Effects of Gully Plugs and Contour Furrows on the Soil Moisture Regime in the Cisco Basin, Utah

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Highlight: Soil moisture patterns in and around gully plugs and contour furrows constructed on Mancos shale-derived soils in Cisco Basin were studied from December of 1965 through December of 1966. Preliminary studies were initiated during the summer and fall of 1965. Results of monthly measurements indicate increased moisture storage immediately beneath treatment depressions, but minimal lateral movement. Results of this study, and others, suggest that treatments of this type on Mancos shale will function primarily to collect runoff, sediment, and possibly associated salts and that increased vegetal production is not a logical expectation.

The East Desert of Utah is characterized by soil which is both highly erodable and relatively unproductive (5 to 7% live plant cover). This is largely due to the Mancos shale formation, a marine deposit of the Cretaceous age, which is typified in the Cisco Basin. The area has some importance as a winter range for sheep and cattle, but low rainfall (average annual is 7.18 inches, 1953–66) is a major limiting factor in forage production and revegetation. In an effort to reduce runoff and sediment production from the basin, the Bureau of Land Management treated select areas with contour furrows and gully plugs. Gifford (1975) and Wight (1975) have recently reviewed the hydrologic impacts of various range improvement practices, including gully plugs and contour furrows.

The objective of this study was to determine the effects of gully plugs and contour furrows on the soil moisture regime of the Cisco Basin. The importance of soil moisture has been emphasized by Houston (1965, p. 25) as follows:

> An understanding of soil moisture regimes and the factors which influence them is basic to improving range productivity in the West. Moisture is no doubt the most important single influence affecting range forage production in the largely semi-arid climate.

Methods and Procedures

A description of the study area and treatments applied has been given by Gifford et al. (1977). For this study, two 40-acre areas were selected: Area 2 in a Nuttall's saltbush (*Atriplex nuttallii*) community which had been treated with gully plugs and contour furrows in 1964, and Area 3 in a mat saltbush (*Atriplex corrugata*) community which had been similarly treated in 1962. Both areas were fenced to exclude livestock.

Treatments were constructed with a crawler-type tractor equipped with a dozer blade (for gully plugs) or a Holt trencher (for contour furrows). Gully plugs were constructed by the bulldozer's scooping out a small basin and depositing the spoil material on the downhill side in the form of a small dam. In some instances the tractor packed down the dam portion with the tracks of the vehicle. The contour furrows were plowed on the contour with the Holt trencher, a concentric disk apparatus. The front disk digs the furrows and the rear and slightly offset disk throws the excavated material onto a spoil bank or throw. Average spacing of the furrows was 25 feet.

A preliminary investigation of the areal distribution of soil moisture around gully plugs and contour furrows was determined gravimetrically during the summer and fall of 1965 using a Veihmeyer tube (Veihmeyer 1929). Measurements were taken at 6-inch intervals to a depth of 24 inches in transects which ran across the treatments. The limited gravimetric sampling served as a basis for developing a sampling procedure using the neutron depth moisture gauge.

Access tubes for measuring soil moisture with the neutron depth gauge were installed to a depth of 5.5 feet during September of 1965 in and around each of the soil surface treatments as shown in Figure 1. Five replications of each of the two types of treatment in each of the two areas were made, one randomly selected from each of these exposure types—east, west, north, south, and alluvial flat. A total of 100 access tubes were installed in the two areas. Results of the preliminary gravimetric sampling indicated that influence of the soil surface treatments on soil moisture extended approximately 4 feet from the edge of the treatments. For this reason, one access tube of each replication (hereafter referred to as position 1 of gully plugs and position 3 of furrows) was located in the water-storing basin of the treatment; one access tube (position 2 of gully plugs and furrows) on the edge; another access tube (position 3 of gully plugs and position 1 of furrows) 4 feet from the edge of the treatments. The last access tube (position 4) was located below the throw of the furrow to detect any lateral movement of moisture downhill through the throw or spoil. Since moisture movement through the dam of the gully plugs was not indicated by preliminary gravimetric data, the last access tube in the gully plugs was located at the head (uphill) end of the pit. In addition to these four tubes, an access tube (position 5) was installed sufficiently far away to be considered unaffected by the treatments and was used as a control. In some instances, the same control tube was used for an adjacent gully plug and furrow replication on the same exposure site. Measurements were taken at the 12-, 18-, 24-, 36-, and 60-inch depths. In the center of the gully plugs (hole #1), the 60-inch depth was established relative to the pretreatment ground

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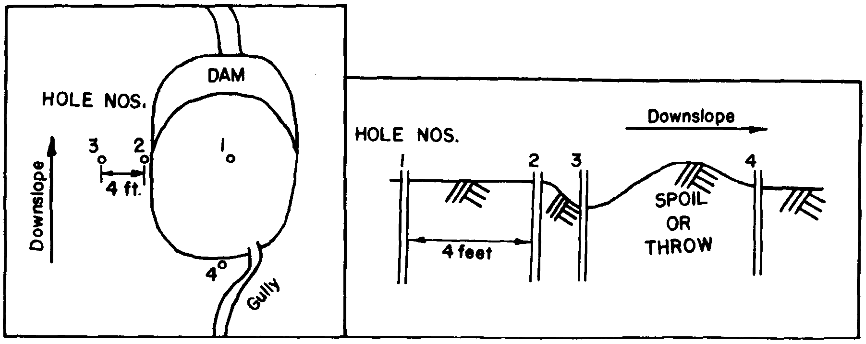

Fig. 1. *Location of soil moisture access tubes around treatments.*

level, while the other depths were measured relative to the bottom of the gully plug.

Certain limitations of the neutron depth moisture probe prohibits accurate moisture readings between 0- to 6-inch depths in the soil. A neutron surface moisture meter was used occasionally to determine soil moisture amounts and distributions in the surface soil.

Soil moisture was measured at each of the sampling points each month from December of 1965 through December of 1966, with the exception that only one set of measurements was made in January and February of 1966—during the last part of January in Area 2 and during the first part of February in Area 3—for a total of 12 dates measured. Data for October of 1966 in Area 3 were incomplete because of instrument failure; therefore, only 11 dates were used in the statistical analysis of Area 3. All data were analyzed as a randomized (split-split) block deisgn and data from the gully plugs and contour furrows were analyzed separately in each area. For the analysis, blocks correspond to different exposures, whole plots correspond to soil moisture access tube locations and soil depths, and dates correspond to the splits.

Rainfall, as measured in standard 8-inch storage gauges, was 5.25 inches during the study period, while the previous 12 months were relatively wet with 13.70 inches.

Results

Monthly soil moisture values, averaged for the 0- to 60-inch depth, indicated that moisture trapped in the treatments is retained in the immediate area of the treatment depression and does not move laterally through the soil to any appreciable extent (Fig. 2a, b, c, d). For the gully plugs on both Area 2 (Nuttall saltbush) and Area 3 (mat saltbush), the analysis of variance showed a significant position × date and depth × date interaction, as might be expected. Averaged over dates and depths, tube 1 in Area 2 (28.6% moisture by volume) and tubes 1 (27.9% moisture by volume) and 2 (24.6% moisture by volume) in Area 3 had significantly more moisture around them than the other tube locations (mean for other locations was 20.0% moisture by volume). Since tubes 1 and 2 were located in and immediately adjacent to the gully plug basin, it is evident that moisture from the basin remains within 4 feet of the treatment. Mean values (averaged over all dates and sampling positions) for percent moisture by volume at the various sampling depths remain nearly constant on Area 2 and decreased slightly with depth on 'Area 3. The lack of a significant position × depth interaction indicated that little moisture was actually moving into the soil profile. This was visually evident in that free water collecting in the two treatments on both areas often stood on the soil surface for days or even weeks, until it eventually evaporated.

For the contour furrows the analysis of variance showed a significant position × date and depth × date interaction, as was also the case with the gully plugs. Averaged over dates and positions, access tube locations 2 (23.3% moisture by volume) and 3 (23.2% moisture by volume) for the contour furrows in Area 2 had significantly more moisture around them than locations 1, 4, or 5 (control) (mean for these latter three locations was 19.9% moisture by volume). Tubes 2 and 3 were located in and immediately adjacent to the furrows, while tubes 1 and 4 were only 4 and 3 feet, respectively, from the furrows. This indicated that the moisture moved out somewhat less than 3 feet laterally from the furrows. In Area 3 soil moisture around tubes 2 (21.7% moisture by volume) and 3 (22.1% moisture by volume) in furrows was not significantly greater than locations 1, 4, or 5 (mean for these latter three locations was 19.2% moisture by volume). This would seem to indicate that the contour furrows in this area were losing their effectiveness; they were put in 2 years prior to those in Area 2. The position × depth inter-

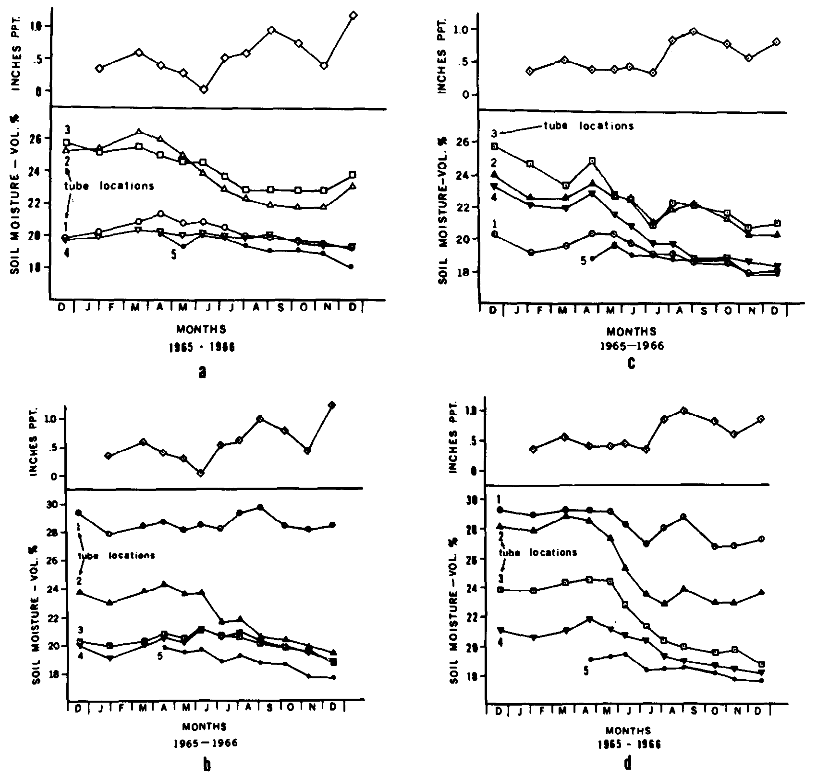

Fig. 2. *Soil moisture variation (0″–60″) around treatments: (a) contour furrows in Nuttall saltbush (Area 2); (b) gully plugs in Nuttall saltbush (Area 2); (c) contour furrows in mat saltbush (Area 3); (d) gully plugs in mat saltbush (Area 3).*

action was not significant (as with the gully plugs) and mean values (averaged over all dates and sampling positions) for percent moisture by volume at the various sampling depths varied only sightly with depth on both areas.

Conclusions

Soil moisture data showed that the gully plugs and contour furrows significantly increased moisture storage immediately beneath the treatment depressions, but not laterally around them. Depth of moisture penetration within depressions apparently seldom exceeded 24 inches.

Based on results of this study and also results presented by Wein and West (1972; 1973), it becomes evident that the primary function of these treatments on Mancos shale-derived soils is to collect runoff and sediment (and possibly associated salt) rather than increased vegetal production.

Lack of both vertical moisture penetration and also lateral movement of moisture within treatment depressions indicates that the potential for salt leaching and eventual increases in salt loading within the Colorado River Basin through subsurface flow contributions is nil, at least where precipitation patterns are similar to those encountered in this study. This aspect, however, warrants additional research to cover a more complete spectrum of possible climatic events.

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