NORTHWEST CROPS & SOILS PROGRAM

2015 Organic Heirloom Spring Wheat Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2015 ORGANIC HEIRLOOM SPRING WHEAT VARIETY TRIAL

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University of Vermont Extension began its heirloom spring wheat trials in 2007 to determine whether heirloom varieties developed before 1950 could thrive in Vermont's climate. 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 spring wheat varieties that are suitable for production in Vermont's growing conditions. 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 April 2015, heirloom spring wheat variety trials were established at Borderview Research Farm in Alburgh, Vermont. The experimental plot design was a randomized block design with four replications. The seedbed was prepared by conventional tillage methods. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 1). The previous crop was summer annual forages. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 19-Apr at a seeding rate of 350 live seeds per square meter. The varieties of heirloom spring wheat grown, and their origin, pedigree, and release date are listed in Table 2.

Table 1. General plot management of the heirloom spring wheat variety trial, 2015.

Trial information	Heirloom spring wheat variety trial
Location	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Summer annuals
Seeding rate (seeds m^{2-1})	350
Replicates	4
Planting date	19-Apr
Harvest date	5-Aug
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, spring disk & spike tooth harrow

Table 2. Varietal information of the heirloom spring wheat, 2015.

Variety	Developed in	Pedigree	Release date
AC Barrie	Sask. Canada	Neepawa/Columbus//BW90	1996
Ceres 05	North Dakota	Marquis/Kota	1926
Champlain	Vermont	Black Sea/Golden Drop	1870
Defiance	Vermont	Golden Drop/White Hamburg	1878
Hope	South Dakota	Yaroslav emmer/Marquis	1927
Komar	North Dakota	Marquis/Kota; Sister selection of Ceres	1930
Ladoga	Leningrad, Rus.	-	1916
Marquis	Ont. Canada	Hard Red Calcutta/Red Fife	1910
Mida 05	North Dakota	Mercury//Ceres/Double Cross	1944
Mida 06	North Dakota	Mercury//Ceres/Double Cross	1944
Red Bobs	Sask. Canada	Selection from fields of Bobs	1926
Red Fife	Canada	-	1860
Reliance	Oregon	Kanred/Marquis	1926
Scarlett	Washington	Too many to list	1998
Spinkcota	Washington	Preston sel./red durum//Preston sel.	1944
Supreme	Sask. Canada	Selection from Red Bobs	1922
Surprise	Vermont	Chile Club/Michigan Club	1909
Thatcher	Minnesota	Marquis/Ilumillo//Marquis/Kanred	1934

Populations were measured on 14-May by taking three 12-inch plant counts per plot. Plots were harvested with an Almaco SPC50 small plot combine on 5-Aug. The harvest area was 5’ x 20’. Grain moisture, test weight, and yield were determined at harvest. Per acre yields were calculated and normalized to 13.5% so varieties could be compared. 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. Crude protein was adjusted to 12% and 14% moisture content for comparison between varieties with different flour moisture. 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.

All data were analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate seeding rate 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 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 temperatures were recorded with a Davis Instruments Vantage Pro2 with Weatherlink data logger on site in Alburgh, VT (Table 3). Alburgh experienced near average temperatures for all months except May, which was 5.5 degrees above the 30 year average. Alburgh received below average rainfall during the spring wheat growing season, totaling 8 inches below the 30 year average. However, above average rainfall occurred throughout the month of June. From April to August there was an accumulation of 4591 Growing Degree Days (GDDs) in Alburgh, VT, which is 100 GDDs higher than the 30 year average.

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)	352	930	938	1188	1184
Departure from Normal	-32	174	-76	-10	45

Based on weather data from Davis Instruments Vantage Pro2 with Weatherlink data logger.
Historical averages for 30 years of NOAA data (1981-2010) from Burlington, VT.

Wheat Yield and Quality

Table 4: Growth and harvest characteristics of heirloom spring wheat for Alburgh, VT, 2015.

Variety	Flowering date	Height	Lodging	Yield at 13.5% moisture	Moisture	Test weight
	Date	in	%	lbs ac^{-1}	%	lbs bu^{-1}
AC Barrie	25-Jun*	44.6*	**0**	957	15.7	55.0*
Ceres 05	**24-Jun**	43.1*	**0**	1480*	14.7*	56.3*
Champlain	29-Jun	45.2*	**0**	1584*	17.6	51.8
Defiance	27-Jun	46.4*	**0**	1473*	14.9*	56.0*
Hope	25-Jun*	45.9*	1.25	1734*	15.6	55.3*
Komar	26-Jun*	42.2	**0**	1198	17.2	53.3
Ladoga	27-Jun	**48.3**	**0**	**2183**	13.7*	55.4*
Marquis	25-Jun*	46.7*	**0**	1635*	14.4*	55.6*
Mida 05	**24-Jun**	42.4	**0**	1657*	14.7*	55.5*
Mida 06	25-Jun*	44.9*	**0**	1438	16.9	53.5*
Red Bobs	**24-Jun**	42.2	**0**	1415	13.7*	56.3*
Red Fife	27-Jun	46.1*	**0**	1706*	19.2	52.3
Reliance	25-Jun*	43.2*	**0**	1070	14.0*	56.1*
Scarlett	25-Jun*	48.0*	2.5	1393	14.4*	53.0
Spinkcota	**24-Jun**	44.0*	**0**	1830*	17.1	55.6*
Supreme	25-Jun*	45.3*	**0**	1735*	**13.1**	**56.5**
Surprise	**24-Jun**	46.9*	**0**	1475*	14.4*	55.0*
Thatcher	28-Jun	45.5*	**0**	1398	18.8	50.4
LSD	3 days	5.8	1.6	730	1.9	3
Trial mean	25-Jun	45.1	0.2	1520	15.6	54.6

*Treatments that did not perform significantly lower than the top-performing treatment in a particular column are indicated with an asterisk.
Treatments indicated in **bold** had the top observed performance in a particular column.

During the 2015 growing season, many observations and measurements were recorded on heirloom spring wheat development. The flowering date was recorded when at least 50% of the plot was in bloom for each of the varieties (Table 4). Five of the eighteen heirloom spring wheat varieties were flowering by 24-Jun and all varieties were flowering by 29-Jun at the latest.

Plant heights were measured on 28-Jul. The average height was 45.1 inches (Table 4). Taller plants are generally desired for their ability to shade out competing weeds. However, tall wheat may be prone to lodging depending on many factors such as stalk strength and over-fertilization. A visual estimation of lodging (%) was performed on 28-Jul. Lodging is defined as the collapse of top heavy plants, particularly grain crops because of excess growth or beating by rain. If lodging was present, its severity was recorded based on a 1 to 5 scale with 1 indicating the entire plot could be harvested with the plot

combine and 5 signifying that none of the plot could be harvested. Very little lodging was observed in the 2015 trial. Only two varieties (Hope and Scarlett) exhibited lodging. Of those, each only exhibited lodging on one out of the four replicates and the severity was considered low.

Insect and disease scouting was conducted on 19-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 prevalent and observed on all varieties and in more than 75% of plots.

Mites were observed on three varieties, Hope, Scarlett, and Surprise. In each case, mites were only observed on one of the four replicate plots. Mites are very small arthopods 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.

Cereal leaf beetle is an invasive species native to Europe that was accidentally introduced to the U.S. in the 1960's. The larvae of the beetle can cause significant damage to grain crops. Cereal leaf beetles were observed on two varieties, AC Barrie and Spinkcota. In each case, cereal leaf beetles were only found on one of the four replicate plots.

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 observed on the varieties Red Fife, Ceres 05, and Surprise. In each of these varities, powdery mildew was only found on one of the four replicate plots. Tan spot, caused by the fungus *Pyrenophora tritici-repenti*, was the most prevalent foliar disease observed in the heirloom spring wheat variety trial. It affected AC Barrie (50% of plots), Ceres 05 (25% of plots), Champlain (50% of plots), Defiance (25% of plots), Hope (50% of plots), Komar (75% of plots), Marquis (50% of plots), Mida 05 (50% of plots), Mida 06 (50% of plots), Red Bobs (100% of plots), Red Fife (50% of plots), Reliance (75% of plots), Scarlett (25% of plots), Spinkcota (25% of plots), and Thatcher (50% of plots). Ladoga, Supreme, and Surprise were not infected with tan spot at the time of scouting. Loose smut (caused by the fungus *Ustilago tritici*) had been observed in previous years and in other 2015 trials, but was not observed on any of the heirloom wheat varieties.

In the Northeast, *Fusarium* head blight (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 2014 trial, thirteen of the 19 varieties displayed bleached grain heads which is associated with the presence of *Fusarium* head blight. Bleached heads with the presence of *Fusarium* head blight were not observed in any varieties in the 2015 trial. However, DON levels (Table 5) were not lower than in previous years.

There was no significant difference in yield among heirloom varieties (Figure 1). The average yield at 13.5% moisture for the trial was 1520 lbs per acre. Ladoga had the highest yield at 2183 lbs per acre. This was statistically similar to Ceres 05 (1480 lbs per acre), Champlain (1584 lbs per acre), Defiance (1473 lbs per acre), Hope (1734 lbs per acre), Marquis (1635 lbs per acre), Mida 05 (1567 lbs per acre), Red Fife (1706 lbs per acre), Spinkota (1830 lbs per acre), Supreme (1735 lbs per acre), and Surprise (1475 lbs per acre). The average harvest moisture for the Alburgh location was 15.6%. Three varieties (Supreme, Ladoga, and Red Bobs) tested below 14% moisture. The highest test weight was in the variety 'Supreme' (56.5 lbs per bushel). 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. The acceptable test weight for bread wheat is 56-60 lbs per bushel. The varieties Ceres 05, Defiance, Red Bobs, Reliance, and Supreme all had a test weight over 56 lbs per bushel.

Table 5: Quality of heirloom spring wheat for Alburgh, VT, 2015.

Variety	Crude protein at 12% moisture	Crude protein at 14% moisture	Falling number	DON
	%	%	sec	ppm
AC Barrie	11.8*	11.6*	331*	4.2*
Ceres 05	11.7	11.5	348*	4.0*
Champlain	12.5*	12.2*	289	3.9*
Defiance	11.3	11.1	318	**3.1**
Hope	12.8*	12.5*	335*	7.1
Komar	12.3*	12.0*	293	4.7
Ladoga	11.5	11.3	334*	3.7*
Marquis	11.4	11.2	339*	4.2*
Mida 05	12.8*	12.5*	297	5.7
Mida 06	**13.1**	**12.8**	272	6.4
Red Bobs	11.1	10.8	**352**	5.3
Red Fife	11.3	11.1	288	6.3
Reliance	10.7	10.4	292	4.7
Scarlett	10.7	10.4	294	4.0*
Spinkcota	12.5*	12.2*	312	3.5*
Supreme	10.7	10.5	309	4.0*
Surprise	11.2	11.0	330*	4.2*
Thatcher	12.5	12.2*	282	5.2
LSD (0.10)	1.4	1.4	27	1.5
Trial mean	11.8	11.5	312	4.6

*Treatments that did not perform significantly lower than the top-performing treatment in a particular column are indicated with an asterisk.

Treatments indicated in **bold** had the top observed performance in a particular column.

Protein levels ranged from 10.7 to 13.1 percent at 12% moisture. Several varieties (AC Barrie, Ceres 05, Defiance, Ladoga, Marquis, Red Bobs, Red Fife, Reliance, Scarlett, Supreme, and Surprise) had crude protein levels below the 12% crude protein level considered optimal for commercial flour production. Mida 06 had the highest crude protein concentrations but was not significantly different than AC Barrie, Champlain, Hope, Komar, Mida 05, and Spinkcota. All of the varieties grown in Alburgh had high falling numbers over 250 seconds. The average falling number was 312 seconds, which once again indicates low enzymatic activity and sound quality wheat. In this year's trial, all the varieties grown in Alburgh had DON levels above 1.0 ppm, higher than the acceptable levels for human consumption.

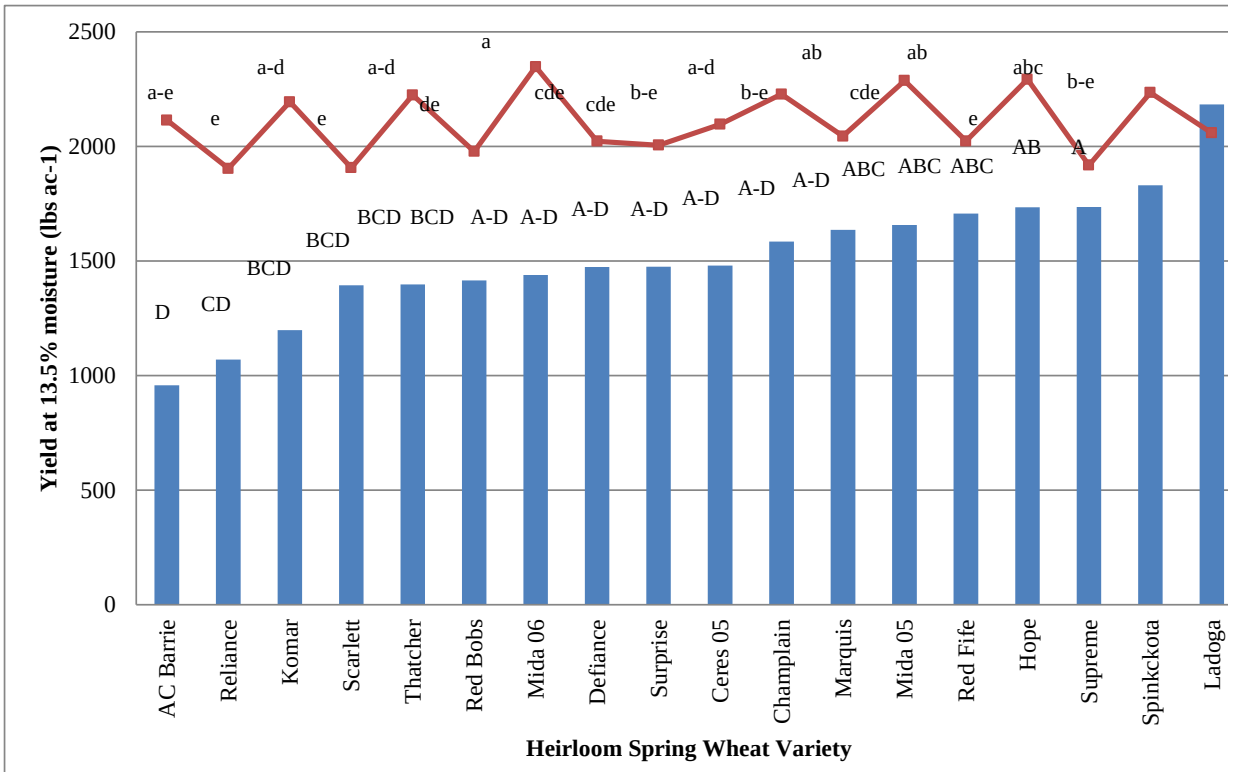

Figure 1. Yield and protein of heirloom spring wheat varieties grown in Alburgh, VT, 2015. Treatments that share a letter did not differ significantly by variety (p=0.10.)

DISCUSSION

Warm temperatures and low precipitation encountered during 2015 contributed to higher yields than in many previous years of heirloom spring wheat trials. However, the warm weather and high precipitation in June were also likely contributors to the high prevalence of foliar disease and accompanying DON levels, which were higher than in many previous years.

There is generally an inverse relationship between yield and protein. As yield increases, protein levels generally decrease, and when yields are low, protein levels are generally high. However, this was not

always the case with the heirloom wheat. Ladoga was the highest yielding heirloom, with a crude protein content of 11.5% at 12% moisture. Several of the other high yielding varieties (Champlain, Spinkcota, Hope, and Mida 05) all had crude protein content above 12% at 12% moisture. This may be evidence that some heirloom varieties are able to outperform modern varieties in the challenging growing conditions of Vermont. Based on these trials, there are several heirloom varieties that will perform well under Vermont growing conditions in both yield and quality.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank the UNFI Foundation for funding this research. Special thanks to Roger Rainville and the staff at Borderview Research Farm for their help with these trials. We would also like to acknowledge Katie Blair, Julija Cubins, Lindsey Ruhl, and Dan Ushkow for their assistance with data collection and entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

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