**Project Final Report 2012-14 Vertical Tillage**

**Michigan Corn Growers**

**Evaluation of Vertical Tillage Tools for Residue Management, Manure Incorporation and Seeding Cover Crops**

This report spans activities from fall 2012 vertical tillage for residue management through 2014 tillage, soybean planting and harvest.

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**Problem Statement:**

Advances in equipment, seed technology and seed genetics have facilitated the transition to no-till and low-disturbance corn and soybean production recent years. Genetically engineered (GE) crops provide above ground protection against European corn borer (ECB) and other major pests, below ground protection against corn root worm, and tolerance to broad spectrum herbicides that have improved weed control. Despite these technological and agronomic advances, **growers are concerned about an emerging problem—excessive corn residue that is slow to breakdown and decompose**. Excessive corn residue interferes with drill and planter performance and leads to poor and uneven germination and emergence, delayed dry down, and reduced yield and profitability.

Some grower's claim that GE corn stalks are larger, remains green longer, and breaks down slower than conventional varieties. Some suspect the *BT* varieties are more resistant to microbial breakdown, but differences may simply be due to healthier plants and less insect damage. There is a need to develop guidelines for efficient and profitable residue management in high-yielding no-till cropping systems.

*Equipment technology*

The specific demands of no-till cropping have led to a new generation of tillage equipment that use coulters or narrowly spaced, shallowly concave disks rather than conventional tillage shanks. These 'vertical' tillage tools fracture and loosen the top 2-3 inches of soil, level wheel tracks, improve infiltration and reduce runoff. They do not bury crop residue but they cut and shatter it into smaller pieces for even distribution and better contact with the soil. Ownership and operating costs for these tillage tools are typically $12-$14/acre per pass across the field, and growers may need multiple passes for heavy residue. **There is a need to develop effective guidelines for managing high-yielding corn residue with vertical tillage**.

**Figure 1. Vertical tillage at the Jay Ferguson farm in Brown City.**

*Integrating vertical tillage tools in the production system*

Vertical tillage tools are expensive, require a relatively high horsepower tractor because they are high-speed implements and thus add to the cost and labor requirements of crop production. Growers are concerned about soil quality, minimizing soil compaction and managing their cropping program to protect soil productivity and resiliency. No-till and reduced tillage cropping systems are important in this effort, but additional protection can be gained by adding organic matter from cover crops or livestock manure. There is a need to evaluate vertical tillage tools as high capacity tools for seeding cover crops, and as manure incorporation tools for effective and efficient nitrogen retention.

**Methods and Procedures**

Project overview: On-farm trials were conducted in six locations: 1) Thelen Farms in Clinton Co., 2) Faivor Farms in Clinton Co., 3) Voisinet Farms in Clinton Co., 4) Crumbaugh Farms in Gratiot Co., Ferguson Farms in Sanilac Co. and in 2014, Sandborn Farms in Eaton Co. The focus at the Thelen, Faivor and Sandborn Farms was on vertical tillage in the spring in high yielding corn residue before soybeans. The focus of the work at the Voisinet Farm was to evaluate vertical tillage as a rapid pass implement to improve the stand of a cereal rye cover crop in the fall following corn harvest. The focus of the demonstration plots at the Crumbaugh and Ferguson farms was soybean establishment following fall and/or spring vertical tillage treatments compared to no tillage.

**Results and accomplishments**

*On-line videos created*

We made a considerable effort to document the field activities with video. This is particularly important to help growers understand the impact of the tools on soil and residue conditions, and in evaluating their planting and field conditions to select the best tillage tool for their conditions. Five short videos document the tools and techniques, soil and residue conditions at each location. The videos and links to the videos are:

1. *Fall Vertical Tillage with Landoll 7450* http://youtu.be/ZGLLrzznK0M
2. *Vertical Tillage Managing Hi-Yielding Corn Residue* *http://youtu.be/WYHJNORcmIY*
3. *Vertical Tillage with Great Plains Turbo-Till* http://youtu.be/T9k6cwHs24A
4. *Vertical Tillage Case IH 330 Turbo* *http://youtu.be/9E7hASWEhx4*
5. *Vertical Tillage Salford RTS, Summers Supercoulter Plus* http://youtu.be/by0QAq7ru-s

*Ferguson and Crumbaugh Farms.*

Paired treatments were established at the John Crumbaugh Farm in Wheeler and at the Jay Ferguson Farm near Brown City. Both growers used the Landoll 7431 for residue management and tillage. The tillage comparisons were: 1) No fall tillage, no spring tillage, 2) one fall pass, no spring tillage, 3) two fall passes, no spring tillage, 4) one fall pass, one spring pass, and 5) two fall passes, one spring pass. In 2012, spring tillage was on May 17 with planting on May 18. Planting was delayed in central Michigan in 2013 due to unusually wet conditions with planting dates ranging from May 7 in Tuscola County to June 5 in Clinton County. July and August were unusually dry, particularly at the Thelen Farm. Harvest dates ranged from October 11 in Gratiot and Tuscola Counties to mid-November in Clinton Co.

At the Crumbaugh Farm in 2012, spring tillage was on May 17 with planting on May 18. Planting was with a JD pneumatic planter. There were heavy rains between planting and emergence that caused some crusting and inhibited emergence. There were no detectable differences between treatments at the first stand count on June 7 with counts ranging from 101,756 to 124,408 plants/acre. At the final count on June 24 there was some stand reduction from rain damage but no significant difference in stand. Plant stand ranged from 94,903 (one fall pass) to 112,433 pl/ac (no-till). A look at the tillage tool action can be seen here: http://youtu.be/ZGLLrzznK0M

The methods, procedures and treatments at the Ferguson farm were the same as at the Crumbaugh Farm except for the use of Case IH planting equipment. Soybeans were planted May 13. At the first stand count May 21 the one fall pass (33,686 pl/ac) and no-till (28,343 pl/ac) treatments were significantly less than the one pass fall/one pass spring (81544 pl/ac), two fall passes (66,211 pl/ac) and the one pass spring/two fall passes (65,050 pl/ac). This indicates the impact of vertical tillage on early season soil warming. By the final stand count on June 12 the difference in stand had disappeared and there were no significant differences between tillage treatments. Final stand counts ranged from 146,362 pl/ac (one spring/two fall) to 177,260 pl/ac (two fall passes).

There was little difference in crop yield related to fall or spring tillage (Table 1). Soybean yields ranged from 58.2 to 61.7 bu/acre at the Crumbaugh Farm and 46 to 49 bu/acre at the J. Ferguson Farm.

Table 1. Harvest moisture and dry soybean yield (2013) following five vertical tillage treatments in corn residue with the Landoll tillage tool.

| | Crumbaugh Farm, Gratiot* | | | J. Ferguson Farm, Tuscola** | |
|---|---|---|---|---|---|
| Tillage | Harvest Moisture, % | Dry Yield, bu/ac | | Harvest Moisture, % | Dry Yield, bu/ac |
| No-Till | 12.2 | 60.5 | | 15.3 | 47.0 |
| 1X Fall | 12.2 | 61.7 | | 15.3 | 46.0 |
| 2X Fall | 12.5 | 58.2 | | 15.5 | 48.0 |
| 1X Fall, 1x Sp | 13.0 | 61.1 | | 15.4 | 49.0 |
| 2X Fall, 1x Sp | 12.4 | 61.3 | | 15.9 | 49.0 |

While one pass in the fall may help size corn residue, two fall passes did not add much benefit. Two spring passes appeared to be excessive in terms of residue reduction and soil disturbance. In medium-textured, loam soil the second pass was deeper than necessary and led to a very loose seedbed that would be vulnerable to crusting or excessive drying. There were less than a dozen slugs found in traps at the Crumbaugh and Ferguson farms indicating very little potential for damage in any of the systems evaluated.

*Thelen and Faivor Farms*

In Clinton Co. we evaluated three tillage treatments at two farms, the Thelen Farm the Faivor Farm. The tillage comparisons were: 1) no tillage, 2) no fall tillage, one pass in the spring, and 3) no fall tillage, two passes in the spring. Tillage was within 24 hours of planting at each location.

Vertical tillage at the Thelen Farm was with a Salford RTS. In 2013, soybeans were planted with a Great Plains No-Till drill with a target population of 180,000 plants per acre. Spring planting conditions were very wet and the soybean crop was not planted until June 5. The corn stalks shattered nicely and were distributed evenly with a single pass of the RTS. Two passes of the RTS seemed excessive in these conditions. Four stand counts were made with the last count on July 10. We were not able to detect a statistical difference in plant stand due to tillage. The no-till stand was 211,876 plants per acre, one pass yielded 203,745 plants per acre and two passes yielded 200,841 plants per acre. Similarly, we failed to detect a yield difference between tillage treatments (Table 2). At the Thelen Farm the plant stands were uniform but a lack of rain in July and August limited yields to near 32 bu. /ac. There were no residue related problems or delays at planting in any of the treatment areas.

Table 2. Harvest moisture and dry soybean yield (2013) following spring vertical tillage of corn residue with the Salford RTS (Thelen Farm) and the Great Plains Turbo-Till (Faivor Farm).

| | Thelen Farm, Clinton Co.* | | | Faivor Farm, Clinton Co.** | |
|---|---|---|---|---|---|
| Tillage | Harvest Moisture, % | Dry Yield, bu/ac | | Harvest Moisture, % | Dry Yield, bu/ac |
| No-Till | 14.2 | 32.3 a | | --- | 48.7 a |
| 1X Spring | 14.2 | 31.8 a | | --- | 47.5 a |
| 2X Spring | 14.3 | 32.6 a | | --- | 49.0 a |
| CV, % | | 5.7 | | | 4.1 |

The same tillage treatments were used at the Faivor Farm. Vertical tillage was with a Great Plains Turbo-Till and planting with a JD 750 no-till drill with a target population of 160,000 plants per acre. Soybeans were planted on May 18. The first stand count was on May 31 and the one-pass treatment (132,481 pl/ac) was significantly greater than no-till (119,355 pl/ac) but there was no difference in plant population between the one-pass and two-pass treatment (130,680 pl/ac; Table 2). The final stand count was on June 7 and the two pass treatment (141,193 pl/ac) stand was significantly greater than no-till (129,286 pl/ac) but there was no significant difference between no-tillage and one pass (135,501 pl/ac), or one pass and two passes.

Similar to at the Thelen Farm, we failed to detect a yield difference due to tillage in 2013. The Faivor Farm, just a few miles south of the Thelen Farm, benefitted from a few timely rains throughout the summer and yields were about 48 bu/acre. There were no residue related problems or delays at planting in any of the treatment areas.

In 2014, the same tillage treatments were repeated at a different location at the Faivor Farm. Following tillage in the spring corn residue was significantly reduced (about 33%) compared to no tillage, but there was little difference between one and two passes with the tillage tool (Fig. 2). Following planting the stand population at the first stand count was significantly greater with no tillage, presumably due to improved seed-to-soil contact in the dry soil (Fig. 3). In the later stand counts there was little difference in plant population due to tillage.

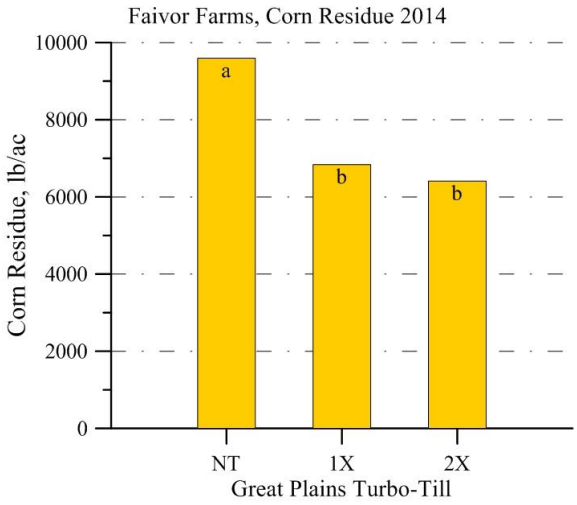


**Figure 2. Residue reduction from tillage at the Faivor Farm in 2014.**

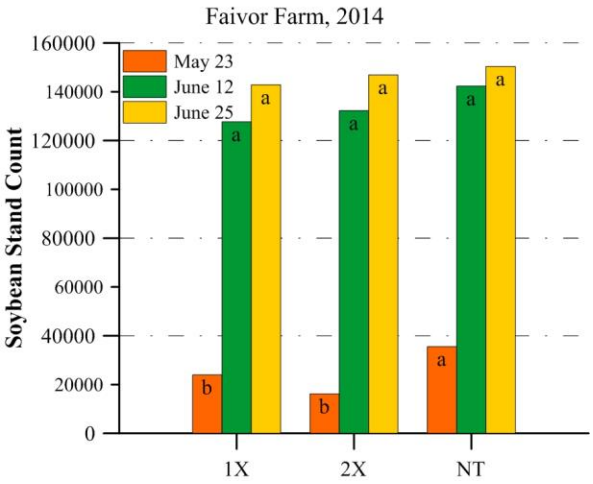


**Figure 3. Plant stand at the Faivor Farm in 2014.**

There was no significant difference in soybean yield due to tillage at the Faivor Farm in 2014.

Table 3. Soybean yield at the Faivor Farm in 2014.

| | Faivor Farm, Clinton Co.** | |
|---|---|---|
| Tillage | Harvest Moisture, % | Dry Yield, bu/ac |
| No-Till | 11.5 | 48.7 a |
| 1X Spring | 11.5 | 47.5 a |
| 2X Spring | 11.5 | 49.0 a |
| CV, % | | 4.1 |

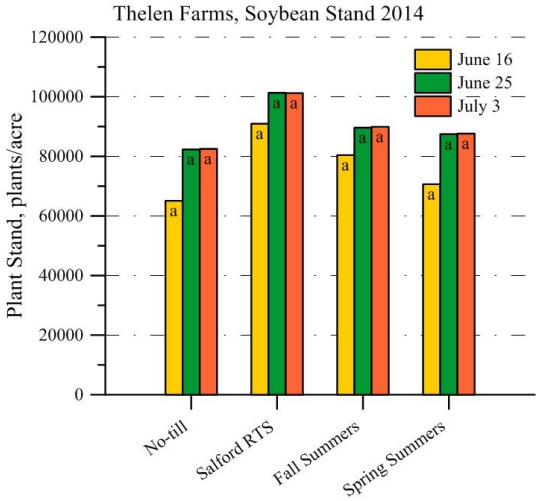


**Figure 4. Plant population at the Thelen Farm, 2014.**

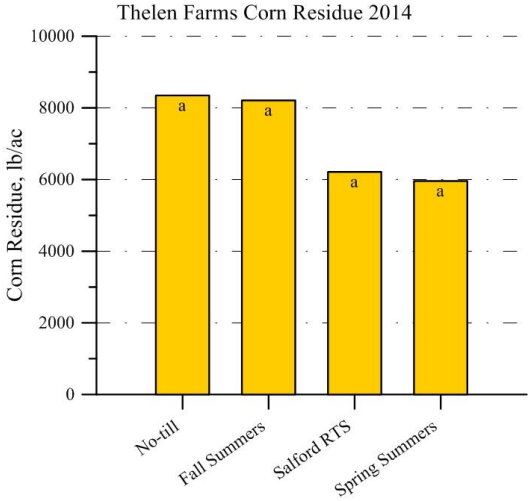


**Figure 5. Corn residue reduction at the Thelen Farm, 2014.**

In 2014, the selection of tillage treatments was expanded at the Thelen Farm to include: 1) no-tillage, 2) Salford RTS in the spring, 3) Summers Supercoulter, one pass in the spring, and 4) Summers Supercoulter, one pass in the fall. There was no significant reduction in corn residue in the fall compared to no tillage following a single pass of the Summers Supercoulter (Fig. 5). Spring tillage reduced corn residue about 25%, a significant reduction with both the Salford RTS and the Summers Supercoulter but there was little difference in residue reduction between the two tillage tools (Fig 4).

There was a mechanical problem affecting planter unit down pressure at the Thelen Farm in 2014 resulting in a lower final stand than planned. Planting was delayed due to wet field conditions. We were unable to detect significant differences in soybean yield due to tillage (Table 4).

Table 4. Soybean yield at the Thelen Farm, 2014.

| | Thelen Farm, Clinton Co.* | |
|---|---|---|
| Tillage | Harvest Moisture, % | Dry Yield, bu/ac |
| No-Till | 11.5 | 48.3 a |
| Salford RTS, 1X Spring | 11.5 | 50.7 a |
| Summers Supercoulter, 1X Spring | 11.5 | 49.5 a |
| Summers Supercoulter, 1X Fall | 11.5 | 48.9 a |
| CV, % | | 3.1 |

*Sandborn Farm*

An additional farm with two additional field sites was added to the project in 2014. Sandborn Farms is located near Portland, MI. In one of the fields, soybeans were planted after a burn-down cereal rye cover crop. In the second field, soybeans were planted in corn residue. In the burn-down rye field there were three replications of 1) no tillage, or 2) one pass with a Case-IH 330 Turbo in the spring. In the corn residue field there were four replications of the same tillage treatments.

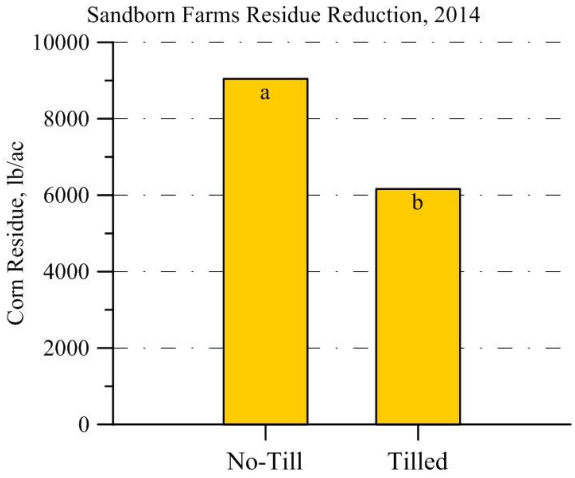


**Figure 3. Corn residue reduction at the Sandborn Farm, 2014**

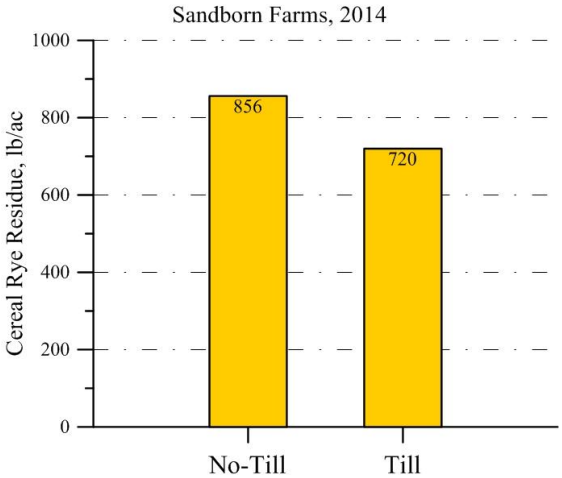


**Figure 2. Cereal rye residue reduction at the Sandborn Farm, 2014.**

Spring tillage with the Case-IH 330 Turbo led to a 33% reduction in corn residue and a 16% reduction in cereal rye residue. The cereal rye residue was very light and although uprooted by the tillage tool it tended to land on top of the tilled soil.

The plant stand in each field tended to be greater following a single pass of the tillage tool but the magnitude of increase was not statistically significant (Figures 6 and 7).

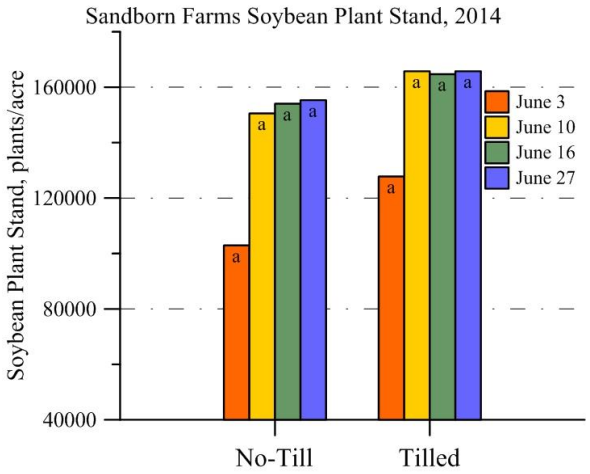


**Figure 6. Soybean plant stand in corn residue, 2014**

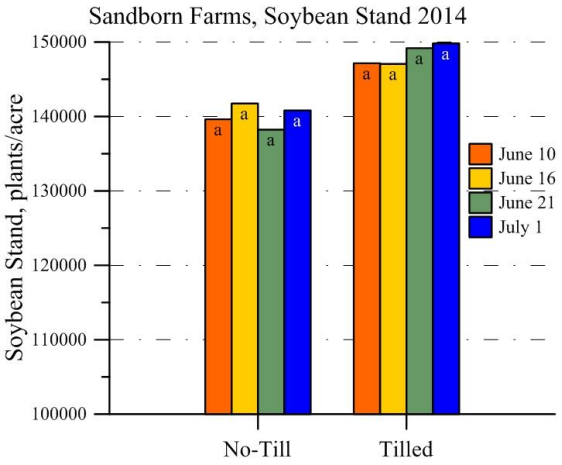


**Figure 7. Soybean stand in burn-down cereal rye, 2014.**

We were not able to detect significant differences in yield soybean yield in either of the Sandborn Farm fields (Figures 8 and 9).

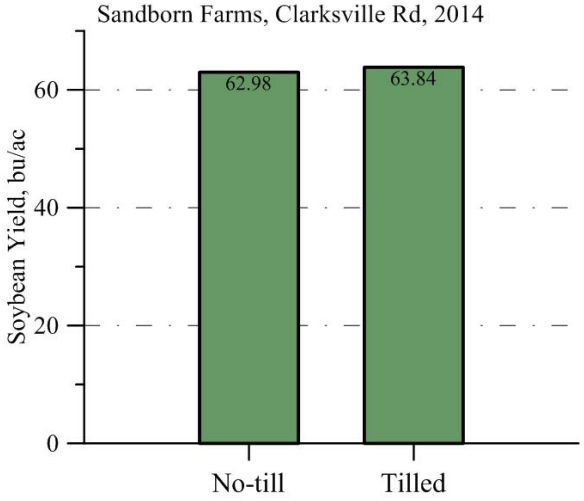


**Figure 8. Soybean yield following vertical tillage in corn stubble, 2014**

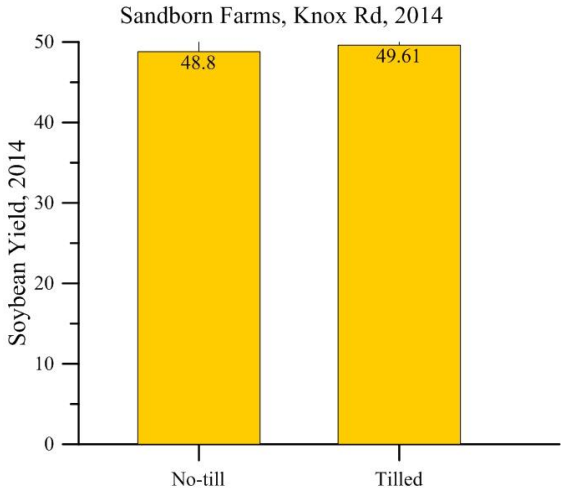


**Figure 9. Soybean yield following vertical tillage of a burn-down cereal rye cover crop, 2014.**

*Voisinet Farm*

The objective at the Voisinet farm in Clinton Co. was to evaluate the impact of vertical tillage with a Case-IH 330 Turbo on cereal rye cover crop stand compared to broadcast alone. The seed was broadcast with 10-12-12 in soybean stubble. Four replications of three tillage treatments

were made in full field strips: 1) no tillage, 2) one tillage pass, and 3) two tillage passes. In 2013 the seed and fertilizer application was done in the morning in mid-October with the tillage the same day. It rained that evening providing perfect conditions for a rye cover crop. The cereal rye aboveground biomass was sampled at three locations in each strip on May 6, 2014 and then sprayed and tilled within a few days. Cereal rye biomass in the one-pass tillage treatment was significantly greater (Figures 10 and 11) than the no tillage treatment, but there was no difference between one and two tillage passes. We did not detect significant differences in plant tissue nitrogen due to tillage treatment (Fig 12).

In 2014, the cover crop was seeded in late October with the same tillage treatments as in 2013.

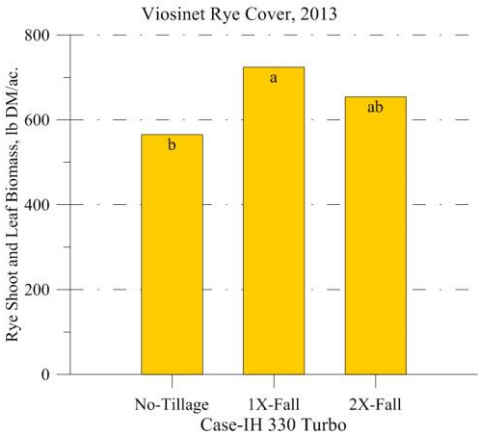


**Figure 5. Cereal rye cover crop biomass, 2013.**

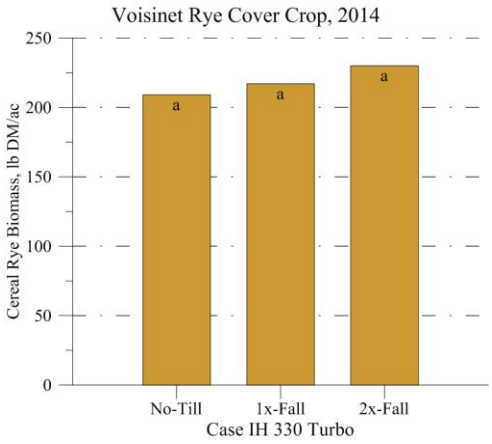


**Figure 4. Cereal rye cover crop biomass, 2014**

There was no detectable difference in nitrogen uptake by the cereal rye cover crop due to tillage.

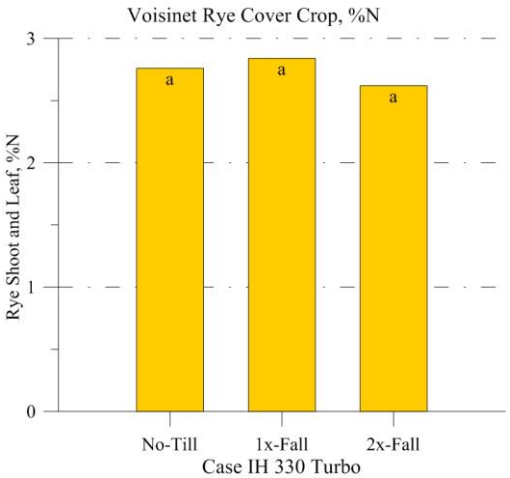


**Figure 7. Cereal rye nitrogen content, 2013.**

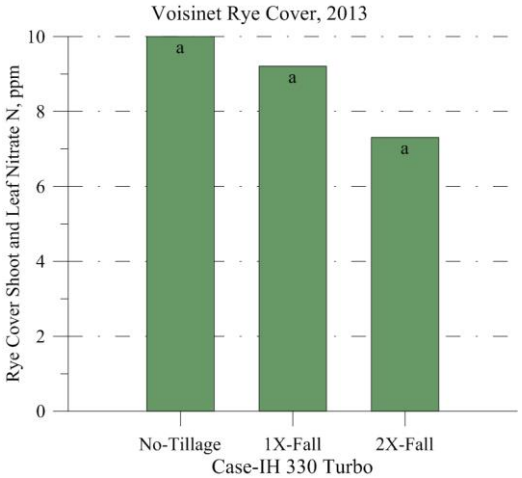


**Figure 6. Cereal rye nitrogen content, 2014.**

*Summary and Conclusions*

Despite technological and agronomic advances, corn and soybean growers are concerned that excessive corn residue is increasingly slow to breakdown and decompose. Excessive corn residue interferes with drill and planter performance and leads to poor and uneven germination and emergence, delayed dry down, and reduced yield and profitability. Some growers claim that GE corn stalks are larger, remains green longer, and breaks down slower than conventional varieties. Some suspect the *BT* varieties are more resistant to microbial breakdown, but differences may simply be due to healthier plants and less insect damage. The objective of this work was to evaluate the role of vertical tillage on corn residue breakdown, soybean emergence and final stand, soybean yield and other key measures of crop progress.

- Based on the results of ten field trials with a variety of vertical tillage tools, vertical tillage of corn residue in the spring or fall did not improve soybean emergence, final stand or soybean yield.
- Fall vertical tillage sized and knocked down corn residue, but it did not lead to a reduction in the volume (lb. /acre) of surface residue at planting time the following spring.
- Spring vertical tillage reduced corn residue 25 to 33% compared to untilled corn residue.
- There was little benefit from two passes with a vertical tillage tool in the fall or spring compared to a single pass in the spring.
- A single pass with a vertical tillage tool can improve a cereal rye cover crop emergence and uniformity in dry conditions, or in firm or trafficked soil with little residue cover.
- Vertical tillage tools vary in their ability to till and loosen the soil, and to cut and size corn residue. On fine-textured soils that respond favorably to tillage, aggressive, fluted coulters or tillage implements with gang angles greater than zero will size crop residue and increase soil loosening and lateral movement.
- If shattering and sizing corn residue is the primary goal, less aggressive coulters and toolbars with a reduced gang angle and an attachment such as a rolling spike harrow can distribute residue evenly while reducing tillage intensity.