NORTHWEST CROPS & SOILS PROGRAM

2016 Manure Incorporation and Reduced Tillage Corn Trial

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2016 MANURE INCORPORATION AND REDUCED TILLAGE CORN TRIAL

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Timely manure incorporation can reduce nutrient losses to the atmosphere and surface runoff. Keeping valuable nutrients, like nitrogen, in the soil can help reduce the purchase of expensive commercial fertilizers. Reduced tillage corn is becoming more common as growers recognize the benefits to soil health and water quality. Some options to implement reduced tillage include no-tillage and vertical-tillage. No-tillage planting uses metal coulters to cut a slot for the seed, rather than tilling the soil. Vertical-tillage lightly tills the top 2-3" of the soil, as the implement is pulled quickly across a field to produce a uniform seedbed without deep tillage.

Little research has been done in the region to assess the combined effects of manure application and reduced tillage practices on silage corn yields and quality. With the increased regional availability of innovative equipment such as manure injectors, aerators, strip tillers, and no-till planters, the University of Vermont Extension's Northwest Crops & Soils Program designed a trial in 2016 to evaluate both manure incorporation and reduced tillage corn planting techniques on corn yield and quality.

MATERIALS AND METHODS

A trial was initiated at Borderview Research Farm in Alburgh, VT in 2016. The experimental design was a randomized complete block with a split plot arrangement and four replications. Main plots were comprised of two reduced tillage methods; subplots consisted of four manure incorporation methods (Table 1).

Table 1. Main plot and subplot treatments of the manure incorporation and reduced tillage corn trial, 2016.

Tillage methods	Manure incorporation methods
No	Aerator
Vertical	Broadcast
Plow	Injection
	Plow

Each plot was 12' x 40' and there were 40' buffers between main plots (Table 2). The soil type at the research site was a Benson rocky silt loam. The previous crop was corn, followed by a cover crop of winter rye. Liquid manure was applied on 17-May at a rate of 6000 gallons ac^{-1}. The manure incorporation methods were applied at the time of manure application (injection) or immediately following application (aerator and plow). Broadcasted manure was left on the surface and not incorporated. Vertical tillage was completed with a John Deere 2623 Vertical Tillage machine VT, on 17-May (Image 1).

Image 1. John Deere 2623 VT vertical tillage.

The corn variety planted was 'TMFZR198' (Mycogen, 86 RM). At planting, a 10-20-20 starter fertilizer was applied at 200 lbs ac^{-1}.

Table 2. Trial specifics for manure incorporation and reduced tillage corn trial, Alburgh, VT, 2016.

Location	**Borderview Research Farm – Alburgh, VT**
Soil type	Benson rocky silt loam
Previous crop	Corn with winter rye cover crop
Plot size (ft)	12 x 40
Replications	4
Manure application date	17-May
Manure application rate (gal ac^{-1})	6000
Tillage (Vertical)	17-May
Corn variety	Mycogen TMFZR198 (86 RM)
Seeding rate (seeds ac^{-1})	34,000
Planting equipment	John Deere 1750 corn planter
Planting date	19-May
Row width (in.)	30
Starter fertilizer (at planting)	200 lbs ac^{-1} 10-20-20
Harvest date	21-Sep

Corn plots were harvested on 21-Sep with a John Deere 2-row chopper, and forage was weighed in a wagon fitted with scales. Dry matter yields were calculated and then yields were adjusted to 35% dry matter. A subsample of the harvested material was collected, dried, ground, and then analyzed at the University of Vermont's Testing Laboratory, Burlington, VT, for quality analysis. Silage quality was analyzed using the FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Dried and coarsely-ground plot samples were brought to the lab where they were reground using a cyclone sample mill (1mm screen) from the UDY Corporation. The samples were then analyzed using the FOSS NIRS DS2500 for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), non-fiber carbohydrates (NFC), and starch.

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. Acid detergent fiber (ADF) is used to determine the digestibility and energy derived from a forage crop. ADF is a direct measurement of the cellulose, lignin, silica, insoluble CP, and ash content of a crop. These components are among the least digestible portions of a plant. Due to this, a lower ADF content correlates to higher plant digestibility.

Non-fiber carbohydrates (NFC) are composed of starch, simple sugars, and soluble fibers. Often NFC is digested more quickly than fiber and provides energy to rumen microbes. The fermentation of NFC is the precursor to volatile fatty acids, which can be used as energy by ruminant animals. Units of glucose are the building blocks of starch. Starch content and digestibility can have major impacts on milk production, specifically the NE_L, or net energy for lactation. Starch levels vary from field to field, depending on growing conditions and variety.

Net energy of lactation (NE_L) is calculated based on concentrations of NDF. 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%. Non-structural Carbohydrate (NSC) are simple carbohydrates, such as starches and sugars, stored inside the cell that can be rapidly and easily digested by the animal. NSC is considered to serve as a readily available energy source and should be in the 30-40% range, on a dry matter basis. Total digestible nutrients (TDN) report the percentage of digestible material in silage. Total digestible nutrients are calculated from NDF and NDFD and express the differences in digestible material between silages.

The silage performance indices of milk per acre and milk per ton were calculated using a model derived from the spreadsheet entitled "MILK2006," 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 meeting animal energy, protein, and fiber needs based on silage quality. The value is based on a standard cow weight and level of milk production. Milk per acre is calculated by multiplying the milk per ton value 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 exist, and
3) Genetic, dietary, and environmental differences affecting feed utilization are not considered.

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 at 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.

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

RESULTS

Seasonal temperature and precipitation recorded at Borderview Research Farm in Alburgh, VT are reported in Table 3. Temperatures through June and July of the growing season were near historical averages, with warmer than normal temperatures at the beginning and end of the growing season (May and August and September). Rainfall through the growing season was less than normal – a total of 7.27 inches below normal through the growing season. There was a total of 2562 Growing Degree Days (GDDs) for May through September—268 GDDs more than the historical average.

Table 3. 2016 weather data for Alburgh, VT.

Alburgh, VT	May	Jun	Jul	Aug	Sep
Average temperature (°F)	58.1	65.8	70.7	71.6	63.4
Departure from normal	1.80	0.00	0.10	2.90	2.90
Precipitation (inches)	1.50	2.80	1.80	3.00	2.50
Departure from normal	-1.92	-0.88	-2.37	-0.93	-1.17
Growing Degree Days (base 50°F)	340	481	640	663	438
Departure from normal	74	7	1	82	104

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.

Impact of Tillage Method

There was no significant difference between the tillage treatments on corn silage yield. The average yield for the trial was 21.5 tons per acre (Table 4).

Table 4. Impact of tillage method on yield, Alburgh, VT, 2016.

Treatment	Yield tons ac^{-1}
No-till	19.8
Vertical till	23.0
Plow	21.9
Trial mean	21.5
LSD (0.10)	NS

NS – No significant difference amongst treatments.

Corn silage quality indicators were impacted significantly by tillage treatment (Table 5). Crude protein and TDN did not differ by treatment. The treatments that received tillage had the lowest fiber concentrations, highest levels of starch and NE_L. Starch and NE_L however, were not significantly different from the vertical tilled plots. This may indicate that the treatments with tillage produced larger ears resulting in better quality feed.

Table 5. Corn silage quality indicators by tillage method, Alburgh, VT, 2016.

Treatment	Forage Quality Characteristics							Milk	
	CP % of DM	ADF % of DM	NDF % of DM	NFC % of DM	Starch % of DM	TDN %	NE_L Mcal/lb	ton^{-1} lbs	ac^{-1} lbs
No-till	9.47	25.0	47.9	52.3	48.5	77.2	0.72	3538	24503
Vertical till	9.45	23.7*	45.1*	**55.5***	**53.0***	**77.4**	**0.73***	**3585**	**28816**
Plow	**9.99**	**22.8***	**44.4***	**55.5***	**53.0***	77.1	**0.73***	3570	27328
Trial mean	9.64	23.8	45.8	54.4	51.5	77.2	0.73	3564	26882
LSD (0.10)	NS	0.94	1.63	1.62	2.24	NS	0.008	NS	NS

*Treatments with an asterisk are not significantly different than the top performer shown in **bold**. NS – No significant difference.

Impact of Manure Incorporation Method

Prior to planting and/or termination, a sample of cereal rye cover crop was taken on 5-May and sent to the lab for analysis. The cover crop from the manure injection treatment had the highest levels of nitrogen (N) and carbon (C) (Table 6), as well as the lowest carbon to nitrogen ratio. The broadcast treatment had the lowest levels of N and C.

Table 6. Impact of manure incorporation method on N and C, Alburgh, VT, 2016.

Treatment	N lbs/acre	C lbs/acre	N %	C %	Ratio C/N
Aerway	31.1	334	3.74	42.5*	11.7
Broadcast	35.5	411	3.52	41.5	12.4
Injection	**48.9**	**458**	**4.25**	**42.6***	**10.4**
Plow	37.8	419	3.62	41.8*	11.8
Trial mean	38.4	405	3.78	42.1	11.6
LSD (0.10)	NS	NS	NS	0.78	NS

*Treatments with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst treatments.

There was no significant difference in yield by manure incorporation treatment (Table 7). The trial mean was 21.4 tons per acre.

Table 7. Impact of manure incorporation on yield, Alburgh, VT, 2016.

Treatment	Yield tons ac^{-1}
Aerway	19.8
Broadcast	**22.0**
Injection	21.8
Plow	**22.0**
Trial mean	21.4
LSD (0.10)	NS

NS – No significant difference in treatments.

Soil health parameters including aggregate stability and active carbon were measured in the various manure treatments. Treatments with broadcast applied manure had the highest levels of aggregate stability and active carbon, but this was not significantly higher than injected or plow treatments (Table 8). The trial mean was 33.5% aggregate stability.

Table 8. Impact of incorporation method on aggregate stability, Alburgh, VT, 2016.

Treatment	Aggregate stability (%)	Active carbon mg kg^{-1}
Broadcast	**38.0**	**1094**
Injection	31.8	951
Plow	30.8	1029
Trial mean	33.5	1025
LSD (0.10)	NS	NS

*Top performing treatments are in **bold**.
NS – No significant difference.

Corn silage quality did differ by manure incorporation method, with regards to CP, ADF, and NDF (Table 9). There was a significant difference in CP, with a trial average of 9.46%. The plow treatment had the highest concentration of CP at 9.99%, this was statistically similar to the broadcast treatments. Acid detergent fiber and NDF were also lowest in the plow and broadcast treatments.

Table 9. Corn silage quality indicators by manure incorporation method, Alburgh, VT, 2016.

Treatment	Forage Quality Characteristics							Milk	
	CP % of DM	ADF % of DM	NDF % of DM	NFC % of DM	Starch % of DM	TDN %	NE_L Mcal/ lb	$tons^{-1}$ lbs	ac^{-1} lbs
Aerway	9.12	25.7	48.0	52.9	49.2	**77.7**	**0.73**	**3572**	24822
Broadcast	9.47*	24.3	46.6*	53.4	50.2	77.3	**0.73**	3554	**27367**
Injection	9.26	24.6	46.9	53.7	50.5	77.2	**0.73**	3551	27122
Plow	**9.99***	**22.8***	**44.4***	**55.5**	**53.0**	77.1	**0.73**	3570	27328
Trial mean	9.46	24.4	44.6	53.9	50.7	77.3	0.73	3562	26660
LSD (0.10)	0.58	1.33	2.30	NS	NS	NS	NS	NS	NS

*Treatments with an asterisk are not significantly different than the top performer in **bold**.
NS – No significant difference amongst treatments.

DISCUSSION

Overall, corn yields in this trial, were excellent and averaged over 21 tons per acre. This demonstrates that growers can utilize manure incorporation and reduced tillage strategies without compromising crop yield. Manure incorporation and reduced tillage strategies had some statistical impact on the forage quality indicators, with the plow treatment performing better in some characteristics.

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