2024 Rye Harvest Date

Dr. Heather Darby, UVM Extension Agronomist
Chloe Jackman, John Bruce and Hillary Emick
UVM Extension Crops and Soils Technicians
802-524-6501

Visit us on the web: http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT
EXTENSION

2024 RYE HARVEST DATE
Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

Cereal rye is a popular cover crop across the Northeast. The interest in growing rye grain for value-added markets (distillers and bakers) or for cover crop seed has increased considerably across the region. As a result, farmers and end-users of rye need information on varieties and agronomic practices that meet the quality required by these grain markets. In 2023-2024, the University of Vermont Extension Northwest Crops and Soils (NWCS) program conducted a harvest date trial to evaluate the effects of harvest date on yield and quality of cereal rye. A quality metric of particular interest is falling number, a laboratory test that measures the viscosity of flour. There are well established ranges for falling number as an indicator of baking and malting quality in wheat and barley. There is less information on the ideal range for falling number in cereal rye. The goal of this project was to evaluate the impact of harvest date on yields and quality parameters, specifically falling number, on four common varieties of cereal rye.

MATERIALS AND METHODS

The experimental design was a randomized complete block with split plots and 4 replicates. The main plots were harvest date and the variety is split-plot. The varieties evaluated were Bono, Danko, Hazlet and Serafino. The field was prepared with a Pottinger Terra Disc ™ prior to planting. Rye was planted with a Great Plains cone seeder on 17-Sep 2023. Plots were 5' x 20' (Table 1).

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 fiber
Tillage operations	Pottinger Terra Disc ™
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	17-Sep 2023
Harvest dates (HD)	HD 1: 19-Jul 2024
	HD 2: 26-Jul 2024
	HD 3: 2-Aug 2024
	HD 4: 9-Aug 2024

Grain plots were harvested with an Almaco SPC50 plot combine at approximately one-week intervals from the end of July to early August. Following harvest, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). Plot yield was weighed on a pound scale. A one-pound subsample was collected to determine quality. 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. The samples were then ground into flour using the Perten LM3100 Laboratory Mill. Falling number was determined using the AACC Method 56-81B, AACC Intl., 2000 on a Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout

damage that has occurred in the grain. It is measured by the time it takes, in seconds, for a stirrer to fall through a slurry of flour and water to the bottom of the tube. Deoxynivalenol (DON) analysis 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. One sample from each variety from the first and last harvest dates were tested for DON levels, and all were determined to be below the 1 ppm threshold for consumption.

Variations in yield and quality can occur because of variations in genetics, soil, weather and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties 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 (i.e. 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 varieties. Treatments that were not significantly lower in performance than the

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

highest value in a particular column are indicated with an asterisk. In this example, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

RESULTS

The weather in the fall of 2023 had close to average precipitation and temperature. The main growing season in the spring and summer of 2024 was warmer than average and wetter. A total of 28.1 inches of rain fell from April through July, 4.91 inches more than normal. A total of 6661 growing degree days (GDDs) accumulated over the fall of 2023 and spring and summer of 2024, 190 GDDs more than normal.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2023 and 2024 growing season.

Alburgh, VT	23-Sep	23-Oct	23-Nov	24-Apr	24-May	24-Jun	24-Jul	24-Aug
Average temperature (°F)	64.7	54.9	35.9	45.7	61.9	68.5	73.7	69.2
Departure from normal	1.97	4.63	-3.39	0.13	3.47	0.95	1.33	-1.45
Precipitation (inches)	2.40	5.38	2.03	4.47	2.27	6.65	6.67	5.78
Departure from normal	-1.27	1.55	-0.67	1.40	-1.49	2.39	2.61	2.24
Growing Degree Days (base 32°F)	980	711	175	327	926	1093	1294	1155
Departure from normal	58	143	-60	-84	108	29	41	-45

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. (http://www.nrcc.cornell.edu/page_nowdata.html).

Impact of Harvest Date

Yield was measured at the time of each harvest date (Table 3). Yields were highest at HD1 (19-Jul) at 5471 lbs ac[-1]. This was statistically similar to HD2 and HD3. The lowest yield was HD4 with 1992 lbs ac[-1]. The highest protein was 7.68% (adjusted to 12% moisture content) on HD3. The other harvest dates ranged from 6.97-7.17% protein. HD4 also produced the rye with the highest starch concentrations at 62.3% (adjusted to 12% moisture content). The other harvest dates ranged from 61.6-62.1%. The average falling number declined steadily over the harvest dates. The highest falling number was on HD1 at 225 seconds average, falling to 209 seconds by the second harvest date, 179 seconds by the third, and 105 seconds on the fourth harvest date.

Table 3. Harvest measurements and grain quality for winter rye harvest dates, Alburgh, VT, 2024.

Harvest date	Yield @ 13.5% moisture	Crude protein @ 12% moisture	Starch @ 12% moisture	Falling number
	lbs ac[-1]	%	%	seconds
19-Jul	**5471**[a †]	7.12[b]	61.9[b]	**225**[a]
26-Jul	4781[a]	6.97[b]	62.1[a]	209[a]
2-Aug	4995[a]	**7.68**[a]	61.6[c]	179[b]
9-Aug	1992[b]	7.17[b]	**62.3**[a]	105[c]
LSD (p=0.10)[‡]	694	0.21	0.21	25.1
Trial mean	4310	7.24	61.9	180

†Treatments marked with the same letter do not differ significantly.
‡LSD; least significant difference at the p=0.10 level.

Impact of Variety

The highest yielding variety across harvest dates was Danko, with 4819 lbs ac[-1]. This was statistically similar to Bono and Serafino. Hazlet had the highest concentration of protein at 7.54%, statistically higher than all other varieties. Bono and Danko were tied for the highest starch concentrations at 62.1%, similar to Serafino. Hazlet had the lowest falling number averaged across the four harvest dates at 158 seconds. This was statistically similar to Danko with a falling number of 167 seconds.

Table 4. Harvest measurements and grain quality for winter rye varieties, Alburgh, VT, 2024.

Variety	Yield @ 13.5% moisture	Crude protein @ 12% moisture	Starch @ 12% moisture	Falling number
	lbs ac[-1]	%	%	seconds
Bono	4312[a †]	7.06[b]	**62.1**[a]	**199**[a]
Danko	**4819**[a]	7.19[b]	**62.1**[a]	167[b]
Hazlet	3469[b]	**7.54**[a]	61.7[b]	158[b]
Serafino	4638[a]	7.16[b]	62.0[a]	196[a]
LSD (p=0.10)[‡]	694	0.21	0.21	25.1
Trial mean	4310	7.24	61.9	180

†Treatments marked with the same letter do not differ significantly.
‡LSD; least significant difference at the p=0.10 level.

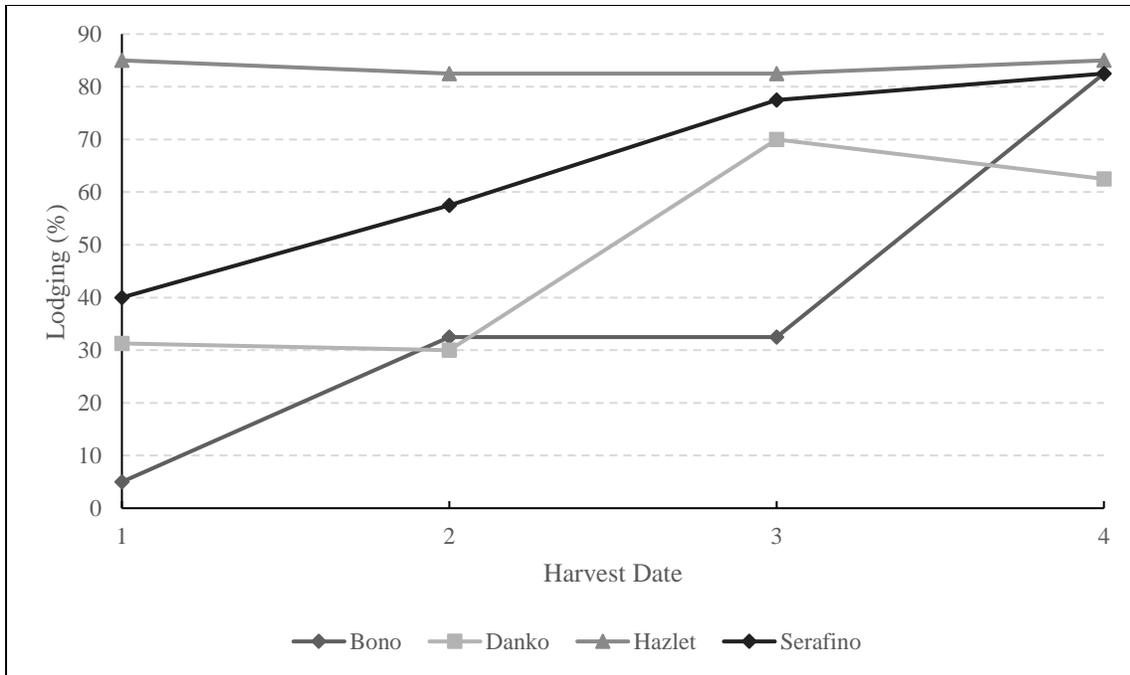*Harvest date x variety interactions*

There were several significant variety x harvest date interactions (Table 5 and 6) including for lodging (Figure 1), test weight (Figure 2), yield (Figure 3), protein (Figure 4), starch and falling number (Figure 5).

Table 5. Harvest measurements and grain quality for winter rye varieties, Alburgh, VT, 2024.

| Variety	Harvest Date	Height	Lodging	Harvest moisture	Test weight
		cm	%	%	lbs bu^{-1}
Bono	1	124	5.00	12.8	56.7
	2	125	32.5	14.2	53.0
	3	126	32.5	15.1	50.9
	4	121	82.5	15.8	52.8
Danko	1	141	31.3	13.6	53.6
	2	140	30.0	14.3	53.9
	3	137	70.0	14.7	52.1
	4	143	62.5	15.9	52.6
Hazlet	1	161	85.0	13.0	52.3
	2	144	82.5	13.8	52.6
	3	148	82.5	14.3	52.3
	4	146	85.0	15.9	50.6
Serafino	1	130	40.0	14.5	51.2
	2	129	57.5	13.4	53.6
	3	134	77.5	14.9	52.0
	4	130	82.5	16.4	52.8
p-value (0.10)		NS[†]	0.001	NS	0.016
Trial mean		136	58.7	14.5	52.7

† NS; Not statistically significant.

Patterns in lodging had little similarity across varieties, but they were all high on the final harvest date (Figure 1). Hazlet had high lodging throughout the trial even at the first harvest date. Serafino's lodging increased steadily as it sat in the field. Danko had a marked increase in lodging between HD2 and HD3, with similar lodging rates in the first and last two harvest dates. Bono had a slight increase in lodging after the first harvest date and a marked increase after the third harvest date.

Figure 1: Interaction between harvest date and variety for lodging.

Test weight had the biggest differences between varieties on HD1, with Bono having the highest and Serafino the lowest. Bono declined in test weight over the first three harvest dates, but on the final harvest date had test weight similar to the test weight on HD2. On the final harvest date, Hazlet had much lower test weight than the rest on (Figure 2).
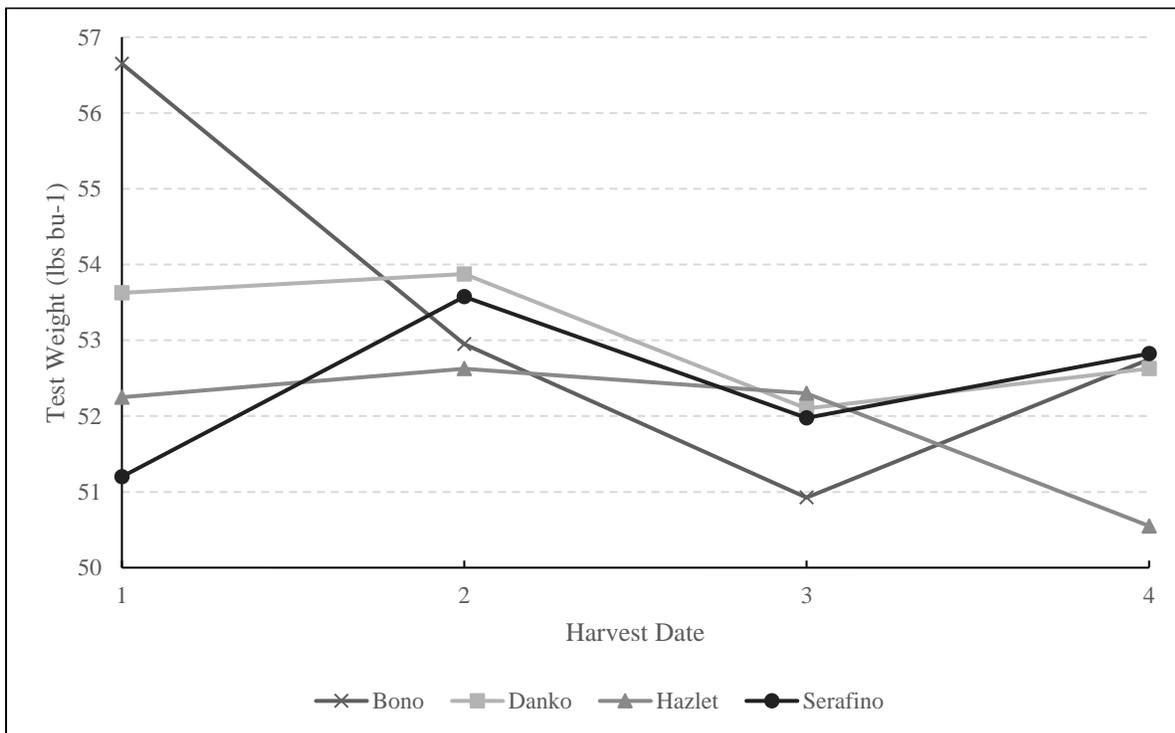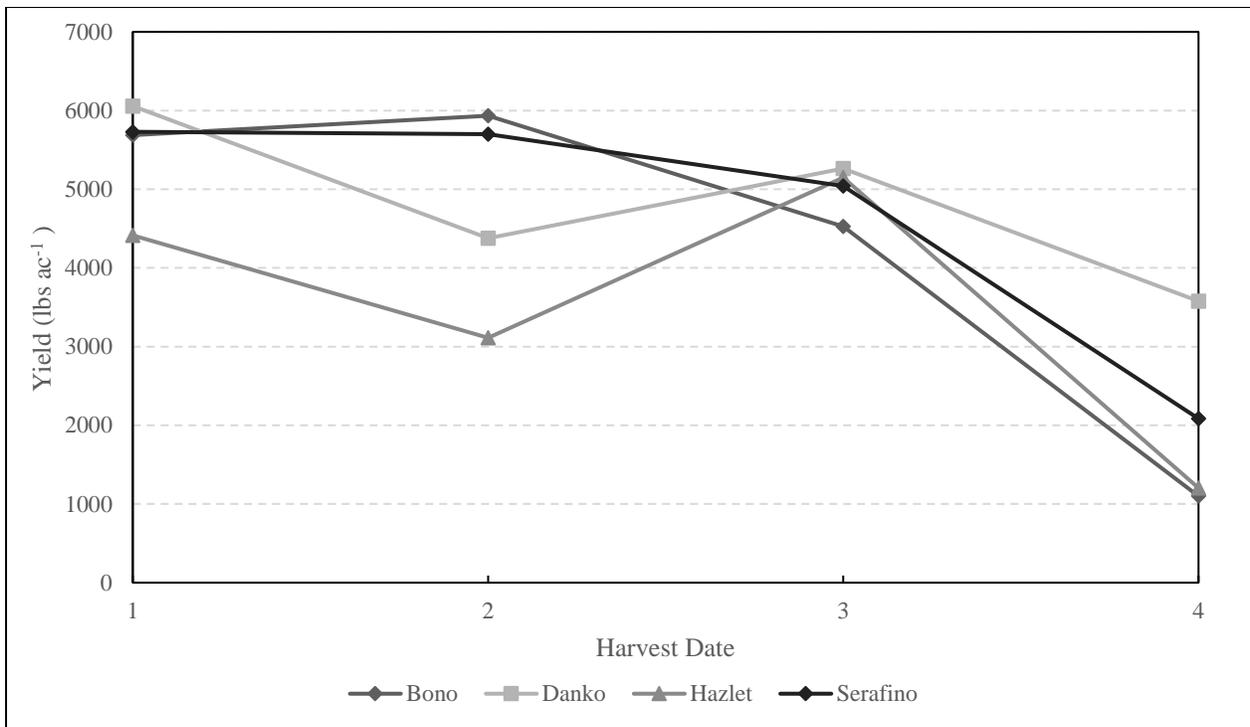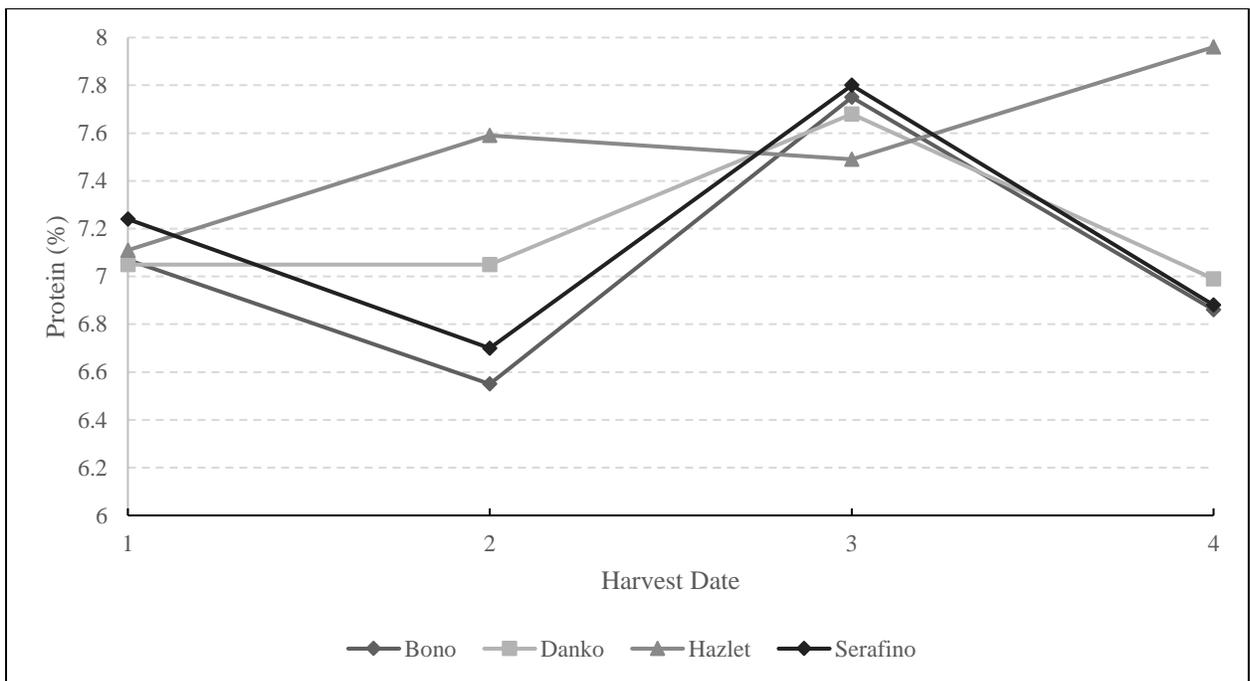

Figure 2: Interaction between harvest date and variety for test weight.

Yield had the biggest differences on HD1 and HD2, and they all decreased by HD4 due to lodging (Table 6, Figure 3). Yields for Danko and Hazlet declined on HD2, unlike Bono and Serafino which stayed relatively consistent from HD1 to HD2 and declined over the last two harvest dates. For starch, all varieties performed similarly except for Hazlet, which was lower than the rest on HD2 and HD4.

Table 6. Harvest measurements and grain quality for winter rye varieties, Alburgh, VT, 2024.

| Variety	Harvest Date	Yield @ 13.5% moisture	Crude protein @12% moisture	Starch @ 12% moisture	Falling number
		lbs ac-1	%	%	seconds
Bono	1	5687	7.07	61.8	231
	2	5934	6.55	62.4	260
	3	4528	7.75	61.5	160
	4	1100	6.86	62.5	146
Danko	1	6057	7.05	61.9	225
	2	4379	7.05	62.2	178
	3	5262	7.68	61.7	185
	4	3578	6.99	62.6	80
Hazlet	1	4412	7.11	61.9	236
	2	3113	7.59	61.6	129
	3	5148	7.49	61.9	202
	4	1203	7.96	61.6	64
Serafino	1	5730	7.24	61.9	209
	2	5698	6.7	62.4	274
	3	5040	7.8	61.3	169
	4	2085	6.88	62.6	132
p-value (0.10)		0.043	0.002	0.002	0.001
Trial mean		4310	7.24	61.9	180

Figure 3: Interaction between harvest date and variety for yield.

Figure 4: Interaction between harvest date and variety for crude protein.

Protein concentrations for the varieties showed a similar pattern for three varieties (Serafino, Danko and Bono) with a slight decrease in protein between the first and second harvest dates, higher protein on the third harvest date, and lower protein again on HD4. Hazlet had higher protein on HD2, a very small decrease in protein on HD3, and an increase in protein on HD4 (Figure 4).
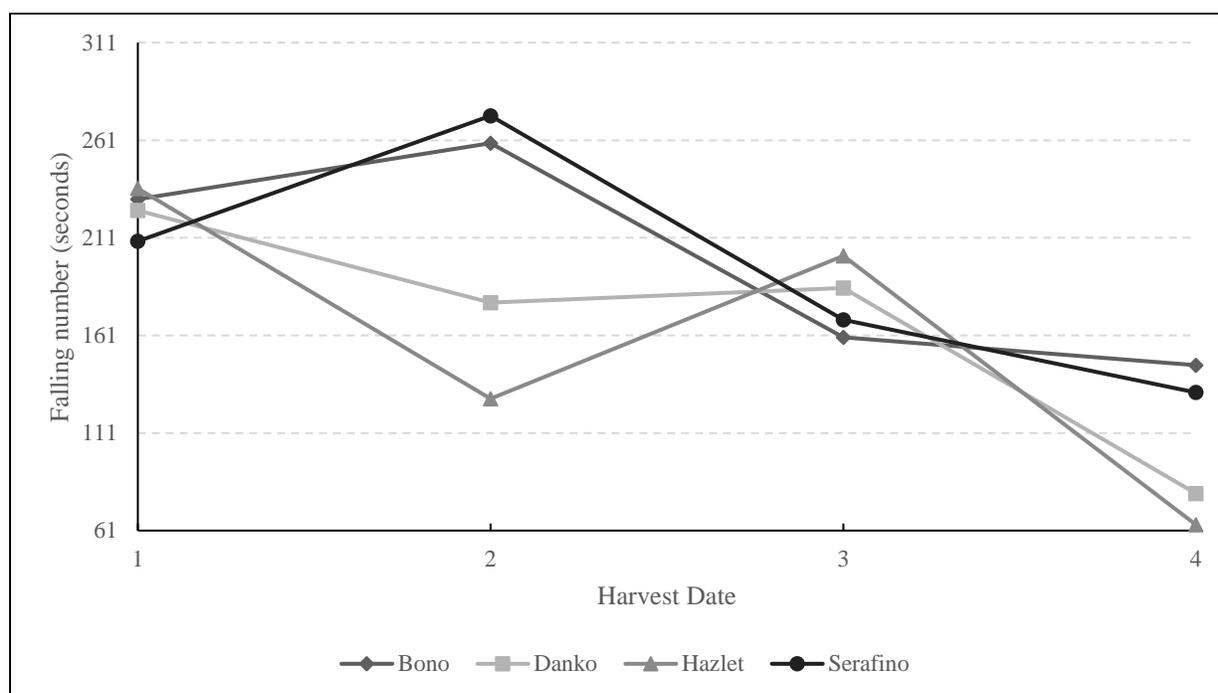
Figure 5: Interaction between harvest date and variety for falling number.

Bono and Serafino showed similar reactions to harvest date in terms of falling number, with slightly higher falling number on the second harvest date but declining steadily on harvest dates 3 and 4 (Figure 5). Danko and Hazlet had falling numbers that fell on HD2, rose or stayed steady on HD3, and declined precipitously on HD4.

Falling number
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 ripening prior to harvest. Falling number is a widely understood indicator of wheat flour quality, though its use as an indicator of rye flour quality is less understood. Low falling number in wheat, below 250, has a negative impact on bread quality and can lead to lower prices paid for the wheat or possible rejection at the mill. The ideal range for wheat is 250-350. High falling numbers, over 400 seconds, can potentially lead to slower fermentation, poorer loaf volume and drier bread texture, depending on the end product although effects of high falling number can be mitigated by addition of malt extract. Because rye bread relies on different grain components to create high-quality bread, and ferments more quickly than wheat, it is expected that lower falling numbers are preferred for rye than for wheat, likely lower than 200 seconds and potentially as low as 100 seconds. For rye, waiting longer to harvest may result in grains that are more suited for baking as currently, bakers seem to desire lower falling numbers than are needed for wheat. One of the goals of this trial is to generate rye with a variety of falling numbers for further bake tests to examine the role of falling number in rye quality.

DISCUSSION

This is the seventh year that a rye harvest date study has been conducted by the NWCS team in Alburgh, Vermont. Falling number typically decreases the longer harvest is delayed, however, this overall trend does have some variation from year to year and is not always linear. This year there was variation in falling number and some varieties did not consistently decrease in falling number over the harvest season (Figure 5). Wet weather during field ripening appears to decrease falling number more quickly than dry weather. During a harvest period with greater amounts of rainfall from week to week, there is greater potential for harvest timing to affect grain quality. This can be an important consideration when attempting to determine ideal harvest windows as farmers may be forced to harvest at an earlier or later date to salvage a crop and maintain grain quality.

Lodging is the percentage of plants that have fallen over while growing, this makes them unsuitable for harvest. In 2024 lodging was high, and the varieties typically increase in lodging with each harvest date. Hazlet had particularly high lodging, between 80 and 90% for all four harvest dates (Figure 1). This impacted both yields and falling numbers. DON, or deoxynivalenol, is a mycotoxin, and above 1 ppm it is unsuitable for human consumption. In previous years, the DON levels exceeded this value and could not be used, and so there were no bake tests performed to determine baking quality. In 2024, all samples tested were below 1 ppm and are safe for consumption. While varieties did not respond consistently to harvest dates, there was wide range of falling numbers generated and with low DON across the trial this was an excellent year to generate rye flours with different falling number for bake tests.

End use should be considered, among other factors, when determining harvest date. Where a low falling number may be appropriate for bakers, because it may also indicate pre-harvest sprouting it is less desired for malting, a process in which grain is sprouted in a controlled method for beer and spirit production. If the rye is destined for a malt house, brewery or distillery, lower falling number may not necessarily be preferred. This research seeks to more clearly identify common and appropriate falling number ranges for cereal rye in the Northeast to assist growers and end-users understand the quality of rye crops.

ACKNOWLEDGEMENTS

UVM Extension helps individuals and communities put research-based knowledge to work.

THE UNIVERSITY OF VERMONT
EXTENSION