2024 Winter Rye Cover Crop and Forage Variety Trial

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2024 WINTER RYE COVER CROP AND FORAGE VARIETY TRIAL
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In addition to the growing value of winter rye as a cereal grain crop, rye has historically been used as a fall cover crop that is terminated in the spring due to its ability to establish late into the fall after row crop harvest and provide ground cover to reduce soil loss. In this role it has been essential in reducing erosion, maintaining a healthy nutrient cycle, and building soil health. Recently, many livestock farmers have also started to harvest the cover crops in the spring for forage. Small grains, such as rye, can produce high quality spring forage and farmers are interested in growing varieties that will provide conservation benefits and produce high yielding and quality forage. In 2023 - 2024, the University of Vermont Extension Northwest Crops and Soils Program initiated a winter rye variety trial to evaluate rye as both a cover crop and a forage.

MATERIALS AND METHODS

The rye variety trial was initiated at Borderview Research Farm in Alburgh, VT in the fall of 2023. Plots were managed with practices like those used by producers in the surrounding area. Agronomic information is displayed in Table 1. The experimental design was a randomized complete block with four replicates. The field was prepared with a Pottinger TerraDisc™ prior to planting. Plots were seeded in 5' x 20' plots with a Great Plains Cone Seeder on 21-Sep 2023 at a seeding rate of 350 live seeds m^{-2}. Treatments were ten varieties of cereal rye including Aroostook, CoverMax, Danko, Hazlet, ND Gardner, Progas, Receptor, Serafino, Spooner, and Tayo (Table 2).

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	Triticale
Tillage operations	Pottinger Terra Disc™
Harvest area (ft.)	5 x 20
Seeding rate (live seeds m^{-2})	350
Replicates	4
Planting date	21-Sep 2023
Harvest dates	Fall establishment: 25-Oct 2023
	Green-up: 17-Apr 2024
	Boot: 9-May through 16-May 2024
	Flowering: 8-Jun 2024

Table 2. Winter rye varietal information, Alburgh, VT, 2023-2024.

Variety	Type	Intended use	Source
Aroostook	Open-pollenated	Cover crop	Albert Lea Seed
CoverMax	Hybrid	Cover crop	Albert Lea Seed
Danko	Open-pollenated	Grain	Albert Lea Seed
Hazlet	Open-pollenated	Grain	Albert Lea Seed
ND Gardner	Open-pollenated	Cover crop/Forage	Albert Lea Seed
Progas	Hybrid	Forage	Albert Lea Seed
Receptor	Hybrid	Grain	Albert Lea Seed
Serafino	Hybrid	Grain	Albert Lea Seed
Spooner	Open-pollenated	Grain	Albert Lea Seed
Tayo	Hybrid	Grain	Albert Lea Seed

Ground cover evaluations were made using Canapeo application on 25-Oct 2023, prior to hard frost and plant dormancy, and again on 17-Apr 2024 to evaluate spring ground cover and winter survival. Fall biomass samples were also collected on 25-Oct 2023. After ground cover evaluations in the spring, initial biomass samples were taken on 17-Apr 2024, with subsequent biomass samples taken when each rye variety reached the boot stage (9-May through 16-May 2024) and again post flowering on 8-Jun 2024, each harvested from a $0.25m^2$ quadrat.

Wet weights were recorded and an approximate 1 lb subsample was collected and dried to determine dry matter content and calculate dry matter yield. Samples from boot stage harvest times were then ground using a Wiley mill to a 2 mm particle size and then to 1mm using a laboratory cyclone mill from the UDY Corporation.

The samples were analyzed for crude protein (CP), acid detergent fiber (ADF), amylase neutral detergent fiber organic matter (aNDFom), and 30-hour NDF digestibility (NDFDom30) at the E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT) with a FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the crude protein content of forages. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of the plant are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. Some of the NDF is digestible, however. This fraction is reported as NDFD and is represented as a percentage of the total NDF.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and mixtures were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant (p<0.10). 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 (LSDs) at the 0.10 level of significance are shown. Where the difference between two hybrids within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two varieties.

Varieties that were statistically similar in performance to one another share a letter. In this example, variety C is significantly different from variety A but not from variety B. The difference between C 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 C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that these varieties yielded significantly different from one another.

Hybrid	Yield
A	6.0b
B	7.5ab
C	**9.0a**
LSD	2.0

RESULTS

Seasonal precipitation and temperature recorded at Borderview Research Farm in Alburgh, VT are displayed in Table 3. The average fall temperature (Sep 2023 to Nov 2023) was 51.8° F, which was 3.21°F warmer than the 30-year normal. The average temperature from Apr 2024 to Jun 2024 was 4.55° F warmer than the 30-year normal. This growing season was wetter than past years with 1.91" of rain higher than the 30-year average. The accumulated Growing Degree Days (GDDs) were higher than the 30-year average during this period experiencing 194 GDDs more than the 30-year average, with a total accumulation (during active growing periods) of 4,212 GDDs.

Table 3. Seasonal weather data collected in Alburgh, VT, 2023-2024.

Alburgh, VT	Sep 2023	Oct 2023	Nov 2023	Apr 2024	May 2024	Jun 2024
Average temperature (°F)	64.7	54.9	35.9	45.7	61.9	68.5
Departure from normal	1.97	4.63	-3.39	0.13	3.47	0.95
Precipitation (inches)	2.40	5.38	2.03	4.47	2.27	6.65
Departure from normal	-1.27	1.55	-0.67	1.40	-1.49	2.39
Growing Degree Days (base 32°F)	980	711	175	327	926	1093
Departure from normal	58	143	-60	-84	108	29

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2020) for Burlington, VT.

Ground cover measurements were taken using the Canopeo application in the fall after plant establishment and again in the spring. Fall ground cover measurements were taken as an indicator of stand establishment and plant vigor. Within the trial Receptor showed the highest percentage of ground cover prior to hard frost in October 2023 with 74.9% cover and was statistically similar to Aroostook, Hazlet, ND Gardener, and Progas. Similar trends followed through into spring ground cover with Receptor once again having the greatest coverage at 84.2% alongside these same varieties (minus Progas). Danko appeared to have the lowest overall coverage during both periods. As seen from fall biomass sample, greater ground cover did not necessarily result in greater biomass production with Receptor having the lowest biomass alongside Serafino at 104 lbs ac^{-1}. Aroostook had nearly twice the biomass production at this sampling time at 207 lbs ac^{-1}.

Table 4. Winter rye ground cover and fall biomass, Alburgh, VT, 2023-2024.

Variety	Fall ground cover %	Fall dry matter %	Fall biomass lbs ac^{-1}	Spring ground cover %
Aroostook	70.7*†	**13.1**	**207**	83.8*
Covermax	64.8	11.2*	120	75.4
Danko	55.4	11.2*	139*	75.0
Hazlet	68.1*	11.9*	169*	80.9*
ND Gardener	67.4*	12.1*	163*	82.3*
Progas	71.4*	9.10	157*	77.0
Receptor	**74.9**	12.0*	104	**84.2**
Serafino	58.0	9.70	104	75.9
Spooner	57.6	11.7*	170*	72.6
Tayo	63.7	12.4*	120	77.7
LSD (0.10)‡	7.83	2.26	73.0	5.50
Trial mean	65.2	11.4	145	78.5

†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.

Rye forage and straw yields were collected at three key periods throughout the 2024 growing season: spring green-up (at approximately 6 inch grazing height), boot stage, and flowering (Table 5). Dry matter yields were high across all varieties during spring green-up period with Receptor having the highest yields at 4313 lbs ac^{-1}. Progas was the only variety at this period that did not perform similarly to other top yielding varieties. Hazlet produced the highest yields at boot stage at 12,762 lbs ac^{-1} and was statistically similar to Covermax, Danko, ND Gardener, Progas, and Receptor. Highest yields at flowering stage were seen with Covermax at 20,313 lbs ac^{-1} and was statistically similar to Receptor only, despite high yields across the trial. Each of these would be suitable for roller crimping and provide good ground cover in addition to producing high amounts of straw.

Table 5. Winter rye dry matter and yields at spring green-up, boot, and flowering growth stages, Alburgh, VT, 2024.

Variety	Spring forage dry matter	Spring forage dry matter yield	Boot stage dry matter	Boot stage dry matter yield	Flowering stage dry matter	Flowering stage dry matter yield
	%	lbs ac-1	%	lbs ac-1	%	lbs ac-1
Aroostook	30.1	4119*	30.1	8562	42.9	17104
Covermax	32.1*†	3980*	32.1*	11284*	47.9*	**20313**
Danko	30.1	4265*	30.1	11237*	43.6	13950
Hazlet	31.8*	4026*	31.8*	**12762**	44.2*	17050
ND Gardener	29.0	4233*	29.0	11344*	**48.2**	16350
Progas	**34.2**	3686	**34.2**	10892*	42.7	17869
Receptor	32.5*	**4313**	32.5*	11758*	42.5	18506*
Serafino	32.3*	4295*	32.3*	9675	44.1	14794
Spooner	29.2	4188*	29.2	9712	45.2*	13988
Tayo	31.6*	4164*	31.6*	9948	43.8	17970
LSD (0.10)‡	2.93	508	2.93	2362	4.12	2200
Trial mean	31.3	4127	31.3	10717	44.5	16790

†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.

Forage quality was analyzed for each rye sample at boot stage as this would be indicative of the optimum period for quality and yields (Table 6). Each of these varieties reached boot stage between 9-May and 16-May 2024, slightly earlier (by two days) when compared to 2023. The highest observed crude protein concentrations were seen in Receptor at 15.9% and was statistically similar to Aroostook, Covermax, Hazlet, ND Gardener, Serafino, Spooner, and Tayo. When looking at forage quality, significant differences were observed in Acid Detergent Fiber (ADF) with Progas alone having the highest ADF concentration at 36.6%. Additionally, differences across rye varieties were observed in amylase Neutral Detergent Fiber organic matter (aNDFom) and Neutral Detergent Fiber Digestibility 30hr (NDFDom30). NDFDom30 indicates the percentage of NDF digested in 30 hours of fermentation, whereas the NDFDom30 yields are indicative of the total amount of feed that would be fermentable during this 30-hour period. All of the varieties within the trial had exceptional NDFDom30 with highest percentage of digestible fibers seen in Aroostook at 80.7% and was statistically similar to Spooner at 76.8%. The NDFDom30 yields showed Aroostook having the highest overall yields at 9,592 lbs ac^{-1} and was statistically similar to Danko, Hazlet, ND Gardener, Progas, and Receptor.

Table 6. Winter rye forage quality at plant boot stage. Alburgh, VT 2024

Variety	Boot stage harvest date	Crude protein	ADF	aNDFom	NDFDom30	NDFDom30
		%	%	%	%NDF	lbs ac-1
Aroostook	9-May	15.1*†	29.3	53.1	**80.7**	**9592**
Covermax	16-May	14.2*	34.6	59.9*	70.4	7727
Danko	13-May	13.4	30.2	53.9	71.0	8399*
Hazlet	16-May	14.5*	34.0	59.6*	71.3	9298*
ND Gardener	9-May	13.8*	31.1	55.0	72.1	8232*

Progas	16-May	13.3	**36.6**	**61.1**	67.5	8238*
Receptor	16-May	**15.9**	32.8	56.8	73.5	8901*
Serafino	16-May	13.8*	34.7	59.0*	68.4	7171
Spooner	9-May	14.0*	29.0	51.3	76.8*	7391
Tayo	16-May	14.9*	32.9	57.7	72.0	6871
LSD (0.10)‡		2.57	1.77	2.71	4.74	1581
Trial mean		14.3	32.5	56.7	72.4	8182

†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.

DISCUSSION

In colder climates, rye can serve as a late season cover crop that has the ability to establish in a corn silage production system after harvest. Like other cover crops, it provides long term benefits towards soil erosion control and improvements in soil health over time. When looking at these twelve rye varieties in this region in terms of stand establishment and ground cover, the majority of the varieties performed similarly in cover crop function providing decent cover throughout winter months. Rye also has the benefit of putting on rapid growth in early season months where other crops may struggle to develop. Past research has shown that while forage quality may be high after spring green-up, yields are far lower than those at boot stage, whereas high yields can be observed at flowering stage, but quality is lower. When looking across other forage types, each of these rye varieties shows high potential as a feed component with decent protein levels as well as NDFDom30 being above 65%. Comparatively, many corn silages and legumes fall below this mark showing that rye could serve as a high-quality feed in addition to the many benefits seen as a cover crop. This could also help to provide good early season grazing.

The majority of these varieties had acceptable levels of CP, however they differed significantly in the yield of NDFDom30 per acre. Aroostook, Hazlet, ND Gardener, and Receptor showed a more ideal intersection of high protein levels and high NDFDom30 yields. This would indicate that these three in particular could serve as some of the higher quality and highest yielding feed ingredients. Interestingly, varieties specifically marketed for forage or cover crop did not necessarily perform better than other varieties.

ACKNOWLEDGEMENTS