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CONTENTS

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DISCUSSION

Proc. Paper 16068

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[*] Discussion period closed for this paper. Any other discussion received during this discussion period will be published in subsequent Journals.

Appendix.—References

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MODELING RILL DENSITY[a]

Discussion by George R. Foster[4] and Leonard J. Lane, A. M. ASCE[5]

The authors contributed to rill erosion modeling for agricultural land by applying concepts from channel morphology and sediment transport theory for noncohesive channels. This discussion describes the writers' analysis of field measurements of rill erosion on agricultural lands.

The authors assumed that agricultural soils are noncohesive when they suggested that critical shear stress for agricultural soils could be estimated from Shields criterion (4). However, this estimate of critical shear stress for erosion of agricultural soils is much too small, as the writers will show from analysis of field data (7). Critical shear stress was obtained (Fig. 2) from these data by plotting observed erosion rate versus shear stress estimated from observed data for discharge, velocity, slope, and unreported measured cross-sectional elevations. Hydraulic geometry from these data and data from a similar study (6) are described by:

$$R_o = 0.50\, A_o^{0.64} \qquad (23)$$

in which R_o = hydraulic radius, in feet; and A_o = flow area, in square feet. An estimate of critical shear stress from Fig. 2 is 0.06 psf.

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[a] March, 1980, by Ruh-Ming Li, Victor Miguel Ponce, and Daryl B. Simons (Proc. Paper 15230).

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Critical shear stress from the Shields criterion is plotted as a function of D_{84} (Fig. 3), assuming a shear velocity of 0.23 fps [corresponding to the second level discharge of Meyer, et al. (7) study], and a specific gravity of 2.65 for sediment particles. Meyer, et al. (7) observed that aggregates greater than 1 mm accounted for 14% of the sediment coming from the rills (7). From Fig. 3, 1 mm for D_{84} gives a critical shear stress of 0.013 psf, significantly less than the observed value of 0.06 psf. The actual D_{84} of the soil was much smaller, which gives an even smaller critical shear stress from the Shields criterion. Therefore, the Shields criterion using D_{84} for primary particles making up tilled agricultural soils like Russell silt loam significantly underestimates critical shear stress for rill erosion. The Shields criterion has proven satisfactory for estimating critical shear stress for transport of aggregates (specific gravity of approx 1.8) and primary particles (specific gravity of 2.65) by flow in rills (5).

Many agricultural soils do not armor. Certainly those studied by Meyer, et al. (3,7) did not armor during their tests. The shear stress required to detach particles is greater than the shear stress required to transport coarse sand that might armor these soils. Usually not enough gravel is available in many highly productive midwestern soils to armor during an annual cropping cycle. Land in cultivated agriculture is usually tilled for seedbed preparation, and sometimes for weed control at least once each year. Tillage buries most of the armor of coarse particles. If armoring does occur, more than a year is usually needed for a complete armor to develop.

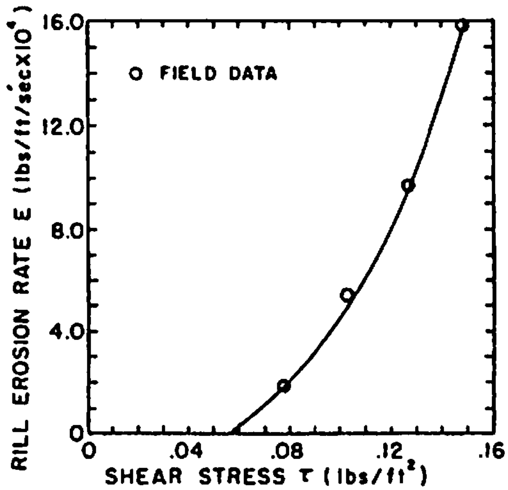

FIG. 2.—Erosion Rate in Rills on Tilled Agricultural Soil, Russell Silt Loam, as Function of Shear Stress of Flow; Data from Ref. 7

Tillage may be the single most important factor related to critical shear stress and rill erosion. Foster (5) measured rill erosion on a cropland soil that had consolidated and had not been tilled for a year. The soil was tilled and the measurements repeated. Rill erosion following tillage was five times the rate before tillage.

Rills in the Meyer, et al. (7) study, unlike the authors' assumption, did not reach a geomorphic equilibrium where shear stress of flow in the channel equals the critical shear stress of the channel boundary. If this type of equilibrium is reached, rill erosion ceases. Rill erosion rates were essentially constant for the duration of both Meyer et al. (3,7) tests.

If any restricting layer is deep, the apparent equilibrium is one where the cross sections of rills erode to an equilibrium shape that erodes downward at an equilibrium rate for steady flow. If a rill reaches a nonerodible layer, it widens and eventually reaches a final width when rill erosion ceases. The time required to reach a final width depends on depth to the nonerodible layer, discharge, critical shear stress, and slope (6).

The authors' channel geometric properties a, T_e, and A_e are functions of discharge Q_e, slope S_e, and soil properties (8). These functions could and should be included in Eqs. 5, 6, 9, 11, 16, and 20–22. The authors arrived at a solution to their equations by assuming an equilibrium where shear stress of flow in the channel equals critical shear stress. This assumption is questionable, and another concept is needed. Given channel morphology relationships for erosion of cohesive soils, rill widths could be determined if Q_e could be estimated (6).

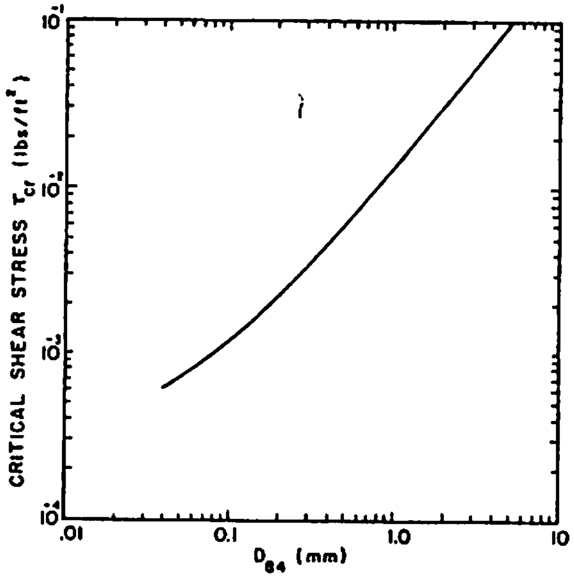

FIG. 3.—Critical Shear Stress from Shields Criterion (4) for Shear Velocity of 0.23 sq ft/sec, Kinematic Viscosity of 1.05 × 10^{-5} sq ft/sec, and Specific Gravity of 2.65 for Sediment Particles

Discharge, Q_e, in each rill is often an independent hydraulic variable and is a function of rilling patterns which may be primarily deterministic rather than random. Microtopography and macrotopography as affected by tillage, land form, and crop, influence rill frequency and discharge in each rill.

Future research on rill density should include studies on rill frequency and the fraction of total discharge in each rill. Also, study of rill morphology relationships as a function of properties of tilled, cohesive agricultural soils as they are affected by tillage, management, and cropping is another important research area.

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