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G81-544 Residue Management for Soil Erosion Control

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Residue Management for Soil Erosion Control

This NebGuide discusses how crop residue can be used to control soil erosion

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Crop residue is increasingly being used as a major tool to reduce the loss of one of Nebraska's most valuable resources--its topsoil. Soil erosion and the subsequent sedimentation have been identified as major water quality problems in the state. Residue reduces soil erosion caused by both wind and water. However, this NebGuide deals mainly with soil erosion caused by water since it accounts for 80 percent of Nebraska's soil loss.

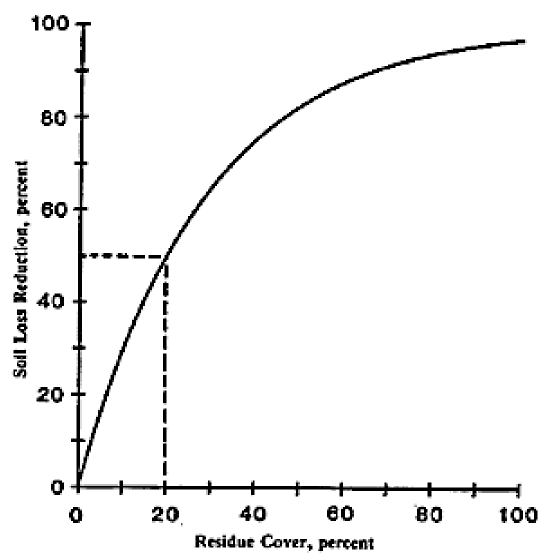

Figure 1. Effect of residue cover on reduction of soil erosion. The example shows that a 20 percent residue cover will reduce erosion by 50 percent of that occurring from a cleanly tilled field.

Today, with an increasing need to evaluate and reduce production costs, residue management through conservation tillage has become an important element in farm management. Conservation tillage includes a variety of tillage and planting systems that leave at least a 20 to 30 percent residue cover on the soil surface after planting. Research conducted in Nebraska and other Midwestern states has shown that maintaining this minimum residue cover can reduce soil erosion by at least 50 percent of that which occurs from a cleanly tilled field (*Figure 1*).

The Erosion Process

Erosion of topsoil begins when water detaches individual soil particles from clods and other soil aggregates. Raindrops are the major cause of soil particle detachment. A single raindrop may seem insignificant, yet when accumulated, raindrops strike the ground with a surprisingly large force. Raindrops can be especially erosive when residue, mulch, or vegetation are not present to absorb the impact forces. During an intense storm, rainfall can loosen and detach up to 100 tons of soil per acre.

A raindrop falling on a thin film of water detaches soil particles more readily than a drop falling on dry soil. Detachment increases as the water on the soil surface becomes deeper, but only up to a depth about equal to the raindrop diameter. Once the water becomes deeper than this, detachment by raindrops is reduced and eventually eliminated because the water layer acts as a cushion.

During rainstorms, a two-fold problem often occurs. The rate of rainfall may exceed the rate at which water can enter the soil. The excess water either collects on or runs off the soil surface. Secondly, raindrop impact forces can result in a partially sealed soil surface, thus reducing infiltration of water into the soil which causes more runoff. If all the water could always enter the soil, detachment and splashing of soil particles would be of minor concern and soil loss would be minimal. However, when the rainfall rate exceeds the soil's infiltration rate and the soil surface storage is filled, runoff will begin. This runoff will travel downhill, carrying soil particles with it (*Figure 2*).

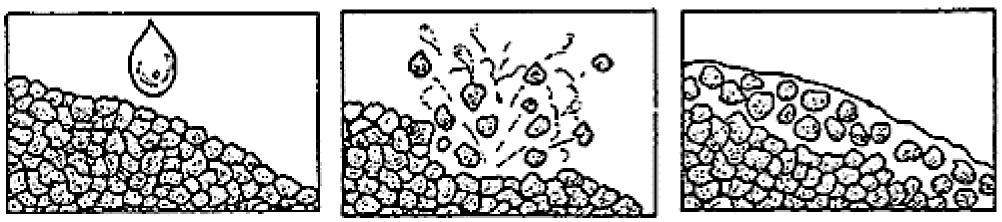

Figure 2. Soil particles and aggregates that have been detached by raindrops are transported down the slope by runoff.

The transport ability of runoff is influenced by the amount and velocity of the flow, which in turn is dependent on the slope of the land. Flat areas may have little or no runoff; consequently, little transport of soil occurs. Runoff from steeper areas flows at greater velocities and may have considerable transport capability. As runoff flows across unprotected soil surfaces, additional soil particles are dislodged, which further magnifies the soil erosion problem.

Soil particle size distribution, organic matter content, and the slope of the land all influence how susceptible different fields are to the forces of erosion. Large-grained particles and aggregates are easily detached by raindrops or flowing water, but are not easily transported. Soils such as clays and fine silts that bond together tightly are not easily detached, but once free are easily transported. For this reason, fine materials can be carried considerable distances, whereas larger particles may be deposited within a short distance along the flow path.

Residue Reduces Erosion

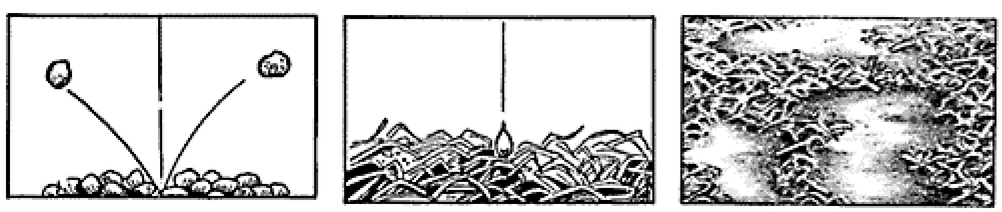

Figure 3. With no protective cover, raindrops can splash soil particles up to three feet away. Residue cover cushions the fall of raindrops and reduces or eliminates splash erosion. Small natural dams are formed and cause ponding of runoff. Sediment is deposited in these ponds and remains in the field.

Residue cover is one of the most effective and least expensive methods for reducing soil erosion. Residue protects the soil surface from raindrop impact, thus reducing soil particle detachment. In

addition, transport
capacity is reduced because residue forms a complex series of small diversion dams that slow the runoff (*Figure 3*). No-till planting systems, which leave the greatest amount of residue cover, can reduce soil erosion by 90 to 95 percent of that which occurs from cleanly tilled, residue-free fields. Although no-till will result in the largest reduction in soil loss, other conservation tillage systems also can be effective in reducing erosion and may be better suited to some farming situations.

Field tests in Nebraska have documented the soil saving benefits of various conservation tillage systems. These results are presented in *Table I* and illustrated in *Figures 4* and *5*. As little as 20 percent residue cover can reduce erosion by up to 50 percent. Several tillage systems are available that can leave this minimum cover in corn, grain sorghum, and small grain residues. These include chisel, disk, rotary-till, ridge-plant, and no-till systems.

Table I. Measured surface cover and soil loss for various tillage systems.

Tillage System Residue Type	**Residue Cover**	**Erosion**	**Erosion reduction from moldboard plow**
	(percent)	(Tons/Acre)	(percent)
Corn Residue[1]			
--Moldboard plow, disk disk, plant	7	7.8	_
--Chisel plow, disk, plant	35	2.1	74
--Disk, disk, plant	21	2.2	72
--Rotary-till, plant	27	1.9	76
--Till-plant	34	1.1	86
--No-till plant	39	0.7	92
Soybean Residue[2]			
--Moldboard plow, disk, disk, plant	2	14.3	_
--Chisel plow, disk, plant	7	9.6	32
--Disk, plant	8	10.6	26
--Field cultivate, plant	18	7.6	46
--No-till plant	27	5.1	64
Wheat Residue[3]			
--Moldboard plow, harrow, rod weed, drill	9	4.2	_
--Blade plow three times, rod weed, drill	29	1.2	72
--No-till drill	86	0.2	96

[1]Nebraska tests after tillage and planting on a silt loam soil having a 10 percent slope, 2 inches water applied in 45 minutes.
[2]Nebraska tests after tillage and planting on a silty clay loam soil having a 5 percent slope, 2 inches water applied in 45 minutes.
[3]Nebraska tests after tillage and planting on a silt loam soil having a 4 percent slope, 3 inches water applied in 75 minutes.

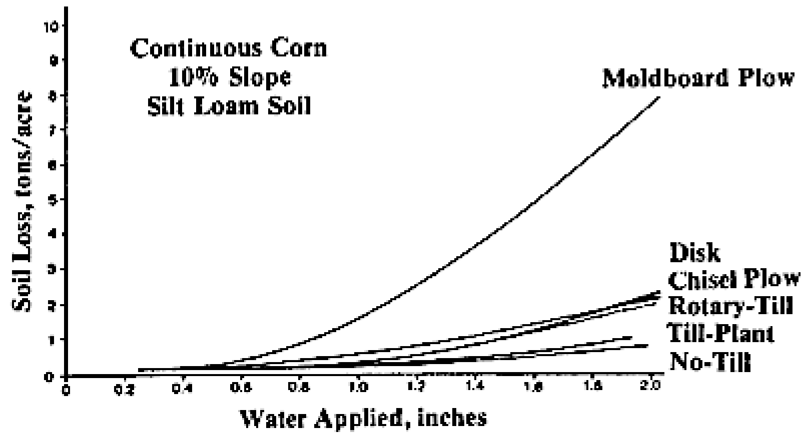

Figure 4. (above) Soil loss associated with tillage systems used for planting corn into corn residue on a silt loam soil at the University of Nebraska Northeast Research and Extension Center near Concord. Water was applied at the rate of 2.5 inches per hour.

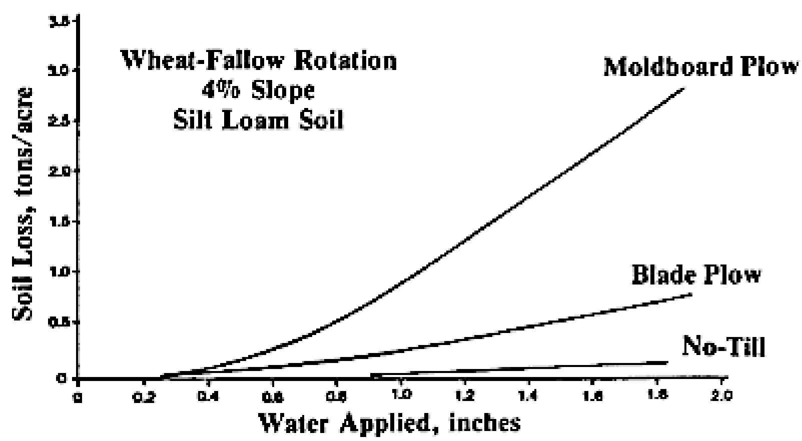

Figure 5. (above) Soil loss associated with various tillage systems used in wheat residue on a silt loam soil at the High Plains Agricultural Laboratory, Sidney, Nebraska. Water was applied at the rate of 2.5 inches/hour. Tillage operations for moldboard plow system were plow, spring tooth harrow twice, rodweed twice; and for the blade plow, undercut three times, and rodweed twice.

Limiting the number of field operations is more crucial than the type of implement used. When using a chisel or disk tillage system in dryland conditions, the number of tillage operations should not exceed two. Additional operations will not leave enough cover for appreciable erosion control.

Soybean residue needs special consideration because of its fragile nature. Erosion from areas where soybeans were grown the previous year will be about 50 percent greater than from areas where corn was grown when the same tillage systems are used (*Figure 6*). Further, in soybean residue, no-till is the only system that consistently leaves at least a 20 percent residue cover. Just a single pass with a tandem disk will usually reduce the cover to about 10 percent in soybean residue, not enough to be considered conservation tillage.

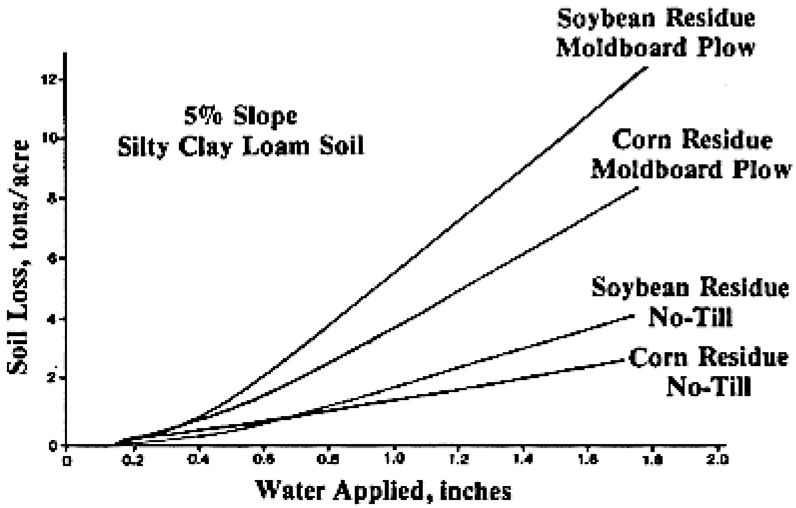

Figure 6. Soil loss associated with the moldboard plow and no-till systems used on a silty clay loam soil having either corn or soybean residue at the University of Nebraska Rogers Memorial Farm near Lincoln. Water was applied at the rate of 2.5 inches per hour.

Residue also reduces surface crusting, sealing, and rainfall-induced soil compaction--all of which increase runoff by reducing infiltration. Runoff can be reduced if the soil infiltration rate is maintained and soil surface storage allows more time for infiltration. Later in the season, the mulch created by the residue protects the soil from the sun and wind, thus reducing water loss by evaporation. Throughout the winter, standing residue also helps to conserve moisture by trapping winter snowfall. This moisture savings can reduce irrigation requirements or "save" a dryland crop in years with low rainfall.

Crop canopies may be effective in reducing erosion, although they usually are not present during the critical erosion period when spring rains occur. Canopy cover from close growing crops, such as small grains or narrow-row soybeans, catch raindrops and keep them from hitting the soil directly. Much of this intercepted water runs down the plant stem, although some drips off the leaves. While these drops have not fallen far, a small amount of soil detachment and transport still occurs.

Residue Management

To achieve good erosion control, residue must be uniformly distributed behind the combine, rather than clumped or windrowed. This will also help reduce potential clogging problems when planting into the residue-covered field. Eliminating fall tillage will leave some standing residue that can catch snowfall, anchor the soil within the row, and be most effective for wind erosion control. However, it may not provide the necessary ground cover to reduce water-induced soil erosion between rows.

Steeper slopes will require more residue than flat areas, such as bottomlands, to maintain erosion control. Structural or other cropping practices may be added to residue management for greater erosion control. These can include terraces, waterways, or contour farming. If terraces and waterways are already established, residue can decrease maintenance requirements by reducing the amount of soil deposited in terrace channels and waterways.

Residue grazing can be practiced although it may remove an excessive amount of residue, depending on the stocking rate and the length of the grazing period. Livestock may also cause soil compaction but this can be minimized by limiting grazing to periods when the ground is dry or frozen.

Estimating Residue Cover

Residue cover can be estimated in the field following one of two simple procedures (see NebGuide *G1132, Estimating Percent Residue Cover*). The line-transect method is a reliable way to determine residue cover by stretching a 100 foot tape diagonally across crop rows and checking every foot to see if that point touches a piece of residue. The percent cover is the number of times residue touches the points checked. Residue cover estimates can also be achieved by comparing field conditions with photographs of known residue cover. Photo comparison is quick, but less accurate than the line-transect method.

Potential Residue Disadvantages

Although residue management can effectively control soil erosion, some problems may result when large amounts of residue are present. Larger amounts of residue can interfere with herbicide incorporation, especially if the soil and residue are wet. Mulches created by crop residue retain soil moisture and keep the soil temperature cooler. These conditions may delay planting and seed germination in poorly drained soils. In addition, wet residue in large amounts can hinder some tillage and planting operations by clogging implements.

Potential problems should not be ignored by the producer. However, good management techniques can minimize many of the disadvantages associated with increased levels of residue. Depending on how much residue is present after harvest, a stalk chopping or shredding operation can minimize potential clogging problems, although this operation increases fuel and labor requirements. Implement manufacturers are responding to the needs of conservation tillage by designing tillage and planting equipment that will perform effectively in increased residue levels.

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