NORTHWEST CROPS & SOILS PROGRAM

2017 Organic Winter Wheat Variety Trial

Dr. Heather Darby, UVM Extension Agronomist
Hillary Emick, Erica Cummings, Abha Gupta, Lindsey Ruhl, and Sara Ziegler
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

2017 ORGANIC WINTER WHEAT VARIETY TRIAL

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

In 2017, the University of Vermont Extension Northwest Crops and Soils Program evaluated 21 winter wheat varieties to determine those that perform best in organic production systems in northern Vermont. The trial was established at the Borderview Research Farm in Alburgh, Vermont.

MATERIALS AND METHODS

The winter wheat variety trial was initiated at Borderview Research Farm in Alburgh in the fall of 2016. Plots were managed with practices similar to those used by producers in the surrounding area. General plot management is listed in Table 1. The experimental design was a randomized complete block with four replicates. Treatments were 21 winter wheat varieties (Table 2). The previous crop was dry beans. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 26-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 insect and disease prevalence. Populations were recorded post-emergence on 12-Oct 2016 by counting the number of wheat plants in three 12-inch sections. Heights and lodging were measured prior to harvest on 19-Jul 2017. Heights were determined by taking three measurements per plot with a meter stick. Lodging was recorded on a scale from zero to five, with zero indicating no lodging and five indicating that 100% of the plot was lodged.

Insect and disease scouting was conducted on 22-Jun 2017. Research technicians looked for the presence of foliar disease and evidence of pest damage. 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	Dry beans
Seeding Rates (lbs ac^{-1})	125 lbs ac^{-1}
Row spacing (in)	6
Replicates	4
Planting date	26-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 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption.

Table 2. Winter wheat varietal information.

Variety	Market class	Seed source
10007W	HRWW	Pioneer Seeds, IA
112313W	HRWW	Pioneer Seeds, IA
Brome	HRWW	Semican, Canada
Byrd	HRWW	Arrow Seeds, NE
WB-Cedar	HRWW	Arrow Seeds, NE
CM15-0004	HRWW	JoMar Seeds, IN
Emerson	HRWW	Albert Lea Seed House, MN
Expedition	HRWW	Albert Lea Seed House, MN
Grainfield	HRWW	Arrow Seeds, NE
LSC Chrome	HRWW	Limagrain Cereal Seeds, CO
LSC Mint	HRWW	Limagrain Cereal Seeds, CO
LSC Pistol	HRWW	Limagrain Cereal Seeds, CO
LSC T158	HRWW	Limagrain Cereal Seeds, CO
LSC Wizard	HRWW	Limagrain Cereal Seeds, CO
Overland	HRWW	Arrow Seeds, NE
Redeemer	HRWW	Semican, Canada
Redfield	HRWW	Albert Lea Seed House, MN
Sy Sunrise	HRWW	Arrow Seeds, NE
Sy Wolf	HRWW	Arrow Seeds, NE
Warthog	HRWW	Semican, Canada
Winterhawk	HRWW	Arrow Seeds, NE

HRWW – Hard Red 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.

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.

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

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 the Northeast. 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, disease and arthropod damage are reported in Table 4. Most varieties exceeded the target plant population of 350 live plants m^2. Redeemer had the highest population (440 plants m^2). This was statistically similar to most other varieties, except LSC Chrome, LSC T158, LSC Wizard, and Warthog. In organic systems, taller plants and higher plant populations are generally desired for their ability to shade out competing weeds, although these characteristics may cause the wheat to be more prone to lodging. No lodging was observed in the 2017 winter wheat trial (data not shown). Brome was the tallest wheat variety at 106 cm (41.5 inches) (Table 4). This was statistically similar to Emerson (94.8 cm) and Redeemer (95.6 cm).

Table 4. Growing season measurements winter wheat varieties in Alburgh, VT, 2017.

Variety	Population	Height @ harvest	Foliar disease	Arthropod damage
	m^2	**cm**	**% leaf affected**	**% leaf damaged**
10007W	400*	80.3	7.00*	2.00*
112313W	429*	87.5	5.35*	1.40*
Brome	380*	**105.5***	10.5*	3.90
Byrd	420*	88.5	15.40*	1.45*
WB-Cedar	422*	83.0	20.0	1.15*
CM15-0004	377*	68.5	12.0*	1.75*
Emerson	422*	94.8*	20.1	0.80*
Expedition	388*	91.9	28.6	2.20*
Grainfield	395*	77.8	4.05*	2.25*
LSC Chrome	348	78.8	**2.70***	1.50*
LSC Mint	396*	89.9	13.6*	**0.70***
LSC Pistol	364*	76.5	29.6	2.40*
LSC T158	352	79.3	19.0	1.60*
LSC Wizard	321	76.1	4.65*	1.00*
Overland	389*	85.1	8.25*	3.05
Redeemer	**440***	95.6*	13.4*	2.25*
Redfield	366*	83.6	25.9	1.95*
Sy Sunrise	359*	71.5	18.0	1.05*
Sy Wolf	371*	76.7	6.55*	2.10*
Warthog	352	85.7	3.65*	2.75
Winterhawk	373*	89.4	9.25*	1.60*
LSD (p = 0.10)	84.1	11.5	13.4	1.75
Trial Mean	384	84.1	13.2	1.85

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

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

The most common arthropods 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 varieties and in most 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 was also observed in some plots. LSC Mint appeared to be the least impacted by arthropod damage, with only 0.7% of leaf surface displaying pest damage. This was statistically similar to the arthropod damage sustained by most of the other varieties, with Brome, Overland and Warthog sustaining more insect damage than other varieties at a statistically significant level.

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. 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. LSC Chrome had the least presence of foliar disease, with 2.7% of leaf surface displaying foliar disease. LSC Wizard, Grainfield, and Warthog also had foliar disease on less than 5% of leaf surface. LSC Pistol was the most prone to foliar disease (lesions covering 29.6% of the leaf surface on average). Expedition, Emerson and WB Cedar also had 20% or more of the leaf surface affected by foliar disease. Leaf spots, caused by several bacterial and/or fungal infections, were very prevalent and affected all varieties and more than 80% of plots. Powdery mildew (caused by the fungus *Erysiphe graminis f. sp. Tritici*) was present in 29% of plots. Some varieties were not infected by powdery mildew: Cedar, Overland, Warthog, and Winterhawk. LSC Mint had the highest level of powdery mildew infection, with all plants sampled infected, although yield did not seem adversely impacted. Leaf rust and stripe rust were both present in the winter wheat trial, with leaf rust affecting 18% of plants sampled and stripe rust affecting 7% of plants sampled.

Loose smut was observed in all plots of Cedar wheat but in no other 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	Moisture	Test weight	Crude protein @ 12% moisture	Falling number	DON
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds	ppm
10007W	2826	18.1	55.9*	10.3	303	0.85*
112313W	3057*	17.7	53.2	10.8	319	0.30*
Brome	3503*	19.8	52.0	11.9	317	2.70
Byrd	3682*	**16.6***	56.1*	11.5	303	1.55
WB-Cedar	3440*	17.8	54.8	11.2	359	1.33
CM15-0004	1341	18.1	52.1	14.1*	324	3.98
Emerson	3597*	18.3	55.3	12.6	331	**0.28***
Expedition	3088*	17.2*	56.8*	11.7	271	1.60
Grainfield	2707	17.5	56.2*	12.2	346	1.58
LSC Chrome	3432*	18.0	**56.9***	11.7	376*	1.93
LSC Mint	**3901***	17.3*	56.1*	11.7	330	2.78
LSC Pistol	2953	17.2*	53.8	11.3	264	1.70
LSC T158	2979	17.0*	56.2*	11.7	314	1.25
LSC Wizard	3270*	17.3*	55.3	12.0	330	2.78
Overland	3519*	17.9	56.1*	11.9	320	1.93
Redeemer	3504*	17.5	56.1*	**15.0***	397*	0.84*
Redfield	3708*	17.5	54.9	12.3	339	3.08
Sy Sunrise	2790	17.6	54.2	12.4	348	3.43
Sy Wolf	2483	19.4	54.0	12.6	257	2.23
Warthog	2582	18.4	55.1	12.0	**399***	2.10
Winterhawk	3229*	18.6	55.4*	12.2	336	2.03
LSD (p = 0.10)	874	0.73	1.55	1.36	37.1	0.89
Trial Mean	3130	17.8	55.0	12.0	328	1.85

*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 3130 lbs ac^{-1} (Table 5). The top yielding variety was LSC Mint, at 3901 lbs ac^{-1}. This was statistically similar to the varieties 112312W, Brome, Byrd, Cedar, Emerson, Expedition, LSC Chrome, LSC Pistol, LSC Wizard, Overland, Reedemer, Redfield, and Winterhawk which all yielded over 3000 lbs ac^{-1}.

Harvest moisture below 16% is desirable for growers 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. LSC Chrome had the

highest test weight at 56.9 lbs bu^{-1}. The varieties Byrd, Expedition, Grainfield, LSC Mint, and Redeemer also had test weight within the industry standard of 56-60 lbs bu^{-1}.

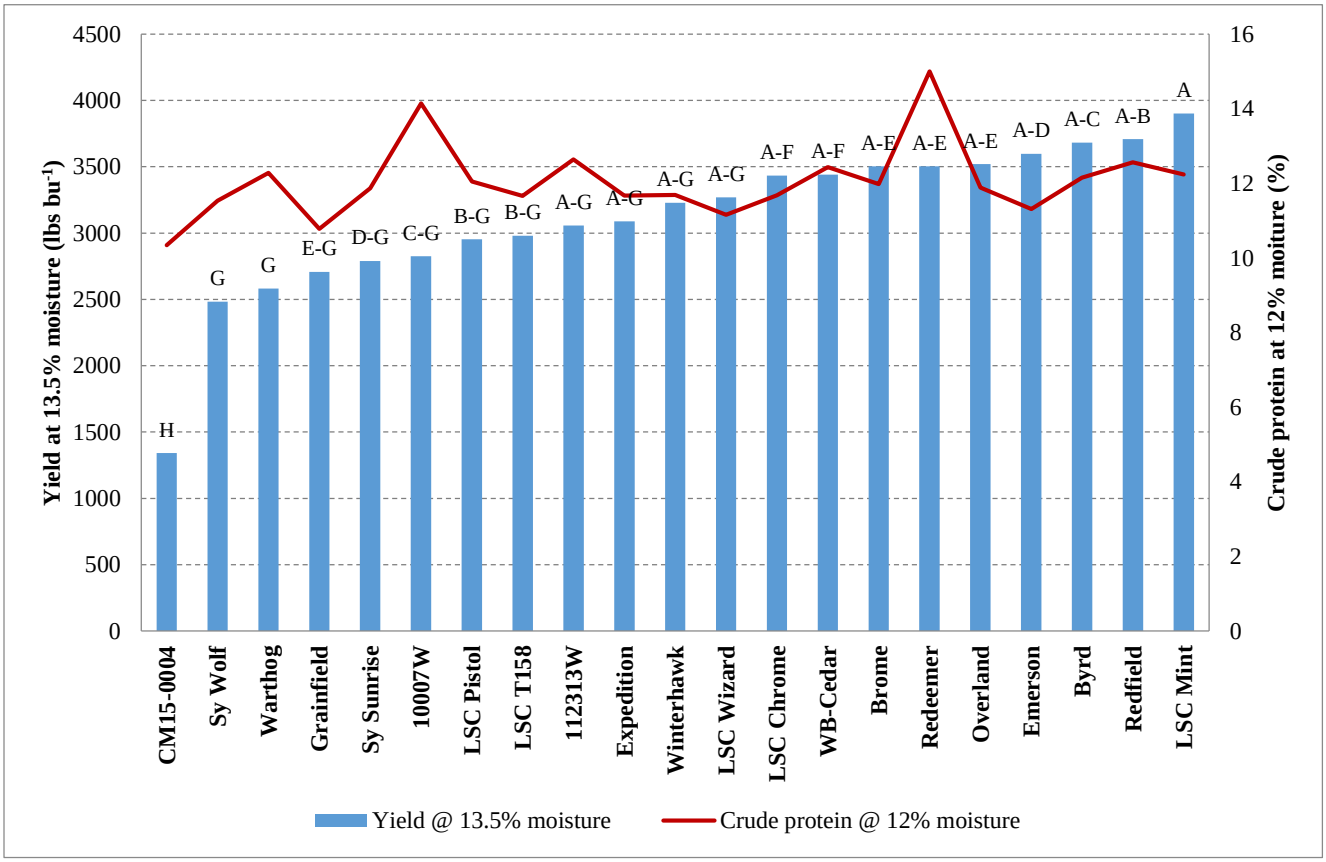

Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2017.
For yield, varieties with the same letter are not significantly different from one another.

Only two winter wheat varieties, Redeemer and CM15-0004, had crude protein 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 winter wheat varieties assessed in 2017, with higher yielding varieties tending to have lower crude protein (Figure 1). One notable exception was the variety Redeemer, which was statistically similar to the top performing varieties for both yield and crude protein. Falling numbers for all varieties were above 200 seconds, indicating sound quality wheat. Four varieties (10007W, 112313W, Emerson and Redeemer) had DON levels below the FDA threshold of 1 ppm which is considered safe for human consumption (Table 5). All other varieties exceeded the 1 ppm threshold.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Roger Rainville and the staff at Borderview Research Farm. This project was funded or partially funded through a USDA OREI grant, award number 2015-5130024153. We would also like to acknowledge Nate Brigham, Julija Cubins, Kelly Drollette, Freddy Morin, Matt Sanders, and Stuart Wolff-Goodrich 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.