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2014 MINIMUM TILLAGE CORN TRIAL
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Minimum tillage practices have significant potential to reduce expenses and the potential negative environmental effects caused by intensive tillage operations. Conventional tillage practices require heavy machinery to work and groom the soil surface in preparation for the planter. The immediate advantage of reduced tillage for the farm operator is less fuel expense, equipment, time, and labor required. It's also clear that intensive tillage potentially 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 increase the potential for 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 tillage strategies including 'strip-till,' 'no-till,' and 'vertical-till.' Strip tillage cultivates a 4-6" strip of soil along both sides 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. It also deeply tills the soil (8-10 inches) where the crop is planted. No-till (Figure 2) implements do not till the soil, but rather use metal coulters to cut the soil and plant seed into the slot created by the coulters (disk openers). An attachment on the back of the planter closes the slot 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. The type of wheel selected will depend on soil types and conditions so may vary from farm to farm. Vertical tillage (Figure 3) is a tillage system, which lightly tills the top 2-3 inches of the soil, preparing a smooth seedbed without introducing tillage pans into the soil profile. Vertical tillage equipment is developed to run shallow and fast over the field sizing and anchoring residue while preparing a uniform seedbed for planting. Over time, it has been found that reduced tillage systems can



Figure 2. No-Till Corn Planting.



Figure 3. Vertical tillage.

improve soil health, nutrient cycling, soil drainage, and crop yields. In 2014, 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, vertical-till, and strip-till on corn silage yield and quality.

MATERIALS AND METHODS

In 2014, 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. Treatments were no-till, vertical-till, and strip-till. Just prior to planting, vertical-till plots were prepared with a 2623VT John Deere tool, and the strip-till plots were prepared with a Blu-Jet Coulter Pro. Plot size was 10' x 40' for the no-till and vertical-till plots and 15' x 40' foot for the strip-till plots. All plots were planted to the variety Pioneer P9188 AMX (91RM) at a seeding rate of 34,000 seeds per acre. The trial was planted on 21-May with a John Deere 1750 conservation corn planter. A 10-20-20 starter fertilizer was applied at 250 lbs per acre to the all plots. A post-plant herbicide, Lumax®, was applied at a rate of 3 quarts per acre to all plots. Additionally, .33 oz of Accent® was applied with the Lumax® on 5-Jun.

Table 1. Agronomic information for the 2014 Minimum Tillage Corn Trial at Borderview Research Farm.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
Corn Variety	Pioneer P9188 AMX (91RM)
Plot size	10' x 40' for No Till and Vertical Tillage Plots 15' x 40' for Strip Till Plots
Replicates	4
Seeding rate	34,000 seeds ac ⁻¹
Row width	30"
Planting date	21-May
Starter fertilizer	250 lbs ac ⁻¹ 10-20-20
Herbicide	3 quarts of Lumax® ac ⁻¹ , .33 oz Accent® ac ⁻¹ 5-Jun
Additional fertilizer	92 lbs available N ac ⁻¹ of Urea (46-0-0), 2-Jul
Harvest date	2-Oct

Urea (46-0-0) was applied as a sidedress at a rate of 92 lbs available N per acre on 2-Jul. Rates were based on pre-sidedress nitrate test results. 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 (NDFD). 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 NDFD. 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 NDFD values based on growing conditions and a variety of other factors. In this research, the NDFD 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 [$100 - (\% \text{ NDF} + \% \text{ crude protein} + \% \text{ fat} + \% \text{ ash})$], 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 to the right, 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 2014 growing season was characterized by a wet spring during the normal planting season and then a colder than normal July and August (Table 2). The area of this corn trial received 4.90” of rain during the month of May. The month of June was 1.1 degrees warmer than normal and received 2.40” of precipitation above the 30-year average. The wet soil conditions in May and June resulted in a spring planting season where finding ideal field conditions were difficult. July and August were a little wetter than the long range average and September was much dryer than average. Much of the area had a damaging frost on 12-Sep and this reduced the ability of the corn to finish maturing and to dry down adequately. During the months of critical plant growth from June through August, 31 less growing degree day units were accumulated and the crops had 3.47 additional inches of precipitation based on long term averages. The 2014 growing season faced some challenges but overall was considered by many to be a good corn season.

Table 2. Data from a weather station in close proximity to Alburgh, VT.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	57.4	66.9	69.7	67.6	60.6	55
Departure from normal	1.0	1.1	-0.9	-1.2	0.0	6.8
Precipitation (inches)	4.90	6.03	5.15	3.98	1.33	2.00
Departure from normal	1.45	2.40	1.00	0.07	-2.31	-1.60
Growing Degree Days (base 50°F)	238	501	613	550	339	69
Departure from normal	40	27	-27	-31	21	69

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

October data represents weather recorded through the last corn harvest, 14-Oct 2014.

Analysis of the data indicates that the different minimum tillage strategies had a significant impact on corn silage yield (Table 3). The highest yields were found on the vertical tillage plots (26.3 tons ac⁻¹) and those yields were not statistically different than the no-till plot harvest yields (24.8 tons ac⁻¹). The strip-till plots had significantly lower corn harvest yield values (14.3 tons ac⁻¹).

Table 3. Impact of minimum tillage on corn silage population and yield, 2014.

Tillage method	DM	Yield at 35% DM
	%	Tons
No-till	58.0	24.8*
Strip-till	50.4	14.3
Vertical-till	59.3	26.3*
LSD (0.10)	7.68	4.7
Trial mean	55.7	21.8

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 methods in this trial (Table 4). There was no significant difference in CP, ADF, NDF, NDFD, TDN, NE_L, NSC, or Milk ton⁻¹. Milk per acre was significantly higher for vertical and no till treatments. This measurement is calculated using yield, as well as quality data, which is why higher yielding plots also result in greater milk per acre. 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, 2014.

Tillage method	Forage quality characteristics							Milk	
	CP	ADF	NDF	NDFD	TDN	NE _L	NSC	ton ⁻¹	ac ⁻¹
	% of DM	% of DM	% of DM	% of NDF	% of DM	Mcal lb ⁻¹	% of DM	lbs	lbs
No-till	7.4	22.6	38.2	45.0	73.8	0.73	46.9	3501	30363*
Strip-till	7.9	23.0	39.2	45.2	73.6	0.73	44.7	3481	18246
Vertical-till	7.9	23.3	39.2	45.5	73.7	0.73	44.4	3493	32285*
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS	NS	6405
Trial mean	7.6	22.9	38.7	45.2	73.7	0.73	45.4	3494	27815

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 results of this year's trials. The average yield for the reduced tillage trial was 21.8 tons ac⁻¹, which is very good when compared to yields of similar relative maturity corn planted by means of conventional tillage. The average yield of this same variety in conventional tillage trials was 21.9 tons ac⁻¹. The no-till (24.8 ton ac⁻¹) and the vertical tillage (26.4 ton ac⁻¹) performed very well. This trial has been in reduced tillage for four years. It is likely

now that the soil has improved to a point where higher yields are supported. As we continue to evaluate better ways of implementing no-till practices, we expect the yields to continue to improve. The strip-till treatments produced significantly lower yields while maintaining similar forage quality characteristics. The benefits of strip-till cropping methods are sound and the low yields produced in this trial may be the result of a slightly more complicated task of planting corn correctly into the strips in a small field plot situation. For strip-till tillage methods to work best, GPS systems and precision agriculture planting techniques are generally implemented. It is of utmost importance that the seed be placed directly in the center of the strips when implementing this type of cropping system. If the seed misses the strip or is placed away from the center, significant yield losses may occur. The dry matter measurements between the three tillage practices evaluated did not vary significantly from each other. The crops grown from these different tillage methods matured and dried down similarly.

Minimum tillage methods did not significantly impact corn silage quality indicating that no-till, strip-till, and vertical tillage 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 and quantity to corn planted conventionally. This was the fourth year of reduced tillage practices in this research plot and yields overall were improved compared to 2012 and 2013 results. Overall, the yields from this year's trial were compatible to yields from conventional tillage practices.

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