Third Year of A Study in the Blacklands of Texas to Measure Differences in Soil Quality Characteristics with Three Tillage Systems and Three Cropping Rotations

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In cooperation with Texas A&M Stiles Research Center, Orthman Manufacturing, Inc. and USDA – Natural Resources Conservation Service (USDA-NRCS) dug into the third year of the long term cooperative evaluating soil quality characteristics. We collected specific physical measurements to better comprehend the soil quality changes in continued conservation tillage system applications. It is all three groups' intentions to inform folks of the changes rarely measured in adopting practices that will help growers significantly reduce erosional issues but gain soil capacity to yield better.

As we have said before, the common crops of the Blacklands are; cotton, corn, grain sorghum, wheat, and hay crops. The study near Thrall is a rotation of three row crops; cotton-corn-grain sorghum. This year we scientists from A&M, USDA-NRCS and Orthman measured water infiltration in the near saturated condition, soil porosity, bulk density, and aggregate stability of dry peds from the surface 1 inch soaked in water. All of these related studies offer growers a better idea what soil changes are affected by tillage and have some measurable way to gauge those changes.

Water infiltration is a standard method of measuring intake of rain or irrigation water into the soil surface in the predominantly downward flow. In Table 1, there are the results of what the scientists collected in the second week of May 2009 and the previous 2 years.

As we jointly collect this data throughout this three year study, we want to provide you a better understanding of the benefits and reasoning why less tillage is profiting growers all across Texas.

Fig.1 The photo to the left shows the Cornell Sprinkle Infiltrometer in the corn on cotton area of the crop and tillage rotation study on the Stiles Foundation Farm near Thrall, Tx. *Photo Courtesy Orthman Mfg*.

Table 1. Near saturated infiltration of Burleson clay, 0 to 2 percent slopes (see next page)
modified Robert Grossman, Ph.D method(USDA-NRCS) of H. van Es Method, Ph.D (Cornell Univ.)

3 Year Data from Stiles Foundation Farm - Near Saturated Hydraulic Conductivity of Burleson silty clay soils 2007-2009

Sorghum/Cotton Cropping Rotation

Tillage Type	2009in/hr - hard	2008in/hr - hard	2009in/hr- soft	2008in/hr- soft	2007in/hr - hard	2007in/hr- soft
ConvTill	1.05	0.28	2.38	1.05	NA	NA
Strip-Till	2.78	1.20	1.25	1.74	NA	NA
DirectSeed	0.61	0.23	1.86	0.92	NA	NA

Corn on Corn Cropping Rotation

Tillage Type	2009in/hr - hard	2008in/hr - hard	2007in/hr - hard	2009in/hr- soft	2008in/hr- soft	2007in/hr- soft
ConvTill	2.58	0.57	0.29	1.58	5.15	0.33
Strip-Till	14.88	11.27	0.34	3.06	0.62	0.37
DirectSeed	0.60	0.27	0.95	2.13	1.45	0.83

Corn on Cotton Cropping Rotation

Tillage Type	2009in/hr - hard	2008in/hr - hard	2007in/hr - hard	2009in/hr- soft	2008in/hr- soft	2007in/hr- soft
ConvTill	1.62	0.64	0.11	0.30	1.99	0.36
Strip-Till	1.22	0.87	0.38	1.21	0.81	0.55
DirectSeed	0.17	0.47	0.29	1.21	1.31	0.68

Note: Intake rates >3.0 in/hr are evidence of soil cracking below 3 inch depth that did not seal during the pre-soak period.

Main Observors: Mike Petersen (Orthman Mfg.), Dennis Neffendorf, Andy Spencer (USDA-NRCS and Archie Abrameit-Texas A&M

Fig. 2 Ring for infiltration is 9.5 inches in diameter, observing different sizes of soil pores. Dime offers reference of some of the 2 to 5mm pores pointed out by red arrows.

Porosity

Another measurement to help understand the intake rate of the Burleson soil, is pore size and space, these scientists observed three different pore sizes of a large ped of soil from the 2 to 6 inch zone in the surface horizon. The pores were counted by the use of hand lenses, using the standard pore size classes from the Field Book for Describing & Sampling Soils, National Soil Survey Center, USDA – Natural Resources Conservation Service, 1998.

The reasoning behind counting of pores in the 2 to 6 inch zone of the same area where the infiltration studies are taken is to correlate how fast or slow water penetrates to fill the remaining portion of the soil profile and get needed water to the roots. The more pores, the faster response to the plant root to take up moisture.

Table 3. Observable soil pores in surface 2 to 6 inch zone for all three years of Stiles Study 2007-2009

Observations at 2 to 6 inch level of 1 sq. decimeter. We observe 3 1-decimeter clods from each row. Values are then averaged.

Corn on Corn		Strip-Till			No-Till			Conv.Till		
	Size	2007	2008	2009	2007	2008	2009	2007	2008	2009
hard row	0-1mm	149	187	82	183	281	77	65	75	48
	1-2mm	0	3	16	2	3	10	2	2	6
	2-5mm	0	3	4	0	0	3	1	0	4
soft row	0-1mm	196	236	171	101	230	142	43	171	80
	1-2mm	6	7	41	4	5	12	1	14	5
	2-5mm	3	0	3	0	0	2	1	0	5

Corn on Cotton ... 2008 is the cotton year

		Strip-Till			No-Till			Conv.Till		
	Size	2007	2008	2009	2007	2008	2009	2007	2008	2009
hard row	0-1mm	NA	228	116	NA	208	77	NA	122	44
	1-2mm	"	4	16	"	2	13	"	2	8
	2-5mm	"	0	5	"	0	2	"	0	2
soft row	0-1mm	"	337	81	"	89	98	"	107	73
	1-2mm	"	9	8	"	10	21	"	4	17
	2-5mm	"	2	5	"	2	6	"	0	5

Cotton on Grain Sorghum --- 2008 is cotton year

		Strip-Till			No-Till			Conv.Till		
	Size	2007	2008	2009	2007	2008	2009	2007	2008	2009
hard row	0-1mm	NA	103	128	NA	171	112	NA	65	77
	1-2mm	"	2	26	"	3	17	"	0	19
	2-5mm	"	1	3	"	0	3	"	0	3
soft row	0-1mm	"	145	194	"	275	129	"	110	70
	1-2mm	"	11	15	"	0	40	"	0	28
	2-5mm	"	4	6	"	0	2	"	0	1

Note: NA - not available

Note: 10x hand lenses are used to observe the different classes and sizes of pores; 1- decimeter clod or ped is 4 inches x 4 inches square (10cm x 10cm). NA – not available

Aggregate Stability Data

As scientists take aggregate stability samples, a major point of reference is how well will soil aggregates hold up to rainfall impact and cutting winds across the soil surface. It also indicates the health of the soil which we have known in another term – soil tilth. Can a soil hold up to forces from cultivator shovels, chisel points, disc blades going across the soil and turning/churning? If soil has enough gluing agents, organic

matter, roots – all holding the particles of soil (sand, silt, and clay) together the soil will have better aggregate stability. Another term for resistance to multiple passes from tillage tools is, – soil resilience.

The following table depicts what we have observed in 2008 and 2009 in the tillage and crop rotation treatments at the Stiles Research Farm.

Table 4.

Aggregate Stability Test

this test is run on the surface 1 inch soil material; a subjective determination of how well soil peds stand up to rain drop impact and wind resorting

We observe 10 small peds from each row in water.

Ratings with numeric values 1 to 5, 5 most stable, 1 not stable

Sampling methodology - Dr. Robert Grossman, USDA-NRCS Nat'l Soil Laboratory, Lincoln, NE

Corn on corn rotation		**Yr sampled-2008**		**Yr sampled-2009**	
Tillage type	row	avg value	range	avg value	range
Strip-Till	hard	2.8	1 - 5	1.6	0-3
	soft	4.4	3 - 5	4.2	1-5
No-Till	hard	2.6	1 - 5	3.3	1-5
	soft	4.6	3 - 5	3.5	1-5
Conv. Till	hard	3.5	1 - 5	2.4	0-4
	soft	3.0	2 - 4	1.7	0-5
Grain sorghum on cotton					
Strip-Till	hard	1.2	0 - 1	0.6	0-2
	soft	2.0	0 - 4	1.9	0-4
No-Till	hard	0.9	0 - 2	2.2	0-4
	soft	2.0	0 - 3	1.3	0-5
Conv. Till	hard	0.1	0 - 1	0.3	0-1
	soft	0.4	0 - 1	1.7	1-4
Cotton on corn					
Strip-Till	hard	2.8	0 - 4	0.6	0-2
	soft	3.1	1 - 5	1.5	0-5
No-Till	hard	2.8	0 - 5	0.9	0-5
	soft	2.6	1 - 4	1.1	0-5
Conv. Till	hard	2.5	0 - 4	0.4	0-1
	soft	1.1	0 - 2	2.0	0-5

Table 5. Bulk Density Compared 2007 to 2009 in Two Crop Systems – Stiles Farm

Tillage Type	**B.D. (g/cm^3)**	**B.D. (g/cm^3)**	B.D. Diff.	**Tillage Type**	**B.D. (g/cm^3)**	**B.D. (g/cm^3)**	B.D. diff.
Corn-on-corn	2007	2009		***Corn-on-cotton***	2007	2009	
ConvTill - hard row#1	1.693	1.639	0.054	*ConvTill - hard row#1*	1.578	1.593	-0.015
ConvTill - hard row#2	1.669	1.691	-0.022	*ConvTill - hard row#2*	1.647	1.654	-0.007
ConvTill - soft row #1	1.472	1.485	-0.013	*ConvTill - soft row #1*	1.370	1.426	-0.056
ConvTill - soft row #2	1.514	1.512	0.002	*ConvTill - soft row #2*	1.651	1.663	-0.012
StripTill - hard row#1	1.603	1.576	0.027	*StripTill - hard row#1*	1.733	1.654	0.079
StripTill - hard row#2	1.466	1.459	0.007	*StripTill - hard row#2*	1.728	1.618	0.110
StripTill - soft row#1	1.504	1.468	0.036	*StripTill - soft row#1*	1.545	1.502	0.043
StripTill - soft row#2	1.537	1.459	0.078	*StripTill - soft row#2*	1.497	1.463	0.034
NoTill - hard row#1	1.377	1.421	-0.044	*NoTill - hard row#1*	1.664	1.661	0.003
NoTill - hard row#2	1.620	1.633	-0.013	*NoTill - hard row#2*	1.600	1.633	-0.033
NoTill - soft row#1	1.720	1.702	0.018	*NoTill - soft row#1*	1.522	1.520	0.002
NoTill - soft row#2	1.351	1.349	0.002	*NoTill - soft row#2*	1.505	1.498	0.007

Discussion of Data….

Infiltration: To nearly all farmers, you already know that water penetrates clayey textured soils much slower than sandy soils; i.e. sandy loams have an infiltration rate of 1.25-1.50 inches per hour (in hr^{-1}), and clays, silty clays 0.25 in hr^{-1} or less. Our reasoning to continue observing water infiltration in the hard and soft rows is to evaluate the controlled traffic process the Stiles Farm is taking until they can obtain RTK guidance. As we look at what occurred for the last three years, we have observed that the more leftover fibrous root system of the corn after cotton is depicting advantages to water infiltration in the strip-till and direct seeding tillage systems in continuous corn and corn on cotton. As the Stiles Foundation Farm is managed with less tillage and now utilizing strip-till, the soils gain porosity, action from worms, old root channels and less tillage to create an ideal seedbed. Water intake trends for the Strip-Till continuous corn compared from ’07 to ’09 is surely up. Direct Seeding (No-Till) in the continuous corn is much the same, a good upward trend. Conventionally tilled in 2008 was better and then in 2009 dropped and was slower. This is apparent in both the hard rows and soft rows. In the sorghum on cotton rotation we see each year in the hard rows the infiltration improved. In the soft rows it is a mixed bag, conventional and direct seeding improved and strip-till was lower.

Porosity*:* Looking at the number of pores in Table 3; we wish we had better information to share that a trend was evident that all was improving. No we cannot do that. The open winter and drying effects in all of the rotations could be the reasoning why the <1mm pore counts are way down in all tillage types 2009 and hard row versus soft row compared to 2008. The overall crop yields were down in 2008 when the rain essentially stopped in June and crops finished poorly.

Aggregate Stability: In Table 4, we look at the 2008 to 2009 data the soil aggregate stability ratings(averages) are generally down in all three tillage types across the three crop rotations. Again that may be explained due to the dryness of the 2008-09 winter months. It also can be considered when we switched from a cotton year in 2008 to corn or grain sorghum in 2009, that with reduced overall residue with a cotton crop that soil aggregates are affected. In the continuous corn however the average values of stability in the strip-till and direct seeding are up and down. Residues left over are very important to soil quality and soil tilth.

Bulk Density: In Table 5, we wanted to look at the density when we started and how it looked 2 years later. It is noticeable that the Direct Seeding plots and strip-till plots yielded improvements but ever so slight. The soft rows show a bit more than the hard rows. Bulk density changes are very slow in heavy textured soils unless a heavy impact from trucks or grain carts or boll buggies have crossed a field when wet.

Inferences

In this 3 year study, we are seeing bulk density values remain high, we stabbed the ground with a Dickey-John hand penetrometer in many locations giving us all good indication that the compaction issue has not gone away. Soil compaction in the 6 to 9 inch zone is prevalent and is a limiting issue for water movement, root development and less than stellar air/gas exchange for roots.

Water absorption is slow in these clayey soils due to the low resident organic matter and with warmer soil temperatures (thermic soil temperature regime), and with open winters the crop aftermath/residue oxidizes readily. Soil organic matter (SOM) is a great component to helping soils absorb water since it acts like a sponge. SOM is the food source for microbes and other soil borne insects which help soils breathe, digest the crop residues, and release to the roots macro and micro nutrients. The Stiles Farm will continue to reap benefits from this rotation to leave residues on the soil surface and add to the low resident organic matter of

the Burleson-type soils. The more clayey Vertisols of the Stiles Farm show changes slowly. We believe this study is proving that to be true.

Limiting the tillage passes and cultivation during the growing season as with Direct Seeding and Strip-Till does help. Our measurements bear that out. However habits and old grandparent tales of need to oxygenate by soil stirring fade very slowly. By being students of the underground and soils, we can see that improper use of wide spread tillage has been hurtful to the soil life and response to water infiltration. In very heavy soils, wise vertical-type tillage has its place and we are carrying observations to gain the why and how much benefit it offers. No doubt, Direct Seeding has a lot of merit. In Black Cotton soils of Texas it remains to be seen if it will always be best. In the Fig. 3 we have a chart to track what the trends may be in the hard and soft rows using average infiltration values from the data over the years of 2007-2009. As one may observe, the Strip-Till approach appears to be improving, the Direct Seeding approach is up and then a small drop off. The conventional tillage approach may be climbing in the hard rows and then all over the board in the soft rows with this corn on cotton rotation. We do watch the economic side of things with these studies also, and that is what others report on with the yields and input costs. This day and age economics are a priority in making farming/management decisions for the grower. Better methods to fertilize enter the management picture also and strip-till really offers that.

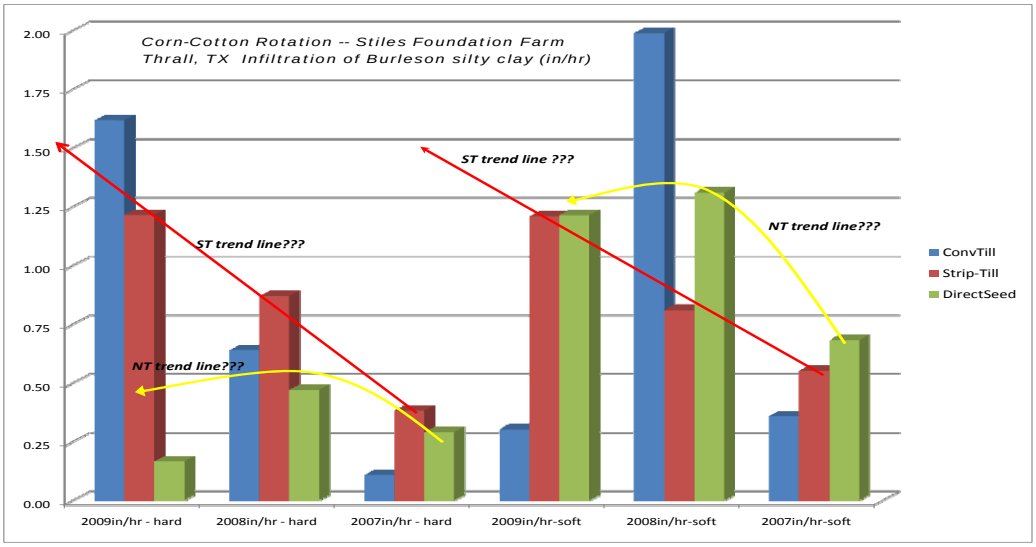

Figure 3. An evaluation of Infiltration in one of the three crop rotations with three tillage options: Direct Seeded, Strip-Till and Conventional Broad-acre tillage. Potential trend lines exhibited for Strip-till and Direct Seeded crops.

We do urge you all to carry out a good soil testing/sampling program with any tillage system you use. But moisture via rainfall or irrigation is so important, and getting that water into the soil to feed the roots is of prime importance. Roots absorb over 98% of all the plants needed water to grow and produce grain, fiber, or fruit. With a poor or insufficient rooting profile, well – yields suffer. A better rooting system will give you the steward/farmer the chance to reap more come harvest time.

Keep watching how this study progresses. All three groups of scientists, Orthman, USDA-NRCS and Texas A&M are considering how long this study will go on. The jury is not out of the courthouse yet.

We do want to thank the Stiles Foundation Farm and Texas A&M for the support and working with us as we carry out this long term study.