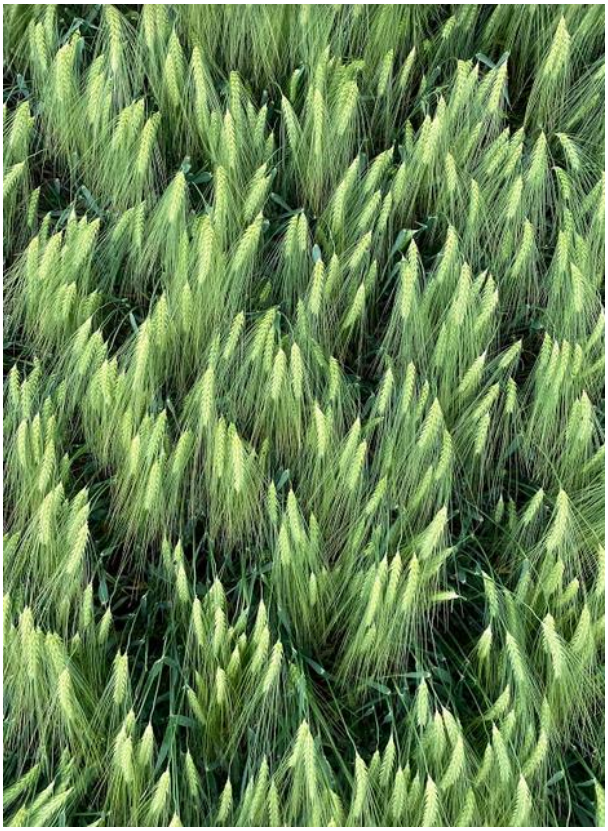
NORTHWEST CROPS & SOILS PROGRAM

2020 Heirloom Hulless Spring Barley Variety Trial



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THE UNIVERSITY OF VERMONT EXTENSION

2020 HEIRLOOM HULLESS SPRING BARLEY VARIETY TRIAL

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There is an interest amongst the Northeast grain industry in hulless barley (also known as naked barley) for specialty food markets. The addition of a specialty grain, such as hulless barley, can support local farm viability by diversifying crop rotations and revenue streams. Unlike malting barley, hulless barley is free threshing. This means the hull easily separates from the grain kernel during harvest and cleaning, producing whole grain barley for human consumption. Because it is whole grain, hulless barley has higher flavor and nutritional value than pearled barley which goes through an abrasion process to remove the hull and bran. This also eliminates a processing step needed to produce barley for food markets. In 2020, the University of Vermont Extension's Northwest Crops and Soils Program continued the second year of a field trial of sixteen heirloom hulless barley varieties with seed provided by Sylvia Davatz of Solstice Seeds (Hartland, VT).

MATERIALS AND METHODS

The trial was initiated at Borderview Research Farm in Alburgh, VT. Plots were managed with practices similar to those used by organic producers in the surrounding area. Three replicates of 16 varieties were planted for evaluation (Table 1). Plots were seeded with a Great Plains Cone Seeder at a rate of 350 live seeds m^{-2} on 18-Apr into 5' x 20' plots (Table 2). The previous crop was soybean and the soil type was Benson rocky silt loam.

Table 1. Hulless barley varieties, 2020, Alburgh, VT.

Variety	Days to Maturity	Provenance†
Arabian Blue	110	Syria/Turkestan
Burbank	89	California
Burbank Purple	96	California
Dolma	88	Northern India
Dolma Purple	88	Northern India
Ethiopian	110	
Excelsior Purple	96	Minnesota
Faust	90	
Glutinous	94	
Queen of Sheba	91	
Sangatsuga	89	Japan
Sheba	93	Ethiopia
Tibetan	95	Tibet
Tibetan Purple	93	Tibet
Valsergerste	96	Switzerland
Zwerggerste	98	Switzerlad/Austria

†Heirloom varieties are not always easy to trace, this is the best information identified.

Table 2. Spring hulless barley agronomic information, Alburgh, VT, 2020.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Soybean
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Planting date	18-Apr
Harvest date	16-Jul
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

Grain plots were harvested with an Almaco SPC50 plot combine on 16-Jul 2020. Prior to harvest, plant heights and lodging were recorded. The height of three plants per plot were measured in centimeters, excluding the awns. Grain yield, test weight, and moisture were determined at harvest. Grain quality was determined at UVM Extension's Northwest Crop and Soils Quality Testing Laboratory (Burlington, Vermont). Samples were ground using the Perten LM3100 Laboratory Mill. Flour was analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. Deoxynivalenol (DON), a vomitoxin, was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.50 to 5.0 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption. One sample of each variety was run to determine that DON values across the trial were less than 1 ppm.

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. Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$.

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

Seasonal precipitation and temperature were recorded onsite at the Alburgh, VT location with a Davis Instruments Vantage Pro2 weather station equipped with a WeatherLink data logger (Table 3). A cooler than average spring but warmer and drier summer led to 3433 Growing Degree Days (GDDs) accumulated from April to July, which was 55 GDDs above the 30-year average. Precipitation from April to July was 3.81 inches below normal. A drier than normal April allowed for early planting of spring grains in the 2020 season. Warm and dry conditions continued through the spring and summer, which lead to earlier harvest as well. For comparison, the 2019 hulless barley trial was planted and harvested on 29-Apr and 6-Aug, respectively, and the 2020 trial was planted and harvested on 18-Apr and 16-Jul.

Table 3. Seasonal weather data collected in Alburgh, VT, 2020.

	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 NOAA data (1981-2010) from Burlington, VT.

During the 2020 growing season, several observations and measurements were recorded. Height and yield are shown in Table 4. There was a wide range in heights. The tallest variety was Faust at 87.6 cm and the shortest was Zwerggerste at only 25.9 cm. Lodging was measured prior to harvest with a wide range across varieties from 0-93%. Four varieties had no lodging observed: Ethiopian, Glutinous, Sheba and Zwerggerste. The five varieties with the most lodging were Burbank, Tibetan Purple, Valsergerste, Arabian Blue, and Burbank Purple.

Hulless barley typically yields less than malting barley, roughly 13% less, because the hull is removed and not included in yield measurements. The hulless barley trial average was 2293 lb ac^{-1}. For comparison, the Spring Malting Barley trial yield average, consisting of all modern varieties, was 4185 lb ac^{-1} (data found in the 2020 Spring Malting Barley Trial report). The Spring Malting Barley yield average, minus the 13% of hull material, is 3640 lb ac^{-1}. The variety that yielded the highest was Faust producing 3053 lbs ac^{-1}, with Valsergeste, Tibetan Purple and Sangatsuga being statistically similar.

Table 4. Spring hulless barley varieties and yields at harvest moisture, Alburgh, VT, 2020.

Variety	Heading date	Height	Lodging	Test weight	Moisture	Yield at harvest
		cm	%	lb/bu^{-1}	%	lbs ac^{-1}
Arabian Blue	14-Jun	74.9 b-f†	60.0 a-c	57.5 a-c	18.2 de	2308 de
Burbank	16-Jun	69.9 c-g	93.0 a	53.3 g	19.9 bc	1639 f
Burbank Purple	14-Jun	72.9 c-f	53.3 a-d	58.5 a	18.4 de	2033 ef
Dolma	13-Jun	59.2 gh	1.33 f	54.5 fg	15.4 h	2196 e
Dolma Purple	14-Jun	79.1 a-c	16.0 d-f	55.1 ef	20.4 b	2506 b-e
Ethiopian	14-Jun	79.9 a-c	0.00 f	54.2 fg	15.7 gh	2038 ef
Excelsior Purple	15-Jun	74.7 b-f	34.0 c-f	56.1 ed	19.0 c-e	2003 ef
Faust	12-Jun	87.6 a	44.3 b-e	56.6 b-d	18.8 c-e	3053 a
Glutinous	18-Jun	53.1 h	0.00 f	50.9 h	17.9 ef	2878 a-c
Queen of Sheba	14-Jun	78.3 a-e	46.7 b-e	57.7 ab	18.2 de	2063 ef
Sangatsuga	14-Jun	66.7 fg	8.33 ef	56.3 c-e	16.8 fg	2745 a-d
Sheba	15-Jun	67.0 e-g	0.00 f	55.5 d-f	15.7 gh	2093 ef
Tibetan	15-Jun	67.6 d-g	9.33 ef	54.2 fg	17.9 d-f	2354 c-e
Tibetan Purple	14-Jun	78.4 a-d	83.0 ab	56.2 c-e	19.2 b-d	2753 a-d
Valsergerste	18-Jun	85.0 ab	61.0 a-c	56.5 b-d	16.7 f-h	2968 ab
Zwerggerste	16-Jun	25.9 i	0.00 f	47.8 i	21.9 a	1063 g
LSD (p= 0.10) ‡	NS§	11.3	40.7	1.3	1.31	529
Trial mean	15-Jun	70.0	31.9	55.0	18.1	2293

† Within a column, varieties marked with the same letter are not significantly different from each other**.**
‡ LSD; least significant difference at p=0.10.
§NS; indicates that there was no significant difference between varieties.

Test weight is the measure of grain density, which is determined by weighing a known volume of grain. The industry standard test weight for malting barley is 48 lbs bu^{-1}. There is not currently a standard test weight for hulless barleys in US markets, but Canadian grain grading standards call for a test weight of 58 lbs bu^{-1} for highest grading, similar to desired test weights for wheat. Test weights for hulless barley are higher than malting barley because the hull is not a component. Hulls are lighter weight and take up volume which would reduce the test weight. Burbank Purple had the highest test weight, 58.5 lbs bu^{-1}, with Queen of Sheba and Arabian Blue statistically similar.

Harvest moisture below 14% is desirable for grain storage. Grain above this moisture content has to be dried down after harvest, adding time and cost to farmers. All hulless barley varieties tested well above the 14% moisture threshold and required additional drying. Dolma had the lowest harvest moisture at 15.4%. Only Ethiopian, Sheba, and Valsergeste were statistically similar. The wide range of moisture content suggests variable time to ripening across varieties. Later harvest could have led to lower grain harvest moisture.

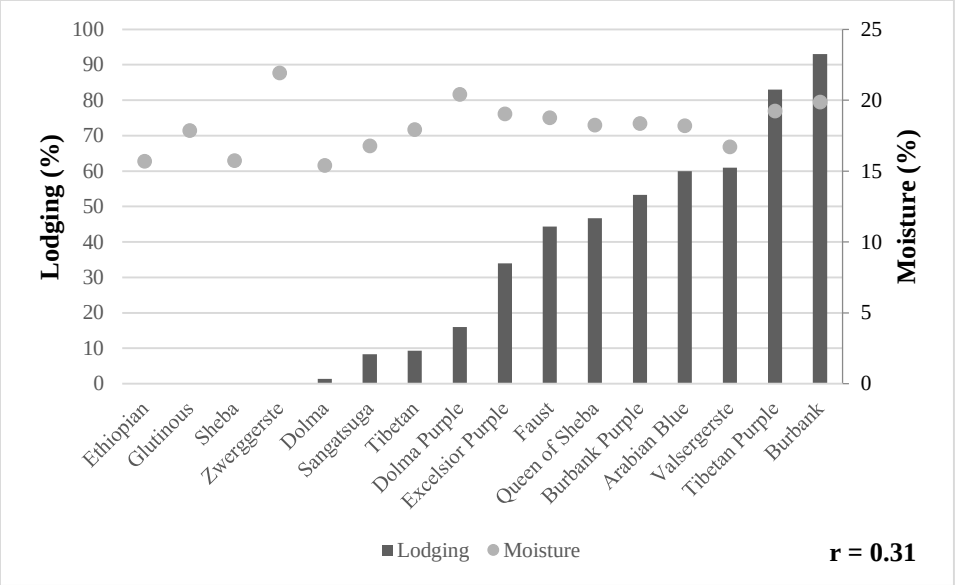

Figure 1. Spring hulless barley lodging and moisture, Alburgh, VT, 2020.

Moisture levels were quite high for this trial, ranging from 15.4% to 21.9% which, as mentioned, could indicate premature harvest. However, some varieties had heavy lodging in the field. Lodging and moisture were poorly correlated (r=0.31) but it is possible, if not likely, that more time left in the field to dry down could lead to more lodging (Figure 1). Additional trials will need to be conducted to evaluate possible lodging resistance, grain moisture and harvest timing.

Table 5. Spring hulless barley grain quality, Alburgh, VT, 2020.

Variety	Crude protein %	Falling number seconds
Arabian Blue	13.6 [cd]	435 [b-d]
Burbank	13.6 [cd]	409 [de]
Burbank Purple	13.6 [cd]	463 [ab]
Dolma	14.3 [b-d]	174 [j]
Dolma Purple	13.9 [b-d]	463 [ab]
Ethiopian	16.8 [a]	329 [g]
Excelsior Purple	13.3 [d]	365 [f]
Faust	13.2 [d]	480 [a]
Glutinous	13.2 [d]	246 [i]
Queen of Sheba	13.8 [b-d]	445 [bc]
Sangatsuga	14.1 [b-d]	398 [e]
Sheba	14.6 [bc]	278 [h]
Tibetan	11.5 [e]	230 [i]
Tibetan Purple	13.8 [b-d]	443 [bc]
Valsergerste	13.3 [d]	426 [c-e]
Zwerggerste	14.9 [b]	410 [de]
LSD (p= 0.10) ‡	1.21	30
Trial mean	13.8	375

†Within a column, treatments marked with the same letter were statistically similar (p=0.10).
‡LSD –Least significant difference at p=0.10.

Grain quality was analyzed for protein and falling number, results are shown in Table 5. Ethiopian had the highest crude protein at 16.8%, adjusted for a 12% grain moisture basis, and Tibetan the lowest at 11.5%. Protein requirements will vary by end-use. For food grade hulless barley, high protein levels are likely more desirable, while lower protein is likely preferred for distilling or malting.

Falling number measures viscosity which is an indicator of enzymatic activity in the grain. It is determined by the time it takes, in seconds, for a stirrer to fall through a slurry of flour and water to the bottom of a test-tube. Falling numbers are best understood for wheat, in which case values between 300-350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor-quality wheat, typically as a result of pre-harvest sprouting damage in the grain. This is most common if there are rain events as the grain is ripening prior to harvest. To the contrary, lower falling number is more favorable for rye, roughly 90-200, if it is going to be used for baking. Research on rye falling number is ongoing and is discussed further in the 2020 Rye Harvest Date Trial Report.

There was a range of falling numbers in this trial from 480 to 174 with a trial mean of 375. The lowest value, 174, was the variety Dolma which also had the lowest moisture of 15.4. The three varieties with the highest harvest moistures each had falling numbers above 400 which is considered slightly high for most baking purposes. Ethiopian, Excelsior, and Sheba tested in what would be the ideal range for wheat for baking. Dolma and possibly Glutinous would be in an acceptable range for rye for baking. More research is needed to evaluate appropriate falling number ranges for hulless barley. Regardless, it will likely depend on intended end use. If the barley is going to be malted, higher falling numbers are preferred because at the malthouse the grain will be sprouted by a controlled method, so there cannot be excessive pre-harvest sprouting damage in the kernels.

DISCUSSION

The 2020 growing season was warmer and drier than the 30-year average. This allowed for early planting in April, low disease pressure, high yields, protein and falling numbers across the grain trials at Borderview Research Farm. Grain yields were high across the board in 2020 and hulless barley yields were higher than expected, even considering they are all heirloom varieties. As mentioned previously, this is still lower than the Spring Malting Barley trial, but much higher than expected and possibly acceptable depending on demand and prices paid by specialty markets.

Although falling number and moisture values were not strongly correlated (r=0.24), this likely suggests there is a range of ripening times between these varieties which all come from many different geographical regions globally. Sylvia Davatz, who supplied seed, observed a range of days to maturity from 88 to 110 for these varieties in her own trials. Research on rye has suggested that lower falling numbers are oftentimes more desirable for end-products depending on use. The wide range of falling numbers produced by this trial may indicate the need for similar research into desirable ranges for hulless barley.

There was a wide range of protein values, from 11.5% to 16.8% with a trial mean of 13.8%. Brewers and distillers typically prefer protein values below 9-11% for 2-row barley and up to 13% for 6-row barley. Higher than 13% is undesirable because protein impacts starch availability, which can reduce alcohol yield during fermentation. Bakers, however, have a wide range of acceptable protein values depending on the end-product, though this value typically refers to gluten proteins specifically. As with falling number,

variable protein levels may be more acceptable to bakers because of the wide variety of food products that can be produced with barley.

Research from Oregon State University (OSU) indicates several possibilities and potential end-uses for hulless barley including food, beverages and feed. Although these parameters were not measured in this trial, OSU research suggests variation in starch composition and β-glucan values can indicate end-use acceptability, with multiple end-uses possible depending on grain characteristics. β-glucan is a soluble fiber that can assist in lowering cholesterol. In 2006, the FDA permitted health claims being made on barley products containing higher than 4% β-glucan, which may allow for product differentiation and higher price potential in the marketplace. However, OSU research indicates that β-glucan levels that are higher than 5% may be less desirable for certain end-uses including beverage production or poultry feed. For more information visit www.barleyworld.org

Market outreach has been generating demand for hulless barley in recent years. Hulless barley in general shows potential as a specialty food grain in the Northeast. Though this data is only based on a single growing season, agronomic performance shows potential for hulless barley as a crop in Vermont and the Northeast. This is the first year enough seed was available to conduct multiple replications and quality analysis for this trial. More research is needed to better understand ideal quality parameters for hulless barley that can be achieved in Vermont, including test weight, protein and falling number, as well as research into potential and acceptable β-glucan ranges. There was a wide range of quality parameters both in the field and the lab. This may be because the varieties in this trial come from diverse regions around the world and are adapted to variable environmental conditions. This trial suggests that a wide range of quality traits exist in the crop and varieties may be selected for cultivation based on those parameters.

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