NORTHWEST CROPS & SOILS PROGRAM

2024 Rye Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2024 RYE VARIETY TRIAL

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The interest in growing cereal rye for grain to be sold as cover crop seed, or to other value-added markets (distillers and bakers), has increased considerably across the Northeast region in recent years. As a result, farmers and end-users are requesting yield and quality information on cereal rye varieties. In 2023-2024, University of Vermont Extension Northwest Crops and Soils (NWCS) Program conducted a variety trial to evaluate yield and quality of cereal rye.

MATERIALS AND METHODS

The rye variety trial was initiated at Borderview Research Farm in Alburgh, VT in the fall of 2023. 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 field was prepared with Pottinger TerraDisc™ to prepare the seedbed for planting. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 21-Sep 2023 at a seeding rate of 350 live seeds m^{-2}. Treatments were ten varieties of cereal rye including Aroostook, Bono, Danko, Hazlet, ND Gardner, Receptor, Rymin, Serafino, Spooner, and Tayo (Table 2).

Table 1. Agronomic and trial information for the rye cover crop variety trial, 2023-2024.

	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Hemp Flower
Tillage operations	Pottinger TerraDisc™
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	21-Sep 2023
Harvest date	22-Jul 2024

Table 2. Winter rye varietal information, Alburgh, VT, 2023-2024.

Variety	**Source**
Aroostook	Albert Lea Seed
Bono	Albert Lea Seed
Danko	Albert Lea Seed
Hazlet	Albert Lea Seed
ND Gardner	Albert Lea Seed
Receptor	Albert Lea Seed
Rymin	Albert Lea Seed
Serafino	Albert Lea Seed
Spooner	Albert Lea Seed
Tayo	Albert Lea Seed

The trial was scouted for arthropod pests and plant diseases on 31-May 2024. 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.

On 21-Jul 2024, one day prior to harvest, three plant heights per plot were measured for each plot, excluding awns. Lodging was assessed visually as percent lodged, with 0% indicating no lodging and 100% indicating the entire plot was lodged. Grain plots were harvested at the Alburgh site with an Almaco SPC50 plot combine on 22-Jul. Seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN) and a one-pound subsample was collected to analyze quality characteristics. Grain quality was determined at the E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT). Grains were analyzed for crude protein and starch content using the Perten Inframatic 9500 NIR Grain Analyzer (Perkin Elmer, Waltham, MA). The samples were then ground into flour using the Perten LM3100 Laboratory Mill (Perkin Elmer). Falling number for all rye varieties were determined using the AACC Method 56-81B, AACC Intl., 2000 on a Perten FN 1500 Falling Number Machine Mill (Perkin Elmer). The falling number indirectly measures enzymatic activity in the grain, which is typically used as an indicator of pre-harvest sprouting. 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. Deoxynivalenol (DON) analysis was done using Veratox DON 2/3 Quantitative test from the NEOGEN Corp (Lansing, MI). 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).

Standard 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 ($p<0.10$).

Treatment	Yield
A	**2100***
B	1900*
C	1700
LSD	300

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.

RESULTS

Seasonal precipitation and temperature recorded at Borderview Research Farm in Alburgh, VT are displayed in Table 3. Fall temperatures at establishment through October 2023 were 6.60° F warmer than average leading to strong winter survival for nearly all the winter wheat varieties. Similar to the 2023 growing season, we saw a significantly wetter season with 29.9 total inches, 4.52 inches above the average. The average temperature during the primary growing season was 5.88° F above average with cumulative Growing Degree Days (GDDs) reaching 5506, 235 above average.

Table 3. Seasonal weather data collected in Alburgh, VT, 2023-2024.

Alburgh, VT	Sep 2023	Oct 2023	Nov 2023	Apr 2024	May 2024	Jun 2024	Jul 2024
Average temperature (°F)	64.7	54.9	35.9	45.7	61.9	68.5	73.7
Departure from normal	1.97	4.63	-3.39	0.13	3.47	0.95	1.33
Precipitation (inches)	2.4	5.38	2.03	4.47	2.27	6.65	6.67
Departure from normal	-1.27	1.55	-0.67	1.4	-1.49	2.39	2.61
Growing Degree Days (base 32°F)	980	711	175	327	926	1093	1294
Departure from normal	58	143	-60	-84	108	29	41

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 winter survival, vigor, height, and lodging (Table 4). Each plot of Rymin within the study showed 100% winterkill and, as such, is not further included in the remainder of the report. Otherwise, the majority of varieties had 100% winter survival, or were statistically similar to those with 100% survival, with the exception of Bono, which averaged 72.5% survival within the trial. To further distinguish between varieties and assess overall plant health at spring green-up, a vigor rating was given to each plot. Those varieties with higher values showed dark green, healthy plant growth with little to no leaf damage as a result of winter kill or disease. Plant vigor was highest with ND Gardener and Spooner rating 8.5 on the vigor scale (0-9), with the lowest being Bono, rating 4.25. These two most vigorous varieties in the spring were also the tallest varieties with Spooner at 172 cm, and ND Gardener at 168 cm. As a result of weather conditions and the overall plant vigor, these were two of the more susceptible varieties to lodging in addition to Aroostook, Hazlet, and Receptor. While these varieties were the most vigorous in terms of plant growth, they were in return far more susceptible to lodging which further impacted yields for a number of these varieties (Table 4).

Table 4. Cereal rye harvest measurements. Alburgh, VT, 2024.

Variety	Winter survival %	Vigor 0-9†	Height cm	Lodging %
Aroostook	97.5*‡	7.75*	152	48.8
Bono	72.5	4.25	121	**1.25**
Danko	**100**	7.75*	144	27.5*
Hazlet	97.5*	7.00	154	62.5
ND Gardener	97.5*	**8.50**	168*	81.3
Receptor	**100**	7.00	132	45.0
Serafino	**100**	7.25	133	10.0*
Spooner	**100**	**8.50**	**172**	43.8
Tayo	**100**	7.25	127	2.50*
LSD (0.10)§	7.36	1.03	6.35	27.0
Trial mean	96.1	7.25	145	35.8

†Vigor 0=low vigor, 9=excellent vigor.
‡Within a column, varieties with an asterisk (*) were not different from the top performer (in **bold**).
§LSD; least significant difference at the p=0.10 level.

There were significant differences across varieties for disease, arthropod, and combined foliar damage (Table 5). Foliar diseases reduce photosynthetic leaf area, deplete plant nutrients, and increase respiration and transpiration within colonized host tissues. The diseased plant typically exhibits reduced vigor, growth, and seed fill, thus impacting grain quality and yields. 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 rye variety trial were rust, brown spot, mosaic virus, and powdery mildew (in order from most severe to least). Serafino appeared to be impacted the least by both arthropods and diseases, however minimal foliar damage was observed within the trial overall.

Table 5. Disease and arthropod damage in winter rye varieties. Alburgh, VT, 2024.

Variety	**Disease damage**	**Arthropod damage**	**Combined foliar damage**
	% foliar surface affected	**% foliar surface affected**	**% foliar surface affected**
Aroostook	8.60	0.800*†	11.6
Bono	2.80*	0.333*	3.53*
Danko	4.40*	0.533*	7.60
Hazlet	4.47*	0.400*	5.47*
ND Gardener	6.67	0.467*	9.53
Receptor	2.20*	0.933	5.27*
Serafino	**0.867**	**0.267**	**1.20**
Spooner	3.80*	1.20	6.53
Tayo	1.00*	0.467*	1.53*

LSD (0.10)‡	0.264	0.638	4.56
Trial mean	3.87	0.600	5.81

† Within a column, varieties with an asterisk (*) were not different from the top performer (in **bold**).
‡LSD; least significant difference at the p=0.10 level.

Moisture measurements were recorded at harvest (Table 6). The ideal moisture content for grain storage is below 13.5%. Each variety at this stage of harvest was above the ideal moisture content for storage and required further drying. The ideal test weight for rye is 56 lbs bu^{-1}; none of the varieties met or exceeded this test weight. However, each variety did surpass the 50 lb bu^{-1} and was comparable to previous years trial averages in 2022 and 2023. Danko had the highest overall test weight at 53.4 lb bu^{-1} and was statistically similar to Bono, Receptor, Serafino, Spooner, and Tayo. Yields were once again lower when compared to peak years likely due to significant lodging within the trial. Trial average for the 2024 growing season was 2945 lbs ac^{-1} with top yielding variety Tayo reaching 3908 lbs ac^{-1}. Other top performing varieties included Bono, Danko, Receptor, and Serafino.

Falling number measures viscosity by recording the time in seconds it takes for a plunger to fall through a slurry to the bottom of a test tube. The viscosity is an indicator of enzymatic (alpha-amylase) activity in the kernel, which most often results from pre-harvest sprouting in the grain. Low falling number means high enzymatic activity, or more pre-harvest sprouting damage. This is most common if there are rain events as the grain is maturing prior to harvest. Values for falling number in each of the varieties was fairly high when compared to 2023, which had a number of varieties below 100 seconds. The highest observed falling number was seen in Serafino (322 seconds) with a trial average of 223 seconds.

Table 6. Cereal rye grain quality. Alburgh, VT, 2024.

Variety	Moisture	Test weight	Yield @ 13.5% moisture	Crude protein @ 12% moisture	Starch @ 12% moisture	Falling number
	%	lbs bu^{-1}	lbs ac^{-1}	%	%	seconds
Aroostook	16.7	51.5	2281	7.13	62.2	160
Bono	16.5	52.8*†	3187*	6.98	62.1	276
Danko	16.4	**53.4**	3199*	6.79	62.5*	210
Hazlet	18.4	50.9	2379	7.14	62.1	159
ND Gardener	19.6	50.3	1951	**8.15**	60.8	162
Receptor	17.3	52.3*	3666*	6.59	62.2	280
Serafino	16.5	53.1*	3880*	6.51	**62.6**	**322**
Spooner	17.4	52.2*	2054	7.20	62.6*	159
Tayo	15.9	52.2*	**3908**	6.47	62.3	278
LSD (0.10)‡	1.24	1.29	936.9	0.352	0.264	31.7
Trial mean	17.2	52.1	2945	7.00	62.2	223

† Within a column, varieties with an asterisk (*) were not different from the top performer (in **bold**).
‡LSD; least significant difference at the p=0.10 level.

Wheat with 12% crude protein is generally considered ideal for baking bread; however, it is unclear how protein concentrations in rye impact the baking characteristics. This year's varieties resulted in a trial mean

of 7.00% compared to a 2023 trial average of 8.5% crude protein (Table 6). Lower protein levels are characteristic of rye. The highest observed value for crude protein was seen in ND Gardener at 8.15%. Starch measurements were also obtained from grain samples with the highest average starch content observed in Serafino at 62.6% and was statistically similar to Danko and Spooner.

DISCUSSION

Despite major flood events and the persistence rainfall experienced throughout the state, the rye crop from this trial was able to be harvested. However, some impacts on yields and quality were noticeable. With a number of the varieties impacted greatly by lodging, the few that were relatively unimpacted (Bono, Tayo, and Serafino in particular) were amongst hybrid rye varieties that stood out in terms of harvestability. However, overall yields for the trial were low compared to past years, with some open pollenated varieties (such as Aroostook and Hazlet) exhibiting particularly low yields in 2024. Similar to previous years, grain quality also seemed to be impacted by weather as more lower levels of crude protein were observed across the trial. One replicate 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.

There are well established ranges for falling number as an indicator of baking and malting quality in wheat and barley, but the ideal range for rye is not yet clearly documented. The ideal falling number range for wheat is 250-350, however lower falling numbers around 150 seconds are acceptable and may be preferable to bakers using rye flours. Because rye bread relies on different grain components to create high-quality bread, and ferments more readily than wheat, it is expected that lower falling numbers are preferred for rye than for wheat, possibly closer to 100-200 seconds. The falling number results in this trial are consistent with our prior studies, but more research is needed to characterize potential end uses for rye with different falling numbers. See the 2020 and 2022 Rye Harvest Date Trial Report for more details about the impact of harvest date and variety on falling number in rye. Furthermore, other compounds such as pentosans, polysaccharides that impact the water holding capacity of the flour, could prove to be more impactful in rye flour and baking quality, highlighting the importance of additional studies with rye. 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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