NORTHWEST CROPS & SOILS PROGRAM

2017 Heirloom Winter Wheat Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2017 HEIRLOOM WINTER WHEAT VARIETY TRIAL

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In 2017, the University of Vermont Extension Northwest Crops and Soils Program evaluated 20 heirloom winter wheat varieties to determine which varieties thrive in organic production systems in northern Vermont. Many consumers are interested in heirloom wheat for flavor, perceived health benefits, or its history, while many farmers are interested in heirloom wheat because it may have superior genetics better adapted to the challenging growing conditions in the Northeast. Production of heirloom wheat may also provide a farmer with a value added market with increased returns. This was the sixth year that this trial was conducted in Vermont.

MATERIALS AND METHODS

The winter wheat variety trial was initiated at Borderview Research Farm in Alburgh, VT in the fall of 2016. General plot management is listed in Table 1. The experimental design was a randomized complete block with four replicates. Treatments were 20 heirloom winter wheat varieties (Table 2). The previous crop was spring barley. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 16-Sep 2016 at a seeding rate of 125 lbs ac^{-1}.

Many observations and measurements were recorded on winter wheat development during the growing season, including populations, height, lodging and pest and disease prevalence. Populations were recorded on 12-Oct 2016 by counting the number of wheat plants in three 12-inch sections. Heights and lodging were recorded on 19-Jul 2017. Heights were determined by taking three measurements per plot with a meter stick. Lodging was visually assessed just prior to harvest and recorded as the percentage of the plot that was lodged.

Insect and disease scouting was conducted on 21-Jun 2017. Five plants in each plot were examined for disease and pest damage. The top two leaves from each plant were examined and the percent of each leaf affected by disease and arthropod damage was recorded.

Table 1. General plot management, 2017.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Spring barley
Seeding Rates (lbs ac^{-1})	125 lbs ac^{-1}
Row spacing (in)	6
Replicates	4
Planting date	16-Sep 2016
Harvest date	28-Jul 2017
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

Plots were harvested with an Almaco SPC50 small plot combine on 28-Jul 2017. The harvest area was 5’ x 20’. Grain moisture, test weight, and yield were determined at harvest. Seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN) and a subsample was collected to determine quality characteristics. Samples were ground using the Perten LM3100 Laboratory Mill. Flour was analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Most commercial mills target 12-15% protein content. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage 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 greater than 350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat. Deoxynivalenol (DON), a vomitoxin, was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5.0 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption.

Table 2. Heirloom winter wheat varietal information.

Variety	Market class[†]	Year	Origin
Blackhull	HRWW	1917	Kansas
Bluejacket	HRWW	1946	Kansas
Clark's Cream	HWWW	1972	Kansas
Columbia	HRWW	1955	Oregon
Coppei	SRWW	1911	Washington
Forward	SRWW	1920	New York
Genesee Giant	SWWW	1893	New York
Goldcoin	SWWW	1890	New York
Honor	SWWW	1920	New York
Kanred	HRWW	1917	Kansas
Oro	HRWW	1927	Oregon
Pride of Genesee	SRWW	1893	New York
Red Chief	SRWW	1901	New York
Red Russian	SRWW	1890	England
Relief	HRWW	1931	Utah
Rio	HRWW	1931	Oregon
Triplet	SRWW	1918	Washington
Turkey Red	HRWW	1873	United States
Ukraine	HRWW	1926	Kiev, Ukraine
Wasatch	HRWW	1944	Utah

[†]**HRWW**-Hard Red Winter Wheat, **HWWW**-Hard White Winter Wheat, **SRWW**-Soft Red Winter Wheat, **SWWW**-Soft White Winter Wheat.

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.

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

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 varieties for most parameters. 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, 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.

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 3. Many of the varieties in the trial were developed in environments much different than Vermont. Hence, it is important to evaluate the varieties for tolerance to our climate. Average precipitation and above average temperatures for the fall of 2017 lead to good establishment and winter survival. The 2017 growing season was both colder and wetter than the 30 year average. While April was somewhat warmer than average, overall temperatures were very mild and 3430 growing degree days (GDDs) at a base temperature of 32°F accumulated from Mar 2017 to Jul 2017, 46 GGDs less than the 30 year average.

Table 3. Seasonal weather data collected in Alburgh, VT, 2016 and 2017.

Alburgh, VT	Sep-16	Oct-16	Nov-16	Mar-17	Apr-17	May-17	Jun-17	Jul-17
Average temperature (°F)	63.6	50.0	40.0	25.1	47.2	55.7	65.4	68.7
Departure from normal	3.03	1.80	1.82	-6.05	2.37	-0.75	-0.39	-1.90
Precipitation (inches)	2.5	5.0	3.0	1.6	5.2	4.1	5.6	4.9
Departure from normal	-1.17	1.39	-0.13	-0.63	2.40	0.68	1.95	0.73
Growing Degree Days (base 32°F)	949	559	270	98	459	733	1002	1138
Departure from normal	91	57	85	-26	71	-20	-12	-59

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.

Populations, heights, lodging, disease and arthropod damage are reported in Table 4. All varieties exceeded 350 plants m^2, indicating that the seeding rate for the trial may have been higher than optimal. Triplet had the highest population (479 plants m^2). This was statistically similar to Black Hull, Blue Jacket, Clark's Cream, Columbia, Genesee Giant, Honor, Kanred, Oro, Pride of Genesee, Red Chief, Rio, Turkey Red, and Ukrainka. In organic systems, taller plants are generally desired for their ability to shade out competing weeds, although tall wheat may be prone to lodging depending on many factors such as stalk strength and over-fertilization. Honor and Pride of Genesee were the tallest varieties at 136 cm (53.5 inches) (Table 4). Dense populations as well as high winds and heavy rain towards harvest likely resulted in high levels of lodging across the heirloom winter wheat trial. The variety with the least lodging was Clark's Cream, with an average 56% of the plants lodged per plot (Table 4). Coppei, Forward, Genesee Giant, and Oro also had less than 75% lodging.

Table 4. Heirloom winter wheat characteristics in Alburgh, VT, 2017.

Variety	Population	Height	Lodging	Foliar disease	Arthropod damage
	m^2	cm	%	% leaf affected	% leaf damaged
Black Hull	429*	122	86.3	18.1*	**0.00***
Blue Jacket	463*	125*	90.0	22.9	**0.00***
Clark's Cream	422*	112	**56.3***	25.0	**0.00***
Columbia	450*	125*	81.3	29.8	**0.00***
Coppei	402	128*	73.8*	17.4*	**0.00***
Forward	380	129*	71.3*	33.1	0.05*
Genesee Giant	422*	131*	70.0*	40.3	**0.00***
Goldcoin	400	117	91.3	26.1	**0.00***
Honor	466*	**136***	86.3	45.8	0.05*
Kanred	450*	120	82.5	26.5	**0.00***
Oro	443*	119	71.3*	20.3	**0.00***
Pride of Genesee	423*	**136***	80.0	23.6	0.10*
Red Chief	431*	115	82.5	17.3*	1.55
Red Russian	416	124*	88.8	18.7*	**0.00***
Relief	400	124*	82.3	13.9*	**0.00***
Rio	431*	123*	82.5	13.3*	**0.00***
Triplet	**479***	131*	96.3	**9.80***	0.05*
Turkey Red	438*	118	78.8	15.0*	0.20*
Ukrainka	474*	132*	81.3	11.8*	0.05*
Wasatch	388	121	68.8	12.1*	**0.00***
LSD (p = 0.10)	62.6	14.0	19.1	7.80	0.50
Trial mean	430	124	80.1	22.0	0.10

Five plants in each plot were examined for disease and pest damage, and are shown in Table 4 as the average percent of each leaf that was affected by either arthropod damage or foliar disease.

Very little arthropod damage was observed in the heirloom winter wheat variety trial. No mite damage was observed and thrip damage was only observed in two plots in the variety trial. Cereal leaf beetle damage was the most common arthropod damage observed but affected only 2% of plots. Cereal leaf beetles overwinter in crop stubble or leaf litter in wooded areas and emerge in the spring to raise a single generation of young per year. The larval stage of the beetle generally causes more damage than the mature insect. Red Chief was the most susceptible to arthropod damage, but still only 1.6% of the leaf surface showed pest damage.

Several foliar diseases were observed during wheat development, including powdery mildew, leaf rust, stripe rust, and several diseases causing lesions and spotting to the leaf, including septoria and tan spot. All diseases were noted as present in all varieties. Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. The diseased plant typically exhibit reduced vigor, growth, and seed fill. The earlier occurrence, greater degree of host susceptibility, and longer duration of conditions favorable for disease development will increase the yield loss. Triplet had the least presence of foliar disease, with 9.8% of leaf surface displaying foliar disease. This was statistically similar to Black Hull, Coppei, Red Chief, Red Russian, Relief, Rio, Turkey Red, Ukrainka, and Wasatch, which all had less than 19% of their leaf surface affected by foliar disease. Genesee Giant and Honor both had more than 40% of their leaf surface affected by foliar disease. Leaf rust was the most prevalent foliar disease in the trial, affecting 89% of the plots observed. Stripe rust affected 44% of plots. Powdery mildew (caused by the fungus *Erysiphe graminis f. sp. Tritici*) was present in 39% of plots.

Loose smut was observed in two plots of Triplet wheat but in no other heirloom winter wheat varieties. Loose smut in wheat is caused by *Ustilago tritici* and can destroy large portions of grain crops. Loose smut replaces grain heads with masses of spores (smut) which infect the open flowers of healthy plants and grow into the seed. Seeds appear healthy and only when they reach maturity the following season is it clear that they were infected.

Table 5. Yield and quality of winter wheat varieties, Alburgh, VT, 2017.

Variety	Yield @ 13.5% moisture	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
Black Hull	1264	18.4	50.8	12.7	299*	**1.83***
Blue Jacket	1372	19.5	53.6*	12.9	253	3.30
Clark's Cream	1615*	17.6	51.3	11.8	236	3.85
Columbia	995	17.1	49.8	12.0	264	4.13
Coppei	1366	17.4	52.8	12.9	246	4.40
Forward	**1745***	16.8*	53.4*	11.9	312*	3.60
Genesee Giant	1155	**16.0***	49.8	11.9	193	3.68
Goldcoin	1396	17.6	52.5	12.3	222	3.40
Honor	1050	16.1*	52.4	12.0	251	4.50
Kanred	1037	18.0	51.4	12.8	282	2.53*
Oro	949	18.9	50.8	13.4	218	3.03
Pride of Genesee	1416	18.4	54.4*	12.2	288	3.15

Variety	Yield @ 13.5% moisture	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
Red Chief	1407	18.8	52.6	**14.5***	283	2.28*
Red Russian	1176	18.3	**55.3***	13.7	297*	2.78
Relief	1146	18.5	53.0	12.6	274	2.35*
Rio	1079	17.9	52.3	12.7	263	2.38*
Triplet	1304	18.9	52.3	13.8	**321***	2.10*
Turkey Red	1433	17.7	51.5	13.6	290*	2.43*
Ukrainka	1279	18.6	51.5	13.8	196	3.35
Wasatch	1228	18.2	51.0	12.6	297*	2.78
LSD (*p* = 0.10)	214	0.88	2.1	0.39	32	0.80
Trial Mean	1271	17.9	52.1	12.8	264	3.09

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

Winter wheat heirloom varieties had an average yield of 1271 lbs ac^{-1} (Table 5). This was lower than in previous years of heirloom winter wheat trials at Borderview Research Farm and likely due to the high degree of lodging in the experiment. The top yielding variety was Forward, at 1745 lbs ac^{-1}. This was statistically similar to Clark's Cream at 1615 lbs ac^{-1}.

Harvest moisture below 15% is desirable for grain storage. Wheat above this moisture content has to be dried down postharvest at additional time and cost to farmers. The wet season and high humidity at harvest time resulted in relatively high moisture content in the wheat harvest and all varieties had to be dried down for storage.

Test weight is the measure of grain density. It is determined by weighing a known volume of grain. Generally, the heavier the wheat is per bushel, the higher baking quality. Red Russian had the highest test weight at 55.3 lbs bu^{-1}. The varieties Blue Jacket, Forward, and Pride of Genesee had statistically similar test weight. Overall test weight was for all varieties was below the industry of 60 lbs bu^{-1}.

Falling numbers for all varieties except Genesee Giant and Ukrainka were above 200 seconds, indicating sound quality wheat (Table 5). No varieties had DON levels below the FDA threshold of 1 ppm. Hence, this wheat was not suitable for human consumption (Table 5). Black Hull had the lowest levels of DON at 1.8 ppm. Only one heirloom winter wheat variety, Red Chief, had crude protein levels above the industry minimum of 14%. No other varieties were statistically similar in crude protein content. Despite the excessive rainfall during the 2017 growing season, crude protein concentrations were relatively high for winter wheat (Figure 1).

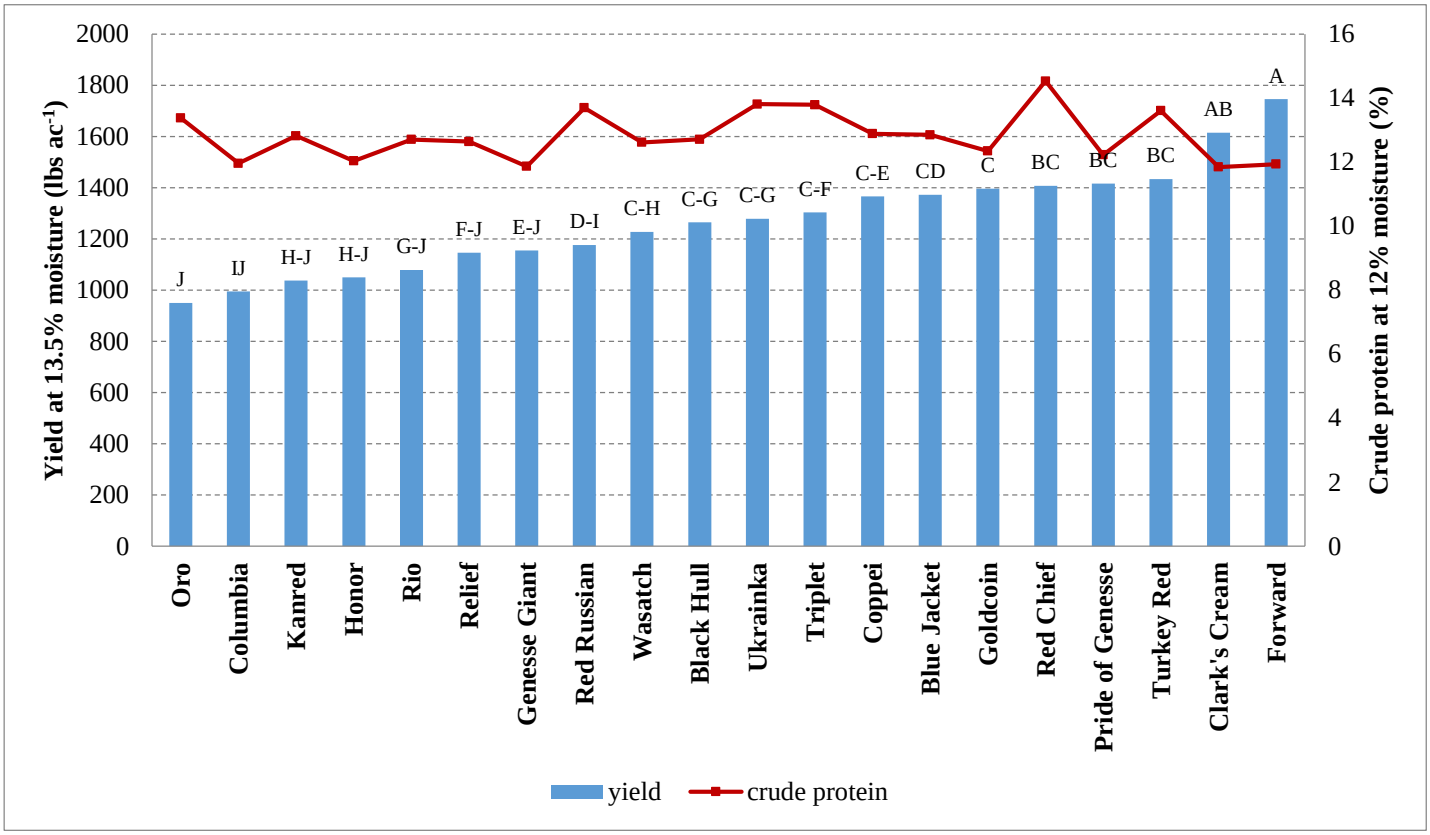

Figure 1. Yield and crude protein of heirloom winter wheat varieties, Alburgh, VT, 2017. *For yield, varieties with the same letter are not significantly different from one another.*

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