2023 Impact of Corn Row Spacing on Interseeded Forage Establishment

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2023 IMPACT OF CORN ROW SPACING ON INTERSEEDED FORAGE ESTABLISHMENT

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Interseeding is a strategy to plant cover crops directly into a growing crop of corn silage providing for earlier planting to hopefully maximize the conservation and ecological benefits of the cover crop. Farmers are interested in selecting cover crop species for specific value-added benefits. As an example, farmers are interested in using cover crops as a high-quality forage. This strategy can increase the direct benefit to the farmer. However, there are several challenges limiting farmer adoption and success with interseeding cover crops. Interseeding when corn is between the V2 to V6 growth stage is preferable because after corn has reached the V6 stage, most seeding equipment is not tall enough, increasing the risk of damaging the corn crop. This requires owning or having access to specialized cover crop interseeding equipment. Another challenge is that typical row spacings and plant populations create shade that limits cover crop establishment and growth. The solar corridor system is an alternative cropping system that is designed to increase the availability of sunlight to all rows, which can improve crop growth and nutrient cycling in the soil. Increasing the row width of corn silage may improve interseeded cover crop growth, but it is still important to maintain cash crop yields.

The ability to establish a perennial forage crop into the growing corn crop might provide additional value to the farm. The University of Vermont Extension Northwest Crops and Soils Program (NWCS) has conducted three years of research trials incorporating solar corridors into corn silage crop systems, comparing corn yield and cover crop biomass in different row spacings, and found that typical 30” row spacing produces significantly higher corn yields compared to 60” row spacing. Inversely, cover crop biomass significantly increases when interseeded into 60” rows compared to 30” rows. There is increasing interest from producers to incorporate alternative cropping systems, but these practices need to be fine-tuned in order to maintain crop productivity and increase interseeded cover crop success. Increasing corn row widths to 36” or 40” may minimize the yield loss while still allowing for successful cover crop establishment. In 2023, UVM Extension NWCS conducted a field experiment and an on-farm research trial at three locations to study the effect that corn row width has on silage yields and interseeded forage establishment.

MATERIALS AND METHODS

Replicated research trial to evaluate the effect of row width on corn yields and establishment of interseeded forages

The field trial was conducted at Borderview Research Farm, Alburgh, VT. The trial evaluated the impact of corn row width on silage yield, as well as establishment of three interseeded forage crop treatments. The experimental design was a randomized complete block with split plot design and replicated four times (Table 1). Main plots were corn row widths (30”, 40” and 60”) and split plots were interseeded forage treatments (alfalfa, orchardgrass/ alfalfa mix, and orchardgrass). The forage treatment descriptions can be found in Table 2. All plots were 35’ long and consisted of 4 rows. To accommodate the wider row spacing, plots were 10’, 14’ and 20’ wide for 30”, 40” and 60” row spacing respectively.

Corn was planted on 16-May. The 30" and 60" plots were planted with a John Deere MaxEmerge 1750 4-row planter (Moline, IL). The 40" plot was planted with a custom-made planter that included John Deere plate row-units on an adjustable tool bar. All plots were planted to meet a target population of 30,000 plants ac^{-1}. To control weeds, Resolve®Q was applied at a rate of 1.5 oz ac^{-1} with Cornerstone Plus at 1 pt ac^{-1} on 10-Jun. Forages were interseeded on 20-Jun at a rate of 20 lbs ac^{-1} (Table 2). On 20-Jun, plots were top-dressed with 46-0-0 plus ContaiN MAX™ at a rate of 250 lbs ac^{-1}. On 26-Sep, prior to corn harvest, ground cover by interseeded forage was measured by processing photographs using the Canopeo© smartphone application. Forage establishment was variable; therefore, biomass samples were only collected in some treatments prior to harvest. Corn plant populations at harvest were assessed by counting the number of plants in the center two rows of each plot. On 27-Sep, 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 representative subsample was collected for each row width, weighed, dried, and weighed again to determine dry matter content. Quality analyses were not conducted on corn silage from this trial.

Table 1. Replicated research trial management, Alburgh, VT, 2023.

Location	Borderview Research Farm - Alburgh, VT
Soil type	Benson rocky silt loam, over shaly limestone, 3-8% slopes
Previous crop	Grain corn
Replicates	4
Corn variety (Relative maturity)	Pioneer P8820Q (88 RM)
Row width (inches)	30, 40, 60
Target population (plants ac^{-1})	30,000
Corn planting date	16-May
Tillage operations	Pottinger TerraDisc
Herbicide (ac^{-1})	Resolve®Q (1.5 oz.) + Cornerstone Plus (1 pt); 10-Jun
Top dress fertilizer (lbs. ac^{-1})	250 lbs ac^{-1} of 46-0-0 plus ContaiN MAX™; 20-Jun
Date of interseeding	20-Jun
Corn harvest date	27-Sep

Table 2. Replicated trial forage treatment seeding rates, Alburgh, VT, 2023.

Forage treatment	Seeding rate (lbs. ac^{-1})
VNS alfalfa	20
Harvestar orchardgrass/ VNS alfalfa	8 12
Harvestar orchardgrass	20

<u>On-farm research trials to evaluate the effect of row width on corn yields and establishment of interseeded forages</u>

The three on-farm research trials were conducted in St. Albans, VT, Highgate, VT, and Fairfax, VT. These trials evaluated the impact of two row widths, 30" and 60", on corn yields and interseeded forage crop establishment.

In St. Albans, corn was planted on 12-May using a John Deere 7200 planter (Table 3). Row units were individually controlled by Ag Leader® SureDrive electric drives. Row widths were 30” and 60”. The 30” rows were planted at a rate of 30,000 seeds ac^{-1} and the 60” rows at a rate of 60,000 seeds ac^{-1} to reach the target corn population of 30,000 plants ac^{-1} overall. Starter fertilizer (32-0-0) was applied at a rate of 8 gal ac^{-1}. Alfalfa was interseeded on 21-Jun at a rate of 20 lbs ac^{-1}. On 25-Sep, corn populations were measured in both 30” and 60” rows by counting the number of plants in 10 ft sections. Corn yield was also measured by collecting and weighing the plants from the 10 ft sections in each treatment area prior to harvest. After weighing, five corn plants were ground through a woodchipper and an approximate 1 lb subsample was collected, weighed, dried, and reweighed to determine dry matter content and yield. Subsamples were ground and analyzed for forage quality at the E. E. Cummings Crop Testing Laboratory at the University of Vermont (Burlington, VT) via near infrared reflectance spectroscopy (NIR) techniques using a FOSS DS2500 Feed and Forage Analyzer. Forage establishment was measured by collecting the material growing within three quadrats that were approximately $0.05m^2$ each then weighed, dried, and reweighed to determine dry matter yield.

Table 3. On-farm trial management, St. Albans, VT, 2023.

Location	Tommary Holsteins - St. Albans, VT
Soil type	Copake fine sandy loam
Previous crop	Corn silage
Tillage	No-till
Rotation	5-year grass, 5-year corn with cover crop
Seeding rate (plants ac^{-1})	30" - 30,000 60" - 60,000
Interseeded forage (lbs ac^{-1})	Orchardgrass/Alfalfa mixture (8/12)
Planting dates	Corn: 12-May Orchardgrass/Alfalfa: 21-Jun
Starter fertilizer (gal ac^{-1})	32-0-0 (8)
Herbicide applications (oz ac^{-1})	Glyphosate (32)
Harvest date (corn & alfalfa)	25-Sep

In the on-farm trial in Highgate, VT, corn was planted on 17-May using a John Deere 7200 planter (Table 4). Row units were individually controlled by Ag Leader® SureDrive electric drives. Row widths were 30” and 60”. The 30” rows were planted at a rate of 30,000 seeds ac^{-1} and the 60” rows at a rate of 60,000 seeds ac^{-1} to meet the target corn population of 30,000 plants ac^{-1}. Starter fertilizer, 32-0-0, was applied at a rate of 8-gal ac^{-1}. The orchardgrass/alfalfa mixture was interseeded on 21-Jun at a rate of 20 lbs ac^{-1}. Prior to harvest on 2-Oct, corn populations, yield, and forage establishment were measured as described for the previous on-farm trial.

In the on-farm trial in Fairfax, VT, corn was planted on 31-May using a using a John Deere 7200 planter (Table 5). Row units were individually controlled by Ag Leader® SureDrive electric drives. Row widths were 30” and 60”. The 30” rows were planted at a rate of 30,000 seeds ac^{-1} and the 60” rows at a rate of 60,000 seeds ac^{-1} to meet the target corn population of 30,000 plants ac^{-1}. Starter fertilizer, 32-0-0, was applied at a rate of 8-gal ac^{-1}. The orchardgrass/alfalfa mixture was interseeded on 3-Jul at a rate of 20 lbs ac^{-1}. Prior to harvest on 2-Oct, corn populations, yield, and forage establishment were measured as described for the previous on-farm trial.

Table 4. On-farm trial management, Highgate, VT, 2023.

Location	Bess-View Farm- Highgate, VT
Soil type	Windsor loamy fine sand
Previous crop	Corn silage
Tillage	Minimum tillage
Rotation	Continuous corn with cover crop
Seeding rate (plants ac^{-1})	30" - 30,000 60" - 60,000
Interseeded forage (lbs ac^{-1})	Orchardgrass/Alfalfa mixture (8/12)
Planting dates	Corn: 17-May Orchardgrass/Alfalfa: 21-Jun
Starter fertilizer (gal ac^{-1})	32-0-0 (8)
Herbicide applications (oz ac^{-1})	Glyphosate (32)
Harvest date (corn & alfalfa)	2-Oct

Table 5. On-farm trial management, Fairfax, VT, 2023.

Location	Four Girls Dairy- Fairfax, VT
Soil type	Belgrade silt loam
Previous crop	Corn silage
Tillage	Conventional tillage
Rotation	5-year grass, 5-year corn with cover crop
Seeding rate (plants ac^{-1})	30" - 30,000 60" - 60,000
Interseeded forage (lbs ac^{-1})	Orchardgrass/Alfalfa mixture (8/12)
Planting dates	Corn: 31-May Orchardgrass/Alfalfa: 3-Jul
Starter fertilizer (gal ac^{-1})	32-0-0 (8)
Herbicide applications (oz ac^{-1})	Glyphosate (32)
Harvest date (corn & alfalfa)	2-Oct

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 at Borderview Research Farm in Alburgh (Table 6), in St. Albans (Table 7), Highgate (Table 8), and Fairfax, VT (Table 9). In Alburgh, temperatures were below normal throughout the growing season. September was the only month that had warmer than average temperatures. From May through September, Alburgh received 25.8 inches of rain, 6.5 inches higher than the 30-year normal for May through September. This season, in Alburgh, there were 2487 Growing Degree Days (GDDs), which falls within the range of required GDDs for corn silage (2200 to 2800) but 62 fewer than normal. Similar conditions were observed at the on-farm sites with below normal temperatures through the season, especially in August. Precipitation totals were 22.0, 25.8, and 26.4 inches for the St. Albans, Highgate, and Fairfax locations respectively and were 2.7, 6.5, and 7.0 inches above normal. GDDs were lowest at the Fairfax site totaling 2321 and highest in St. Albans at 2544, with Highgate in between at 2431.

Table 6. Weather data for replicated trial, Alburgh, VT, 2023.

Alburgh, VT	May	June	July	August	Sept
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 (50-86°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.

Table 7. Weather data for the on-farm trial in St. Albans, VT, 2023.

St. Albans, VT	May	Jun	Jul	Aug	Sep
Average temperature (°F)	59.7	66.3	73.4	68.1	64.8
Departure from normal	1.35	-1.15	0.96	-2.65	0.08
Precipitation (inches)	1.53	3.60	9.19	4.97	2.72
Departure from normal	-2.23	-0.66	5.13	1.43	-0.95
Growing Degree Days (50-86°F)	324	489	726	561	444
Departure from normal	22	-35	31	-80	57

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 8. Weather data for the on-farm trial in Highgate, VT, 2023.

Highgate, VT	May	Jun	Jul	Aug	Sep
Average temperature (°F)	59.7	65.8	72.0	67.1	64.2
Departure from normal	1.27	-1.62	-0.43	-3.68	-0.53
Precipitation (inches)	2.02	3.96	10.7	6.32	2.80
Departure from normal	-1.74	-0.30	6.65	2.78	-0.87
Growing Degree Days (50-86°F)	319	475	682	529	426
Departure from normal	17	-49	-13	-112	39

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 9. Weather data for the on-farm trial in Fairfax, VT, 2023.

Fairfax, VT	May	Jun	Jul	Aug	Sep
Average temperature (°F)	59.0	64.8	71.5	66.0	63.8
Departure from normal	0.65	-2.64	-0.90	-4.71	-0.97
Precipitation (inches)	1.81	5.70	8.80	6.91	3.14
Departure from normal	-1.95	1.44	4.74	3.37	-0.53
Growing Degree Days (50-86°F)	298	445	668	497	413
Departure from normal	-4	-79	-27	-144	26

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.

Interactions

There was a significant row spacing by forage type interaction (p=0.0984) for corn silage yield in the replicated trial in Alburgh, VT (Figure 1). Similar trends in corn silage yields were observed in the plots that were interseeded with orchardgrass and the orchardgrass/alfalfa mixture where the 30-inch rows yielded the highest and yields declined in 40- and 60-inch plots. However, corn silage yields remained more constant across the three row spacings when alfalfa was interseeded.

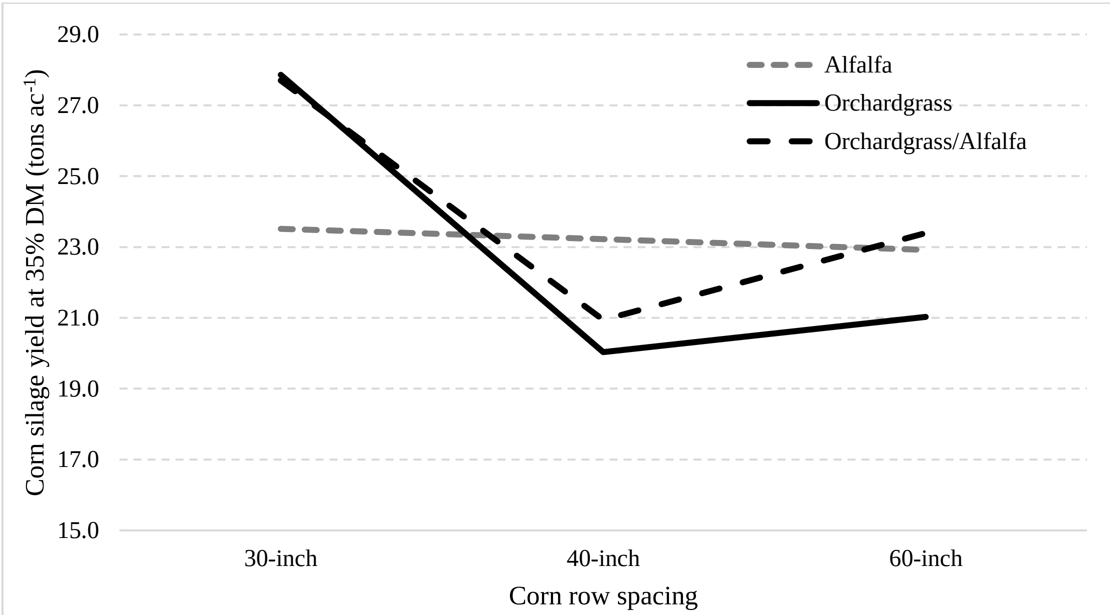

Figure 1. Corn silage yield by corn row width and interseeded forage treatment, Alburgh, VT, 2023.

Impact of Row Width

There were significant differences in corn and interseeded forage performance across the row spacing treatments (Table 10). Interseeded forage ground cover, height, and dry matter yield was highest in the 60-inch rows and was significantly higher than the other two spacing treatments which performed similarly to one another. While the significant increase in establishment and growth in the 60-inch rows was expected, these data suggest that increasing row widths from 30 to 40 inches did not provide any benefit to the interseeded forage in that season. It is important to recognize, however, that these assessments were made at the time of corn harvest. These perennial forages would be expected to continue to grow post-harvest and the following spring, at which time a more comprehensive assessment of establishment could be made. Images 1-4 show forage growth in early May 2023 in plots that were interseeded in the summer of 2022. You can see the variable and minimal establishment in the middles of the 30-inch row plots compared to the more even and full establishment in the 60-inch rows plots.

Table 10. Interseeded forage and corn silage performance by row spacing, Alburgh, VT, 2023.

Row width	**Ground cover**	**Forage height**	**Forage yield**	**Corn population**	**Corn yield, 35% DM**
	%	cm	lbs ac^{-1}	plants ac^{-1}	tons ac^{-1}
30-in.	3.75b†	4.14b	4.87b	33707b	**26.4a**
40-in.	3.73b	5.08b	13.8b	**34974a**	21.4b
60-in.	**26.2a**	**17.9a**	**94.6a**	28288c	22.4b
LSD (*p*=0.10)‡	7.36	4.96	39.4	1215	2.04
Trial mean	11.2	9.05	37.8	32323	23.4

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Top performers are in **bold.**
‡LSD –Least significant difference at p=0.10.

Images 1-4 (left to right). Alfalfa in 30-inch and 60-inch rows, orchardgrass in 30-inch and 60-inch rows.

Maintaining adequate corn populations while increasing row widths can be a challenge in these systems. In this trial, the populations were over 5,000 and 6,000 plants ac^{-1} lower in the 60-inch plots compared to the 30- and 40-inch plots respectively. Seeding rates and planting equipment need to be adjusted appropriately to achieve optimal seeding rates at these wider row spacings. In the end, corn silage yields were five- and four-tons ac^{-1} higher in the 30-inch rows compared to the 40- and 60-inch rows respectively. The fact that the corn populations were lower in the 60-inch rows, but yields were similar to the 40-inch rows, suggests that the plants were able to compensate the lower populations.

Similar trends were seen in the on-farm trials (Table 11). For statistical analysis, data from the three locations were combined with the locations serving as replicates. Across the three locations, corn populations and yields were numerically lower, but statistically similar in the 60-inch rows compared to the 30-inch rows. Interseeded forage yield, however, was more than 20 times higher in the 60-inch rows and was much higher than the yields obtained in the replicated trial.

Table 11. Interseeded forage yield and corn performance at two row spacings, on-farm, 2023.

Row width	Forage yield	Corn population	Corn yield, 35% DM
	lbs ac^{-1}	plants ac^{-1}	tons ac^{-1}
30-in.	27.6b†	**30368**	**27.3**
60-in.	**644a**	27505	25.2
LSD (p=0.10)‡	531	NS§	NS
Trial mean	336	28936	26.2

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Top performers are in **bold.**
‡LSD –Least significant difference at p=0.10.
§NS- No significant difference at p=0.10.

The on-farm trial average forage yield at the time of corn harvest was 336 lbs ac^{-1} which, while still not very substantial, was almost 10 times greater than the average forage yield in the replicated plot trial. These data suggest that increasing corn row spacing can provide better interseeded forage establishment results without significantly compromising corn yields. Spring assessments of the forage stands will provide a better understanding of the final establishment of the forage, which will impact the viability of wider adoption of this practice in the future.

Impact of Forage Type

The interseeded forage type had no impact on the ground cover at harvest, corn population, or corn yield (Table 12). All three forage types had low ground cover at the time of corn harvest; the trial average was 11.2%. With overall low growth at that time, it is not surprising that the interseeded forages had no impact on corn yields at harvest. The forage treatments did differ in height and yield at the time of corn harvest. The orchardgrass was the tallest at 12.0 cm, which was statistically similar to the orchardgrass/alfalfa treatment. The alfalfa alone was the smallest at 5.39 cm. Forage dry matter yield at the time of corn harvest followed the same trend as forage height. Overall, however, forage biomass was extremely low averaging only 37.8 lbs ac^{-1} across the trial. It is important to recognize, however, that these species could continue to grow post-harvest and the following spring. Establishment was measured at this time to ensure data were collected in the event that corn harvest significantly damaged the forage. However, spring assessments will provide a more comprehensive understanding of forage establishment and survival in this trial.

Table 12. Interseeded forage and corn silage performance by forage type, Alburgh, VT, 2023.

Forage type	Ground cover	Forage height	Forage yield	Corn population	Corn yield, 35% DM
	%	cm	lbs ac^{-1}	plants ac^{-1}	tons ac^{-1}
Alfalfa	9.71	5.39b†	14.4b	32324	23.2
Orchardgrass	11.2	**12.0a**	**67.4a**	**32439**	23.0
Orchardgrass/Alfalfa	**12.8**	9.75ab	31.5ab	32206	**24.0**
LSD (*p*=0.10)‡	NS§	4.96	39.4	NS	NS
Trial mean	11.2	9.05	37.8	32323	23.4

†Within a column, treatments marked with the same letter were statistically similar (p=0.10). Top performers are in **bold.**
‡LSD –Least significant difference at p=0.10.
§NS- No significant difference at p=0.10.

DISCUSSION

In both the replicated and on-farm trials, the 60-inch rows did allow for better establishment and in-season growth of the interseeded forages with little to no reduction on corn silage yields. The replicated trial saw a 4 ton ac^{-1} difference between the 30-inch and 60-inch treatments, which was a smaller difference than has been observed in most years of this these trials (Figure 2). Maintaining adequate populations to allow for maximal light infiltration, while producing practical yields, can be a challenge. More research still needs to be done on selecting hybrids that will perform well at high seeding rates. Flex ear hybrids have the potential to make up for lower populations and still produce adequate yields by increasing ear size when planted at those low seeding rates. Nonetheless, the majority of corn silage yield comes from the stover and fewer plants per acre, or smaller plants, will likely result in less overall biomass. Attention must be paid during planting to ensure populations are maintained if row spacing is increased. The forage species selected are commonly grown in Vermont and therefore, present opportunities for adoption. While little biomass was observed by the time of corn harvest, these perennial crops continue to grow post-harvest and the following spring and have been shown to establish satisfactorily in wider row spacings, as demonstrated in Images 1-4. However, as with any interseeding, conditions at the time of seeding and through the season significantly impact interseeding success. With variable results, additional research is needed before this practice is widely adopted.

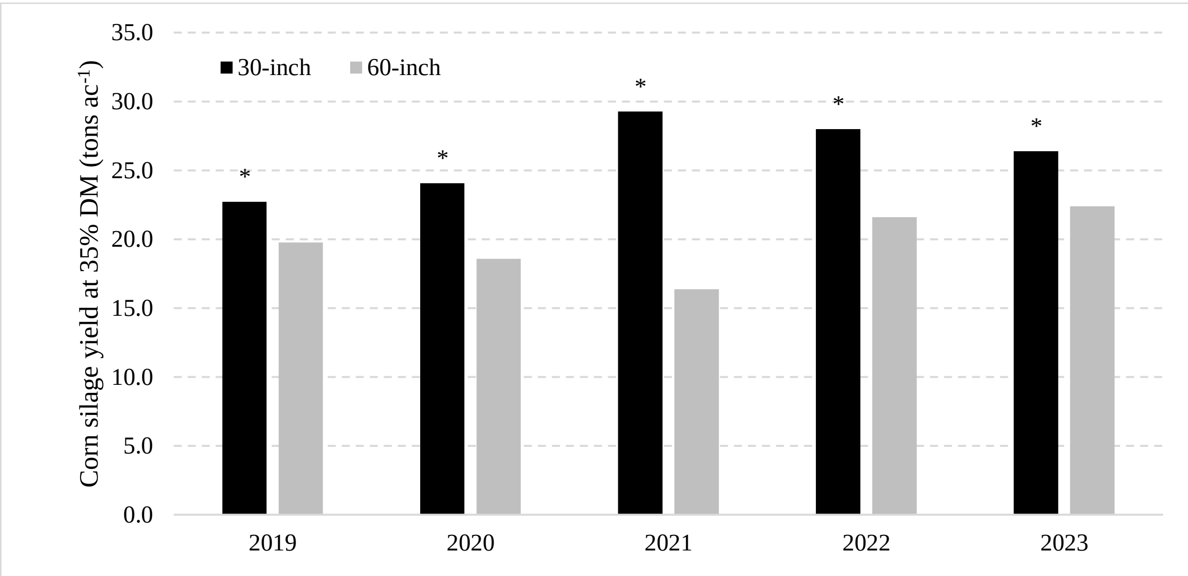

Figure 2. Corn silage yield in 30" and 60" rows by year, Alburgh, VT, 2019-2023. An asterisk (*) indicates a statistically significant (p=0.10) difference between treatments for that year.

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