NORTHWEST CROPS & SOILS PROGRAM

2017 Organic Spring Barley Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2017 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 2017, 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

In 2017, 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.

Spring barley variety	Type	Seed source
2ND28065	6-row	North Dakota State University
2ND33710	2-row	North Dakota State University
2ND33757	2-row	North Dakota State University
2ND33760	2-row	North Dakota State University
2ND33821	2-row	North Dakota State University
AAC Synergy	2-row	Agriculture and Agri-Food Canada
Acorn	2-row	Ackerman, Germany
Bettina (SC 14129 O2)	2-row	SECOBRA, France
Conlon	2-row	North Dakota State University
Esma	2-row	Ackerman, Germany
Explorer	2-row	SECOBRA, France
KWS Beckie	2-row	KWS Cereals USA LLC, Germany
KWS Fantex	2-row	KWS Cereals USA LLC, Germany
KWS Josie	2-row	KWS Cereals USA LLC, Germany
KWS Tinka	2-row	KWS Cereals USA LLC, Germany
LCS Genie	2-row	Limagrain Cereal Seeds
LCS Odyssey	2-row	Limagrain Cereal Seeds
Manta	2-row	Ackerman, Germany
ND Genesis	2-row	North Dakota State University
Newdale	2-row	Agriculture and Agri-Food Canada
Pinnacle	2-row	North Dakota State University
Quest	6-row	University of Minnesota

Sangria	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 was corn. In April 2017, 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 27-Apr at a seeding rate of 350 live seeds m^2 into a Benson rocky silt loam. Plot size was 5' x 20'.

Table 2. Agronomic and trial information for spring barley variety trial, 2017.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
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)	350
Replicates	3
Planting date	27-Apr
Harvest date	1-Aug

Flowering dates were recorded when at least 50% of a plot was in bloom. On 28-Jun plots were scouted for disease and insect pests. Five plants per plot were randomly selected throughout the trial. The top three leaves on the five plants were scouted and every disease symptom and sign of insect damage was recorded. The Clive James, 'An Illustrated Series of Assessment Keys for Plant Diseases, Their Preparation and Usage' 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, 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. Prior to harvest, barley heights were measured, excluding awns, in centimeters, three times per plot. In addition, at the time of harvest lodging was rated on a 1 to 5 scale, 1 indicated minimal lodging and 5 meant the plot was completely lodged and could not be harvested. On 1-Aug, 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 Mini GAC moisture and test weight meter. 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.

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 2017 site are shown in Table 3. The growing season this year was marked by higher than normal temperatures in April and lower than average temperatures in May, June, July, and August. Rainfall amounts were higher than average throughout the growing season resulting in 7.39 inches of precipitation more than normal. From April to August, there was an accumulation of 4440 Growing Degree Days (GDDs) which was 50.9 GDDs below the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2017.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	47.2	55.7	65.4	68.7	67.7
Departure from normal	2.37	-0.75	-0.39	-1.90	-1.07
Precipitation (inches)	5.22	4.13	5.64	4.88	5.54
Departure from normal	2.40	0.68	1.95	0.73	1.63
Growing Degree Days (32-95°F)	459	733	1002	1138	1108
Departure from normal	75.4	-22.7	-11.9	-60.3	-31.4

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

Most varieties bloomed (50% or more of the total plot) by the third week in June. The earliest flowering varieties were Conlon, 2ND33710, 2ND33757, and 2ND33760 on 19-Jun, and LCS Odyssey was the latest flowering on 28-Jun (Table 4). There were significant differences among varieties for plant disease, plant height, and lodging (Table 4). Plots were scouted for disease and insect pests on 28-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). The lowest amount of overall plant disease were on Esma, KWS Fantex, KWS Tinka, Manta, ND Genesis, and Sy Sirish with no disease recorded. The highest amount of overall plant disease was 2ND33757 (16.7 %). Loose smut (Ustilago tritici) infected spikes were seen in fourteen varieties; 2ND28065, 2ND 33757, AAC Synergy, Acorn, Bettina, Explorer, LCS Genie, LCS Odyssey, ND Genesis, Newdale, Pinnacle, Sangria, Sy Sirish, and Tradition. 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 was caused by brown wheat mite (Petrobia latens) and thrips (species unknown). Additional insect pests identified include, Cereal leaf beetle (Oulema melanopus (L.)) Leaf miner (species unknown), aphids, and slugs.

The tallest variety was 2ND33757 at 91.6 cm. Other tall varieties include; 2ND33710 (90.6 cm), 2ND33760 (88.7 cm), Quest (88.2 cm), Newdale (86.9 cm), ND Genesis (86.2 cm), 2ND33821 (85.3

cm), and AAC Synergy (84.7 cm). The shortest variety measured 66.2 cm (Manta). Only ND Genesis had no recorded lodging while Pinnacle had a 4.00 out of 5.00 rate for lodging.

Table 4. 2017 spring barley agronomic characteristics in Alburgh, VT.

Variety	Flowering	Plant disease	Plant height	Lodging
	date	%	cm	rating (1-5)
2ND28065	22-Jun	3.00*	83.3	1.33*
2ND33710	19-Jun	3.00*	90.6*	2.33
2ND33757	19-Jun	16.7	**91.6***	1.33*
2ND33760	19-Jun	8.33	88.7*	1.00*
2ND33821	22-Jun	8.67	85.3*	1.00*
AAC Synergy	22-Jun	0.33*	84.7*	0.33*
Acorn	27-Jun	**0.00***	71.6	1.67
Bettina (SC 14129 O2)	27-Jun	1.67*	79.2	2.33
Conlon	19-Jun	0.67*	79.9	1.33*
Esma	22-Jun	**0.00***	71.2	2.67
Explorer	22-Jun	0.67	68.8	2.33
KWS Beckie	23-Jun	0.33*	69.7	1.00*
KWS Fantex	22-Jun	**0.00***	70.7	1.67
KWS Josie	22-Jun	0.67*	68.7	1.67
KWS Tinka	22-Jun	**0.00***	76.4	1.67
LCS Genie	27-Jun	3.33*	69.9	2.33
LCS Odyssey	28-Jun	1.67*	71.0	2.67
Manta	23-Jun	**0.00***	66.2	1.00*
ND Genesis	22-Jun	**0.00***	86.2*	**0.00***
Newdale	22-Jun	0.33*	86.9*	1.00*
Pinnacle	22-Jun	16.0	78.4	4.00
Quest	22-Jun	16.7	88.2*	1.00*
Sangria	24-Jun	1.33*	65.1	1.00*
SY Sirish	22-Jun	**0.00***	67.3	3.33
Tradition	22-Jun	6.67	79.6	0.33*
LSD (0.10)	-	5.83	8.11	1.36
Trial Mean	-	3.60	77.6	1.61

*Varieties with an asterisk are not significantly different than the top performer in **bold**.
(-) no statistical analysis performed for this variable.

Spring Barley Yield and Quality:

Varieties differed significantly in harvest moisture, test weight, and yields (Table 5). The highest yielding variety was ND Genesis (3499 lbs ac^{-1}) and the lowest yielding was Pinnacle (1750 lbs ac^{-1}) (Figure 1). Other high yielding varieties included: Sangria (3348 lbs ac^{-1}), Conlon (3347 lbs ac^{-1}), AAC Synergy (3315 lbs ac^{-1}), Manta (3263 lbs ac^{-1}), Explorer (3237 lbs ac^{-1}), KWS Fantex (3219 lbs ac^{-1}), KWS Tinka (3216 lbs ac^{-1}), Newdale (3208 lbs ac^{-1}), 2ND33757 (3191 lbs ac^{-1}), 2ND33760 (3161 lbs ac^{-1}), 2ND33821 (3147 lbs ac^{-1}), Esma (3111 lbs ac^{-1}), 2ND33710 (3096 lbs ac^{-1}), Quest (3030 lbs ac^{-1}), and

Tradition (2852 lbs ac^{-1}). Quest had the lowest moisture at harvest (11.1 %) and Bettina had the highest harvest moisture at 16.1%. Nine of the twenty-five varieties trialed had moistures above 14% at the time of harvest; therefore, those nine required additional drying. Conlon had the highest test weight of 46.8 lbs bu^{-1}. Other varieties with high test weights included: Explorer (46.3 lbs bu^{-1}), Tradition (46.3 lbs bu^{-1}), 2ND33757 (45.9 lbs bu^{-1}), 2ND28065 (45.5 lbs bu^{-1}), AAC Synergy (45.4 lbs bu^{-1}), Esma (45.4 lbs bu^{-1}), ND Genesis (45.2 lbs bu^{-1}), Newdale (45.1 lbs bu^{-1}), Manta (44.8 lbs bu^{-1}), LCS Genie (44.7 lbs bu^{-1}), Manta (44.8 lbs bu^{-1}), and 2ND33760 (44.6 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, 2017.

Variety	Harvest moisture	Test weight	Yield @ 13.5% moisture
	%	lbs bu^{-1}	lbs ac^{-1}
2ND28065	14.4	45.5*	2666
2ND33710	14.2	44.5	3096*
2ND33757	14.2	45.9*	3191*
2ND33760	14.3	44.6*	3161*
2ND33821	14.9	42.9	3147*
AAC Synergy	15.1	45.4*	3315*
Acorn	12.8	38.2	2721
Bettina (SC 14129 O2)	16.1	42.5	2496
Conlon	13.5	**46.8***	3347*
Esma	13.7	45.4*	3111*
Explorer	13.4	46.3*	3237*
KWS Beckie	12.4	38.5	2171
KWS Fantex	13.1	43.4	3219*
KWS Josie	12.7	40.9	2717
KWS Tinka	14.2	43.5	3216*
LCS Genie	14.0	44.7*	2407
LCS Odyssey	13.6	40.4	1859
Manta	13.4	44.8*	3263*
ND Genesis	15.0	45.2*	**3499***
Newdale	14.0	45.1*	3208*
Pinnacle	13.4	41.7	1750
Quest	**11.1***	44.3	3030*
Sangria	13.8	43.5	3348*
SY Sirish	13.2	41.5	2419
Tradition	11.9*	46.3*	2852*
LSD (0.10)	1.21	2.25	681
Trial Mean	13.7	43.7	2898

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

There were significant differences among varieties for protein, falling number, DON, germination energy, grain plumpness, and thins (Table 6). Tradition had the highest crude protein content at 10.5% and the variety with the lowest protein content was Acorn (7.81%) (Figure 1).

Table 6. Quality results for the 25 spring barley varieties trialed in Alburgh, VT, 2017.

Variety	Protein @ 12% moisture	Falling number @ 14% moisture	DON	Germination energy	Plumpness	Thins
	%	seconds	ppm	%	%	%
2ND28065	8.85	368*	0.37*	**99.0***	92.3	6.38
2ND33710	9.48	361*	1.60	97.3*	92.1	6.44
2ND33757	9.27	362*	1.67	**99.0***	87.3	11.6
2ND33760	9.01	312	1.65	98.0*	87.7	10.5
2ND33821	8.61	330*	1.13	93.7	**97.6***	2.00*
AAC Synergy	8.55	266	2.10	95.7*	96.5*	3.10*
Acorn	7.81	342*	0.93*	90.7	94.2	5.26
Bettina (SC 14129 O2)	8.96	282	0.73*	93.7	95.0*	4.34
Conlon	9.58	314	1.53	95.0	97.0*	**1.42***
Esma	8.24	251	0.63*	94.7	95.4*	4.33
Explorer	8.62	275	0.93*	98.4*	96.4*	4.46
KWS Beckie	8.27	338*	0.43*	96.7*	94.9*	4.83
KWS Fantex	8.13	374*	1.33	96.7*	95.7*	3.98*
KWS Josie	8.39	361*	**0.27***	97.0*	90.0	9.12
KWS Tinka	8.40	275	1.23	92.3	95.8*	3.72*
LCS Genie	9.22	**380***	2.33	95.3	95.0*	6.01
LCS Odyssey	8.00	333*	0.73*	92.0	96.5*	4.94
Manta	8.36	311	1.00*	96.3*	94.3	5.41
ND Genesis	8.08	318	2.17	97.3*	95.3*	4.63
Newdale	9.26	320	0.80*	97.0*	92.8	6.15
Pinnacle	9.51	355*	0.87*	86.7	87.6	11.0
Quest	9.51	369*	0.83*	98.0*	93.3	7.82
Sangria	8.13	323	1.07	94.0	94.9*	4.63
SY Sirish	8.72	351*	1.27	96.3*	95.4*	4.30
Tradition	**10.5***	359*	1.77	95.7*	95.8*	3.89*
LSD (0.10)	0.65	50.6	0.77	3.66	3.00	2.78
Trial Mean	8.78	329	1.18	95.5	93.9	5.61

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

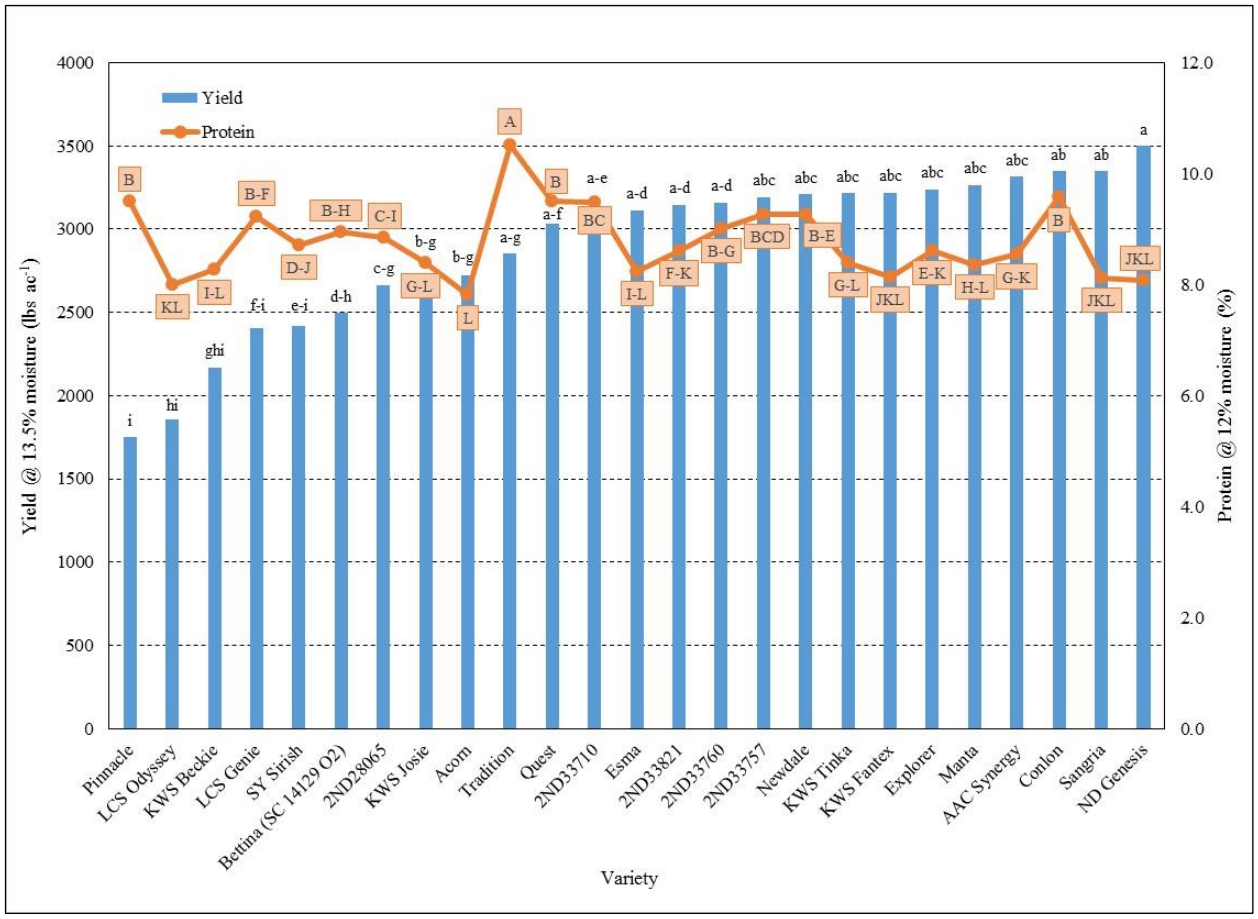

Figure 1. Yield and crude protein for the 25 spring barley varieties trialed in Alburgh, VT, 2017.
Varieties with the same letter did not differ significantly.

LCS Genie had the highest falling number of 380 seconds. The variety with the lowest falling number was Esma at 251 seconds. The variety with the lowest concentration of DON was KWS Josie (0.27 ppm) (Figure 2). Other varieties with low DON concentrations included: 2ND28065 (0.37 ppm), KWS Beckie (0.43 ppm), Esma (0.63 ppm), Bettina (0.73 ppm), LCS Odyssey (0.73 ppm), Newdale (0.80 ppm), Quest (0.83 ppm), Pinnacle (0.87 ppm), Acorn (0.93 ppm), Explorer (0.93 ppm), and Manta (1.00 ppm). Twelve out of the twenty-five spring barley varieties trialed had DON levels below the FDA recommendation of <1ppm. 2ND28065 and 2ND33757 had the highest germination rate of 99.0% and Pinnacle had the lowest rate of 86.7%. Seventeen of the twenty-five varieties trialed met industry malting standards (95% or above) for seed germination. The variety with the plumpest kernel size was 2ND33821 (97.6%) and the least plump was 2ND33757 (87.3%). All of the twenty-five varieites trialed met industry standards for plumpness, >80% for a two-row and >70% for a six row barley. Conlon had the lowest amount of thins (1.42%) while 2ND33757 had the highest (11.6%).

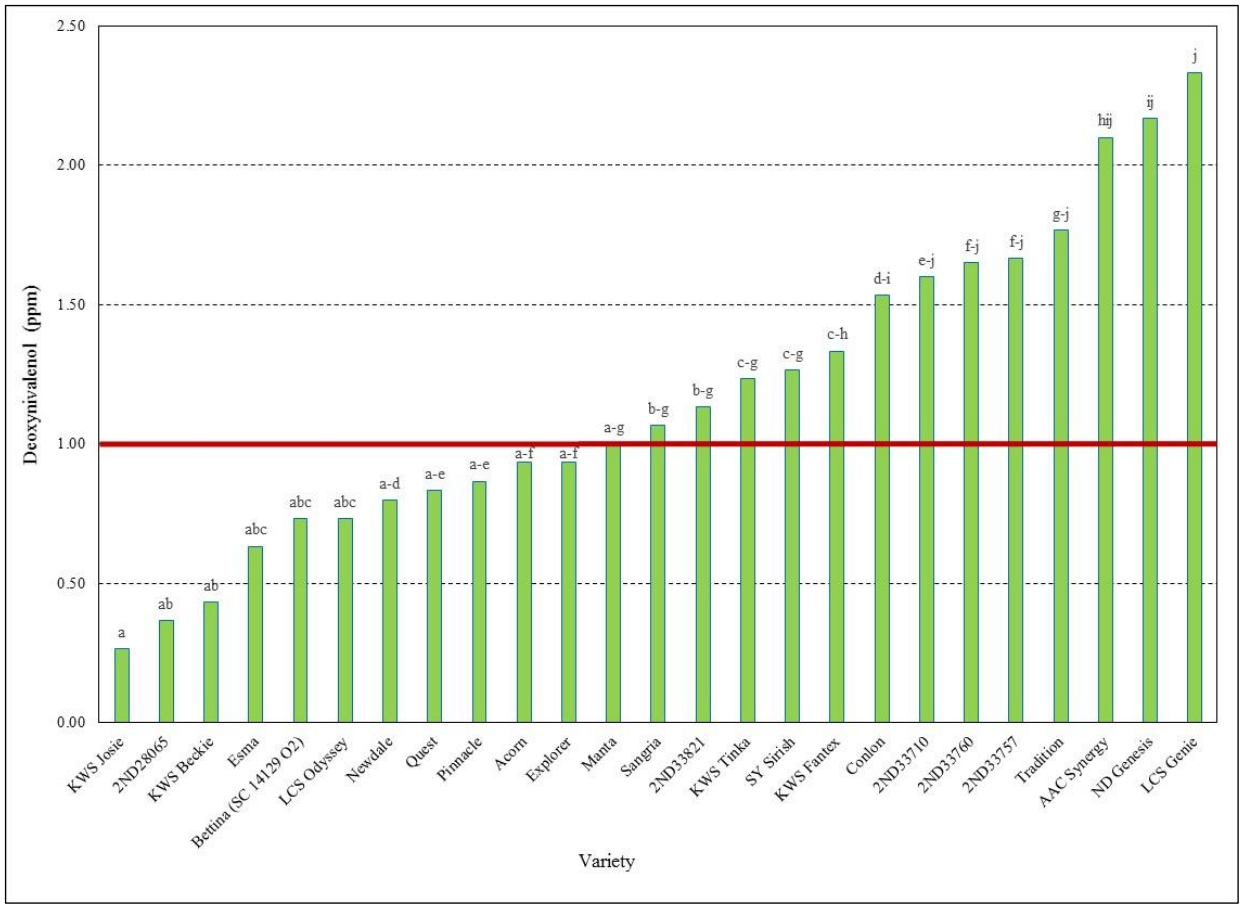

Figure 2. Deoxynivalenol (DON) comparison of the 25 spring barley varieties trialed in Alburgh, VT, 2017.
Varieties with the same letter did not differ significantly.

DISCUSSION

It is important to remember that the results only represent one year of data. Overall, the 2017 growing season was challenging for growing spring barley. The cooler than average temperatures, along with higher than normal rainfall, throughout much of the growing season likely had impact on yield and quality. The average yield was 2898 lbs ac^{-1}, which was 315 lbs lower than the 2016 average yield. Test weight, a measure of grain plumpness, was also an indicator used to determine malt quality 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 as all varieties were above 87% for plumpness.

Protein was the quality parameter most severely affected by the weather conditions this season. The average barley protein concentrations this year was 8.78%. Nine of the 25 spring barley varieties had protein levels that met industry standards; sixteen fell below these standards. For malting purposes, high quality barley typically has low to moderate protein concentrations ideally 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. Seventeen of the 25 varieties trialed had germination rates above 95%. 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. All of the 25 varieties trialed had falling numbers above 220 seconds. Twelve of the 25 varieties trialed were at or below the 1ppm FDA recommended limit for DON concentration.

Interestingly, there were no varieties that across the board out-performed the others. The spring barley varieties, Newdale and Quest, had the best overall yields and quality.

It is important, as you make variety choices on your farm, that you evaluate data from test sites that are as similar to your region as possible. It is our intention to continue this research in 2018.

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