2012 Minimum Tillage Corn Trial

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Minimum tillage practices have tremendous potential to reduce expenses and potential negative environmental effects caused by cropping operations. Conventional tillage practices require heavy machinery to plow and groom the soil surface in preparation for the planter. The immediate advantage of reduced tillage is less fuel expense, equipment, time, and labor required. It's also clear that intensive tillage increases nutrient and soil losses to our surface waterways. By turning the soil and burying surface residue, more soil particles are likely to detach from the soil surface and run off from agricultural fields. Reducing the amount and intensity of tillage can help build soil structure and reduce soil erosion.

Figure 1. Strip tillage.

Many growers are interested in a variety of minimum till strategies including 'no-till,' 'strip-till,' and 'zone-till.' No-till implements do not till the soil, but rather use metal coulters to cut the soil and plant seed into the seed bed created by the coulters (disk openers). An attachment on the back of the planter closes the seed bed and maximizes seed to soil contact to facilitate germination. This can be done in a variety of ways. Some systems use a heavy press wheel, while others use spiked wheels or even rubber wheels to perform this critical action. Strip tillage cultivates an 8-10" strip of soil along either side of the planted row (Figure 1). Strip tillage allows the soil in close proximity to the seed to dry out and warm up faster than it would without tillage. Zone tillage works a much smaller area than strip tillage, only tilling 5-6" of the soil directly adjacent to the seed (Figure 2). Zone-till implements can be attached to the front of a corn planter. Over time, it has been found that reduced tillage systems can improve nutrient cycling, soil drainage, and even crop yields.

Figure 2. Zone tillage.

In 2012, the University of Vermont Extension's Northwest Crops and Soils Program conducted a corn trial at Borderview Research Farm in Alburgh, VT. The objective was to evaluate the impact of no-till, zone-till, and strip-till on corn silage yield and quality.

MATERIALS AND METHODS

In 2012, a study evaluating three reduced tillage methods was conducted at Borderview Research Farm in Alburgh, VT (Table 1). The soil was a rocky Benson silt loam. The experimental design was a randomized complete block with four replicates. The plot length was 45'. Treatments were no-till, zone-till, and strip-till. All plots were planted to the variety Mycogen TMF2T108(82-RM) at a seeding rate of 36,000 seeds per acre. The zone-till plots were planted on 8-Jun and the strip-till and no-till plots were planted on 10-Jun. No-till plots were planted with a John Deere 1750 corn planter; zone-till plots were planted with a White 6100 zone-till planter; and strip-till plots were prepared with a Blu-Jet Coulter Pro and planted with a John Deere 1750 corn planter. No-till and strip-till plots had four 30” rows and were 12’ wide. Zone-till plots had six 30” rows and were 15’ wide. A 10-20-20 starter fertilizer was applied at 200 lbs per acre to the strip-till and no-till plots. A liquid 9-18-9 starter fertilizer was applied at 5 gallons to the acre in the zone-till plots. Additionally, the strip till plots had 15 gallons per acre of 10-34-0 and 25 gallons per acre 32-0-0 UAN banded in at a depth of 8 inches when the strips were created. A pre-plant glyphosate herbicide, Roundup®, was applied at a rate of 2 quarts per acre to all plots.

Table 1. Agronomic information for the 2012 Minimum Tillage Corn Trial at Borderview Research Farm.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Winter rye
Corn Variety	Mycogen TMF2T108 (82-RM)
Plot size	12’ x 45’ (no-till and strip-till); 15’ x 45’ (zone-till)
Replicates	4
Seeding rate	36,000 seeds ac^{-1}
Row width	30”
Planting date	8-Jun zone-till 10-Jun strip-till and no-till
Starter fertilizer	200 lbs. ac^{-1} 10-20-20 (no-till and strip-till), 5 gal ac^{-1} of 9-18-9 (zone-till)
Pre-plant fertilizer	15 gal ac^{-1} 10-34-0, 25 gal ac^{-1} 32-0-0 UAN (strip-till)
Pre-plant herbicide	RoundUp®, 2 qts. ac^{-1}
Additional fertilizer	80 lbs. available N ac^{-1} of Urea (46-0-0), 12-Jul (zone-till and no-till) 50 lbs. available N ac^{-1} of Urea (46-0-0), 12-Jul (strip-till)
Harvest date	9-Oct

Urea (46-0-0) was applied as a sidedress at a rate of 80 lbs available N per acre for the zone-till and no-till plots and at a rate of 50 lbs available N per acre on the strip-till plots on 12-Jul, according to pre-sidedress nitrate test results. Populations were again counted immediately before harvesting the corn plots on 9-Oct. A John Deere two-row chopper was used to harvest corn, and whole-plant silage was collected in a forage wagon and weights calculated from wagon mounted scales. A subsample of chopped silage was taken to determine moisture and quality of the forage.

Silage quality was analyzed using wet chemistry at Cumberland Valley Analytical Services in Hagerstown, MD. Plot samples were analyzed for crude protein (CP), starch, acid detergent fiber (ADF), neutral detergent fiber (NDF), and digestible neutral detergent fiber (dNDF). 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 the amount of nitrogen 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. In recent years, the need to determine rates of digestion in the rumen of the cow has led to the development of dNDF. This in vitro digestibility calculation is very important when looking at how fast feed is being digested and passed through the cow's rumen. Higher rates of digestion lead to higher dry matter intakes and higher milk production levels. Similar types of feeds can have varying dNDF values based on growing conditions and a variety of other factors. In this research, the dNDF calculations are based on 30 hour in vitro testing.

Net energy for lactation (NE_L) is calculated based on concentrations of NDF and ADF. NE_L 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 NE_L 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 NE_L at an intake of three times maintenance. Starch can also have an effect on NE_L, where the greater the starch content, the higher the NE_L (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.

Non-fiber carbohydrate (NFC) and nonstructural carbohydrate (NSC) are also totaled and reported. NFC is comprised of starch, simple sugars, and soluble fiber, and is digested more quickly and efficiently than fiber. NFC provides energy for rumen microbes, once it is fermented by volatile fatty acids. NFC and NSC are sometimes referred to almost interchangeably, but pectin levels are included in NFC and omitted from NSC. In addition, NFC is calculated by difference [100 – (% NDF + % crude protein + % fat + % ash)], whereas NSC is determined through enzymatic methods. NSC should be in the 30-40% range, on a dry matter basis. NFC is generally between 35-40% in a high milk production ration, though levels as high as 42% are acceptable, due to the variability of particle size, frequency of feeding, dry matter intake, and other factors.

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 NE_L calculation and can be used to make generalizations about data, but other considerations should be analyzed when including milk per ton or milk per acre in the decision making process.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and hybrids were treated as fixed. Hybrid mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

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 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 the example below, 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.

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

RESULTS

The 2012 growing season was warmer and dryer than the long term averages in this part of Vermont (Table 2). In May, the soil warmed up quickly with above average temperatures and near normal precipitation amounts. The month of June was 1.20 degrees Fahrenheit warmer and 0.5” dryer than 30 year averages. Most of the precipitation fell early in the month and towards the end of June and for the months of July and August the test plots lacked sufficient moisture. July had 0.4” less precipitation than the 30-year average. The month of August was 1” below normal precipitation levels and 2.3 degrees warmer than normal. In summary, during the months of critical plant growth from June through August an extra 116 growing degree days were accumulated and the crops were deficient 1.9” of precipitation based on long term averages.

Table 2. Data from a weather station in close proximity to Alburgh, VT (South Hero, VT).

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	60.5	67.0	71.4	71.1	60.8	52.4
Departure from normal	4.10	1.20	0.80	2.30	0.20	4.20
Precipitation (inches)*	3.9	3.2	3.8	2.9	5.4	4.1
Departure from normal	0.5	-0.5	-0.4	-1.0	1.7	0.5
Growing Degree Days (base 50°F)	370	504	657	650	364	172
Departure from normal	102	30	17	69	46	60

Average temperature for August-October is taken from Burlington, VT.
* Precipitation records for June and July are taken from Burlington, VT.

Analysis of the yield data indicates there were significant differences between minimum tillage methods when looking at population, dry matter, and yields (Table 3). The no-till plots had statistically significant lower harvest populations than the zone-till plots. The no-till plots also did not dry down as well or yield as high as the strip-till and zone-till treatments. Interestingly, the strip-till plots outperformed (18 tons) the zone-till plots (16.5 tons) even though the final plant populations were lower.

Table 3. Impact of minimum tillage on corn silage population and yield, 2012.

Tillage method	Harvest population	DM	Yield at 35% DM
	plants ac^{-1}	%	tons
No-till	19347	39.7	12.7
Strip-till	21388*	45.3*	**18.0***
Zone-till	**25052***	**48.9***	16.5*
LSD (0.10)	5284	**5.9**	2.7
Trial mean	21929	44.6	15.7

Treatments indicated in bold had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.

Standard components of corn silage quality were not affected by minimum tillage method in this trial (Table 4). There was no significant difference in CP, ADF, NDF, dNDF, starch, TDN, NE_L, NFC, NSC, or Milk ton^{-1}. Milk per acre analysis resulted in significantly different results based on minimum tillage method in this year's trial. The strip-till (17786 lbs.) and zone-till (17709 lbs.) treatments were higher in milk per acre than the no-till (13064 lbs.) treatment. Trial averages for the components analyzed were comparable to corn grown using conventional tillage practices.

Table 4. Impact of minimum tillage on corn silage quality, 2012.

Tillage method	Forage quality characteristics									Milk	
	CP	ADF	NDF	dNDF	Starch	TDN	NE_L	NFC	NSC	ton^{-1}	ac^{-1}
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM	Mcal lb^{-1}	% of DM	% of DM	lbs	lbs
No-till	**9.6**	23.9	41.9	57.1	33.1	72.3	0.76	44.0	33.9	2922	13064
Strip-till	9.4	24.7	43.4	54.6	31.9	71.6	0.75	42.6	32.7	2826	**17786***
Zone-till	9.0	**21.4**	**37.0**	**58.0**	**38.4**	**74.6**	**0.78**	**49.1**	**39.0**	**3056**	17709*
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3595
Trial mean	9.3	23.3	40.8	56.5	34.5	72.8	0.76	45.2	35.2	2935	16187

Treatments indicated in bold had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.
NS – No significant difference was observed between treatments.

DISCUSSION

It is important to note that the results of this trial represent only one year of data and only in one location. Based on the analysis of the data, some conclusions can be made about the research trial this year. Harvest population was low (21,929 plants per acre) compared to the initial seeding rate (36,000 plants per acre). One would expect to see some reduction (10%-15%) in germination rate versus the initial planting rate but a 40% reduction is excessive. This may be attributed to soil conditions at the time of planting or shortly after planting resulting in poor germination rates. Reduced tillage fields have been noted to be colder and wetter as compared to conventional tillage. These environmental variables could cause reduced populations. Decreased populations could also be a result of mechanical issues with the planters, particularly the planter used for the no-till and strip-till treatments. The average yield was 15.7 tons per acre, which is low compared to yields of similar relative maturity corn planted by means of conventional tillage. However, the strip-till treatment averaged 18 ton of corn silage per acre, and for a 82 RM day corn this is similar to what one would expect from conventional tillage practices. Increased yields in the strip-till plot may be a result of the extra fertilizer applied pre-plant. Also, of the different tillage systems evaluated in this trial, the strip-till system makes the best seedbed to place the corn seed into which may have helped the corn plants to get a more vigorous start. The dry matter rates on the harvested corn varied between tillage methods as well. The analysis of the data indicates that the zone-till plots had the lowest moisture content and the no-till plots had the highest moisture content. The data seems to indicate that the no-till corn plots were probably not as physiologically mature as the strip-till and the zone-till corn plots due to the differences in planting methods and fertilization. The no-till corn probably germinated later and with less uniformity than the other two tillage methods. This conclusion is based on the lower population rates observed in the no-till treatments and low yields recorded. This could result in higher moisture levels in the plant at harvest.

Minimum tillage did not significantly impact corn silage quality indicating that strip-till, zone-till, and no-till have comparable effects on quality. The only significant difference observed was in milk per acre. The corn silage harvested in this trial was similar in quality to corn planted conventionally. This was the second year of reduced tillage practices in this research plot and yields overall were improved compared to 2011 results. Additional years of reduced tillage trials in this trial area will help determine if and how long a field must be in minimum tillage to overcome yield drags associated with soil condition.

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