



2015 Organic Heirloom Winter Wheat Variety Trial



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2015 ORGANIC HEIRLOOM WINTER WHEAT VARIETY TRIAL

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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 variety trial was established to determine heirloom winter wheat varieties that are suitable for production in Vermont's growing conditions. This was the fourth year that this trial was conducted in Vermont. These projects were funded through the UNFI Foundation that has set a priority to **protect the biodiversity** of our seed supply and the stewardship of genetic resources of organic seed.

MATERIALS AND METHODS

In the fall of 2014, an heirloom winter wheat variety trial was initiated at Borderview Research Farm in Alburgh, VT. General plot management is listed in Table 1. The experimental design was a randomized complete block with 4 replicates. Treatments were 34 winter wheat heirloom varieties (Table 2). Plots were managed with practices similar to those used by producers in the surrounding area. The previous crop was oats and barley. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 22-Sep 2014 at a seeding rate of 125 lbs ac⁻¹.

Plots were harvested with an Almaco SPC50 small plot combine on 3-Aug 2015. 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 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption. The varieties of heirloom winter wheat grown, and their market class, year, and origin, are listed in Table 2. Results were analyzed with an analysis of variance in SAS using the PROC MIXED procedure with the Tukey-Kramer adjustment, which means that each cultivar was analyzed with a pairwise comparison (i.e. 'Turkey Red' statistically outperformed 'Clark's Cream', 'Turkey Red' statistically outperformed 'Gold Drop', etc.). Relationships between variables were analyzed using the GLM procedure.

Table 1. General plot management.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Oats and barley
Seeding Rates (lbs ac ⁻¹)	125 lbs ac ⁻¹
Row spacing (in)	6
Replicates	4
Planting date	22-Sep 2014
Harvest date	3-Aug 2015

Harvest area (ft)
Tillage operations

5 x 20
Fall plow, spring disk & spike tooth harrow

Table 2. Heirloom winter wheat varieties, market class, year of release and place of origin.

Variety	Market class	Year	Origin
Bacska	HRWW	1900	Hungary
Blackhull	HRWW	1917	Kansas
Bluejacket	HRWW	1946	Kansas
Clark's Cream	HWWW	1972	Kansas
Columbia	HRWW	1955	Oregon
Coppei	SRWW	1911	Washington
Federation	SWWW	1914	Australia
Florence	HWWW	1914	Australia
Forward	SRWW	1920	New York
Genesee Giant	SWWW	1893	New York
Goldcoin	SWWW	1890	New York
Gold Drop	HRWW	1843	England
Honor	SWWW	1920	New York
Hybrid 63	SWWW	1907	Washington
Kanred	HRWW	1917	Kansas
Karkov MC22	HRWW	1923	Quebec, Canada
Lennox	HRWW	1975	Ontario
Michikof	HRWW	1920	Indiana
Minard	HRWW	1915	Minnesota
Minturki	HRWW	1919	Minnesota
Oro	HRWW	1927	Oregon
Pesterboden	HRWW	1892	Hungary
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
Russian	HRWW	1917	Virginia
Sonora	SWWW	1770	Mexico
Triplet	SRWW	1918	Washington
Turkey Red	HRWW	1873	United States
Ukrainka	HRWW	1926	Kiev, Ukraine
Vermont Read	SRWW	1898	Vermont
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. At the bottom of each table, a p value is presented for each variable (i.e. yield). A small p-value indicates strong statistical differences between varieties. A large p-value indicates weak statistical differences between varieties. A p value of 0.1 indicates that the differences between varieties are significant at 10% level of probability. Where the p value is 0.1, you can be sure in 9 out of 10 chances that there is a real difference between the varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk.

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 3. Temperatures were below average in November of 2014, and March, April, June and July of 2015. Temperatures were higher than normal in October 2014 and May 2015. Although June was wetter than average, it was the only month that was wetter than average, and overall 2014-2015 was a very dry winter wheat growing season (between September 2014 and July 2015, there were 12.76 inches of precipitation less than normal). While few months were warmer than average, overall temperatures were very mild and resulted in 5269 growing degree days (GDD) at a base temperature of 32°F through the growing season, 372 GGDs more than the 30 year average. Many of the heirlooms in the trial were developed in environments much different than New England. Hence, it is important to evaluate the varieties for tolerance to our climate. All varieties were able to survive the winter.

Table 3. Seasonal weather data collected in Alburgh, VT, 2014 and 2015.

Alburgh, VT	Sep-14	Oct-14	Nov-14	Mar-15	Apr-15	May-15	Jun-15	Jul-15
Average temperature (°F)	60.6	51.9	36.9	26.0	43.4	61.9	63.1	70.0
Departure from normal	0.0	3.7	-1.3	-5.1	-1.4	5.5	-2.7	-0.6
Precipitation (inches)	1.33	4.27	1.56	0.02	0.09	1.94	6.42	1.45
Departure from normal	-2.31	0.67	-1.56	-2.19	-2.73	-1.51	2.73	-2.70
Growing Degree Days (base 32°F)	860	622	204	70	373	930	938	1188
Departure from normal	2	120	19	70	-11	174	-76	-10

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 2015 growing season, many observations and measurements were recorded on heirloom winter wheat development, including flowering date, height, and lodging (Table 4).

The flowering date was recorded when at least 50% of the plot was in bloom. The majority (27 varieties) of heirloom winter wheat varieties were flowering by 13-Jun and all varieties were flowering by 18-Jun.

Heights and lodging were measured on 28-Jul 2015 before the wheat was harvested. Heights were determined by taking three measurements per plot with a yardstick. In organic systems, taller plants are generally desired for their ability to shade out competing weeds. All of the varieties grown in this study would be considered tall when compared to many of today's modern cultivars. Tall wheat may be prone to lodging depending on many factors such as stalk strength and over-fertilization. Lodging was measured as a percent of plot lodged on 28-Jul 2015. It was measured with a visual rating on a scale of 0-100, where 0 represented no lodging.

Hybrid 63 was the tallest growing heirloom wheat, which grew 49.2 inches (Table 4). Vermont Read was the shortest growing heirloom wheat, which grew 34.3 inches. Two of the tallest varieties, Sonora and Federation, had no lodging although they were not significantly shorter than the tallest variety. Even with its height, Hybrid 63 was not significantly different than these top performers for lodging. Rio, even though it was the shortest heirloom wheat grown, had a lodging rate of almost 40%. Only Minard was significantly different from the top performers, with a lodging rate of 86.7%.

Table 4. The flowering dates, heights, and lodging of heirloom winter wheat varieties in Alburgh, VT, 2015.

Variety	Flowering Date	Height (inches)	Lodging (%)
Bacska	13-Jun	42.6*	53.3*
Blackhull	13-Jun	42.3*	20.0*
Bluejacket	13-Jun	39.7	10.0*
Clark's Cream	15-Jun	37.5	3.3*
Columbia	11-Jun	38.9	21.7*
Coppei	11-Jun	43.0*	23.3*
Federation	11-Jun	42.7*	0.0*
Florence	13-Jun	44.6*	16.7*
Forward	18-Jun	41.9*	3.3*
Genesee Giant	11-Jun	40.6*	0.0*
Goldcoin	13-Jun	41.8*	3.3*
Gold Drop	15-Jun	46.8*	28.3*
Honor	13-Jun	44.0*	13.3*
Hybrid 63	11-Jun	49.2*	21.7*
Kanred	10-Jun	40.2	40.0*
Karkov MC22	18-Jun	44.5*	68.3*
Lennox	11-Jun	45.9*	45.0*
Michikof	13-Jun	46.8*	16.7*
Minard	11-Jun	42.5*	86.7
Minturki	13-Jun	43.9*	66.7*
Oro	15-Jun	39.7	36.7*
Pesterboden	11-Jun	44.4*	60.0*
Pride of Genesee	15-Jun	45.2*	23.3*
Red Chief	11-Jun	41.8*	50.0*
Red Russian	13-Jun	39.2	33.3*
Relief	11-Jun	42.2*	33.3*
Rio	13-Jun	40.4	38.3*
Russian	13-Jun	43.8*	55.0*
Sonora	10-Jun	44.3*	0.0*
Triplet	15-Jun	41.0*	28.3*
Turkey Red	11-Jun	44.1*	78.3*
Ukrainka	11-Jun	44.4*	60.0*
Vermont Read	11-Jun	34.3	6.7*
Wasatch	13-Jun	40.6*	56.7*

Insect and disease scouting was conducted on 12-Jun (data not shown). Research technicians looked for the presence of a variety of foliar diseases, including loose smut, powdery mildew, and *Fusarium* head blight (FHB), as well as the presence of mites or insects and evidence of pest damage.

Thrips are small insects with fringed wings that feed on a variety of plants by puncturing the cells and sucking up the contents. Damage caused by thrips includes discoloration and leaf scarring, reduced growth of the plant, and they can also act as a disease vector. Thrips were observed in 13 of the 34 varieties (Red Russian, Genesee Giant, Gold Drop, Coppei, Kharkov, Pride of Genesee, Sonora, Bacska, Wahsatch, Michicof, Rio, Turkey Red, and Federation). Thrips were present in all three replicates of the Federation variety, and in the other 12 varieties were only present in one of the three replicate plots.

Mites were observed in 29 out of 34 heirloom winter wheat varieties. The varieties that were mite-free are Gold Coin, Triplet, Hybrid 63, Red Russian, and Wahsatch. Mite infestation was worst in the Michicof and Rio varieties. Mites are very small arthropods that feed on the sap of leaves of wheat and other grain crops. Leaves affected by mites may appear yellowish or silvery in early stages of infestation and later take on a scorched appearance. Injury caused by mites can result in stunted plants.

Several foliar diseases were observed during wheat development, including powdery mildew and tan spot. Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. The diseased plant typically exhibits 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. Powdery mildew (caused by the fungus *Erysiphe graminis f. sp. Tritici*) was prevalent in the 2015 variety trial and was observed on all varieties and in more than 75% of plots. Tan spot, caused by the fungus *Pyrenophora tritici-repentis*, was also very prevalent and affected all varieties and more than 75% of plots. The variety Minturki had the lowest rates of both powdery mildew and tan spot observed in the trial. *Stagonospora nodorum* may result in lightweight, shriveled kernels and lower yields. *Stagonospora* was observed in 31 out of 34 varieties. It was not observed in the varieties Forward, Coppei, or Honor.

Other foliar diseases were not as prevalent but were observed in some varieties. Septoria blotch is a foliar disease caused by the fungus *Mycosphaerella graminicola*. It was only observed on one variety (Wasatch) and only in one of the three trial plots. Rust is caused by several species of fungi in the genera *Puccinia*. Rust was observed in the varieties Florence, Russian, and Gold Coin. It was only observed in one out of the three replicate plots in each of these varieties. Loose smut was not observed in any of the heirloom winter wheat plots in the 2015 variety trials.

Fusarium head blight (FHB) is a foliar disease of particular concern to wheat growers. In the Northeast, FHB is predominantly caused by the species *Fusarium graminearum*. This disease is very destructive and causes yield loss, low test weights, and low seed germination. It is of particular concern due to contamination of grain with mycotoxins. A vomitoxin called deoxynivalenol (DON) is considered the primary mycotoxin associated with FHB. The spores are usually transported by air currents and can infect plants at flowering through grain fill. Eating contaminated grain greater than 1ppm poses a health risk to both humans and livestock. In the 2015 trial, only six of the 34 varieties (Coppei, Genesee Giant, Gold Drop, Kharkov, Red Chief, and Red Russian) displayed bleached grain heads which are associated with the presence of *Fusarium* head blight. FHB was only observed in one plot out of the three replicates for each variety. However, DON levels (Table 5) were not lower than in previous years.

Table 5. Yield and quality of heirloom winter wheat varieties, Alburgh, VT, 2015.

Variety	Yield @ 13.5% moisture lbs ac ⁻¹	Moisture %	Test weight lbs bu ⁻¹	Crude protein @ 12% moisture %	Falling number seconds	DON ppm
Bacska	1353*	14.5	53.3*	17.0	247*	4.1*
Blackhull	1018	11.7	53.7*	15.8	272*	5.1*
Bluejacket	572	15.4	55.0*	16.7	218*	4.9*
Clark's Cream	811	17.0	52.0*	16.3	191*	8.5
Columbia	870	13.7	52.3*	15.9	269*	5.5*
Coppei	1651*	13.6	52.2*	16.7	285*	4.3*
Federation	1588*	13.2	55.7*	16.6	251*	6.8
Florence	1555*	14.9	53.0*	17.3	261*	5.8*
Forward	743	16.6	50.2	16.3	283*	4.8*
Genesee Giant	1035	19.0	49.8	16.2	86	8.2
Goldcoin	958	14.4	52.8*	15.9	191*	5.4*
Gold Drop	656	17.2	56.0*	17.0	295*	4.4*
Honor	727	13.6	49.0	15.2	185*	7.4
Hybrid 63	1888*	10.3	55.5*	16.2	364	2.0*
Kanred	1107	11.8	55.3*	17.0	308*	3.5*
Karkov MC22	1116	9.8	54.7*	17.2	276*	1.9*
Lennox	2533*	9.7	55.0*	15.2	357*	1.5*
Michikof	1338*	14.3	54.8*	16.4	356*	1.7*
Minard	1806*	10.1	56.3*	17.2	296*	1.4*
Minturki	1528*	11.3	55.8*	16.6	330*	2.2*
Oro	1197	13.4	52.8*	16.5	246*	5.0*
Pesterboden	1458*	12.9	55.8*	16.1	291*	2.4*
Pride of Genesee	723	16.0	54.8*	16.5	224*	8.1
Red Chief	1147	12.4	54.8*	17.2	310*	2.8*
Red Russian	944	11.4	53.3*	17.0	312*	5.0*
Relief	589	15.3	55.5*	17.1	297*	3.3*
Rio	855	17.1	51.7*	16.7	263*	3.5*
Russian	1579*	11.8	56.0*	16.5	339*	2.1*
Sonora	2306*	10.5	57.0*	16.3	271*	5.9*
Triplet	655	15.9	50.3*	16.5	283*	5.2*
Turkey Red	1576*	11.4	56.2*	16.4	295*	1.8*
Ukrainka	1389*	11.0	53.8*	17.4	266*	3.7*
Vermont Read	834	14.0	52.8*	17.3	134	6.3*
Wasatch	1239*	12.4	54.3*	17.3	270*	3.9*
Trial mean	1216	13.5	53.9	16.6	268	4.4
<i>p</i> -value	<0.0001	NS	0.0006	NS	<0.0001	<0.0001

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

NS – No significant difference amongst varieties.

Winter wheat heirloom varieties had an average yield of 1216 lbs ac⁻¹. The highest yielding variety was Lennox at 2533 lbs ac⁻¹). This was statistically similar to the varieties Sonora, Hybrid 63, Minard, Coppei, Federation, Russian, Turkey Red, Florence, Minturki, Pesterboden, Ukrainka, Bacska, Michikof, and Wahsatch. The highest yielding

variety from the 2012, 2013 and 2014 trials (Forward, which yielded 2849 lbs ac⁻¹ in 2014) was among the lowest yielding varieties in the 2015 trial.

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. Sonora had the highest test weight at 57 lbs bu⁻¹. This was statistically similar to all varieties except Forward, Genesee Giant, and Honor. Sonora, Minard, Turkey Red, Gold Drop, and Russian all had test weights meeting the industry standard of 56-60 lbs bu⁻¹. Of these varieties, Sonora, Minard, Turkey Red, and Russian were also high yielding varieties. Harvest moisture ranged from 9.7% (Lennox) to 19% (Genesee Giant) with an average harvest moisture of 13.5%

All the heirloom winter wheat varieties had CP levels above the industry minimum of 14%. There is often an inverse relationship seen between yield and protein, and this was somewhat true of the heirloom winter wheat varieties assessed in 2015. The three highest yielding varieties were among the lowest crude protein levels (Figure 1). Falling numbers for most varieties were above 200 seconds and under 350 seconds, indicating sound quality wheat (Table 5). Five varieties (Genesee Giant, Vermont Read, Honor, Gold Coin, and Clark's Cream) had falling numbers below 200, indicating a high level of sprouting damage in these varieties. Except for Clark's Cream, all of the other varieties with low falling number are soft white winter wheat varieties that are not used for bread baking. DON levels for all varieties were above the FDA threshold of 1 ppm which is considered safe for human consumption (Table 5). All of the 2015 wheat trials at Borderview Farm had high DON levels.

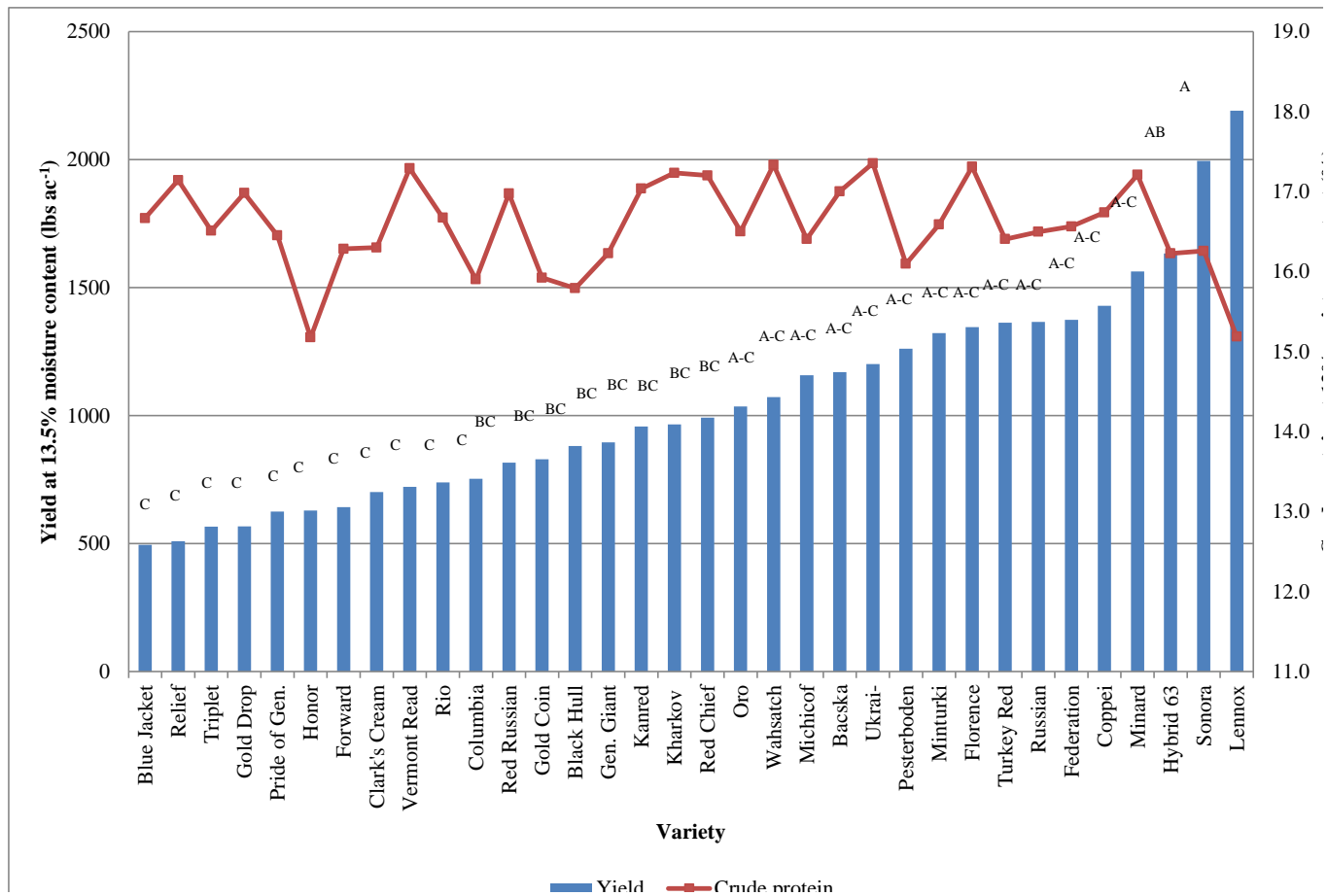


Figure 1. Yield and crude protein of heirloom winter wheat varieties, Alburgh, VT, 2015. For yield, varieties with the same letter are not significantly different from one another. There were no significant differences in crude protein.

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