2017 Winter Barley Seeding Rate, Cover Crop and Variety Trial

Dr. Heather Darby, UVM Extension Agronomist
Hillary Emick, Erica Cummings, Abha Gupta, Lindsey Ruhl, and Sara Ziegler
UVM Extension Crop and Soil Technicians
(802) 524-6501

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2017 WINTER BARLEY SEEDING RATE, COVER CROP, AND VARIETY TRIAL

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

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 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 region. This was the second year of the trial to evaluate the effects of variety, seeding rate, and fertility building cover crops on winter barley yields and quality. The study began in 2015 in coordination with the University of Massachusetts-Amherst.

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 fertility building cover crops tilled into the soil prior to planting the winter barley crop. Three cover crop treatments (crimson clover, sun hemp, and a crimson clover/sun hemp mix) were planted on 8-Aug 2016. The cover crops were tilled into the soil prior to planting the winter barley crop. The first split plot was two varieties of winter barley (Endeavor and Wintmalt) were planted on 27-Sep 2016. 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 with a Great Plains cone seeder. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 1).

Cover crop biomass sampled were collected 19-Sep 2016. Two 0.25m^2 quadrats of biomass per replicate were collected and were dried, weighed, ground, and analyzed for nitrogen content. Winter survival was assessed by a visual estimate on 5-May 2017. Heading date was recorded in early June when greater than 50% of the plot was heading. Barley heights and lodging were recorded on 20-Jul 2017 just prior to harvest on the same date.

Table 1. Winter barley agronomic characteristics and trial information.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Spring barley
Seeding rate (plants m^{2-1})	300, 400 and 500
Row spacing (in)	6
Replicates	4
Planting date	27-Sep 2016
Harvest date	20-Jul 2017
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 20-Jul 2017. 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 sample 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 this 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). The mild fall weather, with warm temperatures and moderate precipitation, promoted good establishment of the winter barley crop during the fall growing season. Winter conditions were somewhat warmer than normal but there was very little snow cover to protect the barley from freezing during cold spells. While April was warmer than normal, the rest of the spring and summer growing season was cooler than average. There were 5208 Growing Degree Days (GDDs) in the eight month winter barley growing season, 311 more growing-degree-days than the 30-year average. The last three months of the growing season were damp and lower than normal in temperature and growing degree days, leading to later maturation and delayed harvest until the end of July.

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

Alburgh, VT	Sep-16	Oct-16	Nov-16	Mar-17	Apr-17	May-17	Jun-17	Jul-17
Average temperature (°F)	63.6	50.0	40.0	25.1	47.2	55.7	65.4	68.7
Departure from normal	3.03	1.80	1.82	-6.05	2.37	-0.75	-0.39	-1.90
Precipitation (inches)	2.50	5.00	3.00	1.60	5.20	4.10	5.60	4.90
Departure from normal	-1.17	1.39	-0.13	-0.63	2.40	0.68	1.95	0.73
Growing Degree Days (base 32°F)	949	559	270	98	459	733	1002	1138
Departure from normal	91	57	85	98	75	-23	-12	-60

*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.

Summary of results:

There were significant differences between treatments in cover crop nitrogen content, heading date, height, lodging, yield, harvest moisture, test weight, crude protein, falling number, DON levels, and germination. Across trial, there were high DON levels. There was somewhat low falling number across the trial, with most samples tested falling below the 250 second industry minimum standard. There was a significant interaction between seeding rate, cover crop and variety in winter survival. There were significant interactions between seeding rate and cover crop in both height and yield. There was a significant reaction between seeding rate and variety in DON.

Interactions between treatments:

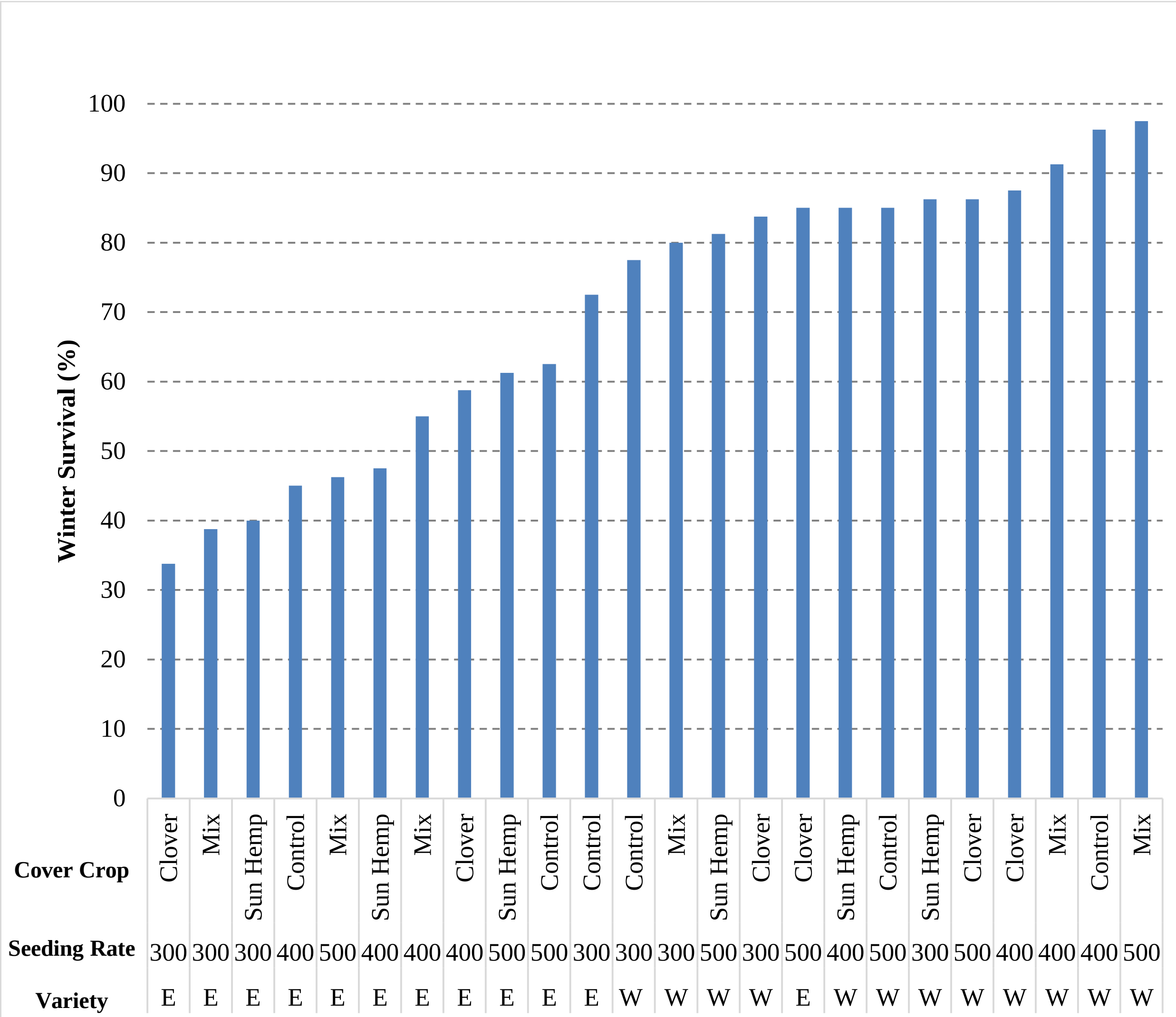

Figure 1. Impact of seeding rate, cover crop, and variety on barley winter survival, Alburgh, VT, 2017.

There was significant interaction between seeding rate, cover crop and variety affecting winter survival (p=0.03). Six combinations had winter survival less than 50%, while another six combinations had winter survival greater than 85% (Figure 1). The Wintmalt variety had higher winter survival than the Endeavor variety, and did particularly well with higher seeding rates and the clover and/or cover crop mixes. The Endeavor variety did not over winter well especially with lower seeding rates.

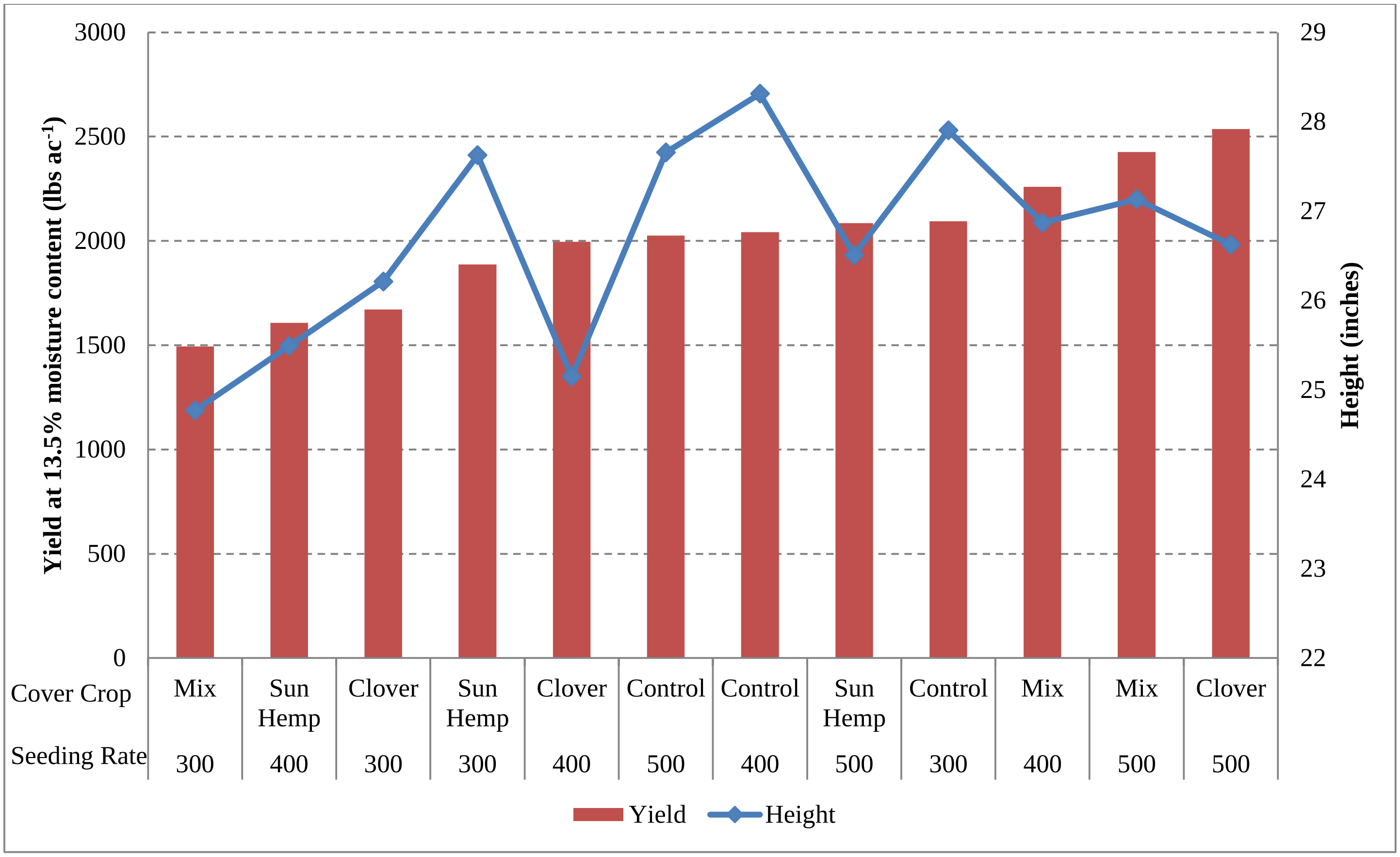

Figure 2. Impact of seeding rate and cover crop on winter barley height and yield, Alburgh, VT, 2017.

There was a significant interaction between seeding rate and cover crop in terms of height (p=0.04) and yield (p=0.01) (Figure 2). Higher seeding rates without cover crops resulted in the tallest barley plants regardless of seeding rate. Lower seeding rates and cover crops produced shorter plants than higher seeding rates and the control (no cover crop treatment). Higher seeding rates and incorporation of cover cops resulted in higher yields that the control. However with lower seeding rates without cover crops outperformed the cover crop treatments. It is possible that extra nitrogen provided by the cover crop treatments helped to increase barley yields under high seeding rates.

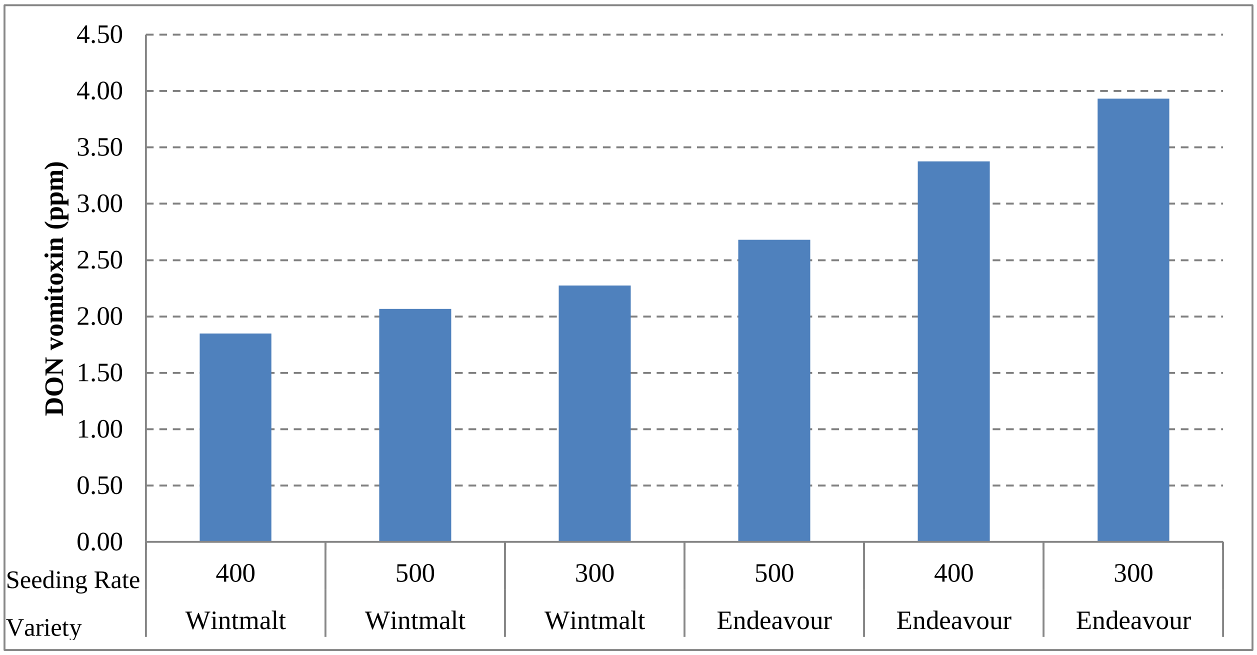

Figure 3. Impact of seeding rate and variety on DON levels in winter barley, Alburgh, VT, 2017.

Finally, there was a significant interaction between seeding rate and variety affecting DON levels (p=0.04) (Figure 3). Across the experiment, Wintmalt barley had lower DON levels than the Endeavor variety. In general for both varieties, the lowest seeding rate also had the lowest DON levels. This may indicate a link between seeding rate and DON concentrations.

Impact of Seeding Rate:

The seeding rates treatments had significant differences in winter survival, yield, crude protein, falling number, and DON (Table 3). The 500 seeds m^2 treatment had the best winter survival at 75.6% survival. This was significantly similar to the 400 seeds m^2 treatment at 70.8%. The 500 seeds m^2 treatment had the highest yield at 2268 lbs ac^{-1}, significantly higher than the other two seeding rates (p=0.0008). The 300 seeds m^2 treatment had significantly higher crude protein levels at 10.7% (p=0.01) and significantly higher falling number at 225 seconds (p=0.03). The 500 seeds m^2 and 400 seeds m^2 treatment had significantly lower levels of DON (p=0.005) although all treatments were above the 1 ppm threshold for human consumption.

Table 3. Impact of seeding rate on barley harvest and quality, Alburgh, VT, 2017.

Seeding rate lbs ac^{-1}	Cover crop N ac^{-1} lbs ac^{-1}	Winter survival %	Heading date	Height cm	Lodging %
300	28.2	64.1	6/10/2017	67.6	**44.9**
400	**28.6**	70.8*	6/9/2017	67.2	47.1
500	**28.6**	**75.6***	6/8/2017	**68.5**	46.9
LSD (0.10)	NS	7.37	NS	NS	NS
Trial mean	28.5	70.2	6/9/2017	67.8	46.3

Seeding rate	Harvest moisture	Test weight	Harvest yield @13.5% moisture	Crude protein @ 12% moisture	DON	Falling number	Germination
lbs ac^{-1}	%	lbs bu^{-1}	lbs ac^{-1}	%	ppm	seconds	%
300	14.7	42.6	1787	**10.7***	3.10	**224***	84.0
400	**14.2**	43.4*	1977	10.3	2.61*	201	83.7
500	**14.2**	**43.8***	**2268***	10.1	**2.38***	199	**89.0**
LSD (0.10)	NS	0.68	203	0.33	0.36	17.5	NS
Trial mean	14.4	43.3	2011	10.4	2.70	208	85.6

*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 was significant in terms of nitrogen ac^{-1}, height, lodging, test weight, and falling number (Table 4). The crimson clover had the highest amount of N ac^{-1}, with 33.2 lbs N ac^{-1}. This was statistically similar to the cover crop mix with 30.1 lbs N ac^{-1} ($p<0.0001$). The no cover crop control treatment resulted in significantly taller barley (71 cm) than the cover crop treatments ($p=0.004$). Barley grown following the crimson clover treatment had the least lodging, statistically similar to the sun hemp and control treatments. Barley grown following sun hemp had significantly lower test weights than the other three treatments as well as significantly lower falling number ($p=0.05$). Cover crop treatment did not significantly impact crude protein concentrations.

Table 4. Impact of cover crop on barley harvest and quality, Alburgh, VT, 2017.

Cover crop	Cover crop N ac^{-1}	Winter survival	Heading date	Height	Lodging
	lbs ac^{-1}	%		cm	%
Control	28.1	**73.1**	6/9/2017	**71.0***	47.8*
Crimson Clover	**33.2***	72.5	6/9/2017	66.0	**41.3***
Sun Hemp	22.7	66.9	6/9/2017	67.4	44.1*
Mix	30.1*	68.1	6/9/2017	66.7	52.1
LSD (0.1)	3.24	NS	NS	2.37	9.35
Trial mean	28.5	70.2	6/9/2017	67.8	46.3

Cover crop	Harvest moisture	Test weight	Harvest yield @13.5% moisture	Crude protein @ 12% moisture	DON	Falling number	Germination
	%	lbs bu^{-1}	lbs ac^{-1}	%	ppm	seconds	%
Control	14.3	43.1*	2054	**10.5**	2.70	213*	**85.8**
Crimson Clover	**14.2**	**43.9***	**2068**	10.3	2.72	**216***	**85.8**
Sun Hemp	14.3	42.9	1860	10.4	2.70	193	85.5
Mix	14.5	43.1*	2060	10.3	**2.67**	210*	85.2
LSD (0.1)	NS	0.79	NS	NS	NS	20.2	NS
Trial mean	14.3	43.3	2011	10.4	2.70	208	85.6

*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 varieties in winter survival, heading date, lodging, yield, harvest moisture, test weight, crude protein, falling number, DON and germination (Table 5). Wintmalt had higher yields and tested better for most quality parameters. Wintmalt had higher winter survival (86.4%) and higher yield (2455 lbs ac^{-1}) ($p<0.0001$). Endeavor had statistically less lodging at 42% ($p=0.03$). Wintmalt had statistically lower harvest moisture (13.2%), higher test weight (44.2 lbs bu-1), and higher falling number (267 seconds) ($p<0.0001$). Wintmalt had significantly lower DON levels, although both varieties exceeded the 1 ppm threshold for human consumption. Endeavor had higher crude protein levels (11.1%, $p<0.0001$) and higher germination rates (89.5%, $p=0.005$).

Table 5. Impact of variety on barley harvest and quality, Alburgh, VT, 2017.

Variety	Cover crop N ac^{-1}	Winter survival	Heading date	Height	Lodging
	lbs ac^{-1}	%		cm	%
Endeavor	28.4	53.9	6/10/2017	**68.3**	42.0
Wintmalt	**28.6**	**86.4**	6/8/2017	67.3	**50.6**
LSD (0.1)	NS	6.01	NS	2.37	6.61
Trial mean	28.5	70.2	1 day	67.8	46.3

Variety	Harvest moisture	Test weight	Harvest yield @13.5% moisture	Crude protein @ 12% moisture	DON	Falling number	Germination
	%	lbs bu^{-1}	lbs ac^{-1}	%	ppm	seconds	%
Endeavor	15.5	42.3	1566	**11.1**	3.33	149	**89.5**
Wintmalt	**13.2**	**44.2**	**2455**	9.7	**2.06**	**267**	81.6
LSD (0.1)	0.42	0.56	166	0.27	0.30	14.3	4.53
Trial mean	14.4	43.3	2011	10.4	2.70	208	85.6

*Treatments in **bold** performed significantly higher than the other treatment.
NS – No significant difference amongst treatments.

DISCUSSION

The cold, damp weather through most of the 2016-2017 winter barley growing season resulted in moderate yields and poorer quality than the first year of the study. DON levels were high while test weight and falling number were less than optimal. The test weights for all barley treatments fell below the industry standard of 48 lbs bu^{-1} and all the barley had to be dried down for storage. 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. Crude protein levels this year largely fell within the industry standards for malting barley of 9.0-12.0%. Similar to 2016, the fertility building cover crop did not impact the barley crude protein concentrations.

These data in this study represent only one year and should not alone be used to make management decisions.

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