NORTHWEST CROPS & SOILS PROGRAM

2023 Organic Spring Wheat Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2023 ORGANIC SPRING WHEAT VARIETY TRIAL

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In 2023, the University of Vermont Extension's Northwest Crops and Soils Program evaluated 43 varieties of hard red spring wheat to identify varieties that perform well in northern Vermont.

MATERIALS AND METHODS

The spring wheat variety trial was initiated at Borderview Research Farm in Alburgh in April 2023. Forty-three varieties of hard red spring wheat were evaluated (Table 1). Of these, 39 were commercially available conventional wheat varieties (Table 1.A), and four were spring wheat crosses under development (Table 1.B).

Table 1.A 39 conventional hard red spring wheat varieties.

Variety	Seed source
AC Scotia	Semican Atlantic Inc., QC, Canada
AC Walton	SeCan, Ottawa, Canada
Alaska	Semican Atlantic Inc., QC, Canada
Bolles	Albert Lea Seed, MN
Boost	South Dakota State University, SD
Camero	Meridian Seeds, ND
Driver	Welter Seed and Honey Company, IA
Dylan	Albert Lea Seed, MN
Forefront	South Dakota State University, SD
Glenn	Albert Lea Seed, MN
Lang-MN	Albert Lea Seed, MN
LCS Albany	Limagrain Cereal Seeds, LLC, CO
LCS Anchor	Limagrain Cereal Seeds, LLC, CO
LCS Breakaway	Limagrain Cereal Seeds, LLC, CO
LCS Iguaco	Limagrain Cereal Seeds, LLC, CO
LCS Nitro	Limagrain Cereal Seeds, LLC, CO
LCS Prime	Limagrain Cereal Seeds, LLC, CO
LCS Pro	Limagrain Cereal Seeds, LLC, CO
LCS Rebel	Limagrain Cereal Seeds, LLC, CO
LCS Trigger	Limagrain Cereal Seeds, LLC, CO
LNR13-0627	Limagrain Cereal Seeds, LLC, CO
Magog	Semican Atlantic Inc., QC, Canada
Major	SynAgri, QC, Canada
Moka	Semican Atlantic Inc., QC, Canada
MS Barracuda	Meridian Seeds, ND
ND Vitpro	North Dakota State University, ND
Oland	Cornville Seed, AZ
Pokona	Semican Atlantic Inc., QC, Canada
Prevail	Whitlter Seed Farm, SD
Prosper	Albert Lea Seed, MN
Raven	C & M Seeds, ON, Canada
Red Fife	Fedco Organic Growers Supply

Rocket	Semican Atlantic Inc., QC, Canada
Rouge De Bourdeaux	Great Lakes Staples Seed
Sabin	Cornell University, NY
Shelly	Dahlman Seed Co., MN
Tom	Cornell University, NY
Torgy	Albert Lea Seed, MN
Wilkin	C & M Seeds, ON, Canada

Table 1.B Four spring wheat crosses varieties and selection locations.

Variety	Origin
1 Adirondack Kelse/AC Walton	Adirondack Hay and Grains, Essex NY
2 Adirondack Kelse/Helios	Adirondack Hay and Grains, Essex NY
3 Butterworks Kelse/AC Walton	Butterworks Farm, Westford VT
4 Grange Corner Faller/Tigre	Grange Corner Farm, Lincolnville ME

The crosses were developed by Dr. Stephen Jones of Washington State University. These crosses were grown on 4 farms in the Northeast and further selection was done by farmers. Four selections are being continued by university collaborators to further refine and evaluate these spring wheat crosses. In the working names of the crosses, the first word is the name of the farm where the particular cross was grown and selected, followed by the names of the parent varieties.

Plots were managed with practices similar to those used by producers in the surrounding area. Agronomic information is displayed in Table 2. The experimental design was a randomized complete block with four replicates. The previous crops was industrial hemp. The field was prepared with a TerraDisc® and spike tooth harrow prior to planting. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 14-Apr at a seeding rate of 350 live seeds m^{-2}.

Table 2. Trial agronomic information, Alburgh, VT, 2023.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Benson rocky silt loam 8-15% slope
Previous crop	Industrial hemp
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Replicates	4
Planting date	14-Apr
Harvest date	6-Aug
Harvest area (ft)	5 x 20
Tillage operations	Pottinger TerraDisc®

Flowering dates were recorded throughout the month of June as the date when 50% of the plot was flowering. Heights and lodging were assessed on 3-Aug. The heights of three plants per plot were measured

in centimeters, including the head but excluding the awns. Lodging was assessed visually and recorded as the percentage of each plot that was too lodged to be harvested.

Plots were harvested with an Almaco SPC50 small plot combine on 6-Aug. 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 the E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, Vermont). Grains were analyzed for protein and starch content using the Perten Inframatic 9500 Grain Analyzer. Samples were 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. An ideal falling number range is between 250-350, which indicates 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 indicates very low enzymatic activity, which can inhibit fermentation but can be suitable for baking with the addition of malt extract. 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.

Varietal 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 this 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 a weather station at Borderview Research Farm are displayed below in Table 3. Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger. The growing season was cooler and much wetter than normal. Between April and August, over 28 inches of rain fell at the farm, 9.65 inches more than the 30 year average. There were 4441 Growing Degree Days (GDDs) accumulated, 304 days less than normal. These cool, wet conditions were challenging for grain growth and harvest timing.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2023.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	48.3	57.1	65.7	72.2	67.0
Departure from normal	2.70	-1.28	-1.76	-0.24	-3.73
Precipitation (inches)	4.94	1.98	4.40	10.8	6.27
Departure from normal	1.87	-1.78	0.14	6.69	2.73
Growing Degree Days (base 32°F)	280	766	1023	1274	1098
Departure from normal	-132	-53	-40	22	-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) from Burlington, VT.

Table 4 displays the harvest data and measurements taken prior to harvest for the spring wheat varieties.

Table 4. Spring wheat field season and harvest data, Alburgh, VT, 2023. †

Variety	Flowering date‡	Height	Lodging	Harvest moisture	Test weight	Yield @ 13.5% moisture content
	date	cm	%	%	lbs bu^{-1}	lbs ac^{-1}
AC Scotia	20-Jun	102*†	30.0*	15.0*	51.4	2558
AC Walton	20-Jun	103*	5.00*	15.5*	52.5	2765
Alaska	19-Jun	99.3*	22.5*	14.4*	54.7*	3049*
Bolles	20-Jun	101*	26.3*	15.5*	51.3	2414
Boost	19-Jun	92.6*	1.30*	17.4	51.7	2351
Camero	19-Jun	101.9*	1.30*	14.6*	54.2*	2481
Driver	19-Jun	96.6*	41.3	16.3*	53.1*	2792
Dylan	20-Jun	95.6*	23.0*	15.6*	53.2*	2731
Forefront	19-Jun	93.7*	3.80*	15.9*	53.5*	3042*
Glenn	20-Jun	99.8*	1.30*	17.0	53.1*	2424
Lang-MN	20-Jun	89.3	31.3*	16.5	52.8	3078*
LCS Albany	20-Jun	93.8*	20.0*	17.3	50.9	2208
LCS Anchor	21-Jun	89.8	15.0*	15.8*	53.6*	2309
LCS Breakaway	20-Jun	103*	35.0	16.8	53.2*	2734
LCS Iguaco	20-Jun	92.8*	30.0*	16.1*	53.0*	2464

LCS Nitro	20-Jun	99.4*	10.0*	19.4	49.6	2476
LCS Prime	20-Jun	87.3	16.3*	14.6*	**57.0***	**3362***
LCS Pro	22-Jun	88.5	18.8*	14.5*	55.0*	2705
LCS Rebel	19-Jun	91.8	3.80*	15.5*	56.0*	2760
LCS Trigger	20-Jun	91.8	0.00*	17.5	52.9*	2711
LNR-13-0627	19-Jun	95.7*	23.8*	16.8	50.2	2510
Magog	21-Jun	94.2*	1.30*	13.8*	54.7*	3011*
Major	18-Jun	91.8*	**0.00***	14.7*	55.5*	2826*
Moka	19-Jun	85.9	25.0*	14.6*	55.5*	3071*
MS Barracuda	20-Jun	93.7*	23.8*	17.8	52.1	2218
ND Vitpro	21-Jun	96.5*	1.30*	15.3*	55.4*	2605
Oland	20-Jun	98.7*	10.0*	15.2*	49.3	1982
Pokona	19-Jun	**104***	46.3	15.6*	54.3*	2475
Prevail	20-Jun	91.8*	**0.00***	14.3*	55.4*	2636
Prosper	20-Jun	90.3	61.3	15.4*	52.6	2839*
Raven	19-Jun	101*	3.80*	15.6*	55.9*	2595
Red Fife	22-Jun	90.5	16.3*	19.5	46.6	1388
Rocket	19-Jun	96.6*	12.5*	15.1*	55.0*	2829*
Rouge de Bordeaux	22-Jun	90.3	42.5	**13.7***	36.4	1963
Sabin	20-Jun	91.8	25.0*	17.1	51.5	2479
Shelly	19-Jun	88.3	15.0*	14.9*	53.0*	2302
Tom	19-Jun	99.0*	12.5*	14.6*	55.4*	3089*
Torgy	19-Jun	97.7*	12.5*	15.9*	52.6	2881*
Wilkin	20-Jun	99.9*	12.5*	16.5*	52.3	2463
Adirondack Kelse/AC Walton	19-Jun	92.8*	**0.00***	16.0*	51.5	2777
Adirondack Kelse/Helios	20-Jun	94.3*	10.0*	15.1*	54.7*	2616
Butterworks Kelse/AC Walton	20-Jun	90.9	**0.00***	16.2*	51.9	2414
Grange Corner Faller/Tigre	19-Jun	101*	6.30*	15.0*	54.2*	2865*
LSD (p=0.10)	NS§	12.5	32.5	2.82	4.10	541
Trial mean	20-Jun	95.1	16.2	15.8	52.7	2610

† Within a column, values labeled with an asterisk (*) were not statistically different from the top performer in **bold** (p=0.10).

‡ There is no optimum value for this characteristic.

§NS; No significant difference between treatments.

All varieties flowered over a five day period between 18-Jun and 22-Jun with a trial average of 20-Jun. Flowering is the developmental stage when wheat is most susceptible to infection with the *Fusarium graminearum* fungus that can produce the vomitoxin deoxynivalenol.

Taller plants are generally better for outcompeting weeds, however, plants that are too tall can result in lodging. The tallest variety was Pokona at 104 cm. This was statistically similar to 29 other varieties that were all over 91.8 cm tall. Five varieties had no lodging including LCS Trigger, Major, Prevail, Adirondack Kelse/AC Walton, and Butterworks Kelse/AC Walton. These were statistically similar to 38 other varieties with less than one-third of the plot lodged.

Moisture content in grain must be under 14% for storage to prevent spoilage. Although the average moisture content of a few varieties were less than 14%, the overwhelming majority of varieties tested over 14% moisture content and all were dried down for storage. Test weight is the measure of grain density, which is determined by weighing a known volume of grain. The industry standard for high quality wheat is 60 lbs bu^{-1}. None of the varieties met this standard in the 2022 trial. The highest test weight was LSC Prime at 57.0 lbs bu^{-1}.

Yields ranged from 1388 to 3362 lbs bu^{-1} at 13.5% moisture content. The highest yielding variety was LCS Prime. This was statistically similar to 11 other varieties that yielded over 2800 lbs bu^{-1}: Tom, Lang MN, Moka, Alaska, Forefront, Magog, Torgy, Grange Corner Faller/Tigre, Prosper, Rocket and Major.

Grain quality characteristics are displayed in Table 5. The ideal range for bread wheat is 12-15% crude protein, though wheat in the 10-12% range may also be acceptable for some baking applications. The highest protein concentration was in Bolles, 16.4% which is slightly above optimum range. All other varieties were within the optimum range for protein for spring wheat. Most varieties were within the optimum range of 60-70% starch. The highest starch variety was Tom at 60.8% - statistically similar to nine other varieties at or above 59.9% starch.

Table 5. Spring wheat harvest and quality data, Alburgh, VT, 2023.

Variety	Crude protein @ 12% moisture content	Starch @ 12% moisture content	Falling number	DON
	%	%	seconds	ppm
AC Scotia	13.5*†	58.9	308	1.40*
AC Walton	13.8*	59.1	301	1.87*
Alaska	13.2*	59.9*	334	2.43
Bolles	16.4	57.2	312	3.07
Boost	14.5	59.1	307	1.87*
Camero	14.5	59.2	227	2.23
Driver	14.1	59.4	257	3.53
Dylan	14.3	59.2	279	2.17*
Forefront	14.3	59.7	288	1.77*
Glenn	15.1	58.8	220	2.50
Lang-MN	14.9	58.7	338	1.27*
LCS Albany	14.1	59.3	228	3.53
LCS Anchor	14.6	59.0	212	1.57*
LCS Breakaway	14.1	59.3	219	2.70
LCS Iguaco	13.8*	59.6	252	2.50
LCS Nitro	13.9*	59.5	260	2.27
LCS Prime	13.3*	60.5*	309	2.27
LCS Pro	13.6*	60.3*	254	2.57
LCS Rebel	14.0	60.0*	239	1.90*
LCS Trigger	13.5*	59.5	308	2.00*
LNR-13-0627	13.5*	59.5	236	0.97*
Magog	13.2*	60.3*	374	1.77*
Major	13.7*	59.7	330	1.97*
Moka	13.2*	60.1*	313	4.53

MS Barracuda	15.1	58.8	221	1.60*
ND Vitpro	14.8	59.2	263	1.33*
Oland	14.7	58.6	168	4.77
Pokona	14.1	59.3	313	1.33*
Prevail	14.5	59.6	295	1.93*
Prosper	14.2	60.8*	257	3.33
Raven	13.5*	59.5	**410***	1.15*
Red Fife	15.1	58.2	189	4.57
Rocket	**13.2***	60.0*	282	3.07
Rouge de Bordeaux	14.9	58.5	257	3.10
Sabin	15.1	58.0	337	1.40*
Shelly	14.2	59.8	284	2.27
Tom	14.2	**60.8***	304	2.20*
Torgy	15.3	58.6	273	1.37*
Wilkin	14.2	60.3*	339	**0.70***
Adirondack Kelse/AC Walton	14.0	58.7	253	2.53
Adirondack Kelse/Helios	14.1	59.6	239	2.10*
Butterworks Kelse/AC Walton	14.9	58.1	280	3.17
Grange Corner Faller/Tigre	14.2	59.0	278	3.53
LSD (p=0.10)	0.75	0.88	44.2	1.52
Trial mean	15.8	52.8	278	2.33

†Within a column, values labeled with an asterisk (*) were not statistically different from the top performer in **bold** (p=0.10).

The ideal range for wheat falling numbers is 250-350. Falling number below 250 has a negative impact on bread quality and might lead to lower prices paid for the wheat or possible rejection at the mill. High falling numbers, over 400 seconds, can potentially lead to slower fermentation, poorer loaf volume, and drier bread texture, depending on the end product. A majority of the varieties had falling number within the ideal range of 250-350 seconds. Eleven varieties below 250 seconds including, Adirondack Kelse/Helios, LCS Rebel, LNR-13-0627, LCS Albany, Camero, MS Barracuda, Glenn, LCS Breakaway, LCS Anchor, Red Fife and Oland. Two varieties were above 350 seconds – Raven and Magog.

There was considerable variation in DON concentrations, ranging from 0.70 – 4.77 ppm. The FDA threshold for human consumption is 1 ppm. The DON vomitoxin is caused by infection with the *Fusarium graminearum* fungus, also known as *Fusarium* head blight (FHB). Fungicides are only somewhat effective in preventing infection and toxin development, so choosing a resistant variety is very important in producing high-quality grain that is fit for human consumption. Two varieties were below the 1 ppm threshold established by the FDA: Wilkin with 0.70 ppm and LNR-13-0627 with 0.97 ppm. These were statistically similar to 20 other varieties with DON concentrations at 2.20 ppm or lower.

DISCUSSION

There is often inverse relationship between yield and crude protein concentration, with higher yields tending to correlate with lower protein concentrations. This year's variety trial had much lower average yields than

the last five years of spring wheat variety trials but higher average protein concentrations (Tables 4 & 5, Figure 1). Unfortunately, almost all varieties had DON concentrations above the 1 ppm threshold for human consumption.

The 2023 growing season was slightly cooler and significantly wetter than the 30-year average. Heavy rainfall through the flowering period when wheat is susceptible to FHB infection and through the harvest season resulted in issues with FHB and harvest timing, leading to unacceptable DON concentrations in most varieties and unacceptable falling number in several varieties.

It is important to note that this only represents one year of data. It is important as farmers make variety selections to evaluate data from multiple years and from test sites that are as similar to their region as possible. Wheat is generally considered a specialty crop in the Northeast and it is recommended growers consider quality standards and post-harvest handling requirements, and communicate with potential buyers during variety selection and prior to planting large acreage of grain.

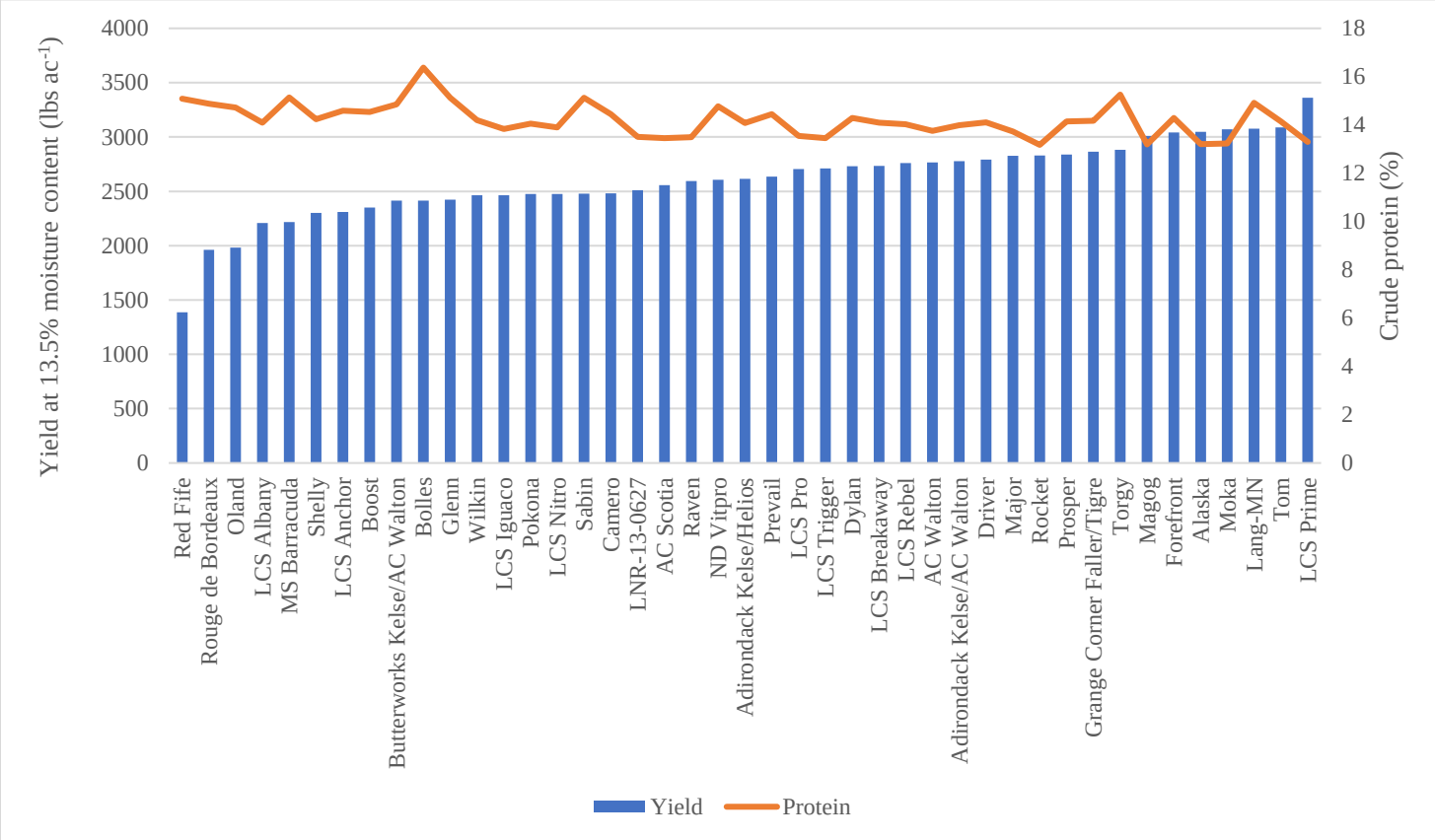

Figure 1. Yield and crude protein content of 43 spring wheat varieties, Alburgh, VT, 2023.

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