2018 Cover Crop Planting Date Trial

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THE UNIVERSITY OF VERMONT EXTENSION

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Maintaining and improving soil health is critical to crop productivity. Cover cropping is one way to prevent soil erosion, maintain and/or improve soil nutrients, improve soil aggregation, prevent nutrient loss from runoff, and increase water retention. Such soil improvements can promote conditions that add resiliency to a crop, especially in light of extreme weather patterns that may affect yields. It can be challenging to grow a successful cover crop, given other demands from a farm operation and weather limitations. In this trial, our goals were to evaluate the effect of cover crop seeding dates and cover crop mixes on biomass production and percent cover.

MATERIALS AND METHODS

Table 1. Agronomic information for the cover crop planting date trial, Alburgh, VT, 2018.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 8-15% slope
Previous crop	Summer annuals
Plot size (ft)	5 x 20
Planting date	24-Aug, 11-Sep, 19-Sep, 27-Sep 2017
Planting equipment	Great Plains NT60 Cone Seeder

The trial was conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of planting date and cover crop mix on biomass yield and percent cover at the end of the growing season and after the winter. The experimental design was a randomized complete block with three replications.

Table 2. Cover crop mixes grown in the cover crop planting date trial, Alburgh, VT, 2018.

Mix #	**Variety**	**Seeding rate lb ac^{-1}**
1	Annual ryegrass	15
	Crimson clover	9
	Arifi radish	3
2	Fridge triticale	40
	Eco-till tillage radish	2
	Freedom red clover	5
	Lynx winter pea	20
3	Winter rye	40
	Dynamite clover	1
	Appin turnip	2
4	Hyoctane triticale	60
	Dynamite clover	3
	Appin turnip	2
7	Everleaf oats	40
	Duration clover	5
	Appin turnip	2
8	Bruiser ryegrass	15.2
	Appin turnip	2.11
9	Fria ryegrass	22
	Eco-till radish	3
10	Everleaf oats	70
11	Eco-till radish	8
12	Dixie crimson clover	10
13	Everleaf oats	70
	Eco-till radish	3
	Crimson clover	10
14	VNS winter rye	75

5	Everleaf oats	60		15	Rye and Vetch	70
	Ground hog radish	3		16	Fria annual ryegrass	30
6	Triticale triticale	60		17	Hairy vetch	24
	Dwarf essex rape	3		18	Control – No cover crop	

Seventeen cover crop mixes (Table 2) were planted at four planting dates: 24-Aug, 11-Sep, 19-Sep, and 27-Sep. These mixes represent both overwintering and winterkilled cover crops. On 17-Oct and 31-Oct 2017, plots from each of the four plantings were photographed in order to assess the percent cover from the cover crops, as opposed to bare ground. Digital images were analyzed with the automated imaging software, IMAGING crop response analyzer, which was programmed in MATLAB (MathWorks, Inc., Natick, MA) and later converted into a free web-based software (www.imaging-crop.dk). At the time of photographing, the biomass within a 0.25 m^2 quadrat was harvested per plot. The biomass was dried at 105^{o} F until a stable weight was reached, which was used to determine dry matter yields. After the winter, percent cover and dry matter yields were measured again on 10-May 2018. These measurements included living and dead plant biomass.

The data was analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and varieties were treated as fixed. 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 treatments 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, except where analyzed by pairwise comparison (t-test). 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 that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the top-performing treatment in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid 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 hybrids 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 the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

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

RESULTS

Seasonal precipitation and temperature 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).

Table 3. Seasonal weather data collected in Alburgh, VT, 2017-2018.

	2017					2018				
Alburgh, VT	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Average temperature (°F)	67.7	64.4	57.4	35.2	18.5	17.1	27.3	30.4	39.2	59.5
Departure from normal	-1.07	3.76	9.16	-2.96	-7.41	-1.73	5.79	-0.66	-5.58	3.10
Precipitation (inches)	5.5	1.8	3.3	2.3	0.8	0.8	1.2	1.5	4.4	1.9
Departure from normal	1.63	-1.80	-0.31	-0.84	-1.59	-1.26	-0.60	-0.70	1.61	-1.51
Growing Degree Days (base 50°F)	553	447	287	18	1	3	6	1	37	352
Departure from normal	-28	129	287	18	1	3	6	1	37	154

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from August-October was provided by the NOAA data for Highgate, VT. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

In 2017, August was cooler and wetter than historical averages while September and October were unseasonably hot and dry. The winter months of November through January were cold and dry. The early months of 2018 experienced a lot of variation. February was unseasonably warm, March was fairly typical, April was unseasonably cold and wet, and May was warm and dry. Overall, between August and May there were a total of 1705 growing degree days (GDDs), which is 608 more than historical averages.

Results by planting date

Table 4. Cover crop yield and coverage for each planting date across all mixtures, Alburgh, VT, 2017-2018.

Planting date	Fall 2017		Spring 2018	
	Dry matter yield	**Percent cover**	**Dry matter yield**	**Percent cover**
	lbs ac^{-1}	**%**	**lbs ac^{-1}**	**%**
24-Aug	**2568**	82.7	1223	65.3*
11-Sep	2138	**87.9**	1307	48.4
19-Sep	1240	81.1	**1868**	**69.0**
27-Sep	288	38.1	1104	58.0
LSD (0.10)	173	3.33	201	5.94
Trial mean	1558	72.5	1375	60.2

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

Unsurprisingly, the 24-Aug planting date generated the most biomass in the fall (Table 4). However, the 19-Sep planting generated the most biomass and percent cover in the spring, although the 24-Aug planting provided a comparable amount of cover. These observations are not surprising, as we would expect some species such as annual ryegrass and oats to produce significant quantities of biomass if planted in late summer. The amount of biomass would decline with later planting dates. However, winter grains must be planted a bit later to establish just prior to winter. Planting winter grains too early may result in high quantities of biomass that can smother the plant crown over the winter. Other research has shown that planting by late September produces the best yields. This study supports this evidence as highest spring cover crop biomass was obtained from the 19-Sep planting date.

Results by cover crop treatment

Table 5. Cover crop yield and soil coverage for each cover crop treatment, Alburgh, VT, 2017-2018.

Mix	Fall 2017		Spring 2018	
	Dry matter yield	Percent cover	Dry matter yield	Percent cover
	lbs ac^{-1}	%	lbs ac^{-1}	%
1	1610	80.9	535	44.0
2	1710	76.9	1948	73.3
3	1995*	80.7	1881	56.0
4	1966*	82.2	1752	67.7
5	1814	74.5	779	33.7
6	1507	71.8	2349*	79.0
7	**2293**	75.6	516	22.3
8	1774	81.4	1062	59.0
9	1828	81.9	1115	58.3
10	1595	73.9	850.0	44.0
11	2004*	**90.2**	243	16.7
12	1019	59.5	1250	75.0
13	1738	79.6	613	34.3
14	1362	76.2	2586*	91.3*
15	903	60.9	**2692**	**93.7**
16	1738	69.7	1724	82.3*
17	729	57.5	1706	92.3*
Control	467	31.2	1157	60.0
LSD (0.10)	367	7.07	427	12.6
Trial mean	1558	72.5	1375	60.2

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

Across all plantings, the top performer for fall yield was treatment 7 (oats, clover, turnip), while treatment 3 (winter rye, clover, turnip), 4 (triticale, clover, turnip), and 11 (radish) performed comparably (Table 5). Top performers for the spring yield included overwintering varieties that had the advantage of being able to grow again in the spring. For the spring, the top performers were treatments 6 (triticale and rape), 14 (winter rye), and 15 (winter rye and vetch). Out of the 4 top performing treatments for spring percent cover, 3 of them had an overwintering variety in their mix.

Results for each planting date

Table 6. Cover crop yield and coverage for the 24-Aug 2017 planting date, Alburgh, VT, 2017-2018.

Mix	Fall 2017		Spring 2018	
	Dry matter yield	Percent cover	Dry matter yield	Percent cover
	lbs ac^{-1}	%	lbs ac^{-1}	%
1	2909	92.9*	610	38.7
2	2435	87.2*	982	65.3
3	3703*	91.2*	834	40.0
4	3359*	88.7*	553	60.0
5	3003	81.4	1284	76.0*
6	2137	81.0	1554	57.3
7	**4260**	76.9	1240	25.3
8	3290*	93.5*	697	52.0
9	3159*	92.2*	520	37.3
10	2401	85.8*	1314	70.7*
11	2931	**95.4**	200	4.00
12	1589	85.1*	802	81.3*
13	3069	84.1*	1407	70.7*
14	1949	84.6*	**2777**	**100.0**
15	1092	71.3	2516*	**100.0**
16	3363*	70.6	1483	96.0*
17	901.4	81.8	1681	**100.0**
Control	688	44.5	1559	**100.0**
LSD (0.10)	1150	13.0	720	30.8
Trial mean	2568	82.7	1223	65.3

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

From the 24-Aug planting, treatments 3 (winter rye, clover, turnip), 4 (triticale, clover, turnip), 7 (oats, clover, turnip), 8 (ryegrass, turnip), 9 (ryegrass, radish), and 16 (ryegrass) were the top performers for yield in the fall (Table 6). Interestingly, none of the top performers for fall yield were top performers for spring yield. Two out of six successful fall yielding treatments included overwintering varieties, however, they also included turnip which would not survive the winter and generate more biomass in the spring.

In the spring, treatments 14 (winter rye) and 15 (rye and vetch) were top performers. This makes sense considering that winter rye and vetch will over winter and continue to grow in the spring. Another interesting result is that in the spring, top performers for percent cover included overwintering treatments, yet also included the control. It is possible that the weed seeds, naturally found in the soil, were able to grow well enough to provide comparable ground cover.

Table 7. Cover crop yield and coverage for the 11-Sep 2017 planting date, Alburgh, VT, 2017-2018.

Mix	Fall 2017		Spring 2018	
	Dry matter yield	Percent cover	Dry matter yield	Percent cover
	lbs ac^{-1}	%	lbs ac^{-1}	%
1	2253	95.5*	176	17.3
2	2729*	93.8*	1764	58.7

3	2258	95.4*	1730	36.0
4	2579*	94.3*	644	33.3
5	2403*	94.4*	476	10.7
6	2341	79.6	2522*	70.7
7	**3186**	92.6*	203	10.7
8	2321	94.8*	696	26.7
9	2349	94.2*	1136	29.3
10	2477*	91.3*	851	42.7
11	2806*	**97.8**	89.2	5.33
12	1443	88.1*	1841	77.3*
13	2138	84.1*	208	10.7
14	1659	89.6*	**2793**	98.7*
15	1327	78.2	2502*	98.7*
16	2242	84.6*	1741	65.3
17	1069	77.3	2175*	**100.0**
Control	898	56.8	1973*	78.7*
LSD (0.10)	830.0	16.2	924	27.8
Trial mean	2138	87.9	1307	48.4

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

The top performers from the 11-Sep planting date for fall yield were treatments 2 (triticale, radish, clover), 4 (triticale, clover, turnip), 5 (oats, radish), 7 (oats, clover, turnip), 10 (oats), and 11 (radish) (Table 7). The treatments generally performed well for percent cover in the fall. In the spring, unsurprisingly, overwintering varieties were more successful with generating biomass and top performers included treatments 6 (triticale, rape), 14 (winter rye), 15 (winter rye and vetch), and 17 (hairy vetch). Surprisingly, the control had a comparably high yield for the spring, which was likely due to the weed seed bank coming out of dormancy.

Table 8. Cover crop yield and coverage for the 19-Sep 2017 planting date, Alburgh, VT, 2017-2018.

Mix	Fall 2017		Spring 2018	
	Dry matter yield	Percent cover	Dry matter yield	Percent cover
	lbs ac^{-1}	%	lbs ac^{-1}	%
1	915	90.5*	759	52.0
2	1412*	87.4	3192	96.0*
3	**1746**	91.7*	3301*	86.7*
4	1535*	90.1*	3416*	**100.0**
5	1539*	87.4	932	29.3
6	1343*	89.6*	3313*	97.3*
7	1286	92.4*	231	10.7
8	1257	94.0*	1816	94.7*
9	1482*	94.3*	1643	86.7*
10	1219	85.1	773	30.7
11	1599*	**97.7**	246	20.0
12	910.3	47.9	1680	94.7*
13	1334*	93.5*	332	20.0
14	1497*	89.7*	2777	89.3*

15	1041	74.6	**4466**	98.7*
16	1081	82.5	2217	98.7*
17	846	55.1	2003	**100.0**
Control	276	16.4	520.0	37.3
LSD (0.10)	449	10.2	1173	16.4
Trial mean	1240	81.1	1868	69.0

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

The top performers from the 19-Sep planting date for fall yield included treatments 2 (triticale, radish, clover), 3 (winter rye, clover, turnip), 4 (triticale, clover, turnip), 5 (oats, radish), 6 (triticale, rape), 9 (ryegrass, radish), 11 (radish), 13 (oats, radish, clover), and 14 (winter rye) (Table 8). Top performers for the spring yield included overwintering varieties. Specifically, top performers were treatments 3 (winter rye, clover, turnip), 4 (triticale, clover, turnip), 6 (triticale, rape), and 15 (rye and vetch).

Table 9. Cover crop yield and coverage for the 27-Sep 2017 planting date, Alburgh, VT, 2017-2018.

Mix	**Fall 2017**		**Spring 2018**	
	Dry matter yield	**Percent cover**	**Dry matter yield**	**Percent cover**
	lbs ac^{-1}	**%**	**lbs ac^{-1}**	**%**
1	364	44.9	593	68.0*
2	265	39.4	1854*	73.3*
3	274	44.4	1659	61.3
4	390	56.7*	**2393**	77.3*
5	312	34.8	422	18.7
6	206	37.2	2008*	**90.7**
7	440	40.4	388	42.7
8	230	43.1	1040	62.7
9	321	46.9	1159	80.0*
10	282	33.6	461	32.0
11	**678**	**70.1**	436	37.3
12	132	16.8	676	46.7
13	409	56.5*	507	36.0
14	344	40.8	1998*	77.3*
15	150	19.3	1284	77.3*
16	268	41.1	1456	69.3*
17	100	15.6	965	69.3*
Control	26.2	6.95	577	24.0
LSD (0.10)	164	14.8	546	26.6
Trial mean	288	38.1	1104	58.0

*Treatments marked with an asterisk were not statistically different compared to the top performing treatment (p=0.10) shown in **bold.**

From the 27-Sep planting date, the highest fall yielding performer was treatment 11 (radish) (Table 9). The top performers for spring yield including overwintering varieties, representing treatments 2 (triticale, radish, clover, pea), 4 (triticale, clover, turnip), 6 (triticale, rape), and 14 (winter rye).

Results from the planting date by variety interaction

The interaction of planting date and variety were significant for fall yield (p=0.0007), fall percent cover (p=0.0019), spring yield (p<0.0001), and spring percent cover (p<0.0001), meaning that cover crop mixture performance differed by planting date. (Figures 1, 2, 3, 4). It was expected that winter terminated cover crops such as oats, annual ryegrass, and tillage radish would produce more biomass and soil coverage if planted in late summer compared to fall. Cover crop mixtures with winter terminated and surviving species tended to experience less variability in cover and yield across planting dates.

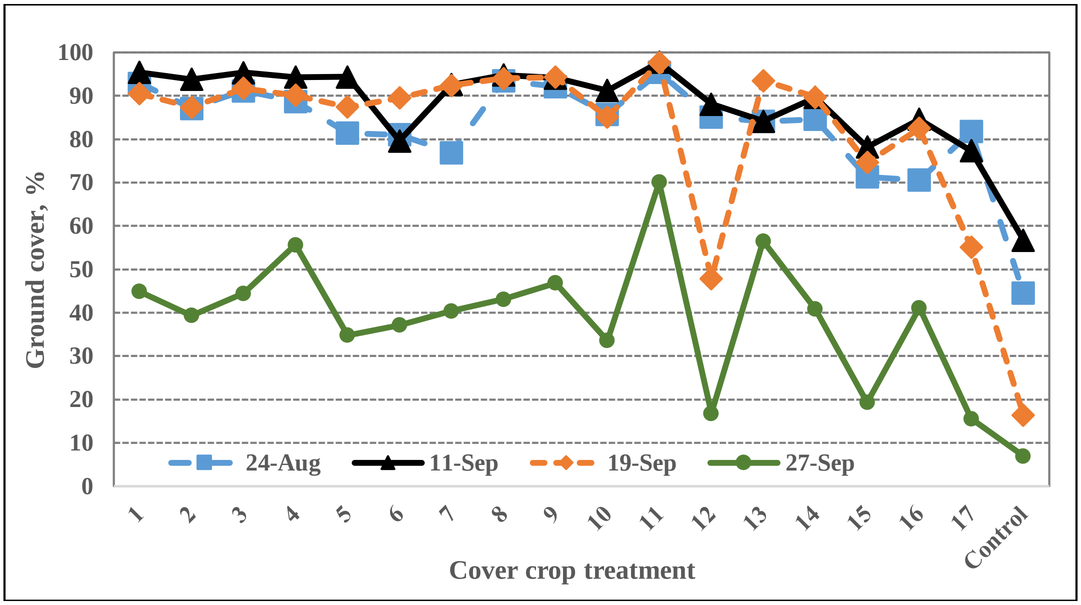

Figure 1. Fall 2017 percent cover for each of the treatments in the 24-Aug, 11-Sep, 19-Sep, and 27-Sep plantings, Alburgh, VT, 2017.

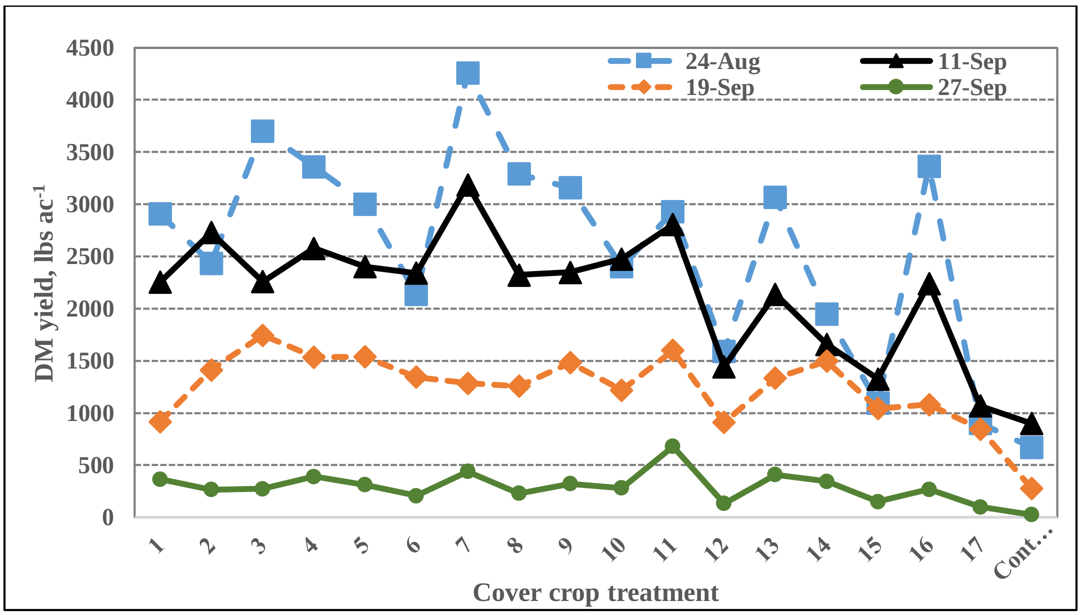

Figure 2. Fall 2017 dry matter yield for each of the treatments in the 24-Aug, 11-Sep, 19-Sep, and 27-Sep plantings, Alburgh, VT, 2017.

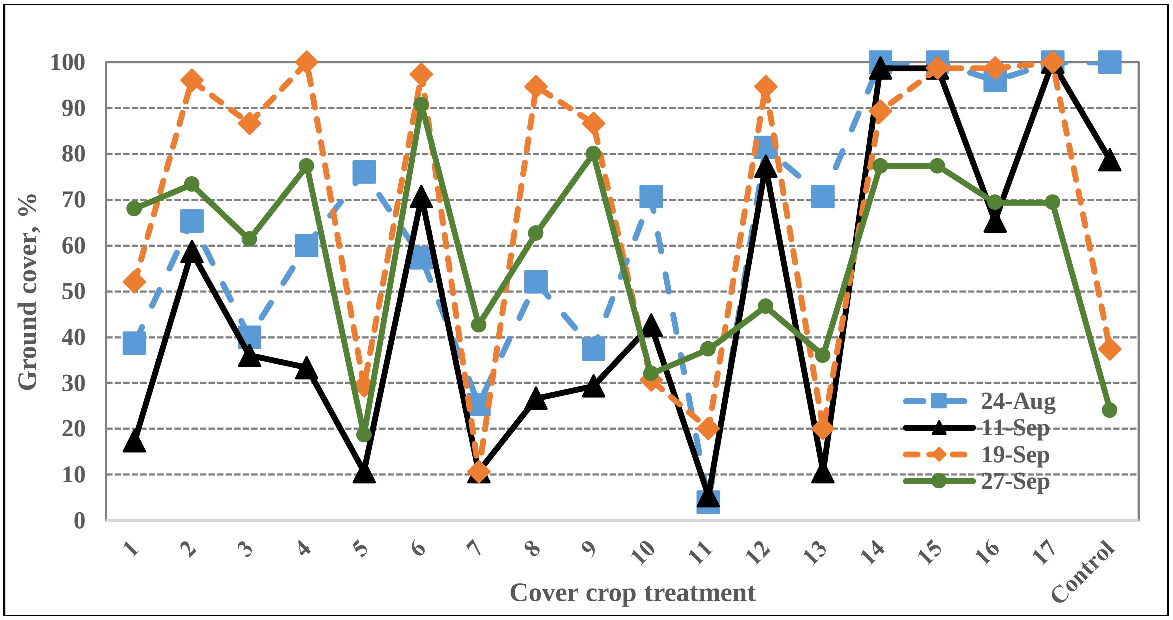

Figure 3. Spring 2018 percent cover for each of the treatments in the 24-Aug, 11-Sep, 19-Sep, and 27-Sep plantings, Alburgh, VT, 2018.

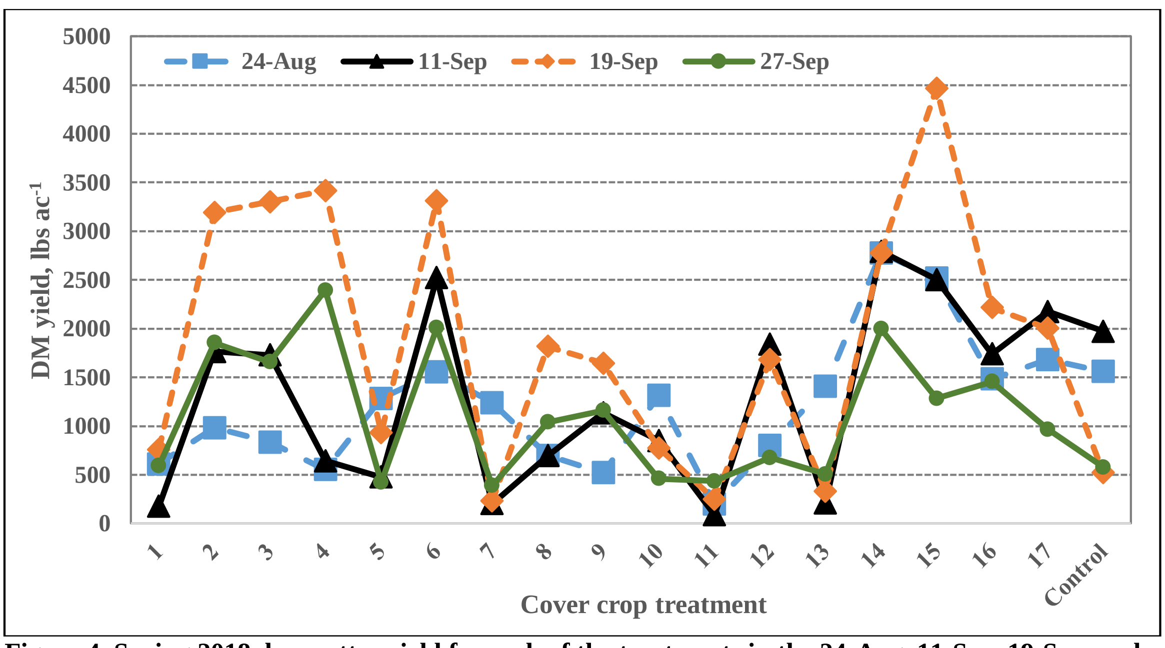

Figure 4. Spring 2018 dry matter yield for each of the treatments in the 24-Aug, 11-Sep, 19-Sep, and 27-Sep plantings, Alburgh, VT, 2018.

DISCUSSION

The trend within each planting date was that the top performers for yield in the spring included an overwintering variety, which is unsurprising since these varieties will be able to grow more biomass in the spring after winter dormancy. However, it is interesting to note that in the 24-Aug, 19-Sep, and 27-Sep plantings top performers for spring percent cover included treatments that did not overwinter. This indicates that these mixes were still able to provide the benefit of ground coverage, consisting of dead plant materials from the fall. Using a winterkilled cover crop variety may also provide the benefit of not having to manage terminating the crop in the spring, when timing of this may be difficult due to wet, spring conditions. Also, it was clear that planting earlier in the fall would result in great fall biomass yields. Cover cropping decisions will have to be made based off of the demands within each operation and field management considerations.

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