The measurement and description of rill erosion

R. J. LOCH  Queensland Wheat Research Institute, Toowoomba, Australia

Abstract. Rill erosion can be the major mechanism of soil loss from sloping, cultivated land. The various methods of measuring and describing rill erosion are discussed, using both published data and results from simulated rainfall studies. To allow comparison of various studies, and the development of predictive models, it is essential to measure rill erosion rates and their change with time. Observations of channel pattern, while seldom made, could be of value in interpreting results.

INTRODUCTION

Rill erosion is the most obvious mechanism of soil loss from sloping, cultivated land (Fig. 1). Preliminary studies using simulated rain on 22.5 m long field plots (Loch, 1978) have shown that rill flow can carry much higher sediment loads than sheet flow, and is probably the major soil erosion process on the swelling clay soils of the Darling Downs area of Queensland. The measurement and description of rill erosion is therefore an important aspect of erosion research in the area. Published rill erosion studies have shown considerable variation in methods of measurement. The aim of this paper is to discuss the various approaches used on the basis of both published data and results obtained from simulated rainfall studies on the eastern Darling Downs.

EROSION RATE — TIME CONSIDERATIONS

The rilling process is basically the development of a drainage network. This development is usually limited to one or two runoff events before cultivation removes the channels formed, usually leaving slight depressions which serve to concentrate runoff from subsequent storms. While all the phases of rill development — initiation, elongation, elaboration, maximum extension and abstraction — may not occur, there is little doubt that rill erosion rate can depend on the stage of channel development that is reached.

This is illustrated by Fig. 2, which shows a gradual decrease in sediment concentration after a peak was reached at 26 min. Romkens et al. (1975) and Parker (1976) have reported a similar decrease in sediment yields from an initial peak concentration. This is usually considered to be an initial channel-forming phase with the rill being incised and loose, and easily eroded material being removed.

The considerable variation in sediment concentration with time, shown by Fig. 2 seems to be characteristic of rilling on the highly erodible swelling clay soils of the Darling Downs. This may be due to random large inputs of sediment from bank collapse.
Meyer et al. (1975) measured total soil loss due to rill erosion for two successive 30 min periods of rainfall. Such measurements, using some form of flow divider, may overcome problems of the variability of sediment loss. However, the lack of information on changes in sediment concentration with time could limit the usefulness of the data. This is particularly so when it is desired to compare results from studies using periods of measurement of different length. The development of predictive models also requires data to be extended to runoff events of differing duration.

The time periods used in published studies vary widely, not only in their duration, but also in the stage of the rilling process that they cover. Meyer et al. (1975) used a period of 30 min rain, but did not specify the length of time taken for runoff to com-
mence. Loch (unpublished data) used a period of 19 min (chosen for convenience) after sediment concentrations showed that rilling had commenced. Young and Wiersma (1973) used a period of 30 min after runoff had equilibrated, after 135 min of rainfall. As rill drainage basins are small it is likely that runoff events will be relatively brief. Measurement should obviously cover the initial period when sediment concentrations are highest, and the total length of time for which measurements are made may depend on either local storm durations or on the need to describe changes in rill erosion rate with time.

CHANNEL PATTERN

Channel pattern is not generally recorded in studies of rill erosion, although it could be of value. Schumm (1977) presents evidence for threshold slopes associated with the change from one pattern to another — e.g. straight to meandering — and notes the work of Edgar (1973) showing that these thresholds can be altered by a change in discharge. Rills produced by the author on rainulator plots with a slope of 0.04 remained straight with some thalweg meander while discharge was less than 1.5 l/s. At discharges greater than 1.5 l/s rills first developed a fan at their outlet, and then a braided area up to 2 m wide several metres upslope. A difference in discharge (e.g. between replicates) can therefore result in a change in rill pattern and probably sediment loss. Moreover, the development of rill pattern with time may help to explain time-dependent changes in sediment loss.

FIGURE 3. Upslope section of rill — 22.5 m long rainulator plot on a black earth.
TABLE 1. Channel pattern and sediment load data for two soil types

<table>
<thead>
<tr>
<th></th>
<th>Black earth</th>
<th>Krasnozem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel pattern</td>
<td>Top half of the plot meandering, lower half braided</td>
<td>Meandering</td>
</tr>
<tr>
<td>Meander amplitude</td>
<td>2 m</td>
<td>7 m</td>
</tr>
<tr>
<td>Sediment concentration</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>Concentration of sediment &lt;0.002 mm</td>
<td>0.8%</td>
<td>0.06%</td>
</tr>
</tbody>
</table>

Channel pattern is also affected by sediment load and type (Schumm and Khan, 1972). This is illustrated by comparisons of soil types in the present study. The author subjected two cultivated soils, a black earth, (a gilgaied, deep, cracking uniform clay) and a krasnozem (a gradational red soil with permeable subsoil), both on 0.04 slope, to similar treatment. Rills were very lightly pre-formed, and simulated rainfall applied. Once runoff had stabilized, clear water was introduced to the rill to increase discharge to approximately 2.2 l/s. The clear water inflow represented approximately 30 per cent of the final discharge. Channel descriptions and other data are shown in Table 1.

For both soils the increase in discharge caused channel widening and meandering, together with the development of a braided area on the black earth. Incision of the rill appeared to be limited to the loose cultivated layer. Bank collapse, due to meandering, appeared to be the major method of entrainment, with the differences between
the soils being quite marked (Figs. 3 and 4). Bank stability could be a factor governing soil erodibility; relating to the degree of consolidation of the cultivated layer. Meyer et al. (1972) reported an effect of tilth on susceptibility to rill erosion, but did not speculate on possible causes. Observations of channel pattern may be very useful in recognizing and interpreting tilth or soil type effects.

CONCLUSIONS

(1) When studies of rill erosion are undertaken, a measure of erosion rate and its change with time appears to be more useful than a measure of total sediment yield. Sampling for erosion rate needs to be carried out as frequently as possible because of large fluctuations in sediment concentration.

(2) Observations of rill pattern are likely to be of value in interpreting the results obtained.

REFERENCES


