Western Illinois University/Allison Organic Research Farm

Tillage/Cover Crop Experiment

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Introduction:

Organic farmers are faced with a challenge – the intensive tillage that is a traditional part of organic grain production (often more than 5 tillage operations per season when primary, secondary and cultivations are considered) is energy intensive and can contribute to soil erosion, soil compaction, loss of organic matter and other forms of soil degradation.

Increasing numbers of organic farmers and researchers are investigating minimum till and no-till practices, but there is still considerable concern about whether such systems can effectively and consistently fulfill key agronomic objectives (e.g., management of weeds, crop residues, cover crops, pest life cycles, manure, compaction…) that have traditionally required tillage in organic farming systems.

An experiment comparing 3 tillage systems (conventional-till, bio-strip-till and no-till) was established in 2008 and harvested in 2009 at the WIU/Allison Organic Research Farm. This experiment was the first stage of a multi-year investigation of strategies for reducing tillage in organic farming systems. A site with low weed pressure was specifically selected for the experiment to improve the likelihood of success of our first attempt at organic no-till. This report presents crop and cover crop measurements, economic and energy analysis and photo documentation of the experiment.

Methods:

The experiment consisted of 12 plots (10'x 450') in a randomized complete block design (4 replications of 3 tillage systems - conventional-till, bio-strip-till and no-till). The site was field 2B, a field with historically low weed pressure that had a compromised stand of winter wheat in spring 2008 as a result of winter flooding.

The winter wheat was incorporated as a cover crop on May 21st, 2008 and multiple shallow tillage operations were performed during the summer to prevent weeds from going to seed. The cover crops were planted on August 14th, 2008 using a 10' conventional drill, with the exception of the radishes. "Graza" radishes were planted with a one row push planter on 30" rows marked by a 4 row Buffalo planter on August 20th, 2008. The seeding rates were as follows:

‘Jerry’ oats = 70#/ac, ‘Aroostook’ rye = 60#/ac, VNS hairy vetch = 25#/ac, and ‘Graza’ forage radish = 2.5#/ac. See table 1 for field map.

Cover crop biomass samples were hand harvested from 3 random sample areas (2 rows x 2’) in each plot on November 20th, 2008. There was little to no additional growth after this date. By mid-December, the oats and radishes had winter-killed and the rye was dormant.

On May 11th, 2009, the conventional-till plots were tilled (~ 3” deep) with a 10’ Howard Rotavator. Prior to tillage, the ground was covered with winter-killed oat residues and patchy weeds, mostly field pennycress.

On May 29th, a culti-mulcher (see photo) was used to lodge the cereal rye in the no-till plots in an easterly direction. The rye was ~ 5’ tall and was shedding pollen at the time of rolling. The culti-mulcher teeth were in the raised position while rolling the rye.

On June 5th, the bio-strip-till plots and the conventional-till plots were tilled (~ 2” deep) with a Howard Rotavator. Prior to tillage, the bio-strip-till plots were covered with some remaining oat residue and patchy weeds (principally, penny cress, lambs quarters and sour dock), some of which were over a foot tall. About 2 hours after the tillage operation, soybeans (Blue River Hybrids 34A7) were planted @ 180,000 seeds/ac in the bio-strip-till and conventional-till plots with a 4 row Buffalo planter. The same variety of soybeans was drilled @ 250,000 seeds/ac in the no-till plots on June 6th with a John Deere 750 no-till drill set to plant ~3” deep with high down pressure. The resulting seed depth was ~ 1”.

The conventional and bio-strip-till plots were rotary hoed at 11 mph on June 23rd and row-cultivated one time with a 4 row Buffalo cultivator on June 30th. Some hand weeding was performed in areas where pre-plant tillage did not effectively kill all weeds in the bio-strip-till system and later in the season along the plot borders.

Sub-plots (~ 50’x 5’) were harvested on November 13th, 2009 with a 2 row plot combine and soybean yields were converted to bu/ac @ 13% moisture. The rest of the field was harvested with a John Deere 9670 STS combine using a 35’ platform on December 2nd. According to the yield monitor, some areas in the field (across multiple plots) had yields over 70 bu/acre.

Results:

All three systems had mean yields over 50 bu/ac, which were some of the highest soybean yields ever recorded at the Allison Farm, but the means were not significantly different at alpha = 0.05. 2008 fall biomass production in the bio-strip-till plots (oats + radishes) was significantly greater than in the no-till plots (cereal rye).

Table 1: **Map of field 2B west (~ 475' x 160')** ⇧**N**

Buffer (oats)
Buffer (oats)
ID 2 (oats/radish) Bio-strip-till
ID 3 (rye/vetch) No-till
ID 1 (oats) Conventional-till
ID 3 (rye/vetch) No-till
ID 1 (oats) Conventional-till
ID 2 (oats/radish) Bio-strip-till
ID 1 (oats) Conventional-till
ID 3 (rye/vetch) No-till
ID 2 (oats/radish) Bio-strip-till
ID 1 (oats) Conventional-till
ID 2 (oats/radish) Bio-strip-till
ID 3 (rye/vetch) No-till
Buffer (oats)
Buffer (oats)

Table 2: **Variation in Soybean Yields and Cover Crop Biomass across Tillage Systems**

Treatment	Soybean Yields (bu/ac)*	Cover Crop biomass (lbs/ac)**
Conventional-till (oats)	55.2	8,163.3
No-till (rye/vetch)	53.8	6,868.5
Bio-strip-till (oats/radish)	53.6	8,847.3
LSD	Alpha (0.05) = 4.2	Alpha (0.05) = 1,746.7

* Soybean variety was Blue River Hybrids 34A7 and the yields were calculated at 13% moisture.

** Cover crop above-ground biomass sampled on November 13th, 2008.

Discussion:

All three systems produced comparably high soybean yields (no significant differences at alpha = 0.05) and had excellent weed control. As a result, it is not possible to identify specific cause and effect relationships, but some potential factors contributing to yield and weed control warrant discussion.

Effective weed management preceding the experiment was probably an important factor contributing to the effective weed management across all the systems during the experiment.

Excellent weed control was achieved in 2007 (partly through manual weeding) when field 2b was the site of a soybean variety trial. After determining that the wheat stand established in fall 2008 had been compromised by flooding, the remaining wheat was incorporated in late May 2009 as a cover crop. Throughout the rest of the summer, multiple flushes of weeds were terminated with shallow tillage. As a result, the fresh weed seed bank in field 2b was exceptionally low going into the experiment.

The cover crop stands established in fall 2008 had excellent growing conditions and produced high levels of biomass (see table 2), with the exception of hairy vetch. The hairy vetch did not seem to compete well with the cereal rye, which resulted in a very poor stand. However, spring biomass production by the cereal rye was very high.

It seems likely that the maturity of the cereal rye during rolling @ anthesis is a major reason why 1 pass with a culti-mulcher resulted in a high % of irreversible lodging. Some plants along the borders of the plots stood back up within a few days after rolling, but the subsequent action of the drill during soybean planting caused almost all of these stems to be irreversibly lodged.

Soybean emergence in both the bio-strip-till and conventional till plots was rapid (~ 4 days) but was less uniform in the bio-strip-till plots. Emergence through the thick residue (~ 2") covering the no-till plots was much slower (~ 10 days). The soybean stand in the no-till plots was the least uniform with some patches greater than 1 m^2 with very few plants. The plants in these thin areas grew quite large and ended up filling in most of the gaps by the end of the season.

The soybean variety used in this experiment (BRH 34A7) was selected based upon its strong performance in recent trials at the Allison Farm. The planting of a soybean variety with good emergence, standability, stress tolerance, and yield potential certainly contributed to the excellent performance of all 3 systems in the experiment.

While the mean yields were not significantly different, it is important to consider how differences in field operations impacted the economics of the systems (See table 4).

The conventional till system had the highest net income ($506/ac) despite having the highest cost of field operations. Its mean yield was numerically the highest (though not significant at alpha = 0.05) and its cover crop expenses were the lowest.

It is important to note that a Howard Rotavator was used to fit the conventional and bio-strip-till plots for planting. The cost of operating a Rotavator is not well documented, but the cost per acre may be lower than for more traditional tillage tools due to the Rotavator being able to accomplish in one pass what would require multiple passes with more traditional tools such as a disk, soil finisher, or field cultivator. The ~ 50% lower estimated fuel consumption for the no-till system relative to the conventional till system relative (see table 3) suggests that at some higher fuel price (higher than the prices underpinning the 2009 IA custom rates) the no-till system would come out ahead.

Table 3: Variation in diesel fuel consumption across tillage systems

Field operation	Conventional-till	Bio-strip-till	No-till
	**estimated gallons of diesel fuel/ac		
Soil finisher	0.9	0.9	0.9
Grain drill	0.3	0.3	0.3
Rotavator	1	*	*
Culti-mulcher	*	*	0.2
Rotavator	1	1	*
Planter	0.4	0.4	*
Grain drill	*	*	0.3
Rotary hoe	0.2	0.2	*
Row crop cultivator	0.4	0.4	*
Combine	1	1	1
Total	**5.2**	**4.2**	**2.7**

* not applicable

** values were adapted from the Farm Energy Audit Spreadsheet developed by Shannon Gomes

Table 4: Variation in economics across tillage systems

	Expenses/Acre				Revenue/Acre	
Treatment	Cover Crop Seed	Soybean Seed	Tillage & Planting	Total Expenses	Soybean Sales @ $12.80/bu	Net Income*
Conventional-till	$8.75	$73.50	$118.3	$200.55	$706.60	$506.05
No-till	$12.6	$101.92	$85.2	$199.72	$688.64	$488.92
Bio-strip-till	$15.23	$73.50	$101.3	$190.03	$686.08	$496.05

*land costs not included

Note: Hairy vetch was planted as part of the no-till system, but we chose not to include the seed cost ($49/ac) because it did not establish. The seed may have been poor quality and/or competition from the rye was too great.

Summary:

All 3 tillage systems exceeded our expectations in 2009, but with only one year of data, we cannot answer important questions about the consistency of reduced tillage systems.

The farm received 20 extra inches of precipitation during April-October, 2009 (compared to 30 year averages), bringing into question how the systems would have performed under more normal conditions. Under dry conditions, the no-till system would likely have some advantage due to the better infiltration and reduced evaporation associated with near 100% residue cover, but depletion of soil moisture by the rye could be detrimental to subsequent crops in some cases. A major question is how the no-till system would have performed with a larger weed seed bank. Future studies should reveal to us that answer and provide even more valuable data.

The following pages contain a time sequence of photos of the experiment.

September 2008

Close-up of bio-strip-till plot. The 'Graza' radishes and 'Jerry' oats are ~ 6" tall and ~ 1 month old.

October 2008

Bio-strip-till plot is in the center with conventional till plots on either side. The 'Graza' radishes and 'Jerry' oats in the bio-strip-till plot are over 2 feet tall.

November 2008

Close-up of 'Graza' radishes in the center surrounded by 'Jerry' oats, the morning after a hard freeze (17˚F).

March 2009

Oats and radishes have winter-killed. Cereal rye strips are starting to green up.

May 2009

In the central bio-strip-till plot, the winter-killed radish rows have less residue compared to winter-killed oats in the inter-row.

The cereal rye in the no-till plot on the left is heading out and is ~ 3' tall.

A very similar culti-mulcher to the implement shown above was used to roll the cereal rye in the no-till plots in late May when it was shedding pollen. The spring tines were raised during the rolling process.

June 2009

A 15’ wide JD 750 drill was used to plant the no-till plots (250,000 seeds/ac) on 6/6.

Planting was in the same direction as the cereal rye was rolled. The drill units were set to plant about 3” deep with high down pressure. Actual seed depth was ~ 1”.

June 2009

Soybeans in the conventional-till and bio-strip-till plots can be clearly seen about 1 week after planting. The beans in the no-till plots are not visible yet.

June 2009

Soybeans are beginning to poking through the cereal rye residue ~ 10 days after planting.

July 2009

After ~ 1 month, the plants in the conventional-till and bio-strip-till plots are larger and darker green than the plants in the no-till plots.

August 2009

After ~ 2 months, the plants in the conventional-till and bio-strip-till plots are still larger and darker green than the plants in the no-till plots. The plot in the center of this photo is a no-till plot.

November 2009

Soybeans are ready for harvest!

Sub-plots were harvested on 11/ 13, using a plot combine. Yields ranged from 51 to 59 bu/ac, but the mean yields for the systems were not significantly different at alpha = 0.05.

Please contact Joel Gruver or Andy Clayton at Western Illinois University School of Agriculture (309-298-1080) for use of these pictures.