NORTHWEST CROPS & SOILS PROGRAM

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 initiated a research trial in 2023 to help identify best practices that support successful cover crop establishment without sacrificing corn silage yields.

MATERIALS AND METHODS

The trial was conducted at Borderview Research Farm in Alburgh, VT (Table 1). The trial evaluated the impact of corn variety and population on cover crop establishment and corn yields. Six corn varieties were planted at seeding rates ranging from 26,000 to 37,000 seeds ac^{-1}. Varieties were selected for fixed and flex-ear characteristics as well as suitability to a northern climate and productivity. Prior to planting, 300 lbs ac^{-1} of 19-19-19 was applied to the field on 8-May. Corn was planted on 13-May using a 4-row cone planter with John Deere row units fitted with Almaco seed distribution units (Nevada, IA). 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 20-Jun. All plots were top-dressed with 46-0-0 plus the inhibitor ContaiN MAX™ at a rate of 250 lbs ac^{-1} on 20-Jun. To control weeds, Lumax® EZ was applied to the whole field at a rate of 3 qt ac^{-1} on 10-Jun. The amount of photosynthetic active radiation (PAR) reaching the ground under the corn canopy was measured on 17-Aug using a LI-COR LI-191R line quantum light sensor equipped with a LI-1500 data logger. 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.

Prior to harvest, corn populations were measured by counting the number of plants in the center two rows of each plot. Corn was harvested on 26-Sep 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 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. Cover crop biomass was insufficient to warrant collection (Figure 1). The cover crop had established poorly across the trial and, due to very wet weather after harvest, the condition did not allow for cover or biomass measures.

Table 1. Trial management details, Alburgh, VT, 2023.

Location	Borderview Research Farm
Soil type	Amenia silt loam, 0 to 3% slopes
Previous crop	Corn grain
Corn variety treatments (relative maturity)	B95R21Q (95 RM) B95V86AM (95 RM) B97G09Q (97 RM) DKC44-80 (94 RM) P8820Q (88 RM) P9608AM (96 RM)
Corn population treatments (seeds ac^{-1})	26,000 29,000 31,000 34,000 37,000
Corn planting date	13-May
Fertilizer applications	19-19-19 (300 lbs ac^{-1}); 8-May 46-0-0 plus ContaiN MAX^{TM} (250 lbs ac^{-1}); 20-Jun
Herbicide application	3 qt ac^{-1} Lumax® EZ; 10-Jun
Cover crop mixture	Annual ryegrass (60%) Red clover (30%) Tillage radish (10%)
Cover crop planting date	20-Jun
Harvest date	26-Sep

Figure 1. Interseeded cover crop in August, Alburgh, VT, 2023.

The NIR procedures and corn silage calibration from Dairy One Forage Laboratories (Geneva, NY) were used to determine crude protein (CP), starch, lignin, acid detergent fiber (ADF), ash corrected neutral detergent fiber (aNDFom), total digestible nutrients (TDN), net energy lactation (NEL), non-fiber carbohydrates (NFC), undigestible neutral detergent fiber (uNDFom; 30h), and neutral detergent fiber digestibility (NDFD; 30h). Milk per acre and milk per ton of harvested feed are two measurements used to combine yield with quality and arrive at a benchmark number indicating how much revenue in milk can be produced from an acre or a ton of corn silage. This calculation relies heavily on the NEL calculation and can be used to generalize about data, but other considerations should be analyzed when including milk per ton or milk per acre in the decision-making process.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at p<0.10. Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or 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. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. Treatments within a column that have the same letter are statistically similar. In this example, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0 indicating the yields of these treatments were significantly different from one another. The letter ‘a’ indicates that treatment B was not significantly lower than the top yielding treatment, indicated in bold.

Treatment	**Yield**
A	6.0[b]
B	7.5[ab]
C	**9.0[a]**
LSD	2.0

RESULTS

Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger (Table 2). Conditions throughout the season were generally cooler and there was excessive precipitation from June through August. There was a total of 25.8 inches of precipitation, 6.5 inches above normal. In Alburgh, VT there were 2487 accumulated Growing Degree Days (GDDs), 62 less than the 30-year average.

Table 2. Weather data for Alburgh, VT, 2023.

	May	Jun	Jul	Aug	Sep
Average temperature (°F)	57.1	65.7	72.2	67.0	63.7
Departure from normal	-1.28	-1.76	-0.24	-3.73	1.03
Precipitation (inches)	1.98	4.40	10.8	6.27	2.40
Departure from normal	-1.78	0.14	6.69	2.73	-1.27
Growing Degree Days (base 50°F)	303	483	712	540	449
Departure from normal	1	-41	17	-101	62

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 few statistically significant interactions between variety and seeding rate (Table 3). There were no significant seeding rate x variety interactions for harvest population, dry matter, or yield. There was a corn seeding rate by variety interaction for the following quality characteristics: aNDFom, NFC, starch, and NE_L. The interactions suggest that quality characteristics of the varieties responded differently to the changing seeding rates. Visual representations of these interactions are shown in Figures 2-4. These interactions show that varieties respond differently to plant density especially with regard to starch (ear size).

Table 3. Significance of main effects and main effect interactions, Alburgh, VT, 2023.

	Variety	Seeding rate	Variety x Seeding rate
Harvest population	*†	***	NS‡
Dry matter	***	NS	NS
Yield, 35% DM	**	*	NS
Crude protein	NS	NS	NS
ADF	***	*	NS
aNDFom	***	*	*
Lignin	NS	*	NS
NFC	***	*	*
Starch	*	NS	*
TDN	**	*	NS
30-hr uNDFom	***	*	NS
30-hr NDFD	***	NS	NS
NE_L	***	*	*
Predicted milk ton^{-1}	***	*	NS
Predicted milk ac^{-1}	**	*	NS

†***p<.0001; **.001<p<.01; *.01<p<0.1

‡NS-No significant difference between treatments.

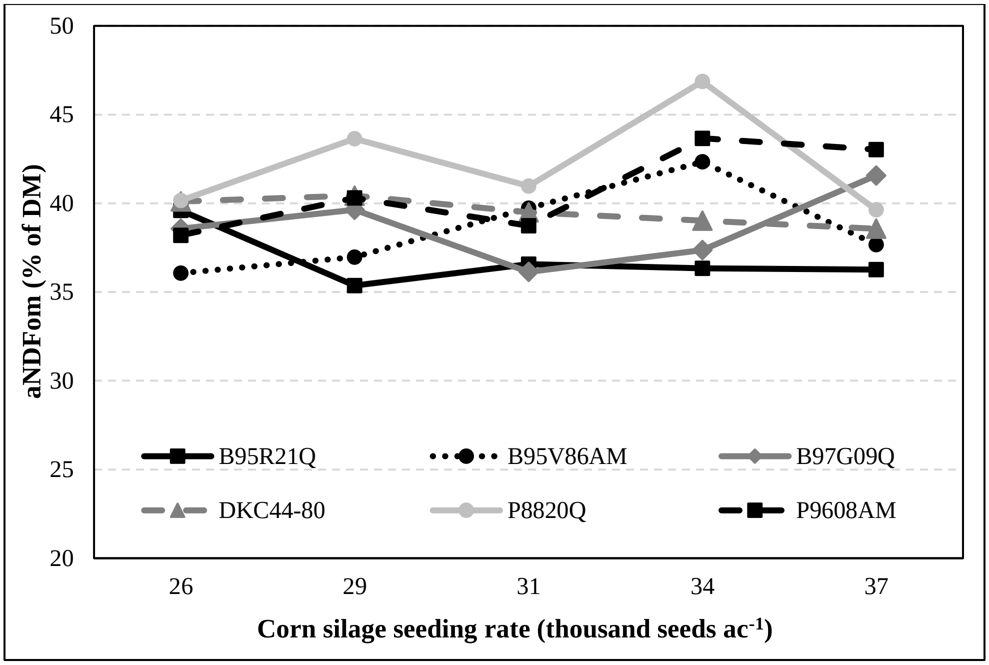

Figure 2. Seeding rate x variety interaction for aNDFom content, Alburgh, VT, 2023.

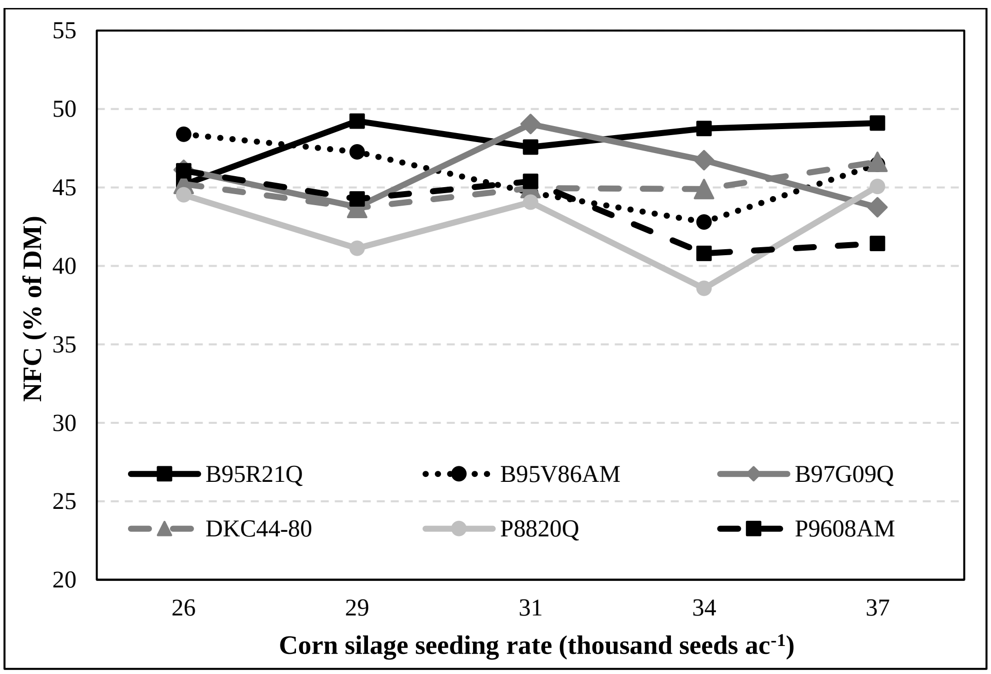

Figure 3. Seeding rate x variety interaction for NFC content, Alburgh, VT, 2023.

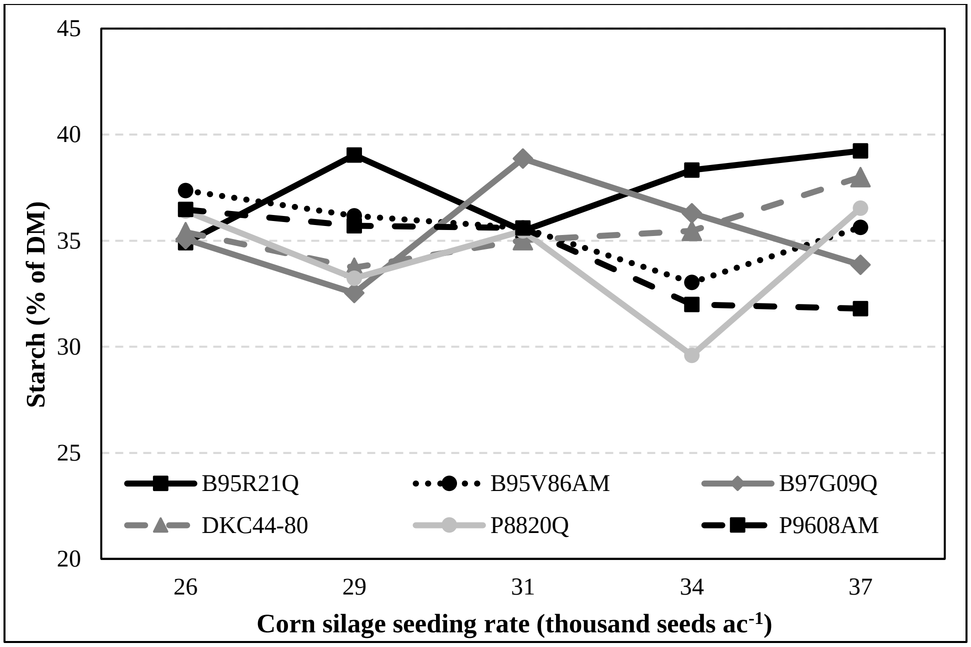

Figure 4. Seeding rate x variety interaction for starch content, Alburgh, VT, 2023.

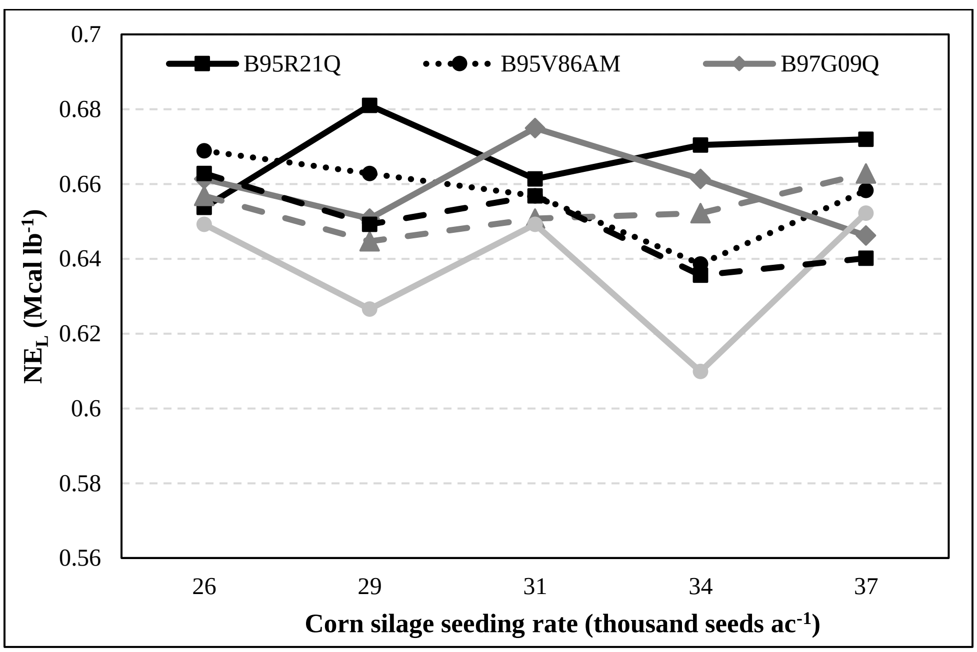

Figure 5. Seeding rate x variety interaction for NE_L content, Alburgh, VT, 2023.

Impact of Corn Seeding Rate

Corn seeding rate had a statistically significant impact on harvest populations and corn yield (Table 4). Populations overall were lower than intended across the treatments. Harvest populations were statistically different between each of the seeding rate treatments, but there were no statistical differences in silage yield for the 29, 31, 34, and 37,000 seeds ac^{-1} treatments. This indicates that no additional yield benefit was gained by seeding at rates higher than 29,000 seeds ac^{-1}. Altering corn seeding rates could potentially help support better cover crop establishment and growth by allowing light to infiltrate through the canopy. Light infiltration between rows is shown in Figure 6 below. This figure provides a visualization of light infiltration but does not, however, state that these differences are statistically significant. Light infiltration decreases with higher seeding rates, but overall infiltration was very low in this year's trial. Light infiltration ranged from 2.8% to 4.5%. The lack of light infiltration and wet field conditions during the season likely resulted in the poor cover crop establishment and growth observed in 2023.

Table 4. Corn harvest characteristics by seeding rate, Alburgh, VT, 2023.

Seeding Rate seeds ac^{-1}	Harvest population plants ac^{-1}	Dry matter %	Corn yield@ 35% DM tons ac^{-1}
26000	25555^{e}†	42.2	23.9^{b}
29000	27515^{d}	42.5	26.2^{ab}
31000	29330^{c}	41.6	28.6^{a}
34000	32283^{b}	43.6	28.5^{a}
37000	**34412^{a}**	42.9	**28.8^{a}**
LSD (p=0.10)‡	852	NS¥	2.97
Trial mean	29819	42.6	27.2

†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-No significant difference between treatments.

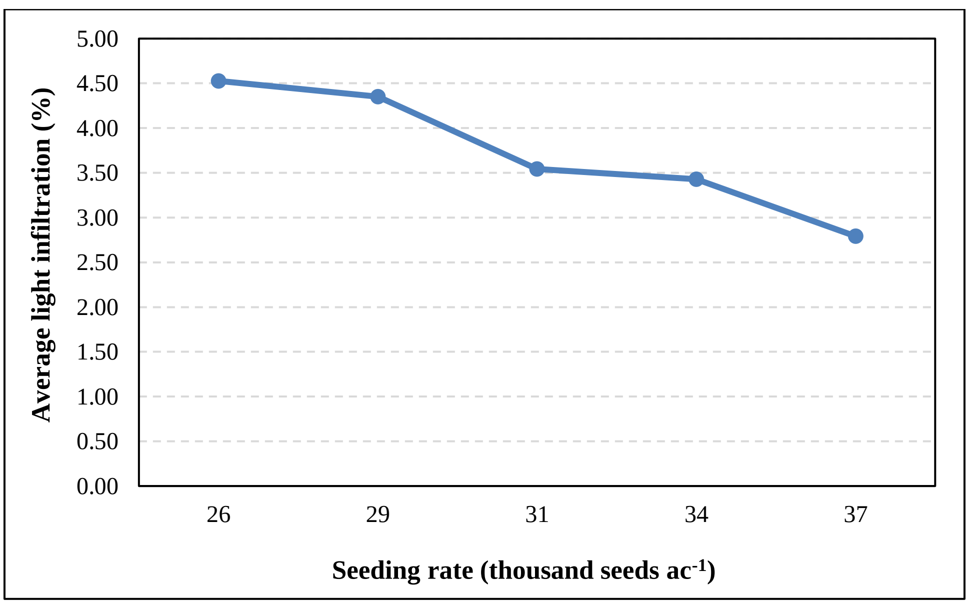

Figure 6. Average light infiltration by corn seeding rate, Alburgh, VT, 2023.

Corn silage quality varied significantly by seeding rate (Table 5). ADF and aNDFom were statistically greater in the 34,000 seeds ac^{-1} treatment, and there was no statistical difference between the other seeding rates for these two metrics. Lignin was the highest in the 29,000 seeds ac^{-1} treatment. The 31,000 seeds ac^{-1} treatment had the greatest NFC, but was only statistically different from the 34,000 seeds ac^{-1} treatment. TDN, NE_L, and milk yield per ton were all greatest in the 26,000 seeds ac^{-1} treatment, but were not statistically different from all other seeding rates except for the 34,000 seeds ac^{-1} treatment. Milk yield per acre was significantly reduced in the 26,000 seeds ac^{-1} seeding rate. 30-hr uNDFom was highest in the 34,000 seeds ac^{-1} treatment.

Table 5. Corn quality characteristics by seeding rate, Alburgh, VT, 2023.

Seeding Rate	CP	ADF	aNDFom	Lignin	NFC	Starch	TDN	30-hr uNDFom	30-hr NDFD	NE_L	Milk yield	
seeds ac^{-1}					% of DM				% of NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
26000	7.23	23.0^{b}†	38.8^{b}	2.92^{b}	45.9^{a}	35.9	**63.3^{a}**	18.5^{b}	52.5	**0.659^{a}**	**3223^{a}**	26976^{b}
29000	7.30	23.5^{b}	39.4^{b}	**3.08^{a}**	44.9^{ab}	35.1	63.0^{ab}	19.1^{b}	51.6	0.652^{ab}	3195^{a}	29458^{ab}
31000	7.22	23.0^{b}	38.6^{b}	2.99^{ab}	**46.0^{a}**	36.0	63.1^{a}	18.7^{b}	51.7	0.658^{a}	3220^{a}	**32201^{a}**
34000	7.06	**24.9^{a}**	**40.9^{a}**	2.97^{b}	43.8^{b}	34.1	62.6^{b}	**20.3^{a}**	50.5	0.645^{b}	3140^{b}	31380^{a}
37000	7.08	23.7^{b}	39.5^{ab}	2.93^{b}	45.4^{a}	35.8	63.1^{a}	19.4^{ab}	50.8	0.655^{a}	3187^{a}	31935^{a}
LSD (p=0.10)‡	NS¥	1.14	1.51	0.10	1.38	NS	0.42	1.04	NS	0.009	43.80	3265.4
Trial mean	7.18	23.6	39.4	2.98	45.2	35.4	63.0	19.2	51.4	0.654	3193	30390

†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-No significant difference between treatments.

Impact of Corn Variety

Corn variety significantly impacted corn harvest characteristics (Table 6). Despite different seeding rate treatments, the average harvest populations were statistically different between varieties. B95V86AM had the highest harvest population, 30,811 plants ac^{-1}, and this was not significantly different from DKC44-80, 30,202 plants ac^{-1}. The variety P8820Q had significantly greater dry matter than the other varieties. P8820Q is the earliest maturing variety, with a relative maturity of 88 days. The relative maturities of the other varieties range from 94 to 97 days. DKC44-80 had the greatest silage yield but was not statistically different from three other varieties: B95R21Q, B95V86AM, and B97G09Q. The lowest yielding variety was P8820Q with a yield of 22.8 tons ac^{-1} at 35% dry matter, which is nearly 7 tons less than the top performer.

Table 6. Corn and cover crop characteristics by variety, Alburgh location.

Variety	Harvest population	Dry matter	Corn yield@ 35% DM
	plants ac^{-1}	%	tons ac^{-1}
B95R21Q	29708^{bc}†	39.1^{c}	26.5^{ab}
B95V86AM	**30811^{a}**	40.6^{c}	29.5^{a}
B97G09Q	29766^{bc}	39.6^{c}	28.6^{ab}
DKC44-80	30202^{ab}	42.7^{b}	**29.7^{a}**
P8820Q	28866^{c}	**49.8^{a}**	22.8^{c}

P9608AM	29563[bc]	43.6[b]	26.1[b]
LSD (*p*=0.10) ‡	933	1.80	3.26
Trial mean	29819	42.6	27.2

†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.

There were statistical differences between varieties in terms of silage quality (Table 7). The trial average crude protein was 7.18%. The variety P8820Q had the highest ADF, aNDFom, and 30-hr uNDFom. B95R21Q had the highest NFC, starch, TDN, 30-hr NDFD, NEL, and milk yield per ton. Predicted milk yield per acre was highest for the variety DKC44-80, which is to be expected because that was also the highest yielding variety.

Table 7. Corn quality characteristics by variety, Alburgh, VT, 2023.

Variety	CP	ADF	aNDFom	Lignin	NFC	Starch	TDN	30-hr uNDFom	30-hr NDFD	NE_L	Milk yield	
	% of DM								% of NDF	Mcal lb^{-1}	lbs ton^{-1}	lbs ac^{-1}
B95R21Q	7.17	21.7[d]	36.8[d]	2.99	**48.0[a]**	**37.4[a]**	**63.5[a]**	17.1[e]	**53.5[a]**	**0.668[a]**	**3284[a]**	30537[ab]
B95V86AM	7.25	23.0[c]	38.6[c]	2.95	45.9[b]	35.6[b]	63.1[ab]	18.8[cd]	51.4[b]	0.657[bc]	3198[bc]	33016[a]
B97G09Q	7.27	22.9[cd]	38.7[c]	2.97	45.9[b]	35.3[b]	63.0[b]	18.0[de]	53.4[a]	0.659[ab]	3235[b]	32250[ab]
DKC44-80	6.96	23.7[bc]	39.5[bc]	2.91	45.1[bc]	35.5[b]	63.2[ab]	19.4[bc]	51.0[b]	0.653[bc]	3201[bc]	**33213[a]**
P8820Q	7.10	**25.8[a]**	**42.3[a]**	3.03	42.7[d]	34.2[b]	62.4[c]	**21.9[a]**	48.3[c]	0.637[d]	3064[d]	24523[c]
P9608AM	7.33	24.6[b]	40.8[ab]	3.01	43.6[cd]	34.3[b]	62.9[b]	20.1[b]	50.7[b]	0.649[c]	3176[c]	28802[b]
LSD (p=0.10) ‡	NS¥	1.25	1.66	NS	1.52	1.70	0.46	1.14	1.56	0.009	47.98	3577
Trial mean	7.18	23.6	39.4	2.98	45.2	35.4	63.0	19.2	51.4	0.654	3193	30390

†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-No significant difference between treatments.

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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