Long-term Research to Improve Productivity of Dryland Soils

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The "pluses" of traditional tillage practices

Agricultural expansion in the Great Plains started with some form of aggressive tillage (usually the moldboard plow). Although tillage practices have changed over the last several decades, some form of tillage is still practiced on most agricultural lands of the northern Great Plains. Traditional crop management in much of the semiarid Great Plains evolved into a wheat-fallow rotation and is widely practiced today.

The practice of summer fallow became widely adopted after the prevailing drought of the 1930's and grew out of a need to manage limited soil water under erratic rainfall patterns of the region. The extra season of soil water storage (afforded by fallowing) supplemented precipitation received during the crop year and served to stabilize grain yield and reduce risk of crop failure.

Summer fallow also provided an opportunity for methodically controlling weeds, usually with some form of tillage, as they emerged during the fallow season. An added benefit to the grower was the release of nitrogen from the decomposition of soil organic matter, which made the nitrogen available to the succeeding crop. This reduced or, in some cases, eliminated the need to apply nitrogen fertilizer and kept operational expenses down.

The "minuses" of traditional tillage practices

However, the continued removal of nitrogen in the grain crop and the erosion of unprotected soil by wind and water that occurred as a result of "clean tillage" has reduced the soil organic matter and organic nitrogen of many soils to about half what is was when the prairie was first farmed. As a result of this loss of organic matter over time, there has been a loss of soil structure such that the soils are more prone to sealing during heavy rainstorms decreasing water infiltration, soil aeration, and the ability of the soil to supply nitrogen to the crops. This can increase soil erosion further reducing soil productivity.

Early research efforts to improve productivity

For over 40 years, research has been conducted by scientists at the Northern Plains Agricultural Research laboratory (NPARL) located at Sidney, MT on methods to reduce soil erosion, store more of the precipitation for crop use, increase crop yields and reduce the cost of land preparation. The early work concentrated on tillage methods that left crop residues on the soil surface to protect it from wind and water erosion. These methods went by a variety of names such as: conservation tillage, trashy tillage, stubble mulching and reduced tillage. ARS scientists at Sidney have conducted research using direct seeding methods without prior tillage, often called no-tillage or zero-tillage for at least 20 years.

Current research efforts to improve productivity

In 1982, research was initiated to find ways to reduce the amount of summer fallow used in the region. Long-term plots were established between Culbertson and Froid comparing conventional summer fallow with continuous cropping practices with and with out tillage. Another long-term study at this location compares the use of a green manure crop in place of fallow to find out if green manure can be used to replace the need for nitrogen fertilizer, avoid excessive use of stored water during the fallow year, and maintain wheat yields and quality. A third long-term study was conducted on the Curtis Rasmussen Farm north of Sidney by mechanically removing topsoil to simulate soil erosion. The objective was to determine the long-term effects of soil erosion on wheat yield and quality using a conventionally tilled summer fallow-wheat rotation. The amount and type of fertilizer required to compensate for the removal of topsoil was also evaluated.

Soil water content, organic matter, organic nitrogen, pH, nitrate, and ammonium concentration are routinely determined on soil samples obtained with a hydraulic sample mounted on a pickup.

Research Results: Continuous Cropping

Substituting a spring wheat or barley crop in place of fallow reduced spring soil water content causing a reduction in spring wheat yield on years with normal or below fall and winter precipitation. However, there was a 30% average increase in total grain production per acre over the last 20 years due to annual cropping. There was no yield or grain quality differences between tilled and direct seeded spring wheat. There has been a small increase in soil organic matter with annual cropping (both tilled and no-till) while soil organic matter has continued to decline with the wheat – fallow rotation. In no-till, soil organic matter and partially decomposed crop residues are accumulating on and near the soil surface which act to increase water infiltration, reduce evaporation and protect the soil from erosion.

Research Results: Green Manure

Killing a green manure crop of lentils at near full bloom has not adversely affected spring soil water content compared to fallow. For the first 5 years, spring soil nitrate levels were lower with the green manure than with summer fallow, and spring wheat grain yields and protein content were reduced. Previous studies have shown that about 40 % of the nitrogen in a green manure crop is available to the following crop the first year and it will take a few years to build up the soil's ability to supply adequate nitrogen to meet crop requirements. It took 2 to 3 green manure-crop cycles (4to 6 years) for this to happen. Since then, spring soil nitrate levels have been higher with the green manure treatment and grain yields and protein content have been equal to that after fallow, even when the fallow received additional N and the crop after green manure did not. From these studies we estimate that lentils grown to full bloom before killing contributes an average of 30 lbs of nitrogen per cycle to the harvested crop under dryland conditions.

Research Results: Erosion Studies

The removal of topsoil initially reduced spring wheat yields and protein content. The addition of N and P fertilizer only partially compensated for the loss of topsoil for the first few years, but the continued use of fertilizer brought production and grain quality up to that with no topsoil removed. Sixteen years later there was no evidence of any recovery from the removal to topsoil. Soil organic matter and organic nitrogen had decreased equally for all soil removal and the no soil removal treatments indicating possible permanent damage from erosion unless management changes. We plan to put one-half of the plots in CRP to determine how rapidly permanent cover will restore soil organic matter and organic nitrogen from eroded soil.