NORTHWEST CROPS & SOILS PROGRAM

2022 Organic Spring Wheat Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2022 ORGANIC SPRING WHEAT VARIETY TRIAL

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In 2022, the University of Vermont Extension's Northwest Crops and Soils Program evaluated 36 spring wheat varieties 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 2022. Thirty-six varieties of hard red spring wheat were evaluated (Table 1).

Table 1. Thirty-six spring wheat varieties and seed suppliers.

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	South Dakota State University, SD
Forefront	South Dakota State University, SD
Glenn	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
LNR13-0627	Limagrain Cereal Seeds, LLC, CO
Lang-MN	Albert Lea Seed, MN
MS Barracuda	Meridian Seeds, ND
Magog	Semican Atlantic Inc., QC, Canada
Major	SynAgri, QC, Canada
Moka	Semican Atlantic Inc., QC, Canada
ND Vitpro	North Dakota State University, ND
Oland	University of Maine, ME
Pokona	Semican Atlantic Inc., QC, Canada
Prevail	South Dakota State University, SD
Prosper	Albert Lea Seed, MN
Red Fife	Fedco Organic Growers Supply

Rocket	Semican Atlantic Inc., QC, Canada
Rouge De Bourdeux	Great Lakes Staples Seed
Sabin	Cornell University, NY
Shelly	Dahlman Seed Co., MN
Tom	Cornell University, NY
Torgy	Albert Lea Seed, MN
Trigger	Saved seed, Borderview Research Farm

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 corn and spring grains. The field was prepared with a TerraDisc and spike tooth harrow prior to planting. The field was fertilized with a blended organic fertilizer (5-4-3) at a rate of 2000 lb ac^{-1} on 15-Apr. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 18-Apr at a seeding rate of 350 live seeds m^{-2}.

Table 2. Trial agronomic information, Alburgh, VT, 2022.

Trial information	Alburgh, VT Borderview Research Farm
Soil type	Covington silty clay loam, 0 to 3 percent slopes
Previous crop	Corn and spring grains
Seeding rate	350 live seeds m^{-2}
Row spacing (in)	6
Replicates	4
Planting date	18-Apr
Harvest date	3-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. The trial was scouted for arthropod pest damage and plant disease symptoms on 8-Jul. Five random plants from each plot were assessed. The top two leaves were examined and evaluated for the presence of disease symptoms and arthropod 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 symptoms. Data was recorded as a percent of the leaf surface that was affected by each foliar symptom. Heights and lodging were assessed prior to harvest 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 3-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. The growing season was cooler than normal overall, although the month of May was warmer than average. There were 3510 growing degree days (GDDs) in the season, 36 growing degree days less than normal. There were 20.1 inches of precipitation, 4.97 inches more than normal.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2022.

Alburgh, VT	April	May	June	July
Average temperature (°F)	44.8	60.5	65.3	71.9
Departure from normal	-0.81	2.09	-2.18	-0.54
Precipitation (inches)	5.57	3.36	8.19	3.00
Departure from normal	2.50	-0.40	3.93	-1.06
Growing Degree Days (32-95°F)	391	883	1000	1236
Departure from normal	-20.0	65.0	-64.0	-17.0

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of data provided by the NOAA (1981-2010) for Burlington, VT.

Table 4 shows data collected throughout the growing season prior to harvest of the spring wheat trial. All varieties flowered over a six day period between 17-Jun and 23-Jun.

Foliar diseases reduce photosynthetic leaf area, use nutrients, and increase respiration and transpiration within colonized host tissues. Diseased plants typically exhibit reduced vigor, growth, and seed fill resulting in yield loss. 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. Tom exhibited the least disease symptoms with only 2.07% of the foliar surface affected by disease symptoms on average. This was similar to 22 other varieties with less than 7% of foliar surface affected by disease symptoms. The variety most impacted by disease symptoms was Oland with 14.4% of the foliar surface affected, similar to two other varieties with more than 10% of the foliar surface affected. The most prevalent disease in the spring variety trial was mosaic virus, with all plots showing symptoms of mosaic virus. 81.9% of plants scouted were affected by mosaic virus, with the average infected plant having 2.46% of its foliar surface affected by mosaic virus. Many plants were also notes to have brown spots that could be characteristic of number of fungal, bacterial or viral infections; 60.6% of plants scouted were affected by browns spots and lesions. 47.4% of plants scouted were impacted by leaf rust and 26.9% of plants scouted were affected by powdery mildew.

Damage caused by arthropod pests includes discoloration, leaf scarring, and reduced growth of the plant, Pests can also act as a disease vector. Arthropod pest damage was also common, with all plots affected by arthropod pests and a trial average of 4.99% of the foliar surface affected by pest damage. LCS Rebel had the least pest damage with 2.67% of the foliar surface damaged by arthropod pests. This was statistically similar to 27 other varieties with less than 6% of the foliar surface affected by pest damage. 90.1% of all plants scouted had damage from thrips. Mites had damaged 80.4% of all plants scouted and cereal leaf beetle had damaged 50.5% of plants scouted. While cereal leaf beetle affected the least number of plants, it caused more damage to the foliar surface on average than the other pests, affecting 2.24% of the foliar surface of damaged plants compared to only 1.36% for mites and 1.48% for thrips and damaging the most foliar surface of any arthropod pest in 2022. A high degree of physical damage to foliar surfaces, mostly caused by wind or sunburn, was also noted in this year's trial. 84.8% of plants scouted had physical

damage to the leaves with the average of 4.21% of the foliar surface affected. These three categories (disease, pest and physical damage) were combined into a total foliar damage category. Oland had a high degree of pest, disease and physical damage and was statistically dissimilar to all other varieties with 30.6% of its total foliar surface damaged. Oland had the second lowest yield in the trial. Driver was the variety with the least total foliar damage at 8.53%, statistically similar to 27 other varieties with less than 18% of the total foliar surface damaged.

Table 4. Spring wheat field season agronomic data, Alburgh, VT, 2022. †

Variety	Flowering date±	Foliar disease	Arthropod pest damage	Total foliar damage	Height	Lodging
	date	% foliar surface affected	% foliar surface affected	% foliar surface affected	cm	%
AC Scotia	19-Jun	8.60	5.53* †	16.9*	104.0*	3.75*
AC Walton	21-Jun	7.87	3.67*	16.3*	96.9	1.25*
Alaska	19-Jun	5.47*	5.00*	14.9*	106.0*	3.75*
Bolles	18-Jun	8.73	6.53	18.3	83.3	**0.00***
Boost	20-Jun	5.07*	4.87*	10.5*	84.4	2.50*
Camero	20-Jun	10.40	4.93*	18.3	86.7	1.25*
Driver	19-Jun	2.93*	4.40*	**8.53***	95.1	**0.00***
Forefront	18-Jun	4.47*	5.60*	14.5*	94.7	2.50*
Glenn	19-Jun	8.00	7.80	21.2	93.0	**0.00***
LCS Albany	19-Jun	5.53*	3.47*	17.1*	78.7	**0.00***
LCS Anchor	18-Jun	4.47*	3.93*	13.0*	80.4	**0.00***
LCS Breakaway	18-Jun	3.33*	6.47	21.0	86.6	**0.00***
LCS Iguaco	20-Jun	3.80*	5.07*	9.80*	90.8	3.75*
LCS Nitro	19-Jun	4.20*	5.20*	12.2*	78.6	**0.00***
LCS Prime	18-Jun	2.67*	3.20*	10.3*	79.5	**0.00***
LCS Pro	18-Jun	4.40*	7.13	15.6*	93.2	1.25*
LCS Rebel	20-Jun	10.53	**2.67***	15.9*	81.3	3.75*
LNR-13-0627	20-Jun	7.47	7.40	20.3	76.8	**0.00***
Lang-MN	17-Jun	6.53*	5.60*	15.0*	83.5	**0.00***
MS Barracuda	20-Jun	5.27*	4.60*	17.3*	89.3	**0.00***
Magog	18-Jun	9.13	5.53*	18.6	100.0*	2.50*
Major	22-Jun	3.87*	4.07*	9.27*	99.3*	6.25
Moka	19-Jun	8.27	3.60*	14.9*	86.6	3.75*
ND Vitpro	20-Jun	3.40*	9.73	17.6*	85.0	**0.00***
Oland	23-Jun	14.40	6.80	30.6	**113.3***	7.50
Pokona	20-Jun	5.00*	3.00*	10.1*	100.5*	1.25*
Prevail	19-Jun	8.73	3.27*	16.8*	87.3	**0.00***
Prosper	20-Jun	2.40*	3.80*	10.6*	91.0	3.75*
Red Fife	20-Jun	8.67	7.93	20.3	109*	16.3
Rocket	19-Jun	3.87*	4.27*	12.7*	95.5	11.3

Rouge de Bourdeaux	23-Jun	4.20*	3.07*	9.93*	89.8	1.25*
Sabin	18-Jun	6.47*	5.13*	15.3*	89.4	**0.00***
Shelly	21-Jun	5.07*	5.93*	16.2*	80.3	**0.00***
Tom	19-Jun	**2.07***	4.40*	8.93*	90.6	1.25*
Torgy	20-Jun	3.80*	3.27*	9.47*	94.3	1.25*
Trigger	20-Jun	3.47*	2.93*	12.5*	90.4	1.25*
LSD (p=0.10)	NS	5.21	3.72	9.18	14.2	6.10
Trial mean	19-Jun	5.90	4.99	15.02	90.7	2.26

† 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.

Taller plants are generally better for outcompeting weeds, however, plants that are too tall can result in lodging. The tallest variety was Oland at 113 cm. This was statistically similar to Red Fife, Alaska, AC Scotia, Pokona, Magog, and Major, which were all over 99 cm tall. Red Fife had the most lodging with 16.3% of this variety being too lodged to harvest. This was statistically similar to Rocket with 11.3% lodged. Fifteen varieties had no lodging, which was statistically similar to 17 additional varieties with lodging less than 4%. Harvest and quality characteristics are displayed in Table 5.

Table 5. Spring wheat harvest and quality data, Alburgh, VT, 2022.

Variety	Test weight	Harvest moisture	Yield @ 13.5% moisture content	Crude protein @ 12% moisture content	Starch @ 12% moisture content	Falling number	DON
	lbs bu^{-1}	%	lbs ac^{-1}	%	%	seconds	ppm
AC Scotia	53.3* †	19.2*	3865*	12.1	60.3	378	0.30*
AC Walton	53.9*	17.6*	3475	11.4	60.7	365	0.77*
Alaska	52.2*	19.6	3649	12.3*	60.2	370	0.43*
Bolles	56.4*	18.6*	3877*	13.1*	59.4	392	1.00*
Boost	49.4	22.2	3179	13.4*	59.4	386	0.60*
Camero	55.4*	18.6*	4309*	13.2*	59.5	344*	1.03
Driver	54.8*	18.4*	4465*	12.0	60.8	334*	2.60
Forefront	56.3*	16.8*	3464	12.8*	60.4	329*	0.57*
Glenn	55.9*	18.2*	3383	13.3*	60.0	367	0.83*
LCS Albany	50.5	18.4*	3666	12.1	60.6	333*	1.10
LCS Anchor	55.9*	17.0*	3351	12.5*	59.7	354*	0.63*
LCS Breakaway	**57.7***	17.0*	3892*	12.7*	60.1	385	1.93
LCS Iguaco	54.1*	17.2*	**4632***	12.3*	60.3	368	0.83*
LCS Nitro	53.7*	18.6*	3147	11.9	60.7	354*	0.73*
LCS Prime	56.7*	18.4*	3793*	10.5	61.6*	364	0.80*
LCS Pro	49.5	16.3*	4570*	13.1*	60.3	337*	2.70
LCS Rebel	55.3*	17.3*	3853*	13.1*	60.3	378	1.43
LNR-13-0627	55.3*	17.5*	4430*	10.7	61.5*	381	1.40
Lang-MN	55.9*	17.9*	4164*	13.7*	59.5	414	0.47*
MS Barracuda	57.1*	16.3*	4121*	12.8*	60.3	384	0.63*

Magog	56.3*	17.0*	4310*	11.5	60.9*	423	0.53*
Major	45.7	22.8	3620	12.0	60.5	358	**0.10***
Moka	49.3	19.8	3585	11.9	60.6	344*	0.20*
ND Vitpro	56.4*	16.8*	4166*	12.8*	60.2	380	1.03
Oland	56.1*	18.2*	2598	11.7	60.3	399	0.67*
Pokona	51.9	18.4*	4247*	11.7	60.8	385	0.37*
Prevail	56.6*	16.9*	3949*	11.6	61.0*	390	1.53
Prosper	55.4*	19.2*	4285*	11.4	61.2*	380	0.80*
Red Fife	44.6	26.2	2548	13.1*	59.5	344*	1.43
Rocket	53.3*	19.3	3553	11.2	61.0*	335*	0.13*
Rouge de Bourdeaux	39.6	32.4	2885	11.7	60.6	**324***	1.27
Sabin	55.1*	17.0*	4298*	13.0*	59.5	444	2.33
Shelly	56.9*	**16.2***	4314*	11.1	**61.8***	385	0.70*
Tom	50.2	20.0	4293*	12.4*	60.5	399	0.93*
Torgy	53.4*	19.5	3508	12.4*	60.4	346*	0.93*
Trigger	52.9*	19.5	3703*	11.1	60.9*	393	0.13*
LSD (p=0.10)	5.63	3.06	945	1.43	0.94	30.1	0.92
Trial mean	53.4	18.9	3810	12.2	60.4	371	0.94

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

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 Breakaway at 57.7 lbs bu^{-1}. Moisture content in grain must be under 14% for storage to prevent spoilage. All the varieties were above 14% moisture at harvest and required drying down for storage.

Yields ranged from 2547 – 4632 lbs bu^{-1} at 13.5% moisture content. The highest yielding variety was LCS Iguaco. This was statistically similar to LCS Pro, Driver, LNR-13-0627, Shelly, Magog, Camero, Sabin, Tom, Prosper, Pokona, ND Vitpro, Lang-MN, MS Barracuda, Prevail, LCS Breakaway, Bolles, AC Scotia, LCS Rebel, LCS Prime, and Trigger, which all yielded over 3700 lbs bu^{-1}.

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. All varieties tested above 10% protein, adjusted to 12% moisture. There were 21 varieties that tested above 12% crude protein. Lang-MN had the highest protein concentration at 13.7%. Most varieties were within the optimum range of 60-70% starch. Eight varieties had less than 60% starch.

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. No varieties tested under 300 seconds, although several were at or above the high end of the acceptable range. There were 26 varieties that had falling number above 350 seconds and 3 of those were above 400 seconds.

There was considerable variation in DON concentrations, ranging from 0.10 – 2.70 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. The lowest DON concentrations were in the variety Major with 0.10 ppm. This is statistically similar to 24 other varieties with DON concentrations at 1.0 ppm or lower.

DISCUSSION

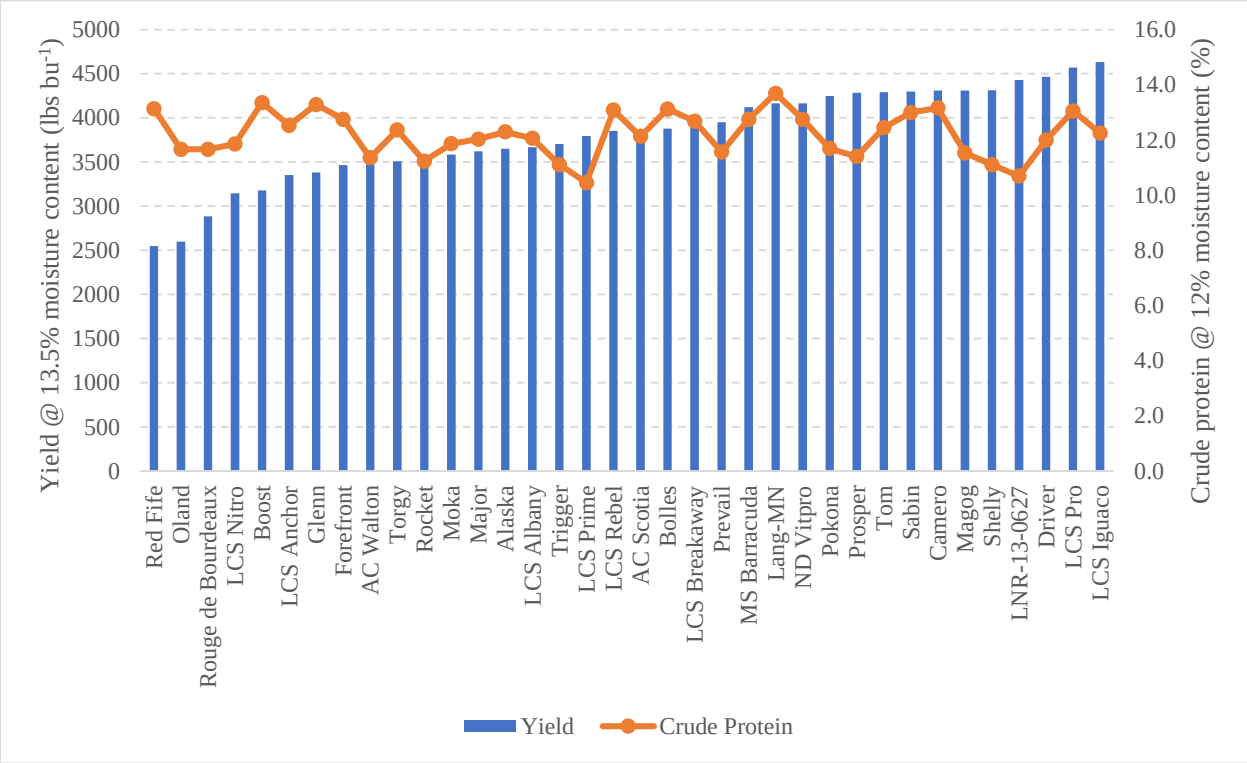

Figure 1. Yield and crude protein content of 36 spring wheat varieties, Alburgh, VT, 2022.

There is often inverse relationship between yield and crude protein concentration, with higher yielding varieties tending to have lower protein concentrations. Thirteen varieties (LSC Rebel, AC Scotia, Bolles, LCS Breakaway, MS Barracuda, Lang-MN, ND Vitpro, Tom, Sabin, Camero, Driver, LCS Pro, LCS Iguaco) had yields above trial average and crude protein levels at or above 12% (Table 5, Figure 1). Unfortunately, several of these otherwise top-performing varieties had DON concentrations above the 1 ppm threshold for human consumption (LCS Rebel, LCS Breakaway, ND Vitpro, Sabin, Camero, Driver, and LCS Pro).

The 2022 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 and

falling number in several varieties. Overall, yields were very good and quality was acceptable for baking for most 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.

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