Impact of corn silage variety and seeding rate on interseeded cover crop establishment

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IMPACT OF CORN SILAGE VARIETY AND SEEDING RATE ON INTERSEEDED COVER CROP ESTABLISHMENT

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With increasing focus on minimizing environmental impacts from agriculture, farmers are looking for strategies that are good for both 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 crop established 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 replicated field experiments in 2022 to help identify best practices that support successful cover crop establishment without sacrificing corn silage yields.

MATERIALS AND METHODS

The field trials were conducted at Borderview Research Farm in Alburgh, VT and at Bridgeman View Farm in Franklin, VT (Table 1). The trials evaluated the impact of corn variety and population on cover crop establishment and corn yields. Six corn varieties were planted at populations ranging from 26,000 to 36,000 seeds ac^{-1}. Varieties were selected for fixed and flex-ear characteristics as well as suitability to a northern climate and productivity. Manure was injected at the Franklin site at a rate of 7159-gal ac^{-1} on 25-Apr. Corn was planted on 13-May at both sites, with the Alburgh site receiving 5 gal ac^{-1} 9-18-9 starter fertilizer at planting. The plots were interseeded with a cover crop mixture of annual ryegrass (60%), tillage radish (10%), and red clover (30%) when the corn reached the V6 growth stage on 2-Jul and 22-Jun in Alburgh and Franklin respectively.

Prior to harvest, corn populations were measured by counting the number of plants in the center two rows of each plot in Alburgh and the number of plants within random 17.5' transects in each plot in Franklin. Corn was harvested on 23-Sep in Alburgh using a John Deere 2-row corn chopper and collected in a wagon fitted with scales to weigh the yield of each plot. In Franklin, the host farmer harvested the trial and weighed each plot using portable truck scales on 27-Sep. At both sites, an approximate 1 lb subsample was collected, weighed, dried, and weighed again to determine dry matter content and calculate yield from each plot. 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 E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT) using a FOSS DS2500 NIRS. Following corn harvest in Alburgh, cover crop ground cover was assessed on 20-Oct using the Canopeo smartphone application. Cover crop biomass was insufficient to warrant collection. In Franklin, the cover crop had established poorly across the trial and, due to very wet weather at harvest, the condition did not allow for cover or biomass measures.

Table 1. Trial management, 2022.

Location	Borderview Research Farm – Alburgh, VT	Bridgeman View Farm – Franklin, VT
Soil type	Covington silty clay loam	Westbury stony fine sandy loam
Corn variety treatments (relative maturity)	B95M87Q (95 RM) B95V86R (95 RM) B97G09AM (97 RM) NK8618 (86 RM) P8820Q (88 RM) P9608Q (96 RM)	B95M87Q (95 RM) B95V86R (95 RM) B97G09AM (97 RM) NK9535 (95 RM) P8820Q (88 RM) P9608Q (96 RM)
Corn population treatments (seeds ac^{-1})	26,000 28,000 30,000 32,000 34,000 36,000	24,000 28,000 31,000 34,000
Corn planting date	13-May	13-May
Cover crop mixture	25 lbs ac^{-1} Annual ryegrass (60%) Red clover (30%) Tillage radish (10%)	25 lbs ac^{-1} Annual ryegrass (60%) Red clover (30%) Tillage radish (10%)
Cover crop planting date	2-Jul	22-Jun
Harvest date	23-Sep	27-Sep

Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the crude protein content of forages. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of the plant are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (aNDFom) which includes cellulose, hemicellulose, and lignin. This measure indicates the bulky characteristic of the forage and therefore is negatively correlated with animal dry matter intake. The portion of the NDF fraction that is estimated to be digestible after 30 hours of fermentation in rumen fluid is represented by the NDF digestibility (NDFD30). The portion of the NDF that is left undigested after 240 hours of fermentation in rumen fluid is represented by uNDF240. The acid detergent fraction (ADF) is composed of highly indigestible fiber and therefore, is negatively correlated with digestibility. The portion of the total dry matter (DM) that contains digestible nutrients is represented by the total digestible nutrients (TDN). The estimated energy available for bodily maintenance plus lactation by a ruminant consuming the forage is represented by the net energy of lactation (NEL) which is expressed on a per pound of dry matter basis. Several forage quality metrics are combined to estimate the milk yield produced by feeding the forage to cattle and is expressed both on a per ton of dry matter and per acre basis.

Data from Borderview Research Farm were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications in the trials were treated as random effects and treatments were treated as fixed. Mean comparisons were made when the F-test was considered significant ($p<0.10$).

Due to weather challenges at harvest, not all plots were harvestable at the Franklin location and therefore, the data were not statistically analyzed.

RESULTS

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at each trial site (Tables 2 and 3). Conditions throughout the season were generally cooler and wetter than normal, although July was drier than normal at the Alburgh location. In total, precipitation was 4.60 inches and 7.21 inches above normal for May-Sep in Alburgh and Franklin respectively. A total of 2500 and 2373 Growing Degree Days (GDDs) were accumulated during the season in Alburgh and Franklin respectively. These were 46 and 175 less than the 30-year normal for these locations respectively.

Table 2. 2022 weather data for Alburgh, VT.

	May	Jun	Jul	Aug	Sep
Average temperature (°F)	60.5	65.3	71.9	70.5	60.7
Departure from normal	2.09	-2.18	-0.54	-0.20	-1.99
Precipitation (inches)	3.36	8.19	3.00	4.94	4.40
Departure from normal	-0.40	3.93	-1.06	1.40	0.73
Growing Degree Days (base 50°F)	394	459	674	630	343
Departure from normal	93	-64	-20	-11	-44

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.

Table 3. 2022 weather data for Franklin, VT.

	May	Jun	Jul	Aug	Sep
Average temperature (°F)	59.6	63.9	70.1	70.0	59.7
Departure from normal	1.19	-3.58	-2.28	-0.70	-2.96
Precipitation (inches)	4.53	5.08	4.71	5.17	7.01
Departure from normal	0.77	0.82	0.65	1.63	3.34
Growing Degree Days (base 50°F)	383	429	620	609	332
Departure from normal	81	-95	-74	-32	-55

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.

Impact of Corn Variety x Corn Seeding Rate

There were no statistically significant interactions between variety and seeding rate for any of the measures at the Alburgh location. This indicates that the varieties responded similarly, in terms of population, yield, and subsequent cover crop ground cover, as seeding rates were altered. This was unexpected as the varieties selected for this trial included both flex and fixed ear characteristics. Fixed ear varieties tend to produce similarly sized ears regardless of seeding rate and therefore, yields are maximized at higher populations. Conversely, flex ear varieties can compensate for lower populations by producing larger ears thus producing higher yields at lower populations than fixed ear varieties. The lack of an interaction suggests that this was not observed in this trial. The lack of interaction may be a result of low populations experienced in the trial. Low populations were likely due to cool and wet conditions at the time planting and emergence.

Impact of Corn Seeding Rate

As anticipated, seeding rate significantly impacted corn populations at harvest (Table 4). Populations overall were lower than intended across the treatments. This led to some of the seeding rate treatments having similar populations at harvest. Despite this, yields did not differ significantly across seeding rates ranging from 18.2 to 20.5 tons ac^{-1}. This indicates that no additional yield benefit was gained by seeding at rates higher than 26,000 seeds ac^{-1}. As discussed in the previous section, there was no significant interaction between ear type (fixed vs flex) and seeding rate for yield, indicating that no additional yield benefit was seen increasing seeding rates beyond 26,000 seeds ac^{-1} for either ear-type. Altering corn seeding rates could potentially help support better cover crop establishment and growth by allowing light to infiltrate through the canopy. However, in this trial this was not the case as no statistical difference was observed in cover crop ground cover across the seeding rates.

Table 4. Corn and cover crop characteristics by seeding rate, Alburgh location.

Seeding Rate seeds ac^{-1}	Population plants ac^{-1}	Corn yield@ 35% DM tons ac^{-1}	Ground cover %
26000	20873d†	18.4	**7.88**
28000	21054d	18.2	7.42
30000	23758c	19.5	5.43
32000	25646b	18.4	4.51
34000	26771ab	**20.5**	5.33
36000	**27661a**	19.9	2.84
LSD (*p*=0.10) ‡	1500	NS¥	NS
Trial mean	24294	19.1	5.57

†Treatments that share a letter performed statistically similarly to one another.
Top performing treatment indicated in **bold.**
‡LSD; least significant difference at the p=0.10 level.
¥NS; not statistically significant.

Table 5. Corn characteristics by seeding rate, Franklin location.

Seeding Rate seeds ac^{-1}	Population plants ac^{-1}	Corn yield@ 35% DM tons ac^{-1}
24000	27961	12.2
28000	26219	**19.6**
31000	30948	18.2
34000	**32276**	19.5
Trial mean	29351	17.9

Top performing treatment indicated in **bold.**

At the Franklin location, populations tracked similarly to seeding rate treatments except for the 24,000 seeds ac^{-1} treatment which produced 27,961 plants ac^{-1} (Table 5). This suggests challenges at planting with obtaining the intended rates. Yields were also similar for all seeding rate treatments except for the lowest rate of 24,000 which only yielded 12.2 tons ac^{-1}.

Corn quality characteristics were measured only at the Franklin location and were not analyzed statistically. However, the data suggested that the seeding rates did not impact corn quality (Table 6). The only parameter that significantly differed numerically was milk yield per acre where the lowest seeding rate produced approximately 34% less than the next highest seeding rate. This is due to the difference in corn yield observed between the seeding rates, not forage quality differences. Although some of the varieties included in the trial possessed flex-ear characteristics, which would allow them to form larger ears at lower populations, these did not translate into significant impacts on corn silage quality parameters.

Table 6. Corn quality characteristics by seeding rate, Franklin location.

Seeding Rate	CP	ADF	aNDFom	Lignin	Starch	TDN	NEL	240-hr uNDF	30-hr NDFD	Milk yield	
seeds ac^{-1}	% of DM						Mcal lb^{-1}	% of NDF		lbs ton^{-1}	lbs ac^{-1}
24000	8.53	20.0	35.6	**2.50**	39.7	**64.0**	0.680	8.57	57.8	3367	14396
28000	**8.68**	19.8	35.3	2.63	39.7	63.8	0.675	8.48	**59.3**	3369	**23108**
31000	8.48	19.8	35.1	2.67	40.7	64.0	**0.681**	8.11	58.2	**3392**	21653
34000	8.43	**19.1**	**34.1**	2.55	**41.6**	63.5	0.677	**8.10**	57.3	3348	22803
Trial mean	8.55	19.7	35.1	2.60	40.3	63.8	0.678	8.32	58.3	3372	21089

Top performing treatments indicated in **bold.**

Impact of Corn Variety

Corn variety significantly impacted corn harvest characteristics at the Alburgh location (Table 7). Varieties NK8618 and P8820Q had significantly lower harvest populations than the other four varieties, which all performed similarly to one another. Yields ranged from 16.4 tons ac^{-1} to 21.8 tons ac^{-1}. The highest yields were observed from variety B97G09AM, which was statistically similar to two other varieties. Varieties did not significantly differ in subsequent cover crop ground cover, which was relatively low across the entire trial.

At the Franklin site (Table 8) harvest populations were approximately 4000 plants lower for variety P8820Q compared to B95M870, which had the highest populations. Variety B95M870 produced the highest yield of 20.3 tons ac^{-1}, almost two tons more than the next highest variety.

Table 7. Corn and cover crop characteristics by variety, Alburgh location.

Variety	Population	Corn yield@ 35% DM	Ground cover
	plants ac^{-1}	tons ac^{-1}	%
B95M87Q	25446a†	20.2ab	2.73
B95V86R	25337a	18.3bc	**9.73**
B97G09AM	25537a	**21.8a**	3.90
NK8618	19965c	17.1c	7.20
P8820Q	23758b	16.4c	5.78
P9608Q	**25719a**	21.0a	4.06
LSD (*p*=0.10) ‡	1500	1.92	NS¥
Trial mean	24294	19.1	5.57

†Treatments that share a letter performed statistically similarly to one another.
Top performing variety indicated in **bold**.
‡LSD; least significant difference at the p=0.10 level.
¥NS; not statistically significant.

Table 8. Corn characteristics by variety, Franklin location.

Variety	Population	Corn yield@ 35% DM
	plants ac^{-1}	tons ac^{-1}
B95M870	**30865**	**20.3**
B95V86R	29870	16.5
B97G09AM	28376	18.5
NK9535	29745	17.2
P8820Q	26758	16.7
P9608Q	30492	17.7
Trial mean	24294	19.1

Top performing variety indicated in **bold**.

Corn variety likely impacted some corn quality parameters at the Franklin site (Table 9). Crude protein levels ranged from 8.28% to 9.10% and were highest in the variety P8820Q. Additionally, 240-hr uNDF and 30-hr NDFD differed between some varieties. The 240-hr uNDF, which represents material left undigested by the animal after 240 hours of exposure to rumen fluid, ranged from 7.94% to 9.28% with the lowest levels observed in variety P8820Q. The 30-hr NDF digestibility ranged from 56% to 59.7% with the highest level observed in variety B95V86R. Little difference was observed in predicted milk yield per ton of dry matter, however, due to differences in yield per acre, predicted milk yield per acre ranged from 19,617 to 24,028 lbs ac^{-1}.

Table 9. Corn quality characteristics by variety, Franklin location.

Variety	CP	ADF	aNDFom	Lignin	Starch	TDN	NEL	240-hr uNDF	30-hr NDFD	Milk yield	
	% of DM						Mcal lb^{-1}	% of NDF		lbs ton^{-1}	lbs ac^{-1}
B95M870	8.48	20.5	36.4	2.53	39.5	**64.2**	0.678	8.33	57.6	3383	**24028**
B95V86R	8.60	**18.8**	**34.1**	2.73	**41.0**	63.7	**0.683**	8.05	**59.7**	**3407**	19689
B97G09AM	8.38	20.1	35.2	2.65	40.2	63.7	0.675	8.12	59.0	3375	21895
NK9535	8.54	20.7	36.1	**2.50**	39.9	64.2	0.680	9.28	56.0	3354	20204
P8820Q	**9.10**	19.0	34.3	2.64	40.4	63.4	0.675	**7.94**	58.6	3363	19617
P9608Q	8.28	19.2	34.5	2.55	40.9	63.8	0.676	8.28	58.8	3344	20707
Trial mean	8.55	19.7	35.1	2.60	40.3	63.8	0.678	8.32	58.3	3372	21089

Top performing variety indicated in **bold**.

DISCUSSION

Interseeding cover crops into corn silage systems is challenging and may have higher success given changes to corn variety selection, 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 variables interact under varying conditions. More data needs to be collected to better understand the interaction of these corn hybrid characteristics with crop management.

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