WHAT'S HAPPENING TO SOILS IN CENTRAL SOUTH DAKOTA – AN EXAMINATION OF SOIL QUALITY

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In some ways our soils have not changed very much from the days of the pioneers. Soils in central South Dakota represent a wide variety of differences in soil properties based on differences in the five soil forming factors of climate, vegetation, parent material, topography, and time. Parent material has especially resulted in a sharp contrast between soils east and west of the Missouri River. Soils west of the Missouri River generally formed in Pierre Shale and as a result are high in clay content, difficult to work, and are of lower inherent productivity. In contrast soils east of the Missouri River are formed in glacial till parent materials. These soils tend to be more loamy with fewer shrink and swell clays, are easier to manage, and often have higher inherent productivity than those soils formed in Pierre Shale. The basic textures, mineralogy, and many of the fundamental properties of these soils are very similar to what the pioneers found when they first started to farm these lands one hundred years ago. Soil texture and mineralogy remain stable over many years and are affected very little by our management practices. These soil properties set limits for what we can expect from our soils. No matter how hard we try we will not be able to convert Promise clay into a Highmore silt loam through changes in management practices.

In other ways our soils have changed a great deal since the days when the first pioneers first broke out the native sod. One hundred years of cultivation have resulted in some predictable changes as a result of soil processes that occur when virgin land is converted to cropland . These include oxidation of soil organic carbon, soil erosion, soil compaction, and changes in soil hydrology.

The oxidation of soil organic carbon occurs rather quickly after soil is exposed by plowing. Soil organic carbon is converted into carbon dioxide faster than it is put back into the ground resulting in a sharp drop in soil carbon content. The loss of soil organic carbon translates into soil that is harder to manage, easier to erode, and less likely to retain water for crop growth. The effect of loss in soil organic carbon on soil tilth or manageability is illustrated in a story from a 1949 issue of the Farmer magazine, as retold by John Beatty, in a column published in the January 17, 1997 Brookings Register entitled "Vermont man built historic plow". The story was about the development of the steel moldboard plow.

"It began to appear as if migration westward would have to stop right there on those rich Illinois prairies. Farmers had been coming from New York, Pennsylvania, Maryland and a half dozen other states to the east to build a great farming empire, some of it right here in what is now South Dakota.

They broke that tough, centuries-old sod with wooden plows and got along fairly well. It was different, however, the second time they plowed. Something had happened to the soil. Instead of falling away from the moldboard, it would ball up and stick to it. They would plow a rod or so, stop, get a paddle out of their hip pockets, scrape, and we suppose, swear a little, then prod their oxen into motion and move another rod or so."

The story goes on to describe the development of the modern steel moldboard plow by a blacksmith named John Deere. The loss of soil tilth is a direct result of loss in soil organic carbon. Soil organic carbon increases the water content at which a soil can be tilled or driven on with minimal damage.

Soil erosion in fields is associated with cultivation worldwide. We are very familiar with water and wind erosion in central South Dakota. The results are evident in wind events usually in early spring and then in downpours in late spring and early summer. Another form of soil loss from cultivation that has been less recognized in the past, but is very significant in rolling topography is tillage erosion. This is soil movement that occurs directly through the action of tillage equipment. Tillage acts as a land leveler to smooth the tops of hills and depositing soil at the base of the slope. Gravity ensures that more soil will go downhill than uphill whether we till on the contour or up and down slope. The result of erosion whether by wind, water, or tillage is higher variability of yields within the landscape and lower yields at the top of the hillslopes.

Soil compaction is often a result of high axle loads on wet soils. The desire to enter fields in time to avoid a yield penalty in the spring from late planting or a yield loss in the fall from late harvesting can result in driving onto or tilling a field when it is too wet. As a result of this action and the loss of soil organic carbon, compaction usually increases as soils are used for cropland.

A second form of soil compaction occurs as a result of removal of crop residues. This allows the impact of raindrops to breakdown soil structure at the surface forming a thin compact layer on the soil surface. This crust results in increased water runoff and if severe enough can result in impeded emergence of seedlings. This problem is especially prevalent on soils of silt loam texture that are low in soil organic carbon.

Soil hydrology is frequently changed as a result of conversion from native grass to cropland. The example above of increased runoff means that less water is available to plants and more water leaves the field. This can alter stream flows creating a greater tendency to flood and increased streambank erosion. Less water in the field often means a greater chance of water stress for crops during the growing season.

A second problem with soil hydrology that has occurred is the unintended result of a conservation practice. Fallow was introduced to conserve water, but in some semi-humid to semi-arid regions such as in central South Dakota too much water is conserved. Instead of being transpired thorough the plant the water drains below the root zone until it appears as a seep on the side or base of a hillslope. Unfortunately many of our parent materials are high in salt content. The flow of water through the parent material dissolves salt. The now salty water flows out of the seep and as the water evaporates salt is left behind.

Lands that are cultivated for crops worldwide generally have lower soil organic carbon, more erosion, greater compaction, and changes in soil hydrology compared to virgin land. So it is not surprising to find these changes after one hundred years of cultivation of prairie in central South Dakota. If one is not careful the changes in soil structure caused by the above processes can result in a decrease in yields over time.

No-till is a soil management practice that has the potential to reduce or in some cases virtually eliminate the destructive soil processes described above. However no-till, as is true for all management systems, requires local adaptation by the producer. Not all no-till systems are created equal. The idea is to optimize the system for your unique situation. A poorly implemented no-till system can be as disadvantageous as a poorly implemented tilled system.

> *"There is no one system which fits all, or even most, or even many circumstances. Each specific system is a unique combination of components, and only the farmer can decide which grouping of components best suit her or his requirements." - Anonymous Quote from ACT (Africans for Conservation Tillage Newsletter, 2000)*

With this in mind, we examined a number of locations in central South Dakota to look at how soils have changed from management systems. The purpose was not to compare conventional to no-till, but rather to gather information about where one might work on optimizing no-till systems in terms of soils.

Soil structure and associated soil properties were measured at twelve different sites in central South Dakota. Long term grasslands, conventionally-tilled, and no-till fields were matched at each site for the same soil series. Measurements made at the sites included description of soil structure, structural stability, soil strength, bulk density, and soil organic carbon.

Soil structure of the grassland was granular while that for the till and no-till showed evidence of current and older tillage pans. There was also some evidence of compaction from equipment on the cropland that was not observed on the grasslands. On some of the no-till sites there was evidence of worm action in the old tillage pans. Aggregate stability was higher in no-till than on the till sites, but the grassland had the highest stability values. These results were related to differences in soil organic carbon between the systems. In the top foot of soil the grass had greater amounts of organic carbon than the till or no-till sites. The surface two inches of no-till had greater amounts of organic carbon than the till, but not as high as the grass. The differences in surface soil organic carbon related closely to the differences in aggregate stability of the surface soil.

The improved structural stability of the no-till surface is important for water infiltration. However evidence from other studies and observations in the field showed that increased aggregate stability is not enough to insure good water infiltration. Aggregate stability must be combined with residue cover as protection against raindrop fall even in no-till systems. No-till systems without adequate residue cover are likely to have the same degree of runoff as tilled systems especially in silt loam textured soils.

Soil bulk density tended to follow the tillage pans. In both no-till and till there was evidence of an increase in bulk density at the depth at which tillage pans were observed in the soil structural descriptions. Grass systems had significantly lower bulk densities than the no-till or till systems. However, when soil strength was measured, the grass systems had the highest values compared to the till and no-till even though all systems had similar water contents at the time of measurement. This may be the result of roots holding structural units together in the grass system.

What do the results mean? The structure observed in the cropland suggests that we need to be concerned about high axle loads on wet fields in both till and no-till systems.

No-till reduces the decomposition rate of soil organic carbon and increases organic carbon near the soil surface. However, for no-till to continue to raise soil organic carbon levels in the soil, crops that produce high amounts of residue and large root systems need to be grown.

Root systems can play a critical role in holding soil aggregates together and lessening compaction. Residue is also required in no-till to prevent aggregate breakdown and crust formation even if aggregate stability is relatively high.

Additional work needs to be conducted with cover crops in no-till systems. Cover crops have the potential to provide cover in no-till systems that for some reason have reduced residue (an example might be where corn is removed as silage). Cover crops may also have the potential to increase bearing strength, and soil organic carbon levels. The potential benefits of cover crops need to be weighed against the possible disadvantages of increased seeding expense and potential competition with crops for water and nutrients.

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