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Crop Residue Management for Water Erosion Control

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Crop residues are playing an increasingly important role in today's agricultural management systems. In the past, residues were normally chopped or disked and plowed under in the process of seedbed preparation. Distributed throughout the deep-tillage layer, the residues decomposed rapidly and recycled organic matter back into the soil. Use of the traditional moldboard plow tillage system also provided a loose, residue-free seed bed. Unfortunately, moldboard plow tillage systems have high soil moisture losses which can reduce yields in low rainfall areas or during dry years.

Incorporating previous crop residues also leaves the soil surface exposed to agricultural runoff which causes soil erosion. Erosion and subsequent sedimentation have been identified as Nebraska's major water quality problem. Approximately 75 percent of the erosion from agricultural land is from row crop areas. In addition to removing valuable top soil, soil erosion removes crop nutrients, pesticides and other materials which may cause water quality degradation.

Residue management through the use of conservation tillage systems is the most cost-effective method for controlling wind and water erosion. Using crop residues to protect the soil surface from rainfall can reduce water erosion by 90 percent. Adopting these tillage systems also reduces fuel, labor and time requirements and conserves soil moisture. See NebGuide G80-535, "Tillage Systems for Row Crop Production," for more information on conservation tillage systems.

Erosion Control

Erosion is initiated by the detachment of soil particles from clods and other soil aggregates. A large portion of soil detachment occurs upon raindrop impact which, during an intense thunderstorm, can loosen and detach up to 100 tons of soil per acre (224 mt/ha). Depending on slope and soil characteristics, this loosened soil is transported and removed by agricultural runoff, which dislodges additional soil particles while flowing across unprotected soil surfaces.

Residue management provides a means for limiting both soil particle detachment and removal from the field. Vegetative residues protect the soil from impact by dissipating the energy of the raindrops. Residues also create an intricate and complex series of diversion dams that slow the runoff water rate and reduce the amount of soil particle detachment. In addition, slowing the runoff rate reduces its capacity to transport dislodged soil particles from the field, thus reducing the erosion rate even more. Moisture conservation also occurs because more time is available for water to infiltrate the soil.

The amount of crop residue produced and subsequently available for erosion control depends mainly on the type and yield of the crop grown and the tillage system used. Generally, higher yields mean more residues. Although corn will produce more residue than soybeans (Figure 1), soybeans and small grain residues contain a large amount of stem material. On an equal weight basis, this stem material can be more effective in controlling erosion than corn residue. Although the amount of residue grown is important, the amount present from seedbed preparation through crop establishment is critical because the greatest potential for erosion in row crop production areas occurs from late April to mid-June. The selection and use of a tillage system largely determines the amount of residue cover during this critical period.

Several conservation tillage systems are available for row crop producers, including the chisel plow, disk, till plant and no-till systems. No one conservation tillage system is superior in reducing soil erosion under all
The approximate percentage of the residue cover remaining on the soil surface after a single pass of different tillage and planting implements is listed in Table 1. These figures may vary with field speed, tillage depth and residue condition. To obtain the percentage of residue remaining for a specific tillage system, multiply the percentages together for each tillage operation within the selected system. As an example, a tillage system having two diskings and a surface planting would retain about 20 percent of the initial residue after all operations. Each disking would leave about 50 percent of the residue; after two diskings about 25 percent of the residue would remain. About 75 percent of a crop's residue remains after normal winter weathering, which further reduces the amount of residue to about 20 percent of the residue on the surface after planting. As a comparison, the moldboard plow system incorporates almost all residues while the no-till system leaves most of the residue on the soil surface. Additional and perhaps unnecessary tillage operations in any system can rapidly decrease the residue cover and increase the potential for soil erosion.

The effectiveness of erosion control through residue management is shown in Figures 2 and 3. While these data are for specific soils and slopes, they show that tillage systems that maintain some residue cover will reduce soil losses. No-till systems, which maintain the greatest amount of surface residue, can result in a 90 percent reduction in soil erosion when compared to the moldboard plow system. However, all the conservation tillage systems studied resulted in erosion losses that were 50 percent or less of those from the moldboard plow system.

Soil loss associated with various tillage systems used in row crop production. Water was applied at rate of 2.5 inches/hour (6.4 cm/hr). Tillage operations for moldboard plow system were plow, disk and harrow; for chisel system, chisel, disk and harrow; and for disk system, disk and harrow. (Siemens and Oshwald, 1976 ASAE Paper 76-2552)
Figure 3. Soil loss associated with various tillage systems used in a wheat-fallow rotation at the High Plains Agricultural Laboratory, Sidney, Nebraska. Water was applied at rate of 2.5 inches/hour (6.4 cm/hr). Tillage operations for moldboard plow system were plow, spring tooth harrow twice, rodweed twice; and for undercut or sub-till, undercut three times, and rodweed twice.

Table 2. Measured surface cover and soil loss for various tillage systems.

<table>
<thead>
<tr>
<th>Tillage Systems</th>
<th>Residue</th>
<th>Percent Surface Cover</th>
<th>Erosion</th>
<th>Percent Reduction Compared To Moldboard Plow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/ac</td>
<td>kg/ha</td>
<td>lb/ac</td>
<td>kg/ha</td>
</tr>
<tr>
<td>Moldboard Plow</td>
<td>nil</td>
<td>----</td>
<td>3.2</td>
<td>3,720</td>
</tr>
<tr>
<td>Chisel</td>
<td>1,600</td>
<td>1,790</td>
<td>13.1</td>
<td>1,510</td>
</tr>
<tr>
<td>Disk</td>
<td>2,000</td>
<td>2,240</td>
<td>28.0</td>
<td>450</td>
</tr>
<tr>
<td>No-Till</td>
<td>4,600</td>
<td>5,150</td>
<td>55.4</td>
<td>930</td>
</tr>
</tbody>
</table>

**Corn Residue**

| Moldboard Plow  | nil     | ----                  | 2.0     | 22,890                                      |
| Disk-Chisel     | 400     | 450                  | 10.8    | 6,660                                       |
| No-Till         | 5,800   | 6,500                | 58.8    | 3,440                                       |

**Soybean Residue**

| Moldboard Plow  | nil     | ----                  | 8.9     | 8,420                                       |
| Undercut        | 960     | 1,070                | 29.3    | 2,360                                       |
| No-Till         | 4,420   | 4,950                | 86.0    | 360                                         |

**Wheat Residue**

| Moldboard Plow  | nil     | ----                  | 9.1     | 8,420                                       |
| Undercut        | 960     | 1,070                | 29.3    | 2,360                                       |
| No-Till         | 4,420   | 4,950                | 86.0    | 360                                         |

1 Illinois tests on 5 percent slope after tillage and planting, 5 inches (12.7 cm) of water applied. Note: soil loss after 8 inches (20.3 cm) of rain was higher for disk than no-till.

2 Illinois tests on 5 percent slope after overwinter weathering but before spring tillage, 5 inches (12.7 cm) water applied.

3 Nebraska tests on 4 percent slope after tillage and planting, 3 inches (7.6 cm) of water applied.

Slopes greater than 5 percent require a higher level of residue to maintain effective erosion control. If residue cover is an integral part of a farmer’s erosion control strategy, then steeper and/or longer slopes will force the producer to limit tillage operations in order to maintain higher residue levels. Flat areas, such as bottomlands, may not need as much residue cover to control erosion caused by agricultural runoff. However, residue cover, especially if standing, may minimize the potential for wind erosion.

Residue needs can be adjusted through specific structural or cropping practices. Installation of terraces can reduce the need for residue cover and will minimize soil losses, especially on steeper slopes. Contour farming also assists in preventing soil losses by agricultural runoff. In fact, to be most effective, chisel plowing and till planting should be done on the contour because these operations can create furrows which have no residue cover. When these furrows run up and down hill, agricultural runoff can concentrate in the furrow and increase erosion through channelization.
Residue placement is important in assessing the erosion control potential. Standing residue can catch some snowfall, anchor the soil within the row, and is most effective in wind erosion control, but may not provide the necessary ground cover to reduce soil erosion between rows.

Uniform residue distribution, rather than clumped or windrowed, is necessary for good erosion control. Although residue grazing can be practiced, it may remove an excessive amount of residue and compact wet soil. The amount of reduction in erosion control depends on the stocking rate and the length of the grazing period.

Field Estimates of Residue

The amount of initial residue present can be estimated using data from Figure 1. Using specific field operations, the amount of residue left after tillage can be calculated with information from Table 1. These data are averages and may not accurately reflect the situation for a particular field. For example, a chisel may leave about 75 percent of residue on the average but, because of different field speeds, tillage depths and chisel points, as little as 25 percent can be left on the soil surface. Consequently, it is best to measure actual residue levels present when determining need and assessing tillage effectiveness.

One method for determining the weight of residue on the soil surface involves collecting the residue from an area such as a square yard (square meter), air drying it, and then weighing the dry residue. Calculations can then be made to determine the weight of residue per acre (hectare).

Two alternate methods have also been developed for estimating the percent cover. They are easy to use since no material has to be collected and weighed. In one method, a 50 ft (15 m) measuring tape is secured diagonally across harvested rows, from ridge top to ridge top. Looking straight down on the same side of the tape, record if there is solid, non-decaying residue beneath it at points 2 ft (0.6 m) apart, for a total of 25 points. Repeat this process in four random locations in the field. Then add up the number of residue ‘‘hits’’ to get the approximate percent cover (hits + 100 points = percent cover). A variation of this method involves walking through the field with a pointed rod and lowering it to the ground 100 times randomly, then recording and adding up the ‘‘hits’’ as before.

The easiest method, requiring only practice to become accurate, is to visually estimate residue cover on the surface. This should be done at several locations in the field. Avoid over-estimating. To assist in visually estimating the amount of cover, a publication with photos of different residues levels is available from the Soil Conservation Service. Ask for Agronomy Technical Note 78.

Residues Conserve Moisture

An added benefit of residue cover on soil surfaces is moisture conservation. Water that is not allowed to leave the field can soak in and become available for crop use. Eliminating unnecessary fall tillage and leaving some standing residues can also conserve moisture since standing residues trap winter snowfall.

Tillage systems that leave a rough soil surface can be of benefit on some soils. However, if left residue-free, a rough soil surface can be broken down and dispersed by rainfall. When dried, the dispersed soil develops a crust which can be impermeable. The presence of crop residues assists in preventing soil crusting, thus maintaining infiltration rates and reducing runoff rates.

Crop residues also act as a mulch, reducing moisture losses through evaporation. However, reducing evaporative losses can be a disadvantage on wet soils and may delay spring field operations.

Some Residue Problems

Although residue management can effectively control erosion, some problems do emerge with increased residue levels. Residues can provide good weed seed environment and may block herbicide movement to the soil. Moist soils, which may interfere with herbicide incorporation, and low temperatures beneath residues may delay planting and seed germination. Excessive residues can clog implements or otherwise hamper tillage and planting operations. They may also provide a winter habitat for rodents, insects and pathogens.

Potential problems should not be ignored by the producer. However, good management techniques can minimize many of the disadvantages associated with residue management. Crop and tillage system rotations can assist in reducing the problems associated with weeds, insects and diseases. Depending on the residue level, a stalk chopping or shredding operation can minimize potential clogging problems, although this operation increases fuel and labor requirements. Implement manufacturers are also responding to the need for conservation tillage by designing tillage and planting implements which will perform efficiently with increased residue levels.