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High Residue Producing Crops and Reduced-Till Improve Soil Productivity

Studies show how practice reduces soil erosion and increases soil organic matter to produce both yield and economic benefits.

Summary: Sustaining or increasing soil productivity and profitability depends on soil and crop management practices that maintain or increase soil organic matter. Crop management systems that include rotations with high-residue producing crops and maintenance of surface residue cover with reduced or no-tillage result in greater soil organic matter, which may improve soil productivity. Increasing input efficiency, protecting the environment, and sustaining the productive capacity of our soils are critical components of successful farm management. The future and viability of agriculture in the Great Plains depend on sustaining the soil resource base and increasing producer profitability. Conservation technologies provide the greatest opportunity to achieve agricultural sustainability and profitability.

It is essential that producers recognize that soil erosion and loss of soil organic matter can reduce soil productivity, which reduces crop yield and profit potential. The practical approach to solving the problem involves a couple of steps: reducing tillage intensity and increasing carbon input through cropping systems that produce more residue. Soil erosion will be minimized and organic matter oxidation reduced.

Level of soil organic matter is determined by numerous soil properties that are influenced by cropping practices such as residue management, crop rotation, and many others. Carbon contained in the crop residue is incorporated into the soil as organic matter through degradation of crop residues by soil microorganisms. In one study, for example, tillage in a wheat-fallow system greatly influenced soil organic matter content. Conventional tillage wheat-fallow rapidly reduced soil organic matter, whereas minimum tillage maintained soil organic matter and ultimately enhanced soil productivity.

Similarly, organic matter increased when quantity of residue produced increased between soybean/soybean, sorghum/soybean, and sorghum/sorghum rotations in eastern Kansas. However, increase in organic matter was significantly greater when all residue was left undisturbed on the soil surface (no tillage) compared to conventional tillage. Increasing the quantity of total carbon input by increasing residue and decreasing quantity of carbon oxidized or lost by decreasing tillage conserves or increases soil organic matter. Studies also show that the more intensive the crop rotation, the more productive the soil becomes.

Our agricultural production system can meet future population demand provided soil and crop management technologies are used to maintain productive capacity of the soil. The challenge is to manage soils so that they will be as productive for future generations as they are today. Understanding those factors that influence soil productivity will help us to identify the appropriate management technologies that sustain or enhance agricultural productivity and profitability.

Erosion

A significant problem associated with decline in agricultural productivity is the loss of topsoil and soil organic matter. The concerns about declining productivity are not new. Data collected in Kansas wheat fields from 1910 to 1946 show that soil N decreased 50 percent in just 40 years. Approximately 95 percent of soil N occurs as organic N in organic matter. Recent studies in Kansas showed significant loss of soil organic matter associated with erosion of organic matter-rich topsoil. Similar results have been reported throughout the U.S. and Canadian prairie regions and confirmed that soil organic matter decreases about 50 percent during the first 50 years of cultivation.

Loss of topsoil by wind and water erosion can reduce the productive capacity of agricultural soils and significantly reduce profit potential. Erosion-productivity relationships were quantified for dryland winter wheat, grain sorghum,

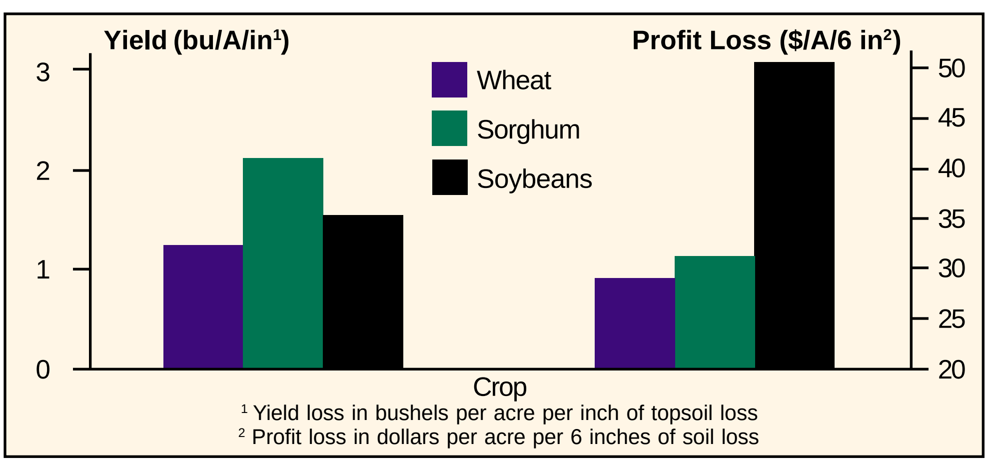

Figure 1. Influence of topsoil on grain yield and profit, Havlin et al., 1994.

and soybeans grown on five Kansas soils over six years. Results indicated that grain yields significantly decreased with decreasing topsoil depth (Figure 1). Yield losses as high as 2 bu/A per inch of topsoil lost resulted. Profit losses were as high as $51/A in the first 6 inches of topsoil eroded.

Data in Figure 1 can be used to project the cumulative yield and profit loss associated with long-term soil erosion. Let's assume that 6 inches of topsoil eroded over 40 years, representing an annual soil loss of 0.15 inches/A/year (Figure 2). As can be seen, using 1990 market prices with deficiency payments, cumulative profit loss over a 40-year span could run as high as $1,027/A. These cumulative profit losses are similar to current land prices in Kansas, thus, if soil erosion had not occurred the producer would have had sufficient revenue to pay for the land.

Water management

Water frequently limits crop yield potential, which is especially true as we move from the Midwest to the Great Plains. Unfortunately, water management is seldom the highest management priority, ranking behind variety selection and fertility. After water, fertility and pests usually become the next most yield-limiting factors.

Table 1. Water-use efficiency, conventional vs. conservation-till.

	Bu/A of rain
USA avg.	3.5
Conventional-till	5.0
Conservation-till	7.0
High yielder	11.0

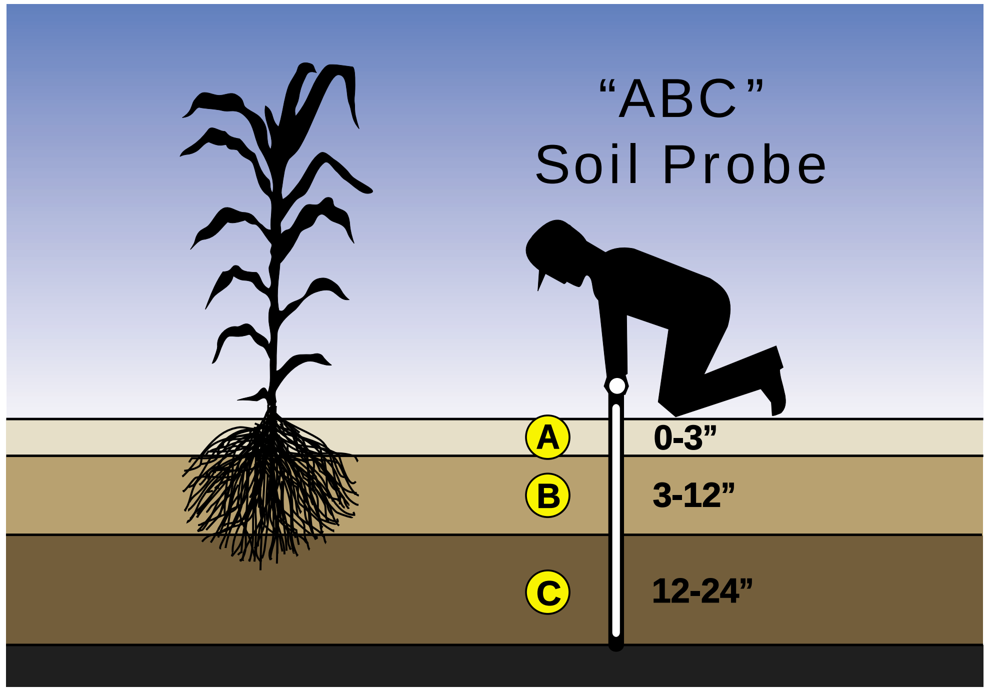

Figure 3. ABC method of sampling.

Growers are reducing water runoff and evaporation, and increasing water infiltration by maintaining surface crop residue cover (reducing tillage intensity). The water loss reductions and increased infiltration are essential to increasing stored soil water. Reduced-till systems almost always improve water-use efficiency (Table 1).

Evaluating the different sources of plant-available water is important in understanding where the investment in water conservation provides the greatest return. Water stored in the soil profile is potentially 100 percent available to the next crop. Therefore, any soil profile water left after harvest must not be lost. The major losses of stored water during non-crop periods occur through weed growth and evaporation from the soil.

The amount of rain that infiltrates the soil greatly increases with standing residue. Rain falling on a bare soil, for example, can seal off the soil surface within 30 minutes. As little as 0.5 inch of rainfall can seal the surface of a bare soil. Once sealed, infiltration slows or ceases and water begins to run off. Surface residue cover can increase the time for infiltration by two- or threefold, greatly reducing runoff and soil loss by erosion.

Nutrient management

Soil testing. Obtaining profitable crop yields, minimizing water- and nutrient-use efficiency, and minimizing environmental impacts of nutrient use require regular soil testing. Soil testing is the best method available to accurately determine nutrient availability and provide a guideline for optimum fertilization.

Soil sampling under reduced-till presents a special problem that should be addressed. Since the land is no longer mixed with a moldboard plow, nutrient stratification can occur (Table 2). Thus, immobile elements such as phosphorus, potassium, and zinc may concentrate

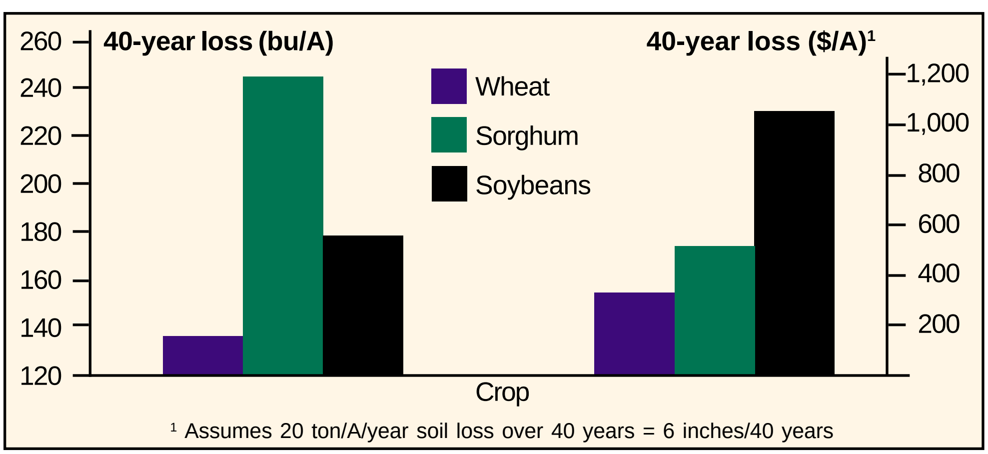

Figure 2. Influence of topsoil erosion on cumulative yield and profit loss, Havlin et al., 1994.

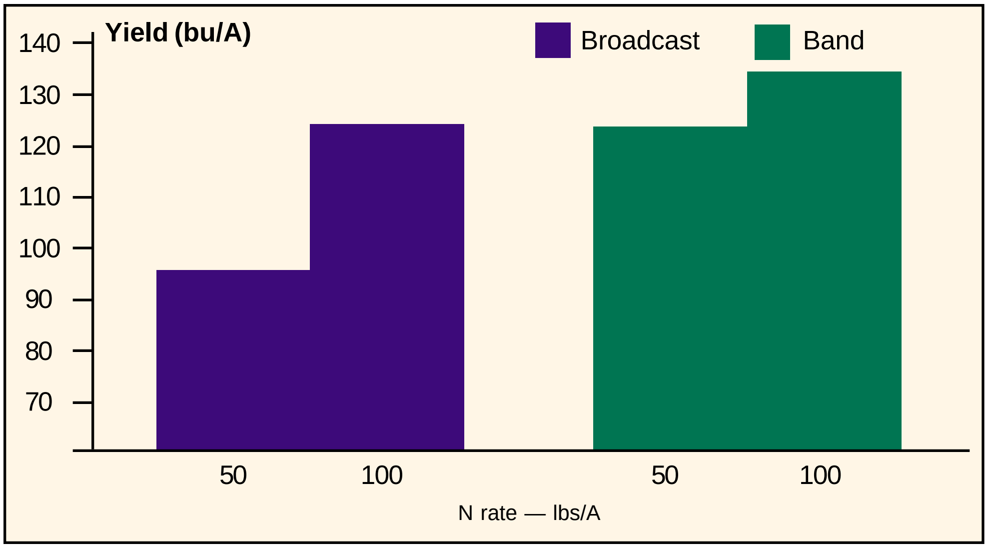

Figure 4. Nitrogen management effects on no-till sorghum yield, Lamond et al., 1991.

near the surface. A possible solution is the "ABC" method of sampling where three samples are taken from three zones (Figure 3). The "A" zone could be 0 to 3 inches, the "B" 3 to 12 inches, and the "C" 12 to 24 inches. It makes good sense to evaluate at least the A and B zones and knife fluid fertilizer down where the roots grow.

Nitrogen. N placement can significantly influence crop growth and yield, especially on high-residue cropping systems. Our no-till studies showed that subsurface band application of N significantly increased sorghum grain yield compared to broadcast (Figure 4). Although not measured directly, the enhanced yield response was likely due to reduced N immobilization, denitrification, and/or volatilization.

Phosphorus. We quantified phosphate rate and placement effects on no-till early winter wheat growth in central Kansas. Compared to broadcast phosphate, the number of tillers, dry matter yield, and phosphate uptake were much greater with band-applied phosphate (Figure 5). The dramatic early growth response to band-applied phosphate was likely due to cool soil temperatures in the fall that reduced phosphate diffusion rate and root growth. Although this early growth response to phosphate placement is critical for maximizing grain yield in areas where the major economic return from winter wheat is realized through grazing, substantially more biomass would be available with band-applied phosphate.

Over the last several decades extensive placement research has been conducted with often contrasting results. For example, numerous factors affect crop response to phosphate placement that include a) soil test phosphate level, b) root contact with fertilized soil, c) phosphate concentration in the fertilized soil solution, and d) environmental factors. Root contact with fertilized soil is influenced by total root length, volume of soil fertilized, and location of the fertilized soil in relation to plant roots. In addition to agronomics, the availability of equipment, labor, fertilizer source, and operating capital are other common factors affecting phosphate placement decisions.

Groundwater quality. The impact of N fertilizer on groundwater quality has become a major concern for the public and fertilizer industry. Adoption of N fertilizer "best management practices" can significantly minimize NO3- contamination of groundwater. The N management studies in no-till sorghum described earlier showed significantly greater recovery of N fertilizer when applied below the soil surface.

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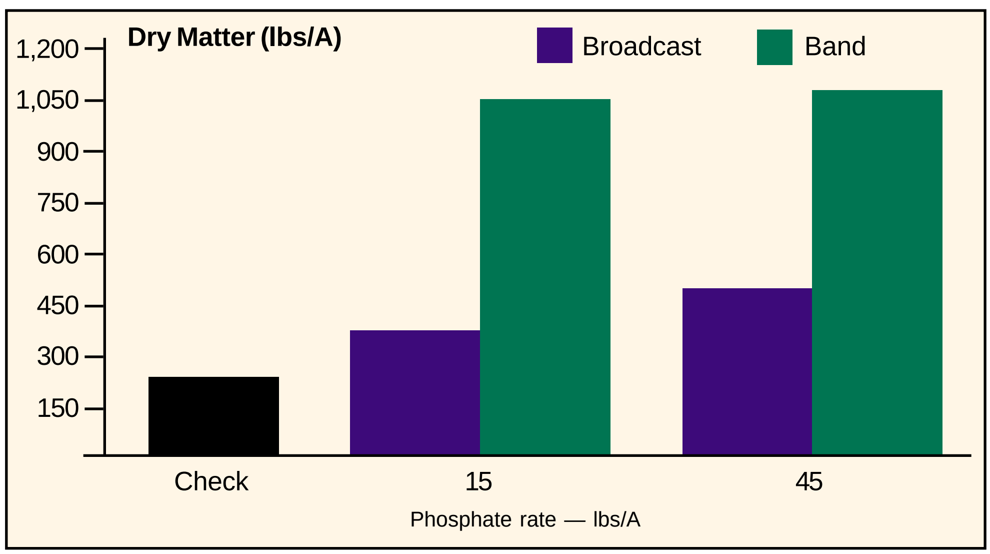

Figure 5. Early no-till winter wheat growth response to phosphate rate and placement, Havlin et al., 1990.

Table 2. Nutrient stratification in western Iowa soils.

Depth	Organic matter	NO_3N	P	K	S	Zn
A (0-3")	2.8%	23	84	231	8.0	4.6
B (3-12")	1.7%	7	15	135	0.1	2.0
C (12-24")	2.2%	6	9	146	0.1	2.0
Clay loam, dryland						