



## 2021 Organic Winter Wheat Variety Trial



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In 2021, the University of Vermont Extension's Northwest Crops and Soils Program evaluated 38 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 2020. 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 9-Sep 2020 at a seeding rate of 350 live seeds m<sup>-2</sup>. Thirty-eight (38) varieties were trialed (Table 2 and 3). All varieties survived the winter.

**Table 1. Trial agronomic information, Alburgh, VT 2020-2021.**

<b>Trial information</b>	<b>Alburgh, VT Borderview Research Farm</b>
<b>Soil type</b>	Covington silty clay loam, 0 to 3 percent slopes
<b>Previous crop</b>	Corn
<b>Seeding rate</b>	350 live seeds m <sup>-2</sup>
<b>Row spacing (in)</b>	6
<b>Replicates</b>	4
<b>Planting date</b>	9-Sep 2020
<b>Harvest date</b>	15-Jul 2021
<b>Harvest area (ft)</b>	5 x 20
<b>Tillage operations</b>	Spring disc & spike tooth harrow

**Table 2. Winter wheat varietal information.**

Variety	Market class†	Seed source
AC Morley	HRWW	Bramhill Seeds, Ontario CA
Arapahoe	HRWW	Albert Lea Seed House, MN
Arrow	SWWW	Pacific Seeds, AU
Brome	HRWW	Semican, Quebec CA
Champlain	HRWW	UVM saved seed
Erie	SRWW	Preferred Seed, NY
Erisman	SRWW	Albert Lea Seed House, MN
Expedition	HRWW	Albert Lea Seed House, MN
Genesee	SWWW	UVM saved seed
IL-13-1960	SRWW	University of Illinois
IL-15-2639	SRWW	University of Illinois
IL-16-8048	SRWW	University of Illinois
Medina	SWWW	Fedco Seeds, ME
Montcalm	HRWW	Meridian Seeds, NE
NY99056-161	SWWW	Cornell University
Overland	HRWW	Arrow Seeds, NE
Redeemer	HRWW	Bramhill Seeds, Canada
Redfield	HRWW	Albert Lea Seed House, MN
Ruth	HRWW	Arrow Seeds, NE
SARE260.06	HRWW	Cornell Experimental
SARE47.04	HRWW	Cornell Experimental
Sirvinta	HRWW	Fedco Seeds, ME
TAM 113	HRWW	Cornell University
TAM 114	HRWW	Cornell University
Turkey Red	HRWW	Albert Lea Seed House, MN
US16-IL-064-006	SRWW	University of Illinois
US16-IL-064-160	SRWW	University of Illinois
VA14HRW-25	HRWW	Cornell University
VA14HRW-41	HRWW	Cornell University
VA16HRW-22	HRWW	Cornell University
Warthog	HRWW	Semican, Quebec CA
Winterhawk	HRWW	Arrow Seeds, NE

†HRWW - Hard Red Winter Wheat, SWWW - Soft White Winter Wheat,  
 SRWW - Soft Red Winter Wheat, HWWW – Hard White Winter Wheat

**Table 3. Heirloom Winter wheat varietal information.**

Variety	Market class†	Origin
Bluejacket	HRWW	Kansas
Clarks Cream	HWWW	Kansas
Genesee Giant	SWWW	New York
Pride of Genesee	SRWW	New York
Red Chief	SRWW	New York
Wasatch	HRWW	Utah

†HRWW - Hard Red Winter Wheat, SWWW - Soft White Winter Wheat, SRWW - Soft Red Winter Wheat, HWWW – Hard White Winter Wheat

Field season data were collected on all the 38 varieties. Heading dates were recorded in early June. When 50% of heads were emerged in the plot, the plot was determined to be headed out. The trial was scouted for arthropod pests and plant diseases on 17-Jun 2021. Three plants from each plot were examined. The top two leaves were examined and evaluated for the presence of disease and insect damage. The Clive James, 'An Illustrated Series of Assessment Keys for Plant Diseases, Their Preparation and Usage' was used to identify and determine the severity of plant disease infection. Damage recorded as a percent of the leaf surface that was affected by each pest and disease. Heights and lodging were determined on 15-Jul. Heights were measured three times per plot, excluding awns. Lodging was assessed visually on a scale from 0-5, with 0 indicating no lodging and 5 indicating the entire plot was lodged.

Plots were harvested with an Almaco SPC50 small plot combine on 15-Jul 2021. 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 one-pound subsample was collected to determine quality characteristics. Grain quality was determined at the E. E. Cummings Crop Testing Laboratory at the University of Vermont (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. Samples from one replicate were evaluated for DON and all samples tested below the quantitative level for the assay (data not shown).

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 slightly warmer than average, leading to strong winter survival. This growing season was much drier than past years with a total precipitation of 10.2 inches—4.99 inches less than normal. The average temperature of the primary growing season (April to July) was 0.99° F below normal. From September 2020 to July 2021, there were 5835 Growing Degree Days.

**Table 4. Seasonal weather data collected in Alburgh, VT, 2020-2021.**

	2020			2021				
	Sep	Oct	Nov	Mar	Apr	May	Jun	Jul
Average temperature (°F)	59.2	48.3	42.0	33.2	48.1	58.4	70.3	68.1
Departure from normal	-3.53	-2.01	2.69	0.93	2.52	-0.03	2.81	-4.37
Precipitation (inches)	2.75	3.56	1.41	0.97	3.52	0.66	3.06	2.92
Departure from normal	-0.92	-0.27	-1.29	-1.27	0.45	-3.10	-1.20	-1.14
Growing Degree Days (32°-95°F)	816	521	352	241	497	818	1149	1301
Departure from normal	-107	-48	117	103	85	-1	86	101

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.

There were significant differences among varieties for height, lodging, arthropod damage, and foliar disease (Table 5). The tallest variety was Pride of Genesee (134 cm). This was statistically similar to two varieties: Sirvinta and Genesee.

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. Earlier occurrence, greater degree of host susceptibility, and longer duration of conditions favorable for disease development will increase the yield loss. Each plot was evaluated for the presence of several individual diseases and disease symptoms. These individual disease ratings were combined into a single foliar disease rating for statistical analysis. The most problematic diseases noted in the winter wheat variety trial were powdery mildew and an unknown foliar disease producing characteristic black spots. Powdery mildew had the highest overall severity and contributed the most to each variety foliar disease rating. Some plots and varieties were heavily affected by powdery mildew while others had no powdery mildew. Turkey Red and Pride of Genesee were the most affected by powdery mildew. Turkey Red and Red Chief were two of the lowest yielding varieties of under 3000 lbs ac<sup>-1</sup>. Spotting, a symptom of a range of foliar diseases was noted in most varieties. Thrips (various species) were the most common 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. Mites (various species) were also another common insect pest on many of the varieties and plots.

**Table 5. 2021 winter wheat agronomic characteristics in Alburgh, VT.**

Variety	Heading Date	Arthropod Pest Damage % foliar surface affected	Disease % foliar surface affected	Height cm	Lodging 0-5†
AC Morley	27-May	2.30*	16.9	121	2.50
Arapahoe	27-May	2.30*	23.8	105	2.50
Arrow	26-May	2.50*	24.8	117	2.00
Bluejacket	31-May	3.80	18.8	122	2.75
Brome	4-Jun	7.10	9.40*	114	<b>0.00*‡</b>
Champlain	27-May	1.80*	9.30*	116	2.50
Clark's Cream	26-May	1.60*	20.5	121	3.50
Erie	26-May	3.80	14.6*	94	0.25*
Erisman	26-May	3.30*	12.3*	98	1.25*
Expedition	25-May	2.70*	24.4	106	3.00
Genesee	29-May	3.80	13.2*	129	2.00
Genesee Giant	26-May	3.00*	20.7	123	3.00
IL13-1960	25-May	3.80	12.8*	107	0.50*
IL15-2639	25-May	2.50*	11.0*	103	0.50*
IL-16-8048	25-May	4.20	16.3	102	1.00*

Medina	28-May	2.30*	13.2*	105	1.75
Montcalm	26-May	3.80	11.5*	107	1.50
NY99056-161	27-May	2.20*	13.0*	96	2.25
Overland	26-May	3.20*	22.1	107	0.75*
Pride of Genesee	28-May	1.30*	30.4	134	1.50
Red Chief	25-May	2.50*	27.9	125	3.00
Redeemer	29-May	6.00	9.20*	110	3.50
Redfield	27-May	<b>0.80*</b>	21.8	92	0.75*
Ruth	25-May	1.30*	21.2	102	<b>0.00*</b>
SARE260.06	31-May	2.10*	9.60*	126	1.25*
SARE47.04	28-May	2.50*	14.1*	107	0.25*
Sirvinta	1-Jun	6.30	12.4*	130	0.75*
TAM 113	25-May	0.90*	21.1	94	0.25*
TAM 114	25-May	0.90*	23.2	98	3.25
Turkey Red	30-May	2.20*	50.5	111	1.75
US16-IL-064-006	25-May	3.90	20.8	103	5.00
US16-IL-064-160	25-May	2.30*	22.5	100	1.25*
VA14HRW-25	25-May	3.50*	8.40*	97	1.25*
VA14HRW-41	26-May	2.80*	11.8*	93	0.50*
VA16HRW-22	26-May	2.20*	16.4	95	2.25
Warthog	27-May	3.50*	<b>6.70*</b>	109	<b>0.00*</b>
Wasatch	1-Jun	2.20*	25.6	120	<b>0.00*</b>
Winterhawk	25-May	4.60	14.0*	101	2.00
LSD (p=0.10)	25-May	2.77	9.45	6.05	1.39
Trial mean	27-May	2.90	17.8	109	1.63

<sup>†</sup>Lodging with a rating of 0 indicates no lodging and a rating of 5 indicates that 100% of the plot was lodged.

<sup>‡</sup>\*Varieties with an asterisk are not significantly different than the top performer in **bold**.

Pride of Genesee had the highest average plant height at 134 cm and Redfield had the lowest at 91.6 cm. Overall, lodging was low in the trial with only US16-IL-064-006 being the only variety with 100% lodging.

Winter wheat varieties had an average yield of 5258 lbs ac<sup>-1</sup> (Table 6, Figure 1) adjusted for 13.5% moisture. The top yielding variety was I1152639, at 7559 lbs ac<sup>-1</sup>. All but two varieties (Red Chief, Turkey Red) in the trial yielded above 3000 lbs ac<sup>-1</sup>.

Harvest moisture below 14% is necessary 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 except for Erisman, TAM 113, VA14HRW-41, and TAM 113 had the lowest harvest moisture at 13.1%. 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<sup>-1</sup>. Red Chief had the highest test weight; 62.2 lbs bu<sup>-1</sup>. In 2021, fourteen of the varieties reached the industry standard for test weight of 56-60 lbs bu<sup>-1</sup>, with Red Chief having the highest test weight of 62.2 lbs bu<sup>-1</sup>.

**Table 6. Yield and quality of winter wheat varieties, Alburgh, VT, 2021.**

Variety	Yield @ 13.5% moisture	Moisture	Test weight	Crude protein @ 12% moisture	Falling number
	lbs ac <sup>-1</sup>	%	lbs bu <sup>-1</sup>	%	seconds
AC Morley	5147	16.2	55.7*†	13.0	308
Arapahoe	4842	16.2	53.1	11.0	309
Arrow	5236	16.2	52.6	11.0	264
Bluejacket	4328	14.6*	60.7*	12.0	357
Brome	6013	17.4	58.5*	11.0	344
Champlain	3799	17.6	53.2*	<b>13.8*</b>	392
Clark's Cream	3522	15.6	57.8*	13.0*	371
Erie	6644	15.4*	60.8*	10.0	300
Erisman	6260	13.8*	61.0*	11.0	295
Expedition	5195	15.1*	56.6*	12.0	330
Genesee	4620	14.2*	59.2*	11.0	222
Genesee Giant	3904	16.7	53.1	12.0	213
I1-13-1960	5925	17.2	52.8	10.0	375
I1-15-2639	<b>7559*</b>	14.4*	61.6*	10.0	296
IL-16-8048	6764*	15.0*	55.9*	10.0	356
Medina	5739	14.8*	59.3*	11.0	249
Montcalm	5174	14.3*	59.8*	11.0	363
NY99056-161	6413	14.5*	59.0*	10.0	294
Overland	5783	14.0*	61.6*	12.0	388
Pride of Genesee	3452	17.4	50.1	13.0	350
Red Chief	2959	14.4*	<b>62.2*</b>	13.0*	291
Redeemer	5213	15.3*	57.6*	13.0	368
Redfield	5391	16.6	54.9*	11.0	370
Ruth	6134	15.0*	58.4*	10.0	376
SARE260.06	4991	15.6	61.2*	13.0	335
SARE47.04	5216	17.5	56.4*	12.0	331
Sirvinta	5444	15.6	58.7*	12.0	348
TAM 113	4216	<b>13.1*</b>	60.6*	10.0	294
TAM 114	6239	14.4*	62.0*	11.0	370
Turkey Red	2828	15.0*	57.8*	13.4*	351
US16-IL-064-006	5832	16.0	56.9*	10.0	335
US16-IL-064-160	5575	15.0*	61.5*	10.0	373
VA14HRW-25	6020	14.9*	55.1*	11.0	349



VA14HRW-41	6191	13.6*	60.8*	10.0	379
VA16HRW-22	6259	16.6	54.9*	11.0	325
Warthog	5913	16.3	58.5*	13.0	366
Wasatch	3203	16.5	57.3*	13.0	395*
Winterhawk	5883	17.3	53.0	11.0	<b>437*</b>
LSD (p=0.10)	866	2.27	7.45	0.95	36.9
Trial mean	5258	15.5	57.6	11.0	336

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

Only three varieties (Erie, I1152639, NY99056-161) 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. Champlain had the highest crude protein at 13.8%. Thirteen varieties tested above 12% crude protein, falling in the ideal range for bread baking.

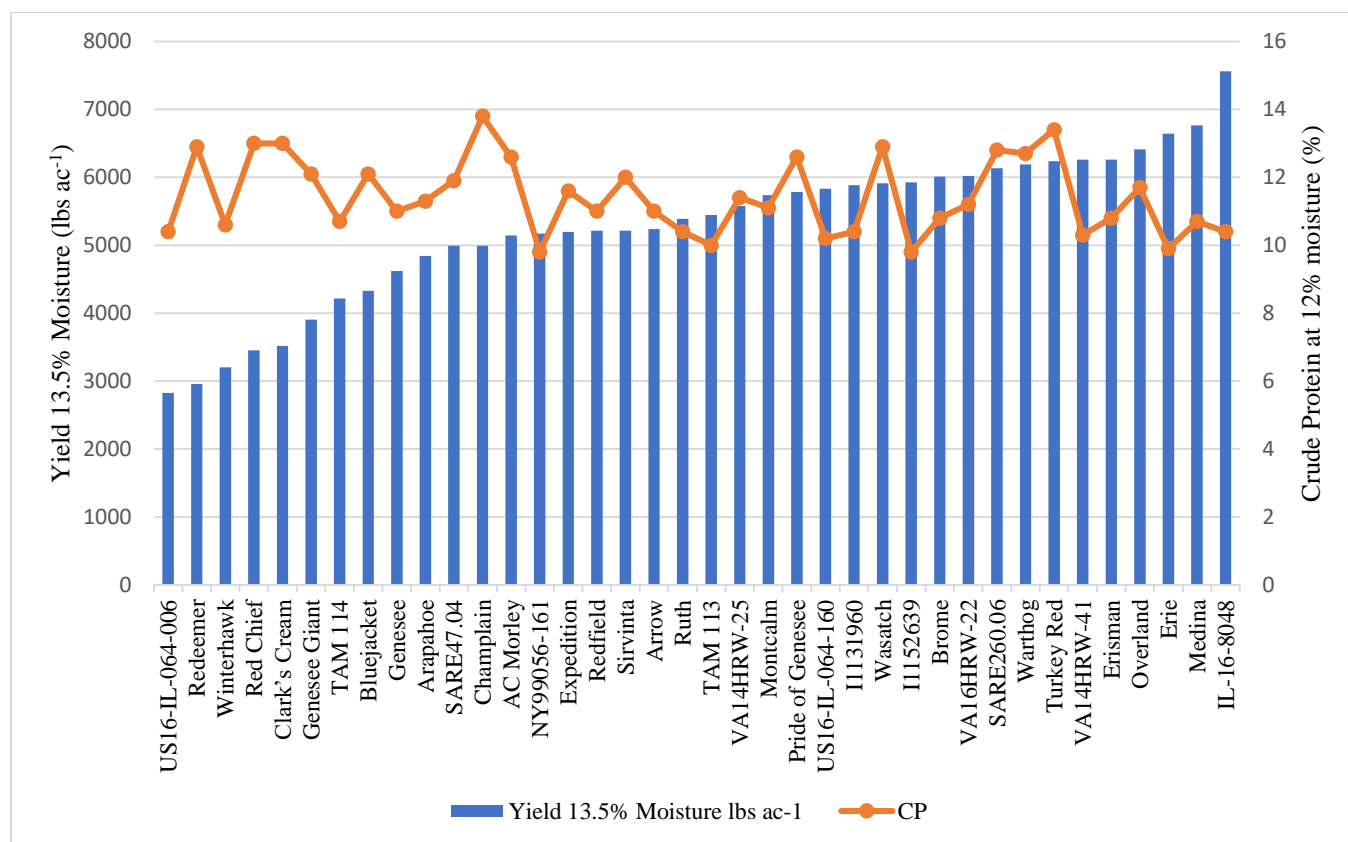


Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2021.

Twelve varieties met the industry ideal range for falling number (300-500 seconds): AC Morley, Arapahoe, Brome, Erie, Expedition, Pride of Genesee, SARE260.06, SARE47.04, Sirvinta, US16-IL-064-006, VA14HRW-25, and VA16HRW-22. The dry weather through July while the grain was ripening allowed for adequate falling numbers.

## DISCUSSION

The winter wheat varieties in this trial had strong winter survival rates. The weather during the 2020-2021 season was warmer and drier than average. The average trial mean for yield was 5258 lbs ac<sup>-1</sup>, adjusted for 13.5% moisture, yielding much higher than previous years. The varieties with the lowest yields also had the highest rates of damage from powdery mildew.

Only three varieties tested below 10% crude protein at 12% moisture. Thirteen of the varieties tested within the ideal range (12-15%) for crude protein for bread baking. Three replicates per variety were 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).

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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