NORTHWEST CROPS & SOILS PROGRAM

2022 Organic Winter Wheat Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2022 ORGANIC WINTER WHEAT VARIETY TRIAL

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With the revival of the small grains industry in the Northeast and the strength of the locavore movement, there is an increasing interest from craft breweries, distilleries, maltsters, and bakers for locally grown grains. In 2022, the University of Vermont Extension Northwest Crops and Soils (NWCS) Program evaluated 39 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 2021. 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 sod. 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 22-Sep 2021 at a seeding rate of 350 live seeds m^{-2}. Thirty-nine (39) varieties were trialed (Table 2 and 3). All varieties survived the winter.

Table 1. Trial agronomic information, Alburgh, VT 2021-2022.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Covington silty clay loam, 0 to 3 percent slopes
Previous crop	Sod
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Replicates	4
Planting date	22-Sep 2021
Harvest date	18-Jul 2022
Harvest area (ft)	5 x 20
Tillage operations	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
Brome	HRWW	Semican, Quebec CA
Champlain	HRWW	UVM saved seed
Epoch	HRWW	University of Nebraska
Erie	SRWW	Preferred Seed, NY
Erisman	SRWW	Albert Lea Seed House, MN
Expedition	HRWW	Albert Lea Seed House, MN
IL-13-1960	SRWW	University of Illinois
IL-15-2639	SRWW	University of Illinois
IL-16-8048	SRWW	University of Illinois
IL-17-17739	SRWW	University of Illinois
IL-17-23874	SRWW	University of Illinois
Medina	SWWW	Fedco Seeds, ME
Montcalm	HRWW	Meridian Seeds, NE
NW13493	HWWW	University of Nebraska
NY99056-161	SWWW	Cornell University
Overland	HRWW	Arrow Seeds, NE
Redeemer	HRWW	Bramhill Seeds, Canada
Redfield	HRWW	Albert Lea Seed House, MN
Rouge d'Ecosse	SRWW	Not commercially available
Ruth	HRWW	Arrow Seeds, NE
SARE260.06	HRWW	Cornell Experimental
SARE47.04	HRWW	Cornell Experimental
Sirvinta	HRWW	Fedco Seeds, ME
TAM 114	HRWW	Cornell University
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
Forward	SRWW	Heirloom variety, NY
Gold Coin	SWWW	Heirloom variety, NY
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 39 varieties. The trial was scouted for arthropod pests and plant diseases on 10 and 13-Jun 2022. Five 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 18-Jul 2022. Heights were measured three times per plot, excluding awns. Lodging was assessed visually as percent lodged, with 0% indicating no lodging and 100% indicating the entire plot was lodged.

Plots were harvested with an Almaco SPC50 small plot combine on 18-Jul 2022. Grain moisture, test weight, and yield were determined at harvest (DICKEY-john Mini GAC moisture and test weight meter, Auburn, IL). 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). Grains were analyzed for crude protein and starch content using the Perten Inframatic 9500 NIR Grain Analyzer. Most commercial mills target 12-15% protein content for bread wheat. Samples were then ground using the Perten LM3100 Laboratory Mill. 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 2/3 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 FDA threshold for human consumption (1 ppm) (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 wetter than past years with a total precipitation of 22.6 inches – over twice the precipitation during the 2021 growing season (total precipitation of 10.2 inches). The average temperature of the primary growing season (April to July) was 1.44° F below normal. From September 2021 to July 2022, there were 5546 Growing Degree Days.

Table 4. Seasonal weather data collected in Alburgh, VT, 2021-2022.

	2021			2022				
	Sep	**Oct**	**Nov**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Average temperature (°F)	63.1	54.6	37.6	32.3	44.8	60.5	65.3	71.9
Departure from normal	0.40	4.31	-1.68	-0.03	-0.81	2.09	-2.18	-0.54
Precipitation (inches)	4.49	6.23	2.26	2.52	5.57	3.36	8.19	3.00
Departure from normal	0.82	2.40	-0.44	0.28	2.50	-0.40	3.93	-1.06
Growing Degree Days (32°-95°F)	933	701	232	170	391	883	1000	1236
Departure from normal	11	133	-3	32	-20	65	-64	-17

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2020) for Burlington, VT.

There were significant differences among varieties for height, lodging, test weight, moisture, arthropod damage, and foliar disease (Table 5). 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. Diseases and symptoms noted in the winter wheat variety trial were mosaic virus, rust, brown spots and lesions that could be a characteristic of several foliar diseases, and powdery mildew (in order from most severe to least). All of the plots had at least one plant exhibiting symptoms characteristic of mosaic virus. Red Chief exhibited the most symptoms of disease-caused damage and was not statistically similar to any other varieties tested. Red Chief also exhibited the second highest degree of arthropod pest damage after Winterhawk (varieties not statistically significantly different). Out of all of the varieties tested, Ruth has the least arthropod-caused damage, and VA14HRW-41 had the least severe disease symptoms. Brown spots and rust were noted in all experimental plots, unlike powdery mildew which was observed in some plots and not others.

Table 5. 2022 winter wheat agronomic characteristics in Alburgh, VT.

Variety	Arthropod damage % foliar surface affected	Disease damage % foliar surface affected	Height cm	Lodging[†] %
AC Morley	2.20*‡	7.20*	127	**0.00***
Arapahoe	1.80*	11.4	104	0.00*
Bluejacket	1.70*	14.1	127	26.3
Brome	2.50	8.70*	119	12.5*
Champlain	2.00*	6.80*	115	0.00*
Clark's Cream	1.50*	10.3	123	17.5*
Epoch	1.50*	11.8	88.9	0.00*
Erie	2.50	7.60*	97.3	0.00*
Erisman	1.50*	6.50*	96.4	0.00*
Expedition	1.90*	9.40	102	0.00*
Forward	2.10*	14.9	126	16.3*
Genesee Giant	2.70	12.5	131	0.00*
Gold Coin	1.80*	9.50	137	41.3
IL13-1960	2.10*	12.6	98.8	0.00*
IL15-2639	2.20*	8.50*	102	0.00*
IL16-8048	1.70*	9.10	89.0	1.25*
IL17-17739	1.80*	4.30*	106	0.00*
IL17-23874	2.00*	7.70	101	3.75*
Medina	1.80*	9.40	111	0.00*
Montcalm	1.50*	6.40*	115	1.25*
NW13493	1.50*	10.5	90.8	0.00*
NY99056-161	1.80*	10.8	105	11.3*

Overland	2.20*	8.60*	96.8	0.00*
Pride of Genesee	2.00*	11.9	**147**	22.0*
Red Chief	3.10	29.9	122	0.00*
Redeemer	1.80*	11.7	116	12.5*
Redfield	2.40*	12.3	91.3	0.00*
Rouge d'Ecosse	1.70*	15.6	134	75.0
Ruth	**1.30***	11.5	94.3	0.00*
SARE 260.06	2.10*	6.30*	126	0.00*
SARE 47.04	2.10*	10.3	111	0.00*
Sirvinta	2.40*	8.00*	132	0.00*
TAM 114	1.90*	12.8	97.0	0.00*
VA14HRW-25	2.10*	6.90*	91.7	2.50*
VA14HRW-41	1.50*	**4.30***	88.0	0.00*
VA16HRW-22	2.50	11.7	89.6	0.00*
Warthog	2.40*	5.50*	111	0.00*
Wasatch	1.90*	16.3	125	35.0
Winterhawk	3.60	12.4	100	0.00*
LSD (p=0.10)	1.18	4.40	7.41	17.6
Trial mean	2.00	10.4	110	7.13

†Lodging with 0% indicates no lodging and a rating of 100% indicates that the entire plot was lodged.
‡*Varieties with an asterisk are not significantly different than the top performer in **bold**.

The tallest variety was Pride of Genesee (147 cm) and was not statistically similar to any other varieties evaluated. VA14HRW-41 was the shortest (88 cm), along with VA16HRW-22, IL16-8048, and Epoch, which all measured less than 90 cm at harvest. Overall, lodging was low in the trial. Most varieties had 0% lodging, 13 varieties had less than 50% lodging, but Rouge d'Ecosse was an outlier and exhibited 75% lodging.

Winter wheat varieties had an average yield of 4599 lbs ac^{-1} (Table 6, Figure 1) adjusted for 13.5% moisture. The top yielding variety was IL15-2639 at 6318 lbs ac^{-1}. All but four varieties (Gold Coin, Pride of Genesee, Wasatch, and Rouge d'Ecosse) in the trial yielded above 3000 lbs ac^{-1}.

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. All varieties had moistures at or above 14% and required drying before storage. Test weight is the measure of grain density, which is determined by weighing a known volume of grain. Industry standard for wheat is 56-60 lbs bu^{-1}. In 2022, 25 varieties reached this threshold. Redfield had the highest test weight (61.4 lbs bu^{-1}) and Champlain the lowest (48.9 lbs bu^{-1}).

Table 6. Yield and quality of winter wheat varieties, Alburgh, VT, 2022.

Variety	Yield @ 13.5% moisture	Moisture	Test weight	Crude protein @ 12% moisture	Starch	Falling number
	lbs ac^{-1}	%	lbs bu^{-1}	%	%	seconds
AC Morley	4578	18.0	54.9	10.5	61.1	324
Arapahoe	4801	16.0*†	58.7*	11.0	60.4	404*
Bluejacket	3148	19.1	53.8	9.80	62.1	376
Brome	4697	22.7	50.3	10.2	62.1	340
Champlain	5071	15.0*	48.9	10.9	61.2	398*
Clark's Cream	3786	15.0*	59.8*	11.2	61.3	**425**
Epoch	4616	16.1*	57.8*	9.60	62.2	334
Erie	5917*	16.7*	56.8*	9.60	61.9	327
Erisman	5827*	15.8*	58.6*	9.60	62.2	343
Expedition	4536	**14.5***	59.0*	9.10	62.9*	379
Forward	3375	16.8*	56.2	8.90	62.7*	342
Genesee Giant	3913	16.4*	57.5*	9.50	62.4*	335
Gold Coin	2837	17.5	55.7	10.6	62.0	388*
IL13-1960	5824*	15.9*	58.0*	8.50	**63.0***	363
IL15-2639	**6318***	16.1*	58.2*	9.00	62.4*	309
IL16-8048	6244*	16.5*	58.0	10.1	61.7	374
IL17-17739	5829*	15.8*	58.8*	9.30	61.8	343
IL17-23874	4933	18.2	54.6	8.80	62.5*****	345
Medina	5338	14.6*	55.5	9.60	62.2	366
Montcalm	5481*	17.5	56.8*	10.1	61.8	355
NW13493	4355	16.1*	58.2*	9.40	62.4*	268
NY99056-161	4932	16.9*	56.4	9.00	62.9*	356
Overland	4762	16.4*	57.9*	9.60	62.1	405*
Pride of Genesee	2776	21.7	53.6	11.2	60.9	410*
Red Chief	3083	19.7	54.8	11.9*	60.5	383
Redeemer	5178	16.5*	57.8*	**12.4***	60.1	**401***
Redfield	4238	15.3*	**61.4***	9.40	61.8	357
Rouge d'Ecosse	1815	20.0	52.3	11.5*	60.7	391*
Ruth	4774	15.9*	57.3*	9.20	61.9	405*
SARE 260.06	4158	18.8	55.7	9.80	61.6	348
SARE 47.04	4597	21.1	51.8	10.4	61.5	345
Sirvinta	4473	18.0	55.0	9.50	62.0	246
TAM 114	4299	16.3*	57.9*	8.90	62.2	372
VA14HRW-25	4973	16.7*	57.4*	10.0	61.4	365
VA14HRW-41	4928	16.2*	57.9*	9.60	61.6	377
VA16HRW-22	5237	21.0	53.8	10.5	61.2	362
Warthog	5527*	15.6*	58.7*	10.2	60.8	389*

Wasatch	2455	16.6*	57.3*	11.5*	60.7	405*
Winterhawk	5723*	18.3	56.5*	9.30	62.2	402*
LSD (p=0.10)	921	2.80	4.80	0.90	0.700	38.8
Trial mean	4599	17.2	56.4	10.0	61.8	363

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

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. Redeemer had the highest protein at 12.4% and was the only variety to test in the ideal range for bread baking (above 12% crude protein adjusted for 12% moisture). There were 22 varieties that tested below 10%, which is generally too low for high quality bread flour. All but two varieties (NW13493, Sirvinta) met the industry ideal range for falling number (300-500 seconds).

DISCUSSION

Interestingly, despite the majority of Vermont experiencing drought conditions, the 2022 growing season at Borderview farm (Alburgh, VT) had over twice the precipitation than the growing season in 2021. The average trial mean for yield was 4599 lbs ac^{-1}, adjusted for 13.5% moisture, which was less than 2021 (5258 lbs ac^{-1}). Red Chief displayed notably severe arthropod and disease-caused damage and had relatively low yields (3083 lbs ac^{-1}, the fifth lowest producer of the varieties tested).

Most of the varieties trialed had acceptable values for most quality parameters except for slightly lower than ideal protein concentrations. One replicate per variety were tested for deoxynivalenol (DON) vomitoxin, and all varieties 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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