



2023 Rye Harvest Date



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Cereal rye is a popular cover crop across the Northeast. The interest in growing rye for grain to be sold to 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 yield and quality information on cereal rye varieties and agronomic best practices for raising high-quality rye. In 2022-2023, 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. One parameter of particular interest is falling number. Falling number is 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 field was prepared with a Pottinger TerraDisc® to prepare the seedbed for planting. The experimental design was a randomized complete block with split plots and 4 replicates. The main plots were harvest date and variety the split-plot. The varieties evaluated were Bono, Danko, Hazlet and Serafino. Rye was planted with a Great Plains cone seeder on 17-Sep 2022. Plots were 5' x 20' (Table 1).

Table 1. Agronomic and trial information for the rye cover crop variety trial, 2022-2023.

	Borderview Research Farm, Alburgh, VT
Soil Type	Benson rocky silt loam
Previous Crop	Spring grains
Tillage Operations	Pottinger TerraDisc®
Harvest Area (ft.)	5 x 20
Seeding Rate (live seeds m ⁻²)	350
Replicates	4
Planting Date	17-Sep 2022
Harvest Dates (HD)	HD 1: 25-Jul 2023
	HD 2: 1-Aug 2023
	HD 3: 6-Aug 2023
	HD 4: 11-Aug 2023

Grain plots were harvested with an Almaco SPC50 plot combine at approximately one week intervals through the end of July and beginning of 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 each harvest date was tested for DON levels and all were determined to be above 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 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.

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

RESULTS

The fall of 2022 had average weather in terms of precipitation and temperature. The main growing season in the spring and summer of 2023 was slightly cooler than average and much wetter. Over 28 inches of rain fell from April through July, 9.65 inches more than normal. A total of 6503 growing degree days (GDDs) accumulated over the fall of 2022 and spring and summer of 2023, 32 GDDs more than normal.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2022 and 2023 growing season.

Alburgh, VT	22-Sep	22-Oct	22-Nov	23-Apr	23-May	23-Jun	23-Jul	23-Aug
Average temperature (°F)	60.2	51.3	41.5	48.3	57.1	65.7	72.2	67.0
Departure from normal	-2.52	0.96	2.24	2.7	-1.28	-1.76	-0.24	-3.73
Precipitation (inches)	4.40	2.56	3.01	4.94	1.98	4.4	10.8	6.27
Departure from normal	0.73	-1.27	0.31	1.87	-1.78	0.14	6.69	2.73
Growing Degree Days (base 32°F)	861	607	346	524	766	1027	1274	1098
Departure from normal	-61	39	111	112	-53	-37	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. (http://www.nrcc.cornell.edu/page_nowdata.html).

Impact of Harvest Date

Yield was measured at the time of harvest (Table 3). Yields were highest at HD4 on 11-Aug at 4430 lbs ac⁻¹. This was statistically similar to yields from HD1 and HD2. The lowest yield was HD3 with 3597 lbs ac⁻¹. The highest protein was 6.87% (adjusted to 12% moisture content) on HD3. The other harvest dates ranged from 6.53-6.58% protein. HD3 also produced the rye with the highest starch concentrations at 63.3% (also adjusted to 12% moisture content). The other harvest dates ranged from 63.0-63.3%. Falling number declined steadily over the harvest dates. The highest falling number was on HD1 at 249 seconds, declining to 165 seconds by the second harvest date, 146 seconds by the third, and 89 seconds on the fourth harvest date.

Table 3. Harvest measurements and grain quality for winter rye harvest dates, Alburgh, VT, 2023.

Harvest date	Yield @ 13.5% moisture lbs ac ⁻¹	Crude protein @ 12% moisture %	Starch @ 12% moisture %	Falling number seconds
25-Jul	4308 ^{a†}	6.53 ^b	63.0 ^b	249 ^a
1-Aug	4422 ^a	6.55 ^b	63.0 ^b	165 ^b
6-Aug	3597 ^b	6.58 ^b	63.3 ^a	146 ^b
11-Aug	4430 ^a	6.87 ^a	63.0 ^b	89 ^c
LSD (p=0.10)‡	533	0.24	0.23	32.7
Trial mean	4189	6.63	63.1	162

†Within a column, treatments with the same letter were not statistically different from the top performer (in bold).

‡LSD; least significant difference at the p=0.10 level.

Impact of Variety

The highest yielding variety across harvest dates was Bono, with 4855 lbs ac⁻¹. This was statistically similar to Serafino with 4407 lbs ac⁻¹. Hazlet had the highest concentrations of protein at 7.19%, statistically dissimilar from the other varieties. Serafino had the highest starch concentrations at 63.31%, similar to Bono and Danko. Danko had the lowest falling number averaged across the four harvest dates at 105 seconds. This was statistically similar to Danko with a falling number of 130 seconds.

Table 4. Harvest measurements and grain quality for winter rye varieties, Alburgh, VT, 2023.

Variety	Yield @ 13.5% moisture lbs ac ⁻¹	Crude protein @ 12% moisture %	Starch @ 12% moisture %	Falling number seconds
Bono	4855 ^{a†}	6.43 ^{bc}	63.1 ^a	184 ^b
Danko	4250 ^b	6.62 ^b	63.1 ^a	130 ^a
Hazlet	3244 ^c	7.19 ^a	62.8 ^b	105 ^a
Serafino	4407 ^{ab}	6.29 ^c	63.3 ^a	229 ^c
LSD(p=0.10)‡	533	0.24	0.23	32.7
Trial mean	4189	6.63	63.1	162

†Within a column, treatments with the same letter were not statistically different from the top performer (in bold).

‡LSD; least significant difference at the p=0.10 level.

Harvest date x variety interactions

There were no statistically significant harvest date x variety interactions; in other words, all varieties performed similarly at each harvest date.

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 in particular, 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. Rye from the 2022-2023 harvest date trial was too high in DON concentrations to be used in bake tests to test for effects of falling number on baking quality.

DISCUSSION

This is the sixth year that a rye harvest date study has been conducted by the NWCS team in Alburgh, Vermont (Figure 1). An overall trend has been clear of falling number decreasing as cereal rye ripens in the field. This overall trend does have some variation from year to year and is not always linear. 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.

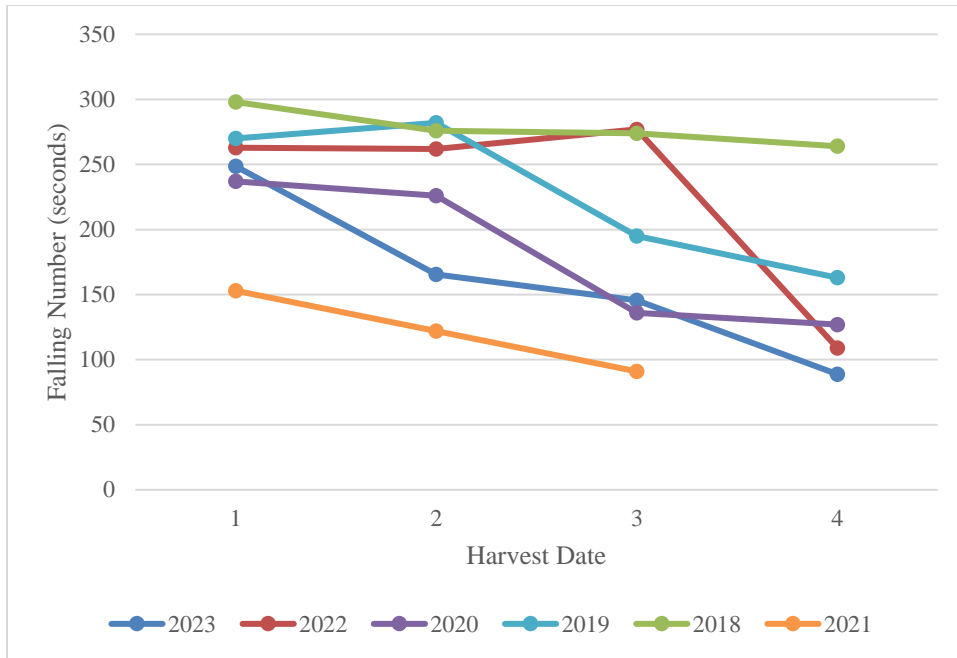


Figure 1. Falling number by harvest date for 6 years of study in Alburgh, VT.

This trend of falling number decreasing from the first harvest date until the last harvest date was consistent for most of the varieties in the 2023 harvest date study (Figure 2). Serafino had a slightly higher falling number in the third harvest date than the second harvest date. However, this difference was not statistically significant.

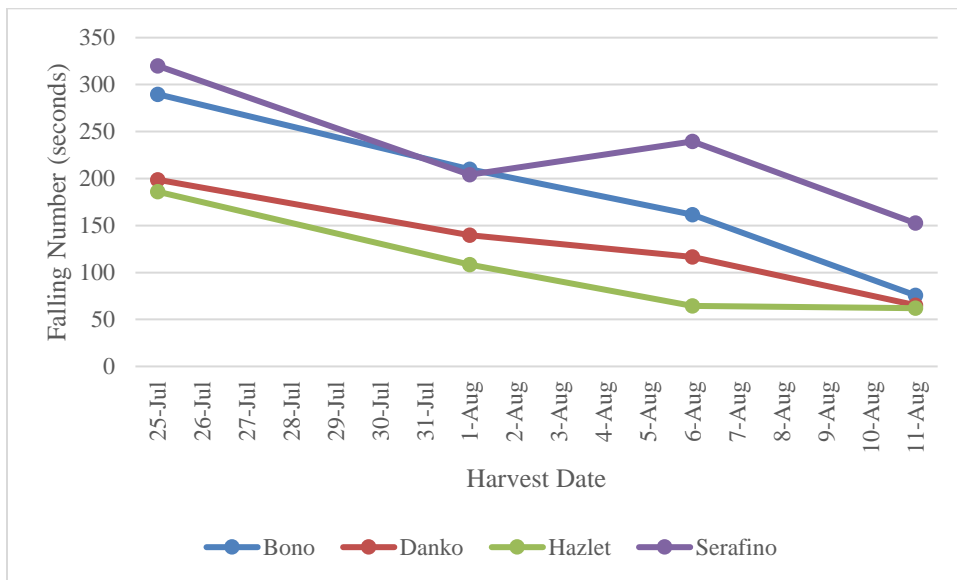


Figure 2. Interaction between harvest date and variety for falling number, 2023.

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. A 2024 rye harvest date trial has been planted in the fall of 2023 with the same four varieties trialed in 2023 to continue to evaluate the impact of harvest date and harvest conditions on cereal rye quality.

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