UNITED STATES DEPARTMENT OF AGRICULTURE
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WESTERN REGIONAL SPRING BARLEY NURSERY
2011 Crop

Preliminary Quality Report

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Detailed Data:

Aberdeen, ID
Idaho Falls, ID
Tiber, 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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Western Regional Spring Barley Nursery – 2011 Crop

Barley samples from the 2011 Western Regional Spring Barley Nursery (WRSBN), were grown at experimental stations in Aberdeen, ID, Idaho Falls, ID and Tiber, Montana, and submitted to the USDA-ARS Cereal Crops Research Unit, in Madison, WI, for malting and quality analysis. (Only a subset of the 31 WRSBN samples was received from Aberdeen). Table 1 is an entry list, with parentages for the 2011 WRSBN, from the agronomic report on these barleys, compiled by Dr. Charles Erickson of the USDA-ARS National Small Grains Germplasm Research Facility, Aberdeen, ID: http://www.ars.usda.gov/main/docs.htm?docid=2923 .

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 WRSBN stations (Table 2), and across all lines (Table 3). Individual station data are reported in Tables 4 through 6. Evaluations of data from individual locations and overall performance of each line, derived mostly from Tables 2 and 3, are presented, as well.

The barleys received from Tiber, Montana were significantly smaller (average kernel weight (mg)) than those from Aberdeen and Idaho Falls, which were also significantly plumper (6/64" screen) than those from Tiber, but not significantly different, on average, from each other (Table 2). This affected Malt Extract (%) averages, with Tiber significantly lower than the other two locations. Tiber, Montana had the highest kernel brightness (Agtron) average – significantly greater than Aberdeen, which was greater than Idaho Falls. Not surprisingly, the converse pattern was displayed for the wort color averages: Idaho Falls higher than Aberdeen higher than Tiber. The Tiber barleys were also distinctive for having significantly lower average barley protein than the other two locations, and this carried through to wort protein, Kohlbach Index, and FAN, with all Tiber averages significantly lower than the other locations. As another consequence of the lower barley protein average, the Tiber barleys showed significantly less average Diastatic Power and Alpha-amylase than Idaho Falls or Aberdeen. Tiber had significantly lower average beta-glucan and viscosity scores than the other locations, but this did not save it from having the lowest average quality score of any location.

2ND24388 was, far and away, the best performing barley submission from Tiber, with the highest Malt Extract score from this location, high DP, and low Beta-Glucan. However, it yielded a hazy wort, with pronounced turbidity. AC Metcalfe, 2B04-0175, 2B06-0929, and 01Ab9663 also produced malts with relatively good quality scores. 05WA-316.99, 06WA-412.4, and WAS 2 were barleys from Tiber which yielded very low malting quality. The former two are feed barleys, and the latter, of "waxy" grade.

Interestingly, the barleys from Aberdeen had the highest Malt Extract (%) average, even though the average plumpness (6/64") and kernel weight (mg) were higher for barleys from Idaho Falls. This clearly was due to the Idaho Falls barleys showing

significantly higher average barley protein levels. The average kernel brightness (Agtron) for these barleys was intermediate to those from the other locations: significantly higher than Idaho Falls and lower than Tiber; wort color then went the other way, with Tiber significantly lower, and Idaho Falls, higher. The average FAN level of the Aberdeen barleys was significantly higher than for the other locations. These barleys produced an excellent average malting quality score of 56.9, which was not significantly lower than the Idaho Falls average. ND23898 had the highest quality score from this location, and included a DP score of 167, and 260ppm FAN. 2B07-1590 and 2ND26333 also yielded excellent overall quality scores. This location's high average quality score was helped by the absence of feed barley among the truncated list of submissions.

As mentioned, the Idaho Falls barley submissions were plump, and relatively large, but they displayed the lowest average barley kernel reflectance via Agtron colorimeter, and this led to significantly higher average wort colors than for the other locations. Average barley protein was highest for Idaho Falls, as were average Beta-glucan, viscosity, and turbidity. Even with relatively high average scores on some of these negative malt quality factors, the average overall quality score was an excellent 60.0 – not significantly different from Aberdeen, but higher than Tiber.

The barley, ND23898, which had scored well with sample grown at Aberdeen, received the maximum quality score of 70, with sample grown at Idaho Falls. Superior Diastatic Power and FAN levels were, again, the impetus of the high overall malt quality score. Another top Aberdeen performer, 2B07-1590, received a stellar 69 malting quality score for barley grown here. Its quality profile showed good amylolytic and cytolytic modification. 2B06-0929 and Harrington were other barleys grown at Idaho Falls, which received excellent quality scores. Feed barleys, such as Steptoe, Baronesse, 05WA-316.99, 05WA-316.99, and 06WA-412.4, from this location, not surprisingly, performed the worst with respect to malting quality.

The quality of each WRSBN submission was compared across the three locations. ND22421 achieved the highest mean overall Quality Score – 61.0. Its Malt Extract (%), S/T, and Diastatic Power mean values were the main reasons for the excellent score. 2B07-1590 had the highest mean Quality Score (58.7), among 2-rowed barleys; its low B-Glucan , Viscosity, and Turbidity levels were noteworthy. Other fine overall performers included ND23898 (59.3), 2ND26333 (57.0), 2B06-0929 (56.3), 2B04-0175 (55.3), and CDC Kindersley (55.0). As expected, the feed barleys, 05WA-316.99 (12.5), Steptoe (15.0), and 06WA-412.4 (16.0), and WAS 2 (17.0), exhibited the lowest Malting Quality Scores, among this year's WRSBN submissions. Their relative lack of amylolytic enzymes and low levels of protein modification, across all locations, were especially pronounced.

*We wish to thank the American Malting Barley Association (AMBA) for supporting this project. This report could not have been produced without the commitment and excellent technical work of our staff: Jordon Geurts, USDA-ARS Biological Science Technician; Keith Gilchrist, USDA-ARS Physical Science Technician; Michael Marinac,

USDA-ARS Physical Science Technician; and Andrew Standish, U. of Wisconsin Research Specialist (AMBA-funded).

Table 1: 2011 Western Regional Spring Barley Nursery, Entry List

Seed Source	Entry Number		Entry	Parentage	TYPE	Grade
WSU	1		Steptoe	CI 15229	6 row	feed
WPB	2		Baronesse	PI 568246	2 row	feed
USDA-ARS	3		Harrington		2 row	malting
USDA-ARS	4		AC Metcalfe		2 row	malting
BARI	5		2B04-0175	2B97-4719/2B97-4004	2 row	malting
BARI	6		2B05-0811	2B99-2763/2B00-0719	2 row	malting
BARI	7		2B06-0929	2B97-4004//2B00-0784/2B99-2771	2 row	malting
BARI	8		2B06-0933	2B97-4004//2B97-4299/2B99-2763	2 row	malting
BARI	9	*	2B07-1516		2 row	malting
BARI	10		2B07-1590	MERIT 16/2B01-2005	2 row	malting
USDA-ARS	11	*	01Ab9663	93Ab375//92Ab5189/M83	6 row	malting
USDA-ARS	12		02Ab17271	85Ab2323/Merit	2 row	malting
USDA-ARS	13	*	2Ab04-X01084-27	98Ab11993/Garnet	2 row	malting
MSU	14	*	MT020162		2 row	feed
MSU	15	*	MT061169		2 row	feed
MSU	16	*	MT070111		2 row	feed
NDSU	17		2ND25276	ND20802/3/ND1922//ND19929/ND20177	2 row	malting
NDSU	18	*	2ND24388	ND17274/ND19119//ND19854	2 row	malting
NDSU	19	*	2ND25272	ND20802/3/ND19922//ND19929/ND20177	2 row	malting
NDSU	20	*	2ND26333	ND22032-2/ND21972	2 row	malting
NDSU	21		ND22421	ND18546/ND19656	6 row	malting
NDSU	22	*	ND23898	Drummond/ND17643	6 row	malting
USU	23		UT04B2041-42	Goldeneye/Columbia	6 row	feed
USU	24	*	UT6R2120-14		6 row	feed
WSU	25		05WA-316.K	Baronesse/PB1-95-2R-522	2 row	feed
WSU	26		05WA-316.99	Baronesse/PB1-95-2R-522	2 row	feed
WSU	27	*	06WA-412.4	Bob/Baronesse//Xena/3/WA 10497-97	2 row	feed
WSU	28	*	WAS 2	Bastama/Meresse	2 row	waxy
WSU	29	*	2004NZ151	00NZ304xCellar	2 row	feed
WSU	30	*	2004NZ163	00NZ304x85Ab2323	2 row	feed
USASK	31	*	CDC Kindersley	SM00490/BM9647D-64	2 row	malting

* new entries

WESTERN REGIONAL SPRING BARLEY NURSERY - 2011 Crop

Table 2 - 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	**39.2**a	**95.0**a	**66.1**b	**82.6**a	**2.0**b	**10.7**b	**4.83**b	**47.1**a	**133**a	**83.9**a	**111**a	**224**a	**1.47**b	**5.4**b	**56.9**a
Idaho Falls, ID	**39.4**a	**95.3**a	**57.4**c	**81.5**b	**2.2**a	**11.7**a	**5.00**a	**45.4**b	**139**a	**82.9**a	**115**a	**198**b	**1.50**a	**10.7**a	**60.0**a
Tiber, MT	**34.5**b	**82.3**b	**85.3**a	**80.4**c	**1.7**c	**10.2**c	**4.09**c	**42.6**c	**115**b	**75.6**b	**56**b	**157**c	**1.45**c	**5.6**b	**41.8**b

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

Steptoe, Baronesse, Harrington, AC Metcalfe, 2B04-0175,2B05-0811, 2B06-0929, 2B06-0933, 2B07-1516, 2B07-1590, 01Ab9663, 02Ab17271, 2Ab04-X01084-27, MT020162, MT061169, MT070111, 2ND25276, 2ND24388, 2ND25272, 2ND26333, ND22421, ND23898, UT04B2041-42, UT6R2120-14, 05WA-316.K, 05WA-316.99, 06WA-412.4, WAS2, 2004NZ151, 2004NZ163, CDC Kindersley

WESTERN REGIONAL SPRING BARLEY NURSERY - 2011 Crop

Table 3 - 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
**Steptoe	40.2bcde	89.0abcd	70.5abcd	74.8l	n.d.	9.8g	3.18i	34.5ghi	55.5l	32.3p	688b	96k	1.75b	83.0a	15.0h
**Baronesse	38.1cdefghi	85.4abcd	71.0abcd	77.5jk	n.d.	10.8cdefg	3.48hi	34.6ghi	80.0jkli	41.7mn	127c	100k	1.54cdefg	57.0b	19.5gh
Harrington	38.1bcde	93.5abc	70.0ab	81.3cd	1.7b	11.1abc	4.67bcd	44.4bcdef	120cdef	79.1cde	147abc	188bcd	1.48bc	6.8a	54.7abc
AC Metcalfe	36.1 ef	87.5bcd	68.0bc	80.9de	2.0ab	11.6abc	4.97b	45.2bcde	140bcd	92.3a	54c	201bcd	1.45c	8.6a	50.7bcd
2B04-0175	38.7bcde	93.1abc	72.0ab	82.4ab	2.0ab	10.7cde	4.79bcd	47.1a	123cdef	82.7bc	57bc	201bcd	1.46c	5.7a	55.3abc
2B05-0811	37.0def	91.0abcd	68.0bc	82.8a	2.0ab	10.5de	4.69bcd	46.3bc	116ef	90.0a	104bc	196bcd	1.47bc	7.1a	52.0abcd
2B06-0929	37.7bcdef	91.0abcd	68.7bc	82.7a	2.0ab	10.8cd	4.70bcd	46.5bc	121cdef	77.6cdef	64bc	201bcd	1.47bc	6.8a	56.3abc
2B06-0933	35f	88.1bcd	73.0ab	82.6a	2.1a	10.2de	4.68bcd	49.9a	120cdef	92.0a	60bc	193bcd	1.47c	7.3a	49.3cd
2B07-1516	36.5def	89.6abcd	70.3ab	81.9abc	2.0ab	10.1de	4.48def	46.4bc	119cdef	76.4cdef	64bc	184cd	1.46c	7.9a	49.7bcd
2B07-1590	38.2bcde	93.0abc	67.7bc	82.4ab	1.9ab	10.7cd	4.49def	43.7cdef	138bcde	87.5ab	82bc	185cd	1.46c	6.3a	58.7abc
01Ab9663	39.1bcd	93.7abc	71.3ab	82.4ab	2.1a	9.7e	4.64cd	49.8a	135bcde	76.4cdef	130abc	200bcd	1.49bc	5.4a	49.3cd
02Ab17271	37.8bcdef	83.5d	75.7a	81.7bcd	1.97ab	10.6de	4.50def	45.4bcd	128cdef	72.4ef	78bc	190bcd	1.46c	6.2a	51.7abcd
2Ab04-X01084-27	37.5cdef	89.3abcd	68.0bc	80.7def	1.8ab	10.8cd	4.32ef	42.1f	117def	77.5cdef	80bc	176de	1.47bc	5.7a	51.0bcd
**MT020162	38.4cdefg	84.4abcd	67.0abcd	80.2efgh	1.8ab	11.4abcd	4.41bcde	40.5cdefgh	112.5efgh	60.8kl	127c	166cdefg	1.49cdefgh	6.4e	47.0abcd
**MT061169	40.0abcd	92.7abc	69.5abcd	80.2efgh	1.8ab	11.7abcd	5.67a	51.9a	115.5defgh	81.7bcdef	66c	194ab	1.46fgh	10.3de	50.5abcd
**MT070111	37.4cdefghi	88.4abcd	76.5a	80.7cdefg	2ab	10.8cdefg	4.21cdefgh	41.1cdefg	103.5ghi	73.0fghij	74c	156fgh	1.50cdefgh	13.2de	41.5bcde
2ND25276	40.2bc	94.3abc	66.3bcd	81.5cd	2.0ab	10.5de	4.49def	44.1bcdef	120cdef	80.1cd	112bc	186cd	1.47bc	10.0a	51.0bcd
2ND24388	45.1a	97.1a	70.0abcd	81.4abcde	n.d.	11.6abcd	4.47bcd	40.4cdefgh	138.5abcd	65.3jk	126c	164defg	1.50cdefgh	9.9de	56.0a
2ND25272	40.5b	94.5abc	70.3ab	80.9de	1.8ab	10.6de	4.23f	42.4def	111f	71.0f	205a	156e	1.53a	9.7a	44.0d
2ND26333	43.2a	96.3ab	63.0cd	79.8f	1.7b	12.3a	4.63cde	39.1g	137bcde	81.9bc	107bc	190bcd	1.47c	6.9a	57.0abc
ND22421	37.3def	97.6a	61.0d	80.1ef	2.2a	12.2a	5.28a	45.9bc	142bc	75.6cdef	154ab	238a	1.52ab	9.8a	61.0a
ND23898	31.8g	87.1cd	73.0ab	79.9f	1.9ab	11.9ab	4.85bc	42.3	163a	73.2def	81bc	213b	1.50abc	8.2a	59.3ab
**UT04B2041-42	32.7jk	85.2abcd	69.0abcd	77.5jk	1.8ab	11.3abcde	3.48hi	32.5i	66.5kl	48.3m	213c	120ijk	1.55cdef	28.0cd	28.5efg
**UT6R2120-14	34.0ijk	77.2d	68.0abcd	76.6k	1.9ab	11.1abcdef	4.26cdefg	39.8cdefgh	108.0fgh	37.4nop	211c	105k	1.56cd	13.8de	25.5fgh
**05WA-316.K	39.4bcde	89.7abcd	65.5bcd	78.3ij	1.9ab	10.6defg	3.57ghi	35.8fghi	78.5jkl	42.7mno	236c	117jk	1.56cde	15.6de	19.0gh
**05WA-316.99	41.1bc	84.7abcd	68.0abcd	76.5k	n.d.	10.6defg	3.45hi	34.3ghi	68.5kl	35.6op	180c	105k	1.53cdefg	36.0c	12.5h
**06WA-412.4	37.8defghij	90.3abcd	75.5ab	77.1jk	n.d.	11.1bcdef	3.46hi	32.3i	83.0ijk	38.8nop	279c	107k	1.56cde	28.0cd	16.0gh
**WAS 2	43.0a	90.6abcd	65.5bcd	77.2jk	***2.0ab	11.5abcd	3.68efghi	33.5hi	57.0l	38.6nop	1367a	119ijk	2.04a	16.7de	17.0gh
**2004NZ151	39.1bcdef	89.7abcd	68.0abcd	80.9bcdefg	2.2a	10.1efg	3.63fghi	37.9efghi	80.0ijkl	56.5l	113c	136hij	1.49cdefgh	13.5de	38.0def
**2004NZ163	40.2abcd	90.1abcd	65.0cd	79.7gh	1.9ab	10.6defg	3.88defghi	38.3defghi	73.5kl	45.8mn	147c	142ghi	1.50cdefgh	8.9de	29.0efg
CDC Kindersley	37.5cdef	87.8bcd	68.7bc	81.4cd	2.0ab	10.9cd	4.92bc	46.6bc	152	87.8ab	50c	208bc	1.42d	6.1a	55.0abc

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

** Samples received from Idaho Falls, ID and Tiber, MT only-- not Aberdeen, ID.

*** Score from one location only.

n.d. Sample's clarity reported as hazy, hence the wort color was not defined.

WRSBN Tiber, Montana
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
5444	Steptoe	6	37.7	80.8	92	**74.0**	n.d.	3	**9.4**	**2.95**	**34.0**	**56**	**31.9**	*524	**84**	*1.76	*68.0	15	26
5445	Baronesse	2	**34.7**	**72.9**	90	**76.5**	n.d.	3	**9.9**	**3.24**	**34.6**	**69**	**39.1**	66	**88**	1.52	*67.0	12	27
5446	Harrington	2	**35.2**	88.7	85	80.5	1.5	1	**9.8**	4.14	43.8	**94**	73.4	51	**157**	1.45	5.2	39	15
5447	AC Metcalfe	2	**33.3**	**72.9**	81	79.9	1.7	1	**10.6**	4.46	44.5	122	91.0	41	**174**	1.43	5.4	47	2
5448	2B04-0175	2	**33.9**	**83.7**	88	81.0	1.8	1	**10.1**	4.31	45.4	121	79.8	41	**170**	1.45	5.7	46	4
5449	2B05-0811	2	**32.6**	**79.6**	86	81.1	1.7	1	**10.1**	4.20	42.3	119	87.8	49	**162**	1.43	5.8	43	9
5450	2B06-0929	2	**33.5**	85.2	90	81.4	1.8	1	**10.1**	4.26	45.1	117	72.1	48	**167**	1.44	4.7	46	4
5451	2B06-0933	2	**31.7**	**80.0**	90	81.4	1.7	1	**9.4**	4.08	**47.8**	109	86.1	47	**160**	1.45	4.8	38	16
5452	2B07-1516	2	**31.9**	**79.9**	83	80.1	1.7	1	**10.1**	4.11	43.7	114	76.2	44	**168**	1.43	4.8	40	12
5453	2B07-1590	2	**33.5**	85.8	88	81.7	1.6	1	**9.5**	**3.84**	41.7	115	82.9	57	**146**	1.44	4.6	43	9
5454	01Ab9663	6	36.9	90.0	87	81.6	1.7	1	**9.1**	**4.03**	46.2	**116**	74.2	67	**161**	1.48	5.5	46	4
5455	02Ab17271	2	**34.1**	**64.3**	90	79.6	1.8	1	**10.5**	4.09	41.7	114	68.7	53	**154**	1.43	6.3	40	12
5456	2Ab04-X01084-27	2	**34.0**	**82.7**	88	79.8	1.7	1	**9.7**	**3.81**	40.9	**96**	71.1	47	**142**	1.46	6.0	33	19
5457	MT020162	2	**35.0**	**71.9**	81	79.7	1.6	1	**10.6**	**3.93**	40.2	104	55.3	79	**146**	1.47	5.5	37	18
5458	MT061169	2	**37.3**	87.7	82	79.8	1.8	1	**10.5**	*5.64	*58.0	105	77.2	47	**153**	1.42	5.7	38	16
5459	MT070111	2	**36.2**	**84.2**	93	80.4	1.6	1	**9.9**	**3.70**	**39.7**	**92**	69.4	76	**138**	1.49	6.7	28	21
5460	2ND25276	2	40.0	92.7	80	81.0	1.8	1	**10.0**	**3.72**	**39.7**	100	73.8	82	**153**	1.47	5.8	44	7
5461	2ND24388	2	43.9	96.1	80	81.8	n.d.	3	11.0	4.15	40.4	131	65.7	76	**151**	1.48	*40.0	59	1
5462	2ND25272	2	39.1	91.4	84	80.1	1.6	1	**10.3**	**3.72**	**39.7**	**98**	61.8	110	**127**	1.53	5.8	31	20
5463	2ND26333	2	39.8	93.1	77	78.8	1.5	1	*11.9	4.06	**35.9**	131	77.0	60	**143**	1.45	5.8	47	2
5464	ND22421	6	32.0	81.8	92	79.0	n.d.	3	**9.8**	**3.96**	43.0	**113**	57.5	52	**135**	1.49	26.0	40	12
5465	ND23898	6	30.3	73.4	84	78.8	1.7	1	**11.0**	**4.10**	**40.2**	151	59.0	46	**156**	1.47	7.3	42	11
5466	UT04B2041-42	6	30.6	76.2	89	**76.6**	1.7	1	**10.7**	**3.19**	**32.8**	**64**	45.8	142	**102**	1.55	13.7	21	24
5467	UT6R2120-14	6	30.6	**60.8**	90	**75.6**	1.7	1	**9.9**	**2.88**	**31.6**	**105**	**33.2**	109	**85**	1.55	9.6	18	25
5468	05WA-316.K	2	**37.0**	**82.9**	79	**77.3**	1.9	2	**9.9**	**3.15**	**34.1**	**66**	**39.5**	147	**97**	1.55	15.3	9	28
5469	05WA-316.99	2	**38.0**	**73.6**	82	**75.7**	n.d.	3	**9.9**	**3.18**	**34.7**	**57**	**34.4**	**166**	**94**	1.55	*36.0	5	29
5471	06WA-412.4	2	**34.9**	**83.6**	91	**76.2**	n.d.	3	**10.2**	**3.16**	**32.6**	**71**	**36.1**	*276	**94**	1.46	4.5	5	29
5473	WAS 2	2	**37.0**	**82.7**	80	**76.2**	n.d.	3	**10.9**	**3.41**	**33.3**	**49**	**36.9**	*827	**104**	1.58	31.0	5	29
5474	2004NZ151	2	**35.8**	**83.1**	82	79.6	*2.3	2	**9.6**	**3.25**	**34.9**	**58**	52.2	98	**116**	1.47	12.5	27	22
5475	2004NZ163	2	38.5	85.3	77	78.8	1.8	1	**10.3**	**3.58**	**36.4**	**59**	43.1	112	**127**	*1.90	15.8	23	23

Table 079

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
5476	CDC Kindersley	2	**32.9**	**73.4**	84	79.8	1.9	1	**10.6**	4.56	43.8	119	74.2	45	**168**	1.48	18.4	44	7
5470	HARRINGTON MALT CHECK	2	39.6	96.2	78	82.0	1.6	1	11.2	4.94	47.0	144	92.5	58	196	1.48	9.5	67	
5472	LACEY MALT CHECK	6	34.0	88.1	54	79.5	2.2	1	12.8	5.47	44.7	152	68.3	74	213	1.41	6.8	70	
Minima			30.3	60.8	77	74.0	1.5		9.1	2.88	31.6	49	31.9	41	84	1.42	4.5	5	
Maxima			43.9	96.1	93	81.8	1.9		11.0	4.56	47.8	151	91.0	166	174	1.58	31.0	59	
Means			35.2	81.3	85	79.2	1.7		10.1	3.77	39.5	98	62.1	73	136	1.48	9.2	33	
Standard Deviations			3.2	8.2	5	2.1	0.1		0.5	0.47	4.7	27	18.2	35	29	0.04	6.8	15	
Coefficients of Variation			9.0	10.0	6	2.7	6.4		4.9	12.44	11.9	28	29.4	48	21	2.97	74.3	45	

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

Neg Std Dev			25.7	56.8	71	72.8	1.4		8.6	2.37	25.4	17	7.4	-32	49	1.35	-11	-12	
Pos Std Dev			44.7	105.8	100	85.5	2.0		11.6	5.18	53.6	179	116.9	179	223	1.61	30	77	

WRSBN Aberdeen, ID
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
5243	Harrington	2	38.1	93.6	65	82.1	1.8	1	11.2	4.83	45.6	132	82.8	268	206	1.51	6.3	60	5
5244	AC Metcalfe	2	38.5	96.4	68	83.0	1.9	1	10.6	4.84	47.3	129	90.7	62	207	1.46	6.4	57	8
5245	2B04-0175	2	40.8	98.7	68	83.9	2.1	1	10.3	4.84	48.5	118	84.7	65	220	1.46	4.5	56	10
5246	2B05-0811	2	39.3	96.2	61	84.2	2.1	1	9.8	4.82	51.3	107	91.1	148	216	1.49	5.2	50	17
5247	2B06-0929	2	40.4	94.7	63	83.9	2.1	1	10.2	4.83	49.1	115	81.5	64	232	1.46	4.6	56	10
5248	2B06-0933	2	37.1	93.7	66	83.3	2.3	1	10.7	5.01	49.9	128	96.5	71	223	1.46	6.2	55	12
5249	2B07-1516	2	40.6	96.4	65	83.3	2.1	1	10.1	4.69	48.1	120	77.4	79	207	1.46	7.4	59	6
5250	2B07-1590	2	40.3	96.3	60	83.2	2.1	1	11.0	4.83	45.9	149	91.3	89	218	1.45	4.9	64	2
5251	01Ab9663	6	39.7	94.5	69	83.5	2.1	1	9.5	4.69	49.5	147	76.9	201	222	1.49	3.3	46	18
5252	02Ab17271	2	39.2	91.2	74	83.4	2.0	1	10.3	4.67	49.0	137	74.5	105	227	1.47	5.3	53	14
5253	2Ab04-X01084-27	2	38.9	89.7	63	81.8	2.0	1	11.0	4.68	45.1	126	83.2	105	219	1.48	4.6	61	4
5254	2ND25276	2	40.8	96.1	66	82.2	1.8	1	10.5	4.84	47.3	140	87.1	103	224	1.45	4.8	55	12
5256	2ND24388	2	41.9	98.0	64	82.6	n.d.	3	10.8	4.54	43.8	150	66.0	185	186	1.48	*40.0	53	14
5258	2ND25272	2	40.4	96.1	67	81.7	1.7	1	10.2	4.34	44.2	127	77.0	111	178	1.46	5	51	16
5259	2ND26333	2	45.6	98.5	62	80.8	1.8	1	12.3	4.99	40.8	144	85.2	132	246	1.46	5.2	63	3
5260	ND22421	6	36.4	96.8	65	80.6	2.2	1	11.8	5.13	46.4	132	76.1	126	259	1.50	7.3	59	6
5261	ND23898	6	32.5	93.6	77	81.2	1.7	1	11.9	5.13	44.0	167	78.7	101	260	1.51	4.9	66	1
5262	CDC Kindersley	2	38.2	93.2	64	82.7	2.1	1	10.7	5.02	48.8	150	91.5	53	248	1.42	5.7	57	8
5255	HARRINGTON MALT CHECK	2	40.4	96.8	76	82.4	1.8	1	11.9	5.04	46.2	148	94.8	54	241	1.45	5.4	69	
5257	LACEY MALT CHECK	6	33.8	88.5	55	79.4	2.1	1	13.0	5.39	44.9	158	72.2	64	245	1.45	11.3	70	
Minima			32.5	89.7	60	80.6	1.7		9.5	4.34	40.8	107	66.0	53	178	1.42	3	46	
Maxima			45.6	98.7	77	84.2	2.3		12.3	5.13	51.3	167	96.5	268	260	1.51	7	66	
Means			39.4	95.2	66	82.6	2.0		10.7	4.82	46.9	134	82.9	115	222	1.47	5	57	
Standard Deviations			2.6	2.4	4	1.1	0.2		0.7	0.20	2.7	15	7.7	56	22	0.02	1	5	
Coefficients of Variation			6.7	2.5	6	1.3	8.8		6.8	4.15	5.7	11	9.3	49	10	1.60	20	9	

Malt Check Data are Excluded from Rank Sorting and Statistics

Table Data Flagged by an Asterisk Exceed the Mean by +/- 3 Standard Deviations and are Excluded from Statistics
For Wort Clarity - 1 = clear, 2 = slightly hazy, 3 = hazy; Wort Colors were not determined (n.d.) on hazy samples

Samples Submitted by WRSBN

Neg Std Dev	31.4	88.0	53	79.4	1.5	8.5	4.22	38.9	89	59.8	-53	156	1.40	2	41
Pos Std Dev	47.3	102.4	79	85.9	2.5	12.9	5.42	54.9	179	106.0	283	288	1.54	9	72

WRSBN Idaho Falls, ID
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)	Viscosity Relative	Turbidity (Hach)	Quality Score	Overall Rank
5411	Steptoe	6	42.7	97.1	49	**75.5**	n.d.	3	**10.2**	**3.40**	**34.9**	**55**	**32.7**	***852**	**108**	*1.73	*98.0	15	31
5412	Baronesse	2	41.5	97.9	52	78.4	n.d.	3	11.6	**3.71**	**34.6**	**91**	44.3	**187**	**112**	1.56	*47.0	27	28
5413	Harrington	2	40.9	98.1	60	81.3	1.9	1	12.3	5.05	43.8	135	81.2	121	202	1.49	9.0	65	4
5414	AC Metcalfe	2	**36.5**	93.2	55	79.7	2.3	1	**13.7**	5.62	43.9	169	95.3	60	221	1.47	14.0	48	22
5415	2B04-0175	2	41.3	97.0	60	82.4	2.2	1	11.7	5.22	**47.5**	131	83.6	65	212	1.48	6.9	64	5
5416	2B05-0811	2	39.0	94.7	57	83.1	2.2	1	11.7	5.06	45.4	121	91.0	114	211	1.50	10.2	63	7
5417	2B06-0929	2	39.3	93.1	53	82.9	2.2	1	12.0	5.00	45.4	132	79.2	80	204	1.52	11.0	67	3
5418	2B06-0933	2	**36.3**	90.6	63	83.2	2.2	1	**10.4**	4.95	**51.9**	123	93.5	61	196	1.50	10.9	55	15
5419	2B07-1516	2	**36.9**	92.5	63	82.4	2.3	1	**10.1**	4.63	**47.3**	122	75.5	68	**178**	1.48	11.4	50	19
5420	2B07-1590	2	40.9	96.8	55	82.4	1.9	1	11.7	4.79	43.6	150	88.3	99	191	1.50	9.5	69	2
5421	01Ab9663	6	40.7	96.5	58	82.2	2.6	1	**10.5**	5.21	**53.6**	141	78.1	123	218	1.50	7.4	56	14
5422	02Ab17271	2	40.1	95.0	63	82.0	2.1	1	**10.9**	4.74	45.4	133	73.9	75	190	1.47	7.0	62	10
5423	2Ab04-X01084-27	2	39.6	95.5	53	80.5	1.8	1	11.7	4.48	40.2	128	78.3	89	**166**	1.48	6.4	59	12
5424	MT020162	2	41.8	96.9	53	80.6	2.0	1	12.1	4.88	40.8	121	66.3	**175**	185	1.51	7.2	57	13
5425	MT061169	2	42.6	97.6	57	80.5	2.6	1	12.9	5.70	45.7	126	86.1	84	235	1.49	14.8	63	7
5426	MT070111	2	38.6	92.6	60	80.9	2.4	2	11.7	4.72	42.5	115	76.5	71	**177**	1.51	19.7	55	15
5427	2ND25276	2	39.9	94.1	53	81.2	2.5	2	11.0	4.90	45.3	119	79.3	**151**	181	1.53	19.4	54	17
5428	2ND24388	2	46.3	98.1	60	81.0	n.d.	3	12.2	4.79	40.3	146	64.9	**176**	**176**	1.52	*86.0	53	18
5429	2ND25272	2	41.9	96.0	60	80.8	2.2	2	11.3	4.63	43.4	107	74.2	**395**	**163**	1.60	18.2	50	19
5430	2ND26333	2	44.1	97.2	50	79.8	1.9	1	12.7	4.83	40.7	137	83.6	130	181	1.49	9.7	61	11
5431	ND22421	6	38.2	98.3	57	79.6	2.1	1	12.5	5.43	45.4	151	75.1	**182**	217	1.53	12.2	63	7
5432	ND23898	6	32.6	94.4	58	79.7	2.2	1	12.9	5.33	42.6	171	82.0	95	223	1.51	12.5	70	1
5433	UT04B2041-42	6	34.7	94.2	49	78.3	1.8	1	11.8	**3.76**	**32.2**	**69**	50.8	**284**	**137**	1.54	13.2	36	23
5434	UT6R2120-14	6	37.3	93.6	46	**77.5**	2.1	1	12.3	5.63	**48.0**	**111**	41.5	**312**	**124**	1.57	18.0	33	25
5435	05WA-316.K	2	41.7	96.5	52	79.2	1.9	1	11.2	**3.99**	**37.5**	**91**	45.9	**324**	**136**	1.56	15.9	29	26
5436	05WA-316.99	2	44.1	95.8	54	**77.3**	n.d.	3	11.3	**3.71**	**33.9**	**80**	**36.7**	**194**	**115**	1.51	*36.0	20	30
5437	06WA-412.4	2	40.6	97.0	60	78.0	n.d.	3	11.9	**3.76**	**32.0**	**95**	41.5	**281**	**120**	1.53	25.0	27	28
5439	WAS 2	2	43.0	98.5	51	78.2	2.0	2	12.1	**3.94**	**33.7**	**65**	40.3	*1907	**133**	*2.18	17.5	29	26
5441	2004NZ151	2	42.3	96.2	54	82.2	2.0	1	**10.6**	4.01	40.9	102	60.7	128	**156**	1.50	8.6	49	21
5442	2004NZ163	2	41.8	94.8	53	80.6	1.9	1	**10.8**	4.18	40.1	**88**	48.4	**181**	**157**	1.52	8.3	35	24

Table 079

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
5443	CDC Kindersley	2	41.3	96.7	58	81.8	1.9	1	11.3	5.19	**47.1**	188	97.8	52	207	1.42	5.8	64	5
5438	HARRINGTON MALT CHECK	2	40.3	96.5	75	82.1	2.0	1	11.7	4.96	45.9	141	90.5	46	200	1.46	8.2	69	
5440	LACEY MALT CHECK	6	33.5	90.6	55	78.7	2.5	2	13.0	5.35	43.5	140	68.4	76	205	1.52	23.0	66	
Minima			32.6	90.6	46	75.5	1.8		10.1	3.40	32.0	55	32.7	52	108	1.42	5.8	15	
Maxima			46.3	98.5	63	83.2	2.6		13.7	5.70	53.6	188	97.8	395	235	1.60	25.0	70	
Means			40.3	95.7	56	80.4	2.1		11.6	4.69	42.2	120	69.2	150	175	1.51	12.2	50	
Standard Deviations			2.9	2.0	4	1.9	0.2		0.9	0.64	5.5	31	19.4	91	37	0.03	4.9	16	
Coefficients of Variation			7.2	2.1	8	2.4	10.5		7.3	13.61	13.0	26	28.0	61	21	2.31	40.4	32	

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 WRSBN, Idaho Falls, ID

Neg Std Dev			31.6	89.7	42	74.6	1.5		9.1	2.77	25.7	26	11.1	-123	64	1.40	-3		
Pos Std Dev			49.0	101.7	69	86.2	2.8		14.2	6.60	58.7	213	127.4	423	286	1.61	27		

Appendix A: METHODS

Cleaning All samples were cleaned on a Carter Dockage Tester and only grain between 5 and 7/64" was used.

Barley Mill Ground barley was prepared with a Labconco Burr mill that was adjusted so that only 35% of the grist remained on a 525 µm sieve after 3 min of shaking and tapping.

Kernel Weight The number of kernels in a 20 g aliquot of each sample was counted electronically and the '1000 kernel weight' was calculated.

Plumpness Samples were sized on a Eureka-Niagra Barley Grader and the percentage of the seeds retained on a 6/64" screen was determined.

Barley Color The brightness of the grains was measured using an Agtron M45-D analyzer.

Barley Moisture Content (Barley 5B) Five g of ground sample was dried for 3 h at 104°C. The percentage of weight loss that occurred during this drying was calculated.

Barley Protein Content Total nitrogen values were obtained using an automated Dumas combustion procedure with a LECO FP-528 analyzer. Nitrogen values were converted to protein percentages by multiplication by 6.25.

Malting Conditions 170 g (db) aliquots of barley were processed in Joe White micro-malters. Samples were hydrated to 47% moisture via a 32 h steep at 19°C: 8 h wet, 8 h air, 5 h wet, 5 h air, 2 h wet, 2 h air, 2 h wet. (Larger barleys, > 42 mg/kernel, received a continuous, wet pre-steep (16°C) of between 1 and 3 h). The samples were germinated for 48 h (18°C), 24 h (17°C), and 24 h (16°C), with moisture adjustment to 47% at 0, 24, and 48 h. The samples received 4 full turns every 2 h. The germinated grain was kilned for 24h as follows: 49°C, 10 h; 54°C, 4 h; 60°C, 3 h; 68°C, 2 h; and 85°C, 3 h, with 30 min. ramps between stages. All stages received 40% total flow, with 0% recirculation for stages 1-3, 50% for stage 4, and 75% for stage 5.

Malt Mill Fine-grind malts were prepared with a Miag laboratory cone mill that was adjusted so that 10% of the grist remained on a 525 µm sieve after 3 min of shaking, with tapping. Malts to be used for moisture, protein and amylolytic activity analyses were ground in a Labconco Burr mill (see Barley Mill).

Malt Moisture Content Determined by Malt 3 (Methods of Analysis of the ASBC, 8th ed, 1992) See Barley Moisture Content.

Malt Protein Content See Barley Protein Content.

Malt Extract Samples were extracted using the Malt-4 procedure (Methods of Analysis of the ASBC, 8th ed, 1992), except that all weights and volumes specified for the method were halved. The specific gravity of the filtrate was measured with an Anton Parr DMA5000 density meter. The density data were used to calculate the amount of soluble material present in the filtrate, and thus the percentage that was extracted from the malt.

Wort Color was determined on a Skalar SAN plus analyzer by measuring the absorbance at 430nm and dividing by a factor determined by collaborative testing.

Wort Clarity was assessed by visual inspection.

β-Glucan Levels were determined on a Skalar SAN plus analyzer by using the Wort-18 fluorescence flow injection analysis method with calcofluor as the fluorescent agent (Methods of Analysis of the ASBC, 8th ed, 1992).

Free Amino Nitrogen Levels were determined on a Skalar SAN plus analyzer using an automated version of the Wort-12 protocol (Methods of Analysis of the ASBC, 8th ed, 1992).

Soluble (Wort) Protein Levels were determined on a Skalar SAN plus analyzer using the Wort-17 UV-spectrophotometric method (Methods of Analysis of the ASBC, 8th ed, 1992).

S/T Ratio was calculated as Soluble Protein / Total Malt Protein

Diastatic Power Values were determined on a Skalar SAN plus analyzer by the automated ferricyanide procedure Malt-6C (Methods of Analysis of the ASBC, 8th ed, 1992).

α-Amylase activities were measured on a Skalar SAN plus analyzer by heating the extract to 73°C to inactivate any β-amylase present. The remaining (α-amylase) activity was measured as described for Diastatic Power Values.

Viscosities were measured on an Anton Paar AMVn rolling ball viscometer. Relative viscosities were reported: flow time of mash extract over the flow time of distilled water.

Turbidities were determined in Nephelometric Turbidity Units (NTU) on a Hach Model 18900 Ratio Turbidimeter.

Quality Scores were calculated by using a modification of the method of Clancy and Ullrich (Cereal Chem. 65:428-430, 1988). The criteria used to quantify individual quality factors are listed in Table A1.

Overall Rank Values were ordered from low to high based on their Quality Scores. A rank of '1' was assigned to the sample with the best quality score.

Appendix B

Quality Score Parameters for 2- and 6-rowed barleys

	2-rowed		6-rowed	
Quality parameter	condition	score	condition	score
Kernel Weight	> 42.0	5	> 32.0	5
(mg)	40.1–42.0	4	30.1–32.0	4
	38.1–40.0	2	28.1–30.0	2
	≤ 38.0	0	≤ 28.0	0
on 6/64 "	≥ 90.0	5	≥ 80.0	5
(%)	85.0–89.9	3	73.0–79.9	3
	< 85.0	0	< 73.0	0
Malt Extract	≥ 81.0	10	≥ 79.0	10
(% db)	79.4–81.0	7	78.2–78.9	7
	78.0–79.4	4	77.7–78.2	4
	< 78.0	0	< 77.7	0
Wort Clarity				
3=hazy	= 3	0	= 3	0
2=slightly hazy	= 2	1	= 2	1
1=clear	= 1	2	= 1	2
Barley Protein	≥ 13.5	0	≥ 14.0	0
(% db)	13.0–13.5	5	13.5–13.9	5
	11.0–13.0	10	11.5–13.5	10
	≤ 11.0	5	≤ 11.5	5
Wort Protein	> 6.0	0	> 6.0	0
(% db)	5.6–6.0	3	5.7–6.0	3
	4.4–5.6	7	5.2–5.7	7
	4.0–4.4	3	4.8–5.2	3
	< 4.0	0	< 4.8	0
S/T (Soluble/Total	> 47	0	> 47	0
Protein, % db)	40–47	5	42–47	5
	< 40	0	< 42	0
DP (Diastatic	> 120	7	> 140	7
Power, ° ASBC)	100–120	4	120–140	4
	< 100	0	< 120	0
Alpha-amylase	> 45	7	> 45	7
(20° DU)	40–45	4	40–45	4
Beta-glucan	< 100	7	< 120	7
(ppm)	100–150	3	120 – 170	3
	> 150	0	> 170	0
Free Amino Nitrogen	> 190	5	> 200	5
FAN (ppm)	180–190	3	190 – 200	3
	< 180	0	< 190	0