NORTHWEST CROPS & SOILS PROGRAM

2018 Organic Winter Wheat Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2018 ORGANIC WINTER WHEAT VARIETY TRIAL

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In 2018, the University of Vermont Extension Northwest Crops and Soils Program evaluated 26 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 2017. 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 26 winter wheat varieties (22 modern varieties and 4 heirloom varieties - Tables 2 and 3). The previous crop was winter barley. The field was disked and spike tooth harrowed prior to planting. Plots were seeded with a Great Plains Cone Seeder on 21-Sep 2017 at a seeding rate of 350 live seeds m^{-2}.

Table 1. General plot management, 2017-2018.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam
Previous crop	Winter barley
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Replicates	4
Planting date	21-Sep 2017
Harvest date	19-Jul 2018
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

Many observations and measurements were recorded on winter wheat development during the growing season, including heading date, height, lodging, and insect and disease prevalence. Heading dates were recorded through June when 50% of the plot was headed (unripe heads had fully emerged from the boot). Heights and lodging were measured on 16-Jul 2018. Heights were determined by taking three measurements per plot with a meter stick. Lodging was recorded on a scale from zero to nine, with zero indicating no lodging and nine indicating that 100% of the plot was lodged.

Insect and disease scouting was conducted on 20-Jun 2018. Research technicians looked for the presence of foliar disease and evidence of pest damage on a whole plot basis. The severity of

disease and arthropod damage was recorded on a scale from zero to nine, with zero indicating no damage and nine indicating that 100% of the plot was severely affected.

Table 2. Winter wheat varietal information.

Variety	Market class†	Seed source
112313W	HRWW	Pioneer Seeds, IA
AC Benefit	HRWW	Bramhill Seeds, Ontario CA
AC Morley	HRWW	Bramhill Seeds, Ontario CA
Brome	HRWW	Semican, Quebec CA
Byrd	HRWW	Arrow Seeds, NE
WB-Cedar	HRWW	Arrow Seeds, NE
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
Marker	SRWW	Bramhill Seeds, Ontario CA
Overland	HRWW	Arrow Seeds, NE
Redeemer	HRWW	Semican, Quebec CA
Redfield	HRWW	Albert Lea Seed House, MN
Sy Sunrise	HRWW	Arrow Seeds, NE
Sy Wolf	HRWW	Arrow Seeds, NE
Warthog	HRWW	Semican, Quebec CA
Winterhawk	HRWW	Arrow Seeds, NE

†**HRWW**-Hard Red Winter Wheat, **SRWW**-Soft Red Winter Wheat.

Table 3. Heirloom winter wheat varietal information.

Variety	Market class†	Year	Origin
Blackhull	HRWW	1917	Kansas
Forward	SRWW	1920	New York
Honor	SWWW	1920	New York
Wasatch	HRWW	1944	Utah

†**HRWW**-Hard Red Winter Wheat, **SRWW**-Soft Red Winter Wheat, **SWWW**-Soft White Winter Wheat.

Plots were harvested with an Almaco SPC50 small plot combine on 19-Jul 2018. 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.

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 4. Many of the varieties in the trial were developed in environments much different than the Northeast, so it is important to evaluate the varieties for tolerance to our climate. Warm and somewhat dry conditions in the fall of 2017 lead to good establishment. The 2018 growing season was somewhat warmer and drier than the 30-year average. A total of 3493 growing degree days (GDDs) at a base temperature of 32° F accumulated from Mar 2017 to Jul 2017, 140 GGDs more than the 30-year average.

Table 4. Seasonal weather data collected in Alburgh, VT, 2017 and 2018.

Alburgh, VT	Sep-17	Oct-17	Nov-17	Mar-18	Apr-18	May-18	Jun-18	Jul-18
Average temperature (°F)	64.4	57.4	35.2	30.4	39.2	59.5	64.4	74.1
Departure from normal	3.76	9.16	-2.96	-0.66	-5.58	3.10	-1.38	3.51
Precipitation (inches)	1.8	3.3	2.3	1.5	4.4	1.9	3.7	2.4
Departure from normal	-1.80	-0.31	-0.84	-0.70	1.61	-1.51	0.05	-1.72
Growing Degree Days (base 32°F)	971	786	202	90	272	853	973	1305
Departure from normal	113	284	17	90	-112	97	-42	107

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.

Heading date, heights, lodging, disease, and arthropod damage are reported in Table 5. Most varieties had headed by 1-Jun and all varieties had headed by 7-Jun. In organic systems, taller plants are generally desired for their ability to shade out competing weeds, although taller plants may cause the wheat to be more prone to lodging. The heirloom variety Forward was the tallest variety at 128 cm (50.4 inches) tall (Table 5). This was statistically similar to Blackhull (124 cm) and Honor (125 cm), both also heirloom varieties. These varieties did have some of the highest severity of lodging. Blackhull had most severe lodging, with 5.25 out of 9. The heirloom varieties Wasatch and Honor and the modern variety LSC Pistol had statistically similar lodging ratings (all above 1.5 out of 9).

Table 5. Winter wheat characteristics in Alburgh, VT, 2018.

Variety	Heading date	Height at harvest	Lodging	Foliar disease	Arthropod damage
		cm	Severity (0-9)†	Severity (0-9) †	Severity (0-9) †
112313W	1-Jun	97.6	**0.00***	1.75*	3.00
AC Benefit	3-Jun	111.0	**0.00***	1.50*	3.00
AC Morley	4-Jun	113.8	**0.00***	**1.00***	3.75
Blackhull	4-Jun	123.9*	5.25	3.00	**2.00***
Brome	7-Jun	106.8	**0.00***	2.25*	3.25
Byrd	1-Jun	88.7	0.50*	3.50	3.00
Cedar	1-Jun	84.8	**0.00***	3.75	2.75
Emerson	5-Jun	99.7	0.25*	2.75	3.25
Expedition	1-Jun	95.3	**0.00***	2.75	**1.75***
Forward	5-Jun	**128.0***	1.50	2.50	**2.00***
Grainfield	1-Jun	90.2	0.25*	2.25*	2.50*
Honor	4-Jun	125.2*	2.50	3.00	2.50*
LSC Chrome	1-Jun	105.1	**0.00***	3.00	**2.00***
LSC Mint	1-Jun	93.4	**0.00***	3.00	2.25*
LSC Pistol	1-Jun	86.8	1.75	3.00	2.25*
LSC T158	1-Jun	91.0	0.50*	3.50	2.50*

LSC Wizard	2-Jun	88.6	**0.00***	1.25*	3.75
Marker	2-Jun	94.1	1.25	1.25*	2.50*
Overland	1-Jun	99.5	**0.00***	3.00	2.50*
Redeemer	4-Jun	103.0	**0.00***	2.25*	2.50*
Redfield	4-Jun	96.9	**0.00***	2.50	2.50*
Sy Sunrise	1-Jun	84.3	**0.00***	3.75	**2.00***
Sy Wolf	1-Jun	89.8	**0.00***	1.50*	2.25*
Warthog	4-Jun	105.5	1.25	2.00*	2.25*
Wasatch	4-Jun	116.8	2.75	1.75*	**2.00***
Winterhawk	1-Jun	91.5	0.25*	2.50	2.50*
LSD (p = 0.10)	NS	7.14	1.23	1.34	0.89
Trial Mean	2-Jun	97.1	0.69	2.47	2.57

*Varieties with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference between varieties.
†Zero indicates no damage and nine indicates that 100% was severely affected.

Overall damage from pests and disease was low in the winter wheat trial. 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. 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. Some degree of mite and thrip damage was observed in all varieties and in most plots. Cereal leaf beetle damage was also observed in four plots. Expedition appeared to be the least impacted by arthropod damage, with an overall severity rating of 1.75 for all insect damage. LCS Wizard had the most insect damage with an overall rating of 3.75; this was statistically similar to AC Morley, Emerson, Brome, AC Benefit, Byrd and 112313W.

Several foliar diseases were observed during wheat development, including powdery mildew, leaf 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. AC Morley had the lowest disease severity, with an overall rating of 1 out of 9. This was statistically similar to Marker, LSC Wizard, AC Benefit, Sy Wolf, Wasatch, 112313W, Warthog, Redeemer, Grainfield and Brome, which all had disease ratings less than 2.50. Leaf spots, caused by several bacterial and/or fungal infections, were very prevalent and affected all varieties and 88% of plots. Powdery mildew (caused by the fungus *Erysiphe graminis f. sp. Tritici*) was present in 55% of plots. Only two varieties, AC Morley and Redeemer, were not infected by powdery mildew. Leaf rust was noted in 33% of plots.

Table 6. Yield and quality of winter wheat varieties, Alburgh, VT, 2018.

Variety	Yield @ 13.5% moisture	Moisture	Test weight	Crude protein @ 12% moisture	Falling number
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds
112313W	**6103***	15.5	58.7	9.33	359
AC Benefit	4048	14.9	60.4	12.8*	368
AC Morley	4448	14.7	61.3	11.6	418
Blackhull	2848	13.9	61.1	12.0	438
Brome	4810	20.9	56.4	12.1	393
Byrd	5066	13.1*	61.7	10.1	429
Cedar	5995*	12.9*	63.1*	10.8	466*
Emerson	4021	17.3	60.5	12.9*	380
Expedition	4809	13.1*	63.1*	11.0	434
Forward	3595	14.8	60.1	11.8	419
Grainfield	5211	12.9	62.2	9.91	391
Honor	2887	12.4	60.1	11.9	425
LSC Chrome	5501*	13.1*	62.5*	11.2	416
LSC Mint	5470*	13.2*	**64.1***	10.8	407
LSC Pistol	5335	12.8	62.2	10.9	395
LSC T158	5510*	13.0*	62.9*	10.2	444
LSC Wizard	4940	13.7*	62.8*	11.8	429
Marker	4803	13.1*	59.5	9.90	378
Overland	5051	13.8*	62.8*	10.8	442
Redeemer	4126	12.9	61.9	**13.6***	**488***
Redfield	5162	12.9*	62.7*	10.8	439
Sy Sunrise	4507	12.7	61.3	10.3	441
Sy Wolf	5071	15.5	62.0	11.2	377
Warthog	4035	14.3	60.9	11.5	427
Wasatch	2895	14.7	59.9	12.6*	459
Winterhawk	5145	15.9	62.8*	11.1	431
LSD (p = 0.10)	751	1.46	1.74	1.01	25.4
Trial Mean	4496	14.8	60.6	11.0	414

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

Winter wheat varieties had an average yield of 4496 lbs ac^{-1} (Table 6). The top yielding variety was 112313W, at 6301 lbs ac^{-1}. This was statistically similar to the varieties Cedar, LSC Chrome, LSC Mint, and LSC T158, which all yielded over 5500 lbs ac^{-1}.

Harvest moisture below 14% 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. Dry weather at the end of the growing season resulted in low harvest moisture across the trial. Most varieties were below 14% moisture content. Eight varieties (112313W, Brome, Emerson, Forward, Sy Wolf, Warthog, Wasatch, and Winterhawk) were over 14% moisture and required drying before 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 64.1 lbs bu^{-1}. This was statistically similar to the varieties Cedar, Expedition, LSC Chrome, LSC Mint, LSC Wizard, Overland, Redfield, and Winterhawk. All varieties in the 2018 winter wheat trials reached the industry standard for test weight.

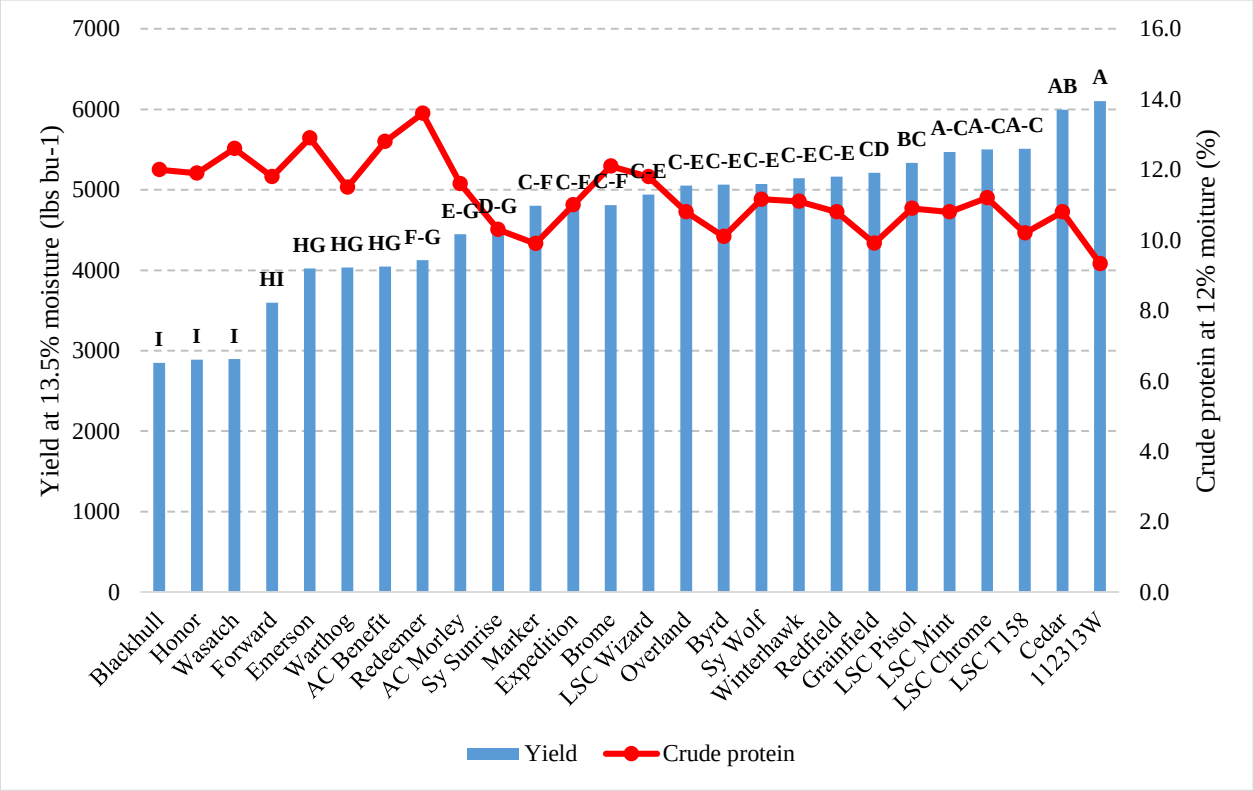

Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2018.
For yield, varieties with the same letter are not significantly different from one another.

None of the varieties had crude protein levels above the industry minimum of 14%. There is often an inverse relationship seen between yield and protein (Figure 1). This was somewhat true of the winter wheat varieties assessed in 2018, both in the sense that this year's trials had comparatively high yields compared to previous years of winter wheat trials at Borderview Research Farm and lower crude protein levels, and in the sense that higher yielding varieties generally had lower crude protein than lower yielding varieties.

Falling numbers for all varieties were above 200 seconds, indicating sound quality wheat (Table 6). Only one replicate per variety was tested for deoxynivalenol (DON) vomitoxin, and all were below the FDA threshold of 1 ppm which is considered safe for human consumption (data not shown).

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Roger Rainville and the staff at Borderview Research Farm. We would also like to acknowledge John Bruce, Erica Cummings, Catherine Davidson, Abha Gupta, Rory Malone, Freddy Morin, Lindsey Ruhl, 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.

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