Interseeding Cover Crops In Corn Silage Cropping Systems

Dr. Heather Darby, UVM Extension Agronomist
Sara Ziegler, John Bruce, and Lindsey Ruhl
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web at http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

INTERSEEDING COVER CROPS IN CORN SILAGE CROPPING SYSTEMS

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

With increasing focus on minimizing environmental impacts from agriculture, farmers are looking for strategies that are good for farm and environmental viability. Cover cropping is one strategy that has been promoted to help farms improve soil health and minimize soil and nutrient losses to the environment. However, with a short growing season it is often difficult to get an adequate cover cropping following corn silage harvest. Therefore, farmers are interested in using interseeding techniques to establish cover crops into an actively growing corn crop. Being successful with this practice will likely require changes to other aspects of the cropping system such as corn populations, corn relative maturity, and the timing of cover crop seeding. The University of Vermont Extension's Northwest Crops and Soils Team implemented two field experiments in 2018 and 2019 to help identify best interseeding practices that support successful cover crop establishment without sacrificing corn silage yields.

MATERIALS AND METHODS

The two field trials were conducted at Borderview Research Farm in Alburgh, VT (Tables 1 and 2). Trial 1 evaluated the impact of corn relative maturity, corn ear type, and corn populations on cover crop establishment and corn yields. Trial 2 evaluated the impact of corn relative maturity, corn ear type, and cover crop interseed timing on cover crop establishment and corn yields. All plots were 10' x 20' and replicated four times.

The experimental design for Trial 1 was a randomized complete block with split plot design. Main plots were corn population (28,000, 30,000, 32,000, 34,000, and 36,000 plants per acre) and split plots were corn maturity (early and late) and ear type (flex and fixed). The trial was interseeded in early July each year. In Trial 2 the experimental design was a randomized complete block with split plot design. Main plots were corn interseed times (V2, V4, and V6) and split-plots were corn varieties of differing relative maturity (early and late) and ear type (flex and fixed).

In 2018, corn was planted on 30-Jun due to multiple planting issues and bird damage. In 2019, corn was planted 23-May. The amount of photosynthetic active radiation (PAR) reaching the ground under the corn canopy was measured using a LI-COR LI-191R line quantum light sensor equipped with a LI-1500 data logger. Light was measured approximately weekly from the time of interseeding into September. To understand how much the corn canopy was obstructing the total available light, a light measurement was taken outside of the corn canopy and then under the corn canopy in the center of each plot. The data were then used to calculate the percent of light infiltrating the corn canopy. Corn was harvested using a John Deere 2-row corn chopper and collected in a wagon fitted with scales to weigh the yield of each plot. An approximate 1 lb subsample was collected, weighed, dried, and weighed again to determine dry matter content and calculate yield. The samples were then ground to 2mm using a Wiley sample mill and then to 1mm using a cyclone sample mill (UDY Corporation). The samples were analyzed for forage quality via Near Infrared Reflectance Spectroscopy at the UVM Cereal Grain Testing Laboratory (Burlington, VT) using a FOSS DS2500 NIRS. Following harvest, ground cover from the cover crop was measured by processing photographs using the Canopeo© smartphone application.

Table 1. Interseeding into corn silage Trial 1 management, Alburgh, VT, 2018-2019.

Location	Borderview Research Farm – Alburgh, VT	
Year	2018	2019
Soil type	Benson rocky silt loam	Benson rocky silt loam
Corn variety/maturity treatments	MY87810 and 2G161 (87 days) SW 4010 and SW 4029 (100 days)	TMF2Q419 and TFM2L395 (95 days) SW 4010 and SW 4029 (100 days)
Corn ear type treatments	Fixed ear (MY87810 and SW 4029) Flex ear (2G161 and SW 4010)	Fixed ear (TMF2L395 and SW 4029) Flex ear (TMF2Q419 and SW 4010)
Corn population treatments (seeds ac^{-1})	28,000 30,000 32,000 34,000 36,000	28,000 30,000 32,000 34,000 36,000
Corn planting date	30-Jun	23-May
Cover crop mixture	25 lbs ac^{-1} Annual ryegrass (70%) Red clover (20%) Tillage radish (10%)	25 lbs ac^{-1} Annual ryegrass (70%) Red clover (20%) Tillage radish (10%)
Harvest date	5-Oct	27-Sep (early RM) 9-Oct (late RM)

Table 2. Interseeding into corn silage Trial 2 management, Alburgh, VT, 2018-2019.

Location	Borderview Research Farm – Alburgh, VT	
Year	2018	2019
Soil type	Benson rocky silt loam	Benson rocky silt loam
Corn variety/maturity treatments	MY87810 and 2G161 (87 days) SW 4010 and SW 4029 (100 days)	TMF2Q419 and TFM2L395 (95 days) SW 4010 and SW 4029 (100 days)
Corn ear type treatments	Fixed ear (MY87810 and SW 4029) Flex ear (2G161 and SW 4010)	Fixed ear (TMF2L395 and SW 4029) Flex ear (TMF2Q419 and SW 4010)
Interseed timing treatments (dates of interseeding)	V2 (2-Jul) V4 (5-Jul) V6 (30-Jul)	V2 (17-Jun) V4 (24-Jun) V6 (1-Jul)
Corn planting date	30-Jun	23-May
Cover crop mixture	25 lbs ac^{-1} Annual ryegrass (70%) Red clover (20%) Tillage radish (10%)	25 lbs ac^{-1} Annual ryegrass (70%) Red clover (20%) Tillage radish (10%)
Harvest date	5-Oct	23-Sep (early RM) 10-Oct (late RM)

Data were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications in the trial were treated as random effects and treatments were treated as fixed. Mean comparisons were made using the Tukey-Kramer adjustment procedure when the F-test was considered significant (p<0.10). Because few significant interactions were observed between year and other variables, data were combined across years prior to the employing the mean comparisons procedure.

RESULTS

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Tables 3 and 4). From June through September 2018 there were 2298 Growing Degree Days (GDDs) accumulated, 242 more than the 30-year normal. Precipitation during this time was at or below normal for all months with a total of 2.81 inches below normal being accumulated. Extended periods of dry weather were experienced, the longest of which was approximately 2 weeks. The hot and dry weather allowed the corn, even the long season varieties, to reach maturity despite later than anticipated planting. Dry conditions however may have led to poor cover crop establishment.

Table 3. 2018 weather data for Alburgh, VT.

	Jun	Jul	Aug	Sep
Average temperature (°F)	64.4	74.1	72.8	63.4
Departure from normal	-1.36	3.47	3.99	2.88
Precipitation (inches)	3.74	2.43	2.96	3.48
Departure from normal	0.11	-1.79	-0.95	-0.18
Growing Degree Days (base 50°F)	447	728	696	427
Departure from normal	-37	98	114	67

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.

From June through September 2019 there were 2065 GDDs accumulated, 11 more than the 30-year normal. Precipitation during this time below normal for all months except for Sep with a total of 2.65 inches above normal being accumulated. Hot and dry weather allowed the corn, even the long season varieties, to reach maturity despite slightly delayed planting.

Table 4. 2019 weather data for Alburgh, VT.

	Jun	Jul	Aug	Sep
Average temperature (°F)	64.3	73.5	68.3	60.0
Departure from normal	-1.46	2.87	-0.51	-0.52
Precipitation (inches)	3.06	2.34	3.50	3.87
Departure from normal	-0.57	-1.88	-0.41	0.21
Growing Degree Days (base 50°F)	446	716	568	335
Departure from normal	-36	86	-14	-25

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.

Trial 1 – Impact of Corn Population and Ear Type

Interactions

There were no statistically significant interactions between main effects (Table 5). This indicates that corn varieties of different ear types responded similarly in terms of yield and quality parameters when planted at different populations.

Table 5. Main effect interactions.

Main effects and interactions	Yield	CP	ADF	30-hr NDFD	Ash	Starch	TDN	NE_L	Milk yield (lbs ton^{-1})	Milk yield (lbs ac^{-1})
Year	***	***	**	***	***	***	***	*	***	***
Corn population	*	NS	NS	NS	NS	NS	NS	NS	NS	*
Corn ear type	NS	***	NS	*	NS	NS	NS	NS	NS	NS
Population x ear type	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* 0.1 < p > 0.05
** 0.05 < p > 0.01
*** p < 0.01
NS- Not statistically significant

Impact of Year

The two years of the trial performed differently in terms of corn yield and quality characteristics (Table 6). Yield varied dramatically between the two trial years with 2018 yields being almost 9 tons ac^{-1} higher than 2019. Crude protein differed by almost 1% as well. These were likely due to lower water and therefore nutrient availability in 2019 compared to 2018. The hot and dry weather also appears to have resulted in higher lignin content as the NDF digestibility was considerably lower in 2019. Because of these yield and quality differences, 2018 would have produced more milk yield both on a per acre and per ton basis.

Table 6. Corn silage yield and quality by year.

Year	Yield at 35% DM	CP	ADF	NDF	Ash	Fat	TDN	30hr-NDFD	NE_L	Milk yield	
	tons ac^{-1}	% DM						% NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
2018	**25.2**	**8.74**	22.5	38.5	4.13	**3.06**	**69.3**	**58.2**	**0.683**	**3369**	**29712**
2019	16.5	7.85	**21.5**	**38.3**	**2.19**	2.85	64.2	44.7	0.671	3158	18254
Level of significance	***	***	**	NS	***	***	NS	***	*	***	***
Trial Mean	21.5	8.24	21.9	38.4	3.3	2.95	66.4	52.4	0.676	3279	24801

* 0.1 < p > 0.05
** 0.05 < p > 0.01
*** p < 0.01
NS- Not statistically significant

Impact of Population

Corn population significantly impacted yield (Figure 1). Statistically, no additional yield benefit was gained by attaining a plant population higher than 30,000 plants ac^{-1}. Population did not impact corn silage quality.

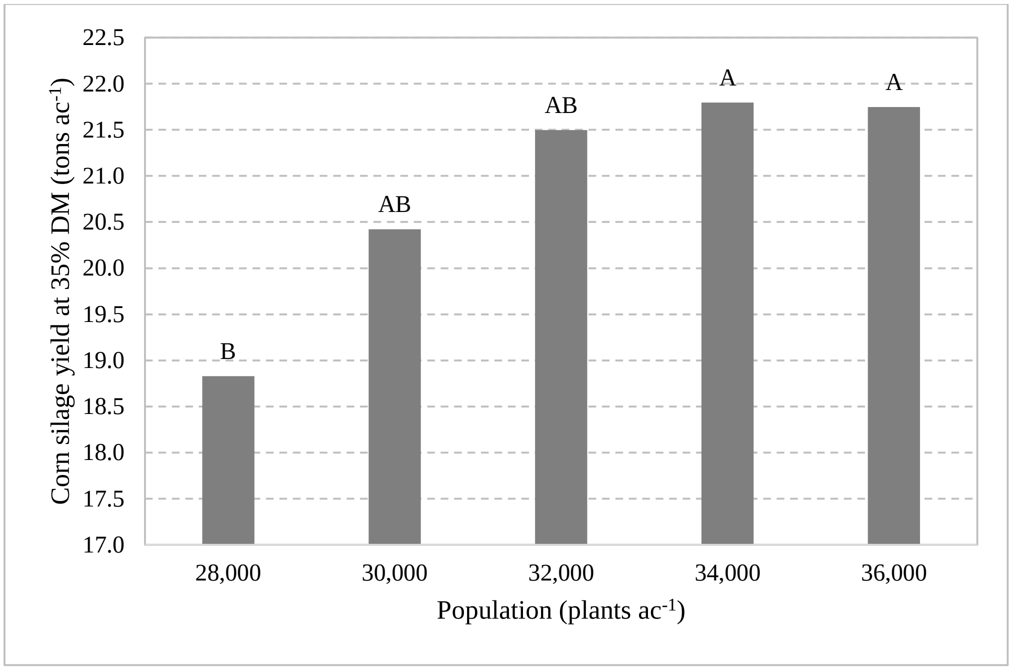

Figure 1. Corn silage yield by plant population.
Treatments that share a letter performed statistically similarly to one another.

By two weeks after cover crop interseeding, the corn canopy had significantly closed reducing 65-70% of the potential light infiltrating to the ground (Figure 2). Therefore, the newly planted cover crop had approximately 2-3 weeks from the time of seeding to germinate and establish prior to full canopy closure, in which very little light penetrated to the ground level for the remainder of the season. This demonstrates the challenge interseeding presents as any delay in seed germination or establishment (i.e. limited moisture, low vigor, etc.) significantly reduces the time available to the cover crop to properly establish increasing the chance of survival through the rest of the growing season.

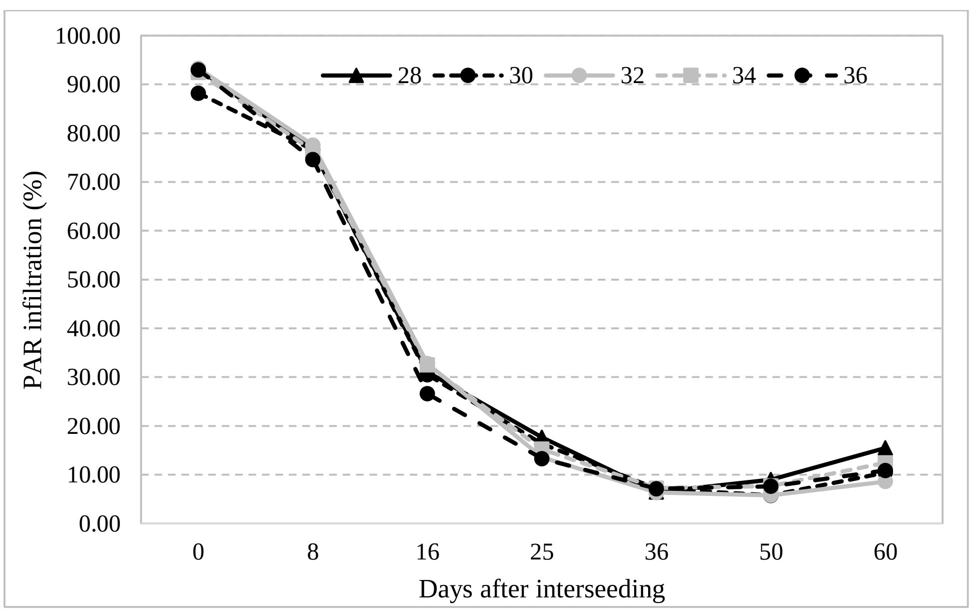

Figure 2. PAR infiltration over the season across corn populations.

Due to complications in the 2018 growing season, cover crop measures were not captured post corn silage harvest. However, these data are available for the 2019 growing season but were not statistically analyzed. Overall, ground cover from interseeded cover crops post corn silage harvest were very low averaging 4.69% with no obvious differences between populations. This will continue to be studied in the coming year.

Impact of Ear Type

Corn hybrids are typically characterized as “flex”, “semi-flex”, or “fixed” ear types. Flex ear hybrids are more cost effective when planted at lower seeding rates as they have the ability to adjust corn ear size relative to plant population to remain high yielding despite fewer plants. Fixed ear types, on the other hand, have been bred to remain consistent in ear size regardless of plant population and are therefore more profitable as populations are increased. These hybrid types also tend to differ in plant architecture or growth habit. Fixed ear hybrids tend to have a more upright leaf structure as they are better suited to the compact nature of high seeding rates. Therefore, we hypothesized that ear type would impact the corn population that would support a high yielding corn crop and successful interseeded cover crop.

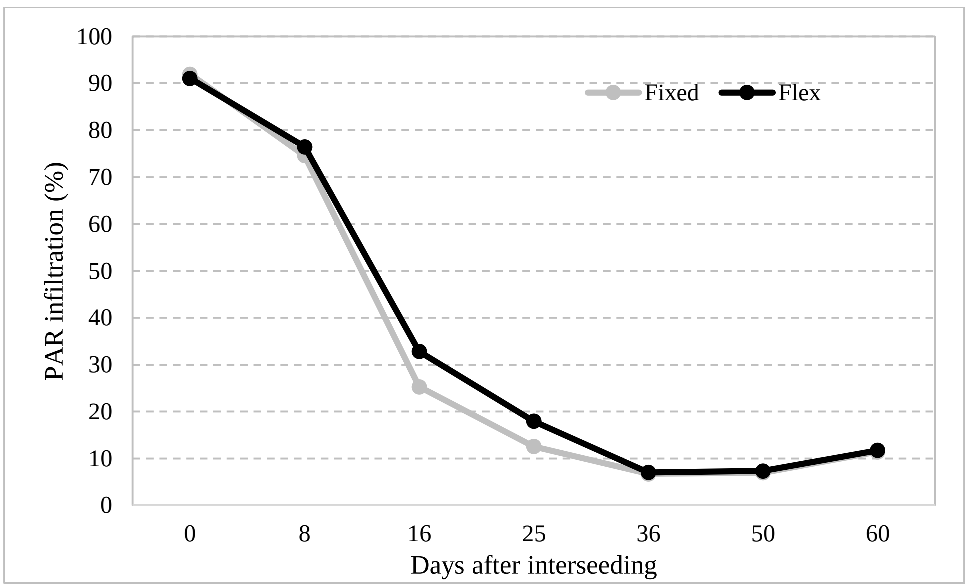

Figure 3. PAR infiltration over the season by corn ear type.

Little difference in light infiltration was observed between corn ear types (Figure 3). Fixed ear varieties limited light infiltration slightly more than flex ear varieties, however, by 36 days after interseeding both had reduced light infiltration by approximately 90% and remained similar for the remainder of the trial. Overall, the ear type did not appear to significantly impact light infiltration through the corn canopy.

Corn ear type did not significantly impact yield and had a minor impact on corn silage quality parameters (Table 7). Crude protein was approximately 0.3% higher in flex ear varieties than the fixed ear varieties. This is to be expected as these varieties can change the size of ears formed depending on resources available (i.e. populations) which impacts the nutrient concentration in the end silage sample. However, the only other quality parameter that was significantly impacted by ear type was NDF digestibility at 30 hours. Again this was higher in flex ear varieties which we’d expect as there is likely a higher proportion of ear material compared to the less digestible fiber materials.

Table 7. Corn silage quality parameters by ear type.

Ear type	Yield at 35% DM	CP	ADF	NDF	Ash	Fat	TDN	30hr-NDFD	NE_L	Milk yield	
	tons ac^{-1}	% DM						% NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
Fixed	**21.4**	8.15	**21.7**	**38.1**	**3.13**	**3.01**	66.7	51.0	0.677	3257	**24591**
Flex	20.3	**8.44**	22.3	38.6	3.19	2.90	**66.8**	**51.8**	**0.677**	**3270**	23375
Level of significance	NS	***	NS	NS	NS	NS	NS	*	NS	NS	NS
Trial Mean	21.5	8.24	21.9	38.4	3.3	2.95	66.4	52.4	0.676	3279	24801

* 0.1 < p > 0.05
*** p < 0.01
NS- Not statistically significant

In both years, cover crop establishment was poor and was difficult to obtain measurements on the minimal and spotty growth. Ground cover measurements could only be captured in some plots post corn harvest. Regardless of the treatment there was less than 5% ground cover provided by the cover crop in late-Oct. More data will be collected in the coming year to better understand these implications.

Trial 2 – Impact of Cover Crop Interseed Timing, Corn Relative Maturity, and Ear Type

Due to weed pressure limiting cover crop success in the trial area in 2019, cover crop establishment data were only available for 2018 and therefore, only data for that year are presented below.

Interactions

Overall, there were few interactions observed between main effects meaning that corn variety responded similarly regardless of interseed timing. More research is needed to full understand how to select varieties that will be synergistic with cover crop establishment.

Impact of interseed timing

Deciding when to interseed a cover crop is challenging. On one hand you want to allow the cover crop time to establish before the corn blocks the light, but on the other hand, you don't want the cover crop to compete with the establishing corn for resources. In addition, you want to make sure that corn herbicides do not impact the interseeded cover crop. Generally, corn can be interseeded anywhere from the V2 to V6 growth stage. After V6, most interseeding equipment is not tall enough, increasing the risk of damaging the corn crop.

Light available at the time of interseeding varied dramatically across the timing treatments (Figure 4). The arrows indicate the date the corn was interseeded corresponding to the V2, V4, and V6 growth stages. At the V2 and V4 growth stages virtually none of the PAR was being obstructed by the corn canopy. However, by the time the corn reached the V6 stage, the canopy was already obstructing almost 70% of the light. That was reduced by an additional 20% by the following week where the level remained for much of the season. However, this did not appear to significantly impact cover crop establishment as post-harvest ground cover was approximately similar to that of the V4 seeded cover crop which had an additional few weeks to grow. However, it is also important to note that following the V2 and V4 interseedings, no rainfall was experienced for 12 days. Therefore, the cover crop may have not germinated as quickly, reducing the impact between the interseed timings.

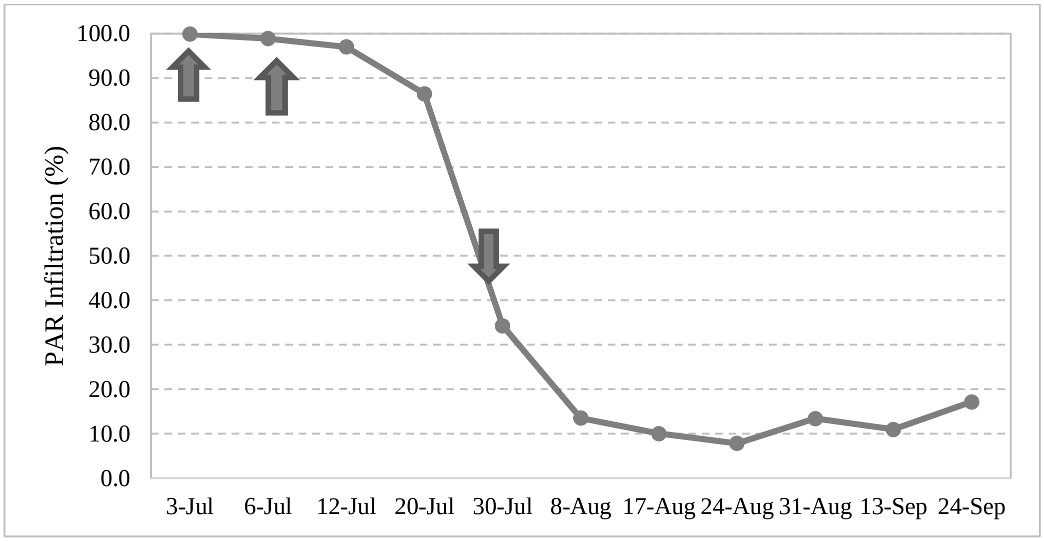

Figure 4. PAR across the season, 2018. *Arrows indicate the V2, V4, and V6 growth stages at which cover crops were interseeded.*

In this trial, as interseeding was delayed to the V6 growth stage, cover crop success, indicated by post-harvest ground cover, decreased (Figure 5). However, ground cover was <50% for all interseed timing treatments. Corn yields were not significantly impacted by timing of interseeding. In addition, corn quality was not impacted by timing of interseeding (Table 8). Image 1 shows the cover crop establishment.

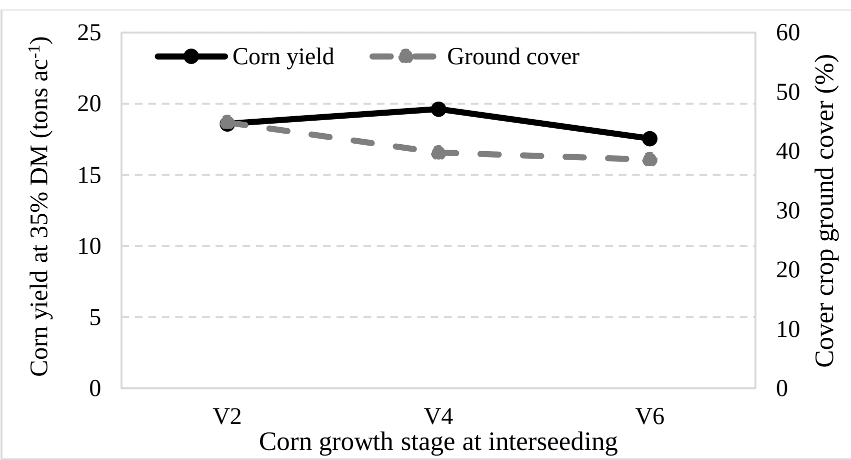

Figure 5. Corn yield and cover crop ground cover by interseed timing, 2018.

Image 1. Cover crop, fall 2018.

Table 8. Corn yield and quality by interseed timing, 2018.

Interseed timing	Yield at 35% DM	DM	CP	ADF	NDF	Ash	Starch	TDN	30-hr NDFD	NE_L	Milk	
	tons ac-1	% DM							% NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
V2	18.6	38.1	18.6	**22.8**	**40.2**	**3.37**	**31.7**	**67.3**	**44.6**	0.659	3004	19578
V4	**19.6**	37.8	**19.6**	23.1	40.6	3.72	30.4	66.7	44.0	0.654	2963	**20264**
V6	17.6	**37.6**	17.6	23.0	41.4	3.49	30.9	67.3	44.2	**0.660**	**3007**	18546
LSD (p = 0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trial mean	18.6	37.8	8.6	23.0	40.7	3.5	31.0	67.1	44.3	0.658	2991	19462

Treatments in **bold** were the top performer for that category.
NS- not statistically significant.

Impact of Corn Ear Type

With fixed ear hybrids having generally a more upright leaf structure, we would expect better cover cropping success with a fixed ear hybrid over a flex ear hybrid. In this trial, we observed approximately 4% higher cover crop success, indicated by post-harvest ground cover, from the fixed ear hybrids (Figure 6). However, these were statistically similar to one another.

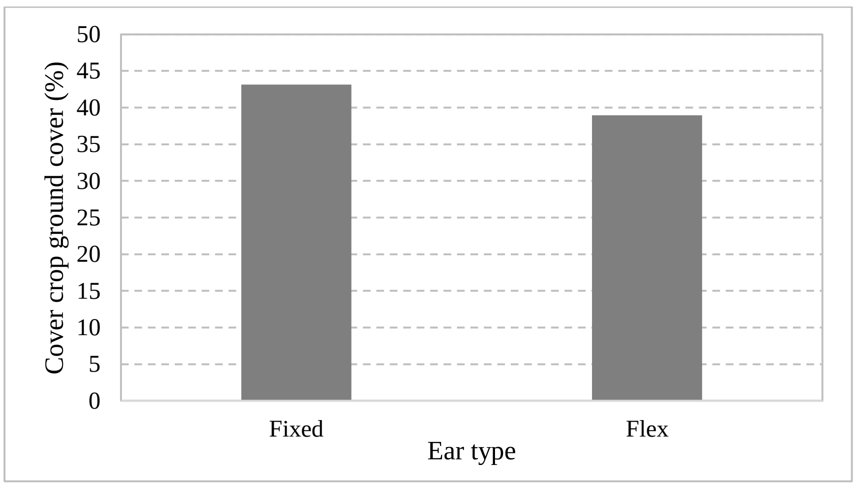

Figure 6. Cover crop ground cover by ear type, 2018.

Corn yield and quality parameters also did not differ across the ear types (Table 9).

Table 9. Corn yield and quality by ear type.

Ear type	Yield at 35% DM	DM	CP	ADF	NDF	Ash	Starch	TDN	30-hr NDFD	NE_L	Milk	
	tons ac^{-1}	% DM							% NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
Fixed	18.0	38.1	8.56	**22.7**	**40.3**	**3.46**	**31.4**	**67.2**	**44.2**	0.658	2995	18872
Flex	**19.2**	**37.5**	8.72	23.3	41.2	3.59	30.6	67.1	44.3	**0.657**	**2987**	20054
LSD (p = 0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trial mean	18.6	37.8	8.6	23.0	40.7	3.5	31.0	67.1	44.3	0.658	2991	19462

Treatments in **bold** were the top performer for that category.
NS- not statistically significant.

DISCUSSION

Interseeding cover crops into corn silage systems is challenging and may have higher success given changes to hybrid relative maturity, leaf architecture, plant populations, and the timing of interseeding. Determining the best combination of characteristics that support high yielding corn crops and successful cover crops requires multiple years of data to better understand how these variable interact under varying conditions. For example, this season's hot and dry weather may have provided adequate weather for long season varieties to outperform short season varieties when this may not be the case under cooler or wetter conditions. Furthermore, the lack of rainfall during cover crop germination and establishment may have impacted the early success and survival of the cover crops across the entire trial. More data needs to be collected to better understand the interaction of these corn hybrid characteristics with crop management.

ACKNOWLEDGEMENTS

This project is generously supported by the Sustainable Agriculture Research and Education (SARE) Program (LNE18-361). UVM Extension would like to thank Roger Rainville and his staff at Borderview Research Farm in Alburgh for their generous help with the trials. We would like to acknowledge Catherine Davidson, Hillary Emick, Amanda Gervais, Haley Jean, Ivy Luke, and Rory Malone for their assistance with data collection and entry. The information is presented with the understanding that no product discrimination is intended and no endorsement of any product mentioned or criticism of unnamed products is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.

THE UNIVERSITY OF VERMONT
EXTENSION