Soil Profile Organic Carbon as Affected by Tillage and Cropping Systems

G.E. Varvel, USDA-ARS (Lincoln, NE) and W.W. Wilhelm, USDA-ARS (Deceased)

Introduction

Emphasis and interest in carbon (C) storage (sequestration) in soils has greatly increased in the last few years, especially C with its' potential to help alleviate or offset some of the negative effects of the increase in greenhouse gases in the atmosphere. Questions still exist with regard to the effects of management practices on C storage and its' location in the soil profile. It is important to evaluate changes in soil C not only in the surface soil layers, but also at deeper depths in the profile. These determinations need to be made before valid conclusions can be reached about both if it is occurring and where in the soil profile is C being sequestered. This opportunity existed in a long-term tillage and cropping system experiment conducted in eastern Nebraska. Our objective was to evaluate the long-term effects of tillage and crop management systems on total soil N and SOC throughout the profile in a rainfed experiment in the western Corn Belt.

Materials and Methods

This experiment was initiated in 1980 at the Rogers Memorial Farm on a silty clay loam soil (deep, moderately well-drained upland Sharpsburg soil formed in loess; fine, smectitic, mesic Typic Argiudolls) approximately 19 km east of Lincoln, NE (latitude 40.843, longitude 96.465) under natural rainfall conditions. The site had a mean average temperature (MAT) of 19.9ºC and mean average precipitation (MAP) of 708.1 mm from 1986 through 2001. The experiment was originally designed as a randomized complete block (six replications) with six tillage treatments. Tillage treatments were chisel plow, tandem disk, moldboard plow, no-till, ridge-till, and subsoil tillage. Corn was the only crop in the experiment for the first 6-yrs. The original design was then modified in 1986 to a randomized complete block design with a split-plot arrangement of cropping systems. Subplot treatments were continuous corn (CC), continuous soybean (CSB), and a 2-year soybean-corn (SB-C) rotation with each phase present each year.

Soil samples were collected in depth increments of 0 to 15-, 15 to 30-, 30 to 60-, 60 to 90-, 90 to 120-, and 120 to 150-cm increments and composited by depth in the fall of 1999 after harvest and analyzed for total C. Bulk densities were used to calculate total soil organic C (SOC). Data were analyzed using regression analyses.

Fig 1. Total SOC levels in the 0 to 15-, 15 to 30-, 30 to 60-, 60 to 90-, 90 to 120-, and 120 to 150-cm depths for each tillage treatment in the fall of 1999 after harvest at the Roger's Memorial Farm near Lincoln, NE.

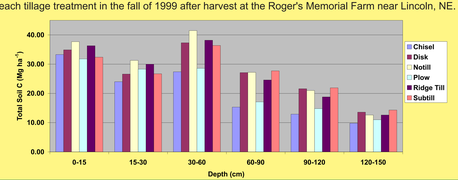
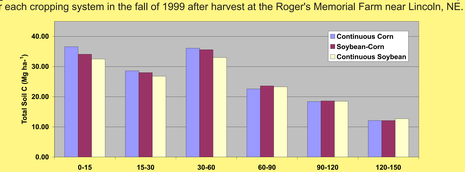


Fig 2. Total SOC levels in the 0 to 15-, 15 to 30-, 30 to 60-, 60 to 90-, 90 to 120-, and 120 to 150-cm depths for each cropping system in the fall of 1999 after harvest at the Roger's Memorial Farm near Lincoln, NE.



Results

Significant differences in total SOC levels were obtained between tillage treatments (Fig.1) and cropping systems (Fig. 2) in both surface depths of 0 to 15-, 15 to 30-cm, but also in the 30 to 60-cm depth. There was no significant tillage treatment by cropping systems effect on total SOC at any depth. Total SOC accumulations throughout the profile were significantly affected by both tillage treatment and cropping system, with those in no-till the greatest among tillage treatments and those in CC the greatest among cropping systems. Total SOC levels were increased at deeper depths in the profile, especially in those tillage systems with the least amount of soil disturbance.

Discussion

The results from this long-term study indicated significant differences in total SOC were obtained among 6 tillage treatments with 3 cropping systems both at individual depths and in total soil profiles. It appears that total SOC levels have increased in most if not all of these tillage treatments, but without initial total SOC levels it cannot be stated unequivocally. It is possible that total SOC levels have actually decreased in some of these tillage treatment and cropping systems, but again that remains to be determined. The results do indicate large differences in the amounts of total SOC in both tillage treatments and cropping systems are present after 15+ years in this study. These data also indicate that these amounts are greatest in no-till and reduced tillage treatments with a CC cropping system and least in plow and chisel tillage treatments with a CSB cropping system at most sampling depths in the profile. These results demonstrate that using conservation tillage has improved total SOC in all of the cropping systems in this study and indicates a good potential for improved soil quality and increased sustainability. In addition, as stated by others researchers, SOC accumulated at the deeper depths in the profile may be more stable and less susceptible to loss if the surface soil is tilled or disturbed in some manner.