Soil Quality team

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Soil Compaction
A Soil Quality Problem

By Perry Wilkerson

Soil compaction can be a very serious problem, many times overlooked or underestimated. We don't think of it as a soil quality problem. It can occur on any soil type, from very sandy, to silty, to very clayey particle sizes. It happens when the soil particles are pressed together, most often reducing or eliminating the pore space between soil particles. The most common causes can be machinery or animal traffic on a soil when it's too wet.

Too much tillage can also aid in the development of compaction problems. While the disc harrow requires the least horsepower to move the soil, it is a compacting tool. The edges of the disc blades exert tremendous pressure on the subsoil at their point of contact, further compacting the soil below.

When compaction happens it increases the weight of solids per unit volume of soil, what you hear often referred to as the bulk density. During compaction, soil aggregates are crushed and soil particles packed closer together, literally squeezing out the pore space. Instead of the ideal 50 percent pore space, compacted soil may be only 30 percent pore space.

As large pores collapse, smaller pores form. But these are less efficient, leading to slower water penetration, poor drainage and poorly aerated soils. Poor aeration limits root growth and nutrient uptake. Soil temperature decreases. This affects the activity of soil organisms by decreasing the rate of decomposition of soil organic matter and release of nutrients. Compaction decreases infiltration and thus increases runoff and the potential hazard of water erosion.

How do you know if you have compaction?

You will notice weak soil structure or a massive condition. The soil structure is gone. A clump of soil is like a brick, but crumbles away when broken up. It takes more horsepower to penetrate a compacted soil. It just has more resistance. The bulk density gets higher and higher. Watch the plants. With compaction the roots are constricted, may be flattened, turned sideways (L) or may have stubby roots.

How can compaction be reduced?

Reduce the number of trips across the area.
Till or harvest when the soils are not wet.
Reduce the pressure of equipment.
Maintain or INCREASE ORGANIC matter in the soil.

Compaction on high organic soils.

Keep in mind that compaction can become very serious. Most producers don't know they have it. Here are some of the effects of compaction:

Compaction reduces the size and number of pore spaces which in turn:

- Reduces seedling emergence.
- Reduces the ability of rainfall to move through the surface layer of the soil (infiltration).
- Increases crusting and cracking of the soil surface.
- Makes the soil too hard for roots and earthworms to penetrate.
- Reduces air spaces in the soil, which limits availability of

oxygen that roots as well as the microbes need.

- Increases the velocity and amount of rainfall runoff, which in turn increases soil erosion.
- Reduces the effectiveness of tile lines and increases the size and number of low spots with standing water.
- Increases the severity of dry years.
- Reduces the availability of fertilizers including nitrogen.
- Decreases yields and lowers profit.

The Many Soil Building Benefits of Continuous No-Till (Guest Article)

By Steve Gibson, Agricultural Extension Agent, Shelby, NC

Over the last 10 years, Many farmer in the Cleveland County area have added continuous no-till as a production practice and each year, more observations are being made by farmers and agricultural professionals. Essentially all the observations verify the benefits of this production practice. Over time, improvements are obvious for all the area's soil types with one exception, some of the more sandy soils. However, even in these soils where response does not seem as dramatic, farmers have benefited due to reduced production costs and the ability for more timely field operations. There is no evidence that the soil's yield potential has decreased, in fact several farmers acknowledge the opposite.

Farmers and agricultural professionals have casually observed the following:

1 The well documented improvement in soil structure has been observed. This is obvious when we consider that crusting problems preventing seedling emergence seemingly are a thing of the past.

2 Compared to conventional systems, there seem to be more beneficial insects, the most obvious being ground predators of worm pests. Less obvious visually, but well documented, is the increase in the importance of parasites of insect pests such as cereal leaf beetle. In this region in the last 10 years, the adverse effect of certain insect pests has continually decreased. In fact, cotton producers have used no in-season insecticides for the last 2 years.

3 No-till systems allow for more timely planting with lower usage of fuel by cheaper to maintain and smaller tractors. Timely planting usually results in increased yields, especially true for small grain crops.

A demonstration now in its 17th year of continuous no-till conducted on county-owned land has verified two other benefits of continuous no-till.

1 The yield potential of a soil over time in continuous no-till is improved by the increase in the cation exchange capacity (CEC) due to an increase in humic and organic matter. This factor, as well as the mulch effect of the surface residue, reduces the adverse effects of droughts. From 1985 till 1995, the percentage humic matter increased by approximately 90%; the CEC by approximately 80%. Also much of the year, residue cover is nearly 100%. From 1995 till the present , the increase in humic matter and CEC have "leveled off."

2 Continuous no-till tends to keep certain plant nutrients in the top soil's top layer and nutrient use by the crops becomes much more efficient.

Beginning in 1996, in the same field, a demonstration comparing nitrogen rates for corn in a dryland situation and an irrigated one to simulate a favorable year has been conducted. The demonstration follows a soybean and corn rotation. Corn yields at different nitrogen rates are measured. In the dryland portion, averaged over 5 years, maximum profits resulted in essence from only 60 lbs. of applied fertilizer nitrogen. In the irrigated portion, profits increased with increased fertilizer nitrogen up to the maximum of 150 pounds. Ammonium Nitrate is the nitrogen source and a corn variety with stress tolerance is planted.

Yields of the lowest fertilizer nitrogen rate of 30 pounds per acre far exceeded what would be expected when applying the Realistic Yield Expectation (RYE) of determining fertilizer nitrogen rates. The 5 year average yield at 30 pounds Nitrogen in the irrigated areas is 93 bushels per acre and 71 bushels for the dryland, 63 and 41 bushels more than what would be predicted by the rye method. Obviously, there is more nitrogen here than is left by the soybeans.

Improved nitrogen efficiency is also evident in no-till wheat studies I made on the Ronnie King farm. Results are:

Topdress N Rate lbs. /ac.	2 year No-till Yield, Bu./ac.	5 Year No-till Yield, Bu./ac.
0	34.6	58.2
82	74.6	79.7
116	85.4	89.7

(Continued on page 3)

Notes:
1- All plots received 20# N/ac. at planting.
2- RYE for 82 and 116 are 60 and 80 Bu./ac.
3– The higher yields in the 5-year field are not surprising. The difference was 23.6 bushels for the no topdress treatment. Using 1.7 # N per bushel, it can be seen that the 5-year no-till field was able to store and release about 40 lbs. of nitrogen.

We are still in the learning phase regarding continuous no-till. Below are some questions which if only partially answered have the potential to provide us with the info such that production practices can be made more efficient. Many answers can be obtained simply by random sampling and observations of continuous no-till sites.

1 What is the importance of winter weed and small grain residue storing and releasing any unused nitrogen for the subsequent spring/summer crop?
2 Can a legume cover crop likewise utilize and store this excess nitrogen?
3 Could not the residue from a legume cover crop supply in many years all the nitrogen required if the RYE method is used?
4 Should not economists place more emphasis on long-term profitability verses potential annual profitability in light of the RYE method and realities of the weather?

Farmers using continuous no-till could benefit from some method of sampling designed to predict the available soil nitrogen for subsequent crops. This could help protect water quality by reducing the over-application of nitrogen, and raise profits!

SOIL QUALITY, WATER QUALITY, AND PHOSPHORUS MANAGEMENT

By: Bobby G. Brock, Conservation Agronomist

Management of phosphorus is getting plenty of attention and will for a while. The build-up of P in the top few inches of crop fields is of particular concern.

The major path of phosphorus losses is through runoff and erosion . So, the control of runoff and erosion would seem to take care of the problem. Well, maybe-maybe not. The use of conservation tillage with minimal ground cover may be sufficient to meet minimal erosion control needs, but is insufficient to make soil quality improvements and runoff reductions that are needed for keeping soil and nutrients in place—and out of the water!

It is well-established that a high degree of ground cover in a conservation tillage program over time will drastically reduce losses of rainfall, soil, and nutrients. Here are a few examples:

- In Florence, S.C., a USDA-ARS/Clemson paired watershed study presently under way shows preliminary results from the year 2000 as follows:

Management	Runoff gal/ac	Soil loss Lb./ac	N loss Lb./ac	P loss g/ha
Convent. Tillage	65,133	1176	5.5	60
No-tillage	3140	12	0.09	5

Notes: This study uses a cotton corn rotation with a cover crop after cotton. Ground cover at planting was 70-90 %.
One trip in spring with para-till in no-till watershed.

- A report in the 4th Quarter, 1999 JSWC on a four year study in Mexico reveals the following:

Measured Loss of	No-Till/Residue Cover				Min. Till	Conv. Till
	0%	33%	66%	100%		
Runoff (mm)	92	24	21	19	92	87
N in Runoff (kg/ha)	3.6	2.67	1.94	0.87	9.32	7.05

Notes: Soil was sandy loam with low bulk density.
Results are from catchment measurements.

The chart below is taken from the same study.

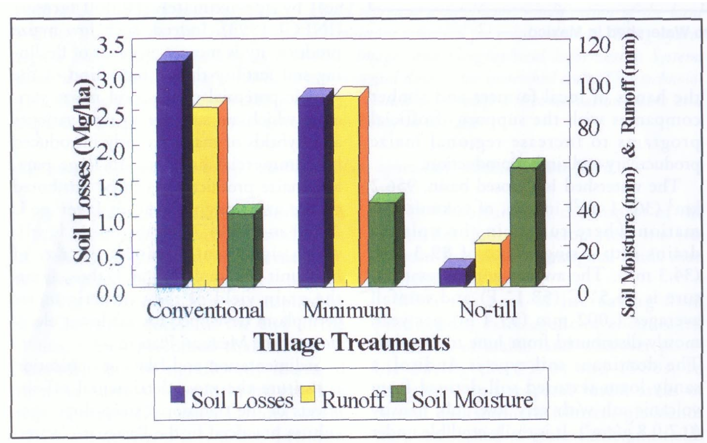

Figure 3. Soil losses, runoff, and 150-mm layer soil moisture for three tillage treatments.

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- Dr. Doug Worsham measured soil losses in no-till vs. conv. till tobacco on a coastal plain soil. Results:

YEAR	FIELD SLOPE	ROW GRADE	CONV LOSS	NO-TILL LOSS
1	1.3%	1.3%	1.1 ton/ac.	0.05 ton/ ac.
2	3.1%	3.1%	4.0 tons/ac.	0.04 ton/ ac.

Notes: Ground cover was virtually 100% (6 tons rye/ acre at planting)

- A recently completed master's thesis at NCSU shows large differences in phosphorus concentrations in run-off from simulated rainfall on a piedmont soil. Conv. till / no-till numbers are shown in the chart below:

P Rate (kg/ ha)	1992 (mg/l)	1993 (mg/l)	1994 (mg/l)	Avg.mg/l
393 / 393 (TSP)	15.2 / 2.6	9.4 / 2.9	16.7 / 4.5	13.8 / 3.3
2052 / 2259 (both as poul-try litter)	21.4 / 4.3	19.2 / 3.1	21.3 / 3.4	20.6 / 3.6

Notes: Per cent ground cover was not reported.

- A VPI study with a rainfall simulator comparing no-till to conventional till also shows significant differences in runoff, soil losses, and phosphorus losses. No-till reduced soil losses by 92% and runoff volumes by 67%. Losses of applied phosphorus were 8.9% for the conventional tilled plots and 0.9% for the no-till.

- In a wheat growing area of Oklahoma, one of a pair of watersheds was converted to no-till management. Reduction of P concentrations were much greater than was the increase in dissolved P. Runoff volume and erosion were reduced by 95%. See figure below, and notice the continued gradual drop in total P losses, whereas the increase in dissolved P was very slight, and soon leveled out.

Keep these studies in mind as the discussion on phosphorus management turns to increased phosphorus concentrations, dissolved phosphorus, and tillage as a management "tool". Glenn Weesies, NRCS erosion specialist at the National Soil Erosion Lab, recently cautioned state agronomists that "the effect of occasional tillage operations in a long-term no-till erosion control effort can be significant—often doubling the RUSLE "C" factor. Under some circumstances, the C value can be more than four times greater because of soil-disturbing operations."

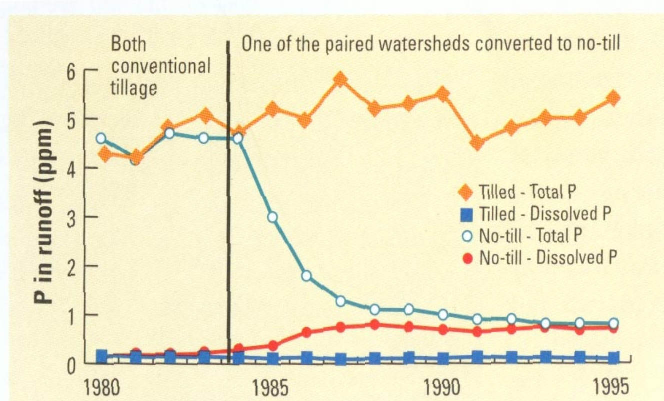

Figure 1. No-till management, starting in 1984, reduced the concentration of total P in runoff in an Oklahoma watershed.