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How To Enhance Soil Organic Carbon Sequestration

Texas studies show optimizing crop yields and reducing soil erosion via proper management practices are paying dividends not only environmentally but in crop yields as well.

Conversion of native grasslands to cultivated cropland generally has resulted in a significant decline in soil organic matter and soil organic carbon with conventional-till under dryland conditions. Researchers have reported that after 27 years of no-till and intensive crop management at Nebraska sites, soil organic levels under no-till were 85 percent of native sod levels whereas soil organic levels in conventional-till, crop-fallow production systems were 40 percent of native sod levels. They also reported that soil organic matter declined with plow tillage under an irrigated sugarbeet/small grain rotation, but that the loss of soil organic matter was reduced with high N rates.

Under irrigated agriculture and with reduced-till, crop residue levels (both above and below ground) may be sufficient to increase soil organic carbon storage in the Great Plains. Irrigated corn produces a large quantity of residue that is returned to the soil surface each crop year. In our studies, about 10,000 lbs/A of corn residue has been returned annually to the soil. With this level of residue input to the soil, the object was to determine if application of liquid N to the residue after harvest (N2 sites) would enhance residue decomposition and soil organic carbon sequestration, knowing at the same time that applying N to the residue may also increase the amount of N available for leaching.

Information is limited on the long-term effects of crop management practices on crop residue production and its subsequent effects on soil organic carbon and total soil nitrogen in irrigated cropping systems in the Great Plains. The object of the project reported here is to evaluate the influence of crop management practices on residue production, total soil N, soil organic carbon sequestration, and soil NO_3-N leaching potential from irrigated locations in north Texas.

SUMMARY

Six-year trends show that soil organic carbon and total soil nitrogen (N) levels are increasing and producing optimum crop yield levels at two grower sites in Texas via the effects of proper crop and fertilization management practices on both corn and wheat grain. Residual soil NO_3-N levels have increased since 1999. However, although sufficient N needs to be applied to optimize irrigated crop yield and economic returns, only the amount needed for optimum yield should be applied to minimize NO_3-N leaching potential. Another year of data collection is being conducted to verify the trends in soil organic carbon sequestration.

Grain/residue yield

Dalhart. At the Dalhart location, hand-harvested corn grain yields averaged 216 and 168 bu/A for the N1 and N2 sites, respectively, from 1999 to 2005. Average combine-harvested corn yield in 2005 for the N2 half of the pivot was 190 bu/A (excluding the outer edge of the field) and 26 bu/A for the hand-harvested N2 sampling sites located in the outer edge of the field, which received no irrigation water in 2005 after corn tasseling. Average grain yield for all crops from 1999 through 2005 is shown in Figure 1.

The average amount of corn and wheat residue returned to the soil for the N1 and N2 sites was 8,915 and 8,376 lbs/A, respectively (Figure 1). Adding wheat to the rotation in 2003 resulted in reduced residue production and residue carbon. Residue carbon concentration has averaged 45 percent with a seven-year average above-ground residue carbon and N input to the soil of about 4,004 and 3,732 lbs/A of carbon and 63 and 81 lbs/A of N per year for the N1 and N2 treatments, respectively (Figures 1 and 2). The N concentration of the residue averaged 0.70 and 0.97 percent, respectively.

Texline. At Texline, combine-harvested yield for the fields averaged 218 bu/A in 2005. Hand-harvested corn grain yields averaged 258 and 228 bu/A in 2005 for the N1 and N2 sites, respectively.

From 1999 to 2005, hand-harvested corn grain yields averaged 226 to 210 bu/A for the N1 and N2 treatments, respectively (Figure 1). The N2 sampling sites are located on a steeper sloping area of the field than the N1 sampling sites. This may have caused the slightly lower grain yields on the N2 sites compared to the N1 sites.

Estimated corn residue amounts returned to the soil averaged 11,127 and 10,989 lbs/A for the N1 and N2 sites, respectively (Figure 1) with an

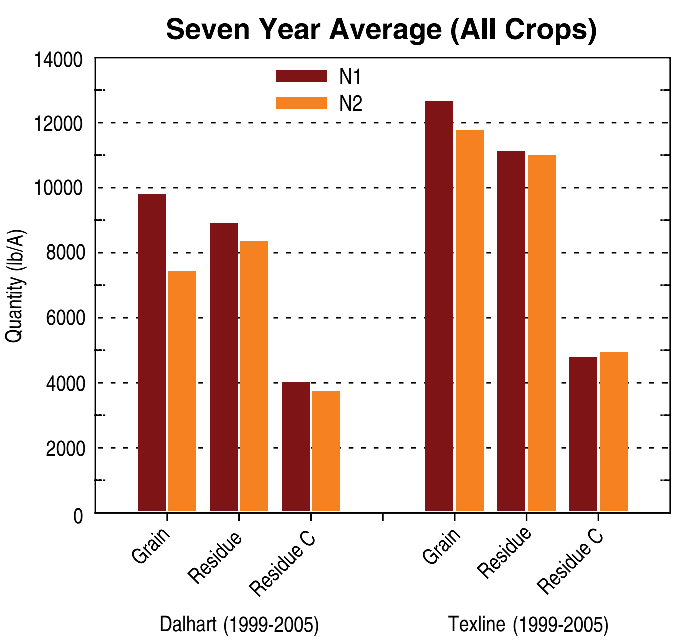

Figure 1. Average annual grain, crop residue, and residue carbon yields at Dalhart and Texline from 1999 through 2005.

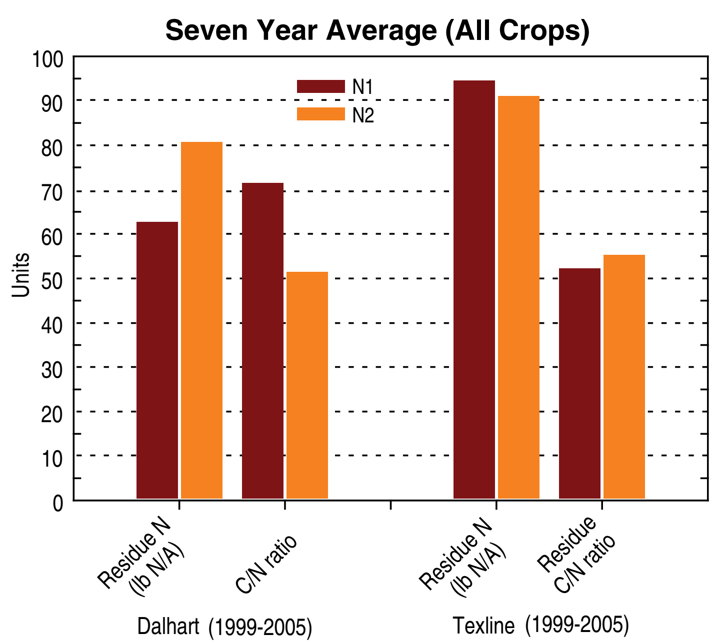

Figure 2. Average annual residual N content and carbon/nitrogen ratio at Dalhart and Texline from 1999 through 2005.

and 45 percent and N concentration of 0.90 and 0.87 percent for the N1 and N2 sites, respectively. Estimated amount of carbon and N returned to the soil surface has averaged 4,774 and 4,935 lbs/A of carbon and 95 and 91 lbs/A of N, respectively, for the N1 and N2 treatments (Figures 1 and 2).

Soil carbon and N

The reduced-till, continuous corn production system from 1999 through 2003 has increased soil organic carbon each additional crop year in the 0- to 6-inch soil depth. Increases were also observed in the 0 to 12-inch and 0 to 24-inch soil depths. Because the soil or carbon inputs have been similar for the N1 and N2 sites at both locations (Figure 3), the difference in soil organic carbon accumulation rates between the N1 and N2 treatments (liquid N added to residue) was not significant. Total soil N has also increased linearly with each additional crop year from 1999 through 2005 in the 0 to 6-inch soil depth at both sites, which supports the observation of increasing soil organic carbon with time and building the N fertility of the soil. The soil organic carbon data from 2005 indicated a decrease in soil organic carbon from 2003 and 2004. The samples were rerun to verify the decrease. This decrease may be an indication that the heavy removal of corn residue by cattle grazing the corn stalks in 2003 and 2004 at Texline and the effects of drought stress at Dalhart, plus inserting wheat in the rotation in 2003, are slowing the rate of soil organic carbon accumulation at both locations. Another year of data will be needed to verify this trend.

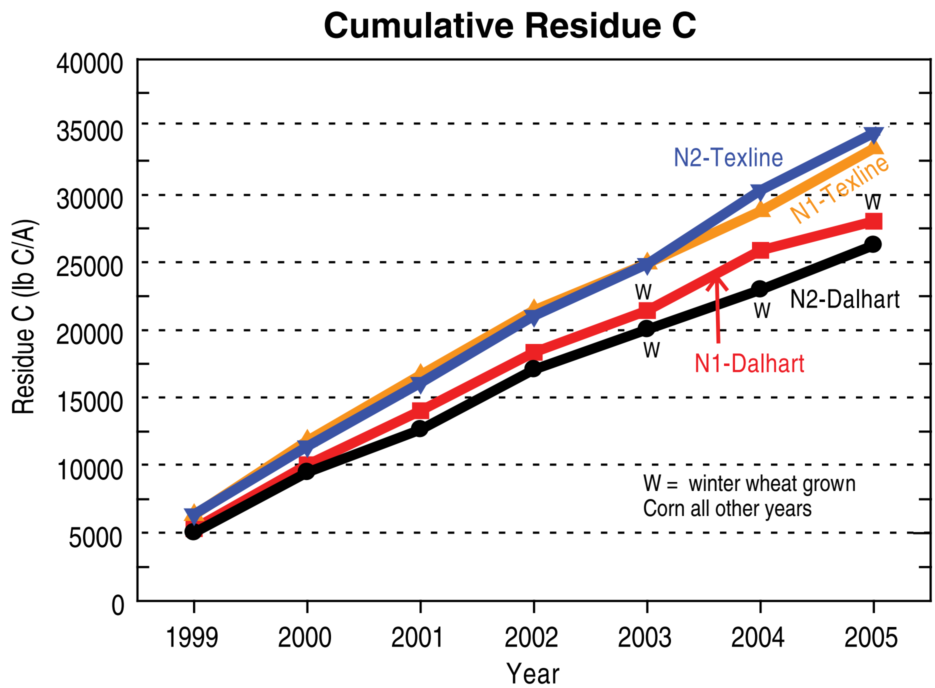

Figure 3. Cumulative increase in residue carbon returned to soil at Dalhart and Texline at N1 and N2 sampling sites.

The increase in soil organic carbon level within the reduced-till, irrigated continuous corn/wheat system at Dalhart indicates that soil organic carbon is building in this fine sandy loam soil at a rate of about 1,000 lbs/A per year when averaged over the N1 and N2 sites. The change in soil profile soil organic carbon levels at the clay loam Texline site shows the same trends as the Dalhart site of increasing soil organic carbon (about 1,000 lbs/A per year), at least through 2003, and total soil N in the cropped area.

NO_3-N levels

Dalhart. Addition of liquid N to the corn residue at the N2 site increased residual soil NO_3-N levels significantly compared with the N1 site. Residual soil NO_3-N levels at the N2 site declined when this practice was terminated in 2002 and winter wheat was added to the crop rotation. The lower rates of N applied to winter wheat resulted in a reduction in soil NO_3-N levels at both N1 and N2 sites, with 2004 and 2005 having the lowest level of residual soil NO_3-N since 1999.

Texline. Residual soil NO_3-N levels had generally increased at both the N1 and N2 sites with each additional crop through 2004, even though N application to the corn residue was discontinued in 2001 at the N2 site. This probably reflects the result of fertilizing for a greater than 250 bu/A corn crop but not achieving this yield potential, which leaves residual N fertilizer in the soil available for leaching below the root zone. Application of N to the corn residue resulted in higher residual soil NO_3-N levels at the N2 site than at the N1 site. Soil NO_3-N had declined from 2004 levels at both sites in 2005, but were still higher than in 1999.

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