SMART-TILL Soil Management Tool

Field Tests Validate What Farmers Are Experiencing

By Daniel Davidson, Ph.D., Agronomist

Soil management tools have become popular the last decade, because they allow farmers to process crop residue and loosen and aerate the soil without doing full-width tillage. Full-width horizontal tillage can damage soil structure and lead to erosive soil losses.

What do all soil management tools have in common? They cut and size residue without moving the soil horizontally like a disk, field cultivator, or soil finisher. However, the SMART-TILL is one of the few soil management tools that loosens and aerates the soil vertically to remove any compaction, improve soil structure, and stimulate soil health.

The SMART-TILL's specially angled tines, adjustable gang angle, and rolling harrow attachment vertically fracture the soil and residue, so it decays while it's tied down to the soil and doesn't blow or move. Along the way, the SMART-TILL can enhance the biology of your soil, which results in better crop performance.

HCC, Inc. set out to evaluate the agronomic performance of the SMART-TILL system by comparing it against different tillage methods and looking at chemical, physical, and biological aspects of the soil, residue management, and yield. In 2013, we conducted a project in Stanton County, Nebraska, and compared a single pass of the SMART-TILL (Model ST151) with rolling harrows against a no-till plot, single pass with a Case IH 430 tandem disk, single pass with an Aerway without rolling harrows, and single pass with a Salford RTS HD Extreme (Independent 4100).

Tillage passes were made two weeks before soybeans were planted in 30-inch rows at 180,000 seeds per acre. The soil was a silty loam to clay loam, calcareous in nature with a high pH (greater than 7) and a tight structure. To make sure the results were reliable, the five tillage treatments were randomized and repeated across five replications, and strips were half-mile runs.

The objective was to scientifically validate many of the benefits that farmers realize when they adopt the SMART-TILL, as well as uncover additional elements that benefit the crop and soil.

SMART-TILL®

HCC, inc.

Yield Results

In 2013, the weather was moderate with above average rainfall and below normal temperatures, and yields were above average. When it comes to evaluating technologies to manage stress and improve plant and soil productivity, weather is always the great equalizer. The better the season, usually the smaller the yield difference; so when treatments separate in very good years, this further validates the value of technology.

The SMART-TILL plots (average of five plots) yielded 76.7 bushels per acre and out-yielded no-till plots by six bushels (70.3 bushels per acre). The other tillage treatments yielded significantly less. The SMART-TILL had a beneficial impact on the soil, which resulted in a better stand and greater yield. This project set out to identify some of those underlying factors that contribute to greater crop performance.

Tillage tools of any type impact soil's physical properties and influence residue management and crop emergence. Many farmers till to manage residue and get a better stand that emerges quicker, something that can be problematic with no-till. And soil management tool manufacturers also want to emulate no-till as close as possible, leaving the residue intact on the surface and not disturbing the soil structure below the surface.

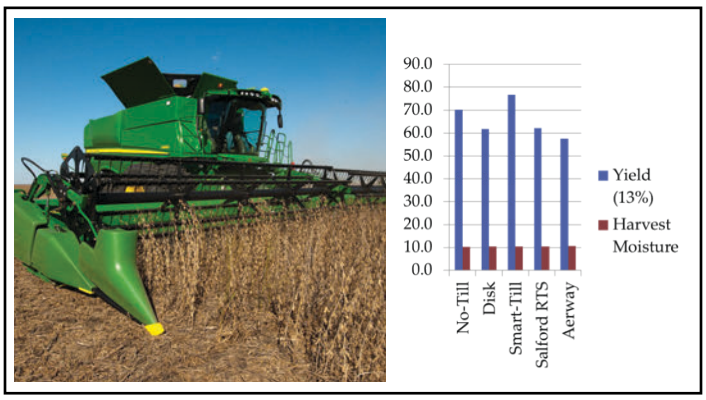

FIGURE 1.

- **SMART-TILL plots out-yield no-till plots and tillage treatments.**
- **Yield was measured with a yield monitor and validated by grain cart scales (within 1%).**

Residue Management

The biggest selling point of soil management tools has always been processing residue by cutting, sizing, and tying it down with soil. The SMART-TILL, with its rolling tines and harrow, processes residue in a unique fashion that effectively gets the residue to decay quickly even though it doesn't cut residue into even segments like other rigs do. Instead the tines cut and fracture the residue; the harrow shears and breaks open the stalks and covers residue with a little dirt to tie it down.

One of the goals of no-till is to keep as much residue on the surface as possible. One pass with the SMART-TILL left much of the residue, and 73% of the soil surface was covered. Under no-till, 87% of the surface was covered. Conservation or minimum tillage has a goal of leaving 30 to 70% of the surface covered with residue, and no-till has the goal of covering 70 to 90% of the soil surface. More than 70% of the field surface was covered after the SMART-TILL pass. More residue means the soil is better protected from the weather elements including rainfall, temperature, and wind.

One of the reasons growers run a disk or finishing tool is to open the soil, so it warms and dries faster and creates a better seedbed. The SMART-TILL not only vertically tills the profile but creates a loose profile and seedbed that leads to quicker germination, a better stand, and fuller rooting.

Soil conditions and residue can impact seedling emergence and plant stand consistency. The goal is to get every seed to germinate and emerge at the same time. Soybeans were seeded at 180,000 seeds per acre, and the average plant count at the V2 to V3 leaf stage was 173,000 for the SMART-TILL compared to 140,000 for tilled plots and only 115,000 for no-till. The SMART-TILL created better seedbed conditions leading to a better plant stand.

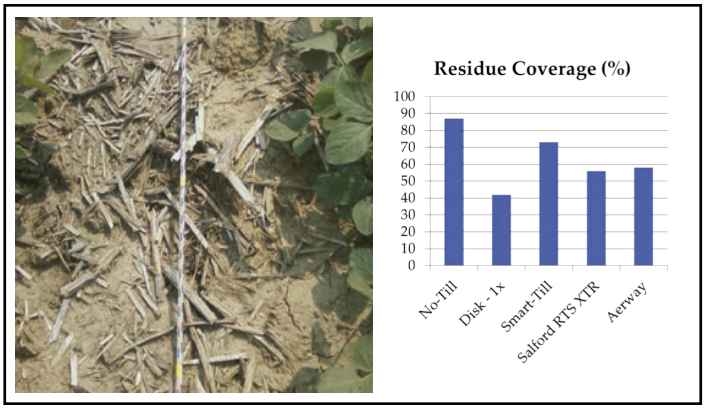

FIGURE 2.

- **According to the rope test, the SMART-TILL left more residue intact on the soil surface than other tillage passes.**
- **With the rope test, you record if the rope touches residue every 12 inches in a 100-foot run.**

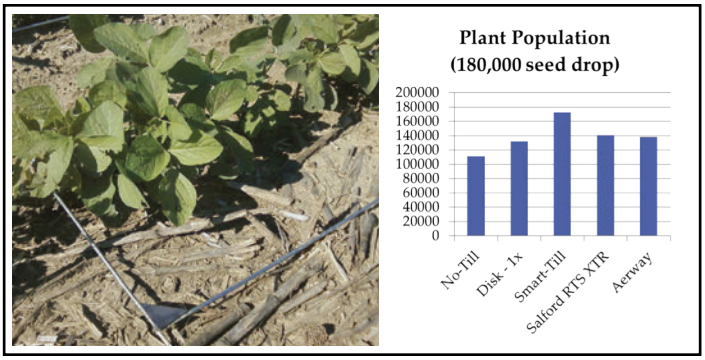

FIGURE 3.

- **The SMART-TILL improved plant population over no-till and other tillage passes.**
- **To measure population, we crafted a square yard quadrant and counted the number of plants in a single row then multiplied by 14,520. This was repeated five times then averaged.**

Soil Improvements

The SMART-TILL can aerate the soil, break up crusting on the surface, and reduce compaction beneath the surface. It can loosen the soil and re-aggregate particles into a better structure for aeration, drainage, and increased root growth.

Soil penetration readings were measured by a penetrometer with readings measured in psi (pounds-per-square-inch pressure to penetrate the soil) and taken at 3-inch depths from 3 to 24 inches. Lower psi readings mean the probe was easier to push in the soil and reflect less density. The SMART-TILL was easier to push through the soil at 3 and 6 inches compared to other treatments, including no-till. However, by 9 inches (below the depth of the SMART-TILL tines) penetration resistance was no different than the other treatments. What is most noteworthy is that no-till had the highest penetration resistance of all treatments, which reflects a very dense soil even after 12 years of continuous no-till.

One of the goals of no-till is to improve soil structure and increase aeration and water infiltration compared to tilled fields. Tillage is known to destroy soil structure and reduce aeration and infiltration. The SMART-TILL's novel fracturing action loosens the soil without any horizontal or vertical movement whereas mechanical sheer forces and pressure increase soil density.

Bulk density is an indicator of soil compaction and porosity. The ideal bulk density for silts, loams, silty clays, and clay loams ranges from 1.0 to 1.4 grams per cubic centimeter. When it reaches 1.6 it can begin to restrict root growth. The SMART-TILL reduced bulk density slightly to 1.04, reflecting less soil density than no-till at 1.07 and staying closest to the density of the soil under the fence line at 0.97.

With the SMART-TILL, you can improve water infiltration immediately, and it helps the soil hold more water, which is especially important in a dry year. The SMART-TILL reduces soil density in the top 6 to 8 inches of soil, and this increases water infiltration rate initially until the upper soil profile is full. However once the profile is full, water infiltration slows down based on what the profile below 8 inches can absorb. After the SMART-TILL pass, the equivalent of 5.5 inches of water infiltrated in the first hour. No-till, disk, and the Salford averaged about 3 inches per hour; and the Aerway averaged 4 inches per hour.

The SMART-TILL fractures the soil, increasing porosity and improving structure without disturbing the residue on the surface or the profile. This improves water infiltration, so the soil can serve as a bigger reservoir and hold more water. However, none of the tillage treatments can change the natural water-holding capacity of the soil, which is a function of porosity, structure, and texture. The soil under the fence row contained 26% available water, and no-till plants had 19% compared to the SMART-TILL's 23%.

The SMART-TILL increases the size of the soil's water reservoir. With more reserves you have a greater tolerance to drought for a longer time period.

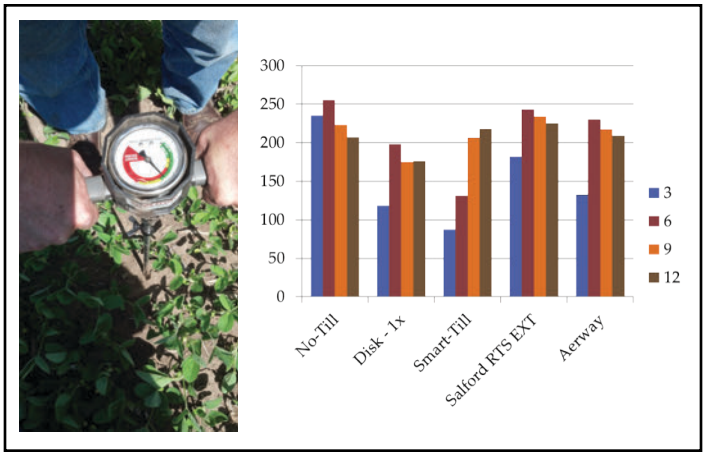

FIGURE 4.

- **Soil penetration readings taken with an analog compaction meter at depths of 3, 6, 9, and 12 inches.**
- **Penetrometer Reading**
  0-100 psi—excellent
  100-200 psi—good
  200-300 psi—dense
  More than 300 psi—compacted

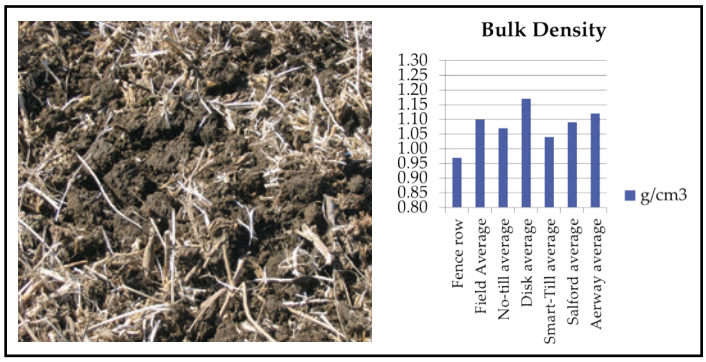

FIGURE 5.

- **The SMART-TILL reduced the bulk density of the upper 6 to 8 inches of the soil profile.**

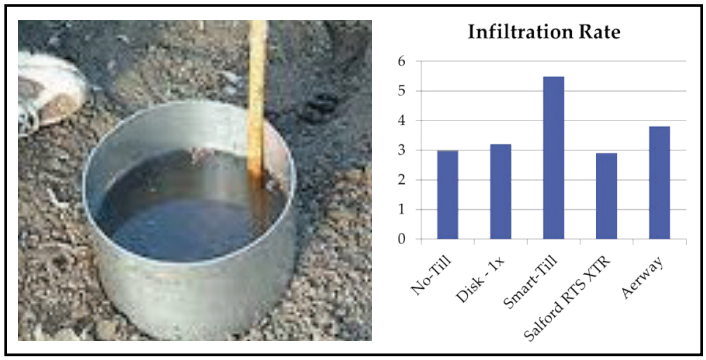

FIGURE 6.

- **Water infiltration measured with an infiltration ring two weeks after treatments applied and before planting.**
- **The greater the water infiltration rate, the more water the soil can absorb after a big rain event.**

Soil Health

Farmers are interested in improving the health of their soil and adopt practices like no-till and planting cover crops. The SMART-TILL can boost soil health, because it helps enhance structure and increases aeration and porosity. Soils that aerate and drain better will exchange more gases with the atmosphere and will be more biologically active.

Today we have techniques for measuring soil health. One of those techniques is the Solvita soil respiration test, also known as Soil Biological Respiration and Nitrification (BRAN) test. A healthier soil has more gas exchange that can be monitored through the 24-hour CO2 burst and nitrogen mineralization, which are both functions of microbial activity in the soil.

Organic matter levels were similar across the field but were higher in the fence row, as expected. The soil health score, CO2 burst, and nitrogen mineralization were greater in the SMART-TILL plots. They reflected greater biological activity, similar to the soil under the fence row and better than the no-till plots. Soil health scores of 3 to 3.5 indicate the soil is moderately balanced in terms of organic matter and microbial activity. Scores from 2.5 to 3.0 are marginal in terms of organic matter and biological activity. The greater the biological activity, the greater the nitrogen mineralization in season. That means you need to supplement with less nitrogen.

A SMART-TILL pass can improve on no-till conditions. Under no-till, the soil can compact from trafficking, reducing aeration porosity and infiltration while keeping the residue parked on the soil surface and stimulating soil biology below. A SMART-TILL is a good addition to any conservation or no-till system. It makes no-till work, and it makes good soil even better.

Treatment	Organic Matter %	Soil Health Score	24-hour CO2 Burst	Nitrogen Mineralization in lbs/A/year
No-till average	2.4	3.07	30.11	24.1
Disk average	2.1	2.72	22.34	17.9
SMART-TILL average	2.4	3.27	36.45	29.2
Salford average	2.3	2.97	28.10	22.4
Aerway average	2.4	3.18	33.50	26.8
Fence row	3.0	3.30	37.08	29.7

Table 1. Comparison of soil health measurements for the different treatments.

To learn more about SMART-TILL, visit www.smart-till.com.