2015

Organic Spring Barley Variety Trial

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NORTHWEST CROPS & SOILS PROGRAM

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UNIVERSITY OF VERMONT EXTENSION
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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 2015, UVM Extension in collaboration with the Uniform Eastern Spring Malting Barley Nursery (UESMBN), conducted a spring malting barley trial to evaluate yield and quality of 20 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 20 spring malt barley varieties, which are listed in Table 1.

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

Spring barley variety	Type	Seed source
AAC Synergy	2-row	Agriculture and Agri-Food Canada
AC Metcalfe	2-row	Agriculture and Agri-Food Canada
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
Full Pint	2-row	Oregon State University
Harrington	2-row	Crop Development Centre (University of Saskatchewan)
Innovation	6-row	Busch Agricultural Resources, LLC
Klages	2-row	USDA-ARS Aberdeen, ID
Lacey	6-row	University of Minnesota
ND Genesis	2-row	North Dakota State University
ND22421	6-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
Robust	2-row	Albert Lea Seeds, MN
Scarlett	2-row	Saatzucht Josef Breun GmbH & Co
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 summer annuals. In April 2015, the trial area was disked and

spike tooth harrowed to prepare for planting. The plots were seeded with a Great Plains NT60 Cone Seeder on 19-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. 2015 agronomic and trial information for spring barley variety trial.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Summer annuals
Tillage operations	Spring plow, disc, and spike tooth harrow
Harvest area (ft)	5 x 20
Row spacing (in)	6
Seeding rate (live seeds/m^2)	325
Replicates	3
Planting date	19-Apr
Harvest date	5-Aug

Barley populations were measured by counting the number of plants in three 12 inch segments randomly throughout each plot on 14-May. Flowering dates were recorded when at least 75% of a plot was in bloom. On 19-Jun, plots were scouted for disease and insect pests. A 0.5 m^2 quadrat was randomly placed in every plot. Within each quadrat, three plants were randomly selected for foliar scouting. All leaves (between 1 and 3 leaves) on the three plants were scouted. The number of leaves exhibiting each disease symptom and insect damage was recorded. Each field was given an overall health rating between 1 and 5 (1 being very poor and 5 being excellent). Loose smut was scouted for in each plot and presence/absence was recorded. 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. 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 on 28-Jul, three plant heights were measured per plot, excluding the awns. A visual estimate of percent of a plot lodged was documented. If lodging was present, the plot was visually assessed for lodging severity on a 0 – 5 scale, where 0 indicates no lodging and 5 indicates severe lodging and a complete crop loss. On 5-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 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 (germinative 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 variety was done in duplicate. Grain assortment or plumpness was determined using the Pfeuffer Soritmat using 100g of clean seed, and was determined by combining the amount of seed remaining on the 2.78mm and 2.38mm sieves.

All data were 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. 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 2015 site are shown in Table 3. The growing season this year was marked by lower than normal temperatures in April, June, and July and higher than normal rainfall in June. From April to August, there was an accumulation of 4613 Growing Degree Days (GDDs) in Alburgh which is 50 GDDs above the 30 year average. Overall, rainfall was 8.12 inches below seasonal norm of 18.02 inches (Apr-Aug).

Table 3. Temperature and precipitation summary for Alburgh, VT, 2015.

Alburgh, VT	Apr	May	Jun	Jul	Aug
Average temperature (°F)	43.4	61.9	63.1	70.0	69.7
Departure from normal	-1.4	5.5	-2.7	-0.6	0.9
Precipitation (inches)	0.09	1.94	6.42	1.45	0.00
Departure from normal	-2.73	-1.51	2.73	-2.70	-3.91
Growing Degree Days (base 32°F)	373	930	938	1188	1184
Departure from normal	-11	174	-76	-10	45

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.

Plant populations were not significantly different between varieties (Table 4). Plots were scouted for disease and insect pests on 19-Jun. The primary plant diseases identified were; Tan spot (*Pyrenophora tritici-repentis*), Spetoria leaf blotch (*Stagonospora nodorum*), and Loose smut (*Ustilago tritici*). The insect pests observed included brown wheat mite (*Petrobia latens*) and thrips (species unknown). Most varieties bloomed (flowering 75% or greater) in the fourth week in June. The earliest flowering varieties were Conlon, Lacey, and Quest on 20-Jun, and CDC Meredith, Klages, Newdale, and Scarlett were the latest flowering on 27-Jun. Plant heights were significantly different among varieties. The tallest variety was Harrington 84.1 cm. Other tall varieties included; Bently (82.4cm), ND Genesis (79.3cm), AC Metcalfe (78.9cm), CDC Copeland (78.9cm), Klages (76.2cm), AAC Synergy (74.2cm), and Lacey (74.2cm). The shortest variety was Full Pint (51.1cm). No lodging was obsevered in any of the plots.

Table 4. 2015 spring barley agronomic characteristics in Alburgh, VT.

Variety	Population	Plant height	Flowering
	m^2	cm	date
AAC Synergy	161	74.2*	25-Jun
AC Metcalfe	141	78.9*	25-Jun
Bently	142	82.4*	25-Jun
CDC Copeland	**187**	78.9*	26-Jun
CDC Meredith	169	71.7	27-Jun
Cerveza	130	67.2	23-Jun
Conlon	127	64.3	20-Jun
Full Pint	164	51.1	23-Jun
Harrington	142	**84.1***	23-Jun
Innovation	117	68.6	21-Jun
Klages	134	76.2*	27-Jun
Lacey	157	74.2*	20-Jun
ND Genesis	167	79.3*	23-Jun
ND22421	111	62.1	22-Jun
Newdale	183	58.7	27-Jun
Pinnacle	136	68.2	25-Jun
Quest	163	73.5	20-Jun
Robust	133	68.7	25-Jun
Scarlett	129	63.9	27-Jun
Tradition	155	73.1	22-Jun
LSD (0.10)	NS	10.2	-
Trial Mean	147	71.0	-

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 ($P < 0.1$).
NA - was not statistically tested.

Spring Barley Yield and Quality:

Varieties differed significantly in quality but not between yields (Table 5). The highest yielding variety was Lacey (2314 lbs ac^{-1}) and the lowest yielding was Conlon (967 lbs ac^{-1}) (Figure 1). CDC Meredith had the lowest moisture at harvest (10.1%). All twenty varieties trialed had moistures below 14% at the time of harvest and therefore did not require any additional drying. Harrington had the highest test weight of 46.3 lbs bu^{-1}. Other varieties with high test weights included AC Metcalfe (45.7 lbs bu^{-1}), Kalges (45.0 lbs bu^{-1}), Full Pint (44.5 lbs bu^{-1}), Tradition (44.3 lbs bu^{-1}), Innovation (44.2 lbs bu^{-1}), CDC Meredith (44.0 lbs bu^{-1}), Lacey (44.0 lbs bu^{-1}), CDC Copeland (43.5 lbs bu^{-1}), and Newdale (43.5 lbs bu^{-1}) However, none of the varieties met the desired barley test weight of 48 lbs per bushel.

Conlon had the highest crude protein content at 9.18% and the variety with the lowest protein content was CDC Meredith (6.26%) (Table 5, Figure 1). Harrington had the highest falling number, 417 seconds. The variety with the lowest falling number, indicating sprouting damage, was Full Pint at 152 seconds (Figure 2).

Table 5. Harvest and quality results for the 20 spring barley samples trialed in Alburgh, VT, 2015.

Variety	Yield @13.5% moisture	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number @ 14% moisture	DON	Germinative energy	Plumpness
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm	%	%
AAC Synergy	1821	11.0	42.0	6.78	199	1.30	93.8	98.2*
AC Metcalfe	1648	11.0	45.7*	8.26*	256	1.80	94.3	94.7
Bently	1787	10.8	40.5	8.20*	317	1.63	95.5*	97.2*
CDC Copeland	1459	11.1	43.5*	6.76	277	1.27	92.8	95.9*
CDC Meredith	1600	**10.1***	44.0*	6.26	239	1.20	92.2	96.0*
Cerveza	2218	10.5*	42.7	6.48	210	0.97	96.5*	95.3
Conlon	967	10.3*	38.3	**9.18***	249	0.67*	88.8	**98.3***
Full Pint	1215	11.3	44.5*	8.48*	152	0.80*	80.3	96.1*
Harrington	1738	11.6	**46.3***	7.87	**417***	0.70*	**99.0***	84.8
Innovation	1687	10.6*	44.2*	7.22	311	1.80	97.5*	97.7*
Klages	1948	11.3	45.0*	7.58	312	1.33	96.2*	91.5
Lacey	**2314**	11.0	44.0*	7.91	336	2.00	97.2*	97.3*
ND Genesis	1378	13.0	42.5	6.58	255	1.90	93.5	96.1*
ND22421	1482	10.3*	41.8	7.44	240	2.57	94.5	98.0*
Newdale	1100	10.7*	43.5*	6.62	273	0.83*	96.3*	93.8
Pinnacle	1440	10.5*	41.8	6.90	306	1.63	91.7	96.2*
Quest	1378	10.4*	41.7	8.50*	316	1.37	97.0*	90.9
Robust	1016	10.9	42.0	8.47*	352	2.30	95.8*	94.9
Scarlett	1342	10.9	42.3	7.41	328	**0.38***	95.3	93.1
Tradition	2026	10.4*	44.3*	7.59	305	1.77	95.8*	97.5*
LSD (0.10)	NS	0.69	3.43	1.08	33.4	0.52	3.52	2.57
Trial Mean	1578	10.9	43.0	7.52	282	1.41	94.2	95.2

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 difference was determined.

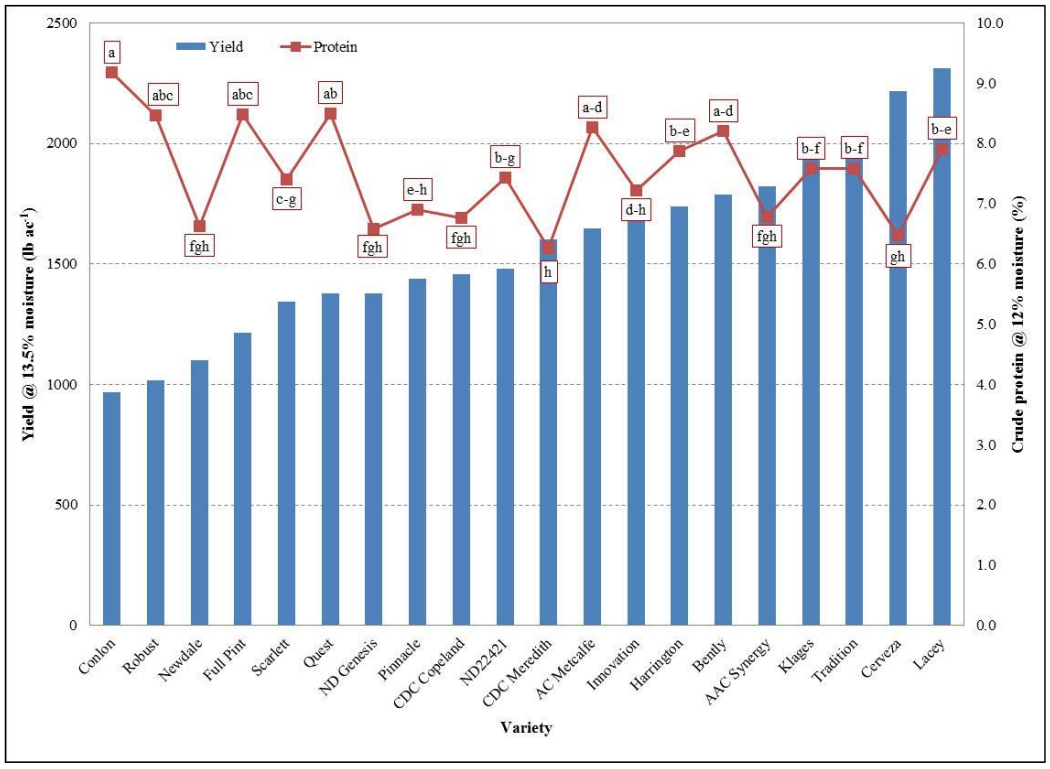

Figure 1. Yield and crude protein for the 20 spring barley varieties trialed in Alburgh, VT.
Varieties with the same letter did not differ significantly.

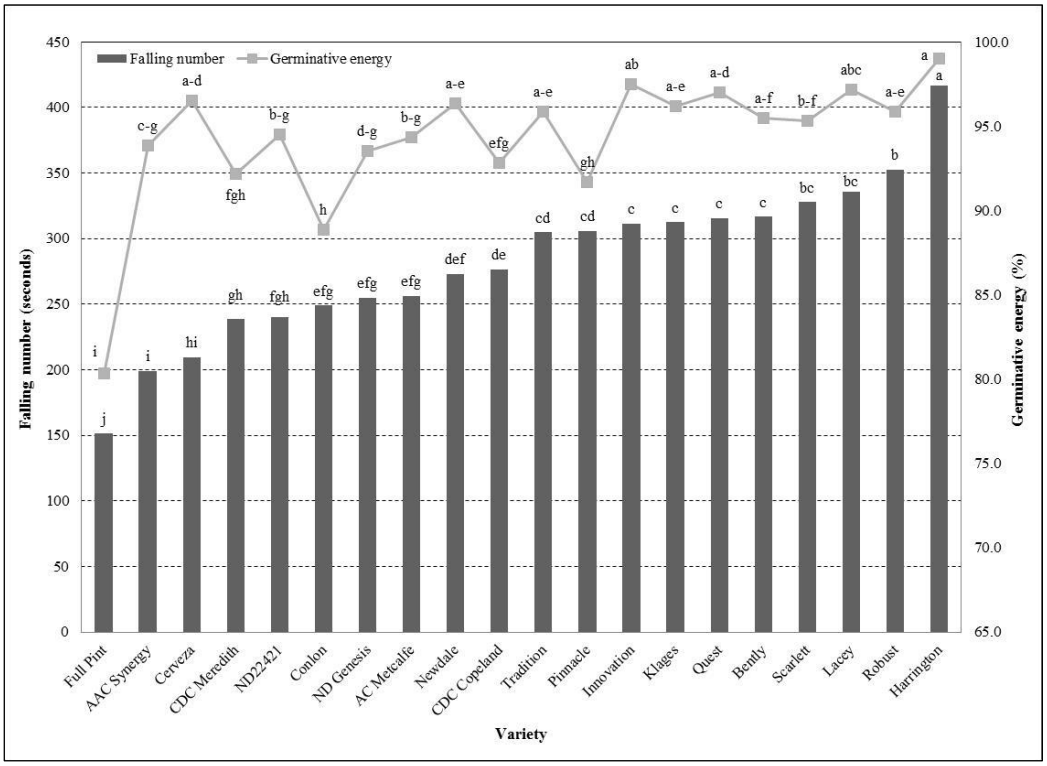

Figure 2. Falling number and germination comparison of the 20 spring barley varieties trialed in Alburgh, VT.
Varieties with the same letter did not differ significantly.

Six of the 20 spring barley varieties trialed were below the FDA's 1ppm limit for DON (Figure 3). The lowest DON concentration was Scarlett (0.38 ppm). Additonal varieties below 1 ppm include; Conlon (0.67 ppm), Harrington (0.70 ppm), Full Pint (0.80 ppm), Newdale (0.83 ppm), and Cerveza (0.97 ppm). The variety with the highest DON concentration was ND22421, 2.57 ppm. Nine varieties, Harrington (99.0%), Innovation (97.5%), Lacy (97.2%), Quest (97.0%), Cerveza (96.5%), Newdale (96.3%), Klages (96.2%), Robust (95.8%), Tradition (95.8%), Bently (95.5%), and Scarlett (95.3%), met industry malting standards (95% or above) for seed germination (Figure 2). The lowest germination rate was Full Pint (80.3%). The variety with the plumpest kernel size was Conlon (98.3%). Eleven other varieties; AAC Synergy, ND22421, Innovation, Tradition, Lacey, Bently, Pinnacle, Full Pint, ND Genesis, CDC Meredith, and CDC Copeland were plump. All of the twenty varieites trialed met industry standards for plumpness, >80% for a two-row and >70% for a six row barley.

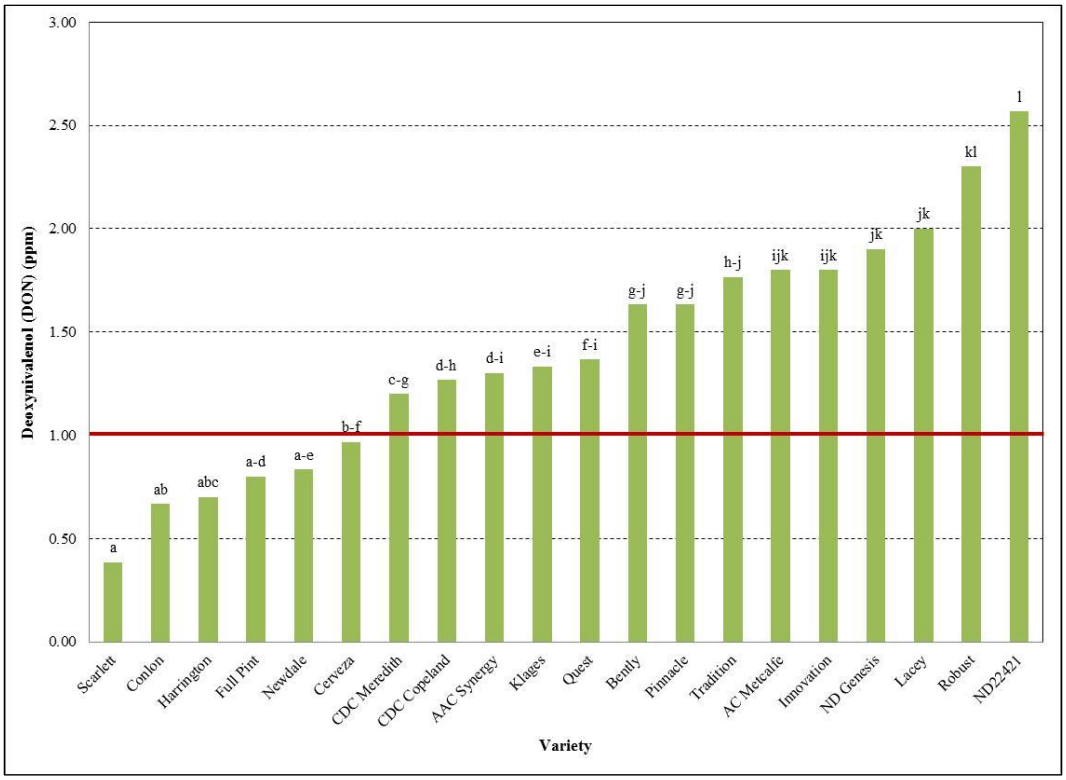

Figure 3. Deoxynivalenol (DON) concentrations for the 20 spring barley varieties trialed in Alburgh, VT.
Varieties with the same letter did not differ significantly.

DISCUSSION

It is important to remember that the results only represent one year of data. The 2015 growing season presented some challenging weather conditions for grain production. The relatively dry conditions in April allowed for timely planting of spring grain mid-April. However, the cool temperatures and excessive rain in June delayed plant development and created the ideal conditions for weed growth. Weed pressure and nutrient leaching could have contributed to the reduction in grain yields this season. Test weight, a measure of grain plumpness, is also an indicator used to determine malt quality. The below average temperatures, and above average rainfall during June, may have caused lower test weights as all

varieties were below the ideal malting test weight of 48 lbs per bushel. However, kernel plumpness did not appear to be impacted, Harrington was the only variety with a plumpness score below 90%. These overly wet conditions did appear to impact protein concentrations. The average percent protein this year was 7.52%, 3.88% lower than the trial mean in 2014. All varieties had lower protein levels this season, only Conlon (9.18%) met industry 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 brewhouse 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 brewhouse extract efficiency. High germinative energy levels, preferably over 95% (three-day test), are essential for a good malting barley. Eleven of the 20 varieties trialed had germination rates above 95%. Interestingly, Full Pint which had a germination of 80.3% correlated with its falling number of 152 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. Seventeen of the 20 varieties trialed had falling numbers above 220 seconds. DON levels were not nearly as high as they were in 2013 but were higher than in 2014. Six varieties were below the 1ppm FDA recommend limit for DON concentration. The average DON level in 2015 was 1.41 ppm, 0.46 ppm above average DON level in 2014.

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