2013

Winter Barley Variety Trial

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NORTHWEST CROPS & SOILS PROGRAM

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2013 WINTER BARLEY VARIETY TRIAL

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With the revival of the small grains industry in the Northeast and the strength of the localvore movement, craft breweries and distilleries have expressed an interest in sourcing local barley for malting. Malting barley must meet specific quality characteristics such as low protein content and high germination. Many farmers are also interested in barley as a concentrated, high-energy feed source for livestock. Depending on the variety, barley can be planted in either the spring or fall, and both two- and six-row barley can be used for malting. In 2012-2013, UVM Extension conducted a winter barley trial to evaluate the yield and quality of publicly available malting and feed barley varieties.

MATERIALS AND METHODS

A winter barley variety trial was initiated at Borderview Research Farm in Alburgh, VT. Winter barley was planted on 24-Sep 2012. Thirty winter varieties (Table 1) were planted in a randomized complete block design with three replicates. The varieties McGregor and Thoroughbred are considered feed-grade barley. The seedbed was prepared by conventional tillage methods. Plots were 3' x 10' and were seeded into a Benson rocky silt loam at 134 lbs ac^{-1} with a Kincaid cone seeder. Rows were spaced at 6". All plots were managed with practices similar to those used by producers in the surrounding areas (Table 2). Winter survival was evaluated on 19-Apr 2013 by visually estimating the percentage of each plot that was still established in the spring. Stand density was also evaluated on 29-Apr by counting the number of plants present in two 33 cm segments in two different rows per plot. Plant leaf disease incidence and the percent of plant infected was evaluated on 20-Jun. Leaf disease was based on a visual rating with a 0-10 scale, where 0 indicates no infection, and 10 indicates severe infection. The percent of plant infection indicates the severity of the grain leaf diseases on the whole plant, and was determined visually where 10% indicates minimal disease coverage and 100% means the entire plant was infected All varieties were harvested with an Almaco SPC50 small plot combine on 17-Jul.

Table 1. Winter barley varieties trialed at Borderview Research Farm in Alburgh, VT.

Winter barley variety	Type	Seed source
AC 05/004/12	2-row	Ackermann Saatzucht GmbH & Co.
AC 06/054/1	2-row	Ackermann Saatzucht GmbH & Co.
AC 07/022/2	2-row	Ackermann Saatzucht GmbH & Co.
Alba	6-row	Oregon State University
Archer	2-row	LimaGrain
Ariane	2-row	KWS Lochow
California	2-row	LimaGrain
Charles	2-row	University of Minnesota
Dan	6-row	Virginia Agricultural Experimental Station
Joy	2-row	KWS Lochow
Liga	2-row	KWS Lochow

Maja	6-row	Oregon State University
Mathias	6-row	Oregon State University
McGregor	6-row	University of Minnesota
NO71DH12	6-row	Oregon State University
OR101	6-row	Oregon State University
Saturn	6-row	LimaGrain
Scala	2-row	KWS Lochow
Streaker	6-row	Oregon State University
Strider	6-row	University of Minnesota
Thoroughbred	6-row	Virginia Tech
VA06H25	6-row	Virginia Agricultural Experimental Station
VA09B-29	6-row	Virginia Tech
VA09B-34	6-row	Virginia Tech
VA10B-43	6-row	Virginia Tech
Violetta	2-row	LimaGrain
02Ab431	2-row	USDA Aberdeen
02Ab671	2-row	USDA Aberdeen
2Ab08-X05W061-208	2-row	USDA Aberdeen
6Ab08-X03W012-5	2-row	USDA Aberdeen

When the barley was in the soft dough stage, spikes in a 1.08 ft^2 area were counted, and a visual estimate of weed density was recorded on a 1 to 5 scale – 1 representing few weeds and 5 indicating heavy weed pressure. Heights were also recorded for each plot at the soft dough stage.

Table 2. Winter barley agronomic characteristics and trial information.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Small grains
Tillage operations	Fall plow, disc, and spike tooth harrow
Plot area (ft)	3 x 10
Row spacing (in)	6
Seeding rate	134 lbs ac^{-1}
Replicates	3
Planting date	24-Sep 2012
Harvest date	17-Jul 2013

Following the harvest of winter barley, seed was cleaned with a small Clipper cleaner. A one-pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial malt houses. Harvest moisture was determined for each plot using a DICKEY-john M20P moisture meter. Test weight was measured using a Berckes Test Weight Scale, which weighs a known volume of grain. Subsamples were ground into flour using the Perten LM3100 Laboratory Mill, and were evaluated for crude protein content using the Perten Inframatic 8600 Flour

Analyzer. In addition, falling number for all barley varieties was determined using the AACC Method 56-81B, AACC Intl., 2000 on a Perten FN 1500 Falling Number Machine. Samples were also analyzed for Deoxynivalenol (DON) using the Veratox DON 2/3 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. Each variety was evaluated for seed germination by incubating 100 seeds in 4.0 mL of water for 72 hours and counting the number of seeds that did not germinate.

Data was analyzed using mixed model analysis procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$). When this was not possible due to inconsistent sample size across varieties, multiple pairwise comparisons were run with the Tukey-Kramer adjustment.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among hybrids is real or whether it might have occurred due to other variations in the field. Least Significant Differences (LSDs) at the 0.10 level of significance are shown. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In the example below, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0 which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Hybrid	Yield
A	6.0
B	7.5*
C	**9.0***
LSD	**2.0**

RESULTS

June 2013 brought above average rainfall to Vermont, saturating many fields at crucial developmental periods during the season. These conditions lead to poor performance, disease and fungal proliferation, and excessive mycotoxin production. Weather data (Table 3) is based on National Weather Service data from cooperative observer stations in South Hero, and Burlington, VT, which are in close proximity to Borderview Farm. Historical averages are for 30 years of data (1971-2000).

Table 3. Weather data for winter barley variety trial in Alburgh, VT.

	Sep 2012	Oct 2012	Nov 2012*	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013
Average temperature (°F)	60.8	52.4	36.7	28.7	20.6	21.9	32.1	43.6	59.1	64.0	71.7
Departure from normal (°F)	0.2	4.2	-1.5	2.8	1.8	0.4	1.0	-1.2	2.7	-1.8	1.1
Precipitation (inches)	5.36	4.13	0.68	3.49	0.6	1.08	1.04	2.12	4.79	9.23*	1.89
Departure from normal	1.72	0.53	-2.44	1.12	-1.45	-0.68	-1.17	-0.7	1.34	5.54	-2.26
Growing Degree Days (base 32°F)	896	652	144	535	47.3	21.5	88.5	348	848	967	1234
Departure from normal	38	150	-40.4	535	47.3	21.4	88.5	-35.6	91.4	-47	36.8

*Based on National Weather Service data from cooperative stations in South Hero, VT

Average winter barley survival was 53.9% (Table 4). Some varieties had as low as 8% average survival. The variety with the highest survival was 2Ab08-X05W061-208 with 94.3% and the lowest was Scala and VA09B-29 both with 8%. In addition to poor winter survival, lodging was also prevalent in the trial plots. The variety that experienced the most lodging was 2Ab08-X05W061-208 with 78.3%. Leaf diseases also affected most varieties. The most diseased variety was 2Ab08-X05W061-208 with 95% of the plants showing symptoms ; these two factors most likely influenced this variety's low yields. The variety least affected by disease was VA09B-34 with only 5% of the plants showing symptoms, however, this was not statistically different than twenty-one other varieties. Several foliar diseases were observed during barley development; Powdery Mildew (*Erysiphe graminis f. sp. Tritici*), Ascochyta Leaf Spot (*Didymella exitialis*), Leaf Rust (*Puccinia recondite*), and Stripe Rust (*Puccinia striiformi*). This was the first confirmed record of Stripe Rust on grains in Vermont. Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. A diseased plant typically exhibits reduced vigor, growth and seed fill.

Table 4. Agronomic characteristics for winter barley variety trial in Alburgh, VT.

Variety	Winter Survival	April population	Height	Lodging	Disease Severity
	%	Plants ac^{-1}	in	%	%
AC 05/004/12	51.7	9438	83.6*	**0.0***	7.0*
AC 06/054/1	83.3	10164	82.9*	**0.0***	23.3*
AC 07/022/2	11.0	2420	75.3	**0.0***	10.0*
Alba	73.3	**18150***	74.0	16.7*	36.7
Archer	79.3	12342	74.4	**0.0***	23.3*

Ariane	80.0	13068	75.4	**0.0***	20.0*
California	64.3	7260	72.6	**0.0***	20.0*
Charles	63.3	10648	56.6	81.7	93.3
Dan	81.7	14036*	70.6	**0.0***	16.7*
Joy	70.0	15004*	74.3	**0.0***	10.0*
Liga	56.7	10890	79.8*	**0.0***	16.7*
Maja	73.3	9922	72.0	45.0	65.0
Mathias	34.0	5082	73.1	6.7*	33.3
McGregor	66.0	15004*	71.9	**0.0***	23.3*
NO71DH12	88.3	14278*	84.3*	50.0	53.3
OR101	75.0	10406	84.4*	8.3*	53.3
Saturn	73.3	10890	64.9	15.0*	35.0
Scala	8.0	6292	64.8	**0.0***	16.7*
Streaker	46.7	11616	72.4	13.3*	23.3*
Strider	46.7	4840	70.4	**0.0***	13.3*
Thoroughbred	8.3	7744	58.4	**0.0***	10.0*
VA06H25	83.3	17182*	75.1	3.3*	20.0*
VA09B-29	8.0	3630	51.3	**0.0***	10.0*
VA09B-34	31.0	4114	69.7	**0.0***	**5.0***
VA10B-43	36.3	6534	59.6	3.3*	10.0*
Violetta	75.0	10648	75.2	5.0*	10.0*
02Ab431	10.7	5808	75.0	26.7	36.7
02Ab671	33.3	11858	**85.5***	25.0	53.3
2Ab08-X05W061-208	**94.3**	10648	60.7	78.3	95.0
6Ab08-X03W012-5	10.7	4598	76.3	**0.0***	50.0
LSD (0.1)	NA	4758.7	7.6	21.1	22.6
Trial Mean	53.9	9849	72.1	13.1	29.8

*Barley that did not perform significantly lower than the top performing treatment (in **bold**) in a particular column is indicated with an asterisk.
NA - was not statistically tested.

The variety VA09B-34 was the highest yielding producing on average with 6276 lbs per acre, nearly three times the trial mean. However, this variety did not perform differently statistically than any other varieties except for Streaker, 02Ab431, and 2Ab08-X05W061-208 (Table 5). Moisture content did not differ statistically across varieties. AC 05/004/12 had the highest protein content of 13.5% although only statistically differing from Alba, Archer, Charles, Joy, Maja, OR101, and VA 09B-29 (Figure 1). Archer had the highest falling number of 335 seconds although only statistically different from Charles, sStrider, VA09B-29, and 2Ab08-X05W061-208. All winter barley varieties had DON levels above the USDA acceptable limit of 1ppm. The variety with the lowest levels was Saturn with 4.8 ppm, almost 5 times the limit for safe human consumption. However, statistically Saturn only performed differently than AC 05/004/12, Strider, and VA10B-43.

Table 5. Yield and quality data for winter barley variety trial in Alburgh, VT.

Variety	Harvest moisture %	Kernel Weight grams/1000 kernels	Yield at 13.5% moisture lbs ac-1	Crude protein @ 12% moisture %	Falling Number (Seconds)	DON ppm	Germination %
AC 05/004/12	13.48	**54.8ab**	1823ab	**13.4a**	294ab	22.9d	71.0
AC 06/054/1	12.80	49.6abcde	3310ab	11.5abc	290ab	15.8abcd	80.0
AC 07/022/2	16.05	46.5abcdef	2031ab	12.9abc	267abc	10.3abcd	92.5
Alba	11.68	41.3abcdef	2229ab	11.1bc	317ab	9.3ab	89.0
Archer	12.86	53.2abc	3392ab	10.9bc	**335a**	12.1abcd	85.5
Ariane	12.30	51.8abcd	3518ab	11.7abc	312ab	11.9abcd	85.5
California	13.38	54.4a	3249ab	11.7abc	264abc	12.3abcd	81.5
Charles	11.36	39.4abcdef	1294ab	10.5c	128d	6.4a	81.5
Dan	13.31	35.4bcdef	1828ab	12.3abc	299ab	7.2ab	**95.0**
Joy	12.84	43.6abcdef	4128ab	10.8bc	307ab	7.5ab	87.0
Liga	13.23	47.7abcdef	3615ab	11.3abc	292ab	12.7abcd	90.5
Maja	12.26	42.2abcdef	1253b	11.1bc	269abc	10.4abcd	94.5
Mathias	12.53	40.4abcdef	1634ab	12.5abc	259abc	15.6abcd	80.0
McGregor	11.82	29.6f	4070ab	11.5abc	293ab	10.5abcd	85.0
NO71DH12	12.06	41.6abcdef	2129ab	12.1abc	277abc	10.9abcd	61.0
OR101	11.97	44.8abcdef	1146ab	10.8bc	265abc	14.8abcd	89.0
Saturn	12.29	37.8abcdef	2672ab	12.1abc	320ab	**4.8a**	92.0
Scala	11.84	36.2abcdef	2681ab	12.7abc	268abc	9.7bab	75.5
Streaker	12.32	38.5abcdef	1151b	12.1abc	291ab	16.5abcd	70.5
Strider	12.52	50.9abcd	1944ab	11.8abc	232bc	21.6cd	76.0
Thoroughbred	12.06	34.7cdef	1006b	11.9abc	260abc	14.2abcd	88.5
VA06H25	11.54	30.5ef	2910ab	11.8abc	262abc	8.7ab	75.0
VA09B-29	11.32	36.1cdef	1097ab	12.6ab	215bcd	16.5abcd	78.5
VA09B-34	**10.40**	38.1abcdef	**6276a**	13.0abc	300ab	8.3abc	87.5
VA10B-43	11.98	39.9abcdef	1370ab	12.0abc	263abc	19.8bcd	71.5
Violetta	12.14	42.3abcdef	3255ab	12.3abc	302ab	12.1abcd	93.5
02Ab431	13.98	38.6abcdef	570b	11.8abc	275abc	13.2abcd	81.5
02Ab671	13.79	46.2abcdef	1828ab	11.3abc	247abc	16.2abcd	85.5
2Ab08-X05W061-208	12.53	33.4def	1106b	11.5abc	187cd	8.5ab	90.0
6Ab08-X03W012-5	-	-	-	-	-	-	-
Probability Level	NS	**	*	*	**	*	NA
Trial Mean	12.5	41.8	2314	11.8	273	12.5	83.6

Within a column, means followed by the same letter are not significantly different (P < 0.1).
*, **, coefficients significant at the 0.01 and 0.0001 probability levels, respectively.
NS - no significant coefficients (P < 0.1).
NA - was not statistically tested.

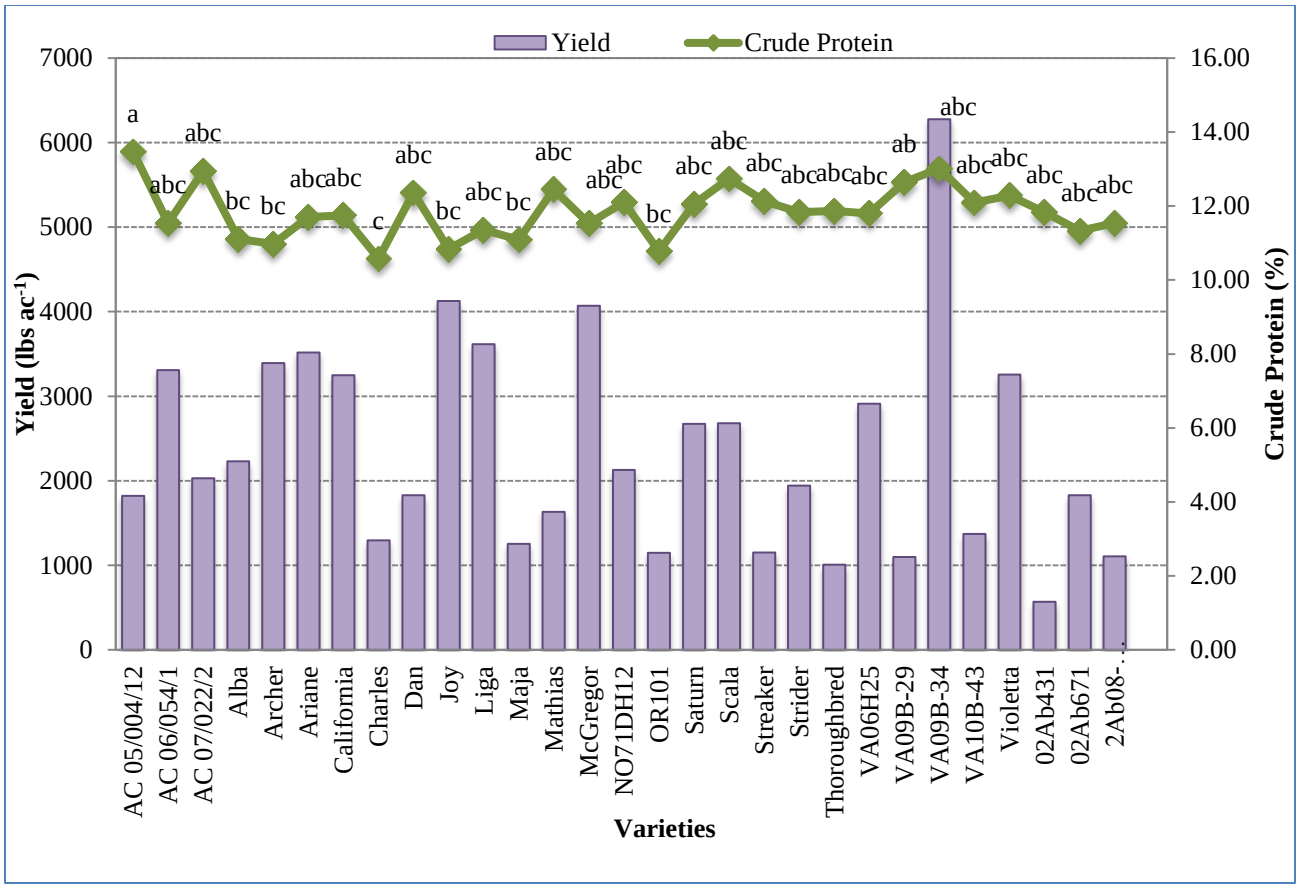

Figure 1. Yield and crude protein for winter barley varieties trialed in Alburgh, VT.

DISCUSSION

Low winter survival, disease, and poor weather conditions attributed to low yields in the winter barley. In addition, there was high leaf disease incidence and also some significant lodging in some varieties and a few plots were accidentally mowed due to communication error which impacted the performance of those plots and therefore influenced the reported performance of those varieties.

For malting purposes, high quality barley typically has low to moderate protein levels ranging from 9.0 – 11.0%. In general, six-row barley varieties usually have higher protein content ranging from 9.0-12.0%, compared to two-row barley varieties, which range from 9.0-11.0%. All winter barley varieties met the minimum malting standard for protein content, however eleven varieties were over 12%. Lower crude protein is more desirable from a malting/brewing perspective, as high protein levels can make beer hazy. Higher crude protein levels are also usually associated with lower starch content. Starch is the principal contributor to brewhouse extract, and higher levels of starch result in more beer produced from a given amount of malt, although some small-scale breweries are minimally concerned with brewhouse extract efficiency. Thousand kernel weight is a measure of kernel density and can be used as an indicator of malt quality. For two-row barley, thousand kernel weights are optimally between 40-50 grams per thousand kernels, whereas six-row barley is optimally between 35-40 grams per thousand kernels. Of the fifteen

two-row varieties, all except Charles, Scala, 02ab431, 2Ab08-X05W061-208, and 6Ab08-X03W012-5 met the minimum thousand kernel weight of 40 grams for malting quality. Of the fifteen six-row varieties all except McGregor, Thoroughbred, and VA06H25, met the minimum thousand kernel weight of 35 grams for malting quality.

High germination levels, preferably over 95% (three-day test), are essential for good malting barley. Germination levels in the winter barley were lower than preferred by the industry; only the variety Dan had 95% germination, all other varieties were below 95% and no varieties had above 95% germination. However, germination was not statistically tested as germination rates were not collected for all plots within varieties. Poor climatic conditions during the growing season likely led to poor quality grain. Falling number is not a standard quality measurement at malt houses. However, research indicates that a falling number of 220 seconds and greater indicates sound malt barley quality. Falling number is related to the level of sprout damage found in the grain. All winter barley varieties with the exception of Charles, VA09B-29, and 2Ab08-X05W061-208, had a falling number of at least 220 seconds. This indicates that all varieties, with the aforementioned exceptions, had little sprout damage and may be of good malting quality in this respect.

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