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Estimating the Effects of Crop Residue Mulches on Soil Erosion By Water

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Most farmers know that conservation tillage is often beneficial. The term can be applied to a variety of tillage methods, but usually not moldboard plowing. One goal of conservation tillage is to keep some crop residue on the field surface, after harvest, to reduce erosion. Trash management and mulch tillage are other terms associated with crop residue management.

This publication describes the concept of crop residue management and should help farmers estimate the good effects of surface crop residue in reducing soil erosion by water.

Crop residue—stalks, stems, straw, and leaves—remaining on the field after harvest can help both farmer and soil. Residue on the field softens the blow of the striking raindrops. This reduces the amount of soil that is detached (broken loose) from larger soil clods and may be carried off by flowing water. Crop residue also slows the surface flow of water and reduces its power to detach and move soil particles. Crop residue on the field may reduce surface crusting and sealing which increases rainfall infiltration and may reduce evaporation.

Uniformly scattered residue is more useful than that bunched by combines; spreader attachments are desirable on combines. Finely chopped and divided residue can be scattered more evenly and is more effective than larger pieces of stalk; chopped cornstalks are more effective than whole ones.

To be most effective, crop residue should cover the soil surface during the time of greatest erosion danger. Most erosion occurs between the beginning of the spring thaw and the time the crop canopy or leaves are developed enough to provide significant protection from raindrop impact—about the first week in July. The time of greatest erosion danger varies with the crop and cropping practices. For example, small grains give earlier protection than soybeans, but soybeans eventually provide a heavier canopy. Likewise soybeans, drilled or in 15-inch rows, will provide more and earlier protection than soybeans in 30-inch rows.

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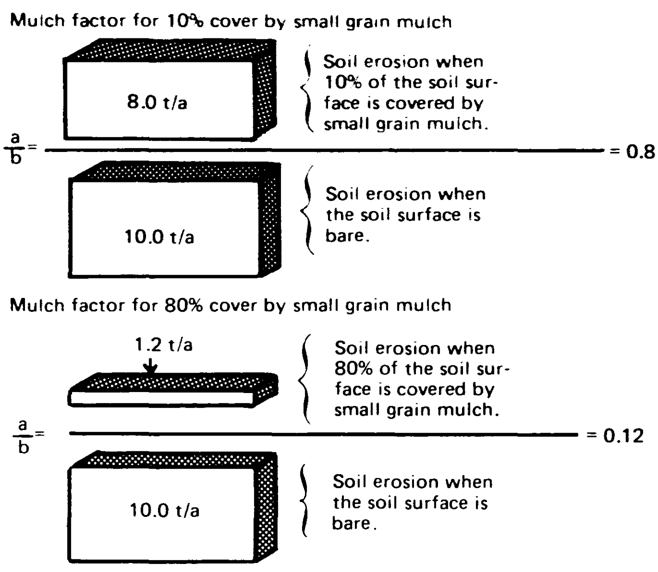
The proportion of the soil surface covered or protected by crop residue directly influences its effectiveness in reducing soil erosion. The quantity of residue remaining after harvesting varies with the yield per acre, the crop species, the amount of straw or stalks removed during harvest, and the type and amount of post-harvest tillage. The proportion of the soil surface covered by residue depends on the amount, the fineness, and the uniformity of spreading. The optimum amount of crop residue on the surface for many fields is between 1-½ and 2 tons per acre. Two tons of residue per acre is the amount remaining from small grain crops averaging 40 bushels per acre or corn crops averaging 70 bushels per acre. The lighter amounts are more desirable on the less erosive and more poorly drained soils; heavier amounts are more suitable on well-drained soils and are needed on the more erosive and steeper soils to adequately control erosion.

The type of tillage also influences erosion. There is less erosion from no-till areas than from chisel-plowed or disked areas although all three areas have the same amount of surface cover.

MULCH FACTOR

Researchers use the term, mulch factor, to indicate the effectiveness of surface residue in reducing soil erosion. Mulch is crop or other plant residue left on the surface. The mulch factor is the ratio of (a) the amount of soil eroded from a surface having a given proportion of the area covered by mulch to (b) the corresponding amount of soil eroded from the same surface when it is bare. Figure 1 illustrates how to determine the mulch factor. Assume a bare field where the amount of soil eroded is (b), 10 tons per acre. When that field is 10 percent covered by small grain mulch, the amount of soil eroded is 8 tons per acre; a/b = 8/10 = 0.8: the mulch factor is 0.8. When the field is 80 percent covered by small grain mulch, the amount of soil eroded is 1.2 tons per acre; a/b = 1.2/10 = 0.12: the mulch factor is 0.12. The mulch factor literally describes the effectiveness of surface crop residues in reducing soil erosion by water.

Figure 1. Determining the mulch factor



Cover photo: Soybean stubble and straw being tandem disked. Right side before disking: 60 percent of the ground is covered. Left side after disking: 18 percent of the ground is covered.

Figure 2 shows ranges of mulch factors for various proportions of surface covered by residue. The figure is adapted from the reports of several researchers. Figure 2 indicates that the mulch factor and thus the amount of soil eroded decreases as the percentage of soil surface covered by mulch increases.

Figure 2. Range of mulch factors for field crops

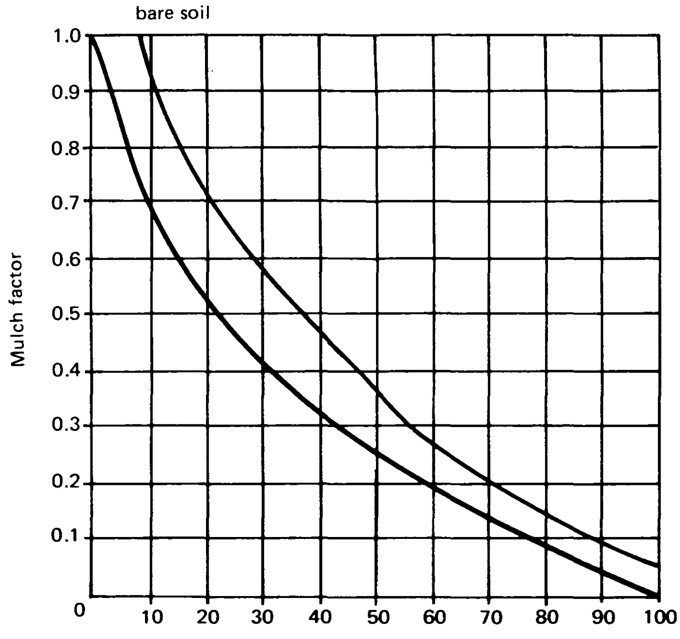
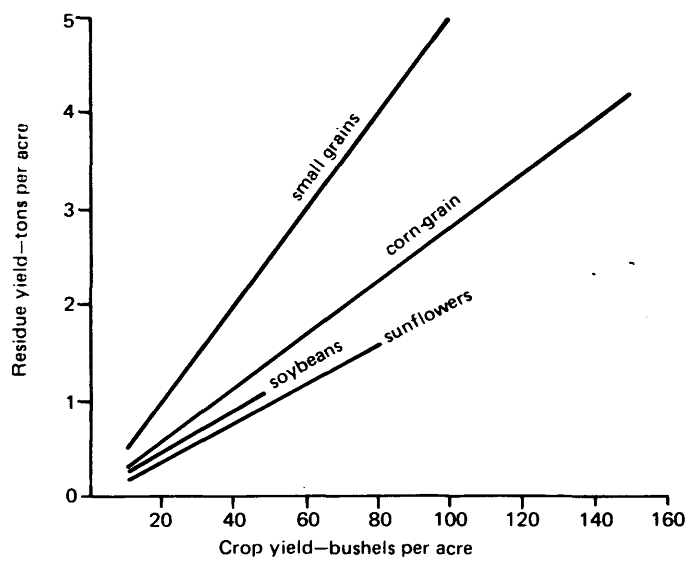


Figure 3. Average residue yield for field crops



Assumptions:
1 pound of residue per pound of shelled corn
1.6 pounds of residue per pound of sunflower seed
100 pounds of residue per bushel of small grain
45 pounds of residue per bushel of soybeans

Small grain stubble and straw being disked and chiseled. Right side after disking: 50 percent of the ground is covered. Left side after disking and chiseling: 24 percent of the ground is covered.

The following example illustrates the usefulness of the mulch factor. A field with 70 percent of its surface covered by mulch would have between 0.15 and 0.20 as much erosion by water as a bare field with similar surface conditions such as roughness. If the mulch was partially buried by disking so that only 20 percent of the surface was covered, there would be 0.50 to 0.70 as much erosion by water as if the soil were bare.

CROP RESIDUE

To repeat, the amount of residue remaining after harvesting varies with the kind of crop grown. The amount of residue on the surface can be measured by collecting all the residue from a known sample area and weighing it. Figure 3 shows the average amounts of residue produced by several crops. Because of the smaller diameters of the stems of small grain and soybeans compared with cornstalks, a ton of soybean or small grain residue has many more stems to cover the ground and is as effective as 2 tons of corn or sunflower residue in reducing erosion by water.

Table 1 illustrates the effectiveness of increasing amounts of residue from various crops in reducing soil erosion by water. The table shows the percent of the surface covered by a given amount of crop residue and the resulting range of mulch factors.

Table 1 applies only to conditions in which all the residue is left on the surface and is fairly evenly spread. Conditions in which portions of the stalks or straw have been removed or covered by tillage are not included. As a practical matter, the proportion of the soil surface covered by residue depends on the types and amounts of post-harvest tillage. Table 2 shows the approximate percent of preceding cover (proportion of the soil surface covered) remaining after various tillages.

Two tandem diskings may leave about 25 percent of the preceding surface cover. Two passes with a chisel plow leaves about 40 percent. One chisel plowing and one disking may leave between 30-40 percent of the preceding surface cover.

If a 100 bushel per acre corn crop produces about 2-¾ tons per acre of stalks covering about 85 percent of the surface, one

Table 1. Relationship between amounts of residue, percent of surface protected, and mulch factors

Chopped cornstalk mulch—tons per acre	Small grain or soybean straw mulch—tons per acre	Percent of surface covered	Range of mulch factors
0.5		30	0.40 - 0.58
1.0	0.5	50	0.25 - 0.35
1.5		60	0.20 - 0.28
2.0	1.0	75	0.11 - 0.17
2.5		80	0.10 - 0.15
	1.5	85	0.07 - 0.12
3.0	2.0	90	0.04 - 0.10
3.5	2.5	95	0.02 - 0.07

Table 2. Influence of tillage on surface residue

Tillage machine	Percentage of preceding cover remaining after each tillage operation
Moldboard plow	0 - 10
Tandem off-set disk	35 - 85
Field cultivator (16 inch sweeps)	25 - 50
Chisel (2 inch points, 12 inches apart)	50 - 80
No-till planter	100
Till planter	70 - 80

Figure 4. Stretch the line between two stakes at right angles to the rows or direction of tillage but from center to center of rows or ridges.

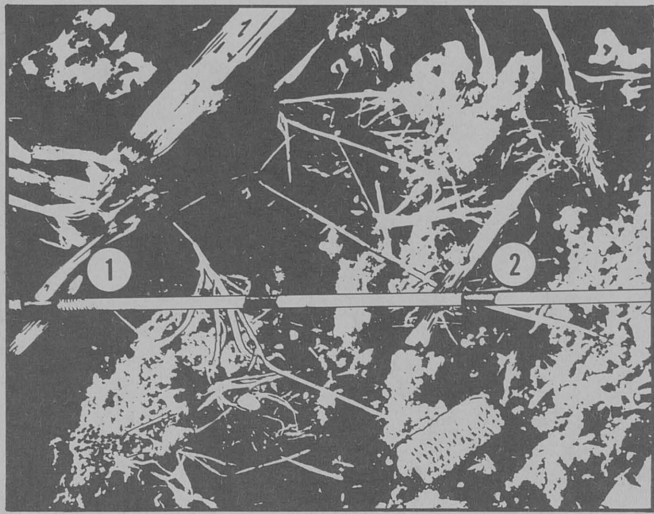


Figure 5. Count the number of points which intersect with significant residue at the same edge (left or right) at each mark on the line.

chisel plowing and one disking may leave enough residue to cover about 30 percent of the surface. This amount of cover may reduce soil erosion by water to half of what would occur following conventional tillage if the conventional plowing and the disking after chiseling were done at about the same time.

One tandem-disking of grain stubble and straw may leave 50 percent of the surface covered; a succeeding chiseling may leave half of the remaining 50 percent or 25 percent covered.

The first tandem disking of a field of cornstalks which covers 85 percent of the ground may leave 70 percent of the ground covered by cornstalks. One tandem disking of soybean straw covering 60 percent of the ground may leave about 20 percent of the ground covered.

ESTIMATING AMOUNTS OF SURFACE RESIDUE

Determining the amount of residue on the field by collecting it from representative areas and weighing it is time consuming and unnecessary. The following method is a variation from grid procedures that have been proven reliable by research.

Take a piece of cotton clothesline or similar rope 10-12 feet long. Wrap pieces of plastic electrical tape at 25, 4-inch intervals around the line leaving a foot or more of unmarked line at each end. Tie firm loops about 2 inches in diameter at each end.

To estimate the amount of residue in the field, pick four areas that appear to be representative of the amount of cover on the field. Stretch the clothesline between 2 stakes across each area at right angles to the direction of tillage or the crop rows. Adjust the line diagonally so that it runs from the center of a row or tillage ridge to the center of the row or tillage ridge at the other end of the line (figures 4 and 5).

Look straight down along one edge of each of the tapes and note whether or not your line of sight intersects with a solid piece of leaf or stalk. Soybean leaves decay or break up rapidly; so ignore these and other thin leaves in counting. Count the number of sightings which intersect with significant residue at the same (either left or right) edge of each of the 25 points on the line. Do this at four locations adding up the number of intersecting points. The total will be a good estimate of the percent of the surface covered by crop residue.

As an example, imagine you counted 5 intersecting points at the first location, 9 at the second, 6 at the third, and 7 at the fourth. Adding these indicates that about 27 percent of the surface is covered. Figure 2 indicates that this amount of small grain straw would reduce soil erosion to about half of what it would be after moldboard plowing.

CONCLUSIONS

Crop residue, left on the surface as mulches, is very effective in reducing soil erosion by water. The stalks and leaves shield the soil from the beating action of raindrops which tear apart soil particles which can then be carried away by the flowing water. The amount of protection depends on the proportion of the surface covered; this proportion is influenced by the amount of residue present and how evenly it is distributed. Amounts present depend on the crop, the amount and coarseness of the residue produced, and the effects of tillage on the residue after harvest.

An estimate of the amount of protection provided may be determined by estimating the percent of surface covered. Percent of cover also may be estimated by using a simple transect method which involves counting the number of points along a line which coincides with the location of pieces of residue. Percent of cover may be translated quickly into a mulch factor or percent of erosion that would result when compared to occurrence on bare soil.

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