NORTHWEST CROPS & SOILS PROGRAM

2019 Rye Nitrogen Fertility Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 RYE NITROGEN FERTILITY 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. This winter hardy grain has the ability to survive cold winters and can be more tolerant of marginal land not suitable for other crops. As a result, farmers and end-users are requesting yield and quality information on cereal rye varieties. In 2018/2019, University of Vermont Extension Northwest Crops and Soils (NWCS) Program conducted a nitrogen (N) fertility trial to evaluate yield and quality of cereal rye under variable nitrogen application periods.

MATERIALS AND METHODS

The experimental design of the study was a randomized complete block with treatment plots replicated four times (Table 1). Treatments were four nitrogen application timings: 90 lbs N ac^{-1} applied in the fall, 90 lbs N ac^{-1} applied in the spring, 45/45 lbs N ac^{-1} split application applied in fall and spring, and a control receiving no N application (Table 2). Nitrogen was applied in the form of calcium ammonium nitrate (21-0-0). The field was plowed, disked, and prepared with a spike tooth harrow to prepare the seedbed for planting. The plots were 5' x 20' and the rye variety, Hazlet was planted with a Great Plains cone seeder on 6-Oct 2018 at a rate of 100 lbs ac^{-1}.

Table 1: Agronomic and trial information for the rye cover crop variety trial, 2018-2019.

	Borderview Research Farm, Alburgh, VT
Soil Type	Benson rocky silt loam
Previous Crop	Corn
Rye variety	Hazlet
Tillage Operations	Fall plow, disc, and spike tooth harrow
Harvest Area (ft.)	5 x 20
Seeding Rate (lbs ac^{-1})	100
Replicates	4
Fertilizer	Calcium ammonium nitrate (21-0-0)
Planting Date	6-Oct 2018
Harvest Date	5-Aug 2019

Table 2. 2018-2019 Winter rye nitrogen application dates.

Treatment	Application date
90 lbs N ac^{-1} Fall	4-Oct
90 lbs N ac^{-1} Spring	29-Apr
45/45 lbs N ac^{-1} Fall/Spring	4-Oct/29-Apr
Control	N/A

Grain plots were harvested at the Alburgh site with an Almaco SPC50 plot combine on 5-Aug. Ergot (*Claviceps purpurea*) is a fungal disease found most commonly in rye, and it can lead to yield reductions and health problems in humans and animals. To assess the amount of ergot present, two 1 ft^2 samples were collected per plot just prior to harvest, and the ergot incidence (percent of affected heads) was recorded. 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 treatments is real or whether it might have occurred due to other variations in the field. Yield data and stand characteristics were analyzed using the PROC MIXED procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and application treatments were treated as fixed. Treatment mean pairwise comparisons were made using the Tukey-Kramer adjustment. Treatments were considered different at the 0.10 level of significance. At the bottom of each table, a level of significance is presented for each variable (i.e. yield). Treatments that differed at a level of significance >0.10 were reported as being not significantly different. Treatments that were not significantly lower in performance than the top performer in a particular column are indicated with an asterisk. In the example, treatment C is significantly different from treatment A but not from treatment B. This means that these treatments did not differ in yield. The asterisk indicates that treatment B was not significantly lower than the top yielding treatment C, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0**
Level of significance	<0.10

RESULTS

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). During the time of this trial, temperatures were below average for every month except July. During the 2018-2019 season, most months saw below average precipitation with the exception of November (’18), December (’18), April (‘19) and May (’19) which saw above average precipitation. There were 5199 growing degree days (GDDs) across the whole season, 20 growing degree days more than the historical average. While winter survival was not measured in this trial, there were some treatment plots in which the rye did not over-winter and were not harvested as a result.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2018 and 2019.

Alburgh, VT	2018			2019							
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Average temperature (°F)	45.8	32.2	25.4	15.0	18.9	28.3	42.7	53.3	64.3	73.5	68.3
Departure from normal	-2.36	-5.99	-0.55	-3.77	-2.58	-2.79	-2.11	-3.11	-1.46	2.87	-0.51
Precipitation (inches)	3.53	4.50	2.96	1.53	1.70	1.36	3.65	4.90	3.06	2.34	3.50
Departure from normal	-0.07	1.38	0.59	-0.52	-0.06	-0.85	0.83	1.45	-0.63	-1.81	-0.41
Growing Degree Days (32-95°F)	435	136	72	23	38	108	346	660	970	1286	1125
Departure from normal	-67	-50	72	23	38	108	-38	-96	-44	88	-14

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).

Ergot incidence ranged from 6.7% in the split 45 lbs N ac^{-1} fall and 45 lbs N ac^{-1} spring application to 10.0% in the control, however there was no statistically significant difference between treatments (Table 4). Highest yields occurred in the split 45 lbs N ac^{-1} fall and 45 lbs N ac^{-1} spring application with similarly high yields from the 90 lbs N ac^{-1} fall application. However, there was no statistically significant difference between treatments. Test weights were highest for the control plots and the 90 lbs N ac^{-1} spring application, but once again there was no significant difference between treatments within the trial.

Table 4: Harvest measurements by treatment, Alburgh, VT, 2019.

Treatment	Ergot incidence	Yield	Test weight
	% affected heads	lbs ac^{-1}	lbs bu^{-1}
45/45 lbs N ac^{-1} Fall/Spring	**6.7**	**2760**	47.4
90 lbs N ac^{-1} Fall	7.1	2641	48.8
90 lbs N ac^{-1} Spring	7.2	2157	**49.3**
Control	10.0	2111	52.1
p-value	NS	NS	NS
Trial mean	7.6	2411	49.3

Treatments in **bold** are top performers.
NS – No significant difference between treatments.

The four treatments were analyzed for crude protein concentration at 12% moisture and falling number (Table 5). There were no significant differences between treatments for either crude protein or falling number. Crude protein ranged from 10.6% to 11.1%. The 90 lbs N ac^{-1} fall application had the highest crude protein concentration, but lowest falling number. Falling number ranged between 185 and 202; an ideal falling number falls around 260 seconds for wheat flour however, lower falling numbers around 150 seconds have been acceptable to bakers while using rye flour. The 90 lbs N ac^{-1} spring application had the highest falling number of 202 seconds. Overall, DON levels were low this year and all treatments had levels of DON less than the 0.5 ppm detection threshold for the Veratox DON 5/5 Quantitative test.

Table 5: Grain quality by treatment, Alburgh, VT, 2019.

Variety	Crude protein @ 12% moisture	Falling number
	%	Seconds
45/45 lbs N ac^{-1} Fall/Spring	11.0	186
90 lbs N ac^{-1} Fall	**11.1**	185
90 lbs N ac^{-1} Spring	10.8	**202**
Control	10.6	195
p-value	NS	NS
Trial mean	10.9	192

Treatments in **bold** are top performers.

NS – No significant difference between treatments.

DISCUSSION

Fall nitrogen applications to cereal rye may improve stand establishment and spur growth before winter dormancy periods. However, from this experiment, it appeared as if timing of nitrogen applications had little or no effect on the yields or quality of rye produced. While fall applied nitrogen treatments appeared to have slightly higher yields than other treatments, these differences were not significant enough to suggest a treatment response. The winter rye was planted relatively late and also had a short time of growth before abnormally cold temperatures occurred in October and November. This likely limited nitrogen uptake and may have been one reason little response was seen from fall N applications. Challenges with hard winter conditions and perhaps site selection resulted in winterkill within several plots in the trial, potentially influencing some of these results. The University of Vermont Extension Northwest Crops and Soils (NWCS) Program intends to repeat this trial in the 2019/2020 growing season as additional research is required to determine impacts of N application timing and rate on cereal rye productivity in the Northeast.

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