NW CROPS & SOILS PROGRAM

2012 Cover Crop Termination & Reduced Tillage Study

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2012 COVER CROP TERMINATION AND REDUCED TILLAGE STUDY

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When a crop such as corn silage is harvested in the fall, the entire plant is removed leaving the soil exposed through the winter. These exposed soils are more prone to run-off and erosion of sediment and nutrients into surface waters. As a means to alleviate these issues, many farmers have started to plant cover crops following harvest. Growing a cover crop can have many positive benefits to the soil and the surrounding environment. Cover crops produce aboveground biomass that can absorb the impact of rain drops and slow the flow of water from melting snow. The root system also aggregates soil particles to create a porous network that allows for improved water drainage. Cover crops can also scavenge excess soil nitrogen, keeping the nitrogen from potentially being lost through leaching, and can also reduce weed pressure in the spring. Many farmers have asked what is the best strategy to terminate cover crops in order to reap the benefits from this practice? Cover crop management can also be paired with reduced tillage practices to further reduce potential erosion. Reduced tillage practices such as no-till, zone-till, and strip tillage cause minimal disturbance to the soil. No-till planting means that the planter seeds directly into untilled soil. No-till planters are equipped with coulters that cut into the soil, creating a slit into which a seed is dropped. Heavy press wheels are then used to close the slit and assure good seed to soil contact. Zone tillage is characterized by a very small 'zone' of tillage (5-6") around the area of seed placement. Zone-till implements are often attached to the front of a corn planter. Strip tillage is another type of reduced tillage that creates an 8-10 inch "strip" of tilled soil around the area of seed placement. These areas of tillage can enable the soil nearest the seed to warm and dry faster than no-tillage systems. It has been suggested that zone and strip tillage may be more advantageous for heavier soil types. Over time minimizing tillage can lead to improvements in soil drainage, nutrient cycling, and crop yields.

Figure 1. Roller crimper.

In 2012, the University of Vermont Extension conducted the fourth year of an experiment to evaluate the impact of cover crop termination and reduced tillage strategies on soil health, soil nitrogen dynamics, and corn silage yield and quality. The goal is to document the positive and negative aspects of each strategy so farmers can decide the best way to terminate covercrops and implement reduced tillage on their farm.

Figure 2. Rye cover crop that has been rolled and crimped.

MATERIALS AND METHODS

The trial was conducted on a silt loam soil at Borderview Research Farm in Alburgh, VT (Table 1). The trial site had been in continuous row crop production under conventional management before implementation of this trial in 2008. On 11-Oct 2011, a winter rye cover crop was seeded at a rate of 100 lbs. acre^{-1}. Plots without cover crops served as a control. All plots were aerated with an AerWay® on 11-Oct 2011, and fertilized with 5700 gallons acre^{-1} of liquid dairy manure on 16-Nov 2011. The experimental design for this study was a randomized strip split block design with four replications. The plot size was 10 ft. x 40 ft. Main plots were cover crop termination method including the following treatments: 1) herbicide burn-down, 2) moldboard plow, 3) roll and crimp, and 4) a control with no cover crop. The split plots were reduced tillage strategies including no-till, zone-till, and strip tillage.

Rolling and crimping is a technique that terminates a cover crop and provides weed-suppressing mulch for the following crop. In order to properly utilize this technique, the cover crop must be flowering before it is terminated. Once the winter rye is in the flowering stage, the cover crop is rolled and the machine crimps the stems, killing the plant (Figures1 and 2). The rolled cover crop acts as a mulch mat, suppressing weeds. The subsequent crop is then planted into the mat using a no-till, zone-till, or strip-till technique. This system has many advantages as it reduces costs associated with both weed control and tillage. However, this practice has not been evaluated in corn silage systems in New England.

Table 1. Cover crop termination and reduced tillage trial information.

Soil type	rocky, silt loam
Previous crop	silage corn, rye cover crop
Cover crop planting date	11-Oct 2011
Cover crop seeding rate	100 lbs. acre^{-1}
Fall fertilizer	5700 gallons dairy manure 16-Nov 2011
Corn planting date	10-Jun 2012
Corn row width	30 inches
Corn seeding rate	36,000 seeds acre^{-1}
Corn harvest date	8-Oct 2012

On 14-May 2012, the soil was sampled to determine soil quality of cover cropped vs. control plots. Soil quality was determined by the Cornell Soil Health Lab in Geneva, NY. Soil quality is monitored to determine if multiple seasons of cover cropping improve soil health. Prior to cover crop termination, a 1 m^2 sample of cover crop was taken on 10-May to determine crop biomass and nitrogen content. Soil nitrate-N was measured weekly from the middle of May until the beginning of July. Samples were analyzed for nitrate-N by the UVM Agricultural and Environmental Testing Laboratory in Burlington, VT. Soil nitrate-N sampling was used to monitor decomposition of the cover crop residue and subsequent nitrogen release. Monitoring soil nitrate-N was terminated once the corn reached V6 growth stage, which is the time of nitrogen top-dress. On 16-May the cover crop in the mold-board plow treatment (Tillage) was plowed in. The herbicide treatment had an application of Cinch ATZ (s-metolachlor and atrazine) applied at a rate of 3 pints acre^{-1} on 3-Jun. The rolling and crimping termination strategy was performed on 10-Jun. Control plots with no cover crop were prepared for planting with conventional tillage methods.

Corn was planted on 10-Jun (var. Mycogen 2T108) at a rate of 36,000 seeds acre^{-1}. The no-till treatment was planted with a John Deere 1750 4-row planter, the zone-till treatment was planted with a White 6100 zone-till planter, and the strip-till treatment was strip tilled with a Blujet Coulter Pro (Figure 3) and planted with the no-till planter. Starter fertilizer was applied at a rate of 200 lbs of 10-20-20 to the acre in the no-till and strip-till treatments. The zone-till treatment had 5 gallons acre^{-1} of 9-18-9 applied as starter fertilizer. The strip-till treatment had an additional 15 gallons acre^{-1} 10-34-0 and 10 gallons acre^{-1} 32-0-0 UAN pre-plant fertilizer injected when the plots were strip tilled.

Figure 3. Blujet Coulter Pro used for strip-tillage.

On 16-Jul, the corn plots were side-dressed with urea-nitrogen (46-0-0). Fertilizer rates were determined with soil pre side-dress nitrate-N tests (PSNTs) taken just prior to the time of top-dress. Top-dress amounts varied by termination treatment, and are listed in Table 2. On 8-Oct corn silage was harvested with a John Deere 2 row chopper, and the forage wagon was weighed with platform scales. A subsample was collected and sent to Cumberland Valley Analytical Services, Inc. in Hagerstown, MD for quality analysis.

Table 2. Cover crop termination date and side-dress fertilizer rates.

Plot details	Roll crimp	Herbicide	Tillage	Control
Termination date	10-Jun	3-Jun	16-May	16-May (plow only)
Sidedress fertilizer rate* (lbs N acre^{-1})	55	80	73	75

*Corn was side-dressed on 16-Jul 2012.

Silage quality was analyzed using wet chemistry techniques at the Cumberland Valley Forage Laboratory. Plot samples were analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), starch, and various other nutrients. Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the CP content of forages. The CP content of forages is determined by measuring total N and multiplying by 6.25. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of plants 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 (NDF). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. Recently, forage testing laboratories have begun to evaluate forages for NDF digestibility. Evaluation of forages and other feedstuffs for NDF digestibility is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDF digestibility (dNDF). Forages with increased NDF digestibility will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20–80%. Total digestible nutrients (TDN) are calculated variables from the measured forage analysis.

Net energy of lactation (NEL) is calculated based on concentrations of NDF and ADF. NEL can be used as a tool to determine the quality of a ration, but should not be considered the sole indicator of the quality of a feed, as NEL is affected by the quantity of a cow's dry matter intake, the speed at which her ration is consumed, the contents of the ration, feeding practices, the level of her production, and many other factors. Most labs calculate NEL at an intake of three times maintenance. Starch can also have an effect on NEL, where the greater the starch content, the higher the NEL (measured in Mcal per pound of silage), up to a certain point. High grain corn silage can have average starch values exceeding 40%, although levels greater than 30% are not considered to affect energy content, and might in fact have a negative impact on digestion. Starch levels vary from field to field, depending on growing conditions and variety.

The silage performance indices of milk per acre and milk per ton were calculated using a model derived from the spreadsheet entitled, "MILK2007" developed by researchers at the University of Wisconsin. Milk per ton measures the pounds of milk that could be produced from a ton of silage. This value is generated by approximating a balanced ration from corn silage that meets animal energy, protein, and fiber needs. The value is based on a standard cow weight and level of milk production. Milk per acre is calculated by multiplying milk per ton by silage dry matter yield. Therefore, milk per ton is an overall indicator of forage quality and milk per acre an indicator of forage yield and quality. Milk per ton and milk per acre calculations provide relative rankings of forage samples, but should not be considered as predictive of actual milk responses in specific situations for the following reasons: 1) Equations and calculations are simplified to reduce inputs for ease of use; 2) Farm to farm differences exists; and 3) Genetic, dietary, and environmental differences affecting feed utilization are not considered.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties 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 (LSD) at the 10% level of probability are shown. Where the difference between two varieties within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Varieties that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In the example below, A is significantly different from C but not from B. The difference between A and B is equal to 1.5 which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0 which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

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

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at the trial location are presented in Table 3. The 2012 season was warmer and drier than normal. In Alburgh, June, July, and August precipitation was 1.9 inches below normal, while the monthly average temperatures were above average by several degrees for the entire 2011-2012 growing season. The total accumulated Growing Degree Days (GDD) for corn growth based on a 50°-86°F temperature scale was 2,717 days, 354 GDD above the 30-year average.

Table 3. 2011-2012 monthly temperature, precipitation, and accumulated GDDs, Alburgh, VT.

Alburgh, VT	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug	Sept	Oct.
Average temp. (°F)	50.1	43.4	29.5	22.2	26.0	39.7	44.9	60.5	67.0	71.4	71.1	60.8	52.4
Departure from normal	1.90	5.20	3.60	3.40	4.50	8.60	0.10	4.10	1.20	0.80	2.30	0.20	4.20
Precipitation (inches)*	3.5	1.4	2.2	1.5	0.7	1.5	2.6	3.9	3.2	3.8	2.9	5.4	4.1
Departure from normal	-0.1	-1.7	-0.1	-0.6	-1.1	-0.8	-0.2	0.5	-0.5	-0.4	-1.0	1.7	0.5
GDDs (base 50°F)	141	51	1	0	0	84	80	370	504	657	650	364	172
Departure from normal	29	51	1	0	0	84	8	102	30	17	69	46	60

Based on data from Davis Instruments Vantage pro2 with Weatherlink data logger. Historical averages for 30 years of NOAA data (1981-2010).
*Precipitation data from June-September 2012 is based on Northeast Regional Climate Center data from an observation station in Burlington, VT.

Cover crop biomass was measured just prior to termination of the 'Tillage' treatment. The cover crop, terminated in early May, was still in the vegetative stage and produced just under one ton of dry matter per acre (Table 4). The plant biomass contained about 2.45% nitrogen, which could potentially translate into 40 lbs. of nitrogen credit acre^{-1}. In order for this nitrogen to be released from the plant biomass, soil microorganisms must break down the residue into plant available forms of nitrogen. The cover crop rolled and crimped on 10-Jun would have a higher dry matter yield, however, at this mature stage, the nitrogen content of the rye would be about half what is reported below (data not shown). Winter rye must be in the flowering stage before it can be successfully rolled and crimped. If terminated prior to this stage, the cover crop can grow back and compete with the following crop.

Table 4. Cover crop biomass and nitrogen content.

Cover crop	Date of measurement	Height	Dry matter	Nitrogen	
		cm	lb ac^{-1}	%	lb ac^{-1}
Rye (*Secale cereal* L.)	10-May 2012	52.9	1694	2.45	41.1

Soil quality was measured on cover cropped and control plots. Other reports have shown cover crops improve the condition of the soil. In this trial, there was no statistically significant difference in soil quality; however the cover cropped treatments did have higher aggregate stability and water holding capacity (Table 5). Aggregate stability is a measure of the extent to which soil aggregates resist falling apart when wetted and hit by rain-drops. Available water capacity reflects the quantity of water that a disturbed sample of soil can store for plant use.

Table 5. Soil health characteristics after three years of implementing various cover crop termination techniques.

Termination method	Aggregate stability %	Water capacity m/m	Surface hardness psi	Subsurface hardness psi	Organic matter %	Active carbon ppm	Potentially mineralizable N µgN/gdwsoil/week
Roll Crimp	46.7	0.170	236	358	4.29	527	14.6
Herbicide	45.7	0.167	201	407	4.29	519	11.1
Tillage	39.0	0.177	221	410	4.12	530	9.8
Control	39.6	0.165	219	410	4.35	563	11.8
Trial mean	42.8	0.170	219	396	4.26	535	11.8
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS

NS – Treatments were not significantly different from each other.

Soil nitrate-N was monitored from the middle of May until the beginning of July. Corn is usually top-dressed with supplemental nitrogen just prior to the period of most rapid N uptake. A pre side-dress nitrate tests (PSNT) was used to determine the available nitrogen in the soil just prior to the V6 stage, or the period of most rapid N uptake. The last soil nitrate-N samples—taken on 6-Jul—were used to determine top-dress rates. We would expect nitrogen tied up in cover crop biomass to be broken down and released in the soil and become available for the corn crop. Soil nitrate levels throughout the growing season are presented in Table 6 and Figure 4.

Table 6. Impact of cover crop termination method on soil nitrate-N levels.

Termination	Soil nitrate-Nitrogen							
	14-May	25-May	31-May	6-Jun	15-Jun	22-Jun	29-Jun	6-Jul
	ppm							
Roll crimp	2.5	9.2	2.9	2.0	5.2	17.0	5.0	18.5
Herbicide	3.6	7.0	8.8*	6.1	10.8	12.3	8.2	12.8
Tillage	2.5	8.8	7.8*	7.5	14.8*	15.0	12.0*	14.9
Control	3.6	9.4	**9.4***	**11.6**	**16.7**	12.8	**13.2***	15.6
Trial mean	3.0	8.6	7.2	6.8	11.9	14.3	9.6	15.4
LSD (0.10)	NS	NS	3.7	2.5	3.4	NS	2.2	NS

NS – Treatments are not significantly different from each other.
* Treatments indicated with an asterisk are statistically similar to the top performer in the column (in bold).

On four of the eight sampling dates (31-May, 6-Jun, 15-Jun, and 29-Jun) the control treatment of no cover crop had the highest soil levels of nitrate-N (Table 6). On three of those dates, the tilled in cover crop was statistically similar to the top performer. In general the roll and crimp treatment led to lower soil nitrate values. The roll and crimp treatment is a high carbon plant material. When soil microbes try to break down this organic matter, they require additional nitrogen to process the high carbon food source. Hence, soil-nitrate that should be available to the crop is scavenged by the microbes to break down the cover crop. Eventually once the cover crop is decomposed, the nitrogen should be recycled into the soil. Unfortunately, this is not occuring during maximum crop need and leads to nitrogen deficient corn.

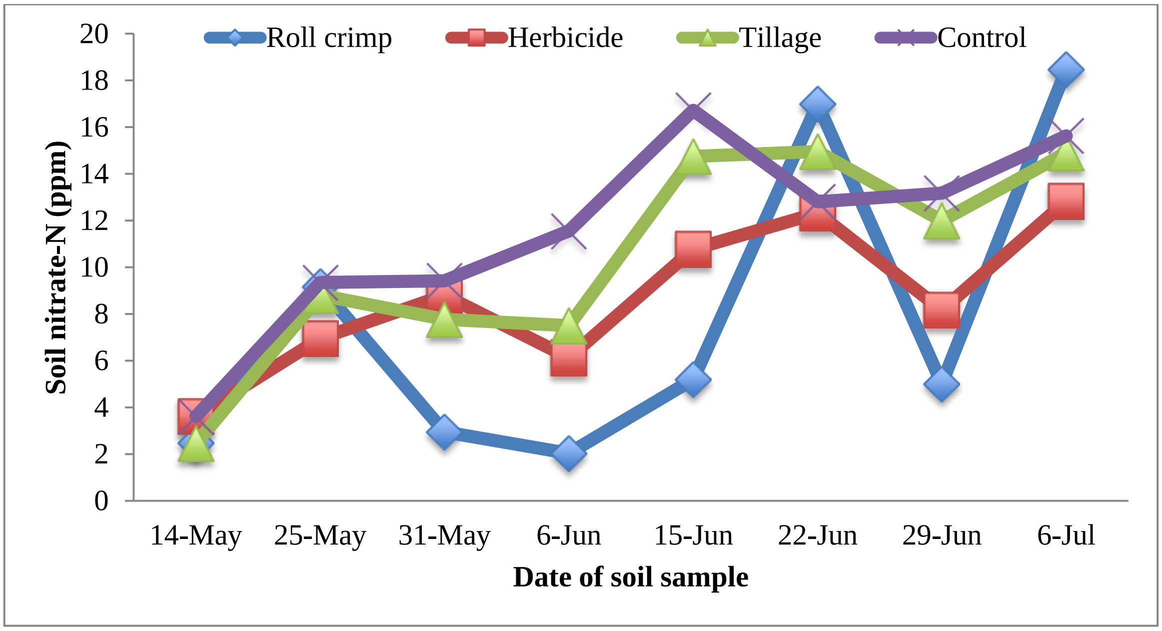

Figure 4. The impact of cover crop termination strategies on soil nitrate-N.

Corn silage yields were highest in plow-down cover crop treatment and in the control with no cover crop (Table 7). These treatments yielded significantly greater than the roll crimp and herbicide terminated cover crop treatments. The average yield in the plow down cover crop plots was 20.2 tons corn silage acre^{-1}. All of the treatments had significantly higher plant populations than the roller crimper treatment. There may be issues with the planters getting through the rolled mat of rye or the corn may have not germinated well under the cover crop. In general, there were not many differences in forage quality based on the cover crop termination method. One exception is digestible NDF. The roller crimped and herbicide terminated cover crop treatments produced corn silage with higher digestible NDF than the control and tillage treatments (Figure 5).

Table 7. The effect of cover crop termination method on corn silage yield and quality.

Termination	Yield at 35% DM	Population	Forage Quality							Milk per Ton	Milk per Acre
			CP	ADF	NDF	dNDF	Starch	TDN	NEL		
	tons ac^{-1}	plants ac^{-1}	%	%	%	%	%	%	Mcal/lb.	lbs.	lbs.
Herbicide	17.6	24532*	8.7	24.3	42.5	54.5*	33.7	71.8	0.749	2799	17131
Roll crimp	11.9	18923	8.7	24.0	41.9	**55.4***	34.1	72.2	0.754	2851	11850
Tillage	**20.2***	**25207***	8.5	25.3	43.3	52.8	32.6	71.3	0.744	2759	**19487***
Control	19.8*	24338*	8.7	24.8	42.5	53.1	33.2	71.6	0.748	2792	19327*
Trial Mean	17.4	23250	8.6	24.6	42.6	53.9	33.4	71.7	0.749	2800	16949
LSD (0.10)	2.00	1949	NS	NS	NS	1.24	NS	NS	NS	NS	1948

NS – Treatments are not significantly different from each other.
* Treatments indicated with an asterisk are statistically similar to the top performer in the column (in bold).

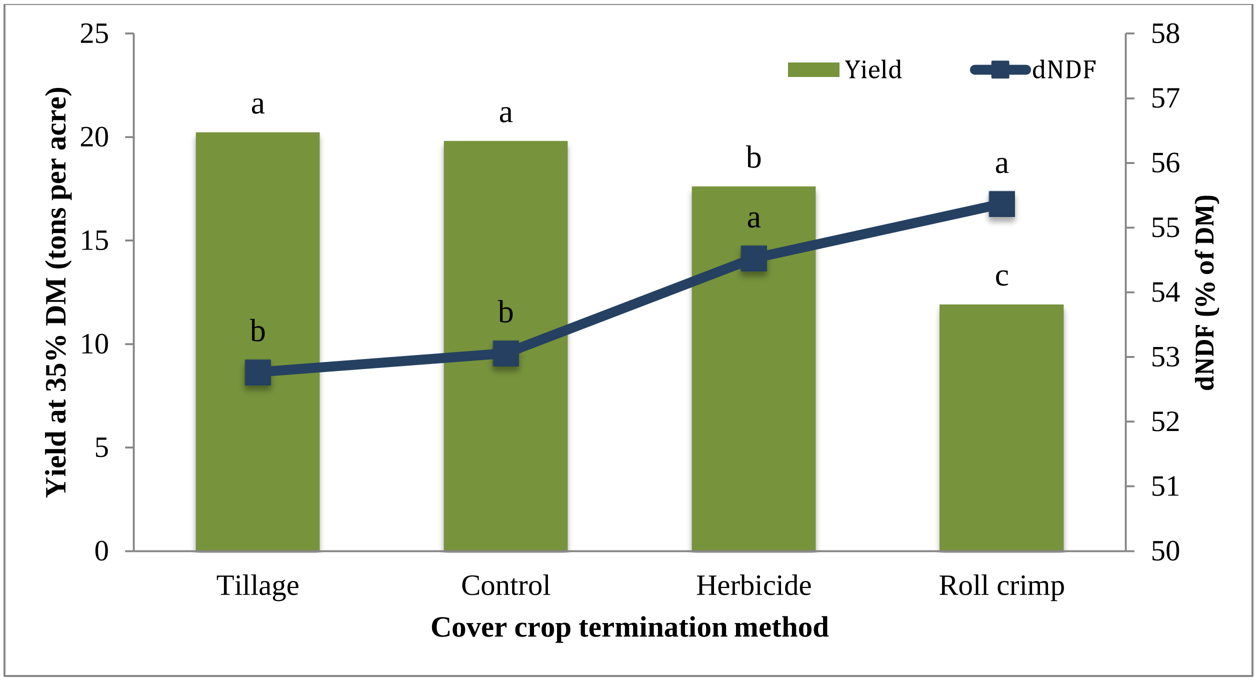

Figure 5. Corn silage yield at 35% dry matter and digestible NDF (dNDF) by termination method.

Table 8. Corn silage yield and quality across tillage types.

Tillage	Yield at 35% DM	Population	Forage Quality							Milk per Ton	Milk per Acre
			CP	ADF	NDF	dNDF	Starch	TDN	NEL		
	tons ac^{-1}	plants ac^{-1}	%	%	%	%	%	%	Mcal/lb.	lbs.	lbs.
No-till	16.9	21178	8.9*	24.5	42.4	54.4	32.8	71.8	0.748	2835	16736*
Strip-till	16.3	18890	**8.9***	24.4	42.2	53.6	33.4	71.7	0.749	2808	15956
Zone-till	**18.9**	**29682**	8.2	24.9	43.0	53.8	34.0	71.7	0.749	2759	**18154***
Trial Mean	17.4	23250	8.6	24.6	42.6	53.9	33.4	71.7	0.749	2800	16949
LSD (0.10)	1.73	1688	0.54	NS	NS	NS	NS	NS	NS	NS	1687

NS – Treatments are not significantly different from each other.
* Treatments indicated with an asterisk are statistically similar to the top performer in the column (in bold).

Zone-till planted corn yielded significantly more than the strip-till or no-till treatments (Table 8). The plant populations for zone-till corn were also significantly greater than the other two planting methods. Planting issues with the no-till planter may have resulted in these low yields. The lower yielding treatments—no-till and strip-till—also had significantly higher crude protein levels. Besides protein levels, there was very little difference in corn quality between the treatments.

ACKNOWLEDGEMENTS

UVM Extension would like to thank Borderview Research Farm for their help implementing the trial. This trial was supported by funding through USDA Northeast SARE and NOAA SEAGRANT program. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

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