2016

Organic Heirloom Spring Wheat Variety Trial

Heather Darby
University of Vermont, heather.darby@uvm.edu

NORTHWEST CROPS & SOILS PROGRAM

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Dr. Heather Darby, UVM Extension Agronomist
Nate Brigham, Erica Cummings, Hillary Emick, Abha Gupta, Julian Post, and Sara Ziegler
UVM Extension Crops and Soils Technicians
(802) 524-6501

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

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Dr. Heather Darby, University of Vermont Extension
Heather.Darby[at]uvm.edu

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 current 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.

MATERIALS AND METHODS

In April 2016, an heirloom spring wheat variety trial was established at Borderview Research Farm in Alburgh, Vermont. The experimental plot design was a randomized block design with three 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 spring barley. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 21-Apr at a seeding rate of 350 live seeds per square meter. The eighteen 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, 2016.

Location	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Spring barley
Seeding rate (seeds m^{2-1})	350
Replicates	3
Planting date	21-Apr
Harvest date	9-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, 2016.

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 17-May by taking three 12-inch plant counts per plot. Plots were harvested with an Almaco SPC50 small plot combine on 9-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 June and July. The month of April was 4.9 degrees colder than average, May was 1.8 degrees warmer, and August was 2.9 degrees warmer. Alburgh received below average rainfall during the spring wheat growing season, 6.36 inches below the 30 year average. From April to August there was an accumulation of 4536 Growing Degree Days (GDDs) in Alburgh, VT, 43 GDDs higher than the 30 year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2016.

Alburgh, VT	Apr	May	Jun	Jul	Aug
Average Temperature (F)	39.8	58.1	65.8	70.7	71.6
Departure from Normal	-4.90	1.80	0.00	0.10	2.90
Precipitation (inches)	2.60	1.50	2.80	1.80	3.00
Departure from Normal	-0.26	-1.92	-0.88	-2.37	-0.93
Growing Degree Days (base 32)	291	803	1017	1201	1224
Departure from Normal	-98	50	3	4	84

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

During the 2016 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). Six of the eighteen heirloom spring wheat varieties were flowering by 23-Jun and all varieties were flowering by 28-Jun.

Plant heights were measured on 3-Aug just prior to harvest. The average height was 36.2 inches (Table 4). Taller plants are generally desired for their ability to shade out competing weeds. However, tall wheat may be more prone to lodging depending on many factors such as stalk strength and over-fertilization. A visual estimation of lodging (%) was performed on 3-Aug. 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. Some lodging was observed in the 2016 trial. Eight varieties (Champlain, Hope, Komar, Ladoga, Red Bobs, Reliance, Spinkcota, and

Table 4: Growth and harvest characteristics of heirloom spring wheat for Alburgh, VT, 2016.

Variety	Flowering date	Height	Lodging	Yield at 13.5% moisture	Moisture @ harvest	Test weight	Foliar disease	Insect damage
	Date	in	%	lbs ac^{-1}	%	lbs bu^{-1}	%leaf affected	%leaf damaged
AC Barrie	**22-Jun**	33.7	**0.00**	1297	11.2	57.0*	1.13	1.60
Ceres 05	23-Jun	35.8	**0.00**	1483	10.8*	57.3*	1.58	2.04
Champlain	27-Jun	38.4*	0.67	1833	11.7	56.5*	0.44	1.80
Defiance	27-Jun	35.4	**0.00**	1442	**10.0***	56.8*	0.42	2.51
Hope	23-Jun	33.7	0.33	1570	10.6*	**58.0***	0.44	1.96
Komar	23-Jun	36.7*	0.67	1683	11.1*	**58.0***	0.89	1.40
Ladoga	26-Jun	35.4	1.33	1679	10.5*	56.5*	0.33	1.69
Marquis	26-Jun	37.5*	**0.00**	1691	10.5*	56.2	0.33	1.87
Mida 05	24-Jun	37.4*	**0.00**	**2007**	12.0	57.3*	0.49	1.93
Mida 06	24-Jun	36.8*	**0.00**	1626	10.5*	54.3	0.64	1.60
Red Bobs	23-Jun	34.3	0.33	1557	12.3	57.0*	0.56	2.18
Red Fife	23-Jun	37.6*	**0.00**	1686	12.6	55.5	0.38	1.85
Reliance	25-Jun	37.6*	0.67	1679	11.6	57.3*	0.42	1.40
Scarlett	28-Jun	**38.9***	**0.00**	1600	11.6	57.3*	**0.16**	1.47
Spinkcota	25-Jun	34.3	0.33	1497	12.7	56.8*	1.00	2.24
Supreme	25-Jun	34.0	**0.00**	1468	10.4*	56.7*	0.36	2.67
Surprise	26-Jun	37.0*	**0.00**	1598	11.3	56.3	0.56	**1.20**
Thatcher	25-Jun	37.0*	0.33	1337	12.0	56.0	0.80	1.85
LSD	NS	2.66	NS	NS	1.08	1.50	NS	NS
Trial mean	25-Jun	36.2	0.26	1596	11.3	56.7	0.61	1.85

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

NS – shows no significate difference.

Thatcher) exhibited a minimal degree of lodging. Of those, Ladoga exhibited the most severe lodging, 1.33 on a scale to 5. Overall, the severity of lodging was considered low.

There was no significant difference in yield among heirloom varieties (Figure 1). The average yield at 13.5% moisture for the trial was 1596 lbs per acre. The average harvest moisture was 11.3%. The highest test weights were in the varieties Hope and Komar (58.0 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. Red Fife and Mida 06 were the only varieties below the ideal test weight of 56-60 lbs per bushel.

Insect and disease scouting was conducted on 7-Jul. 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 thrips and evidence of insect damage. Five plants in each plot were examined for disease and insect damage, shown as the average percent of each leaf that was affected by either insect damage or foliar disease (Table 4).

Overall insect and disease damage was low. The variety Scarlett had the least foliar disease and Surprise had the least insect damage, however, the difference was not significant between varieties (Table 4).

Table 5: Presence of disease and insect pests for heirloom spring wheat for Alburgh, VT, 2016.

Variety	Powdery Mildew	Leaf Spots	Physiological Spotting	FHB	Mites	Thrips	Cereal Leaf Beetle	Leaf Rust	Loose Smut
AC Barrie	X	X	X	X	X	X		X	
Ceres 05	X	X	X	X	X	X			X
Champlain	X	X	X	X	X	X		X	X
Defiance	X	X	X	X	X	X		X	X
Hope	X	X	X	X	X	X			X
Komar	X	X	X	X	X	X		X	
Ladoga		X	X	X	X	X		X	X
Marquis	X	X	X	X	X	X			X
Mida 05	X	X	X	X	X	X		X	X
Mida 06	X	X	X	X	X	X			X
Red Bobs	X	X	X	X	X	X			
Red Fife	X	X	X	X	X	X			X
Reliance	X	X	X	X	X	X			X
Scarlett		X	X	X	X	X		X	X
Spinkcota		X	X	X	X	X			X
Supreme	X	X	X	X	X	X			X
Surprise	X	X	X	X	X	X	X		X
Thatcher	X	X	X	X	X	X		X	X

X = Presence of disease/insect pest. Blank = No presence of disease/insect pest.

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 (Table 5).

Mites were also prevalent and observed on all varieties (Table 5). 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.

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 one variety, Surprise (Table 5).

Observed on all varieties was foliar disease resistance discoloring, also called physiological spotting. While the discoloring looks a leaf disease, it is actually a genetic resistance response.

Several foliar diseases were observed during wheat development, including powdery mildew and leaf spots. 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 all but three varieties (Ladoga, Scarlett, and Spinkcota). Leaf spots, which can include, tan spots caused by the fungus *Pyrenophora tritici-repenti*, Septoria, and Stagonospora, were present on all varieties this year. Loose smut (caused by the fungus *Ustilago tritici*) was observed in all but three heirloom wheat varieties (AC Barrie, Komar, and Red Bobs) (Table 5).

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 1 ppm 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. In the 2016 trial, bleached heads were observed on all varieties. DON levels were lower than in previous years (Table 6).

Table 6: Quality of heirloom spring wheat for Alburgh, VT, 2016.

Variety	Crude protein at 12% moisture	Crude protein at 14% moisture	Falling number	DON
	%	%	sec	ppm
AC Barrie	15.9*	15.6*	284*	0.17
Ceres 05	16.4*	16.1*	289*	0.17
Champlain	16.3*	15.9*	254	0.17
Defiance	16.5*	16.2*	273	**0.00**
Hope	15.5	15.2	301*	0.05
Komar	16.5*	16.2*	294*	0.20
Ladoga	15.9*	15.5*	289*	**0.00**
Marquis	16.3*	15.9*	278*	0.03
Mida 05	15.9	15.5	277*	0.07
Mida 06	**16.7***	**16.3***	237	0.20
Red Bobs	15.5	15.1	**307***	0.13
Red Fife	14.9	14.5	255	0.33
Reliance	15.6	15.3	286*	0.10
Scarlett	16.5*	16.1*	263	0.03
Spinkcota	16.6*	16.2*	271	0.10
Supreme	16.4*	16.0*	249	0.03
Surprise	16.6*	16.2*	287*	**0.00**
Thatcher	16.4*	16.0*	236	0.20
LSD (0.10)	0.80	0.78	29.8	NS
Trial mean	16.1	15.8	274	0.11

*Treatments that did not perform significantly lower than the top-performing treatment, shown in bold, in a particular column are indicated with an asterisk.
NS – shows no significate difference.

Protein levels ranged from 14.9 to 16.7 percent at 12% moisture. All varieties had crude protein levels above 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, Ceres 05, Champlain, Defiance, Komar, Ladoga, Marquis, Scarlett, Spinkcota, Supreme, Surprise, and Thatcher. Mida 06 also had the highest crude protein concentrations in the 2015 trial. All of the varieties had falling numbers over 235 seconds. The average falling number was 274 seconds, which indicates low enzymatic activity and sound quality wheat. In this year's trial, all the varieties grown had DON levels below 1.0 ppm, acceptable levels for human consumption.

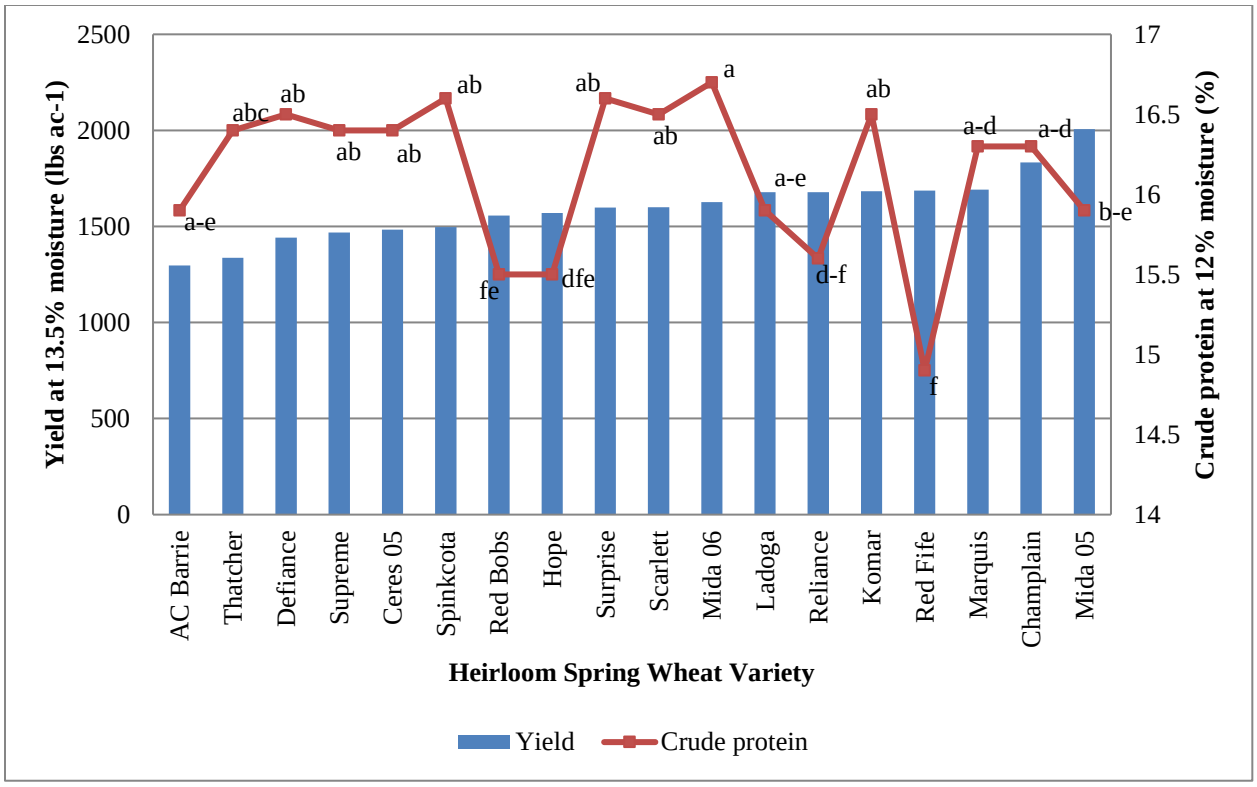

Figure 1. Yield and protein of heirloom spring wheat varieties grown in Alburgh, VT, 2016. Treatments that share a letter did not differ significantly by variety (p=0.10.)

DISCUSSION

Warmer temperatures and low precipitation encountered during 2016 contributed to higher yield and quality than in many previous years of heirloom spring wheat trials.

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. Champlain, Marquis, and Ladoga were high yielding heirlooms, with crude protein content statistically similar to the top performer. 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.

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