Northwest Crops & Soils Program | UVM Extension

2020

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2020 SOYBEAN COVER CROP TRIAL

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In 2020, the University of Vermont Extension Northwest Crops and Soils Program investigated the impact of various cover crop mixtures on the 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 2019-2020 to investigate the impacts on soybean yield and quality following annual cover crop mixtures with a soybean crop.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm, Alburgh, VT in the 2019-2020 season. The experimental design was a complete randomized block with four replications (Table 1). The treatments were 10 cover crop monocultures or mixtures planted on 20-Aug 2019. Treatments consisted of cover crops that would over winter and others that would be terminated by winter conditions. Cover crop treatments and seeding rates are listed in Table 2. Fall biomass samples were collected on 29-Oct 2019 from a 0.25m^2 area in each plot. Samples were weighed prior to and after drying to determine dry matter content and calculate yield. On 28-Apr 2020, cover crop height and ground cover were measured in all plots. Ground cover was assessed using the beaded string method allowing for distinction between living and dead cover (Sloneker and Moldenhauer, 1977). Soil health samples were also collected from all plots and air-dried prior to being sent to the Cornell Soil Health Laboratory (Ithaca, NY) for analysis. On 5-May, cover crop biomass was measured for plots containing living cover crop biomass using the same sampling protocol as in the fall. All cover crop treatments were terminated in the spring, just prior to soybean planting using a moldboard plow and disc harrow.

Table 1. Trial management details, 2019-2020.

	Borderview Research Farm-Alburgh, VT
Soil types	Benson rocky silt loam
Previous crop	Winter wheat
Tillage operations	Moldboard plow and disc
Plot size (feet)	5 x 20
Row spacing (inches)	30
Replicates	4
Starter fertilizer (gal ac^{-1})	5 gal ac^{-1} 9-18-9
Planting dates	Cover crops: 20-Aug 2019 Soybeans: 12-Jun 2020
Weed control	1 qt. ac^{-1} Roundup PowerMAX® applied 13-May 2020
Harvest date	15-Oct 2020

On 12-Jun 2020, the soybeans were planted into the terminated cover crop treatments using a John Deere 1750 corn planter at 185,000 seeds ac^{-1} treated with soybean inoculant and with 5 gal ac^{-1} starter fertilizer (9-18-9). The variety SG0975 (maturity group 0.9, Genuity® RoundUp Ready 2 Yield) soybean was obtained from Seedway, LLC (Hall, NY) for the trial. Soybeans were sprayed with Roundup PowerMAX® herbicide following planting to control weeds. 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.

Table 2. Annual cover crop mixture treatments grown in 2019 prior to soybeans in 2020.

Species	Variety	Over-winters?	Seeding rate lbs. ac^{-1}
Annual ryegrass	Centurion	No	25
Radish	Daikon		3
Oats	Everleaf 125	No	75
Radish	Daikon		3
Oats	Everleaf 125	No	75
Crimson clover	Diogene		10
Oats	Everleaf 125	No	125
Annual ryegrass	Centurion	No	30
Crimson clover	Diogene	No	15
Radish	Daikon	No	6
Triticale	Trical815	Yes	100
Winter rye	VNS	Yes	100
No cover		No	N/A

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 treatments were treated as fixed. Treatment 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 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). 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 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 Day (GDD) accumulations of 2611, 134 above the 30-year normal.

Table 3. 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.

In the fall, cover crop treatments differed significantly in dry matter yield between the cover crop treatments (Table 4). Fall dry matter yield ranged from 0.31 tons ac^{-1} (Control) to1.80 tons ac^{-1} (Oats), and the trial average was 1.26 tons ac^{-1}. The highest yielding treatment, oats, was statistically similar to three other treatments (Oat/radish, Annual ryegrass/radish, and Oat/crimson clover). All cover crop treatments had fall yields that were significantly greater than the control. In the spring, the winter rye had the highest biomass, 2.07 tons ac^{-1}, which was statistically greater than all other treatments. The triticale produced the second highest spring biomass, 1.73 tons ac^{-1}. Typically, in the region, annual ryegrass is winter-killed, but mild winter conditions allowed for the cover crop to survive into the spring. The annual ryegrass and the annual ryegrass/radish treatments produced 1.00 tons ac^{-1} and 0.66 tons ac^{-1} respectively. All other treatments were winter-killed and did not produce any spring biomass. The cover crop treatment had no statistically significant impact on soybean yield or test weight in 2020. Soybean yield ranged from 3334 lbs. ac^{-1} (Oat/crimson clover) to 3696 lbs.ac^{-1} (Winter rye), and the trial average was 3486 lbs. ac^{-1}. The average test weight was 56.6 lbs. bu^{-1}.

Table 4. Cover crop and soybean harvest characteristics, 2019-2020.

Cover crop treatment	Over-winters	Dry matter yield		Soybean harvest 2020	
		Fall 2019	Spring 2020	Yield at 13% moisture	Test weight
		tons ac^{-1}		lbs. ac^{-1}	lbs. bu^{-1}
Annual ryegrass, radish	Noǂ	1.57[ab]†	0.66[d]	3422	56.7
Oats, radish	No	1.71[ab]	0.00[e]	3445	56.6
Oats, crimson clover	No	1.56[ab]	0.00[e]	3334	56.6
Oats	No	**1.80[a]**	0.00[e]	3482	56.8
Annual ryegrass	Noǂ	1.44[bc]	1.00[c]	3353	56.3
Crimson clover	No	1.26[c]	0.00[e]	3613	56.5
Radish	No	1.23[cd]	0.00[e]	3451	**57.0**
Triticale	Yes	0.77[e]	1.73[b]	3499	56.4
Winter rye	Yes	0.94[de]	**2.07[a]**	**3696**	56.6
No cover	No	0.31[f]	0.00[e]	3569	56.8
LSD (p = 0.10)‡	N/A	0.303	0.26	NS§	NS
Trial mean		1.26	0.55	3486	56.6

ǂGenerally, annual ryegrass does not over winter in our region, however, more mild than usual conditions through the winter allowed the treatments containing annual ryegrass to survive into the spring of 2020.
†Within a column, treatments marked with the same letter were statistically similar (p=0.10).
‡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 mid-May through the end of June (Table 5, Figure 1). Overall, soil nitrate-N (NO_3) was highest in plots that had the radish cover crop treatment. The radish treatment had significantly greater soil NO_3 than all other treatments on three of the dates (12-May, 19-May, and 15-Jun). On 2-Jun and 29-Jun, the radish treatment was statistically similar to the cover crop mixtures that contained radish (oat/radish and annual ryegrass/radish). Overall, the annual ryegrass/radish and oats/radish treatments both had relatively high soil nitrate-N concentrations, and had the second and third highest soil NO_3 concentrations on 2, 15, and 29-Jun. The two overwintering cover crop treatments, triticale and winter rye, had some of the lowest soil nitrate-N concentrations. On all five dates, both triticale and winter rye treatments had soil NO_3 concentrations that were not significantly different than the control. Plots that had the annual ryegrass treatment, had soil nitrate-N concentrations similar to the two overwintering species.

Table 5. Soil nitrate-N (NO_3) concentration (ppm) by cover crop treatment, Alburgh, VT, 2020.

Cover crop treatment	Over-winters	Soil NO_3 (ppm)				
		12-May	19-May	2-Jun	15-Jun	29-Jun
Annual ryegrass, radish	Noǂ	7.15[b]†	7.49[c]	12.6[ab]	22.8[b]	20.3[b]
Oats, radish	No	7.77[b]	10.1[b]	12.4[ab]	22.1[bc]	20.7[ab]
Oats, crimson clover	No	6.26[b]	6.96[cd]	10.8[bc]	16.2[de]	17.0[bc]
Oats	No	7.64[b]	7.65[c]	10.6[bc]	18.0[cd]	16.1[bc]
Annual ryegrass	Noǂ	3.63[c]	5.20[de]	9.00[c]	14.9[de]	13.4[c]
Crimson clover	No	2.99[c]	5.78[cde]	10.9[bc]	19.1[bcd]	16.1[bc]
Radish	No	**9.90[a]**	**12.5[a]**	**15.5[a]**	**31.8[a]**	**26.8[a]**
Triticale	Yes	2.64[c]	4.60[e]	8.72[c]	12.8[e]	14.8[bc]
Winter rye	Yes	2.54[c]	4.74[e]	10.3[bc]	11.9[e]	15.3[bc]

No cover	No	2.53[c]	5.07[de]	9.63[bc]	14.7[de]	18.4[bc]
LSD (p = 0.10)‡	N/A	2.03	1.96	3.26	4.44	6.23
Trial mean		5.31	7.01	11.1	18.4	17.9

ƗGenerally, annual ryegrass does not over winter in our region, however, more mild than usual conditions through the winter allowed the treatments containing annual ryegrass to survive into the spring of 2020.
†Within a column, treatments marked with the same letter were statistically similar (p=0.10).
‡LSD; Least significant difference at the p=0.10.
§NS; No significant difference between treatments.

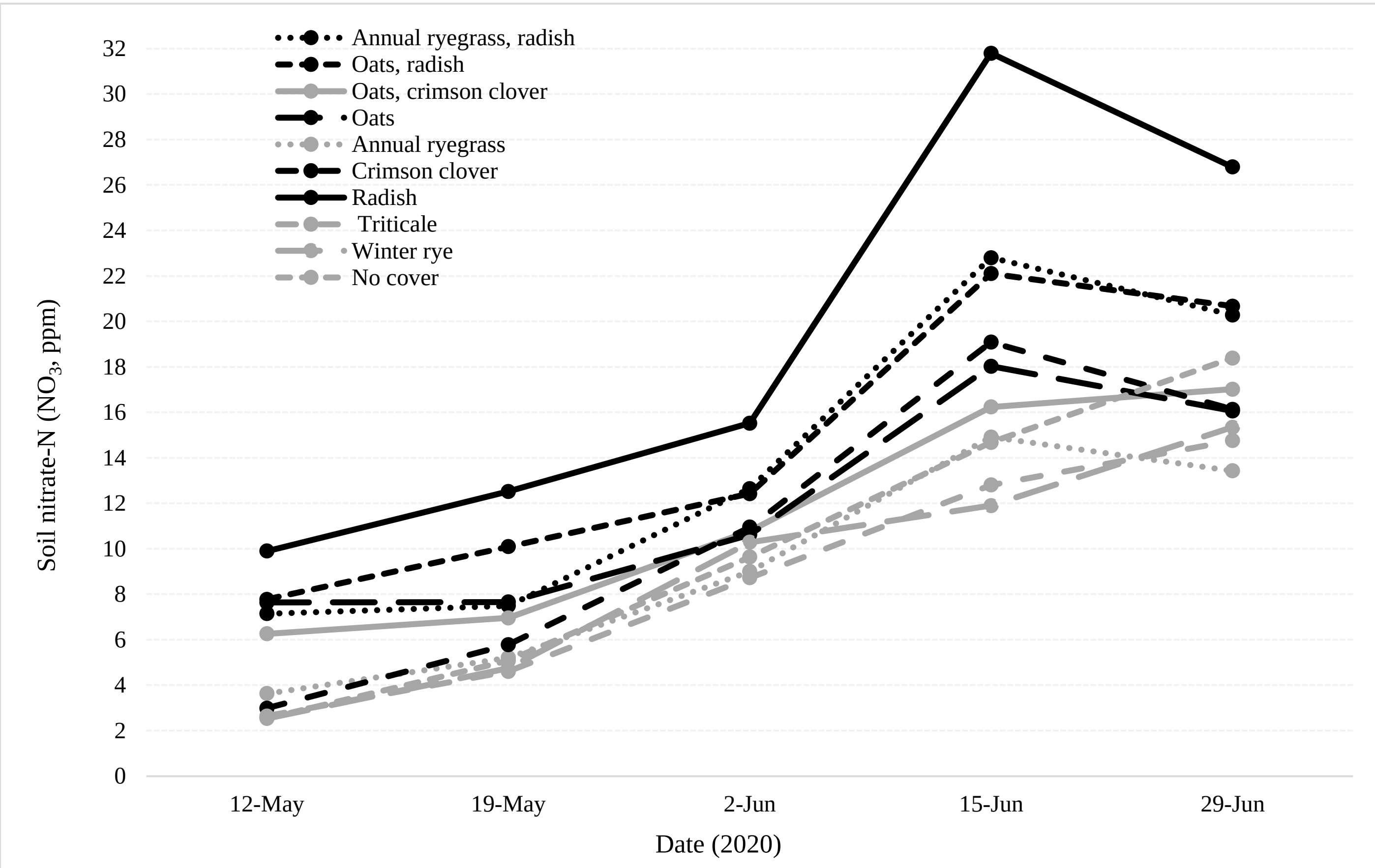

Figure 1. Soil nitrate-N (NO_3) concentration (ppm) by cover crop treatment, Alburgh, VT, 2020.

Table 6 below displays the impact of cover crop type (overwinter vs. winterkill) on soybean yield over the past four years. In 2017, we saw a significant decrease in soybean yields when following an overwintering cover crop. In 2018, while there was a decrease in soybean yields following an overwintering cover crop, it was not significantly different than the yield of soybeans planted following a winter-killed cover crop. In 2019, the trend was similar to that of 2018. This year, the results were similar to the previous two years, although the difference in soybean yield was only 0.2 bu. ac^{-1} less in plots that had an overwintering cover crop. This yield difference was less than in the past three years.

Table 6. Soybean yield by cover crop type, Alburgh, VT.

Overwinter	Soybean yield (bu. ac^{-1})			
	2017	2018	2019	2020
Yes	60.4	61.1	72.3	65.9
No	**67.9**	**63.9**	**79.0**	**66.1**
p value	0.007	§NS	NS	NS
Trial mean	64.2	62.6	76.3	66.0

The top performers are in **bold.**
§NS; No significant difference between treatments.

DISCUSSION

In the fall of 2019, all the cover crop treatments produced dry matter yields that were greater than the control, and the oat treatment had the greatest yield. The triticale and winter rye treatments (both overwintering species) had the two lowest fall yields other than the control. The mild winter conditions this season allowed for the annual ryegrass to survive and produce spring biomass. The winter rye treatment had the greatest spring biomass, followed by the triticale. 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 soybean yield in 2020 was not significantly impacted by cover crop treatment, but soybean yield was the greatest in plots that had the winter rye treatment (Figure 2). The trial average this season was 3696 lbs. ac^{-1}, which was lower than in the past three years of this trial. But similar to 2018 & 2019, soybean yield was not negatively impacted by cover crop type in 2020. The radish treatment had the highest soil nitrate-N (NO_3) concentration on all sampling dates, and the other two cover crop treatments that contained radish (Annual ryegrass/radish and Oats/radish) had relatively high soil NO_3 concentrations as well. Most treatments had soil nitrate-N peak around 15-Jun, just after soybean planting. The radish treatment had a dramatic increase in soil nitrate-N from 2-Jun (15.5ppm) to 15-Jun (31.8 ppm), when soil nitrate-N concentration doubled. The winter rye, triticale, and annual ryegrass treatments all had a much more gradual increase in soil NO_3, and none had concentrations that were much different from the control. While soil nitrate-N was significantly different between cover crop treatments, the extra nitrogen available did not seem to impact soybean yields. As a result, 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 performance.

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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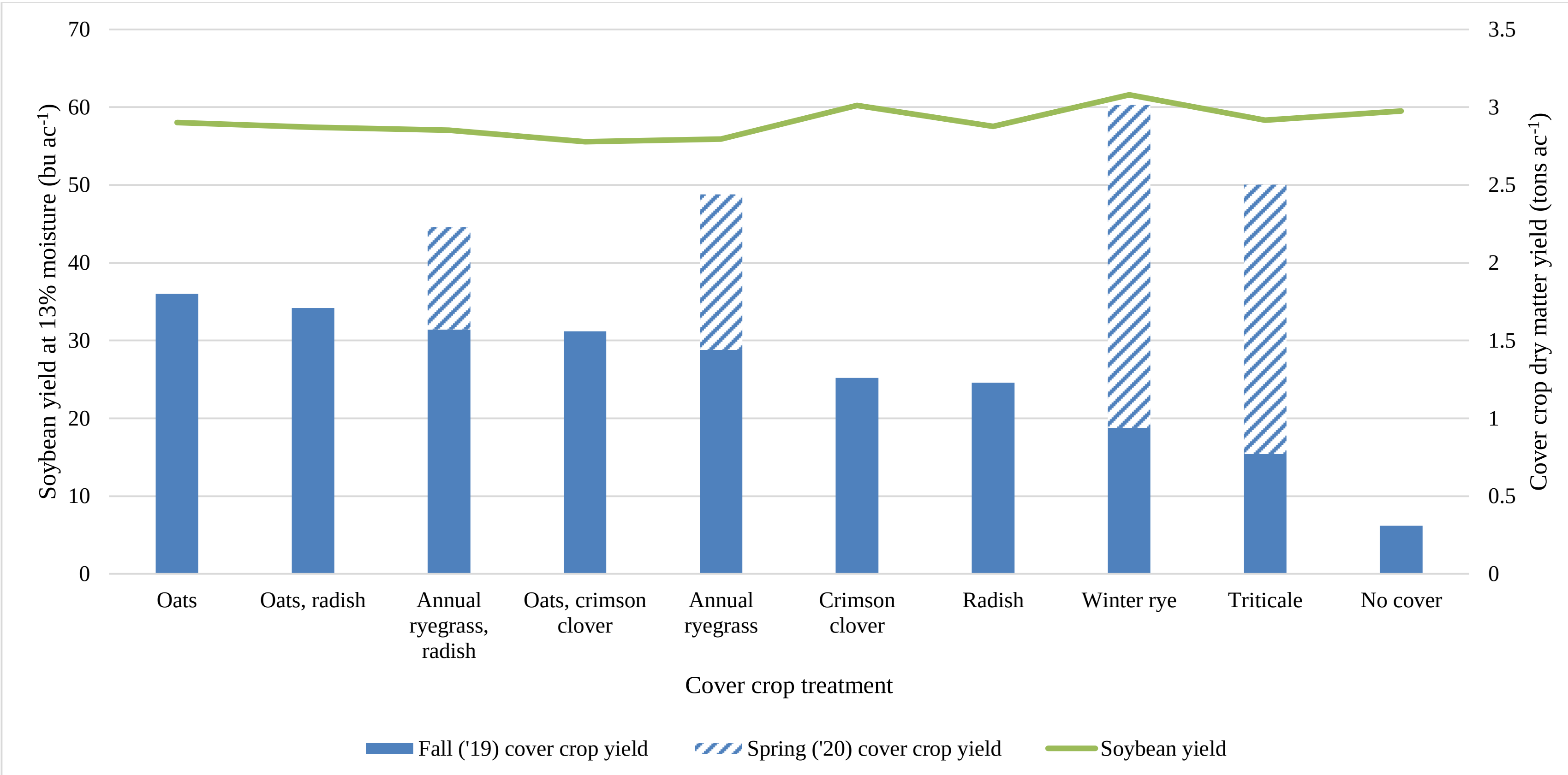

Figure 2. Cover crop biomass and soybean yield by cover crop treatment, 2020.