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No-Tillage and N Fertilization Enhance Soil Carbon Sequestration

Studies show that returning N treated residue to soil works better in no-till than in conventional-till systems.

Summary: Data presented here show that a fertility program that optimizes grain yield potential will also optimize crop residue production. When returned to the soil, this residue can have a positive influence on soil organic matter (SOM). Nitrogen (N) fertilization enhances soil carbon (C) sequestration. Studies also show C sequestration response is superior in no-till (NT) systems when compared to conventional-till (CT). Management systems that increase SOM levels 1) help improve soil quality, productivity, water infiltration, and fertility, 2) lower soil bulk density, and 3) reduce soil erosion.

Conversion of our native grass-lands to cultivated crop land generally has resulted in a significant decline in SOM under CT. Farming methods that use mechanical tillage, such as moldboard plow for seedbed preparation or disking for weed control, contribute to releasing increased levels of carbon dioxide (CO_2) into the atmosphere. Atmospheric CO_2 levels have increased from 280 ppm (pre-industrial) to about 365 ppm today, with agriculture contributing to that increase. Current farming practices, such as reduced tillage, however, are helping to reduce the level of CO2 released into the atmosphere. Application of plant nutrients to optimize grain yield potential generally results in increased crop residue production. Returning this residue to the soil surface in reduced tillage systems is having a positive impact on SOM. Changing management practices to increase SOM levels is contributing to improved soil quality and productivity.

In this article, we will discuss SOM changes that have occurred under various cropping systems as the result of several long-term studies. We'll take a look at the influence of 27 years of NT intensive cropping management on SOM and compare it, over the same period of time, to a predominantly crop-fallow CT environment. Comparisons will also be made to SOM levels in an adjacent native sod area its owner claims had not been tilled.

Eleven years

The first long-term N project was a dryland, NT continuous cropping study at Akron, CO. Corn was grown every other year with spring barley, winter wheat, or oat/pea hay crops substituted in alternate years.

Over an 11-year span, N increased the amount of crop surface residue returned to the soil (Figure 1). SOM increased with increasing N rates. Total soil nitrogen (TSN) in the 0 to 6-inch soil depth also increased with increasing N rates (data not shown). The increase in SOM with increasing N rates produced a significant decrease in soil bulk density at the 0 to 3-inch soil depth.

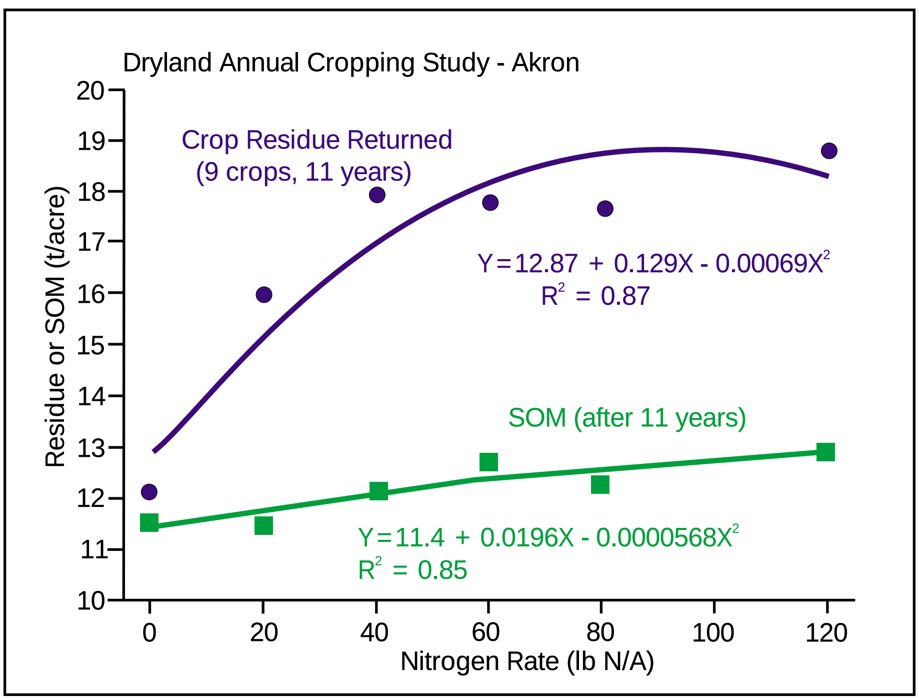

Figure 1. Above-ground crop residue returned to soil and changes in SOM as function of N rate in annual cropping rotation , Halvorson, et al., 11 years, Akron, CO.

The study produced very positive changes that promise to enhance the performance of disk drills in NT environments.

Nine years

The second N study examined a dryland, NT crop rotation (winter wheat-corn-fallow, and winter wheat-sorghum-fallow or 3 complete rotation cycles over 9 years), again at Akron. Total above-ground crop residue (averaged over both rotations) increased with increasing N rate (Figure 2). This translated into increasing SOM levels with increasing N rates in the 0 to 6-inch soil depth for both crop rotations. Demonstrated was the positive influence that N fertilization can have on SOM in an NT, dryland cropping environment.

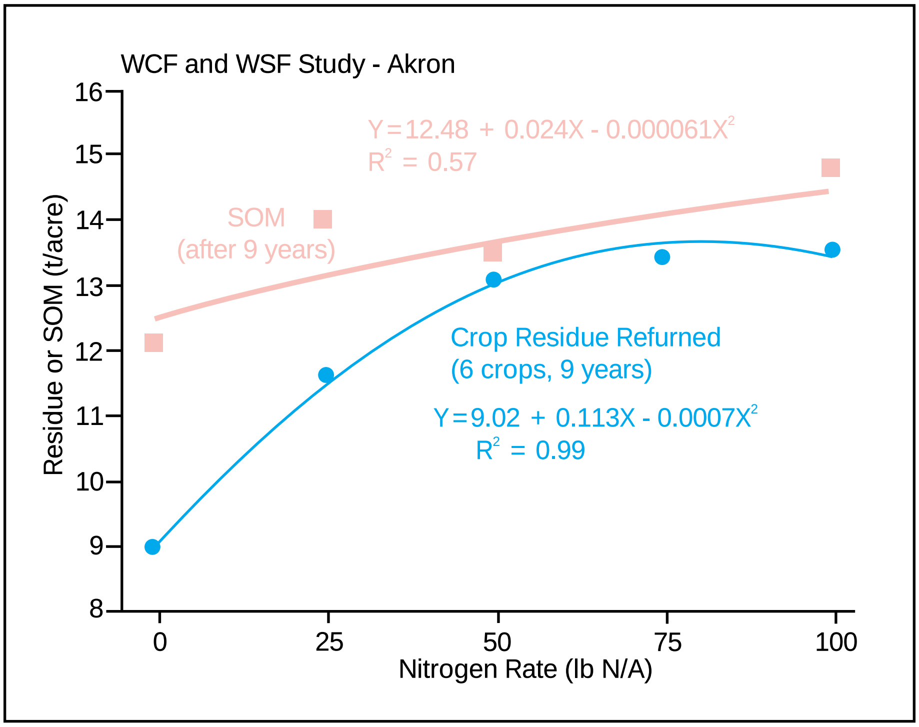

Figure 2. Above-ground crop residue returned to soil and changes in SOM as function of N rate in annual cropping rotation, Halvorson, et al., 9 years, Akron, CO.

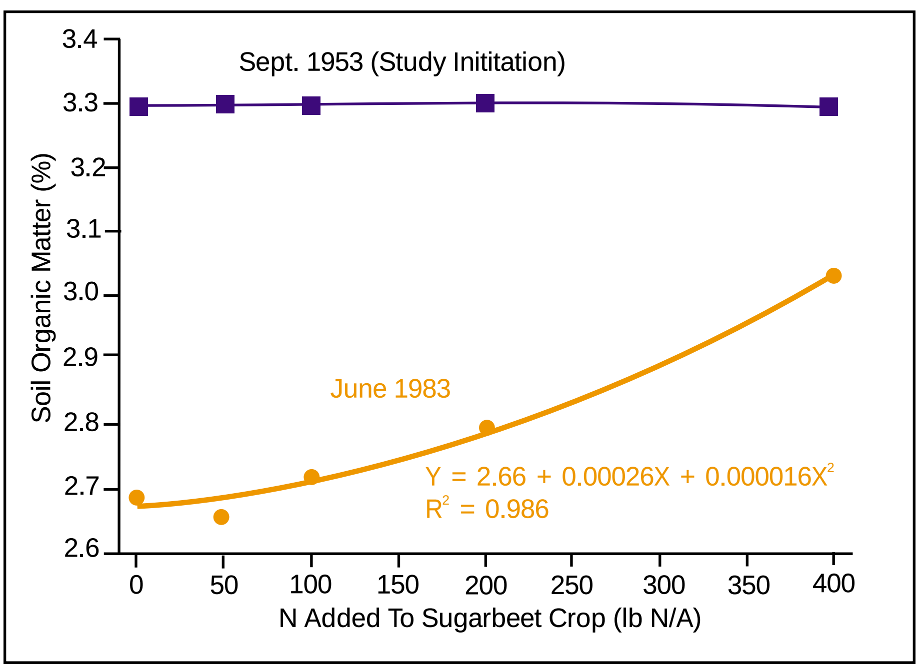

Figure 3. Changes in SOM as function of N rate in 21 crops over 30 years, Halvorson, et al., Sidney MT.

Thirty years

The third N study involved a small grain/sugar beet rotation conducted under an irrigated, intensive tillage environment (moldboard plowing, disking, mulching, leveling) for seedbed preparation. The study began the fall of 1953 at Sidney, MT, and continued until 1983. From 1954 through 1959, all crop residues were removed from the plot area.

From 1960 through 1980, above-ground crop residues were returned to the soil. In 1981, the study was converted to a continuous corn rotation using a reduced tillage, ridge-till system. Corn stalks were removed in 1981 and 1982. Soil samples were collected in June 1983 to assess SOM levels. The estimated quantity (dry weight basis) of spring wheat straw and sugar beet tops returned to the soil increased with increasing N rate. Wheat grain yields, however, were near maximum with residual N remaining from the applications of 200 lbs/A of N to sugar beets. Sugar beet sucrose yields peaked at N rates of about 100 lbs/A.

In September 1953, SOM concentration was 3.3 percent for all N treatments (Figure 3). In June 1983, SOM concentrations in the 0 to 6-inch soil depth were lower than in 1953, with increasing SOM concentrations with increasing N rate. Soil bulk densities were not measured in 1953 or 1983, therefore we cannot accurately calculate the tons per acre of SOM present for each N rate. The apparent loss of SOM from 1953 to 1983 probably resulted from the intensive tillage operations performed to prepare a seedbed for sugar beets.

In this study, all surface residue was

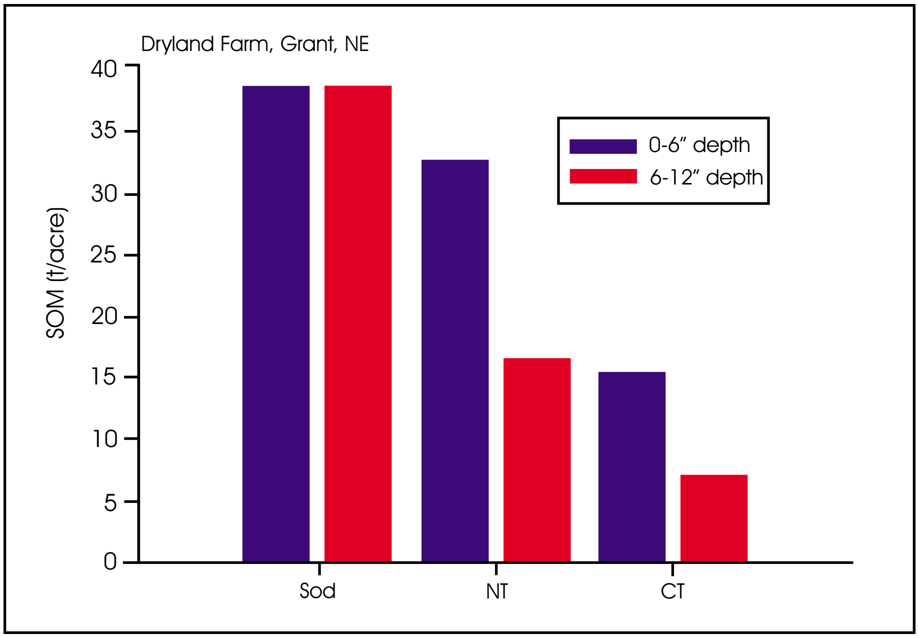

Figure 4. Comparison of SOM levels between an NT system after 27 years, a CT system after 50+years, and native sod, Halvorson, et al., Grant, NE.

buried by tillage from 1953 until 1981. Tillage mixed the crop residue with soil, putting it in direct contact with soil microbes that break down the residue, releasing CO_2 and nutrients. Tillage provides aeration to the soil, which accelerates residue decomposition. Even though tillage was more intensive in this irrigated environment, the quantity of crop residue returned to the soil increased with increasing N rate, which had a positive effect on SOM concentration.

Advantage no-till

The influence of tillage system on SOM is vividly demonstrated in the samples collected from a dryland farm near Grant, NE, in June 1999. Soil samples were taken from four separate locations in each field and analyzed separately. The NT field had previously been in a crop-fallow CT environment for 25+ years before conversion to an NT more intensive cropping system.

The SOM levels shown in Figure 4 reflect the positive influence of NT and an intensive crop rotation after 27 years (winter wheat, corn, millet being the predominant crops in rotation with no fallow). The SOM in the NT field is contrasted with that from an adjacent field, on a similar soil and slope. The field was maintained in a CT environment with a predominantly crop-fallow farming system during the same time period of the NT field. For comparison, we also sampled a native sod area in the adjacent farmstead, which its owner claimed had never been tilled.

As you can see, the NT system had much higher levels of SOM than the CT field. After 27 years, SOM level in the NT system was 85 percent of the native sod SOM level in the 0 to 6-inch soil depth, whereas the SOM level of the CT field was only 40 percent of the native sod level. In the 6- to 12-inch soil depth, SOM levels of NT and CT fields were 82 and 35 percent, respectively, of the native sod SOM level.

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