Impact of Cover Crops on No-Till Spring Grain Production

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Soil health is fundamentally important to crop productivity. Cover cropping is one method of improving soil health, by preventing soil erosion and nutrient runoff, improving soil aggregation and nutrients, as well as providing other benefits to soils and crop productivity. Cover crops have also been noted for their ability to suppress weeds. Some cover crops have been noted for their allelopathic characteristics, which can decrease the germination of weeds. Farmers are striving to reduce inputs and welcome the multiple benefits that cover crops afford. No-till and reduced tillage practices can also increase water infiltration and reduce soil degradation while keeping carbon in the soil. Different types of cover crops, such as grasses, legumes, and brassicas, have different benefits for soil health and nutrient retention. Cover crops are even being utilized as a forage on dairy farms. There is a need for more research on cover crops to define the best species, varieties, and mixes for a Northeastern climate and for achieving higher cash crop yields. To examine the efficacy of winter terminated cover crops on yield of no-till spring wheat, the University of Vermont Extension's Northwest Crop and Soils (NWCS) Program conducted a field trial with cover crops planted in fall 2017 and a crop of spring wheat grown in the 2018 field season. The suitability of the cover crops to serve as a forage were also examined.

MATERIALS AND METHODS

Winter terminated cover crops were planted on 17-Aug 2017 at Borderview Research Farm in Alburgh, VT with a cone seeder into 5' x 20' plots (Table 1). The treatments included five cover crop treatments and a non-cover cropped control. Cover crop treatments consisted of 'Hayking' Sudangrass at 65 lbs ac^{-1}, 'Everleaf' oats at 125 lbs ac^{-1}, 'Wonderleaf' millet at 30 lbs ac^{-1}, 'Glenn' spring wheat at 125 lbs ac^{-1} , and a cover crop mix of 'Everleaf' oats, 'Frostmaster' peas, 'Dixie' crimson clover, and 'Eco-till' radish at 80, 30, 8, and 3 lbs ac^{-1} respectively. The experimental design was a randomized complete block with eight replicates. Fall biomass was harvested from a 0.25 m^2 quadrat in each plot on 7-Oct 2017, in order to calculate dry matter yields and forage quality. The biomass harvested from the non-cover cropped control consisted of weeds. The biomass samples were dried, ground in a Wiley mill, then ground again in an UDY Corporation cyclone laboratory mill (1mm screen). Ground samples were analyzed on 14-Jan 2019 for dry matter, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and 30-hour digestible NDF (NDFD), and lignin using a FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer at the University of Vermont's Cereal Grain Testing Laboratory, in Burlington, VT. Samples were then analyzed for carbon and nitrogen at the University of Vermont's Agricultural and Environmental Testing Laboratory on a CN Elemental Analyzer.

The CP content of forages are mixtures of true proteins; amino acids and non-protein nitrogen, and is determined by multiplying the amount of nitrogen by 6.25. The more fiber a forage contains, the greater the feeding value, since the fiber components of the plant are the less digestible fraction. Neutral detergent fiber (NDF) measures the total fiber content, which includes cellulose, hemicellulose, and lignin. NDFD is based on the in vitro digestibility calculation over a specified period of time. In this report, NDFD is based on 48-hour in vitro testing.

Hard red spring wheat (variety: Major) was planted into no-till plots on 2-May 2018 with a Sunflower grain drill at a rate of 125 lbs ac^{-1}. Spring wheat heights, lodging, and bird damage data (three heights in cm per plot) were collected on 7-Aug. Heights were determined by measuring three heights per plot with a meter stick. Lodging and bird damage was assessed visually and recorded as a percentage of the plot. The 5' x 20' plots of spring wheat were harvested on 10-Aug 2018 with an Almaco SPC50 plot combine. Yield was determined at harvest.

Table 1. No-till spring grain cover cropping trial specifics for Alburgh, VT, 2018.

	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam 3-8% slope
Previous crop	Spring barley
Cover crop planting date	17-Aug 2017
Plot size (feet)	5 x 20
Replicates	8
Spring wheat planting date	2-May 2018
Spring wheat seeding rate (lbs ac^{-1})	125
Harvest date	10-Aug 2018

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$. Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or 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. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different 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 the yields of these treatments were significantly different from one another. The asterisk indicates that treatment B was not significantly lower than the top yielding treatment, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0**
LSD	2.0

RESULTS

Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Tables 2 and 3). August 2017 was colder and wetter than average, while September and October were hotter and drier than average. The following winter months were cold and dry with little variation from historical averages, followed by departures from the historical averages in an unseasonably warm February and unseasonably cold and wet April, followed by a warm and dry May.

Table 2. Seasonal weather data collected in Alburgh, VT for Aug-Dec 2017.

	2017				
Alburgh, VT	**August**	**September**	**October**	**November**	**December**
Average temperature (°F)	67.7	64.4	57.4	35.2	18.5
Departure from normal	-1.07	3.76	9.16	-2.96	-7.41
Precipitation (inches)	5.5	1.8	3.3	2.3	0.8
Departure from normal	1.63	-1.80	-0.31	-0.84	-1.59
Growing Degree Days (base 32°F)	1108	971	786	202	56
Departure from normal	-31	113	284	17	56

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.

Table 3. Seasonal weather data collected in Alburgh, VT for Jan-Aug 2018.

	2018							
Alburgh, VT	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**
Average temperature (°F)	17.1	27.3	30.4	39.2	59.5	64.4	74.1	72.8
Departure from normal	-1.73	5.79	-0.66	-5.58	3.10	-1.38	3.51	3.96
Precipitation (inches)	0.8	1.2	1.5	4.4	1.9	3.7	2.4	3.0
Departure from normal	-1.26	-0.60	-0.70	1.61	-1.51	0.05	-1.72	-0.95
Growing Degree Days (base 32°F)	53	93	90	272	853	973	1305	1264
Departure from normal	53	93	90	-112	97	-42	107	125

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.

The summer of 2018 was hotter and drier than normal, with above average and record-setting temperatures from July to August. From May to August, less precipitation than average was received. Between May 2018 and August 2018, there were 4395 Growing Degree Days (GDDs), 287 above the 30-year average.

Winter Terminated Cover Crop Results

The oats, cover crop mix, and spring wheat treatments had the highest dry matter yields, which were significantly greater than those of the millet, Sudangrass, and the control. The control, which consisted of weeds, had significantly higher CP concentrations, followed by Sudangrass, millet, and the mix. Wheat had significantly lower CP concentrations than all of the other treatments (Table 4).

Table 4. Impact of treatment on cover crop yield and forage quality, Alburgh, VT, 2018.

Treatment	DM yield lbs ac^{-1}	DM %	CP % of DM	ADF % of DM	NDF % of DM	NDFD % of DM	Lignin % of DM
Control	1973^{b}	94.4^{b}	**20.1^{a}**	**23.7^{c}**	**40.5^{c}**	28.1^{c}	**3.41^{c}**
Wonderleaf millet	1787^{b}	94.3^{bc}	16.1^{b}	32.5^{ab}	56.8^{ab}	31.5^{b}	5.31^{ab}
Mix	2897^{a}	93.9^{c}	15.1^{bc}	30.4^{b}	50.0^{c}	34.8^{a}	3.68^{c}
Everleaf oats	**2922^{a}**	94.1^{bc}	14.1^{c}	30.6^{b}	55.2^{bc}	**35.0^{a}**	3.96^{c}
Hayking sudangrass	1858^{b}	94.3^{bc}	16.3^{b}	34.6^{a}	61.4^{a}	32.0^{b}	4.77^{b}
Glenn spring wheat	2655^{a}	**95.0^{a}**	10.9^{d}	33.3^{a}	58.3^{ab}	25.5^{d}	5.72^{a}
LSD (0.10)	639	0.465	1.29	2.42	5.55	1.22	0.558
Trial mean	2349	94.3	15.4	30.8	53.7	31.1	4.48

Treatments within a column with the same letter are statistically similar. Top performers are in **bold**.
LSD – Least significant difference.

The control, oats, and cover crop mix had the lowest ADF and NDF concentrations, which is an indicator of higher quality. The Sudangrass, millet, and wheat had the highest ADF and NDF concentrations. The mix and oats had significantly higher 30-hour digestible NDF (NDFD) than the other treatments. The control, oats, and mix had the significantly lower lignin content in comparison to all other treatments.

Table 5. Cover crop treatment carbon and nitrogen results, 2018.

Treatment	Carbon %	Nitrogen %	C:N ratio
Control	41.5^{b}	**2.89^{a}**	**14.6^{c}**
Wonderleaf millet	41.4^{b}	2.36^{b}	17.7^{b}
Mix	40.2^{c}	2.28^{b}	18.0^{b}
Everleaf oats	41.4^{b}	2.19^{b}	19.01^{b}
Hayking sudangrass	42.6^{a}	2.34^{b}	18.5^{b}
Glenn spring wheat	**42.9^{a}**	1.61^{c}	26.9^{a}
LSD (0.10)	0.632	0.209	1.62
Trial mean	41.7	2.28	19.1

Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
LSD – Least significant difference.

Table 5 shows the carbon and nitrogen content of the cover crops by treatment. Spring wheat and Sudangrass had significantly higher percentages of carbon than other treatments, and the mix had significantly less than other treatments. Percent nitrogen was significantly higher in the control and significantly lower in the spring wheat. The millet, mix, oats, and Sudangrass did not significantly differ from each other.

No-till Results

There were no lodging or bird damage evident in the trial. Many of the plots were overgrown with weeds and had little to no spring wheat present at harvest. There was not enough seed produced from most plots to be able to measure harvest moisture and test weight, due to the minimum amount of grain required by the moisture meter.

Table 6. Spring wheat (var 'Major') heights and yields by treatment, Alburgh, VT, 2018.

Treatment	Average wheat height cm	Wheat grain yield lbs ac^{-1}
Control	28.6[d]	0.00[b]
Wonderleaf millet	35.6[cd]	13.2[b]
Mix †	75.1[ab]	625[a]
Everleaf oats	**80.7[a]**	**644[a]**
Hayking Sudangrass	42.4[c]	17.4[b]
Glenn spring wheat	63.8[b]	97.8[b]
LSD (0.10)	13.4	129
Trial mean	54.3	233

Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
LSD – Least significant difference.
†- 'Everleaf' oats, 'Frostmaster' peas, 'Dixie' crimson clover, 'Eco-till' radish

The height of the wheat grown following cover crops treatments mix, oats, and spring wheat had significantly greater heights than the other cover crop treatments, where the oats were the top performer, followed by the mix (Table 6). The oats and mix were statistically similar. The oats and mix also resulted in the highest wheat yields (Figure 1), and were significantly greater than all of the other treatments ($P<0.0001$).

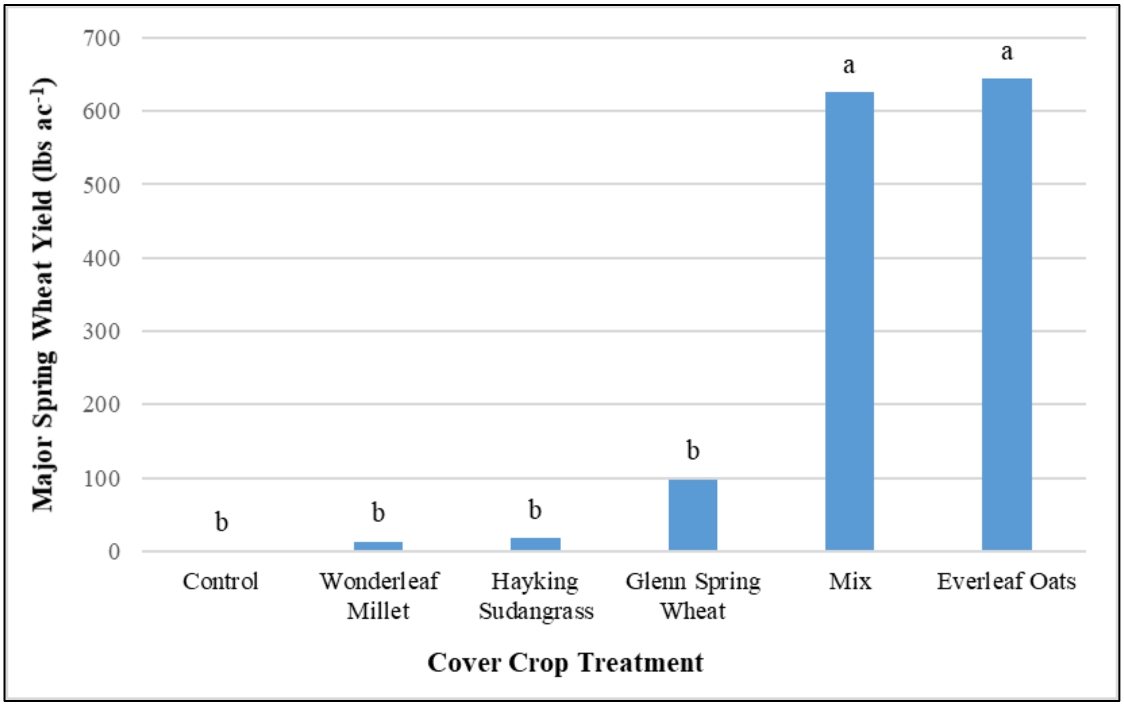

Figure 1. Major spring wheat yields by cover crop treatments, Alburgh, VT, 2018.

DISCUSSION

The cover crops exhibited value as a forage for livestock operations. The oats and oats mix provided high forage quality and spring wheat yields. While there was a poor overall yield in this trial for spring wheat, the Everleaf oats and cover crop mix were the top-performing treatments in terms of subsequent spring wheat heights and yields. The oats and mix yields were approximately 500 lbs ac^{-1} greater than the next highest yielding cover crop, the Glenn spring wheat, and at least 30-fold greater than the yields of the other cover crop treatments.

The presence of Everleaf oats in both the oats and cover crop mix treatments appears to be a key factor in the positive correlation of the two treatments with spring wheat yield. The summer annuals would likely respond more favorably if planted with Everleaf oats. The nitrogen and C:N ratios of Everleaf oats and the mix did not significantly differ from each other, or the millet and Sudangrass. This may indicate that the nitrogen content of the oats and mix was not a sole factor influencing subsequent spring wheat yield. Although weed biomass was not recorded, usually treatments containing oats had far less weed pressure compared to other treatments. Oats have been documented to produce root exudates that can suppress seed germination. Further research must be conducted to evaluate if oats can provide adequate weed suppression.

It is important to remember this trial only represents one season of data. Further study is needed to evaluate the efficacy of oats as cover crops. If the results of this trial are reproducible in future years, oats may be a cover crop that farmers could implement to suppress weeds and improve soil health and water quality while also increasing their subsequent cash crop yields.

ACKNOWLEDGEMENTS

This research trial was funded by UMaine OREI grant #2015-51300-24153. The UVM Extension Northwest Crops and Soils Program would like to thank Roger Rainville and the staff at Borderview Research Farm for their generous help and hosting this trial as well as John Bruce, Freddy Morin, Haley Jean, Lindsey Ruhl, and Sara Ziegler for their assistance with data collection and entry. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

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