



## 2023 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 2023, the University of Vermont Extension Northwest Crops and Soils (NWCS) Program evaluated 40 winter wheat varieties (Tables 2 and 3) 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 2022. 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 sweet corn. The field was prepared with a Pottinger TerraDisc prior to planting. Forty varieties were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 17-Sep 2022 at a seeding rate of 350 live seeds m<sup>-2</sup>.

**Table 1. Trial agronomic information, Alburgh, VT 2022-2023.**

Trial information	Alburgh, VT
	Borderview Research Farm
Soil type	Covington silty clay loam, 0 to 3 percent slopes
Previous crop	Sweet Corn
Seeding rate (live seeds m <sup>-2</sup> )	350 live seeds m <sup>-2</sup>
Row spacing (in)	6
Replicates	4
Planting date	17-Sep 2022
Harvest date	24-Jul and 25-Jul 2023
Harvest area (ft)	5 x 20
Tillage operations	Pottinger TerraDisc®

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

Variety	Market class <sup>†</sup>	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
Viking 211	HRWW	Albert Lea Seed House, MN
Warthog	HRWW	Semican, Quebec CA
Winterhawk	HRWW	Arrow Seeds, NE

<sup>†</sup>**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

The trial was scouted for arthropod pests and plant diseases on 4 and 5-Jun 2023. 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 was recorded as a percentage of the leaf surface that was affected by each pest and disease. Heights and lodging were determined on 19-Jul. 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 24-Jul and 25-Jul 2023. 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.

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, as all varieties survived. This growing season was significantly wetter than past years with a total precipitation of 39.9 inches – almost doubling the precipitation during the 2022 growing season (total precipitation of 22.6 inches). The average temperature of the primary growing season (April to July) was 0.58° F below normal. From September 2022 to July 2023, there were 5738 Growing Degree Days (GDDs).

**Table 4. Seasonal weather data collected in Alburgh, VT, 2022-2023.**

	2022			2023				
	Sept	Oct	Nov	Mar	Apr	May	Jun	Jul
Average temperature (°F)	60.2	51.3	41.5	32.2	48.3	57.1	65.7	72.2
Departure from normal	-2.52	0.96	2.24	-0.07	2.70	-1.28	-1.76	-0.24
Precipitation (inches)	4.40	2.56	3.01	2.00	4.94	1.98	4.40	10.75
Departure from normal	0.73	-1.27	0.31	-0.24	1.87	-1.78	0.14	6.69
Growing Degree Days (32-95°F)	861	607	346	103	524	766	1027	1274
Departure from normal	-61	39	111	-35	112	-53	-37	22

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, 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 risk of 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 noted in the winter wheat variety trial were mosaic virus, powdery mildew, brown spot, and rust (in order from most severe to least). Most of the plots had at least one plant exhibiting symptoms characteristic of mosaic virus and about 60% of the plots exhibited powdery mildew symptoms. NW13493 exhibited the most symptoms of disease-caused damage and was not statistically similar to any other varieties tested. Interestingly, NW13493 exhibited some of the lowest degree of arthropod damage and was not significantly different from IL17-23874 which had the least damage. Brome exhibited the highest degree of arthropod pest damage (some varieties not significantly different). Out of all the varieties tested, IL17-23874 had the least arthropod-caused damage, and VA14HRW-25 had the least severe disease symptoms.

**Table 5. 2023 winter wheat agronomic characteristics in Alburgh, VT.**

Variety	Heading date <sup>†</sup>	Flowering date <sup>‡</sup>	Arthropod damage % foliar surface affected	Disease damage % foliar surface affected	Foliar damage totals % foliar surface affected	Height cm	Lodging <sup>§</sup> %
AC Morley	31-May	5-Jun	1.35	6.05	8.25	120	47.5
Arapahoe	31-May	5-Jun	0.90	5.70	7.15*¥	105	18.8
Bluejacket	31-May	5-Jun	2.10	6.50	9.50	121	35.0
Brome	1-Jun	6-Jun	2.65	6.65	12.9	109	9.30
Champlain	30-May	4-Jun	1.80	4.60	8.25	112	51.3
Clark's Cream	1-Jun	5-Jun	2.10	10.8	14.9	120	47.5
Epoch	30-May	3-Jun	0.80	9.90	11.2	88.2	0.00*
Erie	31-May	4-Jun	1.05	3.80*	6.35*	88.3	0.80*
Erisman	30-May	4-Jun	0.70*	3.65*	<b>4.50*</b>	99.7	8.80
Expedition	30-May	4-Jun	0.85	9.65	13.1	102	0.00*
Forward	31-May	4-Jun	1.55	6.60	9.90	119	56.8
Genesee Giant	31-May	5-Jun	2.15	8.45	11.6	123	66.8
Gold Coin	30-May	6-Jun	1.45	5.90	9.20	129	56.3
IL13-1960	30-May	4-Jun	1.80	11.0	13.1	114	20.0
IL15-2639	30-May	5-Jun	0.80	5.30	7.15	100	5.00
IL16-8048	30-May	6-Jun	1.35	6.75	8.45	91.3	0.00*
IL17-17739	30-May	4-Jun	1.80	4.05*	6.00*	99.7	28.3
IL17-23874	30-May	3-Jun	<b>0.20**</b>	4.75	5.05*	104	37.5
Medina	30-May	5-Jun	1.40	5.10	7.95	103	5.00
Montcalm	30-May	4-Jun	1.00	7.10	8.60	119	70.5
NW13493	31-May	5-Jun	0.50*	24.8	26.4	102	24.5

NY99056-161	1-Jun	5-Jun	1.65	5.00	7.90	101	32.0
Overland	30-May	5-Jun	0.65*	9.70	10.4	95.9	0.00*
Pride of Genesee	31-May	5-Jun	0.50*	7.90	11.6	<b>140*</b>	84.3
Red Chief	31-May	5-Jun	0.45*	14.1	16.1	126	63.8
Redeemer	30-May	5-Jun	0.55*	3.75*	6.80*	112	20.0
Redfield	30-May	4-Jun	0.95	7.60	10.1	87.7	5.00
Rouge d'Ecosse	5-Jun	8-Jun	1.15	9.35	11.8	127	88.3
Ruth	30-May	3-Jun	0.25*	14.0	15.0	99.8	0.00*
SARE 260.06	31-May	4-Jun	1.50	6.80	8.95	117	37.0
SARE 47.04	29-May	4-Jun	2.40	4.70	11.6	107	40.0
Sirvinta	29-May	4-Jun	1.70	4.40	8.60	127	58.8
TAM 114	30-May	6-Jun	1.30	12.8	14.6	94.2	18.8
VA14HRW-25	30-May	5-Jun	1.00	<b>2.20*</b>	4.60*	103	13.8
VA14HRW-41	30-May	4-Jun	2.25	2.35*	5.55*	94.7	15.0
VA16HRW-22	31-May	4-Jun	0.85	5.50	6.75*	92.5	0.00*
Viking 211	30-May	6-Jun	1.05	4.00*	5.25*	101	38.8
Warthog	1-Jun	3-Jun	1.35	3.96*	10.7	98.5	1.30
Wasatch	30-May	6-Jun	0.45*	13.6	15.2	124	47.5
Winterhawk	31-May	5-Jun	1.55	4.60	7.30	98.2	<b>0.00*</b>
LSD (p=0.10)			0.97	3.85	4.52	9.91	31.9
Trial mean	31-May	4-Jun	1.25	7.33	9.94	108	28.8

† Heading date is used as a reference, no statistical analysis on this parameter.

‡ Flowering date is used as a reference, no statistical analysis on this parameter.

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

§ Lodging with 0% indicates no lodging and a rating of 100% indicates that the entire plot was lodged.

The tallest variety was Pride of Genesee (140 cm) and was not statistically similar to any other varieties evaluated. Redfield was the shortest (87.7 cm), along with Erie and Epoch, which all measured less than 90 cm at harvest. Overall, lodging was variable this season. Seven varieties had 0% lodging, 24 varieties had less than 50% lodging, but Rouge d'Ecosse had the highest percentage of lodging at 88.3% (Table 5).

Winter wheat varieties had an average yield of 3887 lbs ac<sup>-1</sup> (Table 6, Figure 1) adjusted for 13.5% moisture. The top yielding variety was IL17-23874 at 5318 lbs ac<sup>-1</sup>. All but six varieties (Red Chief, Genesee Giant, Gold Coin, Pride of Genesee, and Wasatch) in the trial yielded above 3000 lbs ac<sup>-1</sup> with Rouge d'Ecosse having the lowest yield of 1784 lbs ac<sup>-1</sup>.

Harvest moisture below 14% is necessary for grain storage. Wheat above this moisture content must be dried down after harvest, adding time and cost to farmers. Only eight varieties had moisture below 14% and the rest 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<sup>-1</sup>. In 2023, three varieties reached this threshold. Winterhawk had the highest test weight (56.7 lbs bu<sup>-1</sup>) and Rouge d'Ecosse the lowest (49.7 lbs bu.; Table 6)

**Table 6. Yield and quality of winter wheat varieties, Alburgh, VT, 2023.**

Variety	Yield	Moisture	Test weight	Crude protein	Starch	Falling number	DON
	@ 13.5% moisture lbs ac <sup>-1</sup>	%	lbs bu <sup>-1</sup>	@ 12% moisture %	%	seconds	ppm
AC Morley	3172	15.7	53.1	12.2	59.7	202	2.20*
Arapahoe	3359	14.7	55.0	10.9	60.9	245	0.40*
Bluejacket	3582	15.0	54.5	10.5	61.4*	242	1.40*
Brome	3524	15.9	53.4	11.2	61.1	219	<b>0.40*</b>
Champlain	3812	15.1	54.8	12.3	59.4	257	0.90*
Clark's Cream	3774	16.6	55.4*	12.0	60.6	233	2.10*
Epoch	4192	16.0	52.9	11.0	61.0	183	1.70*
Erie	3878	15.9	52.7	10.4	61.3	192	0.60*
Erisman	4319	14.7	55.9*	10.5	61.1	248	0.90*
Expedition	4266	14.1	55.7*	11.0	61.4*	271	0.80*
Forward	4027	14.0	53.9	11.4	61.0	192	3.60
Genesee Giant	2803	14.5	52.9	11.9	60.7	79.0	0.90*
Gold Coin	2746	<b>13.2*</b>	52.8	11.3	61.1	129	2.60*
IL13-1960	5317*†	14.8	56.5*	9.50	61.5*	279	0.40*
IL15-2639	3941	16.1	54.4	10.8	61.2	275	0.70*
IL16-8048	3426	14.2	55.0	10.4	61.2	269	0.80*
IL17-17739	5055*	14.8	56.0*	11.1	60.8	293*	0.40*
IL17-23874	<b>5318*</b>	16.1	53.7	9.80	61.7*	199	0.50*
Medina	3559	13.7*	54.0	11.2	61.0	121	2.90
Montcalm	3578	13.3*	55.6*	11.2	60.9	251	3.40
NW13493	3734	13.7*	52.8	11.3	60.9	121	1.40*
NY99056-161	4019	14.2	52.7	10.3	<b>61.7*</b>	129	3.50
Overland	3446	13.9*	54.6	10.4	61.6*	310*	0.70*
Pride of Genesee	2206	13.2*	53.6	12.7*	59.9	138	2.40*
Red Chief	2806	15.9	53.9	12.1	60.3	234	0.90*
Redeemer	3897	14.6	53.8	13.3*	59.5	288*	0.60*
Redfield	4140	14.2	53.7	11.7	60.2	280	1.00*
Rouge d'Ecosse	1784	16.4	49.7	<b>13.6*</b>	59.2	195	4.30
Ruth	5021*	14.7	54.2	10.6	61.3	298*	1.70*
SARE 260.06	3546	15.0	54.1	11.6	59.9	234	1.90*
SARE 47.04	3926	15.2	53.7	11.2	60.7	196	0.70*
Sirvinta	4230	13.7*	52.6	12.0	56.3	178	2.10*
TAM 114	5139*	15.3	54.5	10.7	61.1	<b>318*</b>	0.60*
VA14HRW-25	4491	16.0	54.0	10.8	60.7	169	1.00*
VA14HRW-41	4921*	13.9*	53.4	11.2	60.4	265	0.40*

VA16HRW-22	5191*	14.3	55.7*	10.8	60.7	297*	1.00*
Viking 211	4765*	14.6	54.4	10.6	60.8	272	1.40*
Warthog	3794	15.6	54.3	10.0	60.2	268	1.40*
Wasatch	2137	17.1	51.5	12.6*	59.8	185	4.00
Winterhawk	4634	15.0	<b>56.7*</b>	10.6	61.4*	299*	0.90*
LSD (p=0.10)	953	1.38	2.05	1.79	1.24	52.1	2.20
Trial mean	3887	14.9	54.0	11.2	60.6	226	1.50

†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. Rouge d'Ecosse had the highest protein at 13.6%, which was one of nine varieties to test in the ideal range for bread baking (above 12% crude protein adjusted for 12% moisture). IL17-23874 and IL13-1960 were the only varieties to test below 10%, which is generally too low for high quality bread flour. Only two varieties (Overland and TAM 114) met the industry ideal range for falling number (300-500 seconds). Nineteen of the forty varieties tested under the 1 ppm DON threshold with Brome, IL17-17739, and IL13-1960 testing the lowest at 0.4 ppm. Rouge d'Ecosse had the highest DON levels at 4.3 ppm. (Table 6).

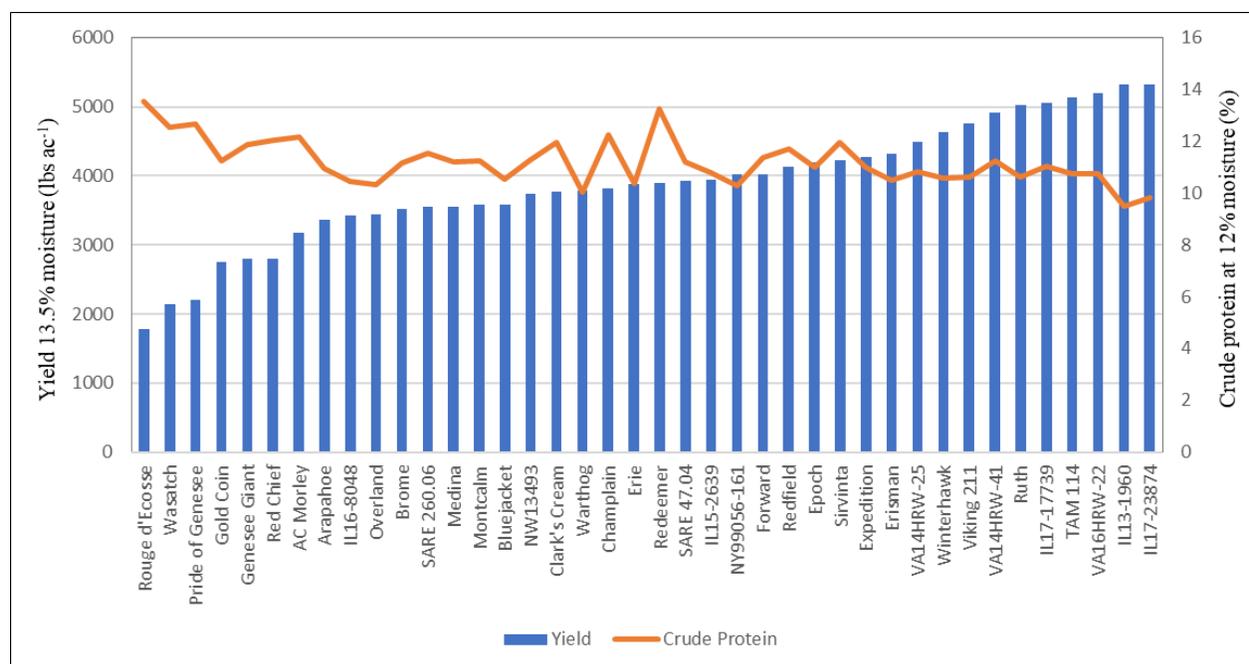


Figure 1. Yield and crude protein of winter wheat varieties, Alburgh, VT, 2023.

## DISCUSSION

The 2023 growing season at Borderview farm (Alburgh, VT) had almost twice the precipitation than the growing season in 2022 (39.9 inches compared to 22.6 inches, respectively). The average trial mean for yield was 3887 lbs ac<sup>-1</sup>, adjusted for 13.5% moisture, which was less than 2022 (4599 lbs ac<sup>-1</sup>). Rouge d'Ecosse had the highest DON levels and at harvest had the highest percent lodging at 88.3%, along with

the lowest yield (1784 lbs ac<sup>-1</sup>). Of the six varieties with yields under 3000 lbs ac<sup>-1</sup> (Red Chief, Genesee Giant, Gold Coin, Pride of Genesee, Wasatch, and Rouge d'Ecosse), five of the six varieties also had 50% or more lodging (Wasatch was less than 50% at 47.5%). Gold Coin, Pride of Genesee, Wasatch, along with Rouge d'Ecosse were all above the DON threshold.

Eight varieties tested within the ideal range (12-15%) for crude protein for bread baking. The rest, except for IL17-23874 and IL13-1960, tested in the acceptable range, greater than 10% crude protein. Many of the varieties trialed had slightly lower than ideal quality parameters, most likely in correlation with the weather conditions this season and the stress the plants were under.

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.

## ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to acknowledge the USDA NIFA OREI Value Added Grains Project Award No. 2020-51300-32379 for their support. The NWSC Team would like to thank Roger Rainville and the staff at Borderview Research Farm. We would also like to acknowledge Anna Brown, John Bruce, Catherine Davidson, Ivy Krezinski, Lindsey Ruhl, Laura Sullivan, Sophia Wilcox Warren, and Sara Ziegler 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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