EFFECT OF SURFACE MULCH COVER AND STONE BARRIER ON RUNOFF AND SOIL LOSS UNDER SIMULATED CONDITION

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ABSTRACT

Rainfall simulator is an useful tool to generate quick and satisfactory information on runoff and soil loss under different surface conditions, involving much less cost and time. The results show that sorghum stover mulch reduced runoff and soil loss considerably. It is also observed that runoff and soil loss increase with increase in degree of slope. Simple application of mulch material on the surface upto 2% slope of the field, involving almost no cost, can act as good inter terrace soil and water conservation treatment in the black soil region, apart from improving in situ moisture condition to increase crop production. Attempt is also made to have effect on runoff and soil loss under steep slopes having stone barrier using mini rain fall simulator. It is observed that stone barrier reduced sediment density considerably.

1.0 INTRODUCTION

It is well recognized that soil erosion is a serious problem throughout India and more specially in black soils of various depths. Even though a few necessary and corrective measures have been evolved and recommended to arrest large scale erosion, still a final solution is problematic and elusive. Vast areas are still denoid of vegetative cover and crops. Reservoirs/dams are being silted up within a short time. Desilting dams at a huge financial outlay has to be resorted to at the cost of other developmental works and other nation building efforts and activities. Information on soil loss under different slopes, vegetative covers and rainfail characteristics is not available. This information is necessary for development of mathematical model for predicting runoff and soil loss to make specific recommendation for conservation and water resource planning in a given region. It will not be possible to generate information from field studies under natural condition because it is time consuming and costly and hence it is proposed to study under controlled condition to have comparative results between the treatments using rainfall simulator (Meyer 1958 and Adhikari et al, 1987). Vegetative barriers in different forms such as mulches, contour cropping, etc are sufficient to reduce erosion to permissible limit on areas upto 4% slope (Bhardwaj, 1994).

Amount of mulch material required to effectively reduce soil erosion is important in evolving ssound soil conservation practices. In the studies conducted both under natural and simulated rainfall conditions, runoff was found to decrease from 55 and 43% under bare plot and from 15 and 13% with mulch treatment @ 8 T/ha under simulated and natural condition respectively (Khera et al 1994). Conservation of soil on arable Lands requires reducing the direct impact of rain drops, maintaining maximum soil infiltrability, increasing surface storage and decreasing the quantity, velocity and transport capacity of runoff water. These can best be achieved either through the use of crop residue as surface mulches or by providing effective plant cover. Plant cover intercepts the rain drops before they reach the ground, neutralizes the stored energy and thereby reduces soil detachment and transportation. Spreading of crop residues on the surface of soil (mulching) helps in conserving soil and water by simulating the ground effect. Hence based on the above criteria, a similar study was planned for black soil under simulated condition and the results are discussed in this paper.

An attempt is also made for assessing soil erosion and run off under stone barrier having steep slope using mini rainfall simulator.

2.0 EXPERIMENTAL PROCEDURE

Development of rainfall simulator: Initially a hemispherical sprinkler type of rainfall simulator with manual oscillation was developed following the one used at IIT Kharagpur (Gulati 1964 and prasad 1969). The tests conducted revealed that distribution of simulated rain was not uniform over the soil tray and the intensity of the rain could not be varied. Apart from the above, the drop size was also not uniform both with respect to space and time. Considering various types of simulators available, efforts were therefore made to correct the above deficiencies and develop an indigenous rainfall simulator by introducing a V- Jet nozzle for uniform drop size connected to an automatic oscillation system (between 15 and 30 oscillations per minute) is fitted with a solenoid valve attached to a timer for intermittent spraying to effect changes in the intensity of simulated rainfall. The clean water is pumped using a reciprocating pump having a facility to deliver the water at a constant pressure which can be varied from 2 PSI to 10 PSI (Fig.1)

The intensity has been varied with controlling the timer as follows. 60 seconds on – 0 second off, 50 seconds on – 10 seconds off, 40 seconds on –20 seconds off, 30 seconds on –30 seconds off, 20 seconds o n- 40 seconds off, 10 seconds on –50 seconds off, and their effect was studied on bare plot, 1/3 of the tray covered with mulch @ 3 t/ha, 2/3 of the tray covered with mulch @ 6 t/ha, and entire tray covered with mulch @ 9 t/ha. The tray size is considered 1x1m.

3.0 DETERMINATION OF UNIFORMITY COEFFICIENT

The simulator as described above was fabricated and put to test to determine the evenness of rainfall distribution over the plot area. The uniformity coefficient (CU) was calculated by using the Christians formula (Thomas, et al 1989)

$$CU = 100\left(1 - \frac{\sum K}{Mn}\right)$$

Where CU is per cent uniformity coefficient, M is mean value of simulated rainfall, n is number of observations and K is deviation of observations from mean. The CU was observed nearly 100% suggesting validity of plot size.

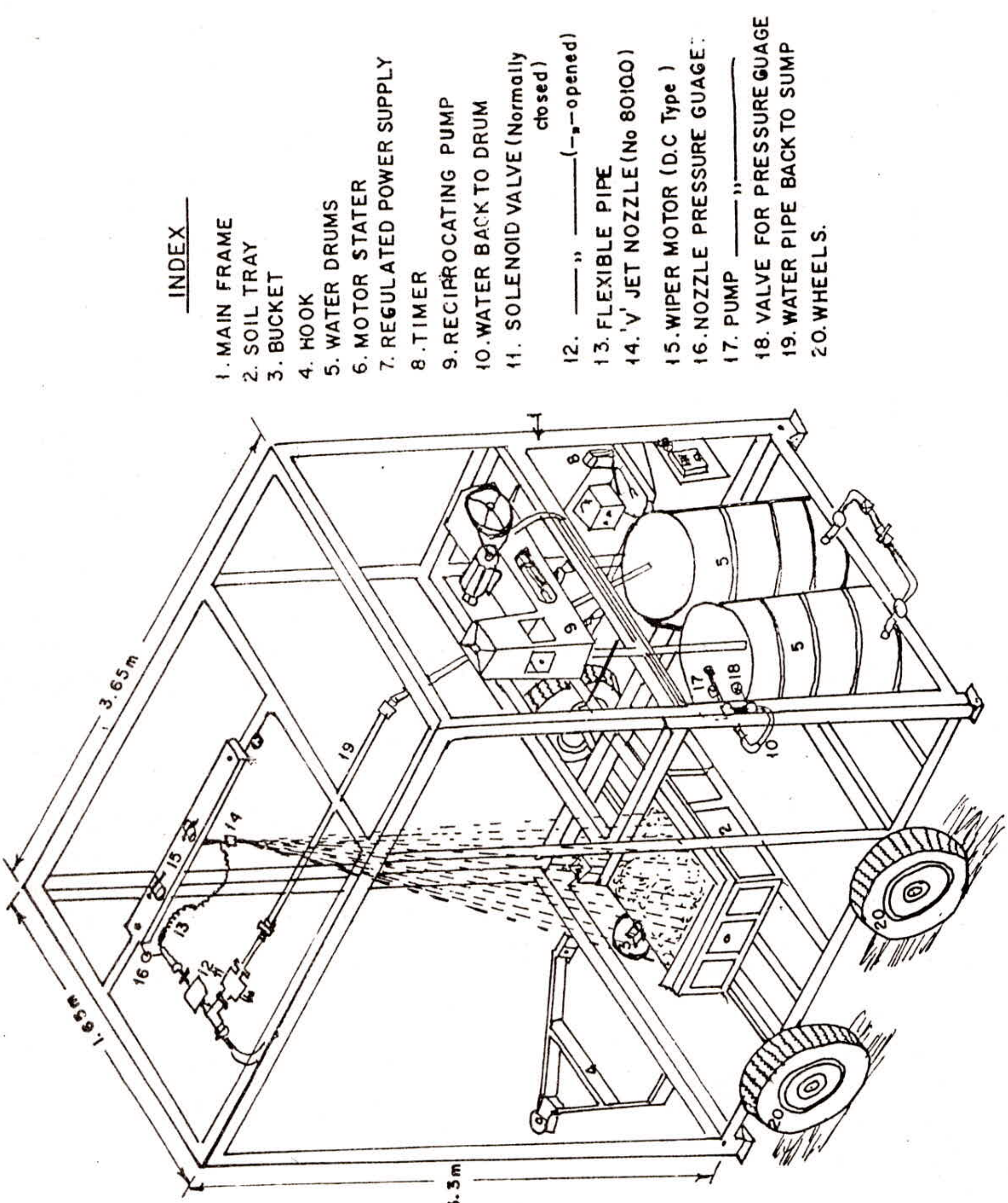


Fig. 1 : Nozzle Type Rainfall Simulator

4.0 RESULTS AND DISCUSSION

It is found from the results that for both 1 and 2% slopes, bare plot gives maximum runoff and soil loss followed by 1/3 of mulch and 2/3 of mulch. The minimum runoff and soil loss is produced from treatment covered with full mulch. The reason is that higher number of obstacles to the flowing runoff water helped in reducing runoff and soil loss. Fig. 2 show the relationship between rainfall versus runoff and rainfall versus soil loss, respectively under bare plot, 1/3, 2/3 and full mulch plot for 1% slope. It can be seen from the figures that runoff and soil loss are maximum in the bare plot, followed by 1/3 mulch, 2/3 mulch and lowest in the full mulch plot for all higher rainfall events (runoff causing rainfall event). The reason may be due to more obstruction resulting in less runoff and soil loss. Similar trend is obtained for the plot under 2 % slope, which is shown in Fig 3. Runoff and soil loss under 1 and 2% slope for bare plot and full mulched plot is also shown Fig. 4 and 5. It is observed that in all the cases, runoff and soil loss is more for 2% slope which conforms to the conventional theory.

An attempt is also made to get the runoff information on heavily cracked soil. The observations were made under dry and wet condition of soil, which is presented in Table-1. It is found from the result that for 24 to 25 mm rainfall of 10 minutes duration, runoff is very negligible (less than 1 mm) even in wet condition. It shows that whenever there are heavy cracks in black soils, particularly in pre-monsoon period, the runoff produced from the catchment areas will be very negligible.

Table 1: Observations on cracked soil

Observation	Rainfall (mm)	Time (minutes)	Runoff
1	24.4	10	0.3 Dry run
2	24.8	10	0.45 Wet run

5.0 USE OF MINI RAINFALL SIMULATOR FOR DETERMINING RUNOFF AND SOIL LOSS FOR SOILS FROM MINE SPOILED AREAS UNDER STEEP SLOPES

The nozzle type rainfall simulator discussed above, can not generate information of runoff and soil loss under steep slopes. Hence attempt is made to use mini rainfall simulator to study under steep slopes.

Rainfall simulator (Fig.6), designed specifically for soil conservation studies was obtained from Eijkelkamp, Netherland and standardised. (Karmphorst 1987)The specifications of the simulator are given in Table2.

Essentially the simulator consists of three parts:

- a sprinkler with a built-in pressure regulator, based on the Mariotte bottle principle, for the production of standard rain shower.

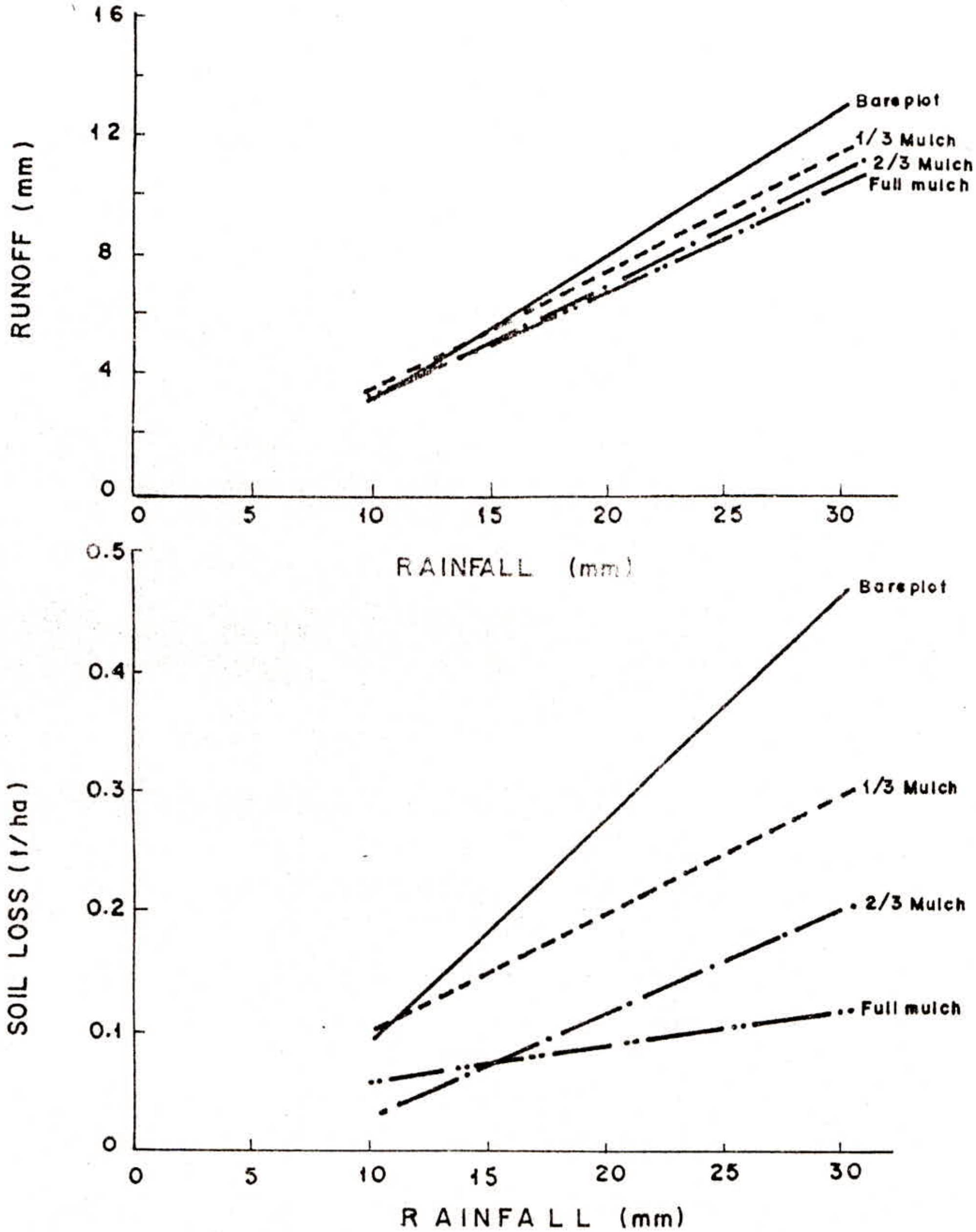
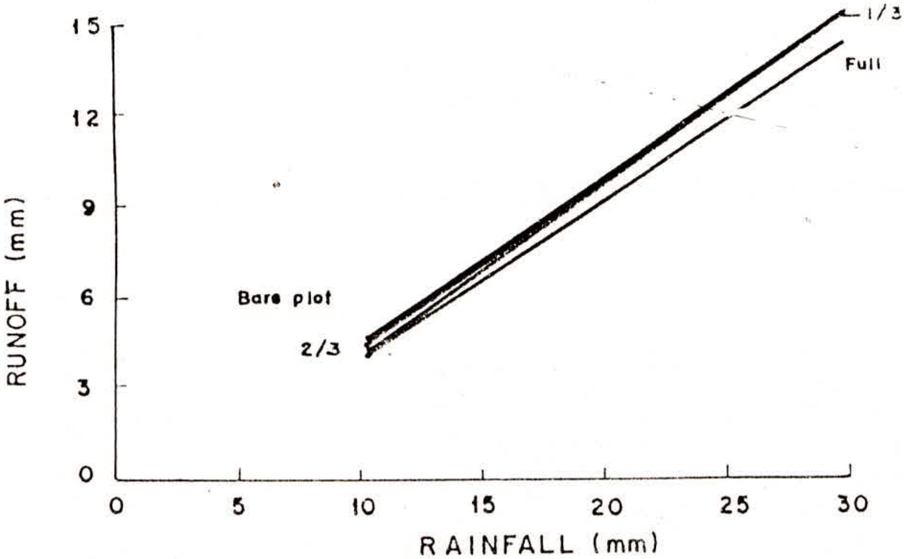


Fig. 2 : Rainfall runoff/soil loss relationship as influenced by different areas of mulch cover under 1% slope.



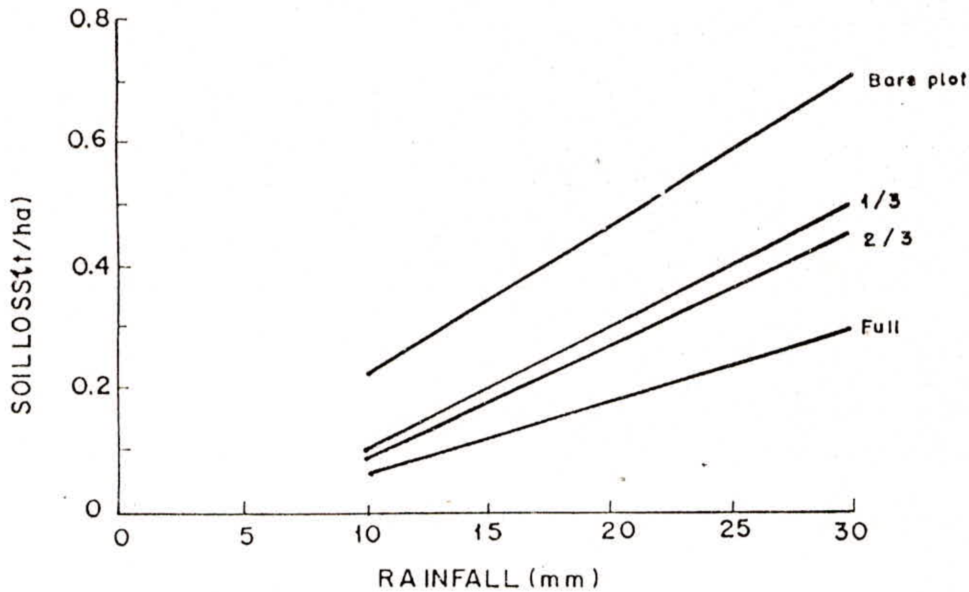


Fig. 3 : Rainfall – runoff/soil loss relationship as influenced by different areas of mulch cover under 2% slope

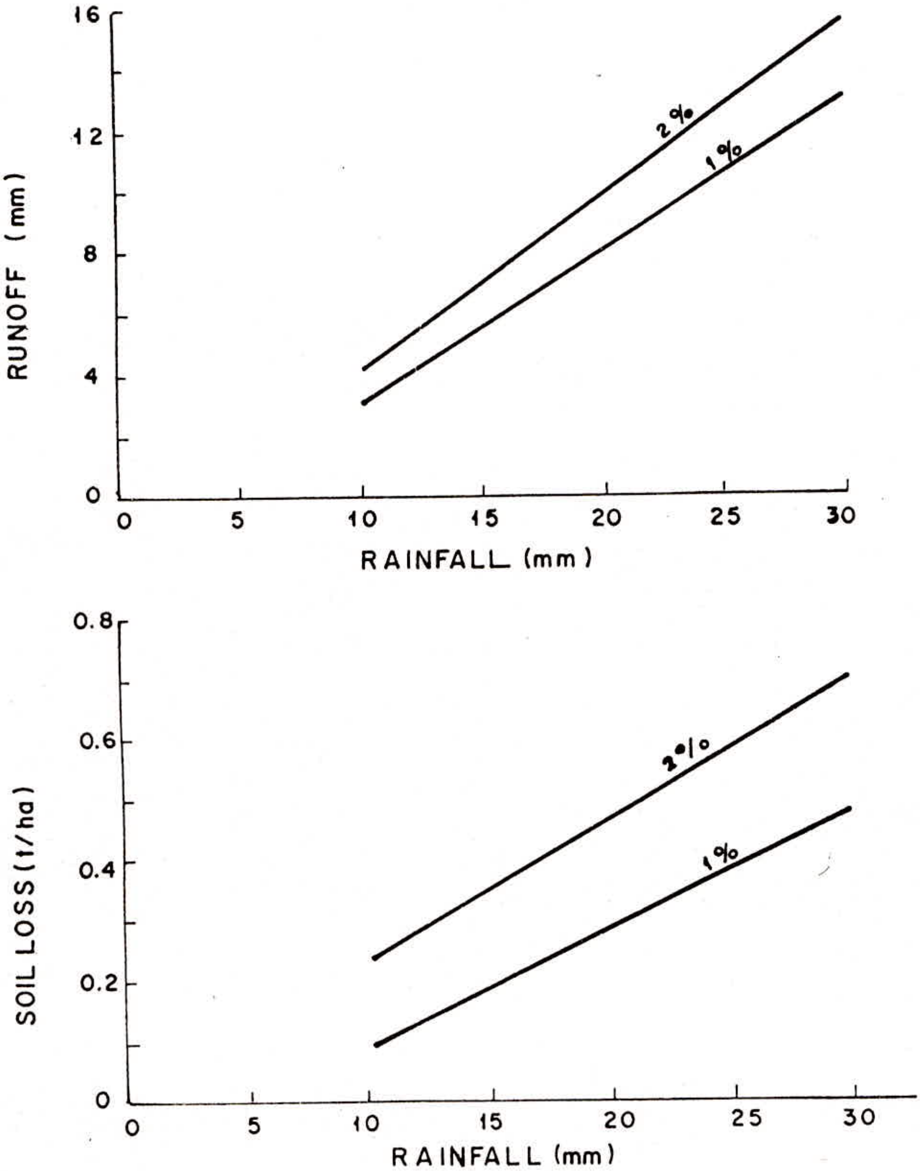


Fig. 4 : Runoff and soil loss in bare plot as influenced by 1% and 2% slope

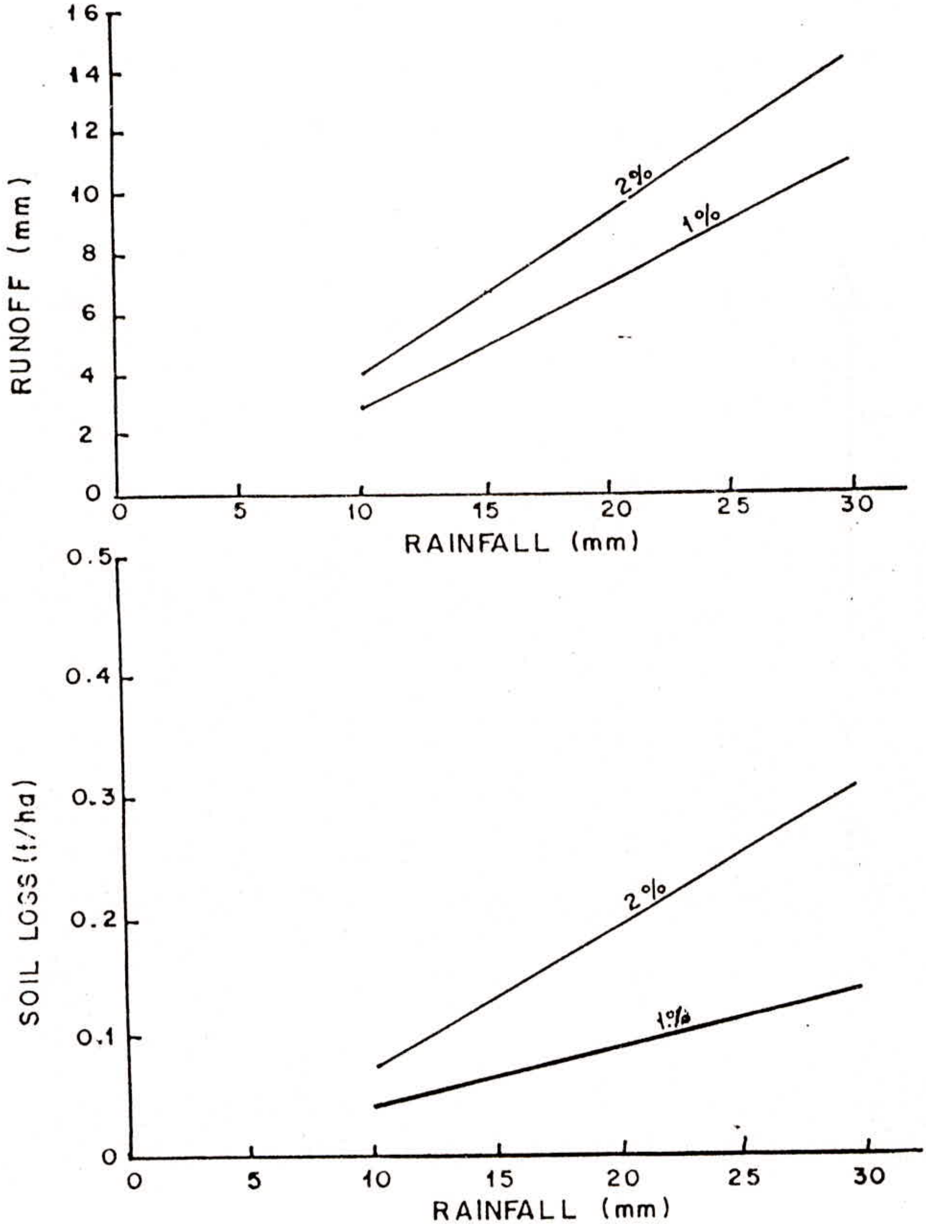


Fig. 5 : Effect of mulching in full area on rainfall – runoff/Soil loss under 1% and 2% slopes

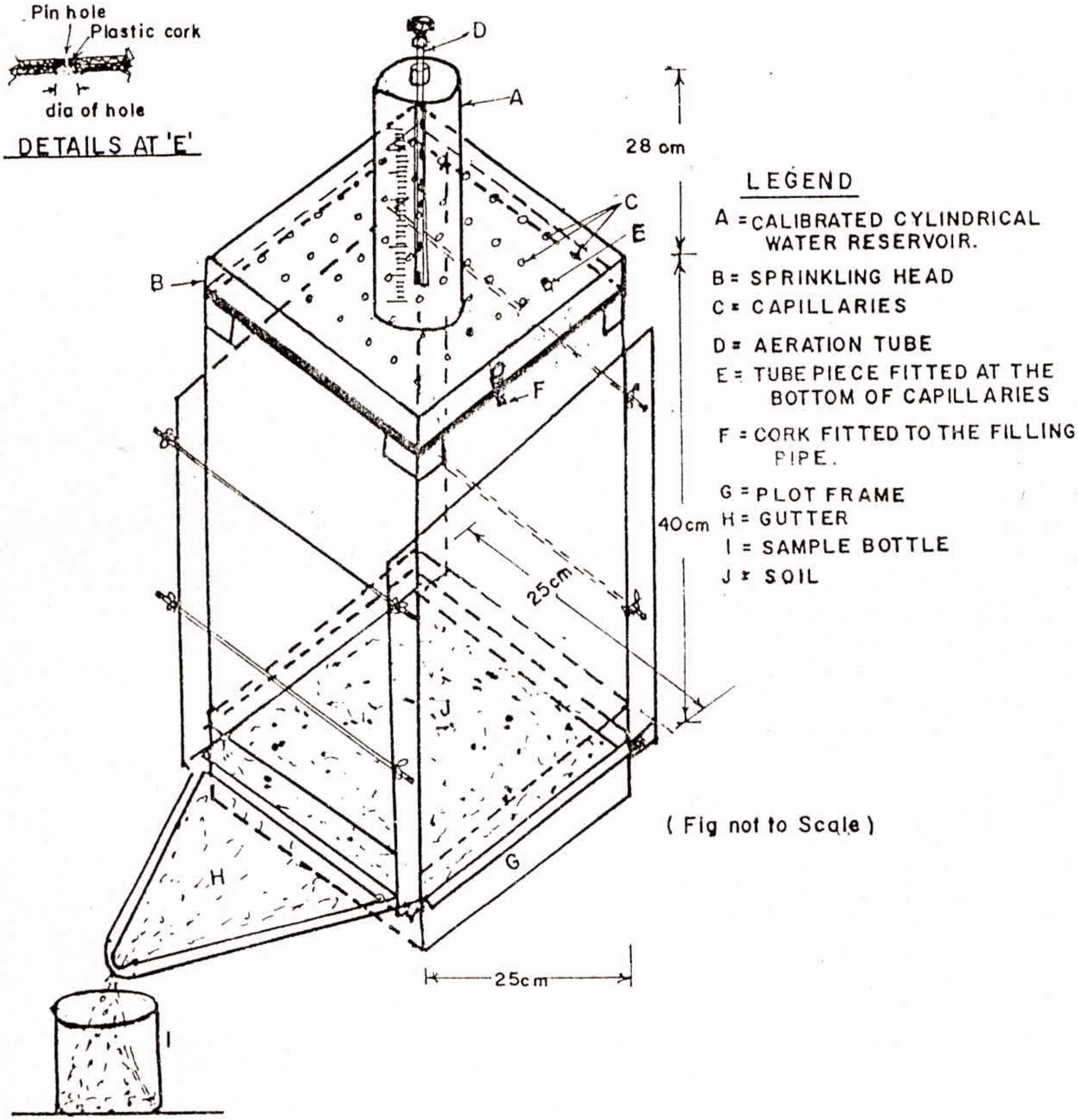


Fig. 6 : Details of mini Rainfall Simulator

- A support for the sprinkler, which also functions as a wind shield in the field.
- A stainless steel frame meant to prevent lateral movement of water from the test plot to the surrounding area. Attached to the plot frame is a gutter for the removal of the runoff and soil-loss to a sample bottle.

Table 2: Specifications of mini rainfall simulator

Magnitude of rainshower	18 mm
Duration of rainshower	3 min.
Intensity of rainshower	6 mm/min.
Average fall height of drops	400 mm
Diameter of drops	5.9 mm
Mass of drops	0.106 g
Number of capillary tubes	49
Kinetic energy of shower	35.4 J/mm
Surface area of test plot	0.0625 sq.m
Slope of test plot	16 %

The sprinkler consists of a calibrated cylindrical water reservoir with a capacity of approximately 1200 ml, which is in open connection with the sprinkling head. Water is discharged from the sprinkling head through 49 capillaries. The discharge rate is determined by the length and the inner diameter of these capillaries.

The pressure head on the capillaries can be increased or decreased by moving the aeration tube upward or downward. The magnitude of this pressure head regulation is sufficient to correct the influence of the viscosity of the water used on the discharge rate of the capillaries. The lower ends of the capillaries are fitted with a short piece of tubing. The inner and outer diameter of this tube control the drop size and drop frequency. Rain shower is respectively initiated or stopped by opening or closing the aeration with a cork respectively.

In order to determine the efficacy of the simulator for using under field conditions and also to assess the transportability of sediment from steep sloes, a study was conducted in the laboratory by bringing soil from the mine area. Soil was prepared and filled up into the tray which was maintained at 16 per cent slope. To start with,. Rainfall was simulated under dry and barren conditions. Subsequently the operation was repeated under different antecedent moisture conditions. The results are presented in Table-3. Under dry conditions, no runoff was produced, however as the moisture content in the surface increased, the runoff as well as sediment density increased indicating a positive effect of antecedent moisture on runoff and soil loss. These results suggest that under such steep conditions, to reduce runoff, it is essential to change the surface configuration for increasing the opportunity time for the rain water to soak through trenches, ditches and open pits, etc. Such information will be highly useful in developing rainfall – runoff models in relation to surface conditions. In order to assess the impact of loose barriers under such conditions on sediment yield, small stone (of one cm size) barriers were created at the centre of tray and rain was simulated. The results presented in Table-3 reveal that sediment density dropped by 50 per cent when compared to bare plot having the same antecedent moisture, while the runoff was almost the same. These preliminary results suggest that organising loose stone checks/gabions/vegetative checks across slope and nala bed would reduce sediment transport from the catchment considerably. Such information, systematically collected, will be useful to develop models for determining the intensity of measures required for sediment control from areas with undulated topography and steep slopes.

Table 3: Simulated rainfall and corresponding runoff, sediment density and antecedent moisture

Rainfall (mm)	Antecedent moisture	Runoff (mm) (%)	Sediment density (g/li)	Remarks
18	0.4	Nil	Nil	Bare plot
18	6.1	9.0	0.18	"
18	11.7	10.8	0.12	"
18	23.9	11.8	0.12	"
18	28.9	12.5	0.05	With stone barrier
18	34.0	13.0	0.03	"

6.0 CONCLUSION

The rainfall simulator is a very handy and useful tool to have quick and comparative results between the treatments under simulated rainfall conditions. The results show that, mulching with sorghum stover control the over land flow and erosion and reduce runoff by 20% and soil loss decrease with increase in intensity of mulching material applied. The result also shows that the vegetative measures can act as an effective tool as supplementary to graded bund for conservation planning in black soil agricultural land having slope of 2% or less for *in situ* moisture conservation. From the mini rainfall simulator studies, it is observed that sediment density dropped by 50 per cent with stone barriers when compared to bare plot.

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