2024 Soybean Cover Crop Termination Trial

NORTHWEST CROPS & SOILS PROGRAM

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2024 SOYBEAN COVER CROP TERMINATION TRIAL

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The University of Vermont Extension Northwest Crops and Soils Program investigated the impact of winter rye cover crop termination method and timing at Borderview Research Farm on soybean crop yield and quality 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. Cereal or winter rye is commonly planted in this region as a cover crop. As soybean production expands throughout Vermont, it is important to understand the potential benefits, consequences, and risks associated with growing cover crops in these systems. 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 2023-2024 to investigate the impacts of winter rye termination methods on the yield and quality of the subsequent soybean crop.

MATERIALS AND METHODS

The cover crop termination trial was conducted at Borderview Research Farm, Alburgh, VT in 2023-2024. Trial management details are described in Table 1. The experiment was a randomized complete block design with four replicates and five cover crop termination methods. There were two early termination methods: Plow, and Early Spray, and three late termination methods: Late Spray, Roll & Plant, and Plant then Roll. Termination treatment details are included in Table 2 below. The previous fall, cereal rye (var. ND Gardner, Albert Lea Seed) was planted on 9-Oct 2023 with a Sunflower no-till grain drill at a rate of 3 million seeds ac^{-1}, approximately 160 lbs ac^{-1}. In the spring of 2024, cover crop biomass was measured prior to termination by collecting a 0.25m^2 quadrat, clipping all above ground plant material, and placing samples in a dryer to remove all moisture before weighing to calculate dry matter yield. Samples were collected on 7-May 2024 to capture rye biomass at the early termination and on 23-May 2024 to capture biomass at the late termination. Soil health samples were collected on the same days as the rye biomass to look for any differences in soil health characteristics. Soil samples were collected according to the Cornell Soil Health sampling protocol and sent to the Cornell Soil Health Laboratory to be analyzed (https://soilhealth.cals.cornell.edu/).

Table 1. Trial management details, Alburgh, VT, 2023-2024.

Location	Borderview Research Farm-Alburgh, VT
Soil type	Benson rocky silt loam, over shaly limestone, 8 to 15% slopes
Previous crop	Perennial grasses/legumes
Plot size (feet)	10 x 40
Row spacing (inches)	30
Replicates	4
Cover crop planting date	9-Oct 2023
Cover crop variety	ND Gardner
Cover crop seeding rate	160 lbs ac^{-1}

Soybean variety	SG 0643XTF (maturity group 0.6, XtendFlex)
Soybean planting date	23-May 2024
Soybean seeding rate (seeds ac^{-1})	180,000
Soybean harvest date	7-Oct 2024

Table 2. Cover crop termination treatments, Alburgh, VT, 2024

Treatment	Cover crop termination details
Plow	Rye plowed under 2 weeks before planting soybeans (7-May 2024)
Early Spray	Rye sprayed with herbicide 2 weeks before planting soybeans (7-May 2024)
Late Spray	Rye sprayed with herbicide at planting of soybeans (23-May 2024)
Roll & Plant	Rye roller crimped just before planting soybeans (23-May 2024)
Plant then Roll	Soybeans planted and then rye roller crimped after soybean emergence (4-Jun 2024)

Soybeans (var. SG0643XTF, Seedway LLC) were planted on 23-May 2024 using a John Deere no-till planter at a rate of 180,000 seeds ac^{-1}. All plots were 40 feet long and consisted of 4 rows with 30-inch spacing. Beginning on 3-Jun 2024, soil moisture was measured using a handheld moisture meter. Soil moisture was measured every two weeks until 18-Jul 2024. On 7-Oct 2024, the soybeans were harvested using an Almaco SPC50 small plot combine and seed was cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN). Seed was weighed for plot yield and tested for harvest moisture and test weight using a DICKEY-John Mini-GAC Plus moisture and test weight meter.

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 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 an 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 treatment 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 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 3). Above average temperatures persisted for all months of the growing season except for August, when the monthly average temperature (69.2°F) was 1.45 degrees below normal. There was a total of 26.0 inches of precipitation this season, 2.86 inches above normal. During the months of June to August, there were five large rain events where Alburgh, VT received 1-3 inches of rain per event. But the heavy rain during the middle of the season was followed by two relatively dry months in September and October. There were 2,905 Accumulated Growing Degree Days this season, 218 above normal.

Table 3. Weather data for Alburgh, VT, 2024.

	2024					
Alburgh, VT	May	Jun	Jul	Aug	Sep	Oct
Average temperature (°F)	61.9	68.5	73.7	69.2	64.7	52.1
Departure from normal	3.47	0.95	1.33	-1.45	2.02	1.81
Precipitation (inches)	2.27	6.65	6.67	5.78	2.61	2.00
Departure from normal	-1.49	2.39	2.61	2.24	-1.06	-1.83
Growing Degree Days (50-86°F)	388	548	732	595	444	198
Departure from normal	87	25	37	-47	56	60

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

Prior to termination, winter rye biomass was measured to understand the impact of delayed termination on spring biomass production. Unsurprisingly, there was significantly more rye biomass at the later termination time (Table 4). From 7-May to 23-May, the rye biomass increased nearly 3.5X. It should be noted that rye biomass was sampled just prior to soybean planting, at the time of cover crop termination in the Late Spray and Roll & Plant treatments. The rye in the Plant then Roll treatment was not terminated until 4-Jun once soybeans had emerged. It is likely that there would be additional rye biomass as the rye continued to grow for about a week following planting. Overall, the quantity of rye biomass was low compared to past years due to late planting in the fall of 2023 and relatively poor establishment.

Table 4. Winter rye spring biomass by termination timing, Alburgh, VT, 2024.

Termination timing	Winter rye DM yield	
	lbs ac^{-1}	tons ac^{-1}
Early	984[b]	0.49[b]
Late	**3424[a]†**	**1.71[a]**
LSD (p = 0.10)‡	810	0.41
Trial mean	2204	1.10

†Within a column, treatments marked with the same letter were statistically similar (p=0.10).
The top performer is in **bold.**
‡LSD; Least significant difference at the p=0.10.

Soil health characteristics at the early and late cover crop termination times are summarized in Table 5. Predicted water capacity and active carbon were statistically higher at the early cover crop termination. Aggregate stability was statistically greater at the later termination time. There were no statistical differences between the termination times for organic matter, soil organic carbon, total carbon, total nitrogen, soil proteins, or soil respiration. With the Comprehensive Assessment of Soil Health (CASH), the Cornell Soil Health Laboratory calculates an overall quality score by averaging individual indicator ratings to provide an indication of the overall health status of the soil. The late termination time had a statistically higher overall score (78.9) than the early termination time (75.4), but both fell within the 'High' functioning range, suggesting overall high-quality soils.

Table 5. Soil health characteristics by cover crop termination timing, Alburgh, VT, 2024.

Termination timing	Predicted water capacity	Aggregate stability	Organic matter	Soil organic carbon	Total carbon	Total nitrogen	Soil proteins	Soil respiration	Active carbon	Overall score
	g H_2O g $soil^{-1}$	%	%	%	%	%	mg protein g $soil^{-1}$	mg CO_2 g $soil^{-1}$	ppm	
Early	**0.244[a]**†	25.4[b]	4.31	2.52	2.56	0.271	6.62	0.551	**758[a]**	75.4[b]
Late	0.233[b]	**36.3[a]**	4.15	2.75	2.76	0.260	6.96	0.520	694[b]	**78.9[a]**
LSD (*p*=0.10)‡	0.006	6.79	NS§	NS	NS	NS	NS	NS	45.2	2.05
Trial mean	0.238	30.9	4.23	2.63	2.66	0.266	6.79	0.535	726	77.1

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

Soil moisture was measured after soybean emergence, starting on 3-Jun, and continued every two weeks until 18-Jul. Results are summarized in Table 6. Soil moisture started out lower and increased later in the season across all the treatments. This coincides with decreased precipitation throughout May, but an increase in heavy rainfall during the months of June and July. There were no statistical differences in soil moisture on 3-Jun, 2-Jul, or 18-Jul. On 17-Jun, soil moisture was greatest in the Plow treatment, but not statistically different from the Early or Late Spray treatments. Soil moisture was lowest in the Roll then Plant treatment, but not statistically different from the Plant then Roll treatment. This indicating that the late terminated cover crops were able to utilize some of the excess moisture during their continued growth.

Table 6. Soil moisture by cover crop termination method, Alburgh, VT, 2024.

Termination method	Soil moisture			
	3-Jun	17-Jun	2-Jul	18-Jul
	%			
Plow	11.6	**14.9**[a]†	15.9	16.7
Early Spray	13.5	13.8[ab]	15.0	19.0
Late Spray	11.8	13.7[ab]	15.3	17.8
Roll & plant	12.2	11.0[c]	14.5	17.4
Plant then Roll	9.73	12.5[bc]	15.7	16.1
LSD (p = 0.10)‡	NS§	2.31	NS	NS
Trial mean	11.8	13.1	15.2	17.4

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

Soybean harvest moisture, yield, and test weight were not significantly impacted by cover crop termination method (Table 7). The average seed moisture was 15.4%, the average soybean yield at 13% moisture was 3028 lbs or 50.5 bu ac^{-1}, and the average test weight was 55.2 lb. bu^{-1}. Overall, there was a significant amount of lodging in the plots making it difficult to harvest.

Table 7. Soybean harvest characteristics by cover crop termination method, Alburgh, VT, 2024.

Termination method	Harvest moisture	Yield at 13% moisture		Test weight
	%	lbs ac^{-1}	bu ac^{-1}	lbs bu^{-1}
Plow	14.9	3146	52.4	56.1
Early Spray	15.0	3078	51.3	55.0
Late Spray	15.5	3114	51.9	55.2
Roll & plant	15.8	2794	46.6	54.7
Plant then Roll	15.6	3007	50.1	55.2
LSD (p = 0.10)†	NS‡	NS	NS	NS
Trial mean	15.4	3028	50.5	55.2

†LSD; Least significant difference at the p=0.10.
‡ NS; No significant difference between treatments.

DISCUSSION

The University of Vermont Extension Northwest Crops & Soils program conducted a research trial in 2023-2024 to investigate the impact of cover crop termination method and timing on subsequent soybean yields. Five cover crop termination methods were selected, two represented early termination strategies and three represented a late cover crop termination. During the soybean growing season there were 2,905 accumulated Growing Degree Days, slightly higher than normal. Temperatures were about 3.5 degrees above average in May, and leading up to planting, Alburgh, VT had received 1.5 inches less precipitation than normal that month. Soil conditions at planting were warm but dry. August was the only month with below average temperatures, about 1.5 degrees cooler than normal. Alburgh, VT received above average precipitation in 2024. There was a total of about 26 inches of rain, 2.8 inches above normal. The heavy rainstorms occurred during the months of June, July, and August, but then conditions were relatively dry for the remainder of the season with below average rainfall in the months of September and October. Heavy rain, saturated soils, and lodging from wind can cause problems like lodging in soybeans, which was observed in this trial. Despite a wet season, timely harvest was possible because of the drier conditions late in the season.

Cereal rye is a fast-growing cover crop and will put on a lot of biomass even under cooler conditions. Unsurprisingly, there was 3.5X more biomass at the late termination time, only two weeks later than the early termination time. Warm temperatures in May resulted in favorable conditions for the rye cover crop to put on a lot of biomass in a short period of time. At the same time that cereal rye biomass was collected, soil health samples were collected to compare soil health characteristics at the two termination times. Changes in soil health happen over a longer period and are the result of multiple years of management practices, so it is not surprising that there were few statistical differences in soil health characteristics between the early and late cover crop termination times. Cover crop termination method treatments had not been implemented yet at the time of soil sampling, so the only differences were the time of sampling and how long the cereal rye had been growing. While the overall score was statistically greater in the late termination, both had scores that fell in the 'High functioning' category of soil health outlined by the Cornell Soil Health Laboratory, suggesting that overall there were high-quality soils in this trial.

Cover crop termination method did not significantly impact soybean yields in 2024, despite significantly higher biomass at the later termination times. Above average precipitation and few differences in soil moisture across treatments suggest that the excess rye biomass was not competing for or removing available water from the crop. Similar results were observed in 2023, but the Plant then Roll treatment did have significantly lower yields than the other four treatments. Temperatures were much cooler in May 2023 than in 2024, and there was delayed emergence in the Plant then Roll treatment. Cool temperatures also persisted for much of the growing season in 2023, exasperating the delayed emergence and potential reduced stand counts in the Roll then Plant treatment. Alburgh, VT has experienced above average rainfall over the last three years. In a 2021 research trial, soybean yields were significantly reduced when planted into living rye. That season, Alburgh, VT received 4 inches less rain than normal. Soil moisture was also statistically lower where soybeans were planted into the living rye. These results highlight the potential risk of planting green or delaying rye termination until after soybean planting, as it can cause reductions in yield in years with suboptimal conditions (i.e. drought, cold temperatures).

It is important to remember that these data only represent one year and one trial location. Cover cropping can be a beneficial management strategy, but it is important to understand the potential benefits, consequences, and risks associated with growing cover crops in soybean production systems.

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