Dr. Ardell Halvorson, Dr. Arvin Mosier, and Curtis Reule

Soil Organic Carbon Levels Increase in Texas Trials

Ongoing study so far shows that maximizing soil productivity in a reduced-till, irrigated contiuous corn production system benefits soil organic carbon sequestration.

Summary: *Corn grain yields have varied due to climatic variation between years and site differences in Texas. At Texline they have averaged 213 bu/A and at Dalhart 217 bu/A. Total residue biomass and residue carbon (C) returned to the soil has been slightly greater at the Texline site (clay loam) than at the Dalhart site (fine sandy loam). Four-year trends in soil organic carbon (SOC) and total soil nitrogen (TSN) show that SOC and TSN levels are increasing at both sites. The SOC and TSN levels of the cropped fields have equaled or exceeded those of native sod. Several more years of data collection will be needed to ascertain whether or not the addition of liquid N fertilizer in the fall to the corn residue before tillage will benefit SOC sequestration. Residual soil NO_3-N levels were very low under native sod at both sites compared with the cropped areas. Residual soil NO_3-N levels at both cropped sites have increased since 1999. Residual soil NO_3-N at both sites was greater where N fertilizer was applied to corn residue after harvest (N2) than with the (N1) fertilizer management treatment. Farmers need to apply nitrogen (N) to optimize yields and economic returns, but should take care to use only that amount of N fertilizer needed for optimal yield in order to minimize NO_3-N leaching potential and nitrous oxide (N_2O) emissions (a greenhouse gas influencing global warming) in irrigated systems. N_2O emissions increase with increasing N fertilizer rate; therefore, avoiding excess N application helps preserve environmental quality.*

Two observation sites in northwest Texas, located near Dalhart and Texline, were initiated in April 1999. Following the 1998 cropping season, two N fertility management levels were established at each location on center-pivot irrigated fields that were being continuously cropped to corn by Jim Poole and business associates. Each pivot received a normal fertilization program (N1) sufficient to produce greater than 250 bu/A corn. Half of each pivot received additional liquid N fertilizer, applied to the corn stalks prior to fall tillage operations to aid in corn residue decomposition (N2) and possibly enhance SOC sequestration. A DMI Ecotiller, a heavy-duty combination disk/chisel plow/ripper implement with a tillage depth of about 12 to 14 inches was used in the fall after harvest. A tandem disk was used in the spring for seedbed preparation. When the corn was about 2 feet tall, an inter-row ripper-dammer/diker machine was used to control weeds between the rows and create small dams between corn rows to reduce water runoff from the field. Herbicides were also applied. The corn planter was equipped with a coulter and residue managers in front of the seed opener. Plant populations have averaged 29,222 plants/A at Dalhart and 32,932 plants/A at Texline from 1999 through 2002.

Available information on the long-term effects of N fertility and tillage system on crop residue production and its subsequent effects of SOC in irrigated cropping systems in the Great Plains is limited. Therefore, in 1999 the authors, in cooperation with Mr. Poole and the Fluid fertilizer Foundation (FFF), selected two irrigated continuous corn fields in north Texas that had been broken out of native sod in 1995. Our objective was to monitor changes in SOC and residual soil NO_3-N over time. Mr. Poole and the FFF were also interested in evaluating the effects of maximum soil productivity (high level of plant nutrient and water) on SOC sequestration.

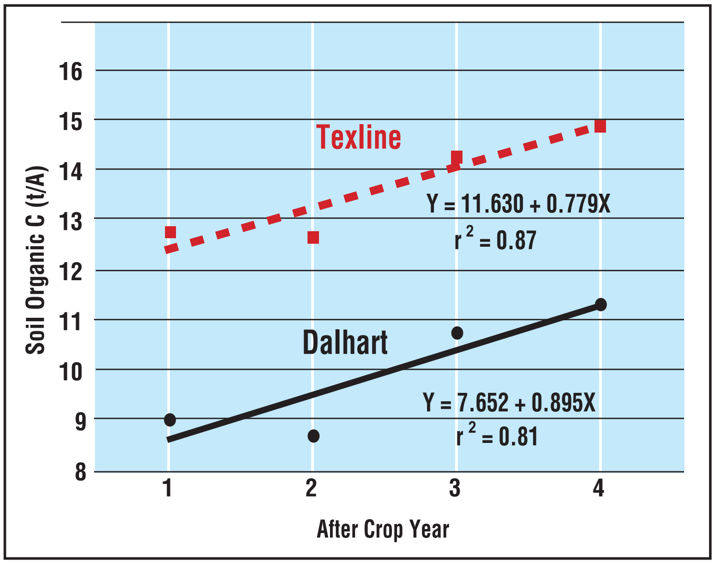

Fig. 1. Change in soil organic C (SOC) with time at Dalhart and Texline, TX in the 0 to 6 inch soil depth.

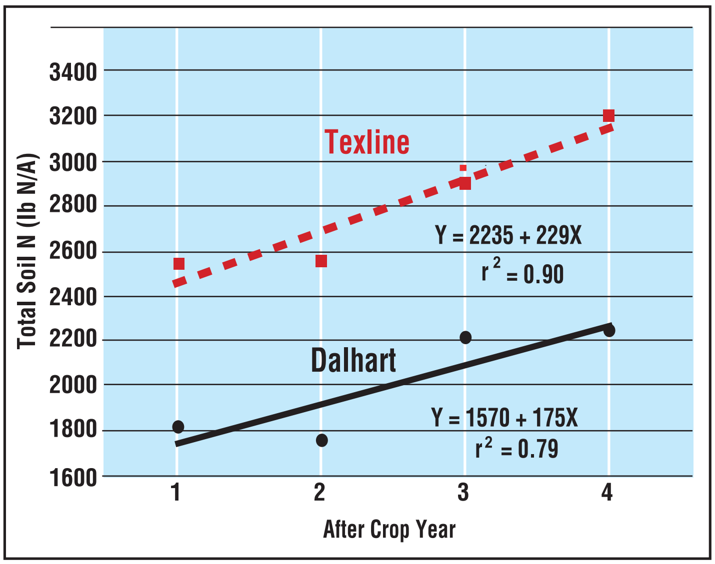

Fig. 2. Change in total soil N (TSN) in the 0 to 6 inch soil depth with time at Dalhart and Texline, TX.

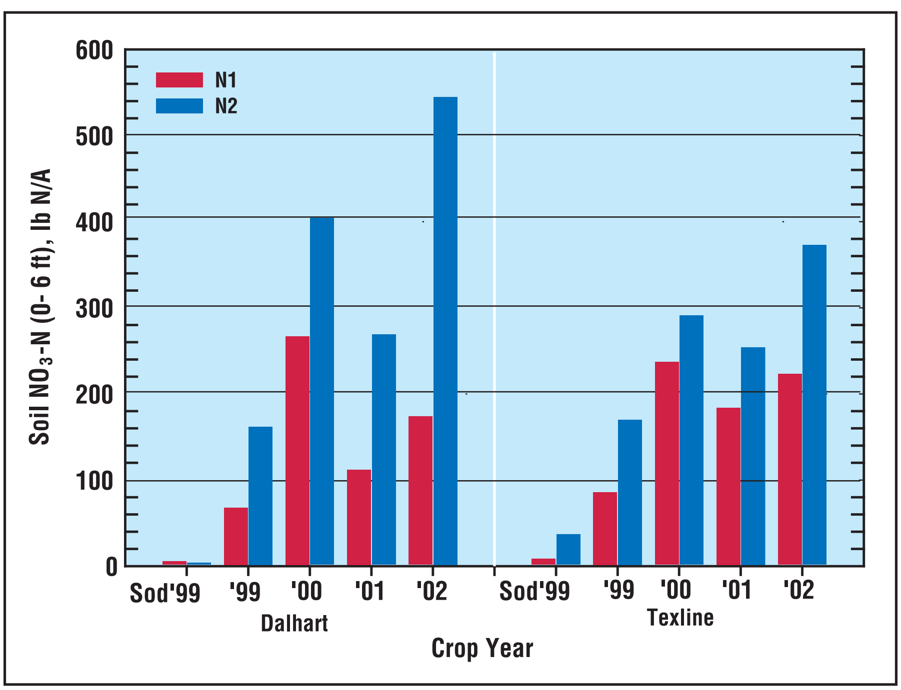

Fig. 3. Soil NO_3-N levels in native sod in 1999 and after corn harvest each year at Dalhart and Texline, TX.

Dalhart site

Soil. The Dalhart site is located on a Dallam fine sandy soil about 9 miles northwest of Dalhart, Texas, on a 500-acre field with a center-pivot irrigation system. In 1999, the site was producing its fifth corn crop since being broken from native grass in 1995.

N applied. The amount of N applied to the whole field (N1) at Dalhart was 315, 327, 266 and 233 lbs/A of N for the 1999, 2000, 2001, and 2002 corn crops, respectively. The amount of N applied to the corn residue after harvest on the southwestern half of the field (N2) was 88, 120, 110, and 50 lbs/A of N in 1998, 1999, 2000, and 2001, respectively.

Grain yield. From 1999 to 2002, combine corn yields over each half of the pivot ranged from 203 to 233 bu/A and averaged 217 bu/A at the (N1) fertility level. At the (N2) fertility level, they ranged from 197 to 224 bu/A and averaged 210 bu/A.

Residue. The amount of corn residue returned to the soil from 1999 to 2002 ranged from 8,873 to 12,120 lbs/A and averaged 10,184 lbs/A at the (N1) fertility level. At the (N2) level, it ranged from 7,020 to 11,385 lbs/A and averaged 9,469 lbs/A. Residue C concentration averaged 45 percent with a 4-year average above-ground residue C and N input to the soil of about 4,588 lbs C/A and 81 lbs/A of N (N1) and 4,271 lbs C/A and 91 lbs/A of N (N2) per year. N concentration of the residue averaged 0.83 (N1) and 1.00 (N2) percent.

Texline site

Soil. The Texline site is located on a gently sloping Conlen clay loam (N2 fertility level) and rolling Dumas clay loam (N1 fertility level) about 11 miles north of Texline, Texas, on a 400-acre field with center-pivot irrigation. In 1999, the cropped area was producing its fourth corn crop since being broken from native grass in the fall of 1995. During the one year prior to April 1996 it was planted to winter wheat and grazed.

N applied. The amount of N applied to the whole field (N1) at Texline was 315, 321, 253, and 200 lbs/A of N in 1999, 2000, 2001, and 2002, respectively. The amount of N applied to the corn residue after harvest on the eastern half of the field (N2) was 88, 132, and 100 lbs/A of N in 1998, 1999, and 2000, respectively. No fall N was applied to the corn residue after the 2001 corn harvest in the (N2) treatment area because of a large amount of residual soil NO_3-N.

Grain yield. From 1999 to 2002, combine grain yields ranged from 178 to 244 bu/A and averaged 213 bu/A at the (N1) fertility level. At the (N2) fertility level, they ranged from 169 to 245 bu/A and averaged 210 bu/A.

Residue. Estimated corn residue amount returned to the soil ranged from 10,780 to 14,653 lbs/A and averaged 12,126 lbs/A at the (N1) fertility level. At the (N2) level, it ranged from 10,404 to 14,437 lbs/A and averaged 11,643 lbs/A. Residue C concentration averaged 44.7 percent and N concentration averaged 0.93 percent. Estimated amount of residue C and N returned to the soil surface has averaged 5,365 lbs C/A and 109 lbs/A of N (N1) and 5,260 lbs C/A and 103 lbs/A of N (N2).

Yearly differences in grain yields and residue production at both sites reflect differences in growing season climatic conditions and corn hybrids grown. A large quantity of residue C is being incorporated into the soil each year in these irrigated, reduced-till continuous corn production systems.

Soil carbon/nitrogen

Soil organic C in reduced-till continuous corn production systems in Texas has increased with each additional crop year since 1999 in the 0 to 6-inch soil depth (Figure 1). Increases were also observed in the 0 to 12- and 0 to 24-inch soil depths. Because the C inputs to the soil have been similar for both N fertility treatments, difference in SOC accumulation between (N1) and (N2) fertility levels is not significant. TSN has also increased with each additional crop from 1999 through 2002 in the 0 to 6-inch soil depth at both sites (Figure 2). This supports the observation of increasing SOC with time.

The SOC level in the cropped area exceeded the level present in the native sod in 1999 at Dalhart (7.76 tons C/A) and at Texline (11.7 tons C/A) in the 0 to 6-inch soil depth. The increase in SOC level within the irrigated continuous corn system indicates that SOC is accumulating in the fine sandy loam soil at Dalhart and in the clay loam soil at Texline when averaged over both N fertility treatments. Since corn residue levels are high for both N fertility management levels, differences in SOC between(N1) and (N2) treatments are small. Several more years of data collection are needed to determine if differences can be detected in SOC changes between the (N1) and (N2) fertility management treatments.

Soil NO_3-N levels

At both Texas sites, soil NO_3-N levels under native sod were very low compared to the residual soil NO_3-N in the cropped areas (Figure 3). Residual soil NO_3-N following corn harvest has been greater for the (N2) treatment than for the (N1) treatment since 1999. This indicates that the addition of extra liquid N to the corn residue after harvest with the (N2) treatment is contributing to a higher residual soil NO_3-N level than with the normal (N1) fertilizer program. For this reason, Mr. Poole reduced the after-harvest N application to the residue at Dalhart in 2001 to 50 lbs/A of N for the 2002 corn crop and applied no N to the residue at Texline in the fall of 2001.

Because the Texas fields have been continuously cropped to corn for seven years since conversion from native sod to cropland, it will be interesting to observe the change in SOC with time and to assess the effects of maximum soil productivity on SOC sequestration and NO_3-N leaching potential. The increase in residual soil NO_3-N levels at both sites with the (N1) treatment 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 and available for leaching below the root zone. Mr. Poole increased the 2003 planting rate to 42,000 seeds/A, trying to increase yield potential toward 300 bu/A.

Dr. Halvorson is soil scientist, Dr. Mosier is research chemist, and Mr. Reule is soil scientist, USDA/ARS, Ft. Collins, CO. ❐