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Wisconsin Agricultural Experiment Station and other State Experiment Stations, Cooperating

MISSISSIPPI VALLEY UNIFORM BARLEY NURSERY - 2001 Crop

Preliminary Quality Report

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Contents

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 to those persons who have a direct and special interest in the development of improved barleys.

This report includes data furnished by the Agricultural Research Service as well as 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 malted and analyzed by the Cereal Crops Research Unit, Madison, WI

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Mississippi Valley Uniform Barley Nursery - 2001

Nursery samples were received for malting quality evaluation from four experimental stations located in three states. Eleven of 28 entries (#18 - #28) were new in this year's nursery (Table 1).

These samples were germinated for 5 days and rotated for 3 minutes every half hour, which should have yielded malts having modification levels that are similar to those produced by industry. The malting conditions and analytical methods employed are listed in Appendix A. The criteria and value assignments used to calculate quality scores are listed in the same Appendix (Table A1).

The mean values of 11 quality factors are listed over the three stations located in the Mississippi Valley area (Table 2) and over all varieties (Table 3). Tables 8 and 9 report the same factors, but also include data from samples that were grown in Aberdeen, Idaho. Individual station data are reported in Tables 4 through 7. The parentages of the nursery entries are listed in Table 1. Evaluations of data from individual locations and overall performance evaluations, derived primarily from Tables 2, 3, 8 and 9, are presented below.

The protein contents of the plump barleys from Crookston, MN (Table 4) were good, with only two lines having unacceptably high levels. The extract values ranged from good to exceptional, except for those of Barbless and Larker. The soluble protein levels ranged from very good to five that were unacceptably high, while nearly half of the S/T ratios exceeded the desired upper limit. A third of the diastatic power values were too low, while over half of the α-amylase levels were too high. The β-glucan levels were generally good, although that of MNBrite was quite low, indicating possible over-modification, and that of ND16903 was high, indicating poor modification. The best performers were 6B95-2482, M109, Robust, 6B95-2089, 6B97-2245, 6B96-3733, M110, Drummond and Lacey.

Most of the plump barleys from Morris, MN (Table 5) had elevated protein contents. The extract values were generally good, with only six falling below the minimum desired limit. Most soluble protein levels were high, with over half exceeding the upper limit. Nearly half of the S/T ratios were high due to the high soluble protein contents. The diastatic power levels were generally a bit high, as would be expected with the high total protein levels. Half of the α-amylase values exceeded the desired upper limit, while β-glucan levels ranged from very good to four that were too high. The best performers were ND16301, 6B95-2089, Lacey, 6B95-2482 and M110.

The barleys submitted from Bottineau, ND (Table 6) were thin, and except for some of the older varieties, had excellent protein contents. The extract values were excellent, except for that of Barbless. The soluble protein and wort color values tended to be a bit high, and nearly all of the S/T ratios exceeded the upper limit. Two thirds of the diastatic power values were too

low, while nearly all of the α-amylase levels exceeded the acceptable upper limit. The β-glucan contents were very good, except for that of ND16903, which was too high. The best performers were 6B95-2482, Drummond and ND16301.

The plump barleys grown at Aberdeen, ID (Table 7) had protein contents that ranged from very good to eleven that were unacceptably high. The extract values were generally good, averaging nearly 80%. The soluble protein levels were mostly good, with only three exceeding the upper limit, but over half of the S/T ratios were unacceptably low. The diastatic power levels varied considerably ranging from four that were too low to five that exceeded the upper limit. Half of the α-amylase values were too high. There were many excellent β-glucan levels, with only those of ND16903 and Barbless exceeding the upper limit. The best performers were ND16301, 6B95-2482, 6B97-2195, 6B97-2245, M109 and M110. A couple of the additions to this nursery, 98AB12362 and 92AB5180 also performed very well.

Overall, the submissions from Crookston and Aberdeen (Tables 2 and 8) performed well. The barleys from these locations were plump and yielded malts with high extract values. The Crookston barleys had better protein levels than those from Aberdeen, while the malts made from the lines grown in Aberdeen had excellent amylolitic levels. The barleys grown in Bottineau had excellent protein contents and good extract values, but the thinness of the kernels and the high soluble protein levels detracted from their quality scores. The barleys grown in Morris were not as plump as the submissions from Crookston or Aberdeen and the high β-glucan, soluble protein and total protein values negatively impacted the malting quality of these submissions.

In general, the samples in this year's nursery had good extract and β-glucan levels, however the soluble protein, S/T and α-amylase values tended to be a bit high (Tables 3 and 9). The new and second year nursery submissions were generally plumper and had lower protein contents than those of the established varieties. The lines that performed best were 6B95- 2482, 6B95-2089, ND16301, Robust, Drummond, Lacey, M109 and M110.

Table 1 **Entries in the Mississippi Valley Uniform Barley Nursery - 2001 Crop**

Entry No.	New Entry	CI# or Contributor	Name	Rowed	Parentage
1		5105	Barbless	6	Oderbrucker/Lion
2		10648	Larker	6	Titan/Kindred/3/Newal/Peatland//Montcalm
3		15773	Morex	6	Cree/Bonanza
4		476976	Robust	6	Morex/Manker
5		Minnesota	Stander (M64)	6	Robust 2*/3/Cree/Bonanza//Manker/4/Robust/Bumper
6		PI 592758	Foster (ND 11055)	6	Robust/3/ND5570//Glenn/Karl
7		Busch Ag. Res.	Legacy (6B93-2978)	6	Bumper/Karl//Bumper/Manker/3/Bumper/Karl/4/Excel
8		PI 603050	MNBrite (MNS85)	6	M90-89/M69
9		North Dakota	Drummond (ND15477)	6	ND9712//Stander/ND12200
10		Minnesota	Lacey (M98)	6	M78/M79
11		Minnesota	M103	6	M84/M81
12		North Dakota	ND16301	6	Foster//ND12200/6B88-3213
13		Busch Ag.	6B95-2482	6	6B89-2126/ND10981
14		Busch Ag.	6B96-3733	6	6B88-3213//6B89-2126/Foster
15		Minnesota	M106	6	M92-334/M81
16		Minnesota	M108	6	M92-395/M83
17		Busch Ag.	6B95-2089	6	6B84-2912/B1601//6B88-3213
18	X	Minnesota	M109	6	Lacey/M95
19	X	Minnesota	M110	6	M93-117/M95
20	X	North Dakota	ND16318	6	ND13063//ND12200/6B88-3213
21	X	North Dakota	ND16903	6	ND14156/ND14296
22	X	North Dakota	ND16922	6	ND14161/ND14296
23	X	Busch Ag.	6B97-2037	6	6B92-7098/6B91-6086
24	X	Busch Ag.	6B97-2195	6	6B92-7098/M75
25	X	Busch Ag.	6B97-2245	6	6B92-7098/M75
26	X	Manitoba	BT386	6	CDC Sisler/M75

MISSISSIPPI VALLEY UNIFORM BARLEY NURSERY - 2001 Crop

Table 2 - Station Means* of Barley and Malt Quality Factors for 28 Varieties or Selections**.

Location	Barley Kernel Weight (mg)		on 6/64" (%)		Barley Color (Agtron)		Malt Extract (%)		Wort Color		Barley Protein (%)		Wort Protein (%)		S/T (%)		DP (°)		Alpha-amylase (20° DU)		Beta-glucan (ppm)	
Crookston, MN	34.1	A	89.9	A	39.6	B	79.7	A	2.3	A	13.0	B	5.62	A	45.7	A	133	B	63.3	A	184	B
Morris, MN	32.3	B	80.3	B	46.4	A	78.7	B	2.3	A	14.2	C	6.32	C	46.3	A	160	A	62.0	A	224	C
Bottineau, ND	28.8	C	60.5	C	46.8	A	79.9	A	3.1	B	12.4	A	5.93	B	50.2	B	126	B	71.0	B	122	A

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

** Barbless, Larker, Morex, Robust, Stander, Foster, Legacy, MNBrite, Drummond, Lacey, M103, ND16301,6B95-2482
6B96-3733, M106, M108, 6B95-2089, M109, M110, ND16318, ND16903, ND16922, 6B97-2037, 6B97-2195, 6B97-224
BT386, BT484, CDC Battleford

MISSISSIPPI VALLEY UNIFORM BARLEY NURSERY - 2001 Crop

Table 3 - Varietal Means* of Barley and Malt Quality Factors for 3 Stations**.

Variety	Rowed	Barley Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)		Wort Color		Barley Protein (%)		Wort Protein (%)		S/T (%)		DP (°)		Alpha-amylase (20° DU)		Beta-glucan (ppm)		Ave. Quality Score	Overall Rank
Barbless	6	30.9	64.3	42.3	76.3	G	1.9	A	13.9	ABC	5.38	A	36.3	A	140	ABCD	52.3	AB	232	CDE	29	21
Larker	6	32.1	78.0	41.0	78.0	F	2.3	ABC	14.5	B	5.58	ABC	41.0	AB	157	AB	58.6	ABC	225	CDE	28	23
Morex	6	29.3	59.2	45.3	78.4	EF	2.3	ABC	14.2	ABC	6.14	ABCD	44.1	ABCD	159	AB	67.9	CDEFG	135	ABCD	28	23
Robust	6	32.1	72.8	43.3	78.8	CDEF	1.8	A	13.6	ABC	5.80	ABCD	44.0	ABCD	157	AB	52.0	AB	209	BCDE	40	3
Stander	6	32.0	81.9	44.0	80.6	ABC	2.9	ABC	12.8	ABC	6.45	BCDE	53.4	EF	127	BCD	80.3	H	183	ABCD	35	10
Foster	6	32.1	77.0	44.0	78.4	F	2.5	ABC	12.9	ABC	5.68	ABCD	47.2	BCDEF	132	BCD	64.5	CDE	260	DE	29	21
Legacy	6	29.9	73.1	40.3	79.5	ABCDEF	2.6	ABC	13.3	ABC	6.43	BCDE	50.7	CDEF	147	ABC	78.1	GH	232	CDE	27	26
MNBrite	6	31.1	74.1	43.7	78.9	CDEF	3.6	C	14.7	C	7.15	E	50.7	CDEF	181	A	70.9	DEFGH	74	AB	23	27
Drummond	6	32.2	82.8	47.7	79.4	ABCDEF	2.3	ABC	13.3	ABC	5.71	ABCD	45.3	ABCD	158	AB	62.9	BCD	146	ABCD	39	5
Lacey	6	32.1	75.6	43.7	79.3	BCDEF	2.2	BC	13.2	ABC	5.53	AB	43.1	ABC	137	BCD	58.6	ABC	161	ABCD	39	5
M103	6	32.2	78.1	43.7	79.7	ABCDEF	2.7	ABC	12.9	ABC	6.11	ABCD	50.0	CDEF	115	CD	68.5	CDEFG	176	ABCD	34	11
ND16301	6	32.7	83.7	47.3	80.1	ABCDE	2.7	ABC	12.4	AB	5.66	ABCD	48.0	BCDEF	143	ABC	63.0	BCD	145	ABCD	40	3
6B95-2482	6	32.3	80.2	46.3	79.6	ABCDEF	2.4	ABC	12.8	ABC	5.44	A	43.6	ABCD	151	ABC	57.2	ABC	203	ABCD	46	1
6B96-3733	6	31.8	82.8	45.3	79.7	ABCDEF	2.5	ABC	13.0	ABC	5.53	AB	44.3	ABCD	150	ABC	63.7	BCDE	202	ABCD	38	7
M106	6	32.0	77.7	43.7	80.4	ABC	2.6	ABC	12.9	ABC	5.99	ABCD	49.7	CDEF	136	BCD	66.2	CDEF	152	ABCD	31	18
M108	6	32.2	78.3	45.7	80.5	ABC	2.7	ABC	12.6	AB	6.15	ABCD	51.4	DEF	113	CD	67.5	CDEFG	189	ABCD	32	14
6B95-2089	6	31.3	76.7	45.0	79.7	ABCDEF	2.2	ABC	13.1	ABC	5.57	ABC	44.5	ABCD	148	ABC	60.2	ABCD	177	ABCD	41	2
M109	6	32.0	72.0	44.7	80.7	AB	2.3	ABC	12.4	A	5.71	ABCD	47.4	BCDEF	143	ABC	64.6	CDE	110	ABC	38	7
M110	6	32.2	76.4	42.7	80.2	ABCD	2.5	ABC	12.6	AB	5.53	AB	45.8	ABCDE	142	ABC	58.3	ABC	202	ABCD	38	7
ND16318	6	32.5	85.1	41.0	79.2	BCDEF	2.7	ABC	12.5	AB	6.00	ABCD	49.1	CDEF	120	BCD	62.8	BCD	233	CDE	32	14
ND16903	6	31.9	82.4	45.0	79.5	ABCDEF	2.4	ABC	13.4	ABC	6.23	ABCD	48.4	BCDEF	144	ABC	68.4	CDEFG	340	E	30	19
ND16922	6	31.4	83.9	48.0	79.6	ABCDEF	2.6	ABC	13.0	ABC	6.19	ABCD	50.2	CDEF	142	ABC	75.1	EFGH	198	ABCD	33	13
6B97-2037	6	33.6	84.7	43.0	79.6	ABCDEF	2.7	ABC	13.7	ABC	6.09	ABCD	46.0	ABCDE	137	BCD	63.2	BCD	167	ABCD	32	14
6B97-2195	6	32.8	76.6	42.0	78.6	DEF	2.5	ABC	13.2	ABC	5.54	AB	44.5	ABCD	139	BCD	50.7	A	81	AB	32	14
6B97-2245	6	31.1	73.8	42.7	78.1	F	2.2	BC	13.2	ABC	5.56	ABC	44.2	ABCD	142	ABC	61.1	ABCD	64	A	34	11
BT386	6	30.6	71.5	48.7	79.8	ABCDEF	3.0	ABC	13.0	ABC	6.58	DE	53.4	EF	127	BCD	76.9	FGH	135	ABCD	28	23
BT484	6	31.6	81.3	44.0	80.2	ABCD	3.2	ABC	12.9	ABC	6.51	CDE	53.1	EF	122	BCD	77.0	FGH	159	ABCD	30	19
CDC Battleford	6	30.4	68.8	45.7	81.2	A	3.3	B	12.7	ABC	6.47	BCDE	53.8	F	101	D	81.2	H	158	ABCD	31	18

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

** Crookson and Morris, MN, and Bottineau, ND

2001 MISSISSIPPI VALLEY REGIONAL NURSERY - 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)	Quality Score	Overall Rank
4588	Barbless	6	32.9	71.6	38	76.6	1.6	1	13.3	4.99	38.4	118	50.1	238	32	25
4590	Larker	6	34.4	88.2	34	77.4	2.4	2	14.6	5.07	36.3	157	50.2	216	35	20
4591	Morex	6	30.0	70.5	42	78.6	2.0	1	13.5	5.71	43.3	145	66.7	125	38	15
4592	Robust	6	34.5	92.2	40	79.2	1.5	1	13.6	5.52	41.6	156	49.4	146	53	3
4593	Stander	6	35.3	97.0	43	81.2	2.7	1	12.3	6.32	54.6	123	80.7	128	39	12
4594	Foster	6	36.1	95.1	41	79.4	2.4	2	12.2	5.45	48.5	117	61.1	225	34	23
4595	Legacy	6	32.0	91.2	*28	79.8	2.5	1	13.2	6.36	51.4	146	78.9	209	34	23
4596	MNBrite	6	32.7	85.3	39	80.2	*5.4	1	14.4	*7.93	57.6	166	75.3	36	26	28
4597	Drummond	6	33.4	91.8	45	79.7	1.9	1	12.9	5.54	45.6	151	64.7	123	46	8
4598	Lacey	6	34.9	91.2	38	79.5	2.1	2	13.4	5.33	41.0	132	57.5	139	46	8
4599	M103	6	34.3	90.2	42	80.4	2.5	1	11.7	5.97	54.1	90	70.4	153	38	15
4600	ND16301	6	35.7	97.1	48	80.7	n.d.	3	12.2	5.62	48.6	130	63.6	154	40	11
4601	6B95-2482	6	35.0	94.4	41	80.0	n.d.	3	12.5	5.13	42.5	140	55.2	234	56	1
4602	6B96-3733	6	33.7	93.5	41	79.4	n.d.	3	13.2	5.20	40.3	151	58.9	172	48	6
4603	M106	6	34.0	88.5	36	80.7	2.2	2	12.6	5.50	46.4	129	66.2	100	36	19
4604	M108	6	33.0	86.7	39	80.7	2.4	1	12.2	5.82	50.2	107	66.8	158	38	15
4605	6B95-2089	6	34.3	92.1	42	80.1	1.9	2	12.8	5.16	42.0	141	56.9	168	52	4
4606	M109	6	35.6	93.4	40	81.3	2.0	2	12.1	5.16	45.1	132	62.3	127	54	2
4607	M110	6	36.1	94.4	38	80.3	n.d.	3	13.0	5.32	43.4	150	57.3	207	47	7
4608	ND16318	6	34.8	96.9	38	79.8	2.5	1	12.2	5.77	49.2	100	64.0	261	35	20
4609	ND16903	6	35.2	93.0	40	79.4	2.1	1	13.8	5.91	44.9	149	67.7	393	39	12
4611	ND16922	6	34.6	98.0	46	80.1	2.0	1	12.2	5.57	48.5	133	74.3	263	42	10
4612	6B97-2037	6	36.1	96.0	38	79.9	1.7	2	13.5	5.38	41.1	122	55.5	227	38	15
4613	6B97-2195	6	35.1	90.5	37	78.7	1.7	1	13.0	4.76	39.2	126	44.1	145	39	12
4614	6B97-2245	6	33.3	88.2	37	78.2	1.6	1	13.3	4.98	38.8	141	53.9	94	49	5
4615	BT386	6	32.4	84.7	40	79.5	2.5	1	13.2	6.13	49.5	131	73.0	202	31	26
4616	BT484	6	33.7	90.0	38	79.8	2.4	1	13.3	6.07	47.6	133	70.4	251	31	26
4617	CDC Battleford	6	31.2	74.3	40	80.6	2.2	1	12.5	5.62	48.5	98	75.9	255	35	20

Table 4

Lab No.	Variety	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)	Quality Score
4589	MOREX MALT CHECK	6	31.3	70.8	75	80.4	2.0	1	13.0	6.15	51.0	122	72.9	76	27
4610	MOREX MALT CHECK	6	31.5	72.0	74	80.3	2.2	1	12.2	6.06	51.9	124	76.7	76	32
Minima			30.0	70.5	34	76.6	1.5		11.7	4.76	36.3	90	44.1	36	26
Maxima			36.1	98.0	48	81.3	2.7		14.6	6.36	57.6	166	80.7	393	56
Means			34.1	89.9	40	79.7	2.1		12.9	5.53	45.6	133	63.2	184	40
Standard Deviations			1.5	7.2	3	1.1	0.3		0.7	0.42	5.3	19	9.6	71	8
Coefficients of Variation			4.4	8.0	8	1.3	16.5		5.4	7.56	11.6	14	15.1	38	19

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 K. Smith, University of Minnesota - St. Paul

2001 MISSISSIPPI VALLEY REGIONAL NURSERY - 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)	Quality Score	Overall Rank
4618	Barbless	6	32.2	73.0	46	75.7	1.9	2	14.6	5.77	40.1	153	49.3	304	31	12
4619	Larker	6	33.3	82.9	44	76.6	1.9	2	15.5	5.66	38.8	175	51.5	249	24	24
4620	Morex	6	31.9	72.8	48	78.4	2.0	1	14.9	6.31	43.2	178	65.0	193	21	28
4621	Robust	6	33.4	80.1	45	78.3	1.8	1	14.5	6.18	44.6	181	50.9	298	31	12
4622	Stander	6	32.2	83.1	45	80.0	2.7	1	13.8	6.82	51.5	137	76.2	281	34	7
4623	Foster	6	33.3	84.7	43	76.9	2.1	2	13.7	5.61	42.9	151	56.9	315	35	6
4624	Legacy	6	31.4	81.0	43	79.0	2.4	1	14.4	6.76	49.5	169	70.2	344	22	27
4625	MNBrite	6	32.2	81.9	43	77.9	2.3	1	16.0	6.97	44.7	214	63.9	125	24	24
4626	Drummond	6	33.7	85.2	49	78.6	1.9	1	14.6	5.80	41.0	182	59.0	207	31	12
4627	Lacey	6	32.8	78.8	46	78.7	2.1	1	14.1	5.69	41.0	153	53.2	227	41	2
4628	M103	6	32.5	82.7	42	78.3	2.5	1	14.8	6.41	45.1	140	62.6	270	31	12
4629	ND16301	6	32.8	83.6	47	79.0	2.1	1	13.8	5.91	44.8	169	59.3	186	43	1
4630	6B95-2482	6	32.7	81.4	44	78.5	2.0	1	13.8	5.87	42.9	174	54.9	283	39	4
4632	6B96-3733	6	30.3	73.9	49	78.1	2.1	1	14.4	5.80	42.3	178	60.0	261	28	20
4633	M106	6	32.3	78.7	49	79.3	2.2	1	14.1	6.35	47.5	160	62.0	250	26	22
4634	M108	6	33.0	83.1	48	79.7	2.4	1	13.8	6.57	49.1	122	64.7	321	24	24
4635	6B95-2089	6	31.1	78.8	46	79.1	2.1	2	13.8	5.91	44.6	168	59.2	245	41	2
4636	M109	6	31.6	72.0	45	80.1	2.1	1	12.7	6.23	49.0	178	63.3	130	31	12
4637	M110	6	32.0	76.5	46	79.6	2.3	2	13.3	5.93	46.5	159	57.5	226	37	5
4638	ND16318	6	32.3	83.8	44	77.6	2.6	1	13.8	6.59	48.0	146	61.2	258	27	21
4639	ND16903	6	31.3	81.2	49	79.0	2.4	1	14.2	6.96	51.0	161	67.9	286	25	23
4640	ND16922	6	31.2	83.0	52	79.2	2.7	2	14.0	7.09	52.6	168	72.6	220	29	17
4641	6B97-2037	6	34.8	87.6	45	78.2	1.8	1	15.0	6.26	43.4	168	59.9	224	32	10
4642	6B97-2195	6	33.1	78.5	42	78.0	2.2	2	14.1	5.95	43.9	163	48.9	73	33	9
4643	6B97-2245	6	31.6	74.5	44	77.5	2.1	2	14.0	5.87	44.8	161	58.2	72	32	10
4644	BT386	6	31.8	78.0	54	79.4	2.8	1	14.2	7.28	53.6	140	74.1	128	29	17
4645	BT484	6	31.7	83.1	48	80.3	2.9	1	13.7	7.02	53.8	126	72.7	168	29	17
4646	CDC Battleford	6	32.9	84.7	53	81.3	3.0	1	13.8	7.28	56.3	117	80.7	140	34	7

Table 5

Lab No.	Variety	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)	Quality Score
4631	MOREX MALT CHECK	6	31.2	72.4	73	80.3	2.2	1	12.1	6.09	51.9	116	68.5	137	36
Minima			30.3	72.0	42	75.7	1.8		12.7	5.61	38.8	117	48.9	72	21
Maxima			34.8	87.6	54	81.3	3.0		16.0	7.28	56.3	214	80.7	344	43
Means			32.3	80.3	46	78.7	2.3		14.2	6.32	46.3	160	62.0	224	31
Standard Deviations			0.9	4.2	3	1.2	0.3		0.7	0.53	4.5	21	8.2	74	6
Coefficients of Variation			2.9	5.2	7	1.5	14.6		4.6	8.40	9.8	13	13.3	33	19

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 K. Smith, University of Minnesota - St. Paul

2001 MISSISSIPPI VALLEY REGIONAL NURSERY - BOTTINEAU, 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)	Quality Score	Overall Rank
4494	BARBLESS	6	27.5	48.3	43	*76.6	2.1	2	13.9	5.37	39.3	148	57.5	155	23	25
4495	LARKER	6	28.7	63.0	45	80.0	2.7	1	13.5	6.02	48.0	140	74.2	211	26	19
4496	MOREX	6	26.1	34.4	46	78.2	3.0	1	14.3	6.40	45.9	155	72.0	88	25	21
4497	ROBUST	6	28.3	46.0	45	79.0	2.2	1	12.6	5.70	45.8	133	55.7	184	35	5
4498	STANDER	6	28.4	65.5	44	80.6	3.3	1	12.2	6.22	54.2	120	84.0	139	31	9
4499	FOSTER	6	27.0	51.2	48	78.8	3.0	1	12.7	5.97	50.2	129	75.5	240	17	28
4500	LEGACY	6	26.2	47.0	50	79.6	2.9	1	12.2	6.17	51.3	125	85.3	143	26	19
4501	MNBRITE	6	28.5	55.1	49	78.6	3.1	1	13.8	6.55	49.8	162	73.6	60	20	27
4502	DRUMMOND	6	29.5	71.3	49	80.0	3.0	1	12.4	5.80	49.4	140	64.9	107	41	2
4504	LACEY	6	28.7	56.7	47	79.8	2.4	1	12.2	5.58	47.2	127	65.0	118	31	9
4505	M103	6	29.8	61.5	47	80.4	3.0	1	12.2	5.96	50.9	114	72.6	104	34	7
4506	ND16301	6	29.6	70.3	47	80.7	2.7	1	11.3	5.44	50.5	130	66.0	94	37	3
4507	6B95-2482	6	29.3	64.9	54	80.2	2.5	1	12.2	5.33	45.3	139	61.6	93	43	1
4508	6B96-3733	6	31.3	80.9	46	81.6	2.7	1	11.3	5.58	50.4	121	72.2	173	37	3
4509	M106	6	29.6	65.9	46	81.1	3.3	1	12.0	6.12	55.1	118	70.4	107	31	9
4510	M108	6	30.6	65.1	50	81.0	3.2	1	11.7	6.06	54.8	109	71.1	88	33	8
4511	6B95-2089	6	28.5	59.1	47	79.8	2.7	1	12.7	5.63	47.0	135	64.4	119	30	12
4512	M109	6	28.9	50.6	49	80.8	2.7	1	12.4	5.74	48.2	120	68.3	74	30	12
4513	M110	6	28.5	58.3	44	80.6	2.6	1	11.5	5.35	47.5	117	60.2	173	30	12
4514	ND16318	6	30.4	74.7	41	80.1	2.9	1	11.5	5.64	50.1	115	63.2	180	35	5
4515	ND16903	6	29.2	73.0	46	80.0	2.6	1	12.3	5.83	49.3	121	69.7	*340	27	17
4516	ND16922	6	28.5	70.8	46	79.6	3.2	1	12.8	5.92	49.4	125	78.3	111	29	16
4517	6B97-2037	6	30.0	70.4	46	80.6	4.7	1	12.6	6.64	53.4	120	74.2	49	27	17
4518	6B97-2195	6	30.1	60.8	47	79.0	3.5	1	12.6	5.91	50.4	128	59.1	24	25	21
4519	6B97-2245	6	28.5	58.8	47	78.5	2.8	1	12.2	5.83	49.1	125	71.3	26	21	26
4520	BT386	6	27.6	51.9	52	80.4	3.8	1	11.6	6.33	57.1	110	83.5	76	25	21
4521	BT484	6	29.5	70.9	46	80.6	4.2	1	11.7	6.43	57.9	106	87.9	57	30	12
4522	CDC BATTLEFORD	6	27.2	47.3	44	81.6	4.8	1	11.7	6.52	56.7	87	87.0	80	25	21

Table 6

Lab No.	Variety	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)	Quality Score
4503	HARRINGTON MALT CHECK	2	38.8	93.5	79	82.2	1.8	1	11.7	5.21	47.4	90	66.2	305	32
4523	HARRINGTON MALT CHECK	2	39.5	94.2	82	81.9	1.8	1	12.1	5.48	49.2	100	72.1	68	39
Minima			26.1	34.4	41	78.2	2.1		11.3	5.33	39.3	87	55.7	24	17
Maxima			31.3	80.9	54	81.6	4.8		14.3	6.64	57.9	162	87.9	240	43
Means			28.8	60.5	47	80.0	3.0		12.4	5.93	50.1	126	71.0	114	29
Standard Deviations			1.3	10.7	3	0.9	0.6		0.8	0.38	4.0	15	8.9	55	6
Coefficients of Variation			4.4	17.7	6	1.1	21.3		6.2	6.38	8.1	12	12.6	48	21

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 S. Askelson, BARI - Ft. Collins, CO

2001 MISSISSIPPI VALLEY BARLEY NURSERY AND ADDITIONS - ABERDEEN

Table 7

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	Quality Score	Overall Rank
2422	Barbless	6	34.0	*64.0	74	*73.5	1.4	2	14.9	4.16	29.4	81	*32.1	*542	6	33
2423	Larker	6	36.9	80.9	69	77.1	1.8	2	14.6	4.89	34.5	134	43.6	237	29	29
2424	Morex	6	35.0	73.6	66	77.9	1.6	1	15.4	5.45	36.7	186	53.9	213	23	31
2425	Robust	6	38.7	90.5	68	79.6	1.7	1	15.2	5.66	38.0	171	49.9	173	32	28
2426	Stander	6	36.7	86.3	80	80.5	1.8	1	13.0	5.56	43.2	138	61.4	242	42	16
2427	Foster	6	39.5	92.6	76	79.7	1.8	1	13.2	5.31	41.0	146	56.6	237	46	9
2428	Legacy	6	34.9	84.0	80	80.0	1.7	1	13.9	5.86	43.8	175	68.7	276	35	25
2429	MNBrite	6	37.9	91.1	72	78.5	1.7	1	16.6	6.14	39.3	232	62.7	144	23	31
2430	Drummond	6	35.6	89.4	78	78.6	1.8	2	14.8	5.15	35.6	183	54.3	134	36	22
2431	Lacey	6	37.8	87.6	71	79.4	1.7	1	15.1	5.41	38.0	172	55.7	100	33	26
2432	M103	6	39.4	90.1	73	79.4	1.7	1	14.1	5.49	39.5	149	58.6	156	36	22
2433	ND16301	6	38.6	94.4	80	80.6	1.7	2	12.8	5.08	40.5	162	55.1	130	53	2
2434	6B95-2482	6	38.5	93.0	76	80.2	1.7	2	13.9	4.95	36.8	167	52.3	149	51	3
2435	6B96-3733	6	39.9	93.3	76	81.0	1.9	1	13.6	6.05	47.0	149	66.5	90	41	18
2437	M106	6	38.0	89.2	74	80.7	1.7	1	13.5	5.89	44.4	161	64.7	95	46	9
2438	M108	6	36.6	82.4	75	80.2	1.7	1	13.0	5.63	44.8	137	60.5	156	42	16
2439	6B95-2089	6	37.0	84.3	72	80.2	1.6	1	14.2	5.03	37.5	148	52.9	202	46	9
2440	M109	6	38.1	87.0	76	80.5	1.7	1	14.0	5.24	38.6	164	54.5	149	47	7
2441	M110	6	38.1	90.9	72	80.4	1.9	2	13.3	5.07	39.0	162	51.6	212	47	7
2442	ND16318	6	38.7	93.7	72	80.7	1.8	1	13.3	5.83	43.8	135	60.0	161	46	9
2443	ND16903	6	36.8	89.2	72	79.8	1.6	1	13.9	5.51	41.5	153	60.8	354	39	19
2444	ND16922	6	36.1	90.3	76	80.1	1.7	1	13.9	5.52	40.8	150	65.0	288	45	13
2445	6B97-2037	6	37.1	87.3	73	79.6	1.5	1	14.3	5.30	38.5	149	55.5	201	36	22
2446	6B97-2195	6	37.1	87.1	73	78.9	1.4	1	13.6	4.75	37.2	142	46.1	87	49	4
2447	6B97-2245	6	38.1	90.1	78	78.0	1.5	1	13.9	4.88	36.7	155	50.6	97	49	4
2448	BT386	6	34.8	80.7	79	80.2	1.8	1	13.8	5.71	43.6	144	64.1	218	45	13
2449	BT484	6	36.5	86.8	75	80.1	2.0	1	13.4	5.78	44.5	123	62.9	250	38	20
2450	CDC Battleford	6	33.2	68.3	76	81.3	1.8	1	13.7	5.54	43.2	107	70.6	251	33	26
2451	M104	6	36.5	85.2	76	80.7	1.6	1	13.9	5.62	41.1	144	62.6	233	45	13
2452	ND17190	6	39.0	95.6	74	78.9	*2.5	1	13.3	6.35	51.0	86	75.9	266	24	30

Table 7

Lab No.	Variety or Selection	Rowed	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°ASBC)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	Quality Score	Overall Rank
2453	6B96-3373	6	37.5	91.0	76	79.3	1.6	1	14.3	5.25	38.3	166	57.3	186	37	21
2454	92AB5180	6	37.5	81.2	72	81.9	2.1	1	11.8	5.36	47.6	141	58.3	74	49	4
2455	98AB12362	6	39.4	92.1	81	81.2	1.8	1	12.8	4.95	41.0	136	53.4	141	57	1
2436	MOREX MALT CHECK	6	31.1	70.4	74	80.1	2.1	1	12.2	5.95	50.6	129	69.9	45	35	
Minima			33.2	68.3	66	77.1	1.4		11.8	4.16	29.4	81	43.6	74	6	
Maxima			39.9	95.6	81	81.9	2.1		16.6	6.35	51.0	232	75.9	354	57	
Means			37.3	87.5	75	79.9	1.7		13.9	5.40	40.5	150	58.3	184	40	
Standard Deviations			1.6	5.9	4	1.1	0.1		0.9	0.45	4.2	28	7.1	68	10	
Coefficients of Variation			4.4	6.8	5	1.3	8.3		6.5	8.26	10.5	18	12.1	37	26	

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 C. Erickson, USDA/ARS - Aberdeen

MISSISSIPPI VALLEY UNIFORM BARLEY NURSERY - 2001 Crop

Table 8 - Station Means* of Barley and Malt Quality Factors for 28 Varieties or Selections**.

Location	Barley Kernel Weight (mg)		on 6/64" (%)		Barley Color (Agtron)		Malt Extract (%)		Wort Color		Barley Protein (%)		Wort Protein (%)		S/T (%)		DP (°)		Alpha-amylase (20° DU)		Beta-glucan (ppm)	
Aberdeen, ID	37.1	A	86.4	A	74.4	A	79.5	A	1.7	A	14.0	C	5.39	A	39.9	A	153	A	56.8	A	198	B
Crookston, MN	34.1	B	89.9	A	39.6	C	79.7	A	2.3	B	13.0	B	5.62	A	45.7	B	133	B	63.3	B	184	B
Morris, MN	32.3	C	80.3	B	46.4	B	78.7	B	2.3	B	14.2	C	6.32	C	46.3	B	160	A	62.0	B	224	B
Bottineau, ND	28.8	D	60.5	C	46.8	B	79.9	A	3.1	C	12.4	A	5.93	B	50.2	C	126	B	71.0	C	122	A

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

** Barbless, Larker, Morex, Robust, Stander, Foster, Legacy, MNBrite, Drummond, Lacey, M103, ND16301,6B95-2482 6B96-3733, M106, M108, 6B95-2089, M109, M110, ND16318, ND16903, ND16922, 6B97-2037, 6B97-2195, 6B97-2245 BT386, BT484, CDC Battleford

MISSISSIPPI VALLEY UNIFORM BARLEY NURSERY - 2001 Crop

Table 9 - Varietal Means* of Barley and Malt Quality Factors for 4 Stations**.

Variety	Rowed	Barley Kernel Weight (mg)	on 6/64 (%)	Barley Color (Agtron)	Malt Extract (%)		Wort Color		Barley Protein (%)		Wort Protein (%)		S/T (%)		DP (°)		Alpha-amylase (20° DU)		Beta-glucan (ppm)		Ave. Quality Score	Overall Rank
Barbless	6	31.7	64.2	50.3	75.6	J	1.8	A	14.2	ABCD	5.07	A	36.8	A	125	DEFG	47.3	A	310	FG	23	28
Larker	6	33.3	78.8	48.0	77.8	I	2.2	AB	14.6	CD	5.41	ABCDE	39.4	AB	152	BCDEF	54.9	ABCD	228	DEF	29	25
Morex	6	30.8	62.8	50.5	78.3	GHI	2.2	AB	14.5	BCD	5.97	BCDEF	42.3	ABCD	166	AB	64.4	DEFGH	155	ABCDE	27	26
Robust	6	33.7	77.2	49.5	79.0	DEFGHI	1.8	A	14.0	ABCD	5.77	ABCDEF	42.5	ABCDE	160	BCD	51.5	ABC	200	BCDEF	38	8
Stander	6	33.2	83.0	53.0	80.6	ABC	2.6	AB	12.8	AB	6.23	CDEFG	50.9	DE	130	CDEFG	75.6	HI	198	BCDEF	37	11
Foster	6	34.0	80.9	52.0	78.7	FGHI	2.3	AB	13.0	ABC	5.59	ABCDEF	45.7	BCDE	136	BCDEFG	62.5	CDEFG	254	EFG	33	19
Legacy	6	31.1	75.8	50.3	79.6	BCDEFG	2.4	AB	13.4	ABC	6.29	EFG	49.0	CDE	154	BCDEF	75.8	HI	243	EFG	29	24
MNBrite	6	32.8	78.4	50.8	78.8	EFGHI	3.1	B	15.2	D	6.90	G	47.9	BCDE	194	A	68.9	EFGHI	91	ABC	23	27
Drummond	6	33.1	84.4	55.3	79.2	CDEFGH	2.2	AB	13.7	ABCD	5.57	ABCDEF	42.9	ABCDE	164	ABC	60.7	BCDEF	143	ABCDE	39	6
Lacey	6	33.6	78.6	50.5	79.4	BCDEFGH	2.1	AB	13.7	ABCD	5.50	ABCDEF	41.8	ABC	146	BCDEF	57.9	ABCDE	146	ABCDE	38	8
M103	6	34.0	81.1	51.0	79.6	BCDEFG	2.4	AB	13.2	ABC	5.96	BCDEF	47.4	BCDE	123	EFG	66.1	DEFGH	171	ABCDE	35	15
ND16301	6	34.2	86.4	55.5	80.3	ABCD	2.4	AB	12.5	A	5.51	ABCDEF	46.1	BCDE	148	BCDEF	61.0	BCDEF	141	ABCDE	43	2
6B95-2482	6	33.9	83.4	53.8	79.7	BCDEF	2.3	AB	13.1	ABC	5.32	AB	41.9	ABC	155	BCDE	56.0	ABCD	190	ABCDE	47	1
6B96-3733	6	33.8	85.4	53.0	80.0	ABCDEF	2.3	AB	13.1	ABC	5.66	ABCDEF	45.0	ABCDE	150	BCDEF	64.4	DEFGH	174	ABCDE	39	6
M106	6	33.5	80.6	51.3	80.5	ABCD	2.4	AB	13.1	ABC	5.97	BCDEF	48.4	CDE	142	BCDEF	65.8	DEFGH	138	ABCDE	35	15
M108	6	33.3	79.3	53.0	80.4	ABCD	2.4	AB	12.7	A	6.02	BCDEF	49.7	CDE	119	FG	65.8	DEFGH	181	ABCDE	34	17
6B95-2089	6	32.7	78.6	51.8	79.8	BCDEF	2.1	AB	13.4	ABC	5.43	ABCDE	42.8	ABCDE	148	BCDEF	58.4	ABCDE	184	ABCDE	42	3
M109	6	33.6	75.8	52.5	80.7	AB	2.1	AB	12.8	A	5.59	ABCDEF	45.2	ABCDE	149	BCDEF	62.1	CDEFG	120	ABCD	41	4
M110	6	33.7	80.0	50.0	80.2	ABCD	2.3	AB	12.8	A	5.42	ABCDE	44.1	ABCDE	147	BCDEF	56.7	ABCD	205	CDEF	40	5
ND16318	6	34.1	87.3	48.8	79.6	BCDEFG	2.5	AB	12.7	A	5.96	BCDEF	47.8	BCDE	124	EFG	62.1	CDEFG	215	DEF	36	14
ND16903	6	33.1	84.1	51.8	79.6	BCDEFG	2.2	AB	13.6	ABC	6.05	BCDEF	46.7	BCDE	146	BCDEF	66.5	DEFGH	343	G	33	20
ND16922	6	32.6	85.5	55.0	79.8	BCDEF	2.4	AB	13.2	ABC	6.03	BCDEF	47.9	BCDE	144	BCDEF	72.6	FGHI	221	DEF	36	13
6B97-2037	6	34.5	85.3	50.5	79.6	BCDEFG	2.4	AB	13.9	ABCD	5.90	ABCDEF	44.1	ABCDE	140	BCDEF	61.3	BCDEF	175	ABCDE	33	18
6B97-2195	6	33.9	79.2	49.8	78.7	FGHI	2.2	AB	13.3	ABC	5.34	ABC	42.7	ABCDE	140	BCDEF	49.6	AB	82	AB	37	11
6B97-2245	6	32.9	77.9	51.5	78.1	HI	2.0	AB	13.4	ABC	5.39	ABCD	42.4	ABCDE	146	BCDEF	58.5	ABCDE	72	A	38	8
BT386	6	31.7	73.8	56.3	79.9	ABCDEF	2.7	AB	13.2	ABC	6.36	FG	51.0	DE	131	BCDEFG	73.7	GHI	156	ABCDE	33	20
BT484	6	32.9	82.7	51.8	80.2	ABCDE	2.9	AB	13.0	ABC	6.33	FG	51.0	DE	122	EFG	73.5	GHI	182	ABCDE	32	22
CDC Battleford	6	31.1	68.7	53.3	81.2	A	3.0	AB	12.9	ABC	6.24	DEFG	51.2	E	102	G	78.6	I	182	ABCDE	32	23

* 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, Crookson and Morris, MN, and Bottineau, ND

Quality Score Parameters for 2- and 6-rowed barleys

	2-rowed		6-rowed	
Quality parameter	condition	score	condition	score
Kernel Weight	> 42.0	5	> 32.0	5
(mg)	40.1–42.0	4	30.1–32.0	4
	38.1–40.0	2	28.1–30.0	2
	≤ 38.0	0	≤ 28.0	0
on 6/64 "	≥ 90.0	5	≥ 77.0	5
(%)	85.0–89.9	3	70.0–76.9	3
	< 85.0	0	< 70.0	0
Malt Extract	≥ 81.0	10	≥ 80.0	10
(% db)	79.5–80.9	7	79.0–79.9	7
	78.0–79.4	4	78.0–78.9	4
	<78.0	0	< 78.0	0
Wort Clarity	= 3	0	= 3	0
3=hazy	= 2	1	= 2	1
2=slightly hazy	= 1	2	= 1	2
1=clear				
Barley Protein	≥ 13.5	0	≥ 14.0	0
(% db)	12.6–13.4	5	12.6–13.9	5
	10.1–12.5	10	10.6–12.5	10
	≤ 10.0	5	≤ 10.5	5
Wort Protein	> 6.0	0	> 6.0	0
(% db)	5.1–6.0	3	5.3–6.0	3
	4.4–5.0	7	4.6–5.2	7
	< 4.4	0	< 4.6	0
S/T (Soluble/Total	> 46.0	0	> 46.0	0
Protein, % db)	40.0–46.0	5	40.0–46.0	5
	< 40.0	0	< 40.0	0
DP (Diastatic	> 140.0	0	> 170.0	0
Power, ° ASBC)	130.1–140.0	4	160.1–170.0	4
	110.0–130.0	7	140.0–160.0	7
	95.0–109.9	4	130.0–139.9	4
	< 95.0	0	< 130.0	0
Alpha-amylase	> 55.0	0	> 60.0	0
(20° DU)	50.1–55.0	4	55.1–60.0	4
	40.0–50.0	7	45.0–55.0	7
	35.0–39.9	4	40.0–44.9	4
	< 35.0	0	< 40.0	0
Beta-glucan	< 40	0	< 40	0
(ppm)	40 –80	3	40 –80	3
	80 – 150	7	80 – 150	7
	150 – 300	3	150 – 300	3
	> 300	0	> 300	0

Appendix A: METHODS

Cleaning All samples were cleaned on a Carter Dockage Tester and any material not retained on a 5/64" screen was discarded.

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 M31A analyzer.

Barley Moisture Content Five g of ground sample was dried for 3 h at 106°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) barley samples were steeped at 16°C for 32-48 h, to 45% moisture, by alternating 4 h of wet steep with 4 h of air rest. The steeped samples were placed in a chamber for 5 d at 17°C and near 100% R.H., in cans which were rotated for 3.0 min every 30 min. The germinated grain (green malt) was kilned for 24 h as follows: 0.5 h from 25 C to 49°C, 9.5 h at 49°C, 0.5 h from 49°C to 54°C, 4.0 h at 54°C, 0.5 h from 54°C to 60°C, 3.0 h at 60°C, 0.5 h from 60°C to 68°C, 2.0 h at 68°C, 0.5h from 68°C to 85°C, and 3.0 h at 85°C.

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. Coarse-grind malts were prepared with a corrugated roll mill that was adjusted so that 75% of the grist remained on a 525 µm sieve. Ground malts for moisture, protein and amylolytic activity analyses were ground in a Labconco Burr mill (see Barley Mill).

Malt Moisture Content See Barley Moisture Content.

Malt Protein Content See Barley Protein Content.

Malt Extract The finely ground 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 subtracting the absorbance at 700 nm from that at 430nm and dividing by a factor that was determined by comparison with values obtained in a collaborative test.

Wort Clarity was assessed by visual inspection.

b-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).

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-6A (Methods of Analysis of the ASBC, 8th ed, 1992).

a-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.

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.