2020

Winter Rye Harvest Date

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NORTHWEST CROPS & SOILS PROGRAM

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THE UNIVERSITY OF VERMONT EXTENSION

2020 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 2020, 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. Wheat and barley require timely harvest to maintain quality, particularly falling number, for successful baking and brewing. It is unclear to what extent harvest timing impacts falling number in cereal rye. Subsequently, there is little knowledge if rye with high or low falling number is required for baking. The goal of this project was to evaluate the impact of harvest date on yields and quality parameters, specifically falling number, across two rye varieties.

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 20-Sep 2019 and plots were 5' x 20' (Table 1). Prior to first harvest date, on 23-Jul 2020 and each subsequent harvest date, three plant heights per plot were measured.

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	20-Sep 2019
Harvest Dates	HD 1: 23-Jul 2020 HD 2: 29-Jul 2020 HD 3: 7-Aug 2020 HD 4: 12-Aug 2020

Grain plots were harvested at the Alburgh site with an Almaco SPC50 plot combine on 23-Jul, 29-Jul, 7-Aug, and 12-Aug. Following harvest, seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN). Grain moisture, test weight, and yield were calculated. An approximate one-pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial mills. Test weight was measured by the weighing of a known volume of grain. Once test weight was determined, the samples were then ground into flour using the Perten LM3100 Laboratory Mill. At this time, flour was evaluated for its protein content, falling number, and mycotoxin levels. 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. Deoxynivalenol (DON) analysis was done using Veratox DON 5/5 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.

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. The winter temperatures were warmer than average, leading to strong winter survival. A cooler than average spring, but warmer and drier summer led to 3433 Growing Degree Days (GDDs) accumulated April to July, which was 55 GDDs above the 30-year average. Precipitation from April to July was 3.81 inches below normal. Overall, precipitation across the entire growing season from September to July, was 1.61 inches below average, with a total of 5317 GDDs from September through July, which was 30 less than average.

Table 2. Temperature and precipitation summary for Alburgh, VT, 2019 and 2020.

	2019				2020						
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Average temperature (°F)	60.0	50.4	31.2	26.0	23.5	21.8	35.0	41.6	56.1	66.9	74.8
Departure from normal	-0.51	2.32	-6.76	0.46	4.62	0.41	3.94	-3.19	-0.44	1.08	4.17
Precipitation (inches)	3.87	6.32	2.38	1.29	2.63	1.19	2.79	2.09	2.35	1.86	3.94
Departure from normal	0.21	2.76	-0.74	-1.06	0.63	-0.53	0.57	-0.72	-1.04	-1.77	-0.28
Growing Degree Days (32°-95°F)	840	571	128	67	37	48	193	315	746	1046	1326
Departure from normal	-15	58	-122	-13	-12	-8	27	-99	-13	35	132

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, harvest moisture, and test weight were measured at the time of harvest (Table 3). From the four different harvest dates (HD), yields were highest at HD1 on 23-Jul at 4648 lbs ac^{-1}. Yields from the first two harvest dates were significantly different from the second two harvest dates. Harvest moisture varied across the month long period with highest harvest moisture occurring during the last period on 12-Aug. The lowest harvest moisture was observed on the first harvest date on 23-Jul. Test weight was highest in HD1 at 56.4 lbs bu^{-1} with no other harvest dates statistically similar. The lowest test weight was observed at HD4 at 50.4 lbs bu^{-1}.

Table 3. Harvest measurements for winter rye harvest dates, Alburgh, VT, 2020.

Harvest date	Yield @ 13.5% moisture	Harvest moisture	Test weight
	lbs ac^{-1}	%	lbs bu^{-1}
23-Jul	4648 a†	13.7 c	56.4 a
29-Jul	4489 a	15.7 b	55.1 b
7-Aug	3402 b	14.2 c	54.3 b
12-Aug	3770 b	18.4 a	50.4 c
LSD (p=0.10)	601	0.6	1.0
Trial mean	3527	15.5	54.0

† Within a column, values marked with the same letter are statistically similar at the p=0.10 level.

The four harvest dates were analyzed for crude protein concentration, adjusted to 12% moisture, and falling number (Table 4). Crude protein ranged from 8.0% to 8.4% with the highest values observed during HD1, HD2 and HD4, which were all statistically similar and the lowest protein observed during HD3 which was statistically lower. Falling number was highest at HD1 with a value of 237 seconds, statistically higher than to HD2 at 226 seconds. After the first two harvest dates, values decreased greatly for HD3 at 136 seconds and HD4 at 127 seconds. Overall, tested DON levels were low this year and all varieties had a DON level suitable for human consumption.

Table 4. Grain quality for the four cereal rye variety harvest dates, Alburgh, VT, 2020.

Harvest date	Crude protein @ 12% moisture	Falling number
	%	seconds
23-Jul	8.4 a†	237 a
29-Jul	8.4 a	226 b
7-Aug	8.0 b	136 c
12-Aug	8.2 a	127 c
LSD (p=0.10)	0.2	11
Trial mean	8.2	182

† Within a column, values marked with the same letter are statistically similar at the p=0.10 level.

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 4052 lbs ac^{-1} and 4102 lbs ac^{-1} respectively, though the yield differences were not significant (Table 5). There were significant differences in test weight by variety, Danko at 54.6 lbs bu^{-1} and Hazlet at 53.5 lbs bu^{-1} and falling number with Danko averaging 224 seconds and Hazlet averaging 139 seconds. Overall, Danko had insignificantly lower yields and protein and significantly higher test weight and falling number.

Table 5. Harvest measurements and grain quality for winter rye varieties and harvest dates, Alburgh, VT, 2020.

Variety	Harvest date	Yield @ 13.5% moisture	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number
		lbs ac^{-1}	%	lbs bu^{-1}	%	seconds
Danko	23-Jul	4659	13.1	57.0	8.5	287
Danko	29-Jul	4443	15.9	55.6	8.4	268
Danko	7-Aug	3294	14.2	55.1	7.9	177
Danko	12-Aug	3815	18.3	50.9	8.1	163
Hazlet	23-Jul	4638	14.3	55.8	8.3	188
Hazlet	29-Jul	4535	15.4	54.5	8.5	184
Hazlet	7-Aug	3510	14.1	53.5	8.0	95
Hazlet	12-Aug	3726	18.5	49.9	8.3	91
Danko	Trial average	4052	15.4	54.6 [a]	8.2	224 [a]
Hazlet	Trial average	4102	15.6	53.5 [b]	8.3	139 [b]
LSD(p=0.10)		NS	NS	0.7	NS	7
Trial mean		4077	15.5	54.0	8.2	181

NS – No significant differences.

Harvest date x variety interactions

There were statistically significant harvest date x variety interactions for falling number and harvest moisture. These interactions indicate that the varieties responded differently to harvest date for these parameters. In terms of harvest moisture, lowest values for Danko were seen prior to the fourth harvest date (18.3%), whereas lowest values for Hazlet were seen on HD1 (14.3%) and HD3 (14.1%).

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 it's 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, possibly closer to 100-200.

Looking at falling number, in the 2019 Harvest Date Trial (Figure 1) Hazlet had a more severe drop in values over the 4-week period, decreasing by 139 seconds from HD1 to HD4, compared to Danko which decreased by 96 seconds from HD1 to HD4. In this year's trial, however, Danko had a more severe drop over the 4-week harvest period, decreasing by 124 seconds from HD1 to HD4, while Hazlet decreased 97 seconds over the same period. Hazlet did have significantly lower falling number values overall in the trial.

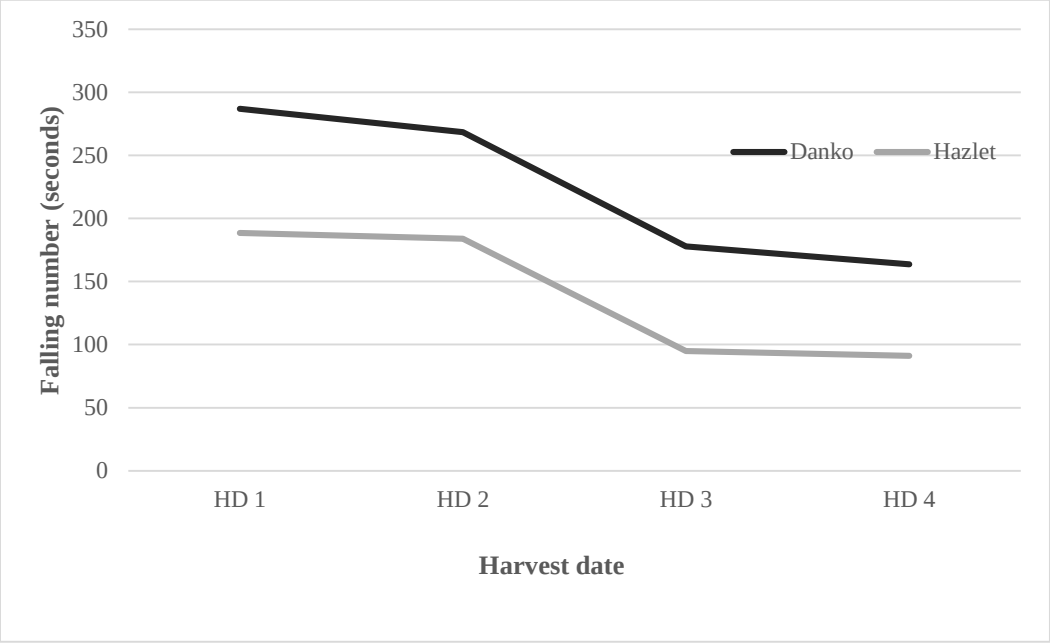

Figure 1. Interaction between harvest date and variety for falling number, 2020.

Figure 2 shows the same falling number trends from Figure 1 alongside observed rainfall between each harvest date. From 1-Apr to 23-Jul (HD1) there was 9.24 inches of rainfall, nearly 4 inches less than the 30-year average. One inch of rain fell between HD1 and HD2, over 4 inches fell between HD2 and HD3, and less than a quarter inch between HD3 and HD4. On 4-Aug, there was a 2.98 inch rainfall event which most likely began the sprouting process in HD3 and HD4. The HD3 occurred three days after the rainfall, with an additional 0.12 inches falling before HD4 (Table 6). Though small amounts of rainfall, or even prolonged periods of humid weather, can increase the risk of pre-harvest sprouting and, in turn, lower the falling number, this is a clear example of that happening in early August.

Table 6. Observed rainfall, 2020.

Date	Rainfall (inches)
27-Jul	1
29-Jul	0.5
30-Jul	0.4
2-Aug	0.31
4-Aug	2.98
9-Aug	0.03
10-Aug	0.01
11-Aug	0.08

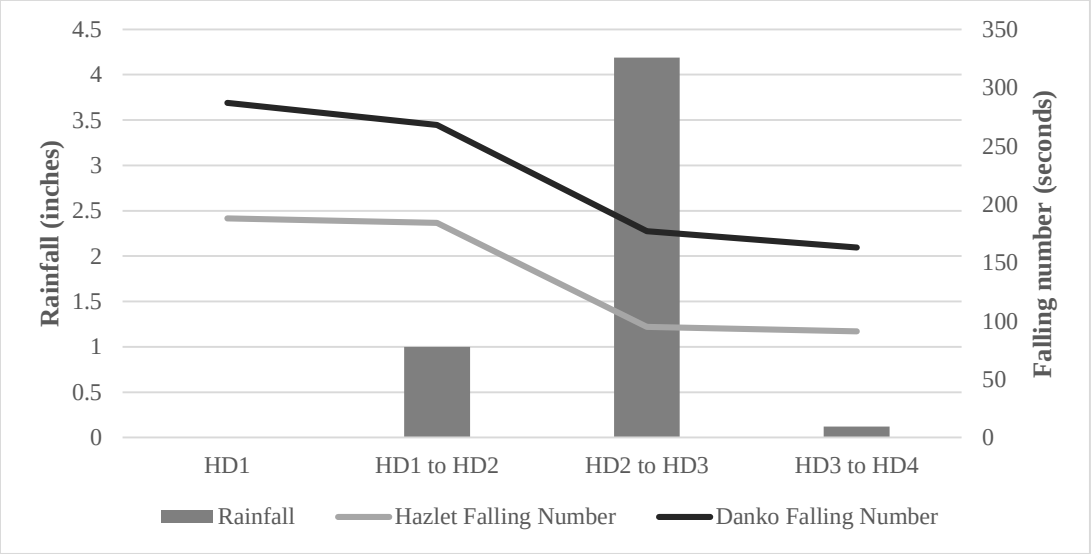

Figure 2. Interactions between rainfall and falling number values during harvest period, 2020.

DISCUSSION

During a harvest period with greater amounts of rainfall from week to week, there is greater potential for reduced quality crops. This can be an important consideration when attempting to determine ideal harvest windows as you may be forced to harvest at an earlier date to salvage a crop and maintain grain quality. While harvest date did not appear to impact yields, it did have an effect on grain quality. 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.

Consistent with last year's observations, falling number had a decreasing trend from the first harvest date until the last harvest date over the four-week window for both varieties. 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. 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.

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