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2016 WINTER BARLEY SEEDING RATE, COVER CROP, AND VARIETY TRIAL

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With the revival of the small grains industry in the Northeast and the strength of the locavore 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 and livestock feed. Winter barley has not been traditionally grown in the Northeast due to severe winterkill. However, newly developed varieties and a changing climate have encouraged our team to investigate this crop for the area. In 2015, we undertook this project in coordination with the University of Massachusetts to evaluate the effects of winter barley variety, seeding rate, and nitrogen (N) fixing cover crops on barley yields and quality.

MATERIALS AND METHODS

The winter barley trial was carried out at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block with split-split plots and four replicates. The main plots were cover crops tilled into the soil prior to planting the winter barley crop. The three cover crop treatments (crimson clover, sun hemp, and a crimson clover/sun hemp mix) were planted on 17-Jul 2015. The first split plot was two varieites of winter barley (Endeavor and Wintmalt) planted on 15-Sep 2015 and the second split plot was three seeding rates (300, 400 and 500 seeds per square meter). The seedbed was prepared by conventional tillage methods. Plots were 5' x 20' and were seeded into a Benson rocky silt loam at 125 lbs ac^{-1} with a Great Plains cone seeder. Rows were spaced at 6". All plots were managed with practices similar to those used by producers in the surrounding areas (Table 1).

Cover crop populations, heights and biomass samples were collected 9-Sep 2015. Fall barley populations were taken on 5-Nov 2015 by counting the number of plants in two twelve inch sections. Soil samples were also collected on this date and evaluated for soil nitrates. Winter survival was assessed by a visual estimate on 25-Apr 2016.

Table 1. Winter barley agronomic characteristics and trial information.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	corn
Seeding rate (plants m$^{2-1}$)	300, 400 and 500
Row spacing (in)	6
Replicates	4
Planting date	15-Sep 2015
Harvest date	8-Jul 2016
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, spring disk & spike tooth harrow

All varieties were harvested with an Almaco SPC50 small plot combine on 8-Jul 2016. 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 ($p<0.10$).

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 following example, 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 AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 2. Historical averages are for 30 years of data (1981-2010). Fall conditions were above average for temperature and below average for precipitation. While April was colder than normal, the rest of the spring and summer growing season was also both warmer and drier than average. There were 5323 Growing Degree Days (GDDs) in the eight month winter barley growing season, 278 more growing-degree-days than the 30-year average.

Table 2. Weather data for winter barley variety trial in Alburgh, VT.

Alburgh, VT	**Sep-15**	**Oct-15**	**Nov-15**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**
Average temperature (°F)	65.2	46.5	42.2	33.9	39.8	58.1	65.8	70.7
Departure from normal	4.70	-1.60	4.00	2.90	-4.90	1.80	0.00	0.10
Precipitation (inches)	0.3	2.5	1.8	2.51	2.56	1.53	2.81	1.79
Departure from normal	-3.30	-1.09	-1.30	0.29	-0.26	-1.92	-0.88	-2.37
Growing Degree Days (base 32°F)	1010	464	329	209	291	803	1017	1201
Departure from normal	158	-37	117	85	-98	50	3	4

*Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

There were significant differences in populations, winter survival, yield, test weight, DON levels, and germination rate between treatments. There were no differences in between treatments in crude protein, falling number, or harvest moisture. Across trial, there were low DON levels, low test weight and low harvest moisture. There was also high falling number across the trial, with all treatments well above the 250 second industry minimum standard.

Impact of Seeding Rate:

The seeding rate treatments differed significantly in populations, winter survival, and germination (Table 3). The 500 seeds $\mathbf{m^2}$ treatment had the best winter survival at 99% survival. This was significantly higher than the other two treatments (p=0.01). The 400 seeds $\mathbf{m^2}$ treatment had the highest germination at 92%. This was significantly different than the 500 seeds $\mathbf{m^2}$ treatment at 86% germination but not significantly higher than the 300 seeds $\mathbf{m^2}$ treatment at 87% germination (p=0.01).

Table 3. Impact of seeding rate on barley harvest and quality, Alburgh, VT, 2015.

Seeding rate lbs ac^{-1}	Populations plants m^2	Winter Survival %	Harvest moisture %	Test weight lbs bu^{-1}	Harvest yield lbs ac^{-1}
300	400	85	12.3	**40.5**	2447
400	420	88	12.2	39.5	2572
500	**493***	**99***	11.2	38.7	**2835**
LSD (0.1)	68	10.8	NS	NS	NS
Trial mean	438	91	11.9	39.6	2618

Seeding rate lbs ac^{-1}	Crude protein @ 12% moisture %	DON ppm	Falling number seconds	Germination %
300	**8.52**	0.16	399	87.5*
400	7.91	0.14	392	**92.1***
500	7.85	**0.10**	**411**	85.8
LSD (0.1)	NS	NS	NS	4.6
Trial mean	8.09	0.13	401	88.5

*Treatments with an asterisk are not significantly different than the top performer in **bold**.

NS – No significant difference amongst treatments.

Impact of Cover Crop:

Cover crops tilled into the soil before the winter barley crop significantly impacted the yield of barley (Table 4). The control treatment with no cover crop had the highest yield. This was statisistically similar to the crimson clover and cover crop mix treatments, but higher than the sun hemp treatment (p=0.02). Cover crop treatment did not impact the quality of the barley (Table 4).

Table 4. Impact of cover crop on barley harvest and quality, Alburgh, VT, 2016.

Cover crop	Populations	Winter Survival	Harvest moisture	Test weight	Harvest yield
	plants m^2	%	%	lbs bu^{-1}	lbs ac^{-1}
Control	417	91	11.3	**40.7**	**2953***
Crimson Clover	**461**	88	11.1	39.9	2868*
Sun Hemp	424	85	**12.7**	39.8	2240
Mix	449	**98**	12.5	38	2411*
LSD (0.1)	NS	NS	NS	NS	544
Trial mean	438	91	11.9	39.6	2618

Cover crop	Crude protein @ 12% moisture	DON	Falling number	Germination
	%	ppm	seconds	%
Control	8.24	0.11	394	86.8
Crimson Clover	**8.38**	0.17	**410**	87.9
Sun Hemp	8.31	**0.10**	394	**91.1**
Mix	7.44	0.16	404	88.1
LSD (0.1)	NS	NS	NS	NS
Trial mean	8.09	0.13	401	88.5

*Treatments with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst treatments.

Impact of Variety:

Variety displayed the most significant differences of the treatments tested in this trial, with significant differences between the Wintmalt and Endeavor varieites in populations, winter survival, test weight, yield, DON levels, and germination (Table 5). Wintmalt had higher populations and winter survival than Endeavor (p<0.01). Wintmalt yielded 3209 lbs ac^{-1} while Endeavor yielded 2027 lbs ac^{-1}, over 1000 less lbs ac^{-1} (p<0.01). Wintmalt also had higher test weight (p=0.01) although both were well below the industry standard of 48 lbs bu^{-1}. While Endeavor was higher in DON (p=0.09), both varieties tested far below 1 ppm standard for human consumption.

Table 5. Impact of variety on barley harvest and quality, Alburgh, VT, 2016.

Variety	Populations plants m2	Winter Survival %	Harvest moisture %	Test weight lbs bu^{-1}	Harvest yield lbs ac^{-1}
Endeavor	395	**100***	**12.5**	38.2	2027
Wintmalt	**480***	74	11.3	**41***	**3209***
LSD (0.1)	68	10.8	NS	2.7	544
Trial mean	438	87	11.9	39.6	2618

Variety	Crude protein @ 12% moisture %	DON ppm	Falling number seconds	Germination %
Endeavor	**8.28**	0.17	391	**90.8***
Wintmalt	7.91	**0.09***	410	86.1
LSD (0.1)	NS	0.07	NS	88.5
Trial mean	8.09	0.13	401	4.6

*Treatments with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst treatments.

Interactions between treatments:

There were very few significant interactions between treatments. There was a significant interaction between variety and cover crop in terms of winter survival and yield (in both cases, the interaction was between the Endeavor variety and sun hemp/clover cover crop mix treatments). The Endeavor variety and cover crop mix demonstrated the poorest winter survival ($p<0.01$) and lowest yield at 1798 lbs ac^{-1} ($p=0.02$).

DISCUSSION

The warm, dry weather through most of the 2015-2016 winter barley growing season resulted in good yields and quality in winter barley. There was little snow cover to insulate the overwintering barley from cold damage, which affected some plots far more than others. The Wintmalt variety proved to overwinter much better in these conditions than the Endeavor barley, as well as having established better during the fall planting. The dry weather reduced disease pressure and there was little evidence of fusarium blight or the associated DON vomitoxin. The test weights for all barley treatments fell below the industry standard of 48 lbs bu^{-1}. Crude protein levels were slightly low this year compared to industry standards for malting barley as well. Ideally, barley will have a crude protein of 9.0-12.0%. The goal of having nitrogen fixing cover crops was to improve the yield and crude protein concentrations of the barley. In 2016, the cover crop treatment did not impact crude protein and had little impacts on barley yields. The lower seeding rates of 300 and 400 seeds per m^2 had lower populations and lower winter survival than the higher seeding rate of 500 seeds per m^2, however theses differences did not result in significant differences in yield. These data in this study represent only one year and should not alone be used to make management decisions.

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