NORTHWEST CROPS & SOILS PROGRAM

2016 Organic Heirloom Winter Wheat Variety Trial

Dr. Heather Darby, UVM Extension Agronomist
Hillary Emick and Erica Cummings
UVM Extension Crops and Soils Technicians
802-524-6501

Visit us on the web: http://www.uvm.edu/extension/cropsoil

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 ORGANIC HEIRLOOM WINTER WHEAT VARIETY TRIAL

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

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 fifth 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 2015, 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 three replicates. Treatments were 20 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 corn. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 25-Sep 2015 at a seeding rate of 125 lbs ac^{-1}.

Table 1. General plot management.

Trial information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
Seeding rates (lbs ac^{-1})	125 lbs ac^{-1}
Row spacing (in)	6
Replicates	3
Planting date	25-Sep 2015
Harvest date	21-Jul 2016
Harvest area (ft)	5 x 20
Tillage operations	Disk & spike tooth harrow

The flowering date was recorded when at least 50% of the plot was in bloom. Heights and lodging were measured on 19-Jul 2016 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. It was measured with a visual rating on a scale of 0-100, where 0 represented no lodging.

Plots were harvested with an Almaco SPC50 small plot combine on 21-Jul 2016. 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 graphic linear model (GLM) procedure in SAS.

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. 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 0.10 indicates that the differences between varieties are significant at 10% level of probability. Where the p-value is 0.10, 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 average or above for most of the growing season, with the exception of a colder than normal April. 2015-2016 was a very dry winter wheat growing season (10.9 inches of precipitation less than normal, not including the winter months). While a few months were warmer than average, overall temperatures were very mild and resulted in 5324 growing degree days (GDDs) at a base temperature of 32°F through the growing season, 278 GDDs 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 despite the lack of protective snow cover.

Table 3. Seasonal weather data collected in Alburgh, VT, 2015 and 2016.

Alburgh, VT	Sep-15	Oct-15	Nov-15	Mar-16	Apr-16	May-16	Jun-16	Jul-16
Average temperature (°F)	65.2	46.5	42.2	33.9	39.8	58.1	65.8	70.7
Departure from normal	4.7	-1.6	4.0	2.9	-4.9	1.8	0.0	0.1
Precipitation (inches)	0.3	2.5	1.8	2.5	2.6	1.5	2.8	1.8
Departure from normal	-3.3	-1.1	-1.3	0.3	-0.3	-1.9	-0.9	-2.4
Growing Degree Days (base 32°F)	1010	464	329	209	291	803	1017	1201
Departure from normal	154	-37	117	85	-98	50	3	4

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 2016 growing season, many observations and measurements were recorded on heirloom winter wheat development, including winter survival, flowering date, disease and pest scouting, height, and lodging (Table 4).

The flowering date was recorded when at least 50% of the plot was in bloom. Warm, dry weather led to early flowering. Clark's Cream was flowering by 4-Jun. The majority of heirloom winter wheat varieties were flowering by 7-Jun and all varieties were flowering by 12-Jun.

'Pride of Genesee' was the tallest growing heirloom wheat, which grew 40.6 inches (Table 4). This was statistically similar to Clark's Cream, 'Coppei', 'Genesee Giant', 'Honor', 'Red Russian', and 'Ukraine'. 'Black Hull' was the shortest growing heirloom wheat, which grew 32.1 inches. Despite its height, Clark's Cream has the least amount of lodging, with 0.3% of the plot lodged. This was statistically similar to eight other varieties with less than 2% lodging ('Blue Jacket', 'Columbia', 'Forward', Genesee Giant, 'Gold Coin', Honor, 'Red Chief', Turkey Red, and Ukraine). All varieties had very low lodging in the 2016 trial (all below 4% lodging).

Table 4. The flowering dates, heights, and lodging of heirloom winter wheat varieties in Alburgh, VT, 2016.

Variety	Flowering date	Winter survival	Height	Lodging
		%	inches	%
Black Hull	8-Jun	95.0*	32.1	2.33
Blue Jacket	7-Jun	92.0*	36.8	1.00*
Clark's Cream	4-Jun	93.0*	37.8*	**0.33***
Columbia	10-Jun	62.0	36.8	1.33*
Coppei	7-Jun	78.0*	40.2*	2.33
Forward	9-Jun	95.0	35.5	1.00*
Genesee Giant	6-Jun	94.0	40.5*	0.67*
Gold Coin	8-Jun	95.0*	35.8	1.67*
Honor	5-Jun	**96.0***	40.5*	1.67*
Kanred	8-Jun	78.0*	35.4	3.00

Oro	8-Jun	85.0*	36.5	2.00*
Pride of Genesee	12-Jun	77.0*	40.6*	2.33
Red Chief	5-Jun	93.0*	38.9*	1.67*
Red Russian	11-Jun	76.0*	39.5*	2.33
Relief	7-Jun	74.0	35.9	3.33
Rio	7-Jun	88.0*	34.4	2.67
Triplet	10-Jun	80.0*	36.7	2.33
Turkey Red	6-Jun	92.0*	36.1	1.00*
Ukraine	8-Jun	90.0*	37.3*	0.67*
Wasatch	6-Jun	96.0*	35.5	3.67
LSD (p=0.10)	2.96 days	21.5	3.55	1.61
Trial mean	7-Jun	86.5	37.1	1.86

*Varieties with an asterisk are not significantly different than the top performer in **bold**.
Flowering date is not notated because there is no set value for best performance.

Insect and disease scouting was conducted in the first week of July. Researchers looked for symptoms of a wide range of 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. Five plants in each plot were examined for disease and pest damage, and are shown in Table 5 as the average percent of each leaf that was affected by either arthropod damage or foliar disease.

Table 5. Disease and arthropod damage in winter wheat varieties, 2016

Variety	Foliar disease	Arthropod damage
	% leaf affected	% leaf damaged
Black Hull	2.86*****	4.30*****
Blue Jacket	2.47*****	1.93*****
Clark's Cream	3.27*****	5.00
Columbia	3.93*****	3.20*****
Coppei	5.27*****	6.40
Forward	1.20*****	3.47*****
Genesee Giant	2.60*****	3.93*****
Gold Coin	3.47*****	2.72*****
Honor	2.40*****	3.07*****
Kanred	8.20	5.00
Oro	4.40*****	**1.67***
Pride of Genesee	2.20*****	6.47
Red Chief	9.53	2.73*****
Red Russian	3.13*****	4.93
Relief	3.33*****	**1.67***
Rio	4.67*****	4.40*****
Triplet	5.27*****	3.13*****
Turkey Red	**0.73***	3.47*****
Ukraine	1.73*****	4.47*****
Wasatch	4.00*****	3.47*****
LSD (p=0.1)	5.25	2.90
Trial mean	3.73	3.77

The most common arthropod pests affecting the winter wheat trials were mites and thrips. 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. Some degree of mite damage was observed in all plots. 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 damage was observed in more than half of the winter wheat trial plots. Cereal leaf beetle damage and European corn

borer damage were also observed in a few scattered plots. 'Oro' and 'Relief' were most resistant to pest damage, with only 1.7% of leaf surface displaying pest damage. This was statistically similar to the pest damage sustained by most of the other heirloom varieties. Five varieties had statistically higher levels of pest damage: Clark's Cream (5.0% of the leaf surface affected by pest damage), Coppei (6.4%), 'Kanred' (5.0%), Pride of Genesee (6.5%) and Red Russian (4.9%).

Several foliar diseases were observed during wheat development, including powdery mildew, leaf rust, and leaf 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*) and leaf rust were less prevalent than leaf spot, and the plots most affected by these diseases were located in a low-lying section of the field with much higher soil moisture. Loose smut was not observed in the heirloom winter wheat variety trial. Turkey Red had the least presence of foliar disease, with 0.7% of leaf surface displaying foliar disease. This was statistically similar to the level of foliar disease in most varieties. Red Chief (9.5%) and Kanred (8.2%) had significantly higher levels of foliar disease.

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 2016 trial, eight of the 20 heirloom winter wheat varieties (Blue Jacket, Clark's Cream, Kanred, Oro, Red Russian, Relief, 'Triplet', and Turkey Red) displayed bleached grain heads which are associated with the presence of FHB. Blue Jacket and Relief displayed bleached heads in two out of three replicates (bleaching was only observed in one plot out of the three replicates in the other affected varieties.) However, DON levels (Table 6) for all wheat plots were far below the 1 ppm threshold for human consumption.

Table 6. Yield and quality of heirloom winter wheat varieties, Alburgh, VT, 2016.

Variety	Yield @ 13.5% moisture	Moisture	Test weight	Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
Black Hull	2476	17.7*****	61.3*****	12.8	362*****	0.20
Blue Jacket	2773	17.7*****	61.5*****	14.0	349	0.20
Clark's Cream	3144	17.0*****	60.2*****	12.6	324	0.10
Columbia	2020	19.2	57.3	13.0	322	0.10
Coppei	2670	18.2	59.5*****	13.7	342	0.10
Forward	**3966***	17.1*****	61.3*****	12.5	307	0.30
Genesee Giant	2948	16.7*****	61.8*****	13.1	315	0.20
Gold Coin	2836	17.3*****	60.7*****	12.6	333	0.10
Honor	2801	**15.9***	60.0*****	12.5	371*****	0.10
Kanred	2253	18.3	60.0*****	13.4	379*****	0.00
Oro	2392	17.7*****	60.8*****	13.6	359	0.10
Pride of Genesee	2696	20.7	56.5	13.4	360*****	0.00
Red Chief	3237	16.7*****	**61.8***	14.4*****	379*****	0.20
Red Russian	2463	18.4	60.2*****	14.8*****	359	0.00
Relief	2292	18.6	58.7*****	13.8	350	0.10

Rio	2505	18.9	60.7*****	13.2	**393***	0.10
Triplet	2800	18.3	60.5*****	13.9	368*****	0.10
Turkey Red	3240	17.4*****	61.2*****	13.0	330	0.00
Ukraine	2810	16.6*****	61.0*****	14.5*****	332	0.10
Wasatch	2570	16.7*****	61.5*****	**15.3***	392*****	0.10
LSD (p=0.10)	583	1.91	3.35	0.91	42.1	NS
Trial mean	2744	17.8	60.3	13.5	351	0.10

*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 2744 lbs ac^{-1}. The highest yielding variety was Forward at 3966 lbs ac^{-1}. This was statistically higher than all other varieties. Clark's Cream (3144 lbs ac^{-1}), Red Chief (3237 lbs ac^{-1}), and Turkey Red (3240 lbs ac^{-1}) were also high yielding varieties. All heirloom winter wheat varieties trialed in 2016 yielded over one ton ac^{-1}.

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 Chief had the highest test weight at 62 lbs bu^{-1}. This was statistically similar to eighteen other varieties with test weights above 59 lbs bu^{-1}. All twenty varieties had test weights greater than the industry minimum of 56 lbs bu^{-1}.

Despite the dry weather through the growing season, humid conditions at harvest time resulted in high moisture content in the harvested grain. Harvest moisture ranged from 15.9% (Honor) to 20.7% (Pride of Genessee) with an average harvest moisture of 17.8%. All the wheat varieties needed to be dried down further for long-term storage.

There is often an inverse relationship seen between yield and protein, and this was mostly true of the heirloom winter wheat varieties assessed in 2016. Yields were high compared to previous years of heirloom winter wheat trials, but only five varieties had crude protein levels at or above the industry minimum of 14%: Blue Jacket (14.0%), Red Chief (14.4%), Red Russian (14.8%), Ukraine (14.5%), and 'Wasatch' (15.3%). Red Chief was notable for having both high yield and high quality, ranking third in both yield and crude protein (Figure 1).

Falling numbers for all varieties were above 200 seconds and most were under 350 seconds, indicating sound quality wheat (Table 6). Several varieties (Black Hull, Honor, Kanred, Oro, Pride of Genesee, Red Chief, Red Russian, 'Rio', Triplet and Wasatch) had falling numbers above 350, indicating relatively low enzymatic activity. These included both soft and hard wheat varieties. DON levels for all varieties were below the FDA threshold of 1 ppm which is considered safe for human consumption (Table 6).

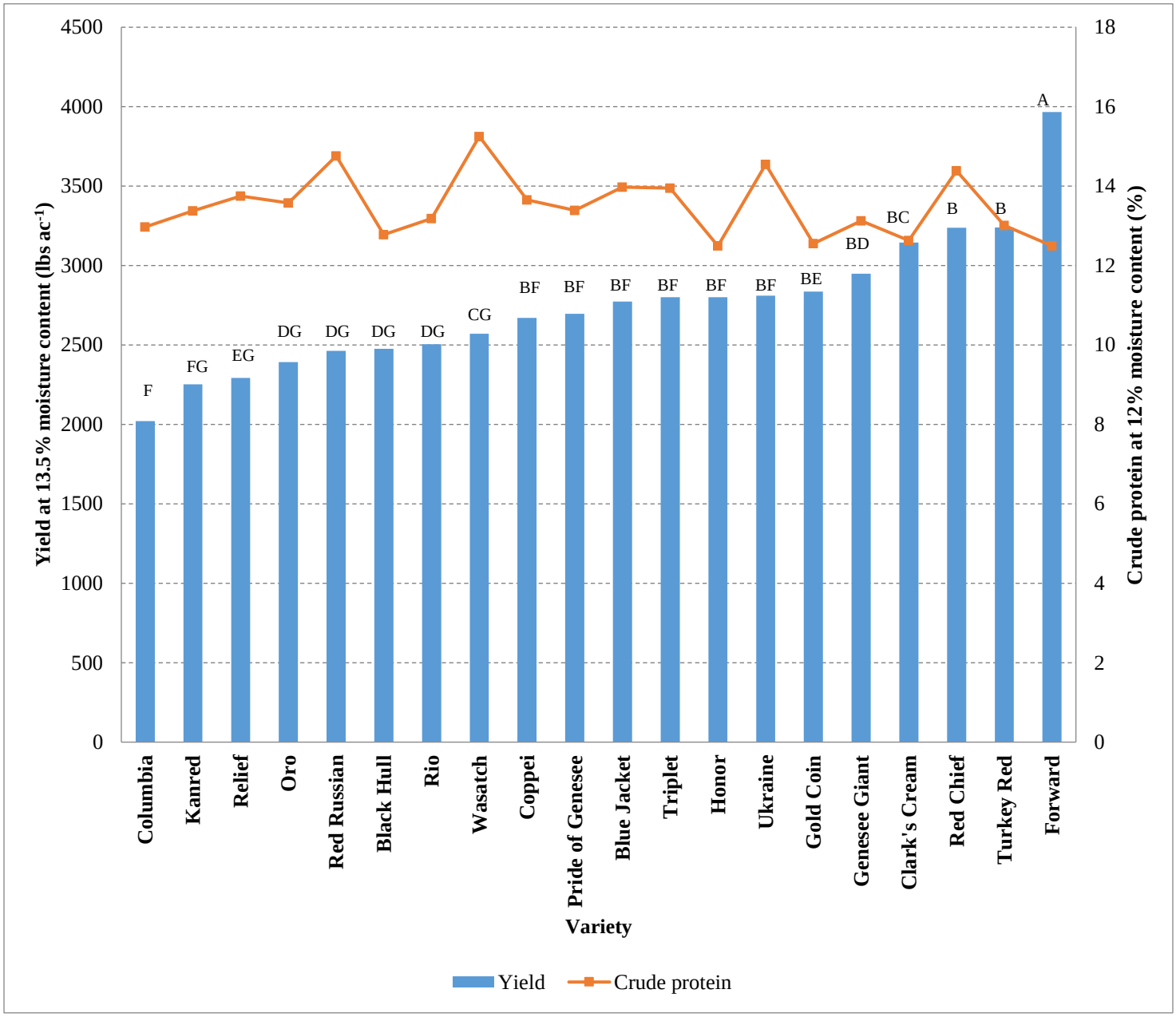

Figure 1. Yield and crude protein of heirloom winter wheat varieties, Alburgh, VT, 2016. *For yield, varieties with the same letter are not significantly different from one another. There were no significant differences in crude protein.*

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Roger Rainville and the staff at Borderview Research Farm for their help with the research trials. We would also like to acknowledge Nate Brigham, Julija Cubins, Kelly Drollette, Abha Gupta, Julian Post, Lindsey Ruhl, Xiaohe "Danny" Yang, and Sara Zeigler 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.

UVM Extension helps individuals and communities put research-based knowledge to work.