Fourth Year of A Study in the Blacklands of Texas to Measure Differences in Soil Quality Characteristics with Three Tillage Systems and Three Cropping Rotations Years 2007-2010

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In cooperation with Texas A&M Stiles Research Center, Orthman Manufacturing, Inc. and USDA – Natural Resources Conservation Service (USDA-NRCS) watered, dug holes, checked and rechecked soil quality characteristics to finalize this study. 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.

This report will be a bit specific to soil characteristics and how tillage interactions can make a difference to how soils respond and water moves. The information is sound and we encourage you to download it and read. Feel free at the end of this report on page 6 to contact the author via e-mail.

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 last week of May 2010 and the previous 3 years.

As we jointly collect this data throughout this four 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.)

4 Year Data from Stiles Foundation Farm - Near Saturated Hydraulic Conductivity

of Burleson silty clay soils 2007-2010 Readings are average of the 10-15 readings per site

Sorghum/Cotton Cropping Rotation GS-2010/Cott-2009

Tillage Type	2010in/hr - hard	2009in/hr - hard	2008in/hr - hard	2007in/hr - hard	2010in/hr - soft	2009in/hr- soft	2008in/hr- soft	2007in/hr- soft
ConvTill	0.53	1.05	0.28	NA	0.66	2.38	1.05	NA
Strip-Till	1.50	2.78	1.20	NA	4.45	1.25	1.74	NA
DirectSeed	7.06	0.61	0.23	NA	1.68	1.86	0.92	NA

Corn on Corn Cropping Rotation

Tillage Type	2010in/hr - hard	2009in/hr - hard	2008in/hr - hard	2007in/hr - hard	2010in/hr - soft	2009in/hr- soft	2008in/hr- soft	2007in/hr- soft
ConvTill	0.49	2.58	0.57	0.29	1.08	1.58	5.15	0.33
Strip-Till	10.89	14.88	11.27	0.34	1.52	3.06	0.62	0.37
DirectSeed	0.36	0.60	0.27	0.95	0.48	2.13	1.45	0.83

Corn on Cotton Cropping Rotation Cotton-2010/Corn-2009

Tillage Type	2010in/hr - hard	2009 - hard row	2008 - hard row	2007- hard row	2010in/hr - soft	2009 -soft row	2008 -soft row	2007 -soft row
ConvTill	0.66	1.62	0.64	0.11	3.00	0.30	1.99	0.36
Strip-Till	0.50	1.22	0.87	0.38	1.14	1.21	0.81	0.55
DirectSeed	0.13	0.17	0.47	0.29	0.34	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. Pre-soak period was 24 hrs, added 12 to 60L of water.
Main Observors: Mike Petersen (Orthman Mfg.), Dennis Neffendorf, Andy Spencer (USDA-NRCS) Archie Abrameit (Texas A&M)

Fig. 2 Method to test water stable aggregates of the surface 1 inch of the soils in each rotation. Sampling procedure was 15 samples per site. See Table 4.

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 2. Observable soil pores in surface 2 to 6 inch zone for all three years of Stiles Study 2007-2010

Stiles Farm Field Research - Soil Quality Items May 2007 thru May 2010
Porosity
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 (Direct Seeding)				Conv.Till			
	Size	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
hard row	0-1mm	149	187	82	91	183	281	77	80	65	75	48	53
	1-2mm	0	3	16	14	2	3	10	23	2	2	6	4
	2-5mm	0	3	4	2	0	0	3	2	1	0	4	1
soft row	0-1mm	196	236	171	198	101	230	202	201	43	171	80	86
	1-2mm	6	7	41	34	4	5	12	11	1	14	5	13
	2-5mm	3	0	3	3	0	0	2	1	1	0	5	2

Corn on Cotton ... 2008 is the cotton year		Strip-Till				No-Till (Direct Seeding)				Conv.Till			
	Size	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
hard row	0-1mm	NA	228	116	131	NA	208	77	73	NA	122	44	64
	1-2mm	"	4	16	4	"	2	13	12	"	2	8	17
	2-5mm	"	0	5	0	"	0	2	2	"	0	2	3
soft row	0-1mm	"	337	81	83	"	89	98	78	"	107	73	101
	1-2mm	"	9	8	29	"	10	21	36	"	4	17	15
	2-5mm	"	2	5	4	"	2	6	5	"	0	5	3

Cotton on Grain Sorghum --- 2008 is cotton year		Strip-Till				No-Till (Direct Seeding)				Conv.Till			
	Size	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
hard row	0-1mm	NA	103	128	69	NA	171	112	92	NA	65	77	75
	1-2mm	"	2	26	36	"	3	17	12	"	0	19	6
	2-5mm	"	1	3	4	"	0	3	2	"	0	3	0
soft row	0-1mm	"	145	194	171	"	275	129	99	"	110	70	60
	1-2mm	"	11	15	24	"	0	40	15	"	0	28	12
	2-5mm	"	4	6	5	"	0	2	3	"	0	1	3

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, 09 and 2010 in the tillage and crop rotation treatments at the Stiles Research Farm.

Table 3. Aggregate stability of the surface 1 inch of the soils during the growing years 2008-2010

Aggregate Stability Test

Corn on corn rotation		Yr sampled-2008		Yr sampled-2009		Yr sampled-2010	
Tillage typ	row	avg value	range	avg value	range	avg value	range
Strip-Till	hard	2.8	1 - 5	1.6	0-3	1.4	0-3
	soft	4.4	3 - 5	4.2	1-5	3.9	1-5
No-Till	hard	2.6	1 - 5	3.3	1-5	3.4	1-5
	soft	4.6	3 - 5	3.5	1-5	3.9	2-5
Conv. Till	hard	3.5	1 - 5	2.4	0-4	2.1	0-4
	soft	3.0	2 - 4	1.7	0-5	0.9	0-2
Grain sorghum on cotton							
Strip-Till	hard	1.2	0 - 1	0.6	0-2	2.4	1-5
	soft	2.0	0 - 4	1.9	0-4	3.9	1-5
No-Till	hard	0.9	0 - 2	2.2	0-4	2.3	0-4
	soft	2.0	0 - 3	1.3	0-5	2.2	0-4
Conv. Till	hard	0.1	0 - 1	0.3	0-1	0.6	0-1
	soft	0.4	0 - 1	1.7	1-4	2.0	1-4
Cotton on corn							
Strip-Till	hard	2.8	0 - 4	0.6	0-2	0.9	0-3
	soft	3.1	1 - 5	1.5	0-5	3.2	1-5
No-Till	hard	2.8	0 - 5	0.9	0-5	1.0	0-2
	soft	2.6	1 - 4	1.1	0-5	2.8	2-5
Conv. Till	hard	2.5	0 - 4	0.4	0-1	0.5	0-2
	soft	1.1	0 - 2	2.0	0-5	1.6	0-4

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

Table 4. Bulk Density Compared 2007 & 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

This data set was taken during the mid-portion of the four year study.

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 four 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, new crops having access to old root channels and less tillage to create an ideal seedbed. It is very obvious that we should be taking these measurements in early May to obtain a more moist condition and these Vertisols have not dried to the extent that we cannot get steady rates when the soils need to be at near saturated condition.

At times this year we poured >60L (16 gallons) of water over the concentrated area between the rows to try and saturate the soil conditions and still did not get the soils to swell enough to close the huge cracks.

We believe that less tillage with the two reduced tillage systems we are improving the trend for the soils to take water in and have it drain deeper into the soil profile. All of us on the team to study the infiltration rates can see it happening, know it is true and have mixed results in the values observed in Table 1.

***Porosity**:* Looking at the number of pores in Table 2; we wish we had better information to share that a trend was evident that all are improving, it does appear to remaining quite stable. The open winter and drying effects in all of the rotations could be the reasoning why the <1mm pore counts are remaining low in all tillage types 2010. We do see that the 1-2mm size pores in the Strip-Till and No-Till the numbers are on an upward trend in the years 2009 and 2010. Farm manager Archie Abrameit has said that runoff still appears to be a problem with the conventional full width tillage system plots of this rotational tillage study.

Aggregate Stability: In Table 3, we look at 3 years of data, the soil aggregate stability ratings (averages) are down in all three tillage types across the three crop rotations during the year following of the cotton crop. Again that may be explained due to the dryness ad the open soil surface with little residue returned to the soil. In the continuous corn however the average values of stability in the direct seeding are improving slowly. In the continuous corn Strip-Till the values are slightly down from ’09 to ’10. Residues left over are very important to soil quality and soil tilth and decreasing tillage is so important in the soils of Central Texas, especially with low residue crops such as cotton.

Bulk Density: In Table 4, 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 four 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. 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.

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.

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.

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