

NORTHWEST CROPS & SOILS PROGRAM



2020 Organic Winter Wheat Variety Trial



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2020 ORGANIC WINTER WHEAT VARIETY TRIAL

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In 2020, the University of Vermont Extension's Northwest Crops and Soils Program evaluated 30 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 2019. Plots were managed with practices similar to those used by producers in the surrounding area. Agronomic information is displayed in Table 1. The experimental design was a randomized complete block with four replicates. The previous crop was corn. The field was disked and spike tooth harrowed prior to planting. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 20-Sep 2019 at a seeding rate of 350 live seeds m⁻². Thirty varieties were planted (22 modern varieties and 8 heirloom varieties, displayed in Tables 2 and 3, respectively), and all survived the winter. Field season data were collected on all the 30 varieties. From 1-Jun to 4-Jun, heading dates were recorded. When 50% of heads were emerged in the plot, the plot was determined to be headed out. Heights were determined on 15-Jul by taking three measurements per plot.

Table 1. Trial agronomic information, Alburgh, VT 2019-2020.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Covington silty clay loam, 0 to 3 percent slopes
Previous crop	Corn
Seeding rate	350 live seeds m ⁻²
Row spacing (in)	6
Replicates	4
Planting date	20-Sep 2019
Harvest date	15-Jul 2020
Harvest area (ft)	5 x 20
Tillage operations	Fall plow, disk & spike tooth harrow

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
Cedar	HRWW	Arrow Seeds, NE
Emerson	HRWW	Albert Lea Seed House, MN
Expedition	HRWW	Albert Lea Seed House, MN
Grainfield	HRWW	Arrow Seeds, NE
LCS Chrome	HRWW	Limagrain Cereal Seeds, CO
LCS Mint	HRWW	Limagrain Cereal Seeds, CO
LCS Pistol	HRWW	Limagrain Cereal Seeds, CO
LCS T158	HRWW	Limagrain Cereal Seeds, CO
LCS 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
Blue Jacket	HRWW	1946	Kansas
Forward	SRWW	1920	New York
Honor	SWWW	1920	New York
Pride of Genesee	SRWW	1893	New York
Red Chief	SRWW	1901	New York
Turkey Red	HRWW	1873	United States
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 15-Jul 2020. 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. Grain quality was determined at UVM Extension's Northwest Crop and Soils Quality Testing Laboratory (Burlington,

Vermont). 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 for bread wheat. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. The falling number indicates the level of enzymatic activity 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 between 300-350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat, typically as a result of pre-harvest sprouting damage in the grain. Falling number above 400 is suitable but may retard fermentation when used for baking. 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.

Stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within the trial were treated as random effects, and treatments were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p < 0.10$).

Variations in project results can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments 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 (LSD's) at the 10% level of probability are shown. Where the difference between two treatments 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 values. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the previous example, treatment A is significantly different from treatment C but not from treatment B. The difference between A and B is equal to 200, which is less than the LSD value of 300. This means that these treatments did not differ in yield. The difference between A and C is equal to 400, which is greater than the LSD value of 300. This means that the yields of these treatments were significantly different from one another.

Treatment	Yield
A	2100*
B	1900*
C	1700
LSD	300

RESULTS

Seasonal precipitation and temperature recorded at Borderview Research Farm in Alburgh, VT are displayed in Table 4. The winter temperatures were warmer than average, leading to strong winter survival. A cooler than average spring but warmer and drier summer led to 3433 Growing Degree Days (GDDs) accumulated April to July, which was 55 GDDs above the 30-year average. Precipitation from April to July was 3.81 inches below normal. Overall, precipitation across the entire growing season from Sep to Jul, was 1.61 inches below average, with a total of 5317 GDDs from Sep through Jul, which was 30 less than average.

Table 4. Seasonal weather data collected in Alburgh, VT, 2019-2020.

	2019				2020						
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Average temperature (°F)	60.0	50.4	31.2	26.0	23.5	21.8	35.0	41.6	56.1	66.9	74.8
Departure from normal	-0.51	2.32	-6.76	0.46	4.62	0.41	3.94	-3.19	-0.44	1.08	4.17
Precipitation (inches)	3.87	6.32	2.38	1.29	2.63	1.19	2.79	2.09	2.35	1.86	3.94
Departure from normal	0.21	2.76	-0.74	-1.06	0.63	-0.53	0.57	-0.72	-1.04	-1.77	-0.28
Growing Degree Days (32°-95°F)	840	571	128	67	37	48	193	315	746	1046	1326
Departure from normal	-15	58	-122	-13	-12	-8	27	-99	-13	35	132

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) for Burlington, VT.

Winter wheat varieties had an average yield of 4786 lbs ac⁻¹ (Table 5, Figure 1) adjusted for 13.5% moisture, which was higher than previous years. The top yielding variety was 112312W, at 5702 lbs ac⁻¹. Every variety in the trial yielded above 3000 lbs ac⁻¹ and only four varieties yielded below 4000 lbs ac⁻¹. Wasatch had the highest average plant height at 120 cm and Grainfield the lowest at 66 cm.

Harvest moisture below 14% is desirable for grain storage. Wheat above this moisture content has to be dried down after harvest, adding time and cost to farmers. Most varieties had moistures at or above 14% and required drying before storage with the exception of Expedition, Grainfield, Honor, LSC Chrome, LSC Pistol, LSC Wizard, and Pride of Genesee. LSC Chrome had the lowest harvest moisture at 13.2%. Test weight is the measure of grain density, which is determined by weighing a known volume of grain. Industry standard for wheat is 60 lbs bu⁻¹. Redeemer had the highest test weight; 61.8 lbs bu⁻¹. In 2020, not all of the varieties reached the industry standard for test weight of 56-60 lbs bu⁻¹. The only varieties that had test weights above 56 lbs bu⁻¹ were 112313W, Honor, Warthog, Cedar, Grainfield, Sy Wolf, Emmerson, Forward, Blue Jacket, and Redeemer.

Table 5. Yield and quality of winter wheat varieties, Alburgh, VT, 2020.

Variety	Heading date	Yield @ 13.5% moisture	Average plant height	Moisture	Test weight	Crude protein @ 12% moisture	Falling number
	date	lbs ac ⁻¹	cm	%	lbs bu ⁻¹	%	seconds
112313W	1-Jun	5702 ^a	77.0 ^g	15.3 ^{a-f}	56.1	9.80 ^{g-i}	348 ^{g-j}
AC Benefit	2-Jun	5169 ^{a-e}	102 ^{c-e}	15.6 ^{a-c}	49.1	11.2 ^{b-f}	325 ^j
AC Morley	3-Jun	4374 ^{d-g}	97.0 ^{b-d}	14.8 ^{b-i}	48.0	10.5 ^{d-i}	350 ^{f-j}
Blackhull	3-Jun	3995 ^{fg}	111 ^{a-c}	15.4 ^{a-d}	46.9	11.5 ^{b-d}	351 ^{d-i}
Blue Jacket	3-Jun	4647 ^{a-g}	116 ^{ab}	14.5 ^{c-k}	60.7	12.30 ^{ab}	354 ^{e-j}
Brome	4-Jun	5083 ^{a-e}	99.0 ^a	16.0 ^a	50.3	11.30 ^{b-e}	371 ^{b-h}
Byrd	2-Jun	5473 ^{a-c}	82.0 ^{de}	14.3 ^{d-k}	47.4	9.60 ^{h-i}	374 ^{b-g}
Cedar	1-Jun	4781 ^{a-f}	72.0 ^g	14.3 ^{f-k}	58.4	11.2 ^{b-f}	408 ^a
Emmerson	4-Jun	5120 ^{a-e}	85.0 ^a	15.1 ^{a-g}	59.3	12.3 ^{ab}	335 ^{ij}

Expedition	1-Jun	4608 ^{b-g}	81.0 ^{fg}	13.4 ^{kl}	47.8	10.5 ^{d-i}	377 ^{b-e}
Forward	3-Jun	4625 ^{b-g}	107 ^{a-c}	14.4 ^{d-k}	59.8	12.2 ^{ab}	360 ^{c-i}
Grainfield	1-Jun	4870 ^{a-f}	66.0 ^g	13.7 ^{j-l}	58.9	10.1 ^{f-i}	374 ^{b-g}
Honor	3-Jun	4292 ^{d-g}	112 ^{a-d}	13.7 ^{j-l}	57.8	12.3 ^{ab}	341 ^{ij}
LSC Chrome	1-Jun	5103 ^{a-e}	80.0 ^{fg}	13.2^l	47.5	10.3 ^{e-i}	378 ^{b-e}
LSC Mint	1-Jun	5529 ^{ab}	86.0 ^g	14.2 ^{f-l}	48.6	10.0 ^{g-i}	358 ^{d-i}
LSC Pistol	1-Jun	4925 ^{a-f}	72.0 ^g	13.8 ^{i-l}	47.8	9.90 ^{g-i}	345 ^{h-j}
LSC T158	1-Jun	4569 ^{b-g}	73.0 ^{fg}	14.0 ^{h-l}	48.4	9.50 ⁱ	345 ^{h-j}
LSC Wizard	3-Jun	5473 ^{a-c}	77.0 ^{b-d}	13.8 ^{i-l}	48.7	9.80 ^{g-i}	379 ^{b-d}
Marker	1-Jun	5575 ^{ab}	81.0 ^g	14.2 ^{f-l}	46.8	10.0 ^{g-i}	343 ^{ij}
Overland	3-Jun	5249 ^{a-d}	84.0 ^{b-d}	14.3 ^{e-k}	48.4	10.3 ^{e-i}	395 ^{a-b}
Pride of Genesee	3-Jun	4424 ^{c-g}	110 ^{ab}	13.9 ^{h-l}	48.3	11.9 ^{bc}	371 ^{b-h}
Red Chief	4-Jun	3968 ^{fg}	111 ^a	15.1 ^{a-g}	48.2	13.4^a	349 ^{f-j}
Red Field	3-Jun	4711 ^{a-g}	80.0 ^{a-c}	14.1 ^{g-l}	48.5	10.8 ^{c-f}	376 ^{b-f}
Redeemer	3-Jun	5020 ^{a-f}	94.0 ^{a-d}	14.2 ^{g-l}	61.8	11.5 ^{b-d}	372 ^{b-h}
Sy Sunrise	2-Jun	4009 ^{fg}	75.0 ^{ef}	14.2 ^{g-l}	47.7	9.60 ^{h-i}	387 ^{a-b}
Sy Wolf	3-Jun	3668 ^g	79.0 ^{a-c}	15.4 ^{a-d}	59.0	10.6 ^{d-f}	351 ^{e-j}
Turkey Red	4-Jun	3991 ^{fg}	100 ^a	15.8 ^{ab}	48.2	12.1 ^b	343 ^{ij}
Warthog	4-Jun	5150 ^{a-e}	96.0 ^a	15.4 ^{a-e}	57.9	11.6 ^{b-d}	387 ^{a-c}
Wasatch	3-Jun	4138 ^{e-g}	120 ^{ab}	15.0 ^{a-h}	49.0	12.2 ^b	354 ^{d-i}
Winterhawk	2-Jun	5338 ^{a-d}	82.0 ^{de}	14.6 ^{c-j}	48.9	10.3 ^{e-i}	397 ^{a-b}
Trial Mean	2-Jun	4786	90.0	14.5	51.8	11.0	363
LSD (p=0.10)		1067	0.76	1.1	NS	1.10	27

^fVarieties marked with the same letter are not significantly different from each other. The top performer is written in **bold**.
NS, no significant difference.

Marker, LSC Mint, LSC Pistol, LSC Wizard, 112312W, Byrd, Sy Sunrise and LSC T158 all tested below 10% protein, adjusted for 12% moisture, which is generally too low for high quality bread flour. The ideal range for bread wheat is 12-15% crude protein, though some artisan bread bakers have found success working with wheat in the 10-12% range, depending on the end-product. Seven varieties tested above 12% protein, falling in the ideal range for bread baking: Red Chief, Honor, Emmerson, Blue Jacket, Forward, Wasatch, and Turkey Red.

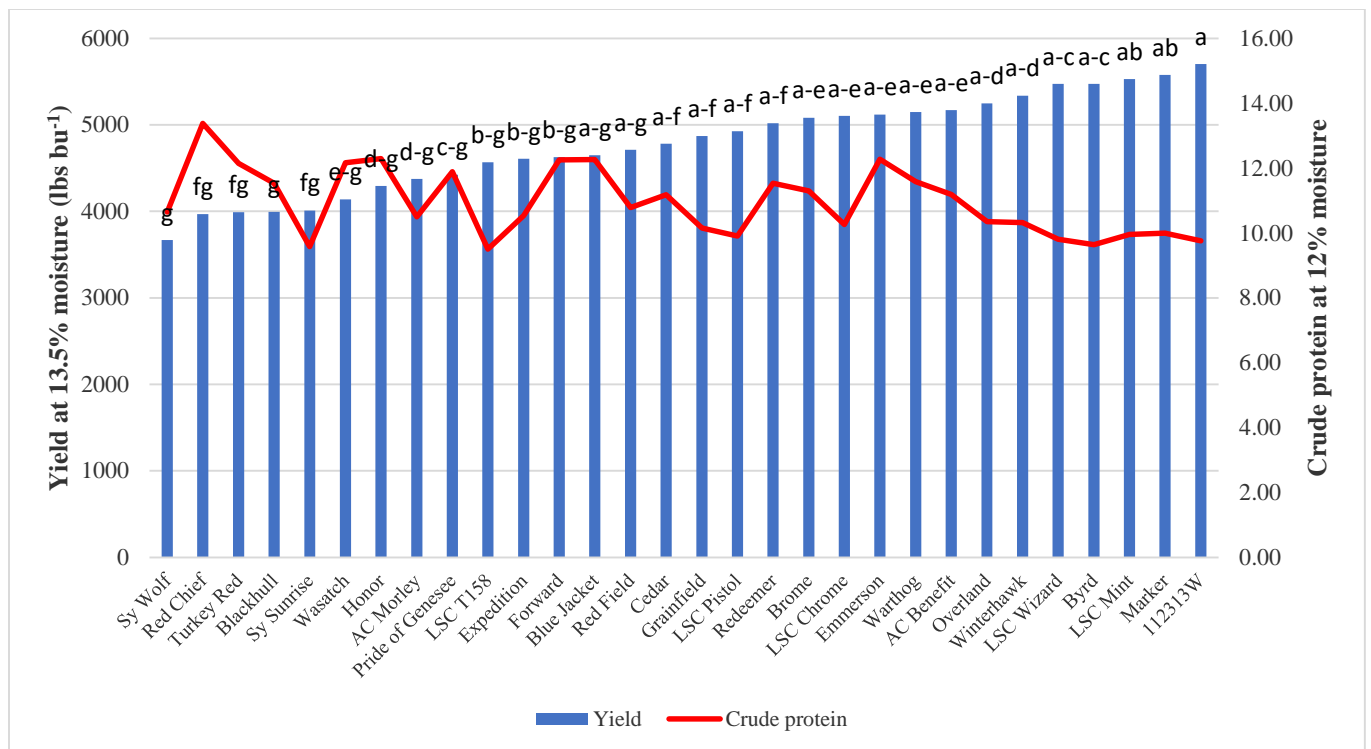


Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2020.

All varieties in the trial are in an acceptable falling number range with the following varieties testing within the industry ideal range of 300-350 seconds: AC Benefit, Emmerson, Honor, Marker, Turkey Red, LSC T158, LSC Pistol, 112313W, Red Chief and AC Morley. Only one variety, Cedar, tested above 400 seconds and none tested below 300. The dry weather through July while the grain was ripening allowed for adequate falling numbers. As mentioned previously, falling number measures viscosity by recording the time in seconds it takes for a plunger to fall through a slurry to the bottom of a test tube. The viscosity is an indicator of enzymatic (alpha-amylase) activity in the kernel, which most often results from pre-harvest sprouting in the grain. Low falling number means high enzymatic activity, or more pre-harvest sprouting damage. This is most common if there are rain events as the grain is ripening prior to harvest. Low falling number, below 250, has a negative impact on bread quality and can lead to lower prices paid for the wheat or possible rejection at the mill. The ideal range for wheat is 250-350. High falling numbers, over 400 seconds, can potentially lead to slower fermentation, poorer loaf volume and drier bread texture, depending on the end product. 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).

DISCUSSION

The wheat varieties in this trial, consistent with all of the winter grain trials at Borderview Research Farm in 2020, had strong winter survival rates. The weather during the 2019-20 season was warmer and drier than average, with 55 more growing degree days than the 30-year average. This allowed for better winter survival and considerably higher yields than the 2018-2019 season, which was cooler and wetter with 74 fewer growing degree days than average.

Harvest moisture and test weight were not ideal but adequate for most end-user needs. Low test weight may have been a result of drought conditions experienced throughout the grain fill period. Only seven varieties hit the ideal crude protein level for bread baking, 12%. Interestingly, of these seven varieties with the highest protein, six of them are heirlooms. Hard red spring wheat tends to hit higher protein levels than winter wheat, and protein in the spring wheat trial was high. All varieties tested within the acceptable falling number range between 300 and 400 seconds.

Overall, DON levels were low this year and all varieties had a DON level suitable for human consumption. DON is produced by Fusarium Head Blight (FHB), a widespread grain disease in the Northeast. Grain is most susceptible to FHB during rainy or especially humid weather, when the grain heads are flowering. FHB incidence was low this year due to the dry weather during the flowering periods in June, and throughout most of the growing season. Infected heads appear bleached and kernels can be tinted pink and/or be shriveled. Because there is a threshold for safe human consumption, many mills and malhouses will request a DON test on grain prior to purchase, even in a low-incidence year.

These data highlight the importance of varietal selection, but also only represent one year of data in ongoing trials. More data and other factors should be considered when making management decisions.

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