79.0 efghi	2.0 cde	11.9 abcdefgh	5.28 de	46.9 efghijkl	156 abc	81.2 cdefghi	73 cde	206 hijkl	1.45 abcd	8.5 bc	58.0 abcd
ND27245	32.5 defgh	94.7 abc	49.3 abcde	79.7 bcdefg	1.9 de	12.2 abcdefgh	5.43 bcde	46.1 hijkl	163 abc	77.3 defghi	93 bcde	206 hijkl	1.47 abc	7.6 bc	60.7 abc
2ND25272	39.8 ab	94.8 ab	44.3 defg	80.5 abc	2.1 cde	10.8 i	4.71 g	46.4 fghijkl	105 g	77.4 defghi	166 ab	175 l	1.46 abcd	7.4 bc	45.7 fghi
2ND27421	42.2 a	94.7 abc	40.7 gh	79.9 abcdef	2.4 abcde	12.1 abcdefgh	5.26 de	45.0 kl	173 abc	78.0 defghi	126 abcd	191 lk	1.47 ab	11.0 bc	55.7 abce
2ND27440	41.0 ab	96.7 a	42.0 fgh	80.4 abcd	2.3 bcde	12.2 abcdefgh	5.20 def	44.1 l	99 g	72.2 ghi	129 abcd	198 ij	1.46 abcd	8.7 bc	54.3 abcde
6B07-1613	33.5 edf	88.7 abcdefg	50.7 abcd	79.0 efghi	2.5 abcde	11.5 cdefghi	5.41 bcde	49.1 cdefg	167 abc	92.7 abc	68 de	225 defghijk	1.46 abcd	8.1 bc	64.7 a
6B07-1770	32.6 defgh	83.4 efgh	46.7 abcdefg	79.0 efghi	2.2 bcde	11.9 abcdefgh	5.24 def	46.8 efghijkl	170 abc	71.1 hi	99 bcde	222 efghijk	1.46 abcd	7.8 bc	58.7 abc
6B08-3428	34.1 de	94.3 abc	45.5 bcdefg	77.5 j	2.5 abcde	12.8 abc	5.65 abcd	46.0 ijkl	172 abc	81.3 cdefghi	191.5 a	232 cdefghi	1.46 abcd	11.3 bc	56.5 abcd
SR440	31.6 defgh	84.9 defgh	42.0 fgh	79.4 cdefg	3.1 a	11.6 cdefghi	5.75 abcd	51.1 abc	138 cdef	93.4 abc	96 bcde	258 abcde	1.47 ab	16.3 b	43.3 gf
SR444	30.7 fgh	89.6 abcdefg	45.7 bcdefg	79.1 efghi	2.5 abcde	12.5 abcdef	5.97 ab	50.0 abcd	172 abc	97.4 a	93 bcde	287 a	1.43 cd	6.6 c	45.3 ghi

* 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; Morris, MN; Sidney, MT

MVSBN Crookston, MN

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)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5301	MOREX	6	30.7	*77.6	48	78.5	1.7	1	11.5	5.09	44.9	155	87.1	53	210	1.44	5.9	60	15
5302	ROBUST	6	31.8	87.2	46	79.7	1.5	1	11.2	4.94	45.3	154	68.3	57	199	1.44	5.2	58	17
5303	LEGACY	6	31.5	90.1	51	80.4	1.8	1	10.5	5.27	50.6	149	91.7	56	215	1.43	5.8	59	16
5304	LACEY	6	32.5	89.1	48	79.8	1.6	1	11.2	4.82	44.1	155	84.3	46	188	1.43	5.7	56	22
5305	TRADITION	6	32.9	95.9	59	79.6	1.6	1	11.1	4.78	43.2	164	87.9	45	197	1.45	7.6	56	22
5306	PINNACLE	2	41.8	98.2	46	81.9	1.8	1	10.3	4.56	45.7	96	70.3	98	170	1.50	10.7	52	31
5307	ND22421	6	34.2	97.2	47	79.4	1.7	1	11.2	5.02	45.1	136	80.3	51	185	1.47	9.9	53	28
5308	2ND24388	2	42.8	98.4	39	81.5	*2.9	2	11.3	4.88	43.4	119	62.2	162	181	1.50	*47.0	57	19
5309	2ND25276	2	41.1	99.1	42	81.5	1.6	1	10.9	4.95	47.0	131	91.8	89	196	1.44	6.5	64	5
5310	SR432	2	32.2	94.9	42	79.9	1.7	1	12.3	5.79	51.0	195	103.5	46	250	1.42	4.8	53	28
5311	M143	6	32.8	89.8	47	80.4	1.7	1	12.2	5.58	48.9	167	90.1	64	252	1.43	5.2	65	4
5312	M145	6	32.9	91.5	45	79.4	1.5	1	12.5	5.48	46.8	187	72.6	75	235	1.42	5.4	70	1
5313	ND26249	6	33.2	92.8	37	79.5	1.8	1	11.6	5.28	48.7	136	82.1	76	221	1.46	7.8	62	8
5314	2ND26333	2	41.2	98.3	39	80.6	1.6	1	12.0	5.30	47.2	131	103.0	67	217	1.45	4.6	61	11
5315	6B07-1753	6	31.6	95.5	53	80.3	1.6	1	10.8	5.03	49.2	170	93.2	45	216	1.45	6.3	55	25
5316	6B07-1819	6	31.2	91.9	46	80.2	1.7	1	10.9	5.03	49.8	149	91.6	56	233	1.44	4.9	55	25
5317	6B07-1825	6	33.2	94.1	51	80.4	1.7	1	11.5	4.89	43.4	166	75.8	77	208	1.47	9.7	61	11
5318	SR434	2	34.2	94.9	46	79.1	2.2	1	13.0	6.11	50.7	171	94.3	67	277	1.44	7.3	42	33
5319	M144	6	31.1	91.7	53	79.4	2.0	1	12.4	6.06	49.8	208	91.1	58	262	1.44	5.2	57	19
5320	M147	6	34.7	98.3	47	78.6	1.8	1	13.7	5.66	43.2	201	79.4	73	220	1.45	6.3	62	8
5321	M149	6	36.2	99.1	51	78.6	1.9	1	13.6	5.48	42.3	210	81.9	107	218	1.48	8.7	62	8
5322	M150	6	32.2	87.4	44	78.8	1.9	1	13.9	5.72	43.0	211	83.6	144	228	1.46	5.6	54	27
5323	ND23898	6	34.1	99.6	48	78.9	1.9	1	13.6	5.97	46.9	186	86.4	58	254	1.49	6.8	58	17
5324	ND25652	6	34.9	98.6	47	79.8	1.8	1	12.7	5.28	44.4	188	89.3	50	217	1.49	7.1	70	1
5325	ND26036	6	32.9	97.0	50	79.8	1.8	1	11.6	5.02	45.8	162	81.3	45	186	1.46	7.4	61	11
5326	ND27245	6	34.7	99.7	53	79.7	1.7	1	12.0	5.15	44.0	175	80.5	54	200	1.46	6.6	64	5
5327	2ND25272	2	44.0	99.2	45	80.6	1.9	1	10.9	4.66	43.4	116	70.5	163	169	1.49	7.7	47	32
5328	2ND27421	2	46.7	98.8	46	80.2	2.4	1	11.8	5.05	42.7	174	69.3	124	186	1.50	*16.5	61	11
5329	2ND27440	2	41.6	98.5	47	79.9	2.1	1	12.5	5.08	42.2	104	69.2	104	186	1.49	11.9	57	19
5330	6B07-1613	6	34.6	96.0	57	79.1	2.3	1	11.9	5.21	46.7	169	92.4	44	214	1.47	8.9	70	1

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)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5331	6B07-1770	6	32.7	84.5	50	78.3	2.0	1	11.9	5.11	44.2	173	72.3	52	214	1.45	7.2	63	7
5332	6B08-3428	6	33.8	94.9	43	77.2	2.2	1	13.2	5.72	45.3	185	90.9	91	238	1.44	6.7	56	22
5333	SR440	2	33.4	96.0	39	79.9	2.5	1	12.2	5.78	48.4	168	102.9	49	259	1.45	7.7	53	28
5334	SR444	2	32.1	92.2	41	79.2	2.1	1	14.0	6.23	46.9	215	105.9	90	293	1.43	4.0	42	33
5294	LACEY MALT CHECK	6	33.5	89.5	57	79.2	2.2	1	12.4	5.63	46.1	153	76.0	85	223	1.48	15.6	70	
5292	HARRINGTON MALT CHECK	2	40.1	95.5	75	82.0	1.7	1	11.6	5.28	47.2	145	99.1	57	228	1.46	5.4	64	
Minima			30.7	84.5	37	77.2	1.5		10.3	4.56	42.2	96	62.2	44	169	1.42	4.0		
Maxima			46.7	99.7	59	81.9	2.5		14.0	6.23	51.0	215	105.9	163	293	1.50	11.9		
Means			35.0	94.9	47	79.7	1.8		12.0	5.29	46.0	164	84.6	75	217	1.46	6.9		
Standard Deviations			4.2	4.1	5	1.0	0.3		1.0	0.43	2.7	31	11.2	33	30	0.02	1.8		
Coefficients of Variation			12.1	4.4	11	1.2	13.8		8.4	8.20	5.8	19	13.2	44	14	1.65	26.8		

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

Neg Std Dev	22.3	82.4	32	76.8	1.1		9.0	3.99	38.0	72	51.1	-25	127	1.38	1.4				
Pos Std Dev	47.7	107.3	62	82.6	2.6		15.0	6.60	54.0	256	118.1	174	308	1.53	12.5				

MVSBN Morris, 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)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5335	MOREX	6	29.1	75.1	44	78.1	2.0	1	11.7	5.39	47.8	157	95.2	79	228	1.43	6.3	54	15
5336	ROBUST	6	31.3	88.1	44	78.8	2.1	1	11.8	5.73	53.1	166	76.8	93	254	1.42	5.1	57	6
5337	LEGACY	6	30.0	83.1	48	79.0	2.4	1	10.5	5.45	53.8	139	83.0	85	230	1.44	9.6	56	10
5338	LACEY	6	31.4	85.6	44	79.8	2.2	1	11.1	5.38	52.4	143	88.3	67	228	1.42	7.7	59	5
5339	TRADITION	6	30.0	80.8	47	78.1	2.2	1	11.6	5.36	48.4	170	96.6	44	241	1.43	7.0	56	10
5340	PINNACLE	2	37.0	91.0	36	80.6	2.2	1	10.2	4.95	51.3	94	75.5	90	197	1.45	6.6	45	24
5341	ND22421	6	33.8	95.5	45	78.9	2.6	1	11.6	5.62	50.8	121	88.6	127	243	1.47	10.9	55	13
5343	2ND24388	2	36.7	90.2	28	79.9	2.9	2	10.5	5.06	50.1	113	82.7	75	209	1.43	*24.0	48	21
5345	2ND25276	2	32.7	80.2	39	81.6	2.7	1	9.8	5.17	56.4	80	86.0	77	206	1.44	10.3	43	27
5346	SR432	2	31.3	92.6	42	79.4	3.1	2	10.8	5.78	55.3	110	76.6	117	252	1.46	15.6	40	31
5347	M143	6	28.5	69.9	52	80.0	2.6	1	10.7	5.50	53.5	118	74.5	60	252	1.44	11.3	45	24
5348	M145	6	29.6	79.1	44	79.4	2.2	1	11.2	5.79	56.3	146	76.7	76	256	1.41	5.1	51	17
5349	ND26249	6	30.1	89.6	35	78.9	2.9	2	10.2	5.35	53.1	76	75.8	168	233	1.47	15.1	44	26
5350	2ND26333	2	35.9	92.8	39	80.6	2.3	1	11.0	5.67	51.8	99	98.6	52	230	1.42	5.4	41	30
5351	6B07-1753	6	28.6	79.7	47	80.6	2.3	1	10.5	5.37	52.1	120	90.4	52	242	1.43	5.7	48	21
5352	6B07-1819	6	29.5	86.6	42	80.3	2.4	1	11.1	5.62	52.2	146	95.1	79	257	1.41	5.1	57	6
5353	6B07-1825	6	29.7	86.0	48	79.8	2.1	1	10.5	4.99	50.7	139	84.4	51	223	1.43	6.3	50	19
5354	SR434	2	31.6	88.3	42	78.9	*3.5	2	12.0	6.08	53.1	125	81.0	154	273	1.49	*24.0	37	33
5355	M144	6	27.0	72.4	50	79.5	2.6	1	11.5	5.82	54.8	128	82.5	53	267	1.42	6.6	43	27
5356	M147	6	28.4	78.2	42	80.0	2.3	1	12.0	5.76	51.3	152	88.8	48	247	1.41	5.8	56	10
5357	M149	6	31.8	88.9	48	79.4	2.4	1	11.7	5.27	49.4	155	79.6	104	217	1.44	8.7	64	1
5358	M150	6	28.2	71.0	42	79.0	2.4	1	11.3	5.45	50.4	144	88.2	62	231	1.40	7.0	52	16
5359	ND23898	6	29.9	87.5	47	79.1	2.3	1	11.6	5.43	49.3	152	89.2	41	245	1.42	7.7	62	3
5360	ND25652	6	30.6	89.2	51	79.5	2.8	1	11.5	5.55	52.4	145	92.4	67	244	1.45	9.9	64	1
5361	ND26036	6	29.0	87.6	47	78.7	2.5	1	11.0	5.37	52.0	136	88.3	51	229	1.42	8.1	51	17
5362	ND27245	6	30.1	91.9	47	80.5	2.4	1	11.8	5.71	50.5	145	84.9	74	233	1.45	9.1	60	4
5363	2ND25272	2	35.2	90.5	39	80.2	2.7	1	10.1	4.76	50.8	88	86.0	108	187	1.42	8.4	39	32
5364	2ND27421	2	38.2	90.9	32	80.6	2.8	1	12.4	5.74	50.3	170	92.2	87	226	1.43	7.0	55	13
5365	2ND27440	2	37.5	95.6	34	81.1	2.5	1	11.4	5.37	48.6	88	80.4	109	215	1.43	6.1	49	20
5366	6B07-1613	6	30.3	74.9	43	79.2	2.7	1	10.5	5.42	53.7	146	97.2	47	232	1.43	7.0	57	6

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)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5367	6B07-1770	6	31.5	78.2	42	79.9	2.6	1	11.1	5.41	52.1	154	78.2	66	244	1.43	8.3	57	6
5368	6B08-3428	6	32.1	86.5	43	77.9	n.d.	3	11.4	5.52	50.1	134	71.3	*213	228	1.45	*51.0	42	29
5369	SR440	2	28.7	68.3	42	78.5	*4.1	2	10.7	5.65	55.9	91	87.5	120	262	1.51	*32.0	28	34
5370	SR444	2	28.7	86.3	46	79.2	3.0	1	11.0	5.88	54.9	141	100.7	70	286	1.41	6.9	48	21
5342	HARRINGTON MALT CHECK	2	39.2	96.8	76	81.6	1.6	1	11.3	5.03	45.9	146	100.0	63	199	1.47	4.4	67	
5344	LACEY MALT CHECK	6	33.4	90.5	58	79.9	2.2	2	12.7	5.51	43.9	150	71.2	95	210	1.48	18.6	69	

Minima			27.0	68.3	28	77.9	2.0		9.8	4.76	47.8	76	71.3	41	187	1.40	5.1		
Maxima			38.2	95.6	52	81.6	3.1		12.4	6.08	56.4	170	100.7	168	286	1.51	15.6		
Means			31.3	84.5	43	79.6	2.5		11.1	5.48	52.0	130	85.7	80	237	1.43	8.0		
Standard Deviations			3.0	7.5	5	0.9	0.3		0.6	0.28	2.3	26	7.7	31	21	0.02	2.6		
Coefficients of Variation			9.4	8.9	13	1.1	11.1		5.6	5.17	4.4	20	8.9	39	9	1.72	33.0		

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

Neg Std Dev			22.4	61.9	27	77.0	1.7		9.2	4.63	45.2	51	62.7	-14	173	1.36	0.1		
Pos Std Dev			40.2	107.0	59	82.2	3.3		13.0	6.33	58.8	210	108.7	174	300	1.51	15.9		

MVSBN Sidney, MT

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)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5371	Morex	6	31.2	83.7	46	77.9	2.2	1	13.6	5.78	44.1	177	85.1	94	251	1.44	6.0	54	24
5372	Robust	6	33.6	90.7	50	78.7	2.1	1	13.1	5.64	45.5	168	65.7	118	240	1.44	6.2	67	2
5373	Legacy	6	32.0	88.7	51	78.6	2.7	1	13.1	6.16	49.5	177	95.7	92	267	1.44	9.2	55	23
5375	Lacey		32.7	90.4	44	78.7	2.3	1	13.2	5.81	46.6	166	80.3	73	234	1.42	9.3	63	6
5377	Tradition	6	33.1	88.3	49	79.1	1.9	1	13.2	5.42	42.2	208	75.5	137	227	1.47	7.8	66	4
5378	Pinnacle	2	35.2	86.6	44	80.4	*3.7	1	11.9	6.05	49.9	118	85.9	64	263	1.47	8.5	45	34
5379	ND22421	6	34.7	89.4	44	78.1	2.2	1	13.2	5.71	44.9	181	75.2	114	208	1.46	7.4	60	14
5380	2ND24388	2	40.1	94.9	48	*81.5	n.d.	3	11.6	5.00	45.5	140	71.9	114	198	1.46	*39.0	63	6
5381	2ND25276	2	36.7	91.2	45	79.2	3.0	1	12.2	6.03	49.9	148	84.9	63	251	1.45	8.1	47	32
5382	SR432	2	34.4	91.9	45	79.0	2.7	1	12.7	6.22	50.6	158	76.7	103	280	1.45	9.9	43	35
5383	M143	6	32.8	87.8	48	79.0	2.3	1	13.6	6.04	46.4	162	77.4	176	272	1.45	6.1	48	31
5384	M145	6	33.6	88.4	48	79.1	1.8	1	13.1	5.59	44.1	183	65.1	182	239	1.45	5.2	63	6
5385	ND26249	6	31.7	91.4	40	79.2	2.1	1	11.8	5.45	48.0	128	68.3	196	228	1.46	8.6	54	24
5386	2ND26333	2	37.8	88.2	51	*81.2	3.1	1	12.2	6.07	49.7	131	85.4	59	263	1.47	10.3	51	27
5387	6B07-1753	6	30.3	80.1	49	79.3	2.0	1	12.2	5.65	47.4	185	79.9	99	238	1.46	7.0	64	5
5388	6B07-1819	6	32.6	85.4	46	79.3	2.1	1	12.8	5.72	45.9	193	80.8	166	264	1.46	6.0	62	10
5389	6B07-1825	6	32.6	87.2	52	79.3	2.2	1	11.9	5.13	44.2	170	69.2	191	212	1.49	14.4	59	16
5390	SR434	2	33.8	90.9	47	78.6	2.5	1	12.6	6.21	50.8	156	82.2	148	263	1.49	11.7	43	35
5391	M144	6	31.6	90.3	56	78.6	1.9	1	13.0	5.92	49.1	176	74.6	144	262	1.48	5.7	53	26
5392	M147	6	31.4	85.9	51	78.6	1.7	1	13.3	5.62	44.1	167	74.1	144	228	1.45	5.6	62	10
5393	M149	6	34.5	89.5	52	78.7	2.2	1	12.8	5.40	43.3	181	69.8	290	217	1.51	*17.6	60	14
5394	M150	6	31.5	88.2	48	78.5	1.7	1	13.3	5.54	43.5	180	75.7	196	217	1.46	4.8	59	16
5395	ND23898	6	32.6	91.7	51	79.1	1.6	1	13.2	5.66	43.6	186	77.5	106	229	1.49	6.7	70	1
5396	ND25652	6	31.7	90.4	54	78.7	1.9	1	11.8	5.34	48.3	171	77.1	83	224	1.48	9.5	61	13
5397	ND26036	6	31.5	88.7	50	78.5	1.8	1	13.0	5.45	42.8	171	73.9	122	203	1.48	10.0	62	10
5398	ND27245	6	32.6	92.5	48	78.9	1.5	1	12.8	5.43	43.7	170	66.4	152	184	1.49	7.0	58	18
5399	2ND25272	2	40.3	94.8	49	80.6	1.6	1	11.4	4.72	45.1	112	75.7	228	168	1.48	6.0	51	27
5400	2ND27421	2	41.6	94.3	44	79.0	1.9	1	12.2	5.00	42.0	174	72.5	168	161	1.49	9.4	51	27
5401	2ND27440	2	*43.9	96.1	45	80.2	2.3	1	12.7	5.16	41.5	104	67.1	175	193	1.47	8.1	57	20
5402	6B07-1613	6	35.5	95.1	52	78.6	2.4	1	12.1	5.60	46.9	186	88.5	113	230	1.48	8.3	67	2

Table 5

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Viscosity (Relative)	Turbidity (Hach)	Quality Score	Overall Rank
5403	6B07-1770	6	33.7	87.5	48	78.8	1.9	1	12.7	5.20	44.1	183	62.8	180	209	1.49	7.9	56	22
5404	6B08-3428	6	34.3	94.4	48	77.8	2.7	1	12.4	5.58	46.7	159	71.7	292	226	1.48	*15.9	57	20
5405	SR440	2	32.6	90.3	45	79.8	2.6	1	11.9	5.81	49.0	156	89.7	118	252	1.46	9.2	49	30
5407	SR444	2	31.2	90.4	50	78.8	2.5	1	12.4	5.79	48.2	161	85.6	119	281	1.44	8.8	46	33
5409	Innovation	6	33.3	91.1	48	78.7	2.6	1	12.4	5.72	47.7	147	78.7	75	228	1.45	9.8	58	18
5410	Celebration	6	31.3	89.5	52	78.0	2.4	1	13.2	5.61	45.5	158	88.1	49	216	1.43	7.9	63	6
5374	HARRINGTON MALT CHECK	2	40.4	96.8	74	82.1	1.7	1	11.4	4.99	46.7	141	96.1	77	197	1.47	4.7	69	
5376	LACEY MALT CHECK	6	33.7	90.0	57	79.4	2.4	1	13.0	5.48	42.5	144	71.0	80	212	1.47	15.8	70	
5406	HARRINGTON MALT CHECK	2	39.4	97.1	75	82.1	1.5	1	12.0	4.91	43.1	142	92.4	70	194	1.46	4.0	67	
5408	LACEY MALT CHECK	6	33.1	89.7	58	79.0	2.3	2	12.9	5.39	43.5	148	72.2	112	207	1.48	19.1	66	
Minima			30.3	80.1	40	77.8	1.5		11.4	4.72	41.5	104	62.8	49	161	1.42	4.8		
Maxima			41.6	96.1	56	80.6	3.1		13.6	6.22	50.8	208	95.7	292	281	1.51	14.4		
Means			33.7	89.9	48	78.9	2.2		12.6	5.62	46.1	164	77.1	137	231	1.46	8.1		
Standard Deviations			2.7	3.3	3	0.6	0.4		0.6	0.36	2.6	23	7.9	59	30	0.02	2.0		
Coefficients of Variation			8.0	3.7	7	0.8	18.4		4.7	6.34	5.7	14	10.2	43	13	1.44	25.2		

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

Neg Std Dev	25.6	79.9	38	77.0	1.0		10.9	4.55	38.2	94	53.5	-39	142	1.40	2.0				
Pos Std Dev	41.8	99.9	58	80.8	3.4		14.4	6.69	54.1	233	100.7	314	320	1.53	14.2				

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

Quality parameter	2-rowed		6-rowed		
	condition	score	condition	score	
Kernel Weight (mg)	> 42.0	5	> 32.0	5	
	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 (% db)	≥ 81.0	10	≥ 79.0	10	
	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 (% db)	≥ 13.5	0	≥ 14.0	0	
	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 (% db)	> 6.0	0	> 6.0	0	
	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 Protein, % db)	> 47	0	> 47	0	
	40–47	5	42–47	5	
	< 40	0	< 42	0	
DP (Diastatic Power, ° ASBC)	> 120	7	> 140	7	
	100–120	4	120–140	4	
	< 100	0	< 120	0	
Alpha-amylase (20° DU)	> 45	7	> 45	7	
	40–45	4	40–45	4	
Beta-glucan (ppm)	< 100	7	< 120	7	
	100–150	3	120 – 170	3	
	> 150	0	> 170	0	
Free Amino Nitrogen FAN (ppm)	> 190	5	> 200	5	
	180–190	3	190 – 200	3	
	< 180	0	< 190	0	