NORTHWEST CROPS & SOILS PROGRAM

2021 Rye Harvest Date

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THE UNIVERSITY OF VERMONT EXTENSION

2021 RYE HARVEST DATE

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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. As a result, farmers and end-users are requesting yield and quality information on cereal rye varieties. In 2021, 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. 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 two common varieties of cereal rye.

MATERIALS AND METHODS

The field was plowed, disked, and prepared with a spike tooth harrow 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 the split plots variety (Danko and Hazlet). The plots were planted with a Great Plains cone seeder on 25-Sep 2020 and plots were 5' x 20' (Table 1).

Table 1. Agronomic and trial information for the rye cover crop variety trial, 2019-2020.

	Borderview Research Farm, Alburgh, VT
Soil Type	Benson rocky silt loam
Previous Crop	Spring grains
Tillage Operations	Fall plow, disc, and spike tooth harrow
Harvest Area (ft.)	5 x 20
Seeding Rate (live seeds m^{-2})	350
Replicates	4
Planting Date	25-Sep 2020
Harvest Dates (HD)	HD 1: 21-Jul 2021 HD 2: 30-Jul 2021 HD 3: 5-Aug 2021 HD 4: 14-Aug 2021

Grain plots were harvested at the Alburgh site with an Almaco SPC50 plot combine at one week intervals through the end of July and beginning of August. Following harvest, seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN). Grain moisture, test weight, and yield were measured. An approximate one-pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial mills. Samples were ground into flour using the Perten LM3100 Laboratory Mill. At this time, flour was evaluated for its protein content and falling number. Grains were analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. The determination of falling number (AACC Method 56-81B, AACC Intl., 2000) was measured on the 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.

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

Seasonal precipitation and temperature recorded at Borderview Research Farm in Alburgh, VT are displayed in Table 2. A cooler than average fall, but warmer and drier summer, led to 2705 Growing Degree Days (GDDs) accumulated April to July, which was 273 GDDs above the 30-year average for those months. The precipitation from April to July was 5.12" below normal. Overall, precipitation across the entire growing season from Sep to Jul, was 3.08" below average.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2020 and 2021 growing season.

	2020			2021				
	Sep	**Oct**	**Nov**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Average temperature (°F)	68.8	59.2	48.3	19.8	33.2	48.1	58.4	70.3
Departure from normal	-1.89	-3.53	-2.01	-3.07	0.93	2.52	-0.03	2.81
Precipitation (inches)	6.77	2.75	3.56	0.47	0.97	3.52	0.66	3.06
Departure from normal	3.23	-0.92	-0.27	-1.30	-1.27	0.45	-3.10	-1.20
Growing Degree Days (32°-95°F)	1141	816	521	32	241	497	818	1149
Departure from normal	-58	-107	-48	21	103	85	-1	86

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).

Between the third and fourth harvest dates, substantial lodging occurred. As a result, the fourth harvest on 14-Aug was unsuccessful and too little usable rye was harvested to be analyzed or included in the data analysis.

Impact of Harvest Date

Yield, harvest moisture, and test weight were measured at the time of harvest (Table 3). Yields were highest at HD1 on 21-Jul at 4773 lbs ac^{-1}. Yield declined steadily through the harvest season and yield from the first harvest date was significantly different from the second two harvest dates. Harvest moisture varied across the study period with highest harvest moisture occurring on 30-Jul, nearly double the harvest moisture on the other two dates and statistically different from both dates. Test weight was highest in HD1 at 54.2 lbs bu^{-1} with no other harvest dates statistically similar.

Table 3. Harvest measurements and grain quality for winter rye harvest dates, Alburgh, VT, 2021.

Harvest date	Yield @ 13.5% moisture	Harvest moisture	Test weight	Crude protein	Falling number
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds
21-Jul	**4773**	17.4*	**54.2**	10.2	**153**
30-Jul	4164	32.5	52.2	**10.9**	122
5-Aug	4035	**15.2***	52.2	10.2	91
LSD (p=0.10)	600.2	0.85	1.51	0.53	19.3
Trial mean	4324	21.7	52.9	10.4	122

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.

Crude protein varied very little across harvest dates. The highest value was 10.9% on the second harvest date, statistically different than the other two harvest dates which both had protein at 10.2%. Falling number across all harvest dates was statistically different. Falling number was highest at HD1 with a value of 157 seconds. After the first harvest date, values decreased greatly for HD2 at 122 seconds and HD3 at 91 seconds.

Impact of Variety

While yields did not differ as an impact of harvest date, there were varietal differences between Danko and Hazlet with an average trial yield of 4498 lbs ac^{-1} and 4119 lbs ac^{-1} respectively, though the yield differences were not significant (Table 4). There were significant differences in test weight and harvest moisture by variety. Hazlet had statistically significantly lower harvest moisture although both varieties had to be dried down for storage on all harvest dates. Danko had significantly higher test weight at 53.1 lbs bu^{-1}. Although crude protein was slightly higher for Hazlet, the difference was not statistically different. Danko had better falling number at 140 seconds, statistically different from Hazlet with a falling number of 101 seconds.

Table 4. Harvest measurements and grain quality for winter rye varieties, Alburgh, VT, 2021.

Variety	Yield @ 13.5% moisture	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds
Danko	**4498***	22.4	**53.1**	10.3*	**140**
Hazlet	4119*	**21.0**	52.6	**10.5***	101
LSD(p=0.10)	NS	0.69	NS	NS	7
Trial mean	4324	21.7	52.9	10.4	122

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. NS – No significant differences.

Harvest date x variety interactions

There were no statistically significant harvest date x variety interactions; in other words, both 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. 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.

DISCUSSION

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. Both varieties trialed in 2021 showed a decrease in falling number as harvest was delayed through the growing season (Figure 1).

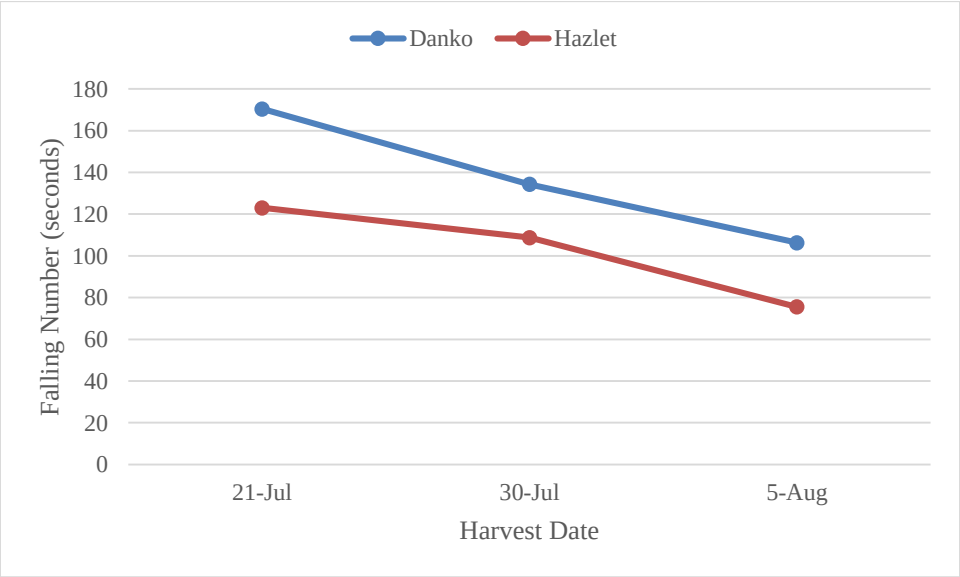

Figure 1. Interaction between harvest date and variety for falling number, 2021.

The trend of falling number decreasing from the first harvest date until the last harvest date has been consistent over the four years of the harvest date study (Figure 2). However, this decrease has not been universally beneficial. In the first three years of the study, the rye falling number started out higher than optimum and standing in the field for some weeks lowered falling number, increasing baking quality. However, in 2021, the falling number at the first date was acceptable and the subsequent drop in falling number may have lowered falling number too far for good rye baking quality (particularly for the third harvest date).

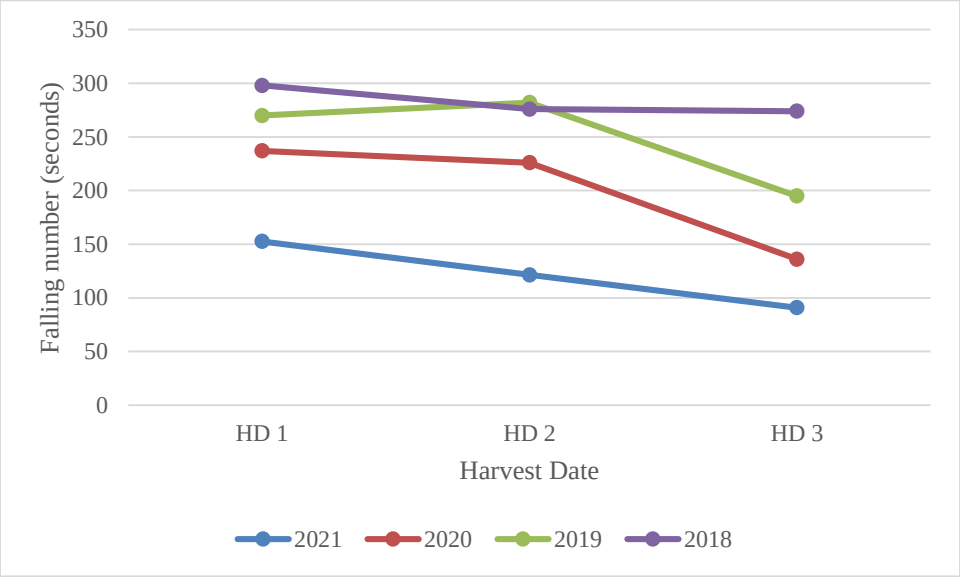

Figure 2. Falling number by harvest date for 4 years of study in Alburgh, VT.

This trial also indicates that for some parameters, such as harvest moisture and falling number, varietal selection can also be important and varieties may react differently to a delayed harvest (Figure 1). In 2021, a Rye Variety Trial was conducted on 12 cultivars of winter rye. This rye was harvested one day after the first harvest date for the harvest date trial. The two varieties trialed in the harvest date trial were also trialed separately in the variety trial. The falling numbers for Danko and Hazlet were similar between the first harvest date in the harvest date trial and the variety trial (Figure 1, Figure 3). There was a very broad range of falling numbers in the variety trial. While the Danko and Hazlet varieties were near or within the ideal falling number range for rye at the first harvest date, several varieties had falling numbers well over the idea range and may have benefited from further time standing in the field before harvest to reduce falling number (KWS Tayo, Serafino, and Brasetto).

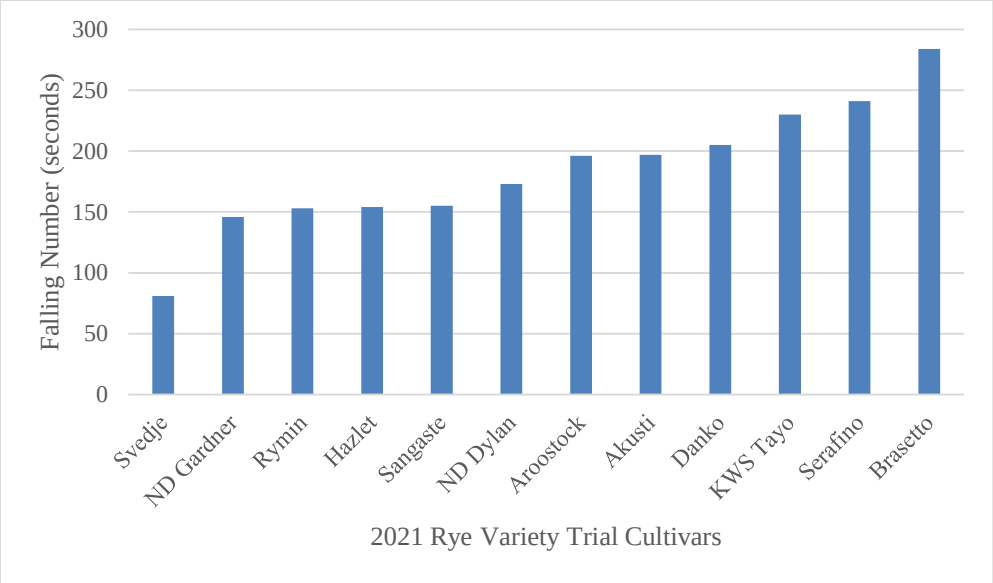

Figure 3. Falling number of 12 rye cultivars in the rye variety trial, Alburgh VT 2021.

End use should be considered, among other factors, when determining harvest date. Whereas low falling number (an indication of pre-harvest sprouting) may be appropriate for bakers, 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 as described here may be less 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.

We intend to continue this research in 2022 to continue to evaluate the impact of harvest date on rye quality through a range of growing season and harvest season conditions.

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