Crop residue requirements for water erosion control in six southern states

R. B. Campbell, T. A. Matheny, P. G. Hunt, and S. C. Gupta

ABSTRACT: We calculated the crop residues needed for water erosion control in six southern states. Six crop sequences were evaluated in each of 14 major land resource areas (MLRA). In 13 of 14 MLRAs, weighted average estimated soil loss exceeds tolerable limits. The exception is MLRA 153, Atlantic Coastal Flatwoods, where the greatest percentage of residues remains available after water erosion control needs are met. In all MLRAs, conservation tillage significantly reduces potential soil losses. In four of six states, 6.0 million metric tons (6.6 million tons), or 60 percent of crop residues, are needed for water erosion control. The remaining 40 percent is available for other uses. In Alabama and Mississippi about 90 percent of the residues produced are needed for water erosion control.

ACHIEVING nonpoint pollution control, crop production, and energy goals requires knowledge about how much crop residues can be removed from the soil without exceeding tolerable soil loss limits. Larson (*4*) discussed current interest in using crop residues to supply some bioenergy needs. Our study focuses on the use of crop residues to control soil loss in the major land resource areas (MLRAs) of six southern states, Alabama, Georgia, Mississippi, North Carolina, South Carolina, and Virginia (*1*).

We followed the procedure outlined for calculating soil erosion losses (*2*). Our estimates of residue production were based on crop yield data from state crop statistical reports for 1975 and appropriate straw/grain ratios (*3*). We estimated land areas for each crop and each soil series from county crop statistical reports and the Soil Conservation Service (SCS) Conservations Needs Inventory for 14 MLRAs (*6*). Within these MLRAs we determined soil losses for six predominant cropping systems using the universal soil loss equation (USLE).

Comparisons of calculated soil losses (A) with soil loss tolerance values (T) enabled us to determine what crop residues are needed to control soil erosion and what residues are available for other uses under each of the cropping systems in the 14 MLRAs.

Cropping systems, residue resources

Table 1 presents the crop sequences, tillage methods, residue production levels, and percentage of total residues produced by the six cropping systems. These six cropping systems and hay production acreage account for about 88 percent of the cultivated land. However, we did not consider hay as a source of available residue because it is generally grown for livestock feed. In addition, much of the land double-cropped in soybeans and small grain is planted by conventional tillage methods and yields less residues than the conservation tillage system. For demonstrational purposes, though, this cropping system is considered a conservation tillage practice. Soybeans are planted in small grain residues, and small grains are planted in lightly disked soybean residues.

The corn-soybean rotation, which is common throughout the Southeast, is a two-year rotation with conventional tillage. Continuous soybeans, corn, cotton, and sorghum are generally planted with conventional tillage systems also.

Conventional tillage generally involves fall disking followed by spring disking and harrowing for seedbed preparation. We assumed crop residues are incorporated into the soil shortly after harvest in all continuous crop tillage systems, except in the case of continuous cotton and the soybean-small grain double-cropping system. This practice reduces the residues left on the soil surface over winter and eliminates canopy cover with its associated soil protection. In the Southeast, however, this condition is mitigated by less intensive winter rains as compared to summer rains. Fortunately, summer rains fall on fields with a higher percentage of canopy cover.

Our estimates of residue production for these six cropping systems—grain yield times the appropriate straw-grain ratio (*3*)—indicate that the soybean-small grain double-cropping system produces the most residues and continuous soybeans the least residues.

Cropland soil erosion

The USLE makes it possible to predict the average rate of soil erosion for alternative cropping systems and control practices on any particular site. Tolerable soil loss (T) is the maximum soil erosion allowable without affecting long-term crop productivity. We compared soil losses (A) with T values in the soil loss ratio A/T. A/T values between 0 and 1 represent manageable soil losses. When A/T exceeds 1, erosion control practices are needed.

We determined weighted average A values by multiplying all A values for each cropping system by the land area in that system, totaling these values, then dividing by the total land area for all cropping systems in the MLRAs.

Weighted average A values exceed T values in all MLRAs, except the Atlantic Flatwoods, MLRA 153 (Figure 1). The low erosion potential in MLRA 153 makes this MLRA the largest potential source of residues for uses other than erosion control.

Estimated A values exceed T values by a factor of 1.8 in 5 of the 33 intrastate MLRAs, which indicates a significant erosion potential. For another 12 MLRAs, A exceeds T by a factor of 3, indicating an even greater erosion problem. And an even

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Table 1. Residue production levels for several major crops, cropping sequences, and tillage methods in the Southeast.

Crop	Crop Sequence	Tillage Method	Residue Production Level (kg/ha)	Percentage of Total Residues Produced
Corn and soybeans	Rotation	Plow	2,244-4,388	18.0
Soybeans and small grains	Double crop	Conservation tillage	4,726-6,898	26.3
Soybeans	Continuous	Plow	2,013-2,750	13.3
Corn	Continuous	Disk	2,816-6,254	36.3
Cotton	Continuous	Plow and disk	2,861-6,104	5.7
Sorghum	Continuous	Disk	1,732-3,359	0.4

more severe erosion problem is indicated in 12 additional MLRAs in which A exceeds T by factors of 4 to 9.

Estimated soil losses averaged over such large acreages of cultivated land may be misleading. In reality, soil loss is described by a distribution function in which some A values are greater as well as less than T. Nevertheless, an average A value characterizes expected erosion hazards in each MLRA.

Our calculations reveal a greater erosion hazard in Alabama and Mississippi than in Georgia, North Carolina, South Carolina, and Virginia (Figure 2). These soil loss values, by the way, agree with soil loss trends reported previously for cropland in the South Atlantic Gulf (5).

With the USLE we calculated A values for each soil series within each MLRA. The cropping management (C) factor used in the USLE was based on current (1975) residue production levels. We selected 0.8 as the conservation practices (P) factor because conventional crops in the Southeast are often planted across slope, varying from up-and-down hill to contour planting. In 1975 about 15 percent of the cropland in the Southeast was stripcropped or terraced (5).

We calculated A/T ratios for continuous soybeans and the soybean-small grain system in three contrasting MLRAs (Figure 2A-F). Figure 2 also relates A/T to the cumulative percentage of land area in the MLRAs. Nearly 99 percent of the soybean-small grain acreage in MLRA 153 has an A/T of 1 or less (Figure 2A). In contrast, only 55 percent of the acreage in continuous soybeans in MLRA 153 has an A/T less than 1 (Figure 2B).

In MLRA 153 in South Carolina 92 percent of the land has slopes less than 2 percent. In MLRA 136 in Virginia and in MLRA 134 in Mississippi most of the slopes range from 2 to 5 percent and 5 to 8 percent, respectively, which increases the erosion hazard. Only land with slopes less than 8 percent is considered potential cropland. Sod crops and trees generally are grown on land with slopes greater than 8 percent.

In the soybean-small grain rotation acreage of MLRA 134, A/T is less than 1 on 41 percent of the land. This compares with 3 percent of the land in continuous soybeans.

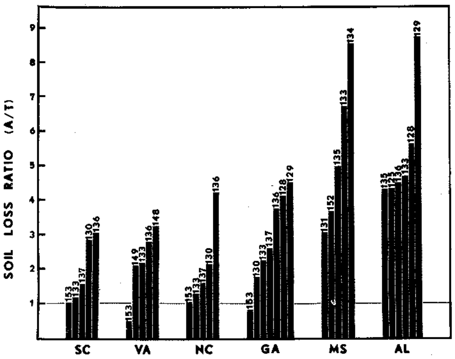

Figure 1. Weighted average soil loss ratios for MLRAs in six southern states. Numbers indicate MLRA.

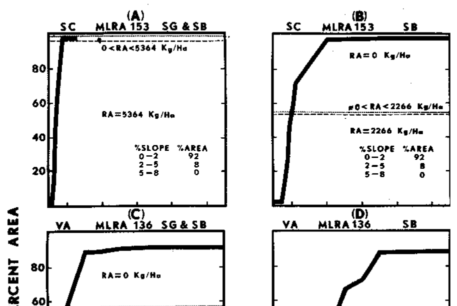

Figure 2. Cumulative percentage of area equal to or less than the soil loss ratio for contrasting MLRAs and two cropping systems: soybean-small grain (SB & SG) and continuous soybeans (SB). Residues available (RA) and slope distribution are shown for MLRAs in South Carolina (SC), Virginia (VA), and Mississippi (MS).

Removable plant residues

Residue available is the plant material that can be removed from the land without increasing soil losses beyond tolerable limits. This applies to on-farm water erosion only and not to wind erosion or interrelated effects of residues, such as sources of plant nutrients and soil aggregation. We calculated the residue available as follows: RA = RP − RN, where RA is the residue available, RP is the residue produced and RN is the residue needed for erosion control.

RN, then, is: RN = 1.3 RC − (1 − A/T) (2,242 ÷ 0.12). RC is the spring residue used as a basis for the cropping management factor (c) in the USLE. Residue present after harvest in the fall is estimated by multiplying this RC value by 1.3 (9). The constant, 2,242/0.12, accounts for an expected 12 percent reduction in erosion for each 2,242 kilograms per hectare of residue incorporated into the soil (8). Thus, when A/T equals or exceeds one, RN equals or exceeds RP, and no residues can be removed from the land without increasing erosion beyond tolerable limits. When A/T is less than one, RN is less than RP, and residues can be removed without increasing erosion beyond tolerable limits.

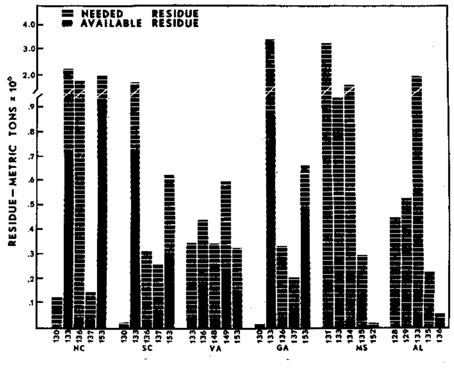

Figure 3. Total residues, residues available, and residues needed for water erosion control in MLRAs in six southern states.

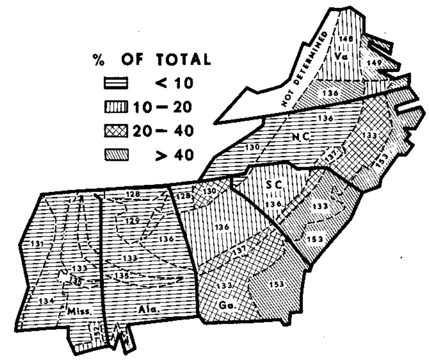

Figure 4. Percentage of total residues available for energy or other uses.

For example, 99 percent of the soils in MLRA 153 in South Carolina with a soybean-small grain cropping system (Figure 2A) have estimated A/T values less than one. Therefore, only 2 percent of the soils need all the residue produced to control water erosion. Some crop residues are needed for erosion control on 3 percent of the soils (between the dotted line and dashed line in Figure 2A). No residues are needed to maintain erosion within tolerable limits on 96 percent of the soils (below the dashed line in Figure 2A).

Estimated soil losses are greater under continuous soybeans than under the other cropping sequences. The percentage of soils with some residues available for uses other than erosion control is thus smaller than for the other cropping sequences (Figure 2B). In MLRA 136 in Virginia and MLRA 134 in Mississippi, estimated soil losses under continuous soybeans are so high that all crop residues produced are needed for erosion control. Because of low residue-producing crops, generally steeper slopes, and more erosive soil in Alabama and Mississippi, most residues produced in the two states, except on the least sloping soils, are needed to control erosion.

Residue sources by MLRA

We summed the available residues over all soil series for each cropping sequence within each MLRA in the six states. Figure 3 shows the residues available, plus the residues needed for erosion control, in each MLRA.

Figure 4 shows the percentages of residues available for uses other than erosion control. The intrastate MLRAs producing high amounts of available residues are 133 and 153 in Georgia, North Carolina, and South Carolina and 149 in Virginia. In these areas the residues needed for water erosion controls range from 25 to 74 percent of the total residues produced. In general, these agricultural lands are gently sloping with a large percentage of the cultivated land in higher residue-producing systems.

The percentage of crop residues needed for erosion control is lowest in the Atlantic Coastal Flatwoods of Georgia. In this area 75 percent of the residues produced—635,208 metric tons—are available for fuel or other uses. There are about 900,000 metric tons of residues available in the Atlantic Coastal Flatwoods region of North Carolina. However, amount of residues available per acre is less in North Carolina than in Georgia.

If crop residues are to be used for off-farm purposes, four states, Georgia, North Carolina, South Carolina, and Virginia, have the highest yield potential under present cropping sytems. About 4.0 million metric tons of residues could be available from designated areas in these states without exceeding tolerable soil loss limits.

In Mississippi and Alabama less than 10 percent of the residues are available. In the Atlantic Coastal Flatwoods of the other four states, more than 40 percent of the residues are available.

REFERENCES CITED

1. Austin, M. E. 1965. *Land resource regions and major land resource areas of the United States.* Agr. Handbook No. 296. U.S. Dept. Agr., Washington, D.C.
2. Gupta, S. C., C. A. Onstad, and W. E. Larson. 1979. *Predicting the effects of tillage and crop residue management on soil erosion.* J. Soil and Water Cons. 34(2): 77-79.
3. Holt, R. F. 1979. *Crop residue, soil erosion, and plant nutrient relationships.* J. Soil and Water Cons. 34(2): 96-98.
4. Larson, W. E. 1979. *Crop residues: Energy production or erosion control?* J. Soil and Water Cons. 34(2): 74-76.
5. Soil Conservation Service. 1977. *Cropland erosion.* Sec. Nat. Water Assessment. U.S. Water Resources Coun., Washington, D.C.
6. U.S. Department of Agriculture. 1967. *National inventory of soil and water conservation needs.* Stat. Bul. No. 461. Washington, D.C.
7. Wischmeier, W. H. 1973. *Conservation tillage to control water erosion.* In *Conservation Tillage.* Soil Cons. Soc. Am., Ankeny, Iowa. pp. 113-114.
8. Wischmeier, W. H., and D. D. Smith. 1965. *Predicting rainfall-erosion losses from cropland east of the Rocky Mountains.* Agr. Handbook No. 282. U.S. Dept. Agr., Washington, D.C.
9. Wischmeier, W. H., and D. D. Smith. 1978. *Predicting rainfall-erosion losses—a guide to conservation planning.* Agr. Handbook No. 537. U.S. Dept. Agr., Washington, D.C. □