2019

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THE UNIVERSITY OF VERMONT EXTENSION

2019 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. 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 impact of winter terminated cover crops on yields 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 fall 2018 and spring wheat grown in the 2019 field season. The suitability of the cover crops as forages were also examined.

MATERIALS AND METHODS

Winter terminated cover crops were seeded on 23-Aug 2018 at Borderview Research Farm in Alburgh, VT with a Sunflower 9412 grain drill (Sunflower Manufacturing, Beloit, KS). The experimental design was a randomized complete block with four replicates, and the previous crops were spring wheat and spring barley (Table 1). There were 5' buffers between replicates and the soil type was Benson rocky silt loam with 8-15% slopes. Application of dairy manure was applied at a rate 6000 gal ac^{-1} prior to planting the cover crop.

Table 1. No-till spring grain cover cropping trial specifics for Alburgh, VT, 2018-2019.

	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam, 8-15% slopes
Previous crop	Spring wheat, spring barley
Cover crop planting date	23-Aug 2018
Plot size (feet)	10 x 20
Replicates	4
Spring wheat planting date	26-Apr 2019
Spring wheat seeding rate (lbs ac^{-1})	150
Harvest date	30-Jul 2019

The treatments included five cover crop treatments and a non-cover cropped control. Cover crop treatments consisted of Sudangrass var 'Piper' at 50 lbs ac^{-1}, oats var 'Everleaf' at 125 lbs ac^{-1}, Millet var 'Wonderleaf' at 30 lbs ac^{-1}, barley var 'Tradition' at 125 lbs ac^{-1}, and a cover crop mix planted at 75 lbs ac^{-1} (Table 2). The mix consisted of Oats var 'Everleaf', crimson clover var 'Dixie', and tillage radish var 'Eco-till' (60, 40, 4 lbs ac^{-1} respectively).

Table 2. Cover crop treatments, 2018-2019.

Cover crop	Variety	Seeding rate lbs ac^{-1}
Sudangrass	Piper	50
Millet	Wonderleaf	30
Oats	Everleaf	125
Barley	Tradition	125
Mix		75
Oats	Everleaf	60 lbs
Crimson clover	Dixie	40 lbs
Tillage radish	Eco-till	4 lbs

Cover crop biomass was measured on 15-Oct 2018 by clipping all aboveground biomass from two 0.25 m^2 quadrats in each plot. The combined biomass was weighed and dried in order to calculate dry matter content and yield. The biomass samples were ground in a Wiley mill, then ground again in an UDY Corporation cyclone laboratory mill (1mm screen) for forage quality analysis. 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 on 16-Jul 2019. 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 30-hour in vitro testing. Percent spring residue cover of the cover crops was measured with the beaded string line-transect method (Sloneker and Moldenhauer, 1977) on 22-Apr 2019. Prior to planting on 25-Apr, 300 lbs ac^{-1} 19-19-19 fertilizer was applied to the area (N, P, K, 57 lbs ac^{-1} each).

Organic ND Vitpro hard red spring wheat (Albert Lea Seed, Albert Lea, MN) was planted into no-till plots on 26-Apr 2019 with a Sunflower 9412 grain drill (Sunflower Manufacturing, Beloit, KS) at a rate of 150 lbs ac^{-1}. On 21-May 2019 spring grains population data were collected by counting the total number of wheat plants in three one-foot sections per plot. On 29-Jul, two 0.25 m^2 quadrats of biomass from each plot was collected and sorted into wheat and weeds, and total weights of the wheat and weeds were measured in order to calculate weed density. Prior to harvest, spring wheat heights and lodging were collected on 30-Jul. Heights were determined by measuring three heights per plot with a meter stick. Lodging was assessed visually and recorded as a percentage of the plot on a 0-9 scale where indicated 0 no lodging present, 1 indicated minimal lodging, and 9 indicated the plot was completely lodged. The spring wheat was harvested on 30-Jul with an Almaco SPC50 plot combine. Harvest areas were 5' x 20'. Grain moisture, test weight, and yield were recorded at harvest. Grain moisture and test weight were determined with a DICKEY-John MINI GAC Plus meter.

Grain quality was determined at UVM Extension's Northwest Crop and Soils Quality Testing Laboratory (Burlington, Vermont). Samples were ground using the Perten LM3100 Laboratory Mill. Flour was analyzed for protein content using the Perten Inframatic 8600 Flour Analyzer. Most commercial mills target 12-15% protein content. Falling number was measured (AACC Method 56-81B, AACC Intl., 2000) on the Perten FN 1500 Falling Number Machine. The falling number is related to the level of sprout damage in the grain. It is determined by the time it takes, in seconds, for a stirrer to fall through a slurry of flour and water to the bottom of a test-tube. Falling numbers greater than 350 indicate low enzymatic activity and sound quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat. Deoxynivalenol (DON), a vomitoxin, was analyzed on one replicate 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.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). 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 $p<0.10$. Pearson correlation coefficients were determined with PROC CORR. 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. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In this example, 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. Treatment B was not significantly lower than the top yielding treatment, indicated in bold. A lack of significant difference is indicated by shared letters.

Treatment	Yield
A	6.0[b]
B	7.5[ab]
C	**9.0[a]**
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 (Table 3). In the fall and winter of 2018, conditions were colder than normal. However, 241 Growing Degree Days (GDDs) were accumulated December through March, when normally no GDDs are accumulated. This unusual presence of winter GDDs was followed by a cold and wet spring that led to only 1976 Growing Degree Days accumulated April to June 2019, which was 178 GDDs below average. Precipitation in April and May was 2.28 inches above average. GDDs ceased to lag behind the 30-year normal in July, which saw higher than average temperatures, less precipitation, and 1286 accumulated GDDs, 88 above the 30-year normal. Overall, precipitation from August 2018 to July 2019 was 0.8" below average. 6279 GDDs were accumulated over the season, 242 above the 30-year normal.

Table 3. Seasonal weather data collected in Alburgh, VT, 2018-2019.

	2018					2019						
	Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Average temperature (°F)	72.8	63.4	45.8	32.2	25.4	15.0	18.9	28.3	42.7	53.3	64.3	73.5
Departure from normal	3.96	2.76	-2.36	-5.99	-0.55	-3.77	-2.58	-2.79	-2.11	-3.11	-1.46	2.87
Precipitation (inches)	2.96	3.48	3.53	4.50	2.96	1.53	1.70	1.36	3.65	4.90	3.06	2.34
Departure from normal	-0.95	-0.16	-0.07	1.38	0.59	-0.52	-0.06	-0.85	0.83	1.45	-0.63	-1.81
Growing Degree Days (base 32°F)	1264	941	435	136	72	23	38	108	346	660	970	1286
Departure from normal	125	83	-67	-50	72	23	38	108	-38	-96	-44	88

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.

Winter Terminated Cover Crop Quality

Fall 2018 cover crop quality results are displayed in Table 4. When sampled in fall 2018, the oats yielded the most dry matter biomass at 2260 lbs ac^{-1}, and was statistically similar to the cover crop mix (2031 lbs ac^{-1}), and the barley (1934 lbs ac^{-1}). The barley and the mix were also statistically similar to the sudangrass. While the millet had significantly lower dry matter biomass on a per acre basis than all other cover crop treatments, it was still significantly higher than the control. The sudangrass had the highest carbon percentage at 43.4%, which was significantly higher than the mix, millet, and barley, and similar to the control and oats. Similar to the 2017-2018 trial, the control had the highest percent nitrogen (5.28%), which was significantly different than all other treatments except the barley (5.17%).

Table 4. Impact of treatment on cover crop yield and forage quality, Alburgh, VT, 2018-2019.

Treatment	DM yield lbs ac^{-1}	DM %	Carbon %	Nitrogen %	CP % of DM	ADF % of DM	NDF % of DM	30 hr NDFD % of NDFom	Lignin % of DM
Barley var 'Tradition'	1934^{ab}	20.4^{bc}	40.8^{c}	5.17^{a}	**36.1^{a}**	28.3	36.1^{ab}	86.9^{a}	7.28^{bc}
Control	712^{d}	**41.8^{a}**	42.4^{ab}	**5.28^{a}**	35.1^{a}	**26.5**	37.2^{ab}	**89.9^{a}**	**5.15^{a}**
Millet var 'Wonderleaf'	1342^{c}	32.8^{ab}	40.7^{c}	4.60^{b}	30.5^{bc}	27.6	47.8^{c}	77.1^{c}	6.20^{ab}
Mix†	2031^{ab}	15.7^{c}	41.6^{bc}	4.14^{cd}	31.7^{abc}	28.4	**34.4^{a}**	80.7^{bc}	7.75^{c}
Oats var 'Everleaf'	**2260^{a}**	17.3^{c}	42.4^{ab}	4.39^{bc}	32.9^{ab}	28.9	40.0^{b}	86.1^{ab}	7.94^{c}
Sudangrass var 'Piper'	1801^{b}	27.3^{abc}	**43.4^{a}**	3.89^{d}	27.3^{c}	29.6	50.3^{c}	76.5^{c}	6.83^{bc}
LSD (0.10)	444	15.5	1.48	0.383	4.57	NS	4.51	5.94	1.55
Trial mean	1680	25.9	41.9	4.58	32.2	28.2	41.0	82.9	6.86

*Treatments within a column with the same letter are statistically similar. Top performers are in **bold**.
LSD – Least significant difference. NS- Not significant.
†- oats var 'Everleaf', crimson clover var 'Dixie', radish var 'Eco-till'

The millet and the sudangrass had significantly lower crude protein concentrations compared to most other treatments. The mix, control, and barley had the lowest NDF concentrations, followed by the oats, which is an indicator of higher quality. The sudangrass and millet treatments had significantly higher NDF concentrations than the other cover crops (50.3%, 47.8%), indicating lower quality. The control, barley, and oats had significantly higher 30-hour digestible NDF (NDFD) than the millet and sudangrass, while the oats were statistically similar to the cover crop mix. The control had significantly lower lignin content in comparison to all other treatments except the millet.

Spring Wheat Harvest Results

Barley and oats, followed by the cover crop mix, provided the most residue and subsequent ground cover prior to planting (Table 5). Barley residue, covered 82.5% of the plot on average, in comparison to 11.5% covered by the control, or 40.5% covered by the millet residue. Spring wheat populations, heights, and lodging was not significantly impacted by the cover crop treatments. The oat treatment resulted in the lowest weed density in the spring wheat crop (Table 5, Figure 1). Only 3.41% of biomass clipped from plots of spring wheat near harvest consisted of weeds. The oats were followed in performance by the mix, with 5.50% weeds. All of the cover crop treatments were statistically similar to each other and outperformed the control, which was 25.3% weeds. As expected, weed density had a strong negative correlation to spring cover (R = -0.7039, p = 0.0001).

Table 5. Field season measurements in no-till spring wheat by cover crop treatment, Alburgh, VT, 2019.

Treatment	Spring ground cover	Population	Average height	Lodging	Weed density
	%	m^2	cm	0-9*	% of biomass
Barley var 'Tradition'	**82.5[a]**	401	81.5	**0.0**	6.93[a]
Control	11.5[d]	450	80.6	1.0	25.3[b]
Millet var 'Wonderleaf'	40.5[c]	441	82.3	**0.0**	8.38[a]
Mix†	64.5[b]	426	**85.5**	0.3	5.50[a]
Oats var 'Everleaf'	75.0[ab]	**509**	81.1	0.5	**3.41[a]**
Sudangrass var 'Piper'	42.0[c]	425	80.1	0.3	7.70[a]
LSD (0.10)	10.9	NS	NS	NS	7.33
Trial mean	52.7	442	81.8	0.3	9.54

*Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
LSD – Least significant difference. NS- Not significant.
†- oats var 'Everleaf', crimson clover var 'Dixie', radish var 'Eco-till'
*0-9 scale; where a rating of 0 = no lodging and a rating of 9 = completed lodged.

Grain yields were statistically similar across the cover crop treatments and all treatments yielded higher than the no cover crop control (Table 6; Figure 1). Harvest moisture, test weight, crude protein at 12% moisture, and falling number did not differ statistically by treatment. All treatments met the USDA standard test weight of 58 lbs bu^{-1}. No detectible levels of DON were found.

Table 6. Spring wheat heights and yields by treatment, Alburgh, VT, 2019.

Treatment	Grain yield	Harvest moisture	Test weight	Crude protein @ 12% moisture	Falling number
	lbs ac^{-1}	%	lbs bu^{-1}	%	seconds
Barley var 'Tradition'	2630[a]	16.6	61.2	**13.8**	385
Control	1528[b]	**14.7**	61.6	13.4	372
Millet var 'Wonderleaf'	2610[a]	17.1	61.1	13.7	383
Mix†	2315[a]	15.2	**62.1**	13.7	381
Oats var 'Everleaf'	2492[a]	16.1	61.8	13.2	**389**
Sudangrass var 'Piper'	**2763[a]**	18.4	60.2	**13.8**	383
LSD (0.10)	697	NS	NS	NS	NS
Trial mean	2390	16.3	61.3	13.6	382

*Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
LSD – Least significant difference. NS- Not significant.
†- oats var 'Everleaf', crimson clover var 'Dixie', radish var 'Eco-till'

Spring wheat yield and weed density are shown in Figure 1, and were negatively correlated (R = -0.5814, p = 0.0029) as expected, with reduced weed biomass resulting in increased yields in cover cropped treatments in comparison to the control.

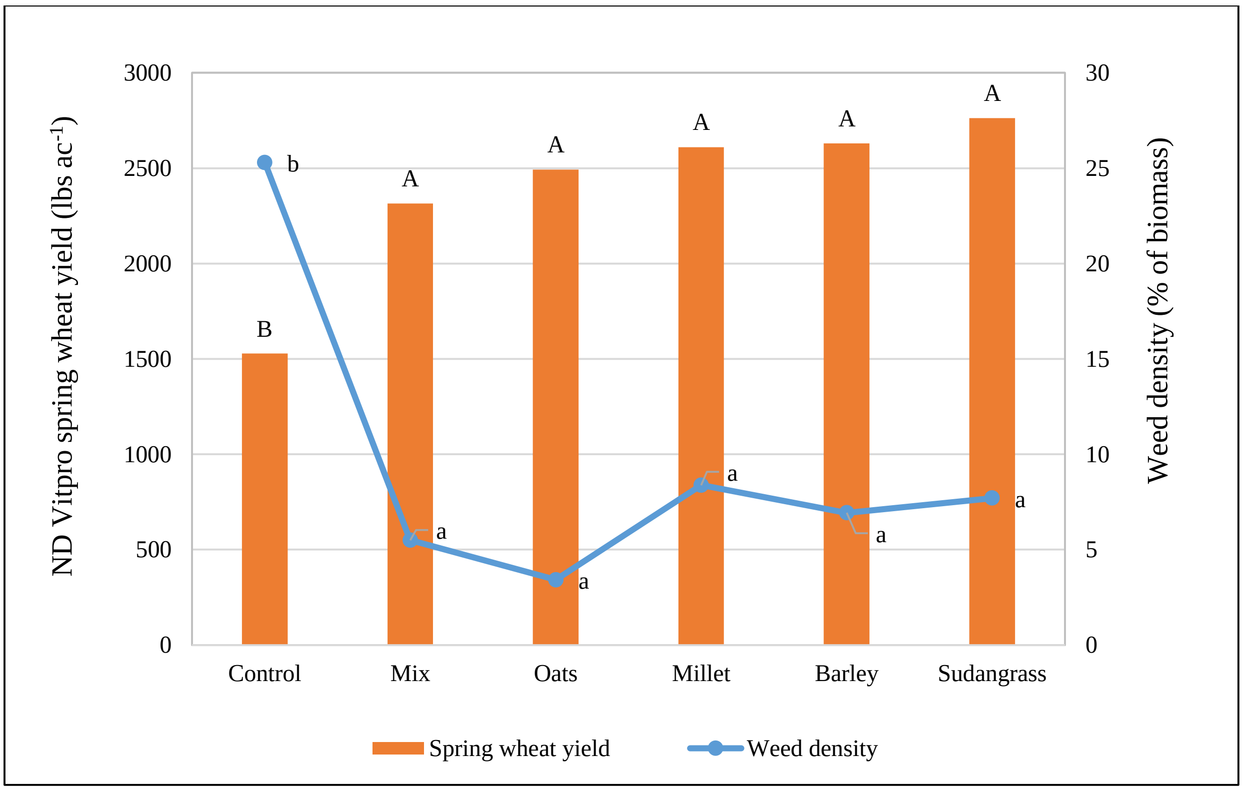

Figure 1. Weed density and spring wheat yields by cover crop species, Alburgh, VT, 2019.

DISCUSSION

The cover crops exhibited value as a forage for livestock operations. The oats, cover crop mix, and barley provided the best establishment and largest cover crop yields, and outperformed the sudangrass and millet in forage quality. Barley outperformed the other treatments in spring ground cover, followed by oats, which was similar to the cover crop mixture containing oats. While not significant, the oats also had the highest spring grain populations and lowest weed density. 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.

This trial demonstrated success of cover crops in weed reduction and increased yields in comparison to the uncover-cropped control. It is important to remember this trial only represents one season of data. Further study is needed to evaluate the efficacy of oats and barley 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 barley, along with oats, may be used to increase cover crop yields while improving soil health and water quality.

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