Eastern Soybean Board Project Final Report

Maximizing Soybean Production in a Changing Climate.

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Due to the relatively short growing season in Vermont, little research has been conducted on soybeans and the insects and diseases that can affect yield and quality. Soybeans could be grown for human consumption, animal feed, and biodiesel in Vermont. The purpose of our trials was to evaluate yield and quality of short season soybean varieties, begin to document optimum planting dates for the region, and continue to work towards developing cover cropping practices for soybeans. With a growing concern of agriculturally related water quality implications in Vermont waterways, farmers are now required in some instances to cover crop their annually cropped fields. However, with this increase in cover cropping there is a need to investigate potential impacts on following cash crops including soybeans. This report will summarize our research and outreach activities for the 2017 growing season.

Weather data was 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 1). Overall the season was cooler and wetter than normal. Almost 1.5 inches of rain fell within the first week of June immediately following planting. Unseasonably cool temperatures and above average rainfall persisted through August followed by above average temperatures and below average rainfall in September and October. The dry warm weather in the fall provided good weather for the soybeans to mature and to be harvested at optimal moisture content. Overall a total of 2580 growing degree days were accumulated May-October, 256 above the 30-year normal.

Table 1. Weather data for Alburgh, VT, 2017.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	55.7	65.4	68.7	67.7	64.4	57.4
Departure from normal	-0.75	-0.39	-1.90	-1.07	3.76	9.2
Precipitation (inches)	5.6	5.64	4.88	5.54	1.84	3.3
Departure from normal	1.95	1.95	0.73	1.63	-1.80	-0.31
Growing Degree Days (base 50°F)	245	468	580	553	447	287
Departure from normal	47	-7	-60	-28	129	175

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.

Soybean Variety Trial

The variety trial included 23 varieties from five different seed companies spanning maturity groups 0.07 to 2.0 (Table 2). The experimental design was a randomized complete block with 4 replicates. The trial was planted on 1-Jun 2017 into a Benson rocky silt loam at a rate of 185,000 seeds ac^{-1} treated with soybean

Table 2. Soybean varieties evaluated in Alburgh, VT, 2017.

Variety	Company	Traits	Maturity group
00717R2X	Channel Bio, LLC	RR2X	0.07
0317R2X	Channel Bio, LLC	RR2X	0.3
0518R2X	Channel Bio, LLC	RR2X	0.5
0616R2X	Channel Bio, LLC	RR2X	0.6
0916R2X	Channel Bio, LLC	RR2X	0.9
1017R2X	Channel Bio, LLC	RR2X	1.0
1117R2X	Channel Bio, LLC	RR2X	1.1
1318R2X	Channel Bio, LLC	RR2X	1.3
1517R2X	Channel Bio, LLC	RR2X	1.5
1816R2X	Channel Bio, LLC	RR2X	1.6
1818R2X	Channel Bio, LLC	RR2X	1.8
S09RY64	Dyna-Gro	RR2Y	0.9
S11XT78	Dyna-Gro	RR2X	1.1
S12RY44	Dyna-Gro	RR2Y	1.2
S12XT07	Dyna-Gro	RR2X	1.2
S16XT58	Dyna-Gro	RR2X	1.6
S18XT38	Dyna-Gro	RR2X	1.8
1218N	King's Agriseed	Conventional	1.2
S20-T6	Syngenta	RR2Y	2.0
SG0975	Seedway, LLC	RR2Y	0.9
SG1055	Seedway, LLC	RR2Y	1.0
SG1311	Seedway, LLC	RR2Y	1.3
SG1776	Seedway, LLC	RR2Y	1.7

inoculant and with 200 lbs ac^{-1} 10-20-20 starter fertilizer. Population counts were taken on 20-Jun and then scouted for insects and disease on 6-Jul, 4-Aug, and 20-Sep. Despite extremely wet and cool conditions this season, the soybeans had little insect or disease pressure early in the growing season. At the first scouting we observed few potato leaf hoppers and some leaf spots which were likely early symptoms of downy mildew. At the August scouting there were very few potato leafhoppers, some soybean aphids, and some plots with mild downy mildew which was sporulating (Images 1 and 2). By the September scouting many diseases were present on the leaves, stems, and pods of the soybeans. Due to the complexity of identifying and quantifying all of the diseases present on the soybean leaves and pods, only presence was noted for the four major diseases seen throughout the majority of the trial: Bacterial Leaf Blight (Pseudomonas syringae pv. glycinea), Downy Mildew (Peronospora manshurica), Frogeye Leaf Spot (Cercospora sojina), and White Mold (Sclerotinia sclerotiorum). The percentage of total plots for each variety that were infected with each of these diseases is summarized in Table 5. The entire plot was then rated on a 1-10 scale for overall disease severity where 1 was low infection. Concurrently, plots were rated for severity of infestation with soybean aphid (Aphis glycines Matsumura) on a 1-5 scale where 1 was low severity.

Image 1. Downy mildew sporulating on the underside of a soybean leaf.

Image 2. Bacterial leaf blight on soybean leaf.

Results

Differences in presence of these four major diseases were not statistically analyzed. As Table 3 shows, most of the varieties were infected with at least two diseases. The overall disease rating for each variety ranged from 2.33 to 6.33. However, plots with high overall disease incidence did not necessarily have high levels of any one particular disease. Varieties did not differ statistically in their overall disease rating. Overall aphid severity was low for all varieties; however, aphids were present in nearly every plot. The varieties S18XT38, SG1776, and S20-T6 had statistically higher levels of aphids compared to all other varieties. These data are intended to provide some insight into relative disease and aphid susceptibility of the varieties.

Table 3. Incidence of four diseases and overall disease and aphid severity, 2017.

Variety	Bacterial Leaf Blight	Downy Mildew	Frogeye Leaf Spot	White Mold	Aphids	Disease
	----------% of plots infected----------				0-5†	0-10‡
00717R2X	100	**0.00**	66.7	**0.00**	1.00*	3.00
0317R2X	100	33.3	66.7	33.3	1.00*	3.33
0518R2X	100	0.0	66.7	33.3	1.67*	**2.33**
0616R2X	66.7	16.7	66.7	16.7	1.67*	2.67
0916R2X	100	16.7	66.7	50.0	1.00*	2.33
1017R2X	33.3	0.00	66.7	0.00	1.00*	3.00
1117R2X	66.7	33.3	66.7	33.3	1.33*	3.00
1318R2X	0.00	66.7	100	100	1.00*	5.00
1517R2X	100	100.	66.7	66.7	1.00*	3.33
1816R2X	**33.3**	66.7	33.3	66.7	**1.00**	2.67
1818R2X	66.7	33.3	100	33.3	1.67*	2.67
S09RY64	66.7	0.00	100	33.3	1.00*	4.33
S11XT78	100	0.00	66.7	66.7	1.33*	3.00
S12RY44	33.3	33.3	66.7	66.7	1.33*	4.00
S12XT07	100	66.7	100	66.7	1.33*	6.33
S16XT58	66.7	33.3	66.7	33.3	1.00*	3.00
S18XT38	66.7	0.0	66.7	33.3	2.00	2.67
1218N	66.7	66.7	66.7	33.3	1.00*	2.33
S20-T6	66.7	100	**0.00**	66.7	2.00	3.00
SG0975	66.7	66.7	66.7	66.7	1.33*	3.33
SG1055	66.7	66.7	100	66.7	1.00*	5.00
SG1311	66.7	33.3	66.7	66.7	1.00*	4.00
SG1776	100	0.00	100	66.7	2.00	4.67
LSD (p = 0.10)	N/A	N/A	N/A	N/A	0.706	NS
Trial Mean	71.0	36.2	71.0	47.8	1.29	3.43

The top performing variety is indicated in **bold**.

*Varieties that performed statistically the same as the top performer are indicated with an asterisk.

NS- Not statistically significant.

N/A- Statistical analysis was not performed for this parameter.

† 0 indicates no aphid presence and 5 indicates severe aphid infestation

‡0 indicates no disease presence and 10 indicates severe disease infection

Soybeans were harvested on 20-Oct, harvest results are shown in Table 4. Despite wet weather through most of the season, soybean yields were quite high this year ranging from 2285 to 4296 lbs ac^{-1} which equate to 38.1 to 71.6 bu ac^{-1}. Fourteen of the 23 varieties in the trial yielded greater than 60 bu ac^{-1}. The highest yielding variety was S20-T6 which yielded 71.6 bu ac^{-1}. This was statistically similar to eight other varieties (Figure 1). Test weight ranged from 52.3 to 59.8 lbs bu^{-1}. All varieties except for two, produced beans with test weights that were statistically similar to the top performer, SG1055. None of the varieties trialed reached the target test weight for soybeans which is 60 lbs bu^{-1}. This may have been due to weather conditions during pod development and seed fill. Plant populations also varied statistically. The highest population of 172,304 plants ac^{-1} was observed in variety S18XT38 which was similar to nine other varieties. Interestingly, the highest yielding variety had one of the lower plant populations of 149,072 plant ac^{-1}.

Table 4. Harvest characteristics of soybean varieties – Alburgh, VT, 2017.

Variety	Company	Maturity group	Harvest population	Harvest moisture	Test weight	Yield @ 13% moisture	
			plants ac^{-1}	%	lbs bu^{-1}	lbs ac^{-1}	bu ac^{-1}
00717R2X	Channel Bio, LLC	0.07	137456	12.0	57.7*	3322	55.4
0317R2X	Channel Bio, LLC	0.30	152944	**11.1***	58.3*	3059	51.0
0518R2X	Channel Bio, LLC	0.50	160688*	11.9	57.3*	3605	60.1
0616R2X	Channel Bio, LLC	0.60	151008	11.3*	58.0*	3469	57.8
0916R2X	Channel Bio, LLC	0.90	133584	11.5*	56.9*	3667	61.1
1017R2X	Channel Bio, LLC	1.00	158752*	11.2*	58.7*	3514	58.6
1117R2X	Channel Bio, LLC	1.10	154880*	11.5*	58.5*	3618	60.3
1318R2X	Channel Bio, LLC	1.30	160688*	11.6*	57.9*	3623	60.4
1517R2X	Channel Bio, LLC	1.50	145200	11.8	57.5*	3563	59.4
1816R2X	Channel Bio, LLC	1.60	137456	11.4*	58.6*	4107*	68.5*
1818R2X	Channel Bio, LLC	1.80	156816*	11.7*	58.8*	3928*	65.5*
S09RY64	Dyna-Gro	0.90	158752*	11.3*	57.7*	3577	59.6
S11XT78	Dyna-Gro	1.10	131648	11.5*	59.0*	3475	57.9
S12RY44	Dyna-Gro	1.20	164560*	11.8	57.9*	3920*	65.3*
S12XT07	Dyna-Gro	1.20	141328	11.6*	57.1*	3776	62.9
S16XT58	Dyna-Gro	1.60	154880*	11.3*	59.4*	3981*	66.3*
S18XT38	Dyna-Gro	1.80	**172304***	11.9	59.1*	3932*	65.5*
1218N	King's Agriseed	1.20	121968	14.0	56.8	2285	38.1
S20-T6	Syngenta	2.00	149072	11.6*	58.4*	**4296***	**71.6***
SG0975	Seedway, LLC	0.90	152944	11.1*	59.2*	3896*	64.9*
SG1055	Seedway, LLC	1.00	143264	11.5*	**59.8***	3300	55.0
SG1311	Seedway, LLC	1.30	139392	12.2	52.3	3906*	65.1*
SG1776	Seedway, LLC	1.70	158752*	11.2*	58.9*	4123*	68.7*
	LSD (p = 0.10)		18671	0.621	2.90	516	8.60
	Trial Mean		149493	11.7	58.0	3650	60.8

The top performing variety is indicated in **bold**.

*Varieties that did not perform significantly lower than the top performing variety are indicated with an asterisk.

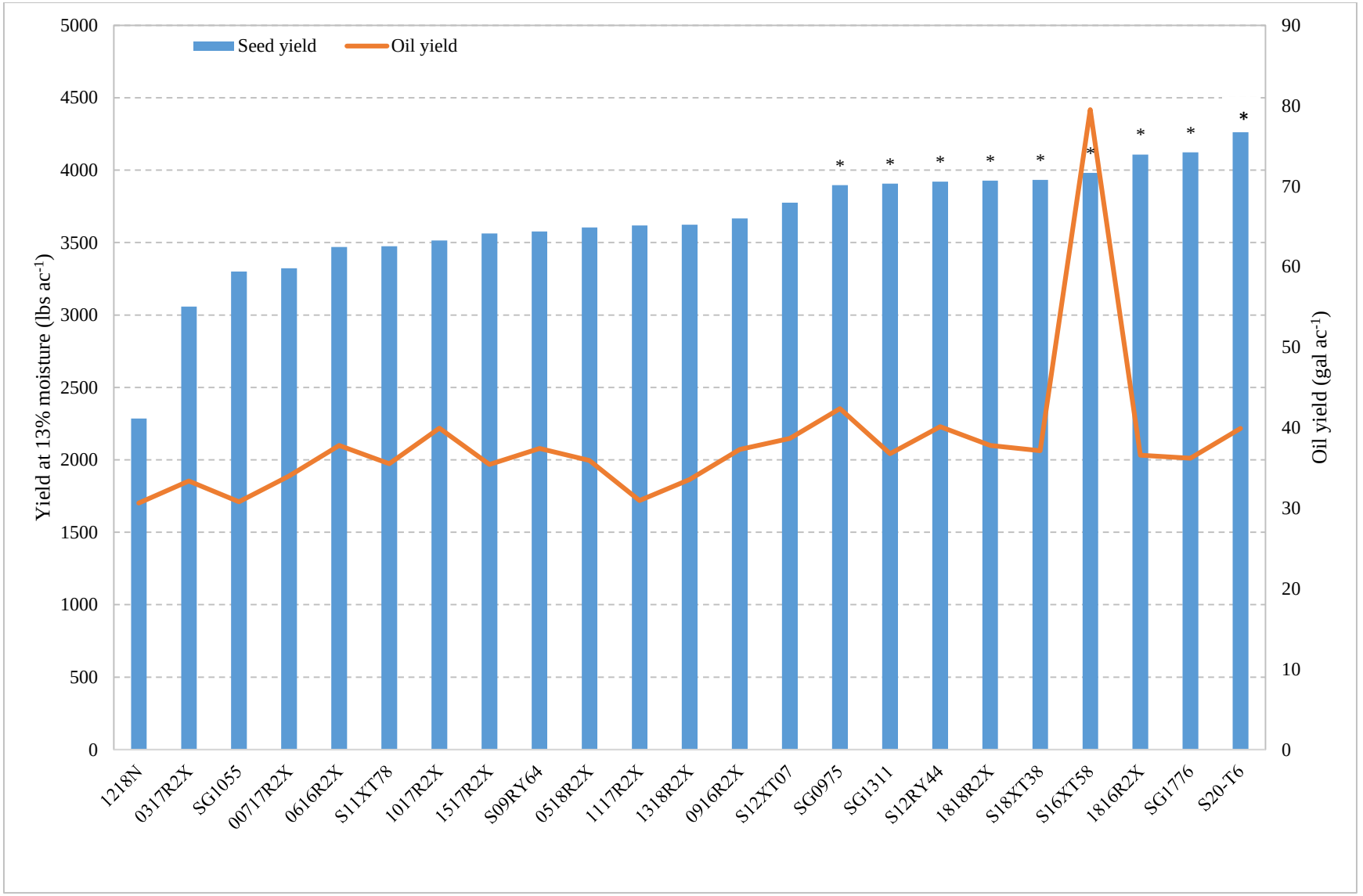

Figure 1. Seed and oil yield at 13% moisture for 23 soybean varieties. The red line indicates the average yield.

**Varieties that did not perform statistically lower than the top performing variety are indicated with an asterisk.*

Varieties did not differ statistically in terms of oil yield.

Oil was extruded from the soybeans with an AgOil M70 expeller press (Mondovi, WI) on 15-Feb, 2018. A known quanitity of soybean seed at a known moisture was extruded and the resulting oil captured and weighed to determine oil content and calculate oil yield. Average oil content for the trial was 8.07% but ranged from 6.56 to 14.9% (Table 5). The highest oil content and yield was produced by variety S16XT58, a 1.6 maturity group soybean variety from Dyna-Gro which produced 79.5 gal ac^{-1}. Soybeans produced in the Midwestern U.S. typically contain approximately 20% oil. It should be noted that a new oil press nozzle was used in pressing these samples which may have contributed to below average values being obtained. In general, mechanical extrusion followed by chemical treatment is the industry standard for soybean oil extraction. In our research we are only able to use mechanical extrusion and would in general lead to lower oil recovery. However, all samples were pressed under similar conditions and therefore the relative differences observed remain. Varieties did not differ statistically in terms of oil content or oil yield.

Table 5. Oil yield of soybean varieties – Alburgh, VT, 2017.

Variety	Company	Maturity group	Oil content	Oil yield @ 13% moisture	
			%	lbs ac^{-1}	gal ac^{-1}
00717R2X	Channel Bio, LLC	0.07	7.95	260	34.0
0317R2X	Channel Bio, LLC	0.3	8.33	255	33.4
0518R2X	Channel Bio, LLC	0.5	7.59	274	35.9
0616R2X	Channel Bio, LLC	0.6	8.12	289	37.8
0916R2X	Channel Bio, LLC	0.9	8.52	285	37.3
1017R2X	Channel Bio, LLC	1.0	8.61	305	39.9
1117R2X	Channel Bio, LLC	1.1	6.56	236	30.9
1318R2X	Channel Bio, LLC	1.3	7.05	256	33.6
1517R2X	Channel Bio, LLC	1.5	8.34	270	35.4
1816R2X	Channel Bio, LLC	1.6	6.72	279	36.6
1818R2X	Channel Bio, LLC	1.8	7.48	289	37.8
S09RY64	Dyna-Gro	0.9	8.08	286	37.4
S11XT78	Dyna-Gro	1.1	7.80	271	35.5
S12RY44	Dyna-Gro	1.2	7.89	306	40.1
S12XT07	Dyna-Gro	1.2	7.87	295	38.7
S16XT58	Dyna-Gro	1.6	**14.9**	**607**	**79.5**
S18XT38	Dyna-Gro	1.8	7.21	283	37.1
1218N	King's Agriseed	1.2	10.3	234	30.6
S20-T6	Syngenta	2	7.13	305	39.9
SG0975	Seedway, LLC	0.9	8.30	323	42.4
SG1055	Seedway, LLC	1.0	7.11	235	30.8
SG1311	Seedway, LLC	1.3	7.16	281	36.8
SG1776	Seedway, LLC	1.7	6.70	276	36.2
	LSD (p = 0.10)	N/A	NS	NS	NS
	Trial Mean	N/A	8.07	291	38.2

The top performing variety is indicated in **bold**.
NS- Not statistically significant

Image 3. Oil press extruding soybeans.

Soybean Planting Date Trial

One of the goals of this planting date study is to determine how late soybeans can be planted in Vermont while still reaching maturity and producing adequate yields. In addition, we would like to determine how soybeans respond to shifting planting dates in terms of other characteristics such as pest and disease pressure. As more producers in the region look for additional crops to diversify their operations, we hope to provide basic agronomic information to help them succeed.

The planting date trial included two varieties, one early (1.0) and one mid-group (1.7) maturity, planted approximately weekly from 20-May through 10-Jun. Plots were planted at a rate of 185,000 seeds ac^{-1} into a Benson rocky silt loam. Seeds were treated with soybean inoculant and planted with 200 lbs ac^{-1} 10-20-20 starter fertilizer. Plant populations were evaluated on 30-Jun and plants were scouted for disease and insect pressure on 6-Jul, 9-Aug, and 19-Sep. Soybeans were harvested on 28-Oct and pressed for oil using an AgOil M70 expeller press (Mondovi, WI) on 15-Feb.

Image 4. Soybeans are smaller as planting dates progress from left to right.

Results

As tables 6 and 7 show, the predominant diseases observed in this trial were White Mold and Downy Mildew. There appears to be a varietal difference with SG 1055 having an overall disease severity rating more than 1.25 higher than SG 1776. The aphid pressure was similar for both varieties with a rating of 1.72. Disease severity did not differ significantly by planting date. Aphid pressure was highest at the 2-Jun planting date.

Table 6. Disease incidence and overall aphid and disease severity by variety, 2017.

Variety	Bacterial Leaf Blight	Downy Mildew	Frogeye Leaf Spot	White Mold	Overall Disease	Overall Aphid
	----------% of plots infected----------				0-5†	0-10‡
SG1055	0.00	44.4	5.56	44.4	4.31	1.75
SG1776	11.1	5.56	5.56	27.8	**2.94**	1.75
LSD (p = 0.10)	N/A	N/A	N/A	N/A	1.22	NS
Trial Mean	5.56	25.0	5.56	36.1	3.64	1.72

The top performing planting date is indicated in **bold**.
*Planting dates that performed statistically the same as the top performer are indicated with an asterisk.
NS- Not statistically significant.
N/A- Statistical analysis was not performed for this parameter.
† 0 indicates no aphid presence and 5 indicates severe aphid infestation
‡0 indicates no disease presence and 10 indicates severe disease infection

Table 7. Disease incidence and overall aphid and disease severity by planting date, 2017.

Planting Date	Bacterial Leaf Blight	Downy Mildew	Frogeye Leaf Spot	White Mold	Overall Disease	Overall Aphid
	----------% of plots infected----------				0-5†	0-10‡
20-May	12.5	12.5	0.00	50.0	4.38	**1.13***
28-May	12.5	12.5	25.0	25.0	3.50	1.63*
2-Jun	0.00	0.00	0.00	37.5	2.88	2.50
10-Jun	0.00	50.0	0.00	50.0	3.75	1.75*
LSD (p = 0.10)	N/A	N/A	N/A	N/A	NS	0.791
Trial Mean	5.00	22.5	5.00	32.5	3.63	1.75

The top performing planting date is indicated in **bold**.
*Planting dates that performed statistically the same as the top performer are indicated with an asterisk.
NS- Not statistically significant.
N/A- Statistical analysis was not performed for this parameter.
† 0 indicates no aphid presence and 5 indicates severe aphid infestation
‡0 indicates no disease presence and 10 indicates severe disease infection

The two soybean varieties differed slightly in terms of seed yield (Table 8). SG 1776 yielded about 400 lbs ac^{-1} more than SG 1055 which equated to about 3 gal ac^{-1} more oil. They did not differ in terms of harvest moisture, test weight, or oil content.

Table 8. Soybean harvest characteristics by variety, 2017.

Variety	Maturity group	Harvest moisture	Test weight	Yield @ 13% moisture		Oil content	Oil yield @ 13% moisture	
		%	lbs bu^{-1}	lbs ac^{-1}	bu ac^{-1}	%	lbs ac^{-1}	gal ac^{-1}
SG1055	1.3	14.5	56.5	3263	54.4	10.0	329	43.1
SG1776	1.7	14.6	56.5	**3535**	**58.9**	9.79	346	45.4
LSD (p = 0.10)		NS	NS	207	3.44	NS	NS	NS
Trial mean		14.5	56.5	3399	56.6	9.92	338	44.2

The top performing variety is indicated in **bold**.
*Varieties that did not perform significantly lower than the top performing variety are indicated with an asterisk.

Planting date also significantly impacted soybean yields (Table 9). The 2-Jun planting date produced the highest yields of 3713 lbs ac^{-1} which equates to 61.9 bu ac^{-1}. This was statistically similar to the 10-Jun planting date. The lowest yield was observed in the 20-May planting date which only produced 3131 lbs ac^{-1} or 52.2 bu ac^{-1}. Oil content was not impacted by planting date. These data suggest that delaying planting until June in this region could lead to increased yields. It should also be noted that May was unseasonably cool and wet which may have impacted soybean performance for these treatments. Additional years and environments of research are required to develop planting date recommendations for the region.

Table 9. Harvest characteristics of soybeans by planting date, 2017.

Planting Date	Harvest moisture	Test weight	Yield @ 13% moisture		Oil content	Oil yield @ 13% moisture	
	%	lbs bu^{-1}	lbs ac^{-1}	bu ac^{-1}	%	lbs ac^{-1}	gal ac^{-1}
20-May	14.8	56.3	3131	52.2	10.2	324	42.4
28-May	14.4	56.5	3280	54.7	10.1	329	43.1
2-Jun	14.4	56.5	**3713***	**61.9***	9.87	367	48.1
10-Jun	14.5	56.7	3472*	57.9*	9.51	332	43.4
LSD (p = 0.10)	NS	NS	292	4.87	NS	NS	NS
Trial Mean	14.5	56.5	3399	56.6	9.92	338	44.2

The top performing variety is indicated in **bold**.
*Planting dates that did not perform significantly lower than the top performer is indicated with an asterisk.
NS- Not statistically significant

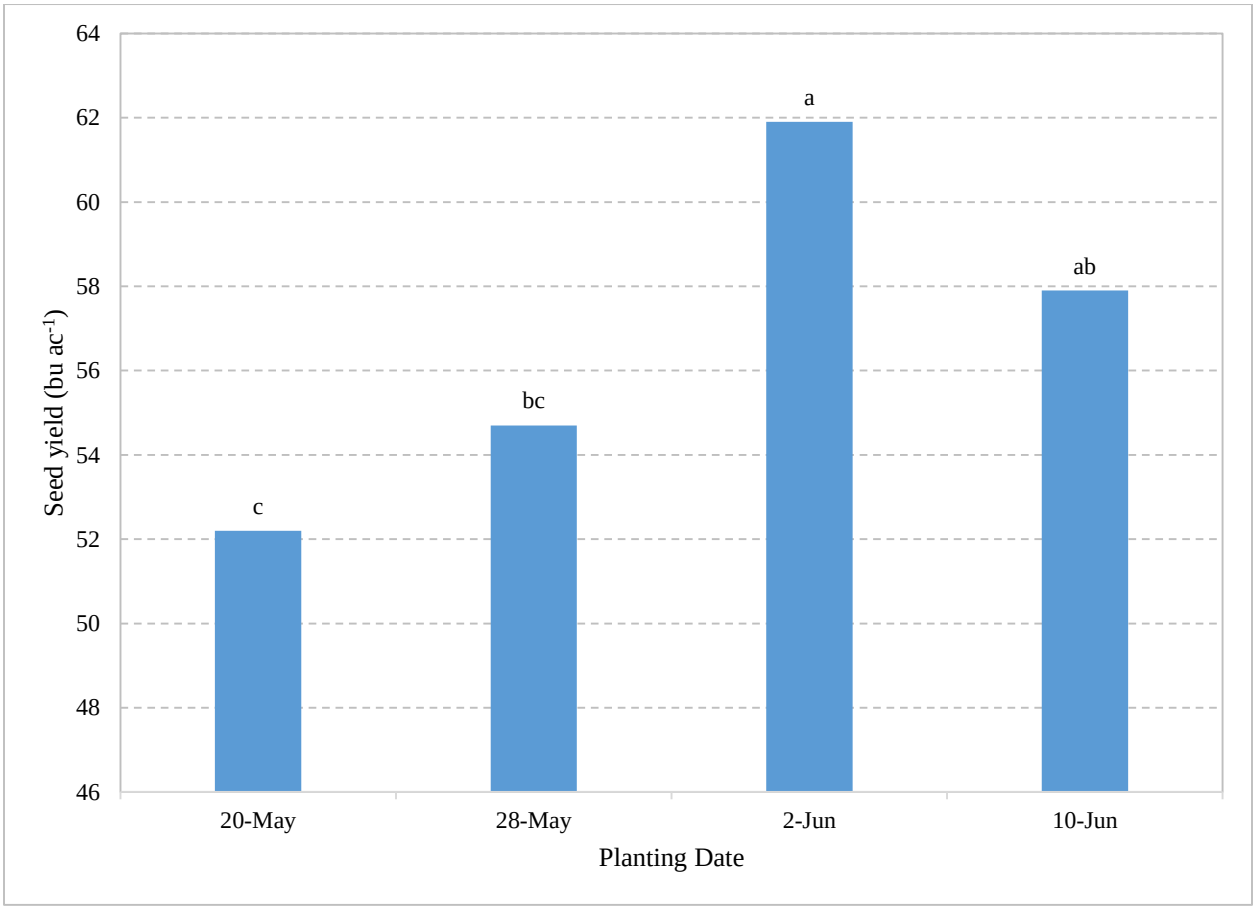

Figure 2. Seed yield at 13% moisture by planting date, 2017. *Planting dates with the same letter indicates they performed statistically similar.*

Cover Crop Trial

In the fall of 2016 10 cover crop treatments (Table 10) were planted at Borderview Research Farm in Alburgh, VT. Four of the treatments included a winter grain, either triticale or rye, and were intended to provide both fall and spring living soil coverage. The other treatments included species that regularly winterkill in our region and were intended to provide living fall coverage and winterkilled spring coverage. Biomass was collected in all plots in the fall and in plots with living material in the following spring. Due to periods of unusually warm temperatures some of the plots with annual ryegrass survived and were also sampled. At the time of the spring biomass collection, percent ground cover was also measured using the beaded string method. Cover crop residue was incorporated into the soil with disc harrows and the soil finished for planting with a spike-tooth harrow and a field finisher. Soybeans were planted into the previously existing cover crop treatments on 29-May at a rate of 185,000 seeds ac^{-1}, treated with soybean inoculant, and planted with 200 lbs ac^{-1} 10-20-20 starter fertilizer. Soybeans were sprayed with RoundUp Power Max herbicide on 5-July to control weeds. Plots were assessed for plant populations on 30-Jun and scouted for insects and disease on 6-Jul and 4-Aug. On 13-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 using a Berckes Test Weight Scale. Soybeans were pressed for oil on 23-Feb, 2018 using an AgOil M70 expeller press (Mondovi, WI) by pressing known weight of soybean seed of a known moisture and capturing and weighing the resulting oil to determine oil content and calculate oil yield.

Table 10. Fall cover crop mixtures planted in Alburgh, VT, 2016.

Mixture #	Species	Variety	Cover crop over-winters	Seeding rate lbs ac^{-1}
1	Annual ryegrass	Fria	yes, ryegrass only	22
	Tillage radish	Eco-till		3
2	Forage rape	Dwarf Essex	yes, triticale only	3
	Triticale	Trical 815		60
3	Forage turnip	Appin	yes, clover and triticale only	2
	Red clover	Dynamite		3
	Triticale	Hyoctane		60
4	Forage turnip	Appin	yes clover and winter rye only	2
	Red clover	Dynamite		1
	Winter rye	VNS		40
5	Annual ryegrass	unknown	no	18 total (premixed)
	Tillage radish	Arifi		
6	Annual ryegrass	unknown	no	24 total (premixed)
	Crimson clover	unknown		
	Tillage radish	Arifi		
7	Forage oats	Everleaf	no	40
	Forage turnip	Appin		2
	Red clover	Duration		5

8	Forage oats	Everleaf	no	60
	Tillage radish	Groundhog		31
9	Red clover	Mammoth	yes, clover and triticale only	5
	Forage brassica	T-Raptor		2
	Winter pea	Lynx		20
	Winter triticale	Fridge		40
10	No cover crop		N/A	N/A

Results

Table 11 summarizes the cover crop production and soil health characteristics in the spring for each treatment. The treatment that produced the most biomass in the fall was treatment 1 (annual ryegrass/tillage radish) which produced 2104 lbs ac^{-1}. This was statistically similar to six other treatments. Treatments 3 and 4, which both included turnip, red clover, and a winter grain (triticale and winter rye respectively), both produced the lowest biomass but were statistically similar to one another. Of the five treatments that survived the winter, treatment 9, which contained red clover, forage brassica, winter pea, and triticale, produced the most biomass with 1494 lbs ac^{-1}. In reality only the triticale and clover survived the winter and produced that spring biomass.

Treatments did not differ in the percent ground cover that they provided. This suggests that, even cover crops that winterkill in our region can provide substantial ground cover in the spring to help protect the soil surface from the impacts of rainfall. Treatments also varied significantly in terms of soil aggregate stability. The highest aggregate stability was obtained by treatment 5 (annual ryegrass/tillage radish) with 33.4% aggregate stability. This was statistically higher than any other cover crop treatment. The next highest treatment was the oat/turnip/clover treatment with 26.5% aggregate stability.

Table 11. Cover crop and soil health characteristics, 2017.

Cover crop mixture	Fall biomass	Spring biomass	Ground cover	Aggregate stability
	-----DM lbs ac^{-1}-----		%	
1	**2104**	127	43.0	22.7
2	1851*	987	**52.0**	26.1
3	1627*	140	49.5	24.7
4	1350	767	37.5	23.2
5	1837*	0	41.5	**33.4**
6	1935*	0	42.0	21.9
7	1883*	0	45.5	26.5
8	1183	0	28.5	25.5
9	2050*	**1494**	46.5	24.8
10	0	0	46	22.8
LSD (p = 0.10)	599	497	NS	5.01
Trial Mean	1582	352	43.2	25.2

*Treatments that did not perform significantly lower than the top performing variety in **bold** are indicated with an asterisk.
NS – Not significant

Soybeans were harvested on 13-Oct 2017. Table 12 summarizes the yield and harvest characteristics of soybeans from each cover crop treatment. Despite relatively wet and cool weather conditions through most of the growing season, the soybeans produced high yields with all producing at least 58 bu ac^{-1}. The highest yielding treatment was the annual ryegrass/crimson clover/tillage radish mixture (mixture 6) which produced 4541 lbs ac^{-1} or 75.7 bu ac^{-1}, an incredible yield, especially for a region with such a short growing season. This was statistically similar to the control and annual ryegrass/tillage radish mixture (mixture 5). The lowest yielding treatment was the triticale/turnip/red clover mixture which only produced 3481 lbs ac^{-1} or 58.0 bu ac^{-1}. Cover crop treatments did not significantly impact harvest moisture or test weight.

Table 12. Soybean harvest characteristics by cover crop, 2017.

Cover crop mixture	Harvest moisture	Test weight	Seed yield @ 13% moisture	
	%	lbs bu^{-1}	lbs ac^{-1}	bu ac^{-1}
1	15.4	54.4	3727	62.1
2	15.3	54.8	3492	58.2
3	15.1	55.7	3481	58
4	15.1	55.4	3769	62.8
5	15.1	55.9	4051*	67.5*
6	14.8	56.7	**4541***	**75.7**
7	14.8	56.3	3839	64
8	15.4	54.2	3847	64.1
9	15.4	54	3657	60.9
10	**14.6**	**56.8**	4088*	68.1*
LSD (p = 0.10)	NS	NS	614	10.2
Trial Mean	15.1	55.4	3849	64.2

The top performing treatment is indicated in **bold**.
*Treatments that did not perform significantly lower than the top performing variety are indicated with an asterisk.
NS – Not significant

Table 13. Soybean yields by overwintering, 2017.

Overwinter	Soybean yield	
	lbs ac^{-1}	bu ac^{-1}
Yes	3625	60.4
No	**4073**	**67.9**
LSD (p = 0.10)	265	4.42
Trial mean	3849	64.2

The top performing treatment is indicated in **bold**.

Of the 10 cover crop treatments examined, five (mixtures 5, 6, 7, 8, and 10) did not produce living vegetation in the spring while the other five treatments did. Overwintering treatments produced on average 4073 lbs ac^{-1} or 67.9 bu ac^{-1} while the treatments that had living spring biomass produced on average 3625 lbs ac^{-1} or 60.4 bu ac^{-1} (Table 32). These data suggest that soybean yields may be negatively impacted by preceding overwintering cover crops (Figure 3).

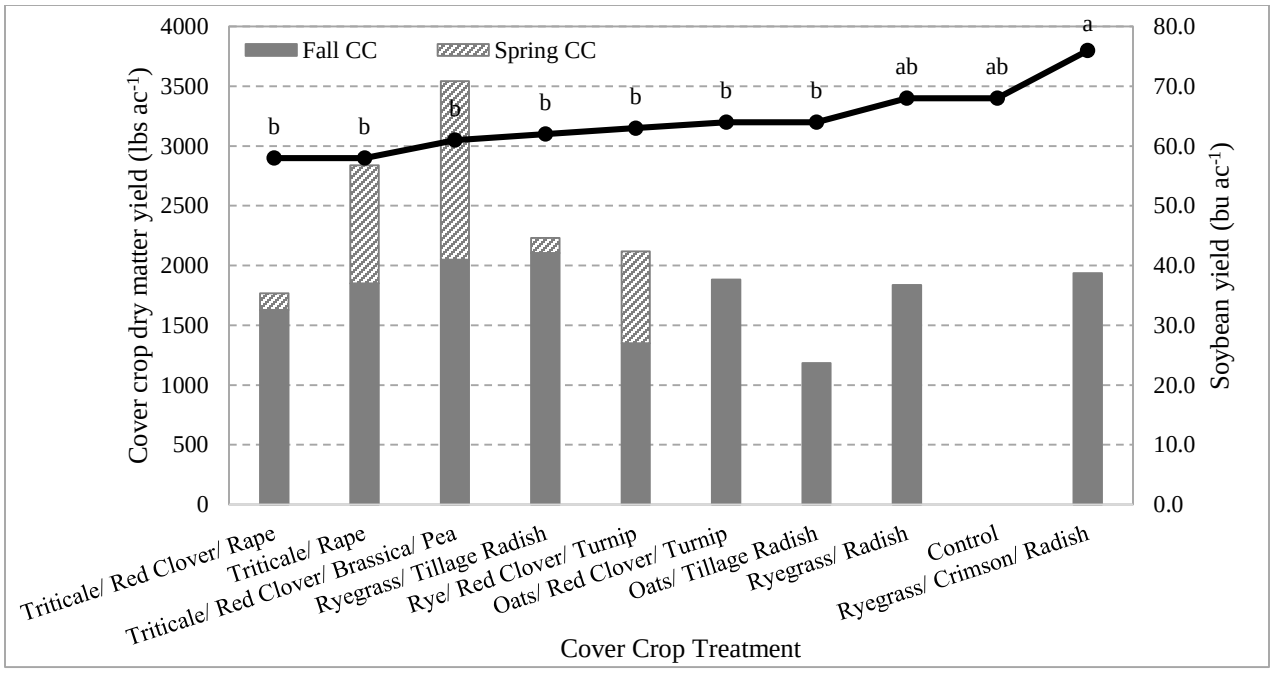

Figure 3. Soybean and cover crop yield by cover crop mixture treatment, 2017.
Treatments that share a letter performed statistically similarly to one another.

However, to fully understand this interaction, more data needs to be collected, such as nutrient content of the cover crop biomass and availability, as differences between mixture composition would likely impact soybean yields differently.

In addition to this experiment, we also attempted to interseed cover crops into established soybeans using a Highboy interseeder (Image 5). Interestingly we found very little to no cover crop establishment within soybean rows but decent establishment surrounding plots (Image 6). This was likely due to canopy density limiting light infiltration at the time of seeding. We will continue to investigate cover crop seeding methods and timings that support cover crop establishment and high yielding soybeans.

Image 5. Highboy cover crop interseeder.


Image 6. Soybean interseeding results, fall of 2017.

Outreach

During this project several outreach events were held in which this project and soybean production information were highlighted (Image 7 and 8). On March 2017 we held our Dairy Producer's Conference and Grain Grower's Conference which attracted 100 and 132 attendees respectively. Materials summarizing past soybean trials were available at this event as well as program staff to discuss soybean production with attendees. The Grain Grower's Conference offered soybean production specific presentations as well. In July we hosted our 10th Annual Field Day at Borderview Research Farm which attracted 340 attendees. At this field day soybean projects were highlighted and results from past projects summarized. Attendees were encouraged to walk through the trials which were labeled with treatments and information about the trials in progress was made available in a booklet given to every attendee. Program staff were available during this session to discuss soybean production with growers. Soybean cover cropping information was shared with 170 agricultural professionals and farmers attending the annual Northeast Cover Crop Council meeting held in Ithaca, NY on November 8th, 2017. This information was also shared with New England Certified Crop Advisors at their annual Professional Development Conference held in Portsmouth, NH on January 25th, 2018.

Images 7 and 8. Visitors investigate the soybean trials during the field day.