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Conservation Tillage and Residue Management to Reduce Soil Erosion

John R. McCarthy
Natural Resources Conservation Service

Donald L. Pfost and H. David Currence
Department of Agricultural Engineering

Crop-residue management through conservation tillage is one of the best and most cost-effective ways to reduce soil erosion. Conservation tillage and residue management may reduce machinery expenses and save soil, labor, fuel and money. Crop residues uniformly distributed over the soil surface will significantly reduce soil losses over an entire field. On terraced land, the resulting reduction in soil losses due to this residue cover can greatly reduce the cost of terrace maintenance.

The erosion process

Two mechanisms are involved in soil erosion: soil detachment and soil transport. Most soil detachment is caused by raindrop impact, a major factor in sheet erosion. The average erosion from cropland in Missouri is about 10 tons per acre per year, equivalent to about 0.07 inches (slightly over 1/16 inch). Sheet erosion can go almost undetected for years, often causing great losses in productivity before the landowner becomes concerned.

Some soil detachment is caused by flowing water, especially where water concentrates to cause gullies. Gullies created by flowing water may be either ephemeral or permanent gullies. Short-lived gullies may be filled in by heavy tillage operations but tend to reform annually in the same location.

How residue reduces erosion

Residue (and crop canopy) can reduce soil detachment by absorbing the impact of falling raindrops. Also, residue may form small dams which retard runoff and create puddles of water that can absorb raindrop energy, thus reducing both detachment and transport of soil particles.

Sufficient amounts of crop residue left on the soil surface can almost eliminate erosion on many fields and greatly reduce erosion on other fields. In areas of concentrated water flow, such as natural or designed drainage ways, crop residues alone generally are not enough to control erosion. Such areas may require permanent grass seedings and/or some structural measures such as diversions or terraces (especially to control gully erosion). On long slopes, detached crop residues may be floated away by the higher water velocities attained in sheet flow. Once removed, erosion due to detachment and transport will accelerate. Terraces and diversions, in combination with crop residues, may be needed to control sheet erosion.

Conservation tillage defined

Conservation tillage is defined to be any tillage/planting system which leaves at least 30 percent of the field surface covered with crop residue after planting has been completed. Figure 1 shows that erosion is reduced by at least 50

percent (compared to bare, fallow soil) if 30 percent of the surface is covered with residue.

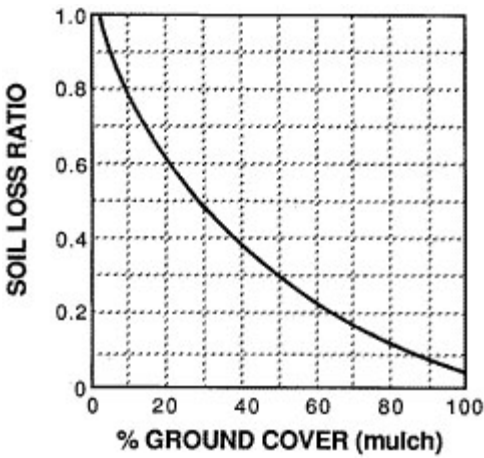


Figure 1
The effect of percent ground cover by residue (mulch) on the soil loss ratio (compared to a bare, fallow soil)

Enhancing residue management

Residue management (through conservation tillage) for erosion control can be enhanced by:

- Selection of crops that produce large amounts of residue (such as corn and grain sorghum) and/or a high degree of soil cover per pound of residue (such as wheat).
- Selection of a crop sequence that frequently renews the residue cover (e.g., double-cropping or use of winter cover crops).
- Use of crops that provide long-lasting residue (i.e., crops with a high carbon-to-nitrogen ratio, e.g., wheat).
- Uniform spreading of the residue by the combine (combines with headers 20 feet, or wider, may require special chaff spreaders).
- Minimizing the loss of cover due to tillage operations.
- Use of irrigation to produce high-yielding crops, especially in drought years.

Other conservation tillage benefits

Minor benefits from conservation tillage may result from less tillage leaving the soil surface rougher to retard runoff and increase infiltration. Random roughness may result in shallow puddles, which absorb some of the impact of falling raindrops (water deeper than the raindrop diameter can absorb a considerable portion of the raindrop energy). Contoured furrows, especially from twisted chisel points or ridge planting, may temporarily impound water during heavy rains. This impounded water can absorb raindrop impact and increase infiltration (especially if compared to furrows up and downhill).

However, little credit for soil-loss reduction is given to these factors, since these benefits may be temporary and usually are eliminated by future rains and/or additional tillage. Residue cover therefore is credited as the major factor for reducing soil loss with conservation tillage.

Estimating percent residue cover

Three methods are commonly used to estimate the percent residue cover remaining after tillage/planting operations.

The photo comparison method

Visual estimates may be made by looking straight down on the soil surface and comparing the appearance with photos of known percentages of the same type of residue. Do not try to estimate percent of cover by looking across a field; bare spots behind residue will be hidden from view.

A more time-consuming and accurate method involves projecting photographic slides of the surface onto a grid and determining the percent of grid intersections coinciding with a piece of residue sufficient to absorb the impact of a raindrop. This method is frequently used for research.

The line-transect method

The line-transect method is a practical field method of estimating the residue cover after any operation. This method involves stretching a 50- or 100-foot tape (or cam line) diagonally across the crop rows, and then checking at every foot mark to see if a piece of crop residue is lying under the mark.

When using a 100-foot tape, the percent cover is equal to the number of marks underlain with a piece of residue. When using a 50-foot tape, double the figure to obtain percentage of cover.

To use this method, look straight down at the same side of the tape and when in doubt if there is residue that will absorb the impact of a raindrop under a mark, do not count it. Care should be taken not to overestimate the percentage of cover. Take the average of at least three such readings at typical spots in the field to have a reliable estimate of the percentage of cover.

Calculating residue production

The following amounts of residue are commonly accepted to be produced by various crops:

Crop	Residue produced per bushel of crop yield
Corn	60 pounds
Grain sorghum	70 pounds
Soybeans	50 pounds
Small grain	100 pounds

Figure 2 shows the relationship of the percent of surface cover to the amount of uniformly distributed residue mulch for various crops. Ninety-five percent surface cover will be provided by 4,500 pounds of small-grain residue or 6,000 pounds of corn or grain sorghum residue. Increasing weights of residue produce diminishing increases in percentages of surface cover, especially after the surface is 90 percent covered.

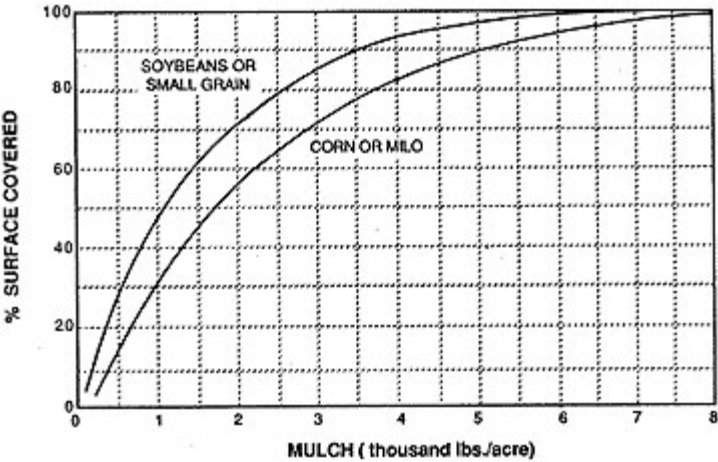


Figure 2
Relation of percent cover to dry weight of uniformly distributed residue mulch.

Post-operation calculations

To estimate the percentage of residue surface cover remaining after future tillage and planting operations, calculations

may be made using the data from Table 1.

Table 1
Influence of field operations on surface residue

Implement	Percent residue remaining	
	Non-fragile (corn)	Fragile (soybeans)
Plows		
Moldboard plow	0 to 10	0 to 5
Moldboard plow — uphill furrow	30 to 40	
Disk plow	10 to 20	5 to 15
Machines that fracture soil		
Paratill/paraplow	80 to 90	75 to 85
V-ripper/subsoiler 12-14 inches deep, 20-inch spacing	70 to 90	60 to 80
Combination tools		
Subsoil-chisel	50 to 70	40 to 50
Disk-subsoiler	30 to 50	10 to 20
Chisel plows		
Sweeps	70 to 85	50 to 60
Straight chisel points	60 to 80	40 to 60
Twisted points or shovels	50 to 70	30 to 40
Combination chisel plows		
Coulter-chisel plows with		
Sweeps	60 to 80	40 to 50
Straight chisel points	50 to 70	30 to 40
Twisted points or shovels	40 to 60	20 to 30
Disk chisel plows with		
Sweeps	60 to 70	30 to 50
Straight chisel points	50 to 60	30 to 40
Twisted points or shovels	30 to 50	20 to 30
Disk harrows		
Offset		
Plowing greater than 10-inch spacing	25 to 50	10 to 25
Primary greater than 9-inch spacing	30 to 60	20 to 40
Finishing 7- to 9-inch spacing	40 to 70	25 to 40
Tandem		
Plowing greater than 10-inch spacing	25 to 50	10 to 25

Primary greater than 9-inch spacing	30 to 60	20 to 40
Finishing 7- to 9-inch spacing	40 to 70	25 to 40
Light tandem disk after harvest, before other tillage	70 to 80	40 to 50
One-way disk with		
12- to 16-inch blades	40 to 50	20 to 40
18- to 30-inch blades	20 to 40	10 to 30
Single-gang disk	50 to 70	40 to 60
Field cultivators (including leveling attachments)		
Field cultivators as primary tillage operation		
Duckfoot points	35 to 60	30 to 55
Sweeps or shovels 6-12 inches	35 to 75	50 to 70
Sweeps 12 to 20 inches	60 to 80	55 to 75
Field cultivators as secondary operation following chisel or disk		
Duckfoot points	60 to 70	35 to 50
Sweeps or shovels 6 to 12 inches	70 to 80	50 to 60
Sweeps 12 to 20 inches	80 to 90	60 to 75
Finishing tools		
Combination secondary tillage tools with		
Disks, shanks and leveling attachments	50 to 70	30 to 50
Spring teeth and rolling basket	70 to 90	50 to 70
Harrows		
Spring tooth (coil tine)	60 to 80	50 to 70
Spike tooth	70 to 90	60 to 80
Flex-tine tooth	75 to 90	70 to 85
Roller harrow (cultipacker)	60 to 80	50 to 70
Packer roller	90 to 95	90 to 95
Rotary tiller		
3-inch deep (secondary)	40 to 60	20 to 40
6-inch deep (primary)	15 to 35	5 to 15
Undercutters		
Stubble-mulch sweep blade plows with		
"V"-blades or sweeps, 30 inches or wider	85 to 95	70 to 80
Sweeps 20 to 30 inches wide	80 to 90	65 to 75
Rodweeders		

Plain rotary rod	80 to 90	50 to 60
Rotary rod with semi-chisels or shovels	70 to 80	60 to 70
Strip tillage machines		
Rotary tiller, 12-inch tilled on 40-inch rows	60 to 75	50 to 60
Row cultivators (30 inches and wider)		
Single sweep per row	75 to 90	55 to 70
Multiple sweeps per row	75 to 85	55 to 65
Finger-wheel cultivator	65 to 75	50 to 60
Rolling-disk cultivator	45 to 55	40 to 50
Ridge-till cultivator	20 to 40	5 to 25
Drills		
Hoe opener drills	50 to 80	40 to 60
Semi-deep furrow drill or press drill (7- to 12-inch spacing)	70 to 90	50 to 80
Deep furrow drill with greater than 12-inch spacing	60 to 80	50 to 80
Single-disc opener drills	85 to 100	75 to 85
Double-disc opener drills (conventional)	80 to 100	60 to 80
No-till drills and drills with the following attachments in standing stubble		
Smooth no-till coulters	85 to 95	70 to 85
Ripple or bubble coulters	80 to 85	65 to 85
Fluted coulters	75 to 80	60 to 80
No-till drills and drills with the following attachments in flat residues		
Smooth no-till coulters	65 to 85	50 to 70
Ripple or bubble coulters	60 to 75	45 to 65
Fluted coulters	55 to 70	40 to 60
Air seeders	Refer to appropriate field cultivator or chisel plow depending on type of ground-engaging device used.	
Air drills	Refer to corresponding type of drill opener.	
Row planters		
Conventional planters with		
Runner openers	85 to 95	80 to 90
Staggered double-disc openers	90 to 95	85 to 95
Double-disc openers	85 to 95	75 to 85
No-till planters with		
Smooth coulters	85 to 95	75 to 90
Ripple coulters	75 to 90	70 to 85

Fluted coulters	65 to 85	55 to 80
Strip-till planters with 2- or 3-fluted coulters	60 to 80	50 to 75
Strip-till planters with row cleaning devices (8- to 14-inch wide bare strip using brushes, spikes, furrowing discs or sweeps)	60 to 80	50 to 60
Ridge-till planter	40 to 60	20 to 40
Unclassified machines		
Anhydrous applicator	75 to 85	45 to 70
Anhydrous applicator with closing discs	60 to 75	30 to 50
Subsurface manure applicator	60 to 80	40 to 60
Rotary hoe	85 to 90	80 to 90
Bedders, listers and hippers	15 to 30	5 to 20
Furrow diker	85 to 95	75 to 85
Mulch treader	70 to 85	60 to 75
Climatic effects		
Overwinter weathering (in northern climates with long periods of snow cover and frozen conditions, weathering may reduce residue levels only slightly, while in warmer climates, weathering losses may significantly reduce residue levels)		
Following summer harvest	70 to 90	65 to 85
Following fall harvest	80 to 95	70 to 80

Data provided in Table 1 was developed from available research data, Natural Resources Conservation Service guides and equipment manufacturer trials.

For a given implement, residue coverage is influenced by speed and depth of operation, soil moisture, texture and condition, plus the type and height of the residue. A disk or chisel will cover considerably more of a flat, fragile residue such as soybeans than of a sturdier, more erect residue such as corn or milo (grain sorghum).

High-yielding corn, grain sorghum and small grains generally leave about 95 percent of the soil surface covered with residue after harvest, if spread uniformly behind the combine. High-yielding soybeans typically produce an 80 to 85 percent residue cover.

The following examples illustrate how to use the data from Table 1 to predict the percentage residue cover remaining after various operations (use chain multiplication and convert percentages remaining for each operation to decimal equivalents).

Example 1

Assume a field of corn in northern Missouri yielded 100 bushels per acre. From Table 2, the residue produced is 60 pounds per bushel (total residue produced = 6,000 pounds per acre).

Table 2
Relationship of residue production to crop yield

Crop	Pounds of residue produced per bushel of crop yield
Corn	60
Grain Sorghum	70

Soybeans	50
Small Grain	100

From Figure 2, 6,000 pounds of uniformly distributed residue per acre will cover 95 percent of the soil surface after harvest. Assume the following operations: Fall chisel with straight points, 10 percent residue decay over winter, spring disk (finishing) and drill soybeans with double-disc openers, conventional drill.

$$\text{initial residue cover} \times \text{chisel} \times \text{winter decay} \times \text{disk} \times \text{drill} = \text{final residue cover}$$

$$95 \text{ percent} \times 0.75 \times 0.90 \times 0.70 \times 0.90 = 40 \text{ percent}$$

The 40 percent residue cover remaining will qualify as conservation tillage (30 percent or more cover after planting) and will reduce erosion to about 40 percent of that from a fall plow system.

Example 2

Assume a field of soybeans yielded 40 bushels per acre. From Table 2, the residue produced is 50 pounds per bushel (total residue produced = 2,000 pounds per acre). From Figure 2, 2,000 pounds of uniformly distributed residue per acre will cover about 72 percent of the soil surface after harvest. Assume the following operations: 20 percent residue decay over winter, apply anhydrous ammonia and no-till plant corn with a fluted coulter.

$$\text{initial residue cover} \times \text{winter decay} \times \text{ammonia applicator} \times \text{plant} = \text{final residue cover}$$

$$72 \text{ percent} \times 0.80 \times 0.70 \times 0.80 = 32 \text{ percent}$$

The 32 percent cover after planting in the soybean stubble will reduce erosion to about 55 percent of that from a fall plow system.

The calculation points out the problems associated with keeping 30 percent residue cover after planting following soybeans due to the fragile nature of the residue. Obviously, no-till planting is the only system that can be relatively certain to qualify as conservation tillage following soybeans.

The calculations of predicted residue aren't as accurate as measurements after planting but do allow one to compare various systems on paper. By calculating the estimated percentage of cover remaining after planting, the corresponding "Soil Loss Ratio" can be estimated for each year of a crop rotation and the average "Soil Loss Ratio" can be calculated for the rotation. Thus, various rotations and tillage regimes can be compared to aid in selecting the most desirable system for a specific conservation plan.

Related MU Extension publications

- G1652, Ridge-Till Tips
<http://extension.missouri.edu/p/G1652>
- G355, No-Tillage and Conservation Tillage: Economic Considerations
<http://extension.missouri.edu/p/G355>

Order publications online at <http://extension.missouri.edu/explore/shop/> or call toll-free 800-292-0969.