Saving Water and Energy - Crop Residue Management

David P. Shelton
Extension Agricultural Engineer
University of Nebraska
Haskell Agricultural Laboratory
Concord, NE 68728
Voice: 402-584-2849 Fax: 402-584-2859
Email: dshelton2@unl.edu

INTRODUCTION

Crop residue left on the soil surface is one of the easiest and most cost-effective methods of reducing soil erosion. Research in Nebraska and other midwestern states has shown that leaving as little as 20 percent of the soil surface covered with crop residue can reduce erosion from rainfall and flowing water by one-half compared to residue-free conditions. Greater amounts of cover will further reduce erosion. (Refer to University of Nebraska NebGuide G81-544, "Residue Management for Soil Erosion Control" [*http://www.ianr.unl.edu/pubs/fieldcrops/g544.htm*] for further details on the erosion process and the benefits of residue cover.) Crop residue also acts as a mulch, helping to reduce soil moisture losses, thus making more moisture available for crop use.

Determining the amount of residue cover can be done in several ways. Obtaining in-field measurements using the line-transect method is the most accurate. (Refer to University of Nebraska NebGuide G93-1133, "Estimating Percent Residue Cover Using the Line-Transect Method" [*http://www.ianr.unl.edu/pubs/fieldcrops/g1133.htm*] for specific procedures.)

In many instances, such as for planning purposes, estimates of percent cover may be adequate. For example, it may be desirable to determine if eliminating a certain operation from a tillage and planting system is likely to result in adequate residue cover to meet the level called for in a conservation plan. The calculation method of estimating residue cover can be useful for such a determination.

The calculation method involves first determining or estimating the amount of residue cover present after harvest. This value is then multiplied by estimates of the percentage of cover that will remain following weathering, tillage, and any other residue-disturbing operations. This article discusses many of the factors that influence the reduction of residue cover, and presents estimates of the amount of residue cover expected to remain following tillage and other residue-disturbing operations.

RESIDUE COVER AFTER HARVEST

Determining the amount of residue cover after harvest is the first step in the calculation method. This is most accurately done by measurements in the field using the line-transect method. If this is not possible, an average value can be used. Table 1 presents typical after-harvest percent residue cover values for various crops. Use these values with caution, as the actual amount of cover in a particular field can vary considerably depending on crop variety and yield, conditions throughout the growing season, and other factors. For all crops, the residue should be uniformly distributed at harvest, not left in windrows, clumps, or bunches.

FACTORS INFLUENCING RESIDUE REMAINING

Fragile or Non-Fragile Residue

Crop residues have been classified as fragile or non-fragile, Table 1. This classification is based on factors such as plant characteristics (size and amount of leaves and stems), total amount of plant material produced, and ease of residue decomposition or breakdown when the residue is disturbed or exposed to the weather. Soybean residue would be an example of a fragile residue, whereas corn and grain sorghum residues are classified as non-fragile.

Residue-Disturbing Operations

Estimates of the percentage of residue cover remaining after various residue-disturbing operations are listed in Table 2. For a given implement, the actual amount of residue remaining will be influenced by many factors, including implement design, adjustments, speed, depth of soil disturbance, previous residue disturbance, and soil and residue condition. The ranges of values given for both fragile and non-fragile types of residue account for some of these factors.

Be conservative and use careful judgement when selecting values from the table. Do not use all high values; the result is usually overestimation of final cover. This is especially true on land that is designated as highly erodible. For these areas, values near the lower end of the range usually result in better estimates of actual cover. However, if all implements are designed, adjusted, and operated with the specific goal of preserving residue cover, values near the middle or upper end of the range may be appropriate.

Moisture and Climate

Biological processes cause a general deterioration of residue condition. Moisture and warmer temperatures increase the rate at which this occurs.

One way that residue cover is affected by moisture and climate is an actual reduction of percent cover due to decomposition or decay of the residue, particularly the leaves and small pieces. In a study of soybean residue, a 31 percent loss of cover occurred between measurements taken after harvest and again before spring field operations in southeast Missouri. Approximately 25 inches of rainfall was received between these two measurements. In northwest Missouri, with cooler temperatures and about eight inches of rainfall during the same time period, losses averaged 12 percent. Conditions in southeast Nebraska and northeast Kansas are generally similar to those in northwest Missouri, and some actual residue cover loss is likely over the winter. However, in much of Nebraska, over-winter losses do not appear to be a significant factor. For example, in a northeast Nebraska study, the amount of soybean residue cover was comparable both after harvest and in the following spring.

Even though actual decreases in percent cover may be minimal, with exposure to the weather, residue becomes more fragile over time. This is most pronounced for residue that has been tilled or otherwise disturbed, but it also occurs with undisturbed residue. Because of less annual precipitation, this change takes place more slowly in western Nebraska than in the eastern part of the state.

Timing of Operations

Weathering and when the residue-disturbing operations are performed are closely related. If residue is disturbed in the fall by grazing, tillage, stalk chopping, manure incorporation, or knifing-in fertilizer, subsequent spring operations reduce cover more than if all operations are conducted in the spring. This is because fall tillage and knifing operations cut or break the residue into smaller pieces, mix soil and residue, and speed over-winter weathering, thus making the residue more susceptible to decomposition and burial in the spring. University of Nebraska research showed that for the same sequence of field operations used in corn residue, residue cover measured after planting averaged 12 percent less when one or more operations were conducted in the fall, compared to performing all operations in the spring. For operations that are done in the fall, use values towards the lower end of the ranges in Table 2 or include an additional weathering reduction factor for fall operations, also listed in Table 2.

In contrast, when operations are conducted with little elapsed time between them, less reduction of residue occurs. In these cases, values near the upper end of the range are generally appropriate. For example, when disking and field cultivating on the same day, the field cultivator may cause little additional loss of cover. The field cultivator simply redistributes the residue that is on the soil surface. Under certain conditions, the field cultivator may also bring buried, coarse residue to the surface, resulting in a slight increase in cover, perhaps up to five percentage points. However, if there are more than a few days and it rains between disking and field cultivation, field cultivation generally results in reduced levels of cover.

Results from a residue grazing study provide an example of the effects of prior residue disturbance on the amount of cover reduction. No-till planting into un-grazed corn residue reduced the cover by 10 percent, from 83 percent cover to 75 percent; whereas no-till planting into residue that had been grazed reduced the cover by 16 percent, from 62 percent cover to 52 percent.

A winter wheat/fallow rotation provides an illustration of the combined effects of weathering and timing of tillage operations. Shortly after harvest, the wheat residue often appears to be quite resistant to breakup and burial by tillage. But, by late the next summer at the end of the fallow period, the residue has become quite fragile. Percent residue cover following a tillage operation near the end of the fallow period is likely to be less than what it would have been following the same tillage operation done shortly after harvest. However, when additional operations are conducted, greater cover reductions will typically occur for the system where tillage was first done shortly after harvest and the disturbed residue was exposed to the weather, compared to the system where the residue remained undisturbed during much of the fallow period and operations were delayed until near the end of the fallow period.

Use values at or near the upper end of the ranges listed in Table 2 when an operation is performed within two or three days of the previous operation. Use values near the middle of the range if a week or more elapses between operations, especially if more than about one-half inch of precipitation or irrigation also occurs. Use values near the lower end of the ranges if operations are conducted over a month apart.

Chopping or Shredding of Residue

Chopping or shredding the residue may result in reduced amounts of cover. In University of Nebraska research on corn residue, tillage and planting systems that included a stalk chopping operation had an average of 22 percent less cover after planting than when the residue was not chopped. Although percent cover appeared to increase immediately after chopping because the residue had been cut into smaller pieces and was redistributed, the chopped residue deteriorated more from the weather and subsequent field operations than non-chopped residue. If the residue is chopped, this additional reduction needs to be included in the calculations to estimate the amount of cover that is expected to remain.

For small grains, if a rotary combine or a combine with a straw chopper is used, the residue should be considered to be fragile. In these cases, use the values in Table 2 that are for fragile residue.

Livestock Grazing

Livestock grazing will reduce the amount of residue cover. The amount of reduction depends on factors that include stocking density (number of animals per acre), animal size, length of the grazing period, whether the residue is from irrigated or dryland crops, how much ear drop or other losses occurred during harvest, how much supplemental feed is supplied, and weather conditions. As an approximation, the Natural Resources Conservation Service estimates that each 1000 pound cow will remove 15 percent of the available cover per acre per month; or 0.5 percent cover removed per cow per acre per day.

Although estimates of cover reduction can be used, the best procedure for grazed residue is to use the line-transect method to measure the amount of cover at the end of the grazing period. This value can then be used for the calculations instead of percent cover after harvest.

Residue Cover Carry-Over

Under certain conditions, residue cover may remain on the soil surface for more than one cropping year. Carry-over is most likely to occur under dry climatic conditions when residue that is classified as non-fragile has received only minimal disturbance, such as with no-till planting. In a long-term experiment using a grain sorghum/soybean rotation, residue cover measured after planting grain sorghum averaged approximately 15 percentage points less for a no-till planting system with row cultivation than no-till without cultivation. Some grain sorghum residue remained on the soil surface during the year that soybeans were grown and was also present the following spring. However, residue cover carry-over is highly variable, and generally should not be relied on to provide significant amounts of cover.

ESTIMATING PERCENT RESIDUE COVER

An approximation of the percent residue cover after planting can be obtained by multiplying the percent residue cover after harvest by the appropriate values from Table 2 for weathering and for each residue-disturbing operation that is conducted or planned.

Selecting appropriate values to use in the calculation method is a key to obtaining reasonably accurate results. All operations and other factors that affect residue cover need to be accounted for. Think in terms of a complete sequence of operations. For each operation, evaluate how the residue will be affected by both prior and subsequent operations and by weathering.

Examples

The following examples illustrate how to use information from Table 2 to estimate residue cover by the calculation method. Assume that a tillage and planting system used in a field of irrigated corn residue in southeast Nebraska consists of three field operations:

1) anhydrous ammonia application in the fall using a knife-type applicator with rigid shanks;
2) tandem disking in the spring; and
3) planting soon after disking using a conventional planter with double disk openers and no coulters.

95% initial cover	x	0.75 knife applicator	x	0.90 winter weathering	x	0.60 disk	x	0.95 planter	=	37% final residue cover

Using the same tillage and planting system in soybean residue would result in only about nine percent cover, which is not enough for effective erosion control.

70% initial cover	x	0.45 knife applicator	x	0.85 winter weathering	x	0.40 disk	x	0.85 planter	=	9% final residue cover

If the corn residue example was changed to dryland production on highly erodible land in northeast Nebraska, and rainfall occurred between the disking and planting operations, less than 20 percent cover would remain after planting.

80% initial cover	x	0.75 knife applicator	x	0.99 winter weathering	x	0.35 disk	x	0.85 planter	=	18% final residue cover

Consider the calculation method to be only a rough estimate since the variables involved prevent accurate determination of percent residue cover. However, this method can be useful in residue management planning by offering a general idea of how much residue cover will remain after a specific sequence of operations. There are also computer programs available to predict percent residue cover. However, these programs use the calculation method and average values for residue cover reduction, and as such should be used only when a rough estimate is satisfactory.

SUMMARY

Crop residue management, or maintaining residue on the soil surface, is the most cost-effective method of reducing soil erosion available to Nebraska farmers. Accurate estimates of percent residue cover are necessary to determine if sufficient cover is available to adequately reduce erosion and to comply with conservation plan specifications. When accurate estimates are needed, percent cover should be measured using the line-transect method.

When only rough estimates of percent cover are adequate, the calculation method is often useful and appropriate. This method can be used for initial planning purposes to evaluate certain crop residue management goals and/or to compare potential residue cover remaining for a variety of tillage and planting systems.

Table 1. Crop residue classification and typical percent residue cover after harvest of various crops in Nebraska. Actual percent cover can vary substantially from these values. Use these values for estimation purposes only when the percent cover for a particular field cannot be more accurately determined using the line-transect or photo-comparison method.

Crop	% Cover
Non-Fragile Residue	
Alfalfa or Other Hay Crops	
Immediately after cutting	35
After regrowth	85
Barley*	85
Corn	
Harvested for grain	
60 to 120 bu/ac grain yield	80
120 to 200 bu/ac grain yield	95
Harvested for silage	15
Forage Silage	
Immediately after cutting	25
After regrowth	85
Grain Sorghum	75
Millet	70
Oats*	80
Pasture	85
Popcorn	70
Rye*	85
Wheat*	
30 to 60 bu/ac grain yield	50
60 to 100 bu/ac grain yield	85
Fragile Residue	
Dry edible beans	15
Dry peas	20
Potatoes	15
Soybeans	70
Sugar beets	15
Sunflowers	40
Vegetables	30

*For small grains, if a rotary combine or a combine with a straw chopper is used, or if the straw is otherwise cut into small pieces, consider the residue to be fragile.

Table 2. Estimated percentage of residue remaining on the soil surface after specific implements and field operations.[1] (Change to decimal value before multiplying. Example: 90% is changed to 0.90.)

Implement	Non-Fragile Residue	Fragile Residue
	Percentage of Residue Remaining	
Plows:		
Moldboard plow	0-10	0-5
Disk plow	10-20	5-15
Machines that fracture soil:		
Paratill/Paraplow	70-90*	60-85*
V ripper/subsoiler (12" to 14" deep; 20" shank spacing)	60-80*	40-60*
Combination tools:		
Chisel-subsoiler	50-70	40-50
Disk-subsoiler	30-50	10-20
Chisel plows with:		
Sweeps	70-85	50-60
Straight spike points	35-75*	30-60*
Twisted points or shovels	25-65*	10-30*
Combination chisel plows:		
Coulter chisel plows with:		
Sweeps	60-80	40-50
Straight spike points	35-70*	25-40*
Twisted points or shovels	25-60*	5-30*
Disk chisel plows with:		
Sweeps	60-70	30-50
Straight spike points	30-60*	25-40*
Twisted points or shovels	20-50*	5-30*
Undercutters:		
Stubble-mulch sweeps or blade plows with:		
V-blades greater than 30" wide	75-95*	60-80*
with mulch treader attached	60-90*	45-80*
V-blades 20" to 30" wide	70-90*	50-75*
with mulch treader attached	55-85*	40-70*
Disks:		
Tandem or offset		
Heavy plowing	25-50	10-25
Primary tillage	30-60	20-40
Secondary tillage	40-70	25-40
Light tandem disk after harvest, before other tillage	70-80	40-50
Field cultivators: (including leveling attachments)		
Used as primary tillage:		
Sweeps 12" to 20" wide	60-80	55-75
Sweeps or shovels 6" to 12" wide	35-75	50-70
Duckfoot points	35-60	30-55
Used as secondary tillage:		
Sweeps 12" to 20" wide	80-90	60-75
Sweeps or shovels 6" to 12" wide	70-80	50-60
Duckfoot points	60-70	35-50

Finishing tools:		
Combination finishing tools with:		
Disks, shanks, and leveling attachments	50-70	30-50
Spring teeth and rolling basket	70-90	50-70
Harrows:		
Springtooth (coil tine)	60-80	50-70
Spike tooth	70-90	60-80
Flex-tine tooth	75-90	70-85
Roller harrow (cultipacker)	60-80	50-70
Packer roller	90-95	90-95
Rodweeders:		
Plain rotary rod	80-90	50-60
Rotary rod with semi-chisels or shovels	70-80	60-70
Row-crop planters:		
Conventional planters with:		
Runner openers	85-95	80-90
Staggered double disk openers	90-95	85-95
Double disk openers	85-95	75-85
Planters with:		
Smooth coulters	85-95	75-90
Ripple or bubble coulters	75-90	70-85
Fluted coulters	65-85	55-80
Strip-till planters with:		
2 or 3 fluted coulters	60-80	50-75
Row cleaning devices (8" to 14" wide bare strip using brushes, spikes, furrowing disks, or sweeps)	60-80	50-60
Ridge-till planter	40-60	20-40
Drills:		
Hoe opener drills	50-80	40-60
Semi-deep furrow drill or press drill (7" to 12" spacing)	70-90	50-80
Deep furrow drill with 12" spacing	60-80	50-80
Single disk opener drills	85-95*	75-85
Double disk opener drills	80-95*	60-80
Drills with the following attachments used in residue laying on the soil surface:		
Smooth coulters	65-85	50-70
Ripple or bubble coulters	60-75	45-65
Fluted coulters	50-70*	35-60*
Drills with the following attachments used in standing stubble:		
Smooth coulters	85-95	70-85
Ripple or bubble coulters	80-85	65-85
Fluted coulters	50-80*	40-70*
Air seeders: (Refer to appropriate field cultivator or chisel plow depending on the type of ground-engaging device used.)		
Air drills: (Refer to corresponding type of drill opener.)		

Row cultivators: (30" and wider)		
Single sweep per row	75-90	55-70
Multiple sweeps per row	75-85	55-65
Finger wheel cultivator	65-75	50-60
Rolling disk cultivator	45-55	40-50
Ridge-till cultivator	20-40	5-25
Other implements:		
Knife-type applicator with:		
Rigid shanks	75-85*	45-70*
with coulters	80-90*	50-75*
Coil shanks	70-80*	40-65*
with coulters	75-85*	45-70*
Closing disks	55-70*	30-50*
Manure injector/applicator with:		
Chisel or sweep injectors	30-65*	5-15*
Disk-type applicators	40-65*	15-40*
Coulter-type applicators	80-95*	65-80*
Rotary hoe	85-90	80-90
Bedders, listers, and hippers	15-30	5-20
Furrow diker	85-95	75-85
Mulch treader	70-85	60-75
Climatic effects of over winter weathering:		
Summer harvested crops	70-90	65-90*
Fall harvested crops	80-100*	75-100*
Fall operations (additional weathering)*	85-95*	80-95*

Weathering losses are highly dependent on precipitation and temperature. In winters with long periods of snow cover and frozen conditions, weathering may reduce residue levels only slightly. In warmer winters without much snow or during wet years, weathering losses may reduce residue levels significantly.

Grazing impacts:

Estimate reduction of residue cover for either fragile or non-fragile residue at 15 percent per 1000 pound cow per acre per month, or 0.5 percent per cow per acre per day. Use the following formulas to estimate residue cover reduction due to grazing and the percentage of residue remaining factor.

Percent Grazing Reduction = (0.5) x (number of animals) x (average animal weight in pounds) x (number of days grazed) ÷ (number of acres grazed) ÷ 1000

Percentage of Residue Remaining Factor = (100 - Percent Grazing Reduction)

[1]Adapted from the pamphlet "Estimates of Residue Cover Remaining After Single Operation of Selected Tillage Machines, published by the Soil Conservation Service and Equipment Manufacturers Institute, February 1992.

*Values adjusted based on University of Nebraska research and field observations.