NORTHWEST CROPS & SOILS PROGRAM

2016 Organic Spring Barley Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 ORGANIC SPRING BARLEY 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. 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 2016, UVM Extension, in collaboration with the Eastern Spring Malting Barley Nursery (ESBN) testing network, conducted a spring malting barley trial to evaluate yield and quality of 25 varieties.

MATERIALS AND METHODS

A spring barley variety trial was initiated at Borderview Research Farm in Alburgh, VT. The experimental plot design was a randomized complete block with three replications. The treatments were twenty-five spring malting barley varieties, listed in Table 1.

Table 1. Twenty-five spring barley varieties trialed at Borderview Research Farm in Alburgh, VT, 2016.

Spring barley variety	Type	Seed source
2ND28065	6-row	North Dakota State University
AAC Synergy	2-row	Agriculture and Agri-Food Canada
AC Metcalfe	2-row	Agriculture and Agri-Food Canada
Acorn	2-row	Ackerman, Germany
Bently	2-row	Field Crop Development Centre (Lacombe, Alberta, Canada)
CDC Copeland	2-row	Crop Development Centre (University of Saskatchewan)
CDC Meredith	2-row	Crop Development Centre (University of Saskatchewan)
Cerveza	2-row	Agriculture and Agri-Food Canada
Conlon	2-row	North Dakota State University
Explorer	2-row	SECOBRA, France
Innovation	6-row	Busch Agricultural Resources, LLC
KWS Beckie	2-row	KWS Cereals USA LLC
KWS Fantex	2-row	KWS Cereals USA LLC
Lacey	6-row	University of Minnesota
LCS Genie	2-row	Limagrain Cereal Seeds
LCS Odyssey	2-row	Limagrain Cereal Seeds
ND Genesis	2-row	North Dakota State University
Newdale	2-row	Agriculture and Agri-Food Canada
Pinnacle	2-row	North Dakota State University
Pioneer	2-row	SECOBRA, France
Quest	6-row	University of Minnesota
Robust	2-row	University of Minnesota

Steffi	2-row	Ackerman, Germany
SY Sirish	2-row	Syngenta
Tradition	6-row	Busch Agricultural Resources, LLC

All plots were managed with practices similar to those used by producers in the surrounding areas (Table 2). The previous crop planted at the site were sunflowers. In April 2016, the trial area was plowed, disked and spike tooth harrowed to prepare for planting. The plots were seeded with a Great Plains NT60 Cone Seeder on 21-Apr at a seeding rate of 325 live seeds per m^2 into a Benson rocky silt loam. Plot size was 5'x 20'.

Table 2. 2016 agronomic and trial information for spring barley variety trial.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Sunflowers
Tillage operations	Spring plow, disc, and spike tooth harrow
Harvest area (ft)	5 x 20
Row spacing (in)	6
Seeding rate (live seed m^2)	325
Replicates	3
Planting date	21-Apr
Harvest date	27-Jul

Barley populations were measured by counting the number of plants in three 12-inch segments randomly throughout each plot on 19-May. A visual estimate of vigor was taken 31-May by rating the plots on a 1-5 scale, 1 for poor vigor and 5 for stong vigor. Flowering dates were recorded when at least 75% of a plot was in bloom. On 29-Jun plots were scouted for disease and insect pests. Five plants per plot were randomly selected throughout each plot. All leaves (between 1 and 3 leaves) on the five plants were scouted and every disease symptom and sign of insect damage was recorded. The W. Clive James, "An Illustrated Series of Assessment Keys for Plant Diseases, Their Preparation and Usage" (1971) was used to determine the severity of plant disease infection. Each plot was then given an overall health rating between 1 and 9 (1 being minimal damage and 9 being severe damage). Loose smut was scouted for in each plot and presence/absence was recorded. Plants with unknown discoloration or damage were pulled, placed in a labeled plastic bag, refrigerated, and identified at the UVM Plant Diagnostic Laboratory. On 27-Jul, the plots were harvested using an Almaco SPC50 small plot combine. At the time of harvest, grain moisture, test weight, and yield were calculated.

Following the harvest of spring barley, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). 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. Generally the heavier the barley is per bushel, the higher malting quality. The acceptable test weight for barley is 48 lbs per bushel. Once test

weight was determined, the samples were then 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 were determined using the AACC Method 56-81B, AACC Intl., 2000 on a Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage that has occurred in the grain. It is measured by the time it takes, in seconds, for a stirrer to fall through a slurry of flour and water to the bottom of the tube. Falling numbers greater than 350 indicate low enzymatic activity and sound quality sample. A falling number lower than 200 indicates high enzymatic activity and poor quality. Deoxynivalenol (DON) analysis was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption. Percent germination (germination energy) was determined by incubating 100 seeds in 4.0 mL of water for 72 hours and counting the number of seeds that did not germinate. Each plot was done in duplicate. Grain assortment or Plumpness was determined using the Pfeuffer Soritmat using 100g of clean seed, and was determined by the combining the amount of seed remaining on the 2.78mm and 2.38mm sieves.

All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate cultivar means when the F-test was significant ($P< 0.10$). There were significant differences among the two locations for most parameters and therefore data from each location is reported independently.

LEAST SIGNIFICANT DIFFERENCE (LSD)

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 varieties is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (e.g. yield). Least Significant Differences at the 10% level of probability are shown. Where the difference between two varieties within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. In the example below, variety A is significantly different from variety C, but not from variety B. The difference between A and B is equal to 725, which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

Variety	Yield
A	3161
B	3886*
C	**4615***
LSD	**889**

RESULTS

Seasonal precipitation and temperature recorded at weather stations in close proximity to the 2016 site are shown in Table 3. The growing season this year was marked by lower than normal temperatures in April and higher than average temperatures in May, June and July. Rainfall amounts were below average throughout the growing season resulting in 5.43 inches of precipitation less than normal. From April to July, there was an accumulation of 3312 Growing Degree Days (GDDs) which was 40.8 GDDs below the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2016.

Alburgh, VT	April	May	June	July
Average temperature (°F)	39.8	58.1	65.8	70.7
Departure from normal	-4.92	1.84	0.01	0.13
Precipitation (inches)	2.56	1.53	2.81	1.79
Departure from normal	-0.26	-1.92	-0.88	-2.37
Growing Degree Days (32-95°F)	291	803	1017	1201
Departure from normal	-97.9	49.5	3.20	4.45

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from 8/17/16-10/31/16 was missing and was replaced by data provided by the NOAA for Highgate, VT. Historical averages are for 30 years of data provided by the NOAA (1981-2010) for Burlington, VT.

Plant populations and vigor were not significantly different between varieties (Table 4). Most varieties bloomed (flowering 75% or greater) by the fourth week in June. The earliest flowering variety was Robust on 21-Jun, and LCS Genie and KWS Fantext were the latest flowering on 4-Jul. Plots were scouted for disease and insect pests on 29-Jun. The primary plant diseases identified were; Powdery Mildew (Erysiphe graminis f. sp. tritici), Tan spot (Pyrenophora tritici-repentis), and Spetoria leaf blotch (Stagonospora nodorum). Loose smut (Ustilago tritici) infected plants were seen in two varieties; Tradition and KWS Beckie. Loose smut caused by the fungus, Ustilago tritici, is carried as dormant mycelium within healthy-looking seed and is spread by planting infected seed. A smut-infected seed or plant cannot be distinguished from an uninfected one until the head starts to emerge. The disease is most obvious just after the time of heading by the characteristic dusty black appearance of diseased heads. The spores are dispersed by the wind during wheat flowering and can infect healthy plants. The predominant insect damage observed were by brown wheat mite (Petrobia latens) and thrips (species unknown). Additional insect pests identified include, Cereal leaf beetle (Oulema melanopus (L.)) and European Corn Borer (Ostrinia nubilalis).

Table 4. 2016 spring barley agronomic characteristics in Alburgh, VT.

Variety	Population	Vigor	Flowering	Disease
	plants m^2	rating (1-5)	date	rating (1-9)
2ND28065	258	3.67	24-Jun	**1.00***
AAC Synergy	289	3.67	27-Jun	**1.00***
AC Metcalfe	318	4.33	24-Jun	**1.00***
Acorn	273	3.67	29-Jun	**1.00***
Bently	254	3.17	27-Jun	**1.00***
CDC Copeland	194	4.00	1-Jul	**1.00***
CDC Meredith	244	4.00	1-Jul	**1.00***
Cerveza	268	4.33	27-Jun	**1.00***
Conlon	342	3.67	27-Jun	**1.00***
Explorer	199	4.33	27-Jun	**1.00***
Innovation	**371**	4.33	23-Jun	2.00
KWS Beckie	277	4.00	1-Jul	**1.00***
KWS Fantex	273	3.33	4-Jul	**1.00***
Lacey	266	4.00	23-Jun	1.67
LCS Genie	349	4.00	4-Jul	**1.00***
LCS Odyssey	263	3.67	1-Jul	**1.00***
ND Genesis	222	4.33	27-Jun	**1.00***
Newdale	246	4.00	3-Jul	**1.00***
Pinnacle	263	3.67	24-Jun	**1.00***
Pioneer	256	**4.67**	1-Jul	**1.00***
Quest	294	3.67	24-Jun	1.67
Robust	256	4.33	**21-Jun**	2.67
Steffi	323	4.33	2-Jul	**1.00***
Sy Sirish	239	4.33	3-Jul	**1.00***
Tradition	263	4.33	23-Jun	1.33
LSD (0.10)	NS	NS	-	0.32
Trial Mean	1100810	3.99	-	1.17

Values shown in **bold** are of the highest value or top performing.
* Barley varieties that are not significantly different than the top performing variety in a column are indicated with an asterisk.
NS - no significant coefficients ($P < 0.1$).
(-) was not statistically tested.

Spring Barley Yield and Quality:

Varieties differed significantly in harvest moisture and test weight but not between yields (Table 5). The highest yielding variety was Cerveza (4243 lbs ac^{-1}) and the lowest yielding was Quest (2460 lbs ac^{-1}) (Figure 1). Robust had the lowest moisture at harvest (8.70 %). Additional varieties with low harvest moistures include; Innovation, Quest, Newdale, and Lacey. Eighteen of the twenty-five varieties trialed

had moistures above 14% at the time of harvest; therefore, those 18 required additional drying. The highest harvest moisture was Acorn (19.0%). Lacey had the highest test weight of 44.5 lbs bu^{-1}. Other varieties with high test weights included Innovation (44.3 lbs bu^{-1}), LCS Genie (43.7 lbs bu^{-1}), Tradition (44.3 lbs bu^{-1}), Innovation (44.2 lbs bu^{-1}), Acorn (43.5 lbs bu^{-1}), KWS Fantex (43.3 lbs bu^{-1}), Sy Sirish (42.7 lbs bu^{-1}), Robust (42.2 lbs bu^{-1}), Pioneer (42.0 lbs bu^{-1}), and 2ND28065 (41.0 lbs bu^{-1}) However, none of the varieties met the desired barley test weight of 48 lbs per bushel.

Table 5. Harvest results for the 25 spring barley varieties trialed in Alburgh, VT, 2016.

Variety	Harvest moisture	Test weight	Yield @ 13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
2ND28065	17.1	41.0*	3312
AAC Synergy	14.1	40.5	3700
AC Metcalfe	15.6	39.0	3452
Acorn	19.0	43.5*	3986
Bently	17.7	36.7	2899
CDC Copeland	17.3	39.2	2573
CDC Meredith	15.8	38.2	3084
Cerveza	12.7	38.0	**4243**
Conlon	15.8	39.0	3176
Explorer	16.4	38.0	3245
Innovation	8.87*	44.3*	3337
KWS Beckie	17.1	39.5	2517
KWS Fantex	17.0	43.3*	3462
Lacey	11.7*	**44.5***	2959
LCS Genie	17.9	43.7*	3671
LCS Odyssey	15.3	37.0	2984
ND Genesis	16.8	39.0	3617
Newdale	11.3*	36.3	2869
Pinnacle	17.7	40.2	3385
Pioneer	16.7	42.0*	2766
Quest	9.03*	37.2	2460
Robust	**8.70***	42.2*	2678
Steffi	16.2	39.8	2810
Sy Sirish	15.0	42.7*	3767
Tradition	12.9	38.7	3379
LSD (0.10)	3.64	3.95	NS
Trial Mean	14.9	40.1	3213

Values shown in **bold** are of the highest value or top performing.
* Barley varieties that are not significantly different than the top performing variety in a column are indicated with an asterisk.
NS - no significant coefficients ($P < 0.1$).

There were significant differences in protein, falling number germination energy and grain plumpness (Table 6). Robust and Steffi had the highest crude protein content at 11.8% and the variety with the lowest protein content was Acorn (8.79%) (Figure 1). Other high protein spring barley varieties include; Lacey (11.6%), Tradition (11.5%), Quest (11.4%), Innovation (11.2%), and Cerveza (10.9%).

Table 6. Quality results for the 25 spring barley varieties trialed in Alburgh, VT, 2016.

Variety	Protein @ 12% moisture	Falling number @ 14% moisture	DON	Germination energy	Plumpness
	%	seconds	ppm	%	%
2ND28065	10.1	361*	**0.03**	**98.3***	91.8
AAC Synergy	9.92	283	0.27	95.0*	97.6*
AC Metcalfe	10.5	204	0.07	76.7	94.8
Acorn	8.79	348	0.23	96.0*	98.3*
Bently	10.6	261	0.20	96.7*	97.7*
CDC Copeland	10.5	203	**0.03**	88.7*	92.7
CDC Meredith	10.1	267	0.23	96.3*	94.7
Cerveza	10.9*	219	0.07	47.7	95.1
Conlon	10.8	297	0.43	96.0*	98.2*
Explorer	10.2	320	0.00	65.0	97.7*
Innovation	11.2*	331	0.10	88.3*	95.4
KWS Beckie	10.1	402*	0.33	93.7*	98.8*
KWS Fantex	10.1	369*	0.30	88.0*	97.8*
Lacey	11.6*	410*	0.07	96.3*	95.4
LCS Genie	9.92	391*	0.10	96.7*	98.6*
LCS Odyssey	9.86	366*	0.30	94.7*	98.7*
ND Genesis	8.84	284	0.10	96.3*	97.9*
Newdale	10.4	253	0.27	74.0	95.0
Pinnacle	9.40	312	0.47	89.7*	97.2*
Pioneer	9.49	272	0.25	97.0*	97.7*
Quest	11.4*	401*	0.27	97.0*	92.8
Robust	**11.8***	**432***	0.80	96.0*	92.2
Steffi	**11.8***	377*	0.30	98.0*	**98.9***
Sy Sirish	10.8	319	0.30	87.3*	98.5*
Tradition	11.5*	417*	0.33	98.0*	96.3
LSD (0.10)	1.00	71.7	NS	21.1	1.77
Trial Mean	10.4	324	0.23	89.9	96.4

Values shown in **bold** are of the highest value or top performing.
*Barley varieties that are not significantly different than the top performing variety in a column are indicated with an asterisk.
NS - no significant coefficients ($P < 0.1$).

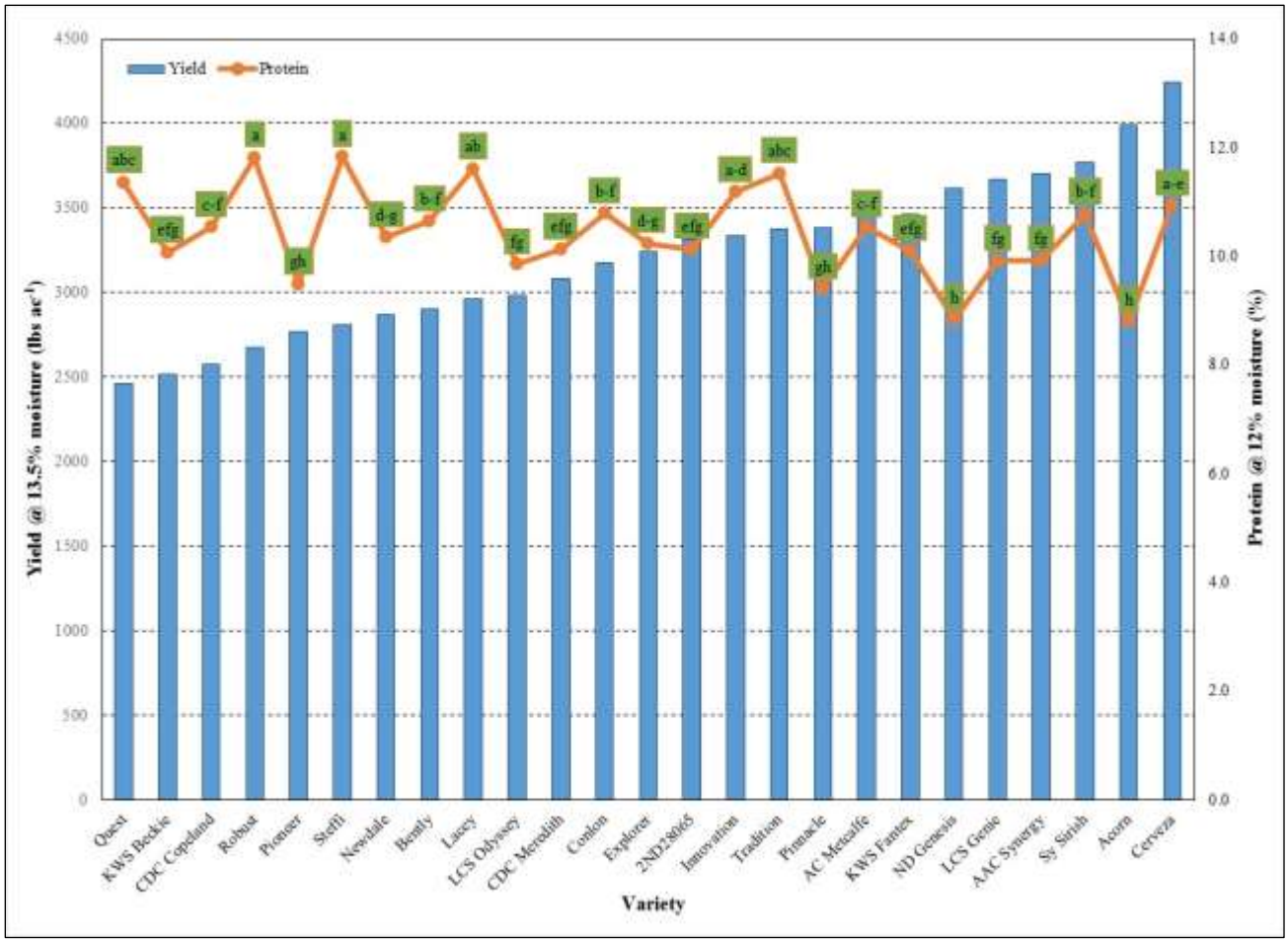

Figure 1. Yield and crude protein for the 25 spring barley varieties trialed in Alburgh, VT, 2016.
Varieties with the same letter did not differ significantly.

Robust had the highest falling number, 432 seconds. The variety with the lowest falling number, indicating sprouting damage, was AC Metcalfe at 204 seconds. DON concentration was not significantly different among varieties.The varieties 2ND28065 and CDC Copeland had the lowest DON concentrations at 0.03 ppm and the highest was Robust (0.8 ppm). All twenty-five spring barley varieties had DON levels below the FDA recommendation of <1ppm. Thirteen varieties, 2ND28065 (98.3%), Steffi (98.0%), Tradition (98.0%), Pioneer (97.0%), Quest (97.0%), Bently (96.7%), LCS Genie (96.7%), CDC Meredith (96.3%), Lacey (96.3%), ND Genesis (96.3%), Acorn (96.0%), Colon (96.0%), Robust (96.0%), and AAC Synergy (95.0%), met industry malting standards (95% or above) for seed germination (Figure 2). The lowest germination rate was Cerveza (47.4%). The variety with the plumpest kernel size was Steffi (98.9%) and the least plump was 2ND28065 (91.8%). All of the twenty five varieties trialed met industry standards for plumpness, >80% for a two-row and >70% for a six-row barley.

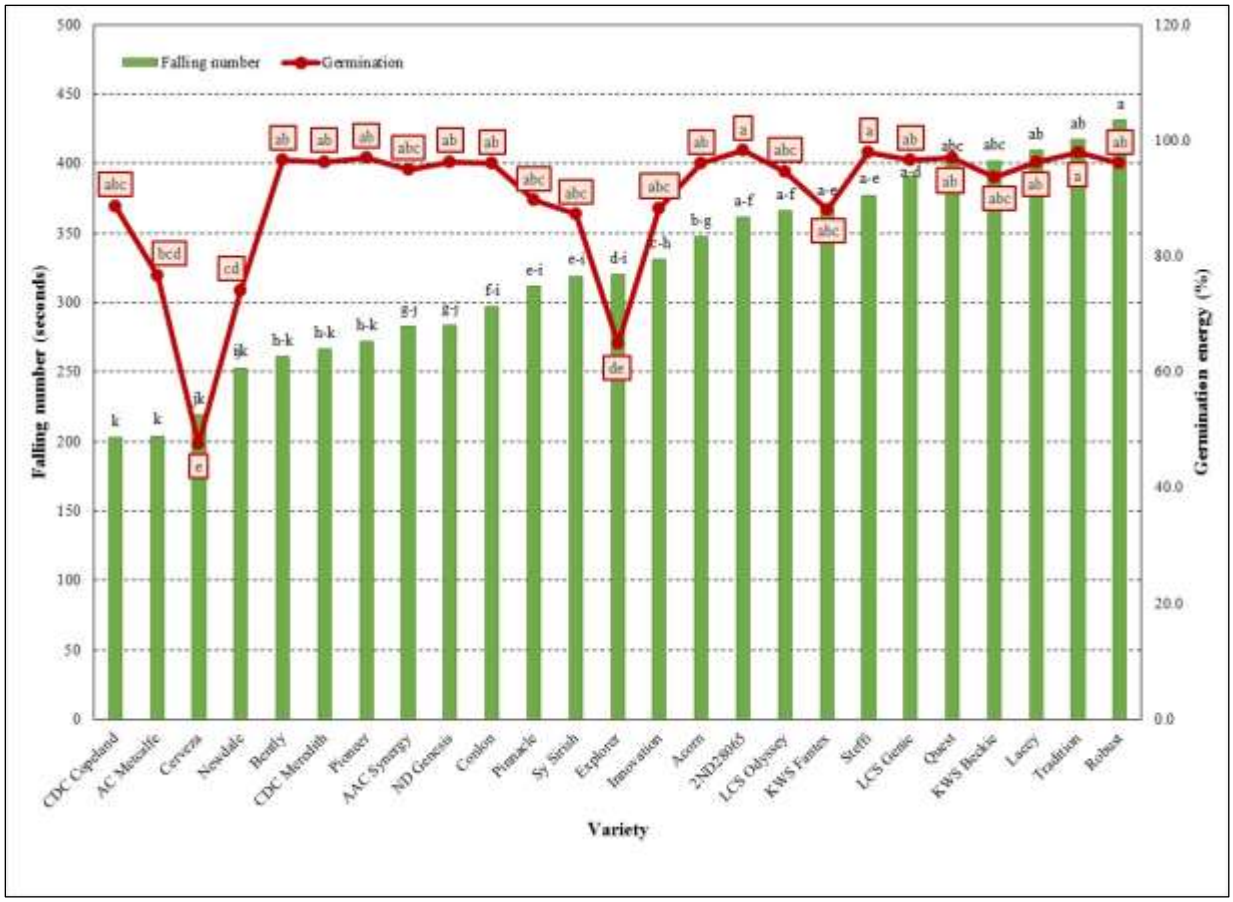

Figure 2. Falling number and germination comparison of the 25 spring barley varieties trialed in Alburgh, VT, 2016.
Varieties with the same letter did not differ significantly.

DISCUSSION

It is important to remember that the results only represent one year of data. Overall, the 2016 growing season was ideal for growing spring barley. The warmer than average temperatures along with below normal rainfall throughout much of the growing season resulted in higher yields and quality. Due to higher than normal bird pressure, possibly due to drought-like conditions, plots were covered with bird netting from soft dough until harvest. There was also an increase in thrip and mite damage recorded which could also be attributed to the dry conditions this season; however, the damage was not severe enough to cause economic loss. The average yield was 3213 lbs ac^{-1}, 1635lbs higher than the 2015 average yield. Test weight, a measure of grain plumpness, also an indicator used to determine malt quality, was the only quality parameter that was low, all varieties were below the ideal malting test weight of 48 lbs per bushel. However, kernel plumpness did not appear to be impacted, all varieties were above 90% for plumpness. The average percent protein this year was 10.4%, 2.88% higher than the trial mean in 2015. Twenty-three of the 25 spring barley varieties had protein levels that met industry standards, only Acorn (8.79%) and ND Genesis (8.84%) fell below these standards. 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%. Lower crude protein is desirable from a malting/brewing perspective as high protein levels can make beer hazy. Higher protein levels are also often associated with lower starch content. Starch is the principal contributor to brew house 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 brew house extract efficiency. High germination energy levels, preferably over 95% (three-day test), are essential for a good malting barley. Fourteen of the 25 varieties trialed had germination rates above 95%. Interestingly, Cerveza which had a germination of 47.73% correlated with its falling number of 219 seconds, indicating sprouting damage. 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. A low falling number (< 220 seconds) indicates a decrease in barley storability, even if the germinative energy is high. Twenty-two of the 25 varieties trialed had falling numbers above 220 seconds. All varieties were below the 1ppm FDA recommend limit for DON concentration. The average DON level in 2016 was 0.23 ppm, 1.18 ppm lower than the average DON level in 2015.

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