NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2010 Cover Crop Termination & Reduced Tillage Study

Dr. Heather Darby
UVM Extension Agronomic Specialist
Rosalie Madden, Erica Cummings, Amanda Gervais, and Philip Halteman
802-524-6501

Visit us on the web! http://www.uvm.edu/extension/cropsoil

2010 Cover Crop Termination and Reduced Tillage Study

Dr. Heather Darby, UVM Extension
heather.darby@uvm.edu

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. First cover crop plants 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 crop plants 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 than 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") just around the area of seed placement. Zone-till implements are often times 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 to soil drainage, nutrient cycling, and crop yields.

Figure 1. Roller crimper.

In 2010, the University of Vermont Extension conducted the second 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 cover crops and implement reduced tillage on their farm.

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

WEATHER DATA

The 2010 growing season brought warmer and slightly wetter weather than average. The month of May, when most corn is planted, was exceptionally dry and warm, and may have delayed germination in some cases. Growing Degree Days (GDDs) are reported using base 50° – 86°F. Accumulated GDDs for corn by harvest was 2810 approximately 350 more GDDs than the 30 year average.

Table 1. 2010 monthly temperature, precipitation, and accumulated GDDs, Alburgh VT.

	May	June	July	August	September	October
Avg. Temperature (°F)	59.6	66.0	74.1	70.4	64.0	50.6
Departure from Normal	3.00	0.20	3.00	1.40	3.60	1.80
Precipitation (inches)	0.92	4.61	4.30	5.48	4.32	*
Departure from Normal	-2.01	1.40	0.89	1.63	0.86	
Corn						
GDDs (base 50°)	332	479	747	634	419	129
Departure from Normal	71.4	4.50	94.6	45.0	107	26.4

*Missing data.
Based on National Weather Service data from cooperative observer stations in South Hero. Historical averages are for 30 years of data (1971-2000).

CULTURAL PRACTICES

The trial was conducted on a silt loam soil at Borderview Farm in Alburgh, VT. The trial site has been in continuous row crop production under conventional tillage for the last 8 years. On October 10, 2009, a winter rye cover crop was seeded at a rate of 100 lbs/acre. Plots without cover crops served as controls. The experimental design was a randomized complete split plot block design with four replications. The plot size was 10’ x 40’. The main plots were cover crop termination method including the following treatments: 1) herbicide burn-down, 2) moldboard plowed, 3) rolled and crimped, and 4) a control with no cover crop. A new termination strategy called “rolling and crimping” was demonstrated as part of this study (Figure 1). In order to properly utilize this technique the rye crop must be in the flowering stage before it is terminated. Once in the flowering stage, the rye is rolled down and the machine crimps the stems, killing the plant (Figure 2). The rolled cover crop acts as a mulch mat, suppressing weeds. The crop is then planted into the mat using a no-till, zone-till, or strip-till planter. 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. The split plots were reduced tillage strategies including no-till, zone-till, and strip tillage.

In mid-April the soil was sampled to determine soil quality of cover cropped and non cover cropped soil. Soil was sampled from multiple locations within a plot to a 6” depth using a trowel. Soil quality was determined by the Cornell Soil Health Lab in Geneva, NY. Soil quality was monitored to determine if a single season of cover cropping would improve soil health. Soil nitrate-N was measured weekly from the beginning of May until the end of June. Multiple soil samples to a depth of 12 inches were taken from each plot, composited, and the subsamples analyzed for soil nitrate-N by the UVM Agricultural Testing Laboratory in Burlington, VT. Prior to cover crop termination, a one-meter^2 sample of cover crop was taken to determine crop biomass and nitrogen content. Soil nitrate-N sampling was used to monitor the decomposition of the cover crop residue and subsequent nitrogen release. Soil nitrate-N sampling was terminated once the corn reached the V6 growth stage (time of nitrogen topdress). On May 11, 2010 the cover crops were terminated with a burn-down herbicide application of glyphosate at a rate of 2 qt/acre. Termination of cover crops through moldboard plowing was completed on May 13, 2010. The rolling and crimping termination strategy was performed on May 27, 2010. Control plots with no cover crop were prepared for planting with conventional tillage methods. On May 29th, 2010 corn was planted (var. Mycogen TMF2L418) in the no-till treatment with a John Deere 1750 4-row planter, in the zone-till treatment with a White 6100 zone-till planter, and in the strip-till treatment with a Blujet Coulter Pro at 34,000 seeds to the acre. Starter fertilizer was applied at a rate of 200 lbs 10-20-20 to the acre. On July 10th, the corn plots were side-dressed with urea-nitrogen (46-0-0). Fertilizer rates were determined with soil nitrate-N tests taken just prior to the time of topdress. On October 11, 2010 the corn was harvested with a John Deere 2 row chopper, and the forage wagon was weighed on a platform scale. A subsample was collected for moisture determination and quality analysis.

PRESENTATION OF DATA

Cover crop biomass and nitrogen concentration at the time of termination is reported in Table 2. The impact of cover cropping on soil quality is reported in Table 4. The influence of cover crop termination strategy on soil nitrate-N is shown in Table 4 and Figure 3. Finally the impact of cover crop termination strategy on corn yield and quality is shown in Table 5 and Figure 4. Dry matter corn yields were calculated and then adjusted to 35% dry matter for the report. The numbers presented in the tables represent the means of four replications. All data was analyzed using a mixed model analysis where replicates were considered random effects. The Least Significant Difference (LSD) procedure was used to separate cover crop termination means when the F-test was significant ($P< 0.10$). Least Significant Differences at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure 9 times out of 10 that there is a real difference between the treatments. Simple single degrees of freedom contrasts were used to compare reduced tillage strategies in the herbicide burn down treatment only. This treatment did not receive any conventional tillage. The goal was to determine if one type of reduced tillage was more advantageous than another. Finally, reduced tillage treatments were also compared with results from treatments with only conventional tillage. The goal was to determine if reduced tillage strategies impacted corn yield and quality compared to standard tillage operations.

RESULTS & DISCUSSION

Cover crop biomass was measured just prior to termination. The cover crops terminated in early May were still in the vegetative stage and produced just over one ton of dry matter per acre (Table 2). The plant biomass contained about 2.77% nitrogen which could potentially translate into 65 lbs of nitrogen per acre (Table 2). 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 that was “rolled and crimped” had almost 3 tons of dry matter by the termination date at the end of May. 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 may grow back and compete with the desired crop. The nitrogen content of winter rye in the flowering stage was almost 50% less compared to cover crops terminated in the vegetative stage (Table 2).

Table 2. Cover crop biomass and nitrogen content at the time of termination.

Cover crop termination strategy	**Cover crop**		
	Dry matter	Nitrogen	
	lb ac^{-1}	%	lb ac^{-1}
Rolled and crimped	5780	1.44	83.2
Herbicide burn-down	2400	2.76	66.2
Plow down	2320	2.77	64.3

Soil quality was measured on cover cropped and non cover cropped plots. Cover crops are known to improve the condition of the soil. In this trial, winter rye grown from Oct. to May positively impacted the quality of the soil (Table 3). A significant increase in aggregate stability indicates that cover crops can improve the physical properties of soil when grown even over a short time frame.

Table 3. Impact of a single season of cover cropping on indicators of soil quality.

Treatment	Aggregate stability	Organic matter	Active carbon	Potentially mineralizable N
	%	%	mg/kg	ug N g^{-1} d soil
Cover crop	**52.8***	**4.95**	**521***	**19.4**
No cover crop	47.7	4.58	441	17.1
LSD (0.10)	3.23	NS	54.4	NS
Mean	50.2	4.76	481	18.2

***** Coefficients significant at the 0.10 probability levels.
NS – None of the treatments were significantly different from one another.

Soil nitrate-N was monitored from the beginning of May until the end of June. Corn is usually topdressed with supplemental nitrogen just prior to the period of rapid uptake. Farmers conduct pre-sidedress nitrate tests just prior to this period which occurs at or around the V6 growth stage of corn. In this study the V6 stage occurred at the end of June into early July. The last soil nitrate-N samples taken in late June were used to determine topdress rates for corn in this experiment. It was hypothesized that nitrogen tied up in cover crop biomass would be released to corn during decomposition. Interestingly, the plots that did not receive cover crop treatments had the highest nitrate-N content from May through June (Table 4). The May 5th measurement of nitrate-N indicated that cover crops may have scavenged almost all available nitrate-N in the soil. During the month of June, the cover crops that were plowed under did have significantly higher soil nitrate-N levels than both the herbicide and rolled and crimped treatments. By June 29th, soil nitrate-N did not differ significantly between plowed down cover crops and non cover cropped plots. The extremely dry conditions during May and early June may have resulted in delayed decomposition of terminated cover crop residues. Overall the rolled and crimped treatment had the lowest amount of soil nitrate-N throughout the testing period (Table 4). The high carbon biomass in this treatment may have resulted in nitrogen being tied up by soil microbes working to breakdown the residue.

Interestingly, in 2009 the plow-down cover crop treatment resulted in higher soil nitrate-N content than non cover cropped plots.

Table 4. Impact of cover crop termination method on soil nitrate-N levels.

Cover crop termination method	Soil nitrate-N sample date							
	5-May	21-May	26-May	2-Jun	9-Jun	15-Jun	22-Jun	29-Jun
	---ppm---------------------------------------							
No cover crop (control)	**5.73***	**10.2***	**8.51***	**12.9***	**9.98***	**11.6***	**14.2**	**15.2***
Rolled and crimped	2.10	2.05	1.62	2.00	2.15	2.59	8.09	3.80
Herbicide burn-down	2.29	3.91	4.38	6.45	4.28	5.18	9.33	9.31
Plow down	1.75	4.23	5.71	9.09	6.68	8.18	11.2	13.7*
LSD (0.10)	0.57	2.30	1.85	2.08	2.35	2.24	NS	2.64
Mean	2.97	5.09	5.06	7.60	5.77	6.87	10.7	10.5

***** Coefficients significant at the 0.10 probability levels.
NS – None of the treatments were significantly different from one another.

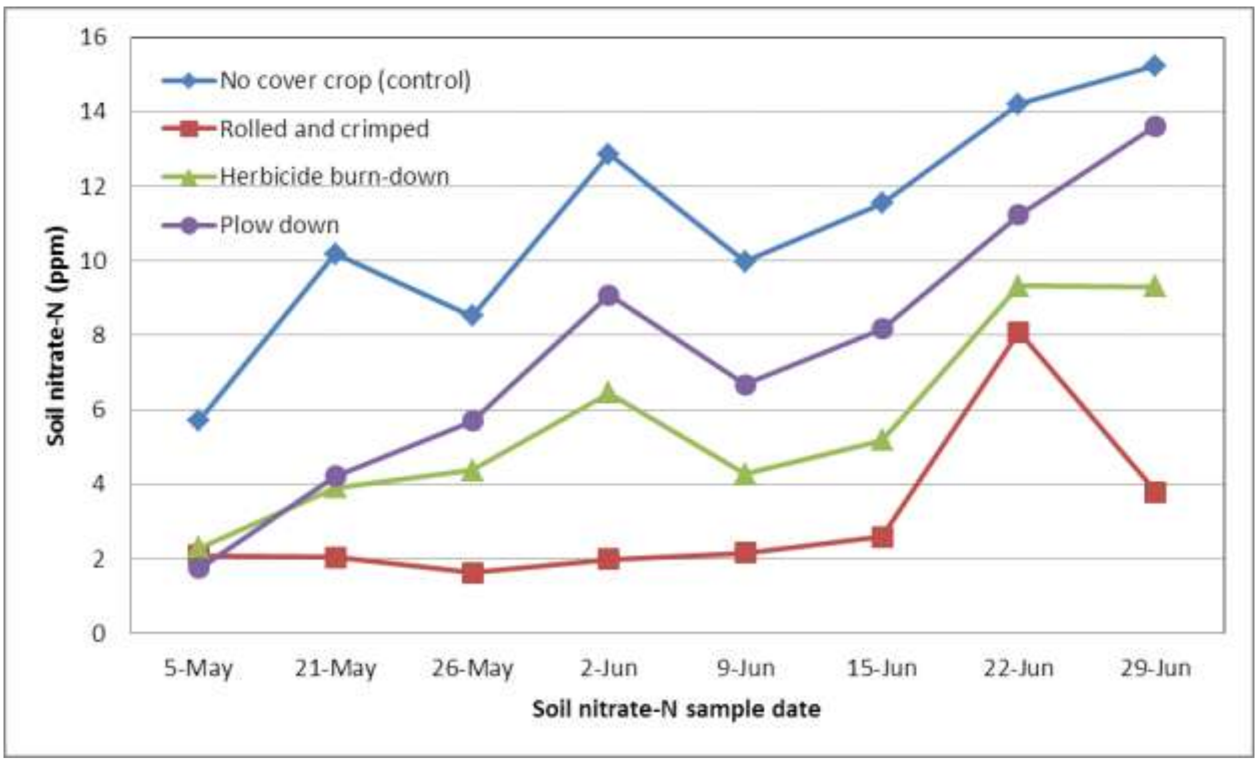

Figure 3. The impact of cover crop termination strategies on soil nitrate-N.

Corn silage yields were highest in non cover cropped and plow-down cover crop treatments (Table 5). These treatments yielded significantly greater than the rolled and crimped and herbicide terminated cover crop treatments. Corn silage in the herbicide and rolled and crimped plots were planted with reduced tillage methods. This could have contributed to the yield drag in these treatments. In addition, the low nitrogen levels in the rolled and crimped plots may have led to yield declines in corn. Corn silage quality was lowest in the rolled and crimped treatment. The reduced quality may be a result of the corn being planted later in the season and hence not developing to the proper harvest moisture.

Table 5. Impact of cover crop termination strategies on corn silage yield and quality.

Termination strategy	DM at harvest	Yield at 35% DM	Forage quality characteristics					Milk per	
			CP	ADF	NDF	dNDF	NEL	ton	acre
	%	tons/ac	%	%	%	%	Mcal/lb		
No cover crop	29.3	19.1*	8.96	24.2	41.1	57.9*	0.75	2920*	19500*
Rolled & crimped	**25.5**	9.50	**9.60**	25.3	43.7	56.4	0.73	2800	9420
Herbicide	31.4	17.0	8.66	**22.9***	**39.0***	**58.4***	**0.76***	**2960***	17600
Plow down	31.7	**20.1***	8.66	23.7*	40.3*	57.1	0.75*	2910*	**20500***
LSD (0.10)	1.78	1.82	0.36	1.16	1.90	1.20	0.01	69.6	2020
Mean	29.5	16.4	8.97	24.0	41.0	57.4	0.75	2890	16800

***** Coefficients significant at the 0.10 probability levels.

NS – None of the treatments were significantly different from one another.

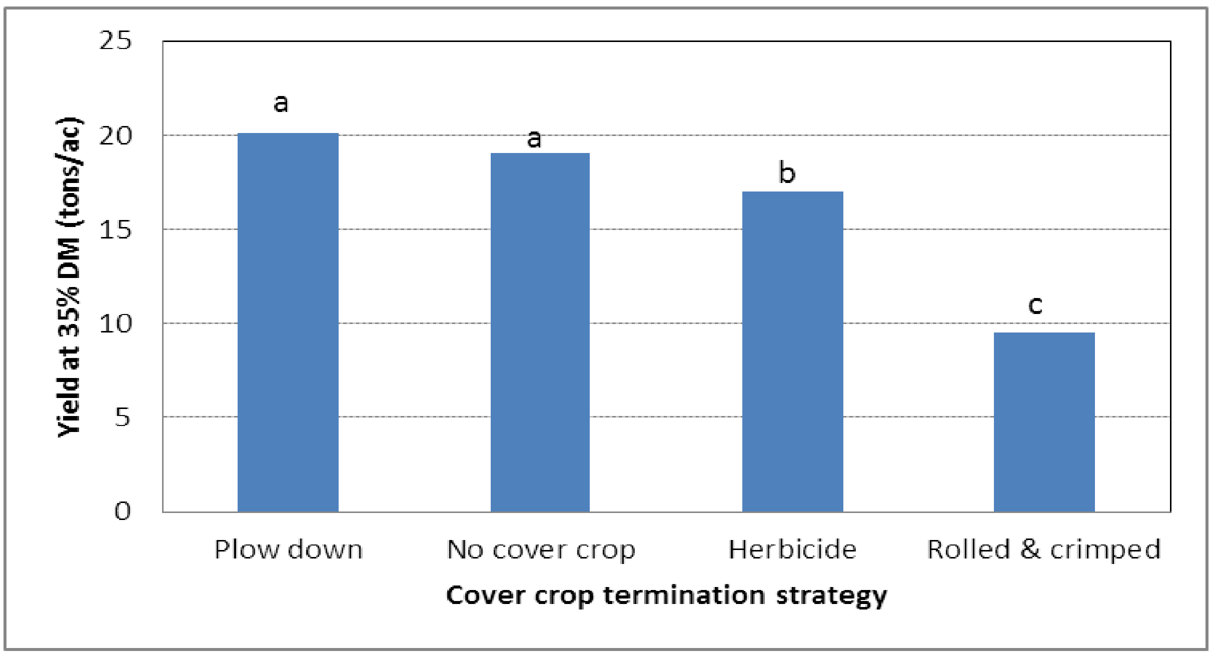

Figure 4. Impact of cover crop termination strategy on corn silage yield.
Treatments with the same letter did not differ statistically in yield.

Soaring fuel prices are pushing farmers to find a means to reduce diesel usage on farms. Implementing reduced tillage could save farmers a considerable amount of money by eliminating costly tillage practices such as moldboard plowing and disking to prepare corn fields for planting. Through this project reduced tillage practices including no-till, zone-till, and strip-till were evaluated under the herbicide burn-down cover crop termination strategy. Terminating the cover crop by herbicide will leave the residue on the surface enabling farmers to plant directly into the killed residue. Based on this first year of data collection, strip tillage resulted in the highest potential milk per acre as compared to no-till and zone tillage systems (Table 6). There was very little difference in corn quality between the treatments.

Table6. Impact of reduced tillage practices on silage corn yield and quality.

Reduced tillage practice	Dry matter	Yield at 35% DM	Forage quality characteristics					Milk per	
			CP	ADF	NDF	dNDF	NEL	ton	acre
	%	ton/acre	%	%	%	%	Mcal/lb		
No-till	30.8	16.7	8.68	**24.2**	**40.8**	57.3	0.75	2880	16900
Strip-till	30.2	**18.4**	8.38	23.1	39.2	57.7	0.76	2940	**18900**
Zone-till	**33.3**	16.0	**8.92**	21.3	37	**60.1**	**0.78**	**3050**	17100
LSD (0.10)	NS	NS	NS	NS	NS	1.33	NS	96.6	NS
Mean	31.4	17.0	8.66	22.9	39	58.4	0.76	2960	17600

***** Coefficients significant at the 0.10 probability levels.

NS – None of the treatments were significantly different from one another.

Corn silage yields were significantly higher under traditional tillage methods when compared to reduced tillage (Table 7). The quality of the corn silage was also better under conventional tillage strategies. Reduced yields under the first few years of reduced tillage are common. It is well documented that there is a transition period that the soil must go through once practices are shifted to reduced tillage. Since the trial site has been in conventional tillage for more than 8 years the soils will need to develop a tolerance to not being tilled.

Table 7. Comparison of silage corn that has been no-till planted into cover crop that has either been terminated with herbicide or plowed down.

Termination strategy	DM at harvest	Yield 35% DM	Forage quality characteristics					Milk per	
			CP	ADF	NDF	dNDF	NEL		
	%	tons/ac	%	%	%	%	Mcal/lb	ton	acre
Herbicide burn-down	30.8	16.7	8.68	24.2	40.8	**57.3**	0.75	2880	16900
Plow down	**33.5**	**22.0**	**8.85**	**23.4**	**39.7**	56.2	0.75	2880	**22200**
P-value (0.10)	*	*	*	*	*	NS	*	NS	NS

***** Coefficients significant at the 0.10 probability levels.

NS – None of the treatments were significantly different from one another.

UVM Extension would like to thank the Borderview Research Farm for their help implementing the trial. This trial was supported by funding through USDA Northeast SARE and NOAA SEAGRANT program.

UVM Extension helps individuals and communities put research-based knowledge to work.

The UNIVERSITY of VERMONT EXTENSION