NORTHWEST CROPS & SOILS PROGRAM

2020 Organic Spring Barley Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2020 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 are interested 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. Both two- and six-row barley can be used for malting. In 2020, 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 26 varieties. Some varieties that had not performed well or are no longer commercially available were dropped from the trial and new varieties have been added.

MATERIALS AND METHODS

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

Table 1. Twenty-six spring barley varieties trialed at Borderview Research Farm in Alburgh, VT, 2020.

Spring barley variety	Type	Seed source
2ND32184	2-row	North Dakota State University
2ND32529	2-row	North Dakota State University
2ND36638	2-row	North Dakota State University
2ND36642	2-row	North Dakota State University
2ND37111	2-row	North Dakota State University
2ND37130	2-row	North Dakota State University
2ND37568	2-row	North Dakota State University
AAC Connect	2-row	Agriculture and Agri-Food Canada (Brandon)
AAC Synergy	2-row	Agriculture and Agri-Food Canada (Brandon)
Accordine	2-row	Ackermann (Germany)
Barbarella	2-row	Limagrain Cereal Seeds
Brunilda	2-row	Ackermann (Germany)
Eifel	2-row	Secobra (France)
Esma	2-row	Ackermann (Germany)
Explorer	2-row	Secobra (France)
Focus	2-row	Secobra (France)
Klarinette	2-row	Secobra (France)
KWS Fantex	2-row	KWS (Germany)
KWS Jessie	2-row	KWS (Germany)
KWS Willis	2-row	KWS (Germany)
LCS Genie	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
Sangria	2-row	Agriculture and Agri-Food Canada (Brandon)
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 soybeans. In April, 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 at a seeding rate of 350 live seeds m^{-2} into a Benson rocky silt loam on 17-Apr. The plot size was 5' x 20'.

Table 2. Agronomic and trial information for spring barley variety trial, 2019.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Soybeans
Tillage operations	Spring plow, disc, and spike tooth
Harvest area (ft)	5 x 20
Row spacing (in)	6
Seeding rate (live seeds m^{-2})	350
Replicates	3
Planting date	17-Apr
Harvest date	24-Jul

Heading date was recorded throughout the month of June as the date when 50% of the plot was fully headed. On 8-Jul, plots were scouted for disease and arthropod pests. Five plants from each plot were examined. The top two leaves were examined and evaluated for the presence of disease and insect damage. The Clive James, 'An Illustrated Series of Assessment Keys for Plant Diseases, Their Preparation and Usage' was used to identify and determine the severity of plant disease infection. Damage recorded as a percent of the leaf surface that was affected by pest or disease.

Barley heights and lodging were recorded on 23-Jul, one day before harvest. Heights were measured, excluding awns, in centimeters for three plants in each plot. Lodging was assessed by visual estimate and recorded as the percentage of the plot was completely lodged and could not be harvested. On 24-Jul, the plots were harvested using an Almaco SPC50 small plot combine.

Following the harvest of spring barley, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). Quality measurements included standard testing parameters used by commercial malt houses. Plot yield was weighed. 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. A one-pound subsample was collected to determine quality. 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. 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 2/3 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 sample was run 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 ($p< 0.10$).

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 this example, 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 letters 'a' and 'b' indicate which varieties are statistically similar to each other in terms of yield; variety B is similar to both varieties A and C, but variety A and C are not statistically similar to each other.

Variety	Yield
A	3161[b]
B	3886[ab]
C	**4615[a]**
LSD	**889**

RESULTS & DISCUSSION

Seasonal precipitation and temperature recorded at a weather station at Borderview Research Farm are shown in Table 3. April and May were cooler and drier than normal, while June and July were warmer and drier than normal. From April through July, there was an accumulation of 3433 Growing Degree Days (GDDs), 55 GDDs above the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2020.

Alburgh, VT	April	May	June	July
Average temperature (°F)	41.6	56.1	66.9	74.8
Departure from normal	-3.19	-0.44	1.08	4.17
Precipitation (inches)	2.09	2.35	1.86	3.94
Departure from normal	-0.72	-1.04	-1.77	-0.28
Growing Degree Days (32-95°F)	315	746	1046	1326
Departure from normal	-99	-13	35	132

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.

Dry spring weather suppressed germination in the field and reduced spring emergence for many varieties (Table 4). The varieties Newdale and Eifel were particularly affected and had populations that were statistically lower than all other varieties. These were also the two lowest yielding varieties (Table 5) due in large part to their poor emergence in the spring.

All varieties headed in a one week period between 14-Jun and 21-Jun.

Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. Diseased plants may exhibit reduced vigor, growth, and seed fill. Earlier occurrence, greater degree of host susceptibility, and longer duration of conditions favorable for disease development will increase the yield loss. When scouted on 8-Jul, each plot was assessed for several distinct diseases. These individual disease ratings were combined into a single foliar disease rating for statistical analysis.

With the dry weather, fungal infections were not an issue of note in the spring barley variety trial. No powdery mildew or fusarium infection was found. Leaf rust was the only fungal infection noted and found on less than 1% of plants scouted. The most common disease symptom noted were leaf spots from a variety of plant diseases, affecting 69% of plants scouted.

The variety with the highest disease burden was Pinnacle, with more than 18% of the foliar surface of this variety affected by disease. This was statistically similar to two other varieties, Sangria and Eifel, which had more than 13% of their folar surface affected by disease. This was the third consecutive year that all plants of the Pinnacle variety were found to be affected by an unknown disease with distinctive foliar lesions that did not appear to spread to surrounding plots.

Table 4. 2020 spring barley agronomic characteristics in Alburgh, VT.

Variety	Population	Heading Date	Disease	Arthropod Damage	Height	Lodging
	plants m^{-2}	date	% foliar surface affected	% foliar surface affected	cm	%
2ND32184	340^{b-f}	6/15/2020^{g-i}	3.80^{e-g}	18.33^{a-c}	67.7^{ab}	13.3^{c-e}
2ND32529	376^{ab}	6/15/2020^{h-j}	3.80^{e-g}	14.07^{b-d}	58.3^{e-j}	1.7^{de}
2ND36638	378^{ab}	6/14/2020^{ij}	**1.20^{g}**	**8.13^{d}**	61.8^{c-e}	**0.0^{e}**
2ND36642	291^{f-j}	6/14/2020^{ij}	3.67^{e-g}	9.93^{d}	61.1^{c-f}	**0.0^{e}**
2ND37111	286^{g-k}	6/15/2020^{h-j}	6.47^{c-g}	18.73^{a-c}	60.9^{c-g}	3.3^{c-e}
2ND37130	318^{c-h}	6/15/2020^{h-j}	4.27^{d-g}	14.87^{b-d}	61.8^{c-e}	1.7^{de}
2ND37568	330^{b-g}	6/15/2020^{h-j}	2.80^{e-g}	13.27^{b-d}	64.1^{b-d}	**0.0^{e}**
AAC Connect	344^{b-e}	6/16/2020^{f-h}	2.27^{e-g}	13.13^{b-d}	60.3^{c-g}	**0.0^{e}**
AAC Synergy	295^{d-i}	6/19/2020^{b}	2.73^{e-g}	13.33^{b-d}	61.7^{c-e}	**0.0^{e}**
Accordine	240^{jk}	6/17/2020^{d-f}	11.07^{b-d}	11.20^{cd}	58.9^{d-i}	31.7^{bc}
Barbarella	332^{b-g}	6/17/2020^{c-e}	8.00^{b-g}	12.73^{cd}	61.1^{c-f}	63.3^{a}
Brunilda	274^{h-k}	6/18/2020^{bc}	5.60^{d-g}	10.33^{d}	55.6^{g-k}	5.0^{c-e}
Eifel	157^{l}	6/19/2020^{b}	13.13^{a-c}	14.47^{b-d}	61.0^{c-f}	30.0^{b-d}
Esma	251^{i-k}	6/18/2020^{bc}	4.40^{d-g}	20.80^{ab}	58.8^{d-i}	5.0^{c-e}
Explorer	266^{h-k}	6/16/2020^{f-h}	5.53^{d-g}	15.13^{b-d}	53.1^{jk}	16.7^{c-e}
Focus	234^{k}	6/16/2020^{f-h}	6.27^{d-g}	15.00^{b-d}	57.6^{e-k}	16.7^{c-e}
Klarinette	254^{i-k}	6/15/2020^{h-j}	8.40^{b-f}	13.27^{b-d}	54.9^{h-k}	3.3^{c-e}
KWS Fantex	292^{e-j}	6/18/2020^{b-d}	8.53^{b-f}	8.93^{d}	47.6^{l}	**0.0^{e}**
KWS Jessie	300^{d-i}	6/15/2020^{g-i}	9.07^{b-e}	9.53^{d}	53.1^{jk}	**0.0^{e}**
KWS Willis	293^{e-j}	6/16/2020^{e-g}	7.07^{c-g}	8.60^{d}	56.0^{f-k}	18.3^{b-e}
LCS Genie	364^{a-c}	6/19/2020^{b}	8.87^{b-f}	10.40^{d}	53.6^{i-k}	46.7^{ab}
ND Genesis	347^{b-d}	6/15/2020^{g-i}	7.33^{c-g}	13.07^{b-d}	64.7^{bc}	**0.0^{e}**
Newdale	171^{l}	6/21/2020^{a}	6.93^{c-g}	23.20^{a}	61.0^{c-f}	**0.0^{e}**
Pinnacle	318^{c-h}	6/16/2020^{f-h}	18.20^{a}	12.93^{b-d}	59.8^{c-h}	5.0^{c-e}
Sangria	260^{i-k}	6/16/2020^{e-g}	14.20^{ab}	13.40^{b-d}	52.9^{kl}	**0.0^{e}**
Tradition	**411^{a}**	6/14/2020^{j}	2.20^{fg}	25.00^{a}	**71.4^{a}**	5.0^{c-e}
LSD (p=0.10)	52.8	1.03 days	6.82	7.93	5.38	28.7
Trial Mean	297	6/16/2020	6.76	13.92	59.2	10.3

Within a column, varieties with the same letter did not vary significantly. The top performer is indicated in **bold**.

Damage from insects and other arthropod pests was a more significant issue than disease pressure in the spring barley trial. All plants scouted showed some level of arthropod damage, with the average plant having more than 10% of the foliar surface damaged. The most common insect pest were mites, which

tend to flourish in hot, dry conditions. 70% of plants scouted showed damage by mites. Thrips were the second most common pest noted, with 51% of plants showing damage from thrips. Damage from cereal leaf beetle, European corn borer, and slugs were also noted during scouting. Tradition had the most arthropod damage, with the average plant of this variety having 25% of the foliar surface damaged by arthropod pests. 2ND36638 had the least pest damage, with just over 8% of the foliar surface damaged by pests. There is sometimes a trend noted with an inverse relationship between disease pressure and insect pressure, where those varieties with higher disease burden tending to have lower arthropod pest pressure. This was not necessarily the case in this year's trial, with the variety 2ND36638 having both the lowest prevalence of disease symptoms and the lowest arthropod damage.

Heights and lodging were measured prior to harvest. Taller plants can be desirable for better competition against weeds; however very tall plants can be prone to lodging. Tradition was the tallest variety at 71.4 cm. This variety did experience some lodging (an average of 5% of these plots were too lodged to harvest), however this was not statistically different from the varieties that did not have any lodging. Barbarella had the most lodging at 63.3%. This was statistically similar to the variety LCS Genie with 47.6% lodging. Neither of these were in the tallest group statistically.

Spring Barley Yield and Quality

Yield and quality varied significantly between varieties of spring barley (Table 5, Figure 1).

Yields in this year's trial were overall very good. The variety 2ND36638 had the highest yield at 4830 lbs ac^{-1}. This was statistically similar with 19 other varieties with yields over two tons ac^{-1}. The varieties Newdale and Eifel had low yields (2903 and 3404 lbs ac^{-1} respectively), statistically different from all other varieties. As noted above, these two varieties were also statistically different from all other varieties in terms of spring populations and suffered from poor germination in the dry spring weather.

Harvest moisture was variable between varieties. Most varieties required drying down for storage.

AAC Connect had the highest test weight at 47.8 lbs bu^{-1}. No variety's test weights met the industry standard of 48 lbs bu^{-1}.

The industry standard for crude protein for malting barley is between 9%-11% for optimal malting quality. Most of the varieties grown in 2019 fell within the industry standard. None were below 9% crude protein. Explorer and Tradition had crude protein levels at or above 12%. Tradition is a six-row barley, for which the acceptable upper limit of protein concentration is higher than for two-row barley (six-row barley has an upper limit of 13.5% protein for acceptable malting quality).

Falling number is an indicator of enzymatic activity and/or sprouting damage. Falling number was generally good across the trial. 2ND32184 and Brunilda had falling numbers less than 200, indicating low enzymatic activity in these varieties.

Table 5. Harvest and quality for 26 spring barley varieties trialed in Alburgh, VT, 2020.

Variety	Yield @ 13.5% moisture content	Harvest moisture	Test Weight	Crude Protein @ 12% moisture content	Falling Number	Germination	Plumpness
	lbs ac^{-1}	%	lbs bu-1	%	seconds	%	%
2ND32184	4417^{ab}	14.2^{e-g}	45.7^{a-e}	10.8^{d-h}	184^{l}	96.7^{c-g}	97.6^{a}
2ND32529	4600^{ab}	14.7^{d-f}	45.9^{a-e}	10.2^{gh}	306^{g-i}	98.3^{a-d}	95.9^{a-c}
2ND36638	**4830^{a}**	15.3^{b-f}	43.7^{b-f}	11.3^{c-f}	320^{e-h}	97.0^{b-f}	97.3^{a}
2ND36642	4768^{a}	15.9^{a-e}	47.3^{ab}	10.0^{h}	274^{i-k}	96.3^{d-h}	95.3^{a-d}
2ND37111	4165^{ab}	15.3^{b-f}	46.6^{a-c}	10.4^{f-h}	353^{cd}	97.7^{a-e}	97.0^{a}
2ND37130	4283^{ab}	16.1^{a-d}	44.6^{a-e}	10.4^{f-h}	352^{cd}	99.3^{a-c}	97.2^{a}
2ND37568	4227^{ab}	16.9^{ab}	43.0^{d-f}	10.6^{e-h}	315^{f-h}	98.0^{a-d}	96.7^{a}
AAC Connect	4351^{ab}	13.9^{fg}	**47.8^{a}**	11.6^{b-d}	328^{d-h}	99.0^{a-d}	92.6^{de}
AAC Synergy	4356^{ab}	14.5^{d-g}	47.4^{a}	11.1^{d-g}	282^{ij}	99.0^{a-d}	97.1^{a}
Accordine	4011^{bc}	14.7^{d-f}	44.8^{a-e}	11.1^{d-g}	248^{k}	95.0^{e-h}	96.9^{a}
Barbarella	4601^{ab}	14.4^{d-g}	42.9^{ef}	11.5^{b-d}	273^{jk}	98.7^{a-d}	96.1^{ab}
Brunilda	4213^{ab}	15.7^{a-e}	46.9^{a-c}	11.0^{d-g}	174^{l}	91.7^{i}	96.3^{ab}
Eifel	3404^{cd}	14.5^{d-g}	45.1^{a-e}	11.7^{b-d}	320^{e-h}	94.7^{f-h}	97.3^{a}
Esma	3870^{bc}	15.1^{c-f}	43.3^{c-f}	11.5^{b-e}	343^{c-f}	96.7^{c-g}	97.3^{a}
Explorer	4498^{ab}	14.4^{d-g}	46.5^{a-e}	12.3^{ab}	334^{c-g}	**100.0^{a}**	95.5^{a-d}
Focus	4204^{ab}	14.4^{d-g}	45.7^{a-e}	11.6^{b-d}	296^{h-j}	98.0^{a-d}	92.8^{c-e}
Klarinette	4164^{ab}	14.2^{e-g}	47.7^{a}	11.7^{b-d}	338^{c-f}	93.7^{hi}	97.5^{a}
KWS Fantex	4184^{ab}	14.4^{d-g}	42.9^{ef}	11.4^{b-e}	393^{ab}	98.7^{a-d}	93.5^{b-e}
KWS Jessie	4609^{ab}	13.6^{fg}	44.3^{a-f}	10.2^{gh}	301^{h-j}	97.7^{a-e}	97.4^{a}
KWS Willis	4542^{ab}	14.4^{d-g}	40.9^{f}	10.9^{d-g}	350^{c-e}	98.0^{a-d}	**97.9^{a}**
LCS Genie	3965^{bc}	14.5^{d-g}	46.8^{a-c}	11.1^{d-g}	364^{bc}	99.7^{ab}	93.4^{b-e}
ND Genesis	4463^{ab}	15.3^{b-f}	47.2^{ab}	**10.0^{h}**	345^{c-f}	98.3^{a-d}	96.8^{a}
Newdale	2904^{d}	17.4^{a}	44.8^{a-e}	13.0^{a}	337^{c-g}	94.0^{j-i}	90.8^{e}
Pinnacle	3865^{bc}	16.7^{a-c}	46.6^{a-d}	10.3^{gh}	341^{c-f}	96.7^{c-g}	96.1^{ab}
Sangria	4264^{ab}	14.4^{d-g}	46.4^{a-e}	11.6^{b-d}	398^{a}	98.7^{a-d}	96.7^{a}
Tradition	4586^{ab}	**12.9^{g}**	46.9^{a-c}	12.1^{a-c}	362^{bc}	99.7^{ab}	95.3^{a-d}
LSD (p=0.10)	748	1.77	3.65	0.94	31.7	2.68	3.18
Trial Mean	4244	14.9	45.4	11.1	317	97.3	95.9

Within a column, varieties with the same letter did not vary significantly. The top performer is indicated in **bold**.

Most varieties met the industry standard of 95% for germination. Brunilda, Eifel, Klarinette and Newdale had germination between 90% and 95%. All varieties were above industry standards for plumpness (>80% for a two-row and >70% for a six row barley).

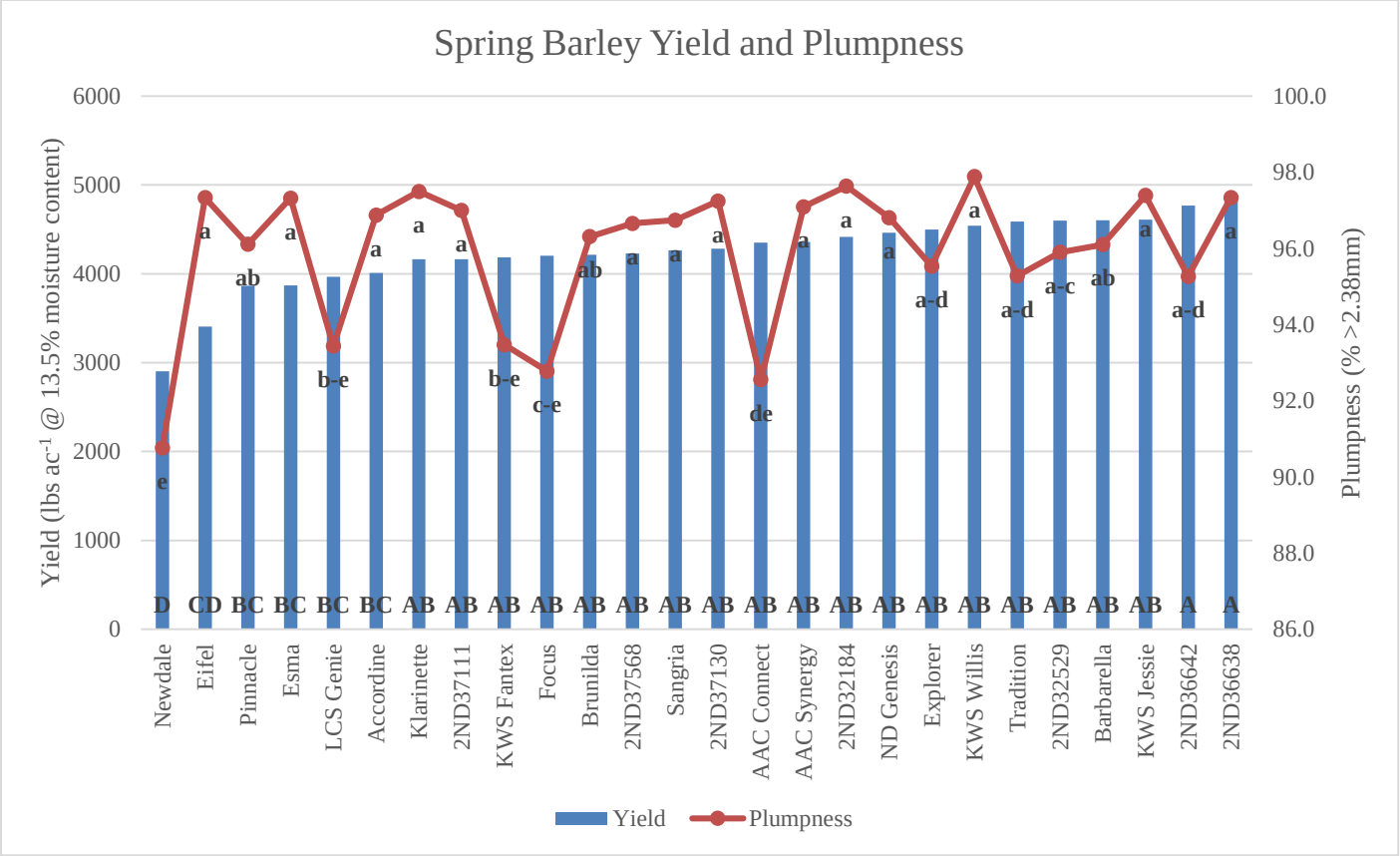

Figure 1. Yield and plumpness for the spring barley varieties trialed in Alburgh, VT, 2020.
Varieties with the same capital letter did not differ significantly by yield. Varieties with the same lower case letter did not differ significanlty by plumpness.

Despite a very dry growing season, particularly challenging with suppressing germination in the spring, 2020 was overall a fairly good year for growing spring barley. Quality parameters were very good for most varieties. Yields were generally very good across the trial.

In terms of quality parameters, the test weight, crude protein, plumpness, germination, DON concentrations, and falling number were all very good, with almost all barley varieties meeting or exceeding industry standards.

We intend to continue this research in 2021.

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