2020 Cover Crop Termination Trial

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2020 COVER CROP TERMINATION TRIAL

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In 2020, the University of Vermont Extension Northwest Crops and Soils Program investigated the impact of spring cover crop termination methods on a subsequent soybean crop's yield and quality at Borderview Research Farm in Alburgh, VT. Soybeans are grown for human consumption, animal feed, and biodiesel, and can be a useful rotational crop in corn silage and grass production systems. As cover cropping expands throughout Vermont, it is important to understand the potential benefits, consequences, and risks associated with growing cover crops in various cropping systems. In an effort to support the local soybean market and to gain a better understanding of cover cropping in soybean production systems, the University of Vermont Extension Northwest Crop and Soils (NWCS) Program, as part of a grant from the Eastern Soybean Board, conducted a trial in 2020 to investigate the impacts of different cover crop termination methods on the yield and quality of the subsequent soybean crop.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm, Alburgh, VT in 2019-2020. The experimental design was a complete randomized block design with split plots and four replications (Table 1). The main plot was spring termination method including tillage, herbicide termination before planting, and herbicide termination after planting (Table 2). Subplots were 2 cover crop treatments, winter rye (WR) and triticale (Tr) which were planted on 20-Aug 2019 (Table 3). On 28-Apr 2020, cover crop height and ground cover were measured in each plot. The beaded string method (Sloneker and Moldenhauer, 1977) was employed so that cover could be attributed to living and/or dead plant biomass.

Table 1. Trial management details, 2019-2020.

Location	Borderview Research Farm-Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Winter wheat
Plot size (feet)	5 x 20
Row spacing (inches)	30
Replicates	4
Cover crop planting date	20-Aug 2019
Soybean variety	SG0975 (maturity group 0.9, Genuity® RoundUp Ready 2 Yield)
Starter fertilizer	9-18-9 (5 gal ac^{-1})
Soybean planting date	20-May 2020
Soybean harvest date	15-Oct 2020

Cover crop biomass was measured prior to termination in the tillage and pre-spray treatments on 5-May and in the post-spray treatment on 19-May. A $0.25m^2$ area in each plot was harvested and samples were weighed prior to and after drying to determine dry matter content and calculate yield. To understand the nutrient release rates of the different cover crop treatments and how this is impacted by termination method, soil samples were collected from all plots and analyzed for soil nitrate-N (NO_3) concentration, approximately every two weeks, starting from mid-May through the end of June. Soil moisture and temperature was measured approximately every other week from planting through the season.

Table 2. Cover crop termination treatments, Alburgh, VT, 2020.

Treatment	Cover crop termination details
Tillage (5-May)	Tilled under with moldboard plow and disc harrow prior to soybean planting
Pre-spray (13-May)	Sprayed with Roundup PowerMAX® at 1qt ac^{-1} prior to soybean planting
Post-spray (27-May)	After soybeans were planted, cover crop was sprayed with Roundup PowerMAX® at 1qt ac^{-1}

On 20-May, the soybeans were planted into each of the termination treatments using a 4-row cone planter with John Deere row units fitted with Almaco seed distribution units (Nevada, IA) at 185,000 seeds ac^{-1} with 5 gal ac^{-1} starter fertilizer (9-18-9). The variety SG0975 (maturity group 0.9) soybean was obtained from Seedway, LLC (Hall, NY) for the trial. An herbicide application error caused the replanting of the soybeans in the tillage terminated plots on 12-Jun 2020.

Table 3. Overwintering cover crop mixtures grown prior to soybean crop, Alburgh, VT, 2019- 2020.

Treatment	Species	Variety	Seeding rate lbs ac^{-1}
Tr	Triticale	Trical815	100
WR	Winter rye	VNS	100

On 15-Oct, the soybeans were harvested using an Almaco SPC50 small plot combine. Seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN). They were then weighed for plot yield and tested for harvest moisture and test weight using a DICKEY-John Mini-GAC Plus moisture/test weight meter.

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 hybrids were treated as fixed. Hybrid 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. 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. In this example, treatment C is significantly different from treatment A but not from treatments B. The difference between B and C is equal to 1.5, which is less than the LSD value of 2.0. This means that these treatments 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 treatments were significantly different from one another.

Treatment	Yield
A	6.0^{b}
B	7.5^{ab}
C	**9.0^{a}**
LSD	2.0

RESULTS

Weather data were recorded throughout the season with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 4). The season began with cooler than normal temperatures, but temperatures quickly increased and remained above normal for much of the season. Rainfall was below normal for much of the season with the region being designated as D0 or abnormally dry (Drought.gov) throughout the season. Much of the rain that fell throughout the season came in short duration storms. For example, in August there were only 6 rain events that accumulated at least 0.1". Of these, 2 events totaled 1.53" and 2.98", contributing 67% of the month's entire accumulation. Furthermore, temperatures remained above normal for much of the mid-summer. In July, 75% of the month saw temperatures climb above 80° F with some days reaching above 90° F. These temperatures contributed to above normal Growing Degree Days (GDDs) accumulations of 2611, 134 above the 30-year normal.

Table 4. Weather data for Alburgh, VT, 2020.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	56.1	66.9	74.8	68.8	59.2	48.3
Departure from normal	-0.44	1.08	4.17	0.01	-1.33	0.19
Precipitation (inches)	2.35	1.86	3.94	6.77	2.75	3.56
Departure from normal	-1.04	-1.77	-0.28	2.86	-0.91	0.00
Growing Degree Days (base 50°F)	298	516	751	584	336	126
Departure from normal	6	35	121	2	-24	-6

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.

Prior to cover crop termination and subsequent soybean planting, the spring soil coverage and cover crop dry matter yield were measured (Table 5, Figure 1). There was no significant difference in spring soil coverage between the termination methods. The average living biomass, dead biomass, and total spring soil coverage were 88.6%, 4.82%, and 93.4% respectively. Cover crop biomass was significantly different between treatments, prior to termination. The tillage treatment had the most spring cover crop dry matter, 2.24 tons ac^{-1}, and was statistically similar to the post-spray treatment, 2.16 tons ac^{-1}. Soybean yield was statistically different between the termination methods. The pre-spray treatment had the highest subsequent soybean yield with 4287 lbs. ac^{-1} or 71.5 bu. ac^{-1}; the tillage treatment (3952 lbs. ac^{-1} or 65.9 bu. ac^{-1}) was statistically similar to the pre-spray treatment. There was no significant difference in soybean test weight between the cover crop termination methods. The trial average was 56.5 lbs. bu^{-1}.

Table 5. Cover crop and soybean harvest characteristics by termination method, Alburgh, VT, 2020.

Termination method	Prior to cover crop termination				Soybean harvest		
	Spring soil coverage			Cover crop dry matter yield	Yield at 13% moisture		Test weight
	Living biomass	Dead biomass	Total				
	%			tons ac^{-1}	lbs. ac^{-1}	bu. ac^{-1}	lbs. bu^{-1}
Tillage	90.7	4.90	**95.6**	**2.24**[a]†	3952[a]	65.9[a]	56.5
Pre-spray	84.1	**8.33**	92.4	1.31[b]	**4287**[a]	**71.5**[a]	**56.6**
Post-spray	**90.9**	1.23	92.2	2.16[a]	2555[b]	42.6[b]	56.4
LSD (*p* = 0.10)‡	NS§	NS	NS	0.618	687.8	11.5	NS
Trial mean	88.6	4.82	93.4	1.90	3597	60.0	56.5

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Highest treatment shown in **bold**.
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

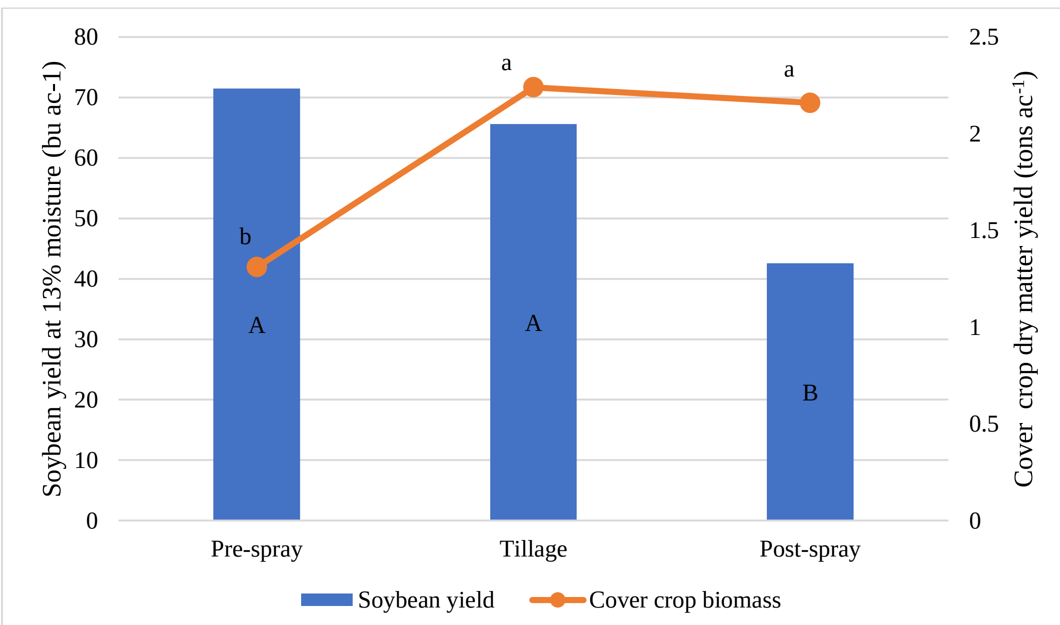

Figure 1. Soybean yield and spring cover crop biomass by cover crop termination method, Alburgh, VT, 2020. Different letters indicate a statistically significant difference between treatments (p=0.10).

Prior to cover crop termination, there was no significant impact of cover crop treatment on spring soil cover or cover crop dry matter yield (Table 6). The average living biomass, dead biomass, and total spring soil coverage were 85.6%, 4.82%, and 93.4% respectively. The average cover crop dry matter was 1.90 tons ac^{-1}. There was also no significant impact of cover crop treatment on the subsequent soybean harvest. Average soybean yield for this season was 3598 lbs. ac^{-1} or 60.0 bu. ac^{-1} and test weight was 56.5 lbs. bu^{-1}.

Table 6. Cover crop and soybean harvest characteristics by cover crop mixture, Alburgh, VT, 2020.

Treatment	Species	Prior to cover crop termination				Soybean harvest		
		Spring soil coverage			Cover crop dry matter yield	Yield at 13% moisture		Test weight
		Living biomass	Dead biomass	Total				
		%			tons ac^{-1}	lbs. ac^{-1}	bu. ac^{-1}	lbs. bu^{-1}
Tr	Triticale	**90.7**	3.60	**94.3**	1.73	3499	58.3	56.4
WR	Winter rye	86.4	**6.05**	92.5	**2.07**	**3696**	**61.6**	**56.6**
LSD (p = 0.10)‡		NS§	NS	NS	NS	NS	NS	NS
Trial mean		85.6	4.82	93.4	1.90	3598	60.0	56.5

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Highest treatment shown in **bold**.
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

About one week after soybeans were planted, soil moisture and temperature were measured every week for eight weeks. Soil moisture was significantly higher in the tillage treatment than in the pre-spray and post-spray treatment (Table 7). The pre-spray treatment had significantly higher soil moisture than the post-spray treatment on 2-, 9-, and 15-Jun. There were no differences in soil moisture between the pre-and post-spray treatments on the remaining five dates. It is possible that the soil moisture was lower in pre- and post-spray treatments because the overwintering cover crops had more time to grow in the spring, removing some of the soil moisture. In a normal year this may not impact the cash crop, but in a dry year, especially with a season-long drought, there could be negative impacts on soybean yield. The tillage treatment had significantly higher soil temperature on all dates (Table 8); the pre-and post-spray treatments were not statistically different from one another on 13- and 21-Jul. It makes sense that soil temperatures were lower in the pre- and post-spray treatments because the cover crop was sprayed but left unincorporated to act as a mulch, protecting soil microbes and preventing the soil from further drying out.

Table 7. Soil moisture by cover crop termination method, Alburgh, VT, 2020.

Termination method	Soil moisture							
	2-Jun	9-Jun	15-Jun	23-Jun	29-Jun	7-Jul	13-Jul	21-Jul
	%							
Tillage	**20.5**[a]†	**21.7**[a]	**22.4**[a]	**24.8**[a]	**22.2**[a]	**12.5**[a]	**24.6**[a]	**14.6**[a]
Pre-spray	15.7[b]	15.9[b]	16.0[b]	12.7[b]	11.8[b]	7.91[b]	17.6[b]	9.91[b]
Post-spray	11.6[c]	12.6[c]	13.7[c]	12.2[b]	10.9[b]	8.13[b]	16.1[b]	8.81[b]
LSD (p = 0.10)‡	1.06	0.951	1.09	1.57	1.55	1.17	1.56	1.12
Trial mean	15.9	16.7	17.4	16.6	15	9.51	19.5	11.1

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Highest treatment shown in **bold**.
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

Table 8. Soil temperature by cover crop termination method, Alburgh, VT, 2020.

Termination method	Soil temperature							
	2-Jun	9-Jun	15-Jun	23-Jun	29-Jun	7-Jul	13-Jul	21-Jul
	°F							
Tillage	**55.6**[a]†	**65.9**[a]	**61.4**[a]	**77.7**[a]	**72.6**[a]	**75.1**[a]	**75.7**[a]	**74.3**[a]
Pre-spray	55.3[b]	64.3[c]	59.1[c]	75.7[c]	71.4[b]	72.1[b]	74.8[b]	72.7[b]
Post-spray	55.1[c]	64.8[b]	59.8[b]	76.4[b]	70.8[c]	71.4[c]	75.0[b]	72.9[b]
LSD (p = 0.10)‡	0.24	0.175	0.23	0.335	0.264	0.42	0.36	0.33
Trial mean	55.3	65	60.1	76.6	71.6	72.9	75.2	73.3

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Highest treatment shown in **bold**.
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

Soils were analyzed for soil nitrate-N (NO_3) concentration starting from 12-May (a week prior to soybean planting) through the end of June (Table 9, Figure 2). There were no statistical differences in soil NO_3 between the three termination methods on 12-May. From 19-May through 29-Jun, the tillage treatment had the greatest amount of soil nitrate-N and was significantly greater than both the pre- and post-spray treatments on all four dates. The pre-spray treatment had significantly greater soil NO_3 than the post- spray treatment on 19-May and 29-Jun. On 15-Jun, there was spike in soil NO_3 in the post-spray treatment, making it significantly higher than the pre-spray treatment. Cover crops take up nutrients like nitrogen and store it in plant biomass, as seen with the pre- and post-spray treatments. For comparison, the plow down of cover crops releases that nitrogen by putting the soil in contact with the biomass and allowing for the decomposition of the plant material. The release of nitrogen from tilling under overwintering cover crops early in the season might make a difference in soybean growth, compared to using an herbicide to terminate the cover crop.

Table 9. Soil nitrate-N (NO_3) by cover crop termination method, Alburgh, VT, 2020.

Termination method	Soil nitrate-N (NO_3, ppm)				
	12-May	19-May	2-Jun	15-Jun	29-Jun
Tillage	5.11	**11.1**[a]†	**16.5**[a]	**23.7**[a]	**27.9**[a]
Pre-spray	**5.97**	5.82[b]	9.2[b]	12.8[c]	16.1[b]
Post-spray	4.83	4.13[c]	7.47[b]	18.8[b]	9.66[c]
LSD (p = 0.10)‡	NS§	1.08	1.78	2.43	3.41
Trial mean	5.31	7.01	11.1	18.4	17.9

†Within a column, treatments marked with the same letter were statistically similar (p=0.10).
Highest treatment shown in **bold**.
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

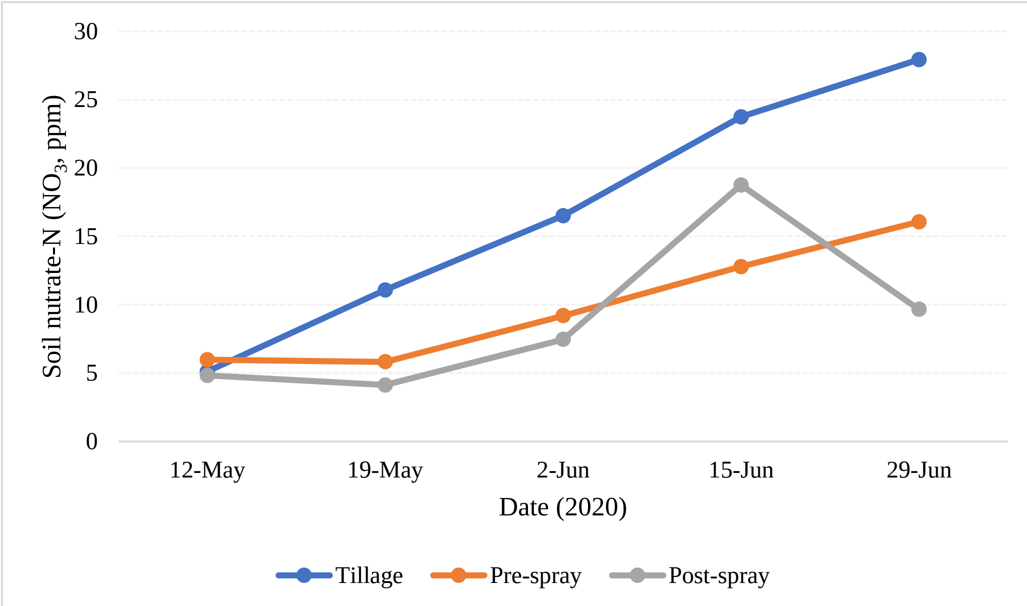

Figure 2. Soil nitrate-N (NO_3) concentration by cover crop termination method, 2020.

DISCUSSION

In 2020, while the season started out cooler than normal, it quickly became warmer than average for most of the season. Rainfall was below average throughout the growing season, and the precipitation came in short duration storms. The cover crop species did not have an impact on the spring soil coverage or cover crop dry matter yield prior to termination, nor did the cover crop type impact soybean yield or quality. Prior to cover crop termination, there were no significant differences in spring soil coverage amongst the plots that would be tilled, sprayed prior to, or sprayed after soybean planting. However, cover crop dry matter was statistically different. The plots that would be tilled had the greatest dry matter yield prior to termination, and the plots that would be sprayed prior to soybean planting, statistically had the lowest dry matter yield. The pre-spray treatment had the greatest soybean yield, and the post-spray treatment had the lowest. The large cover crop biomass prior to termination may have impacted soybean yields in the post-spray treatment, and inversely the lack of spring biomass in the pre-spray treatment may have allowed for a more successful soybean yield. These differences in cover crop biomass prior to termination may have added to the significant difference in soybean yield, in addition to any effects from the termination methods. Soil moisture and temperature were highest in the tillage treatment, as well as overall soil nitrate-N. The tillage and the pre-spray treatment both had gradual increase in soil nitrate-N from 12-May to 29-Jun, although overall soil nitrate-N levels were much lower in the pre-spray treatment. The post-spray treatment also consistently had lower soil nitrate-N levels until a spike on 15-Jun, but then a drop in soil nitrate-N on 29-Jun. The additional available nitrogen in the tillage treatment did not appear to have an impact on soybean yield since the tillage treatment was statistically similar to the pre-spray treatment in terms of soybean yield. It should be noted that soybeans were replanted later (12-Jun) in the tillage treatment due to herbicide application error.

Overall, soybean yields in this trial were comparable to the yield of soybeans in other trials conducted at Borderview Research Farm in 2020. These data suggest that soybeans can successfully be grown following an overwintering cover crop and but may be negatively impacted by the amount of cover crop biomass prior to spring termination. For comparison, in the 2019 trial, there was no significant difference in soybean yield between termination methods, even though the overall spring cover crop biomass was significantly different. However, soybean yields last year were impacted by the cover crop type. Soybean yields were lowest where there was winter rye likely because the winter rye had the most spring soil coverage and biomass. These data indicate the need for more research on integrating cover crops into a soybean production system in order to make it a viable option for farmers. We will continue to investigate cover cropping practices in soybeans in this region to gain a better understanding of successful cover cropping practices and their impacts on soybean performances. UVM Extension Northwest Crops and Soils Program plans to repeat this trial in 2021.

REFERENCES

Sloneker, L. L. and W. C. Moldenhauer, 1977. Measuring the amounts of crop residue remaining after tillage. J. Soil Water Conserv. 32:23 l-236.

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