NORTHWEST CROPS & SOILS PROGRAM

Interseeding Cover Crops In Corn Silage Cropping Systems

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INTERSEEDING COVER CROPS IN CORN SILAGE CROPPING SYSTEMS

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With increasing focus on managing environmental impacts from agriculture, farmers are looking for ways to minimize environmental impacts without sacrificing crop productivity. Cover cropping is one strategy that has been promoted to help retain nutrients and soil on farms to minimize losses to the environment. However, with the short growing season we experience in this northern region, having adequate time in the fall to harvest corn silage and plant cover crops while conditions are optimal for their establishment is difficult. 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 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 (Table 1). 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.

Table 1. Interseeding into corn silage trial management, Alburgh, VT, 2018.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Corn variety/maturity treatments	MY87810 and 2G161 (87 days) SW 4010 and SW 4029 (100 days)
Corn ear type treatments	Fixed ear (MY87810 and SW 4029) Flex ear (2G161 and SW 4010)
Corn population treatments (seeds ac^{-1})	28,000 30,000 32,000 34,000 36,000
Interseed timing treatments (dates of interseeding)	V2 (2-Jul) V4 (5-Jul) V6 (30-Jul)
Corn planting date	30-Jun
Cover crop mixture	25 lbs ac^{-1} Annual ryegrass (70%) Red clover (20%)

	Tillage radish (10%)
Harvest date	5-Oct

The experimental design for Trial 1 was a randomized complete block with split plot design. Main plots were corn population (28,000, 32,000, 34,000, and 36,000 plants per acre) and split plots were corn maturity (87 and 100 RM) and ear type (flex and fixed). 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 (87 and 100 RM) and ear type (flex and fixed). Corn was planted on 30-Jun due to multiple planting issues and bird damage. 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 12-Jul to 24-Sep. 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.

Variations in yield and quality can occur because of variations in genetics, soil, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among hybrids 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 hybrids 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 hybrids. Hybrids that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid 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 hybrids 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 hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Hybrid	Yield
A	6.0
B	7.5*
C	**9.0***
LSD	2.0

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 (Table 2). From June through September there were 2298 GDDs accumulated, 285 more than the 30-year normal. Precipitation during this time was at or below normal for all months with a total of 2.78 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 2. 2018 weather data for Alburgh, VT.

	Jun	Jul	Aug	Sep
Average temperature (°F)	64.4	74.1	72.8	63.4
Departure from normal	-1.38	3.51	3.96	2.76
Precipitation (inches)	3.74	2.43	2.96	3.48
Departure from normal	0.05	-1.72	-0.95	-0.16
Growing Degree Days (base 50°F)	447	728	696	427
Departure from normal	-27	88	115	109

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, Maturity, and Ear Type

Impact of Population

Corn population impacted corn yield and cover crop ground cover. Corn yields ranged from 14.1 to 17.9 tons ac^{-1} (Figure 1) but were not statistically different from one another. Yields generally increased with increasing seeding rate until 32,000 seeds ac^{-1} after which yields declined slightly. Ground cover followed the opposite trend decreasing as populations increased.

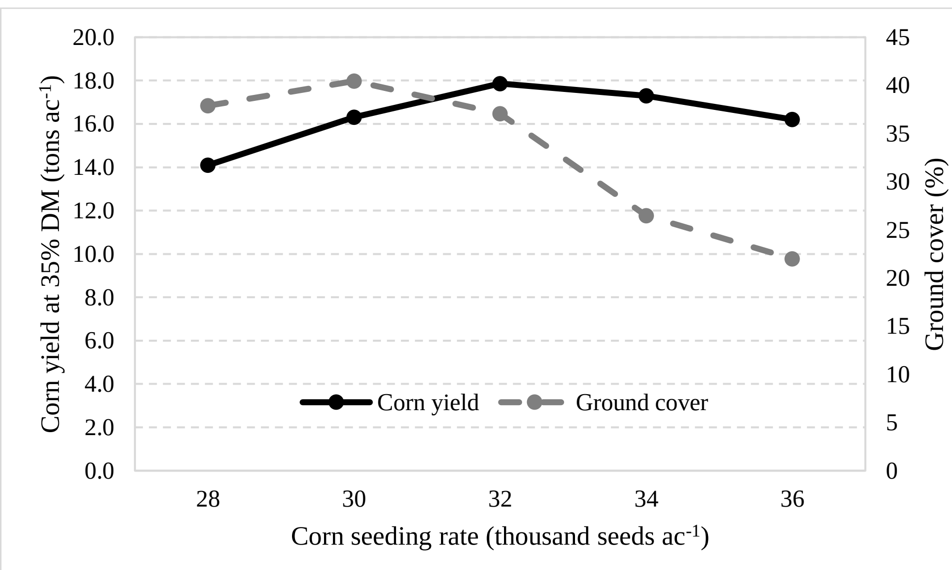

Figure 1. Corn yield and ground cover by seeding rate, 2018.

Cover crop ground cover is one indicator of cover crop establishment success as the better the cover crop establishes and fills in, the less bare ground should be exposed through its canopy. We hypothesized that lower light availability under dense corn canopies will reduce cover crop establishment success and would therefore be reflected in lower ground cover. However, the populations allowed similar amounts of light to infiltrate the canopy throughout the season (Figure 2). Despite slightly lower light availability within the relatively high yielding corn crop at the 32,000 seeds ac^{-1} treatment, the cover crop was still able to maintain over 30% ground cover post-harvest.

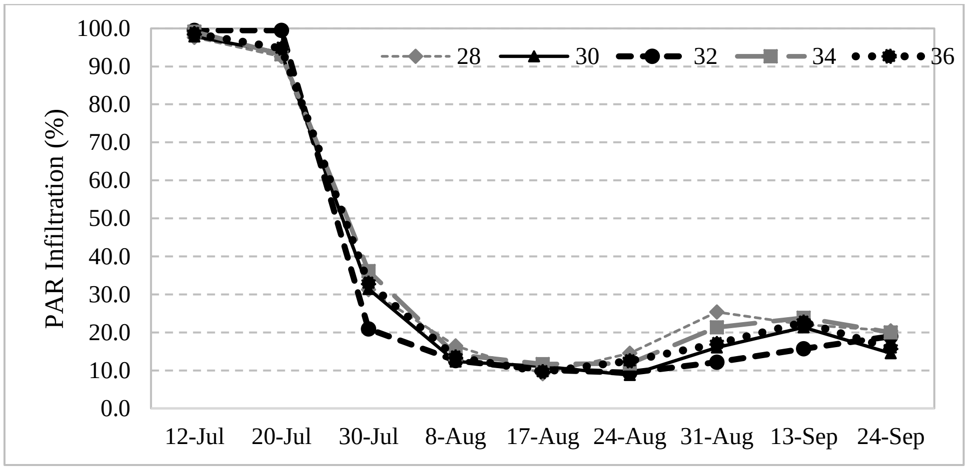

Figure 2. PAR infiltration over the season across corn seeding rates, 2018.

When corn hybrids were separated by relative maturity, corn seeding rate significantly impacted cover crop ground cover for long season hybrids (Figure 3). The two highest seeding rates resulted in cover crop ground cover levels below 30% whereas the other seeding rates all supported >35% ground cover.

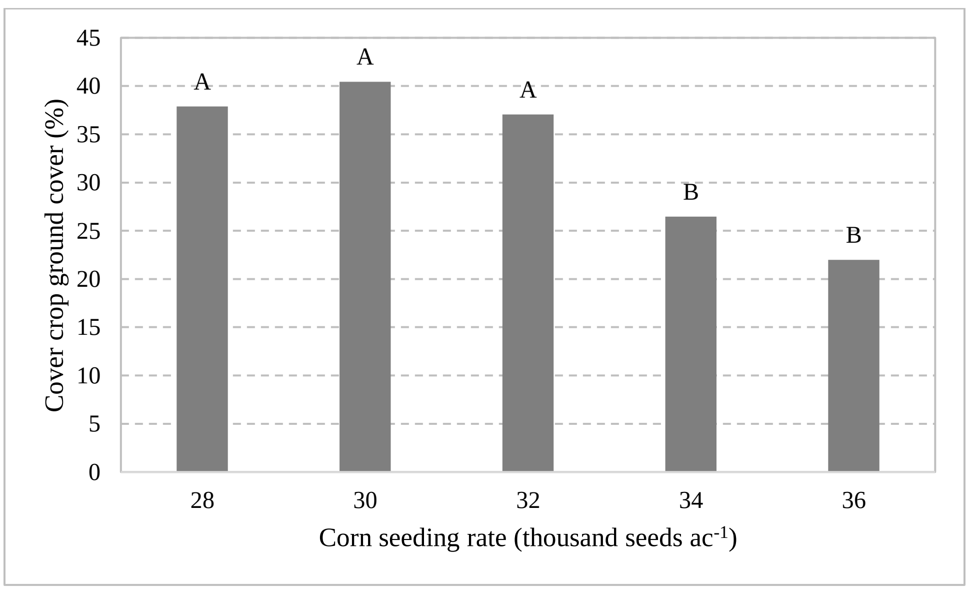

Figure 3. Cover crop ground cover by corn seeding rate of long season corn, 2018.
Treatments that share letters performed statistically similarly to one another.

In general, the canopy closed within two weeks of the cover crop being interseeded at which point PAR infiltration was reduced to by 65-80%. The sharp growth of the corn canopy and subsequent decline in light availability was likely attributed to a 0.70" rain event on 17-Jul, the first substantial rainfall in 11 days. The amount of time until canopy closure was likely influenced by these dry conditions and may differ in other years. This period of drought also coincided with the interseeding of the cover crop and likely slowed its emergence. This situation exemplifies the challenge with managing interseeded cover crops in this region.

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 become 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. We found that ear type did not significantly impact corn yield across populations (Figure 4).

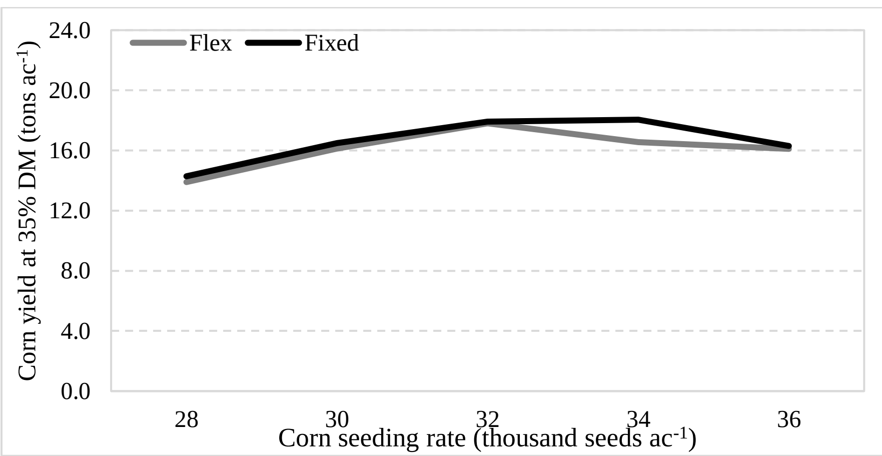

Figure 4. Corn yield by hybrid ear type across plant populations, 2018.

Although we did see a divergence of about 2 tons ac^{-1} in the fixed ear hybrid yields above 32,000 seeds ac^{-1}, we did not observe a difference at low populations (Figure 5). Furthermore, in terms of cover crop ground cover, the opposite trend was observed than expected with the fixed ear hybrid plots outperforming flex ear hybrid plots, in terms of cover crop ground cover, at low populations while the opposite occurs at higher populations. None of these differences were statistically significant.

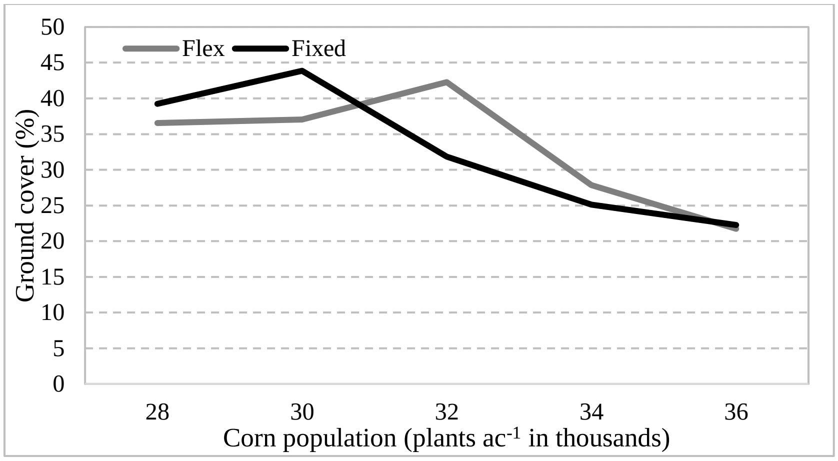

Figure 5. Cover crop ground cover in flex and fixed ear hybrid plots by population, 2018.

Impact of Hybrid Relative Maturity

Corn hybrids are also characterized by the length of the growing season required for the hybrid to reach physiological maturity. Long season corn varieties, or those with higher relative maturities, are generally regarded as having higher yield potentials as they are able to maximize resources over the longer growing period. This trend was observed in this trial as the long season hybrids produced yields approximately 3 tons ac^{-1} higher than short season hybrids (Figure 6). However, in northern regions where the growing season is relatively short and is often shortened further due to unfavorable weather, short season varieties are being promoted as potential tools to be more resilient to unpredictable weather. These varieties likely have faster growth rates than longer season varieties as they are bred to mature in shorter periods of time. The short season hybrids did reach significantly lower dry matter contents at harvest compared to long season hybrids, with the short season reaching 36.4% and the long reaching 39.0%. In this trial, however, light infiltration remained higher for longer in short season variety plots (Figure 7).

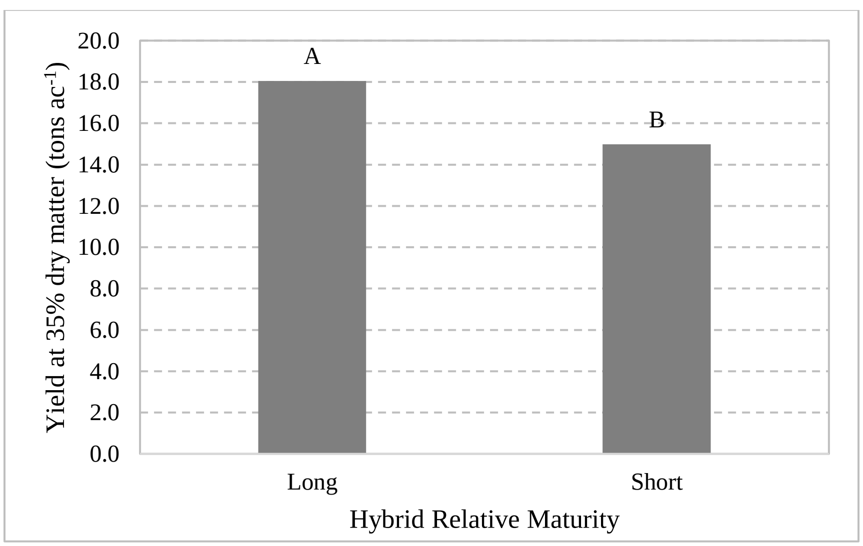

Figure 6. Corn yield by hybrid relative maturity.

Treatments that share letters performed statistically similarly to one another.

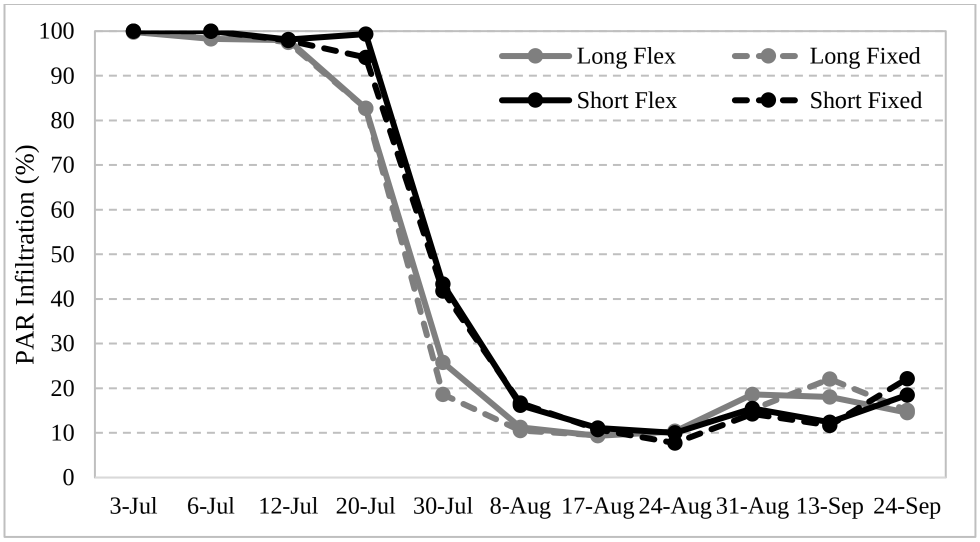

Figure 7. PAR infiltration by relative maturity and ear type across the season, 2018.

Light infiltration was approximately 10% higher in short season plots two weeks after corn was planted and approximately 20% higher after three weeks. As mentioned previously, the cover crop was interseeded on 12-Jul but rainfall was not experienced until 17-Jul. The cover crop therefore likely only had about 10 days to germinate and establish before the corn canopy significantly reduced the available light. Unfortunately, we were unable to collect cover crop ground cover data from the short season varieties to see whether cover crops established better where yields were lower. This experiment will be repeated in 2019 to continue to investigate these variables. Corn quality also differed slightly across relative maturities (Table 3). Protein was slightly higher in short season varieties but long season varieties had lower ADF and higher starch. Due to the significant difference in yields, milk per acre was higher in long season varieties. All other measures did not differ statistically between relative maturity groups.

Table 3. Corn quality by relative maturity, 2018.

Relative maturity	DM	CP	ADF	NDF	Ash	Starch	TDN	30-hr NDFD	NE_L	Milk	
	% of DM							% of NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
Long Season	39.0	8.61	**22.0**	**38.0**	**2.05**	**34.4**	**69.4**	**45.1**	**0.684**	**3165**	**20027**
Short Season	**36.4**	**8.89**	23.0	38.9	2.32	31.6	69.2	44.4	0.682	3155	16481
LSD (p = 0.10)	1.20	0.259	0.624	NS	NS	1.93	NS	NS	NS	NS	2124
Trial mean	37.7	8.71	22.5	38.5	2.19	33	69.3	44.7	0.683	3160	18254

Treatments in **bold** were the top performer for that category.

NS- not statistically significant.

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

Timing Trial- Impact of Cover Crop 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. 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. In this trial, as interseeding was delayed to the V6 growth stage, cover crop success, indicated by post-harvest ground cover, decreased (Figure 8). 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 4). Image 1 shows the cover crop establishment.

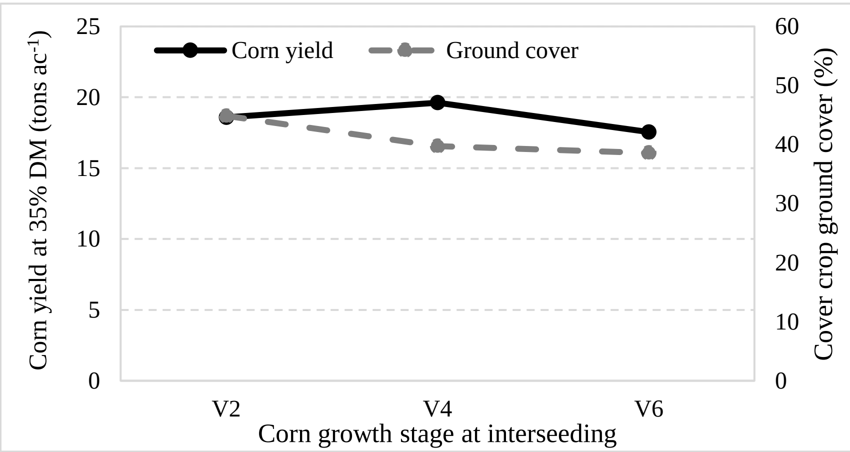

Figure 8. Corn yield and cover crop ground cover by interseed timing, 2018.

Image 1. Cover crop, fall 2018.

Table 4. Corn quality by interseed timing, 2018.

Interseed timing	DM	CP	ADF	NDF	Ash	Starch	TDN	30-hr NDFD	NE_L	Milk	
				% of DM				% of NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
V2	38.1	18.6	**22.8**	**40.2**	**3.37**	**31.7**	**67.3**	**44.6**	0.659	3004	19578
V4	37.8	**19.6**	23.1	40.6	3.72	30.4	66.7	44.0	0.654	2963	**20264**
V6	**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
Trial mean	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.

Light available at the time of interseeding varied dramatically across the timing treatments (Figure 9). 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.

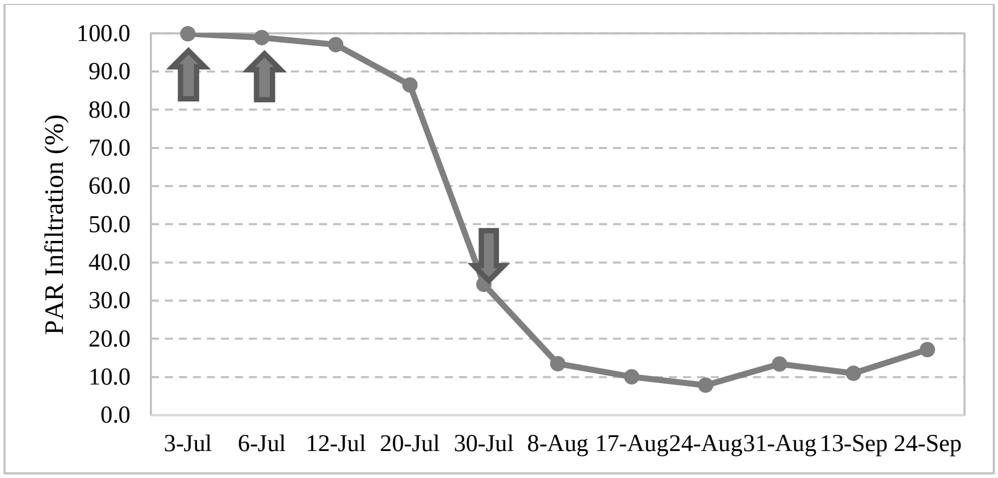

Figure 9. PAR across the season, 2018.
Arrows indicate the V2, V4, and V6 growth stages at which cover crops were interseeded.

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 the highest cover crop success, indicated by post-harvest ground cover, from the fixed ear hybrids, however, this was only observed when interseeded at the V2 growth stage and was not statistically significant (Figure 10). Corn yield and quality parameters also did not differ across the ear types.

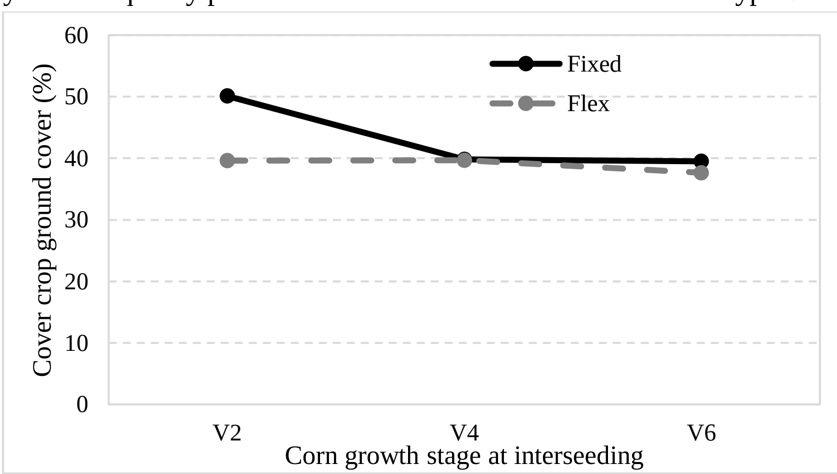

Figure 10. Ground cover by ear type across interseed timing treatments, 2018.

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

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