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INFLUENCE OF MULCH AND COVER CROPS ON SURFACE RUN-OFF AND SOIL EROSION ON TEA LANDS DURING THE EARLY GROWTH OF REPLANTED TEA

*W. B. Manipura

Large-scale replanting of old tea land with selected clones is presently being carried out in tea estates. During the early stages of growth of young tea there is very little ground cover which results in run-off and soil losses. An experiment was carried out to determine the effect of cover crops grown between tea rows and mulching of inter-rows on run-off and soil erosion. Mulching with grass loppings reduced run-off and soil erosion markedly compared with leaving the land clean weeded and bare. *Eragrostis curvula* grown between tea rows as a cover also reduced erosion to the same extent as mulching. *Stylosanthus gracilis* grown as a ground cover also reduced run-off and soil erosion but to a lesser extent than mulching. The increased run-off and soil losses in the bare plot appeared to be caused by a breakdown of the surface structure of the soil and also by regular manual weeding which loosened the surface soil.

Tea plantations in Ceylon are generally situated on sloping land with varying degrees of steepness. The extent of soil erosion varies widely depending on the cover of tea and the method of soil management. Regular clean weeding with the use of mechanical implements has led to serious soil erosion in some tea estates. Clean weeding not only keeps the land bare but also leaves a loose layer of soil on the surface which could easily be carried away with the run-off. Due to the beating action of rain drops on bare soil, the soil aggregates are broken down and the finer soil particles block the soil pores and there is a gradual sealing of the soil surface. (Baver 1956; Ellison 1952). The immediate effect of rain on bare soil is, therefore, a gradual reduction in infiltration capacity resulting in increased run-off and soil erosion.

By minimizing run-off not only is soil erosion reduced but also, the conservation of incident rainfall for use by crops during periods of water stress is increased. This factor is particularly important in areas subject to long dry spells. It is, therefore, necessary to devise suitable agronomic practices to obtain the maximum infiltration of incident rainfall and also to reduce soil erosion. The importance of protecting the soil surface from rainfall thereby increasing infiltration and reducing run-off and erosion has long being recognized. Numerous workers in temperate countries have emphasized the importance of mulches and ground covers as suitable measures to reduce soil erosion. (Baver 1956; Mannering & Meyer 1963; Wischmeier 1966).

The problem of extensive soil erosion in old tea land where the cover of tea is poor was pointed out by the Committee on Soil Erosion (1931). Holland and Joachim (1935) demonstrated the effectiveness of cover crops in reducing soil erosion in such land. Tea estates are now adopting large scale replanting of old seedling

*Agronomist, Tea Research Institute of Ceylon, Talawakelle, Sri Lanka.

tea with high yielding clonal tea. The very good cover obtained with clonal tea and the adoption of soil conservation measures such as contour planting, terraces and contour drains reduces soil erosion to a large extent. During the first two or three years, however, the young tea affords very little protection to the soil. Unless adequate measures are taken to provide some ground cover either by growing cover crops between tea rows or by mulching, soil erosion could be a serious problem during the early years of the growth of replanted tea. The experiment described in this paper was aimed at making preliminary investigations on the effect of cover crops and mulch on run-off and soil erosion on land replanted with clonal tea during the early stages of growth.

EXPERIMENTAL

The experiment was carried out at St Coombs (elevation 1200 m amsl) in a field where the old tea had been uprooted. The soil was a well-drained clay loam of the red yellow podzolic soil group. Four plots 2.1 m (7 ft) wide and 9.1 m long (30 ft) were laid down on an uniform slope of about 26%. Adjacent plots were separated by borders measuring 1.3 m (4 ft). The sides (down the slope) of each plot was bounded by galvanized iron sheets, 22.5 cm (9 in.) high and they were buried 10 cm (4 in). into the ground. A drain 22.5 cm deep was cut at the upper end of each plot and at the lower end, a collecting trough 15 cm deep and 20 cm wide was buried to collect the run-off water from the plot. The water from the collecting trough, was led into a settling tank and then to a run-off recorder (manufactured by Casella, London). The collecting trough, settling tank and the run-off recorder were covered to prevent any rain falling directly on them. The run-off recorder was designed to record on a chart the rate of run-off against time and it was calibrated using a garden tap before installing in the plot. Much of the soil carried by the run-off water settled in the collecting trough and in the settling tank. The weight of soil so collected was weighed on each day when soil losses were detected and expressed in terms of dry soil by means of a sample dried for 24 hrs at 105° C. Some of the fine clay fractions would not have settled in the tanks, but this would have amounted to only a negligible fraction of the soil collected in the tank and in the collecting trough. Rainfall was measured by a siphoning type of rain guage designed to measure the rate of rainfall which was installed adjacent to the plots.

The plots were laid down in July 1969. One year old tea plants of clone TRI 2023 were planted at a spacing of 1.2 m (4 ft) by 0.6 m (2 ft). The treatments of ground cover applied to the four plots were as follows :

Plot 1—Mulched with loppings of Guatemala Grass (*Tripsacum laxum*) at the rate of 25 tonnes per hectare (fresh).

Plot 2—Two rows of *Eragrostis curvula* established between tea rows.

Plot 3—A single row of *Crotalaria anagyroides* established between tea rows. (Later replaced with *Stylosanthus gracilis*).

Plot 4—No ground cover—(bare).

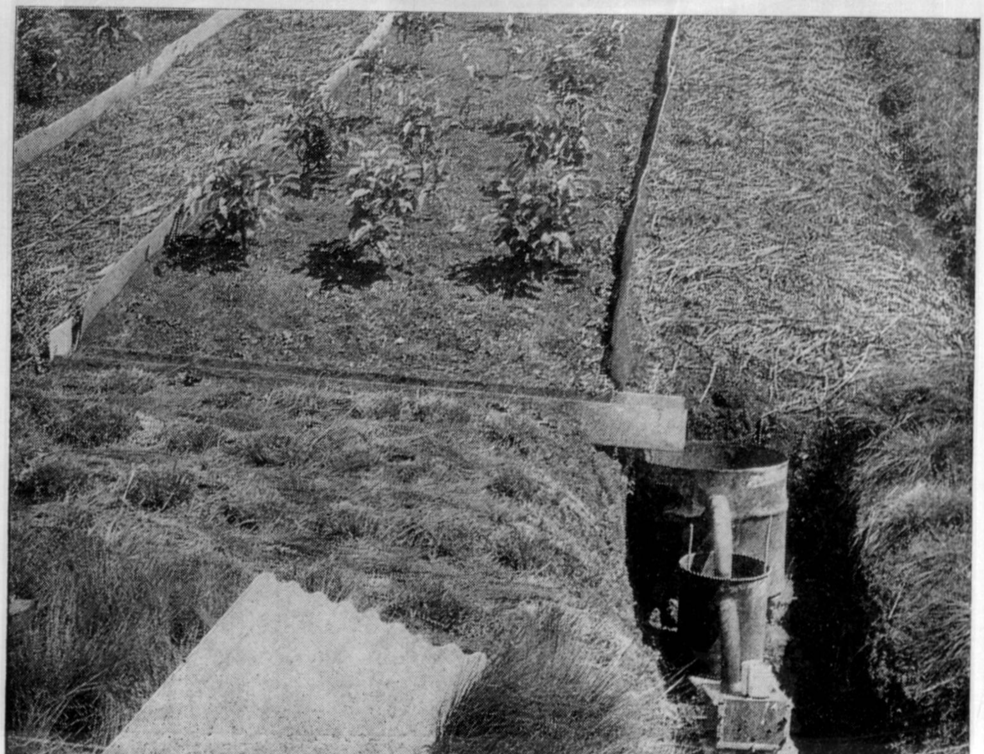

FIG. 1—*Layout of the run-off plot (bare, clean weeded) with the collecting trough, settling tanks and run-off recorder.*

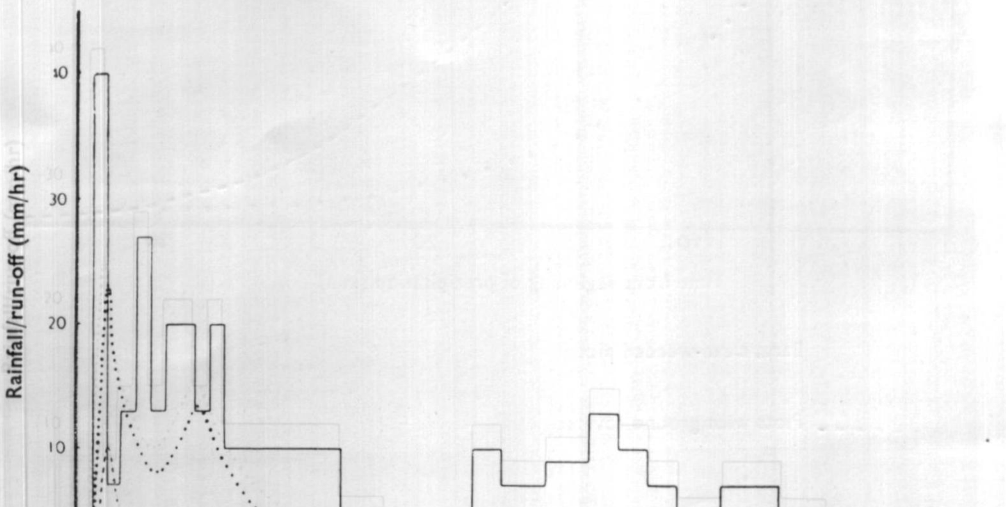

FIG. 2—*Rainfall histogram and run-off hydrographs for the storm on* 13*th October* 1970.

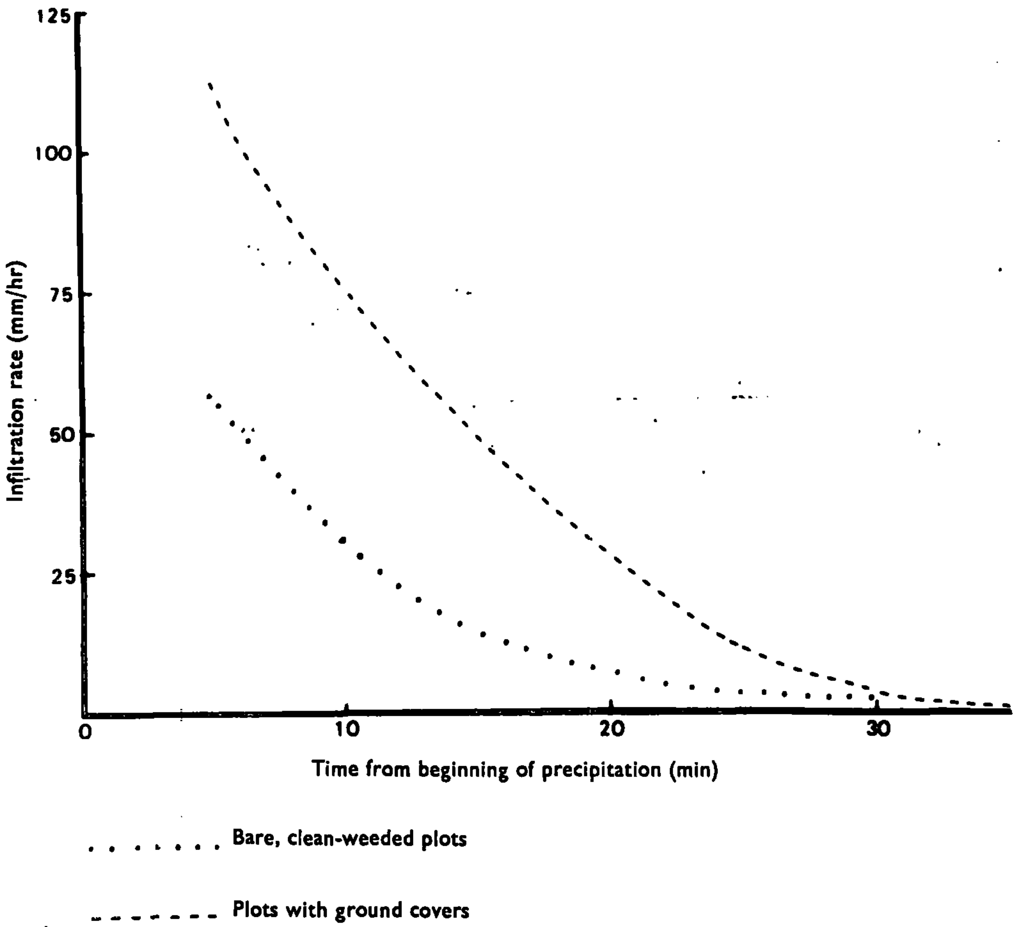

FIG. 3—*Infiltration curves for bare plot and plots with ground covers on 22nd April* 1971.

TABLE 1 — *Rainfall, run-off & soil losses data*

Date	Total Rainfall mm	Duration	Maximum intensity (mm/hr) for 5 min. Interval	Run-off for corresponding period (mm/hr) Mulch	*E. curvula*	*S. gracilis*	Bare	Soil losses (tonnes/hectare) Mulch	*E. curvula*	*S. gracilis*	Bare
13/10/70	43	4 hr 55 min.	40	—	—	9	23	—	—	0.10	1.15
2/11/70	26	5 hr 15 min.	67	—	—	11	42	—	—	0.20	1.53
18/11/70	20	2 hr 45 min.	40	—	—	—	2	—	—	—	—
29/11/70	51	6 hr 35 min.	73	—	—	14	26	—	—	0.25	5.62
12/12/70	21	2 hr 35 min.	64	—	—	28	56	—	—	0.10	2.28
13/12/70	8	2 hr 30 min.	23	—	—	2	10	—	—	—	0.15
17/12/70	16	7 hr 30 min.	27	—	—	—	2	—	—	—	—
18/ 4/71	11	1 hr 5 min.	53	—	—	1	29	—	—	—	1.93
20/ 4/71	16	0 hr 45 min.	67	—	—	9	47	—	—	0.02	4.97
22/ 4/71	26	0 hr 35 min.	128	2	17	21	71	—	—	0.12	17.04
23/ 4/71	6	3 hr 25 min.	27	—	—	4	10	—	—	—	0.32
24/ 4/71	24	7 hr 0 min.	40	—	—	—	33	—	—	—	1.30
29/ 4/71	16	4 hr 0 min.	7	—	—	—	4	—	—	—	—
2/ 5/71	9	5 hr 40 min.	238	—	—	—	6	—	—	—	0.65
12/ 5/71	43	2 hr 50 min.	94	2	—	31	71	—	—	0.05	12.59
13/ 5/71	11	0 hr 35 min.	33	—	—	—	8	—	—	—	—
27/ 5/71	18	2 hr 25 min.	27	—	—	—	2	—	—	—	—
29/ 5/71	19	9 hr 0 min.	—*	—	—	—	12	—	—	—	0.35
16/ 9/71	22	2 hr 50 min.	60	—	—	6	20	—	—	—	0.15
20/ 9/71	38	13 hr 45 min.	60	—	—	—	12	—	—	—	—
21/ 9/71	99	—*	—*	—	—	4	30	—	—	—	1.90
22/ 9/71	25	12 hr 45 min.	17	—	—	—	2	—	—	—	—
23/ 9/71	25	11 hr 30 min.	22	—	—	—	1	—	—	—	—
24/ 9/71	25	10 hr 30 min.	26	—	—	—	1	—	—	—	—

* Rainfall Recorder out of order

In Plot 1, depending on the rate of decomposition, application of mulch was repeated at 4 to 6 monthly intervals to maintain a mulch layer 5-10 cm thick. *E. curvula* was cut at 2-3 monthly intervals and the loppings spread on the surface. *C. anagyroides* did not establish satisfactorily. In March 1970 it was, therefore, replaced with *Stylosanthus gracilis* which was planted between the tea rows to give a strip 1 m wide when fully grown. All plots were regularly weeded using a hoe (scraper) as done in normal estate practice. Fertilizer was applied regularly as recommended by Tolhurst (1961).

RESULTS

Although the plots were laid down in July 1969 proper records were kept only from October 1970 to September 1971. This delay was mainly due to the delay in establishing a proper stand of cover crops between tea rows in plots 2 and 3. In plot 3, *C. anagyroides* had to be replaced with *S. gracilis* as the former failed to make satisfactory growth. *E. curvula* in plot 2 gave a satisfactory cover in about six months from planting and by lopping the grass at regular intervals and spreading the loppings on the surface an effective soil cover was maintained. *S. gracilis* was lopped about once in four months and the loppings were spread on the surface, but they decomposed rapidly. The ground cover obtained with *S. gracilis* was generally poor compared with that from grass.

Rainfall, run-off and soil loss data for the days on which any appreciable run-off could be detected are presented in Table 1. The presence of ground covers either as mulch or as a cover crop grown between tea rows reduced run-off and soil losses markedly. Mulch and *E. curvula* almost completely eliminated run-off and soil losses. During the period of study run-off occurred only on one occasion (22nd April 1971) in the plot with *E. curvula* and on two occasions (22nd April 1971 and 12th May 1971) in the mulch plot. The maximum rainfall intensities recorded for a five-minute duration on 22nd April 1971 and 12th May 1971 were 128 and 94 mm/hr respectively. In the bare plot, run-off occurred on 24 days with considerable soil losses. In the plot where *S. gracilis* was grown as a ground cover run-off occurred on 11 days but the soil losses were markedly reduced compared with that on the bare plot. No appreciable soil losses were evident in the mulch plot and in the plot with *E. curvula.* The total soil loss during the period of study for the bare plot was 51.93 tonnes/hectare and for the plot with *S. gracilis.* O.84 tonnes/hectare.

The rainfall histogram and the run-off hydrographs for the bare plot and the plot with *S. gracilis* on the 13th October 1970 are shown in Figure 2. A maximum rainfall intensity of 40 mm/hr was observed for a five-minute duration on this day and the run-offs observed for the corresponding period were 23 mm/hr and 9 mm/hr for the bare plot and that with *S. gracilis* respectively. There was no run-off observed in the mulch plot and the plot with *E. curvula.* The soil losses in the bare plot and the plot with *S. gracilis* on this day were 1.15 tonnes/hectare and 0.10 tonnes/hectare respectively.

Figure 3 shows the infiltration curves on 22nd April 1971, for the bare plot and for the plots with the three ground covers. As there were no large difference between the rates of infiltration for the three type of ground covers, a curve representing mean infiltration rates for the three types of covers mulch, *E. curvula* and *S. gracilis* is shown. The greater infiltration due to the presence of ground covers compared with the bare plot was clearly evident.

DISCUSSION

The importance of ground covers in reducing run-off and soil erosion has been long recognized. The impact of rain drops on bare soil results in a breakdown of the soil aggregates and a dispersion of soil particles which seals up the soil pores in the immediate surface which leads to reduced infiltration (Baver 1956). Under these conditions there could be increased run-off and soil losses depending on the slope of land, length of slope and erodibility of soil and rainfall characteristics. Hasselo & Sikurajapathy (1965) estimated that about 251 tonnes/ hectare could be lost during a four-year replanting period in tea estates. During the first two or three years after replanting, the young tea plants afford very little protection to the soil due to the poor ground cover, and it is, therefore, necessary to adopt suitable techniques to provide a ground cover during the early stages of the growth of the young tea. The treatments tested in the present investigation were two types of cover crops grown between tea rows and mulching of inter-rows with grass loppings compared with leaving the land bare.

The results obtained are of a preliminary nature and more a comprehensive study on infiltration capacity of soils, permeability of the soil profile, and rainfall, run-off and soil losses for long periods are required for planning of soil and water conservation measures. The data presented, however, help to demonstrate the effectiveness of ground covers on minimizing run-off and soil losses. Mulching with grass loppings almost completely eliminated surface run-off and soil losses. *E. curvula* grown between tea rows which was regularly lopped and the loppings spread on the surface as a mulch, was as effective as mulching. *S. gracilis* was relatively less effective in reducing run-off and erosion compared with *E. curvula*. This is probably due to the poor cover obtained with *S. gracilis* and the lack of a surface mulch.

The effectiveness of mulching and cover crops in markedly reducing run-off shows that these soils have inherently high infiltration characteristics if breakdown of the surface structure due to direct action of rain drops is prevented. It was observed that in the bare plot there was considerable sealing of the soil surface and soil losses were mainly due to sheet erosion. The soil surface in the mulch plot and the two cover crop plots were maintained in a more friable condition, which helped in greater absorption of rainfall. Soil erosion in the bare plot was further accelerated by regular clean weeding using a hoe which maintained a loose layer of soil on the surface which could be easily carried away with the run-off.

Mannering & Meyer (1963) suggested that the effect of mulch in reducing erosion were twofold. Firstly the mulch on the surface intercepted the rain drops and dissipated their energy thus preventing detachment of soil particles and sealing of the soil surface. Secondly there was a decrease in the soil content of run-off due to reduced flow velocity and the resulting decrease in particle detachment and carrying capacity of the run-off. They reported that high rates of mulch application almost completely eliminated run-off and controlled erosion.

It is also possible that cover crops could also minimize soil erosion for similar reasons. Baver (1956) suggested that the reduction in soil erosion by vegetation is due to (a) the interception of rainfall by the vegetation canopy, (b) the decrease of the velocity of run-off and the cutting action of water, (c) root effects in increasing granulation and porosity, (d) biological activities associated with vegetative growth and their influence on soil porosity and (e) the transpiration of water leading to subsequent drying out of the soil. In tea land, however, the selection of a suitable cover crop with low growth habit which gives a sufficient soil cover and which is easy to establish is important. The delay in the establishment of a cover crop may result in the loss of soil in the early stages. Furthermore the cover crops may compete for moisture resulting in the retardation of growth and even death of young tea plants (Manipura 1971).

In land replanted with young tea, soon after planting there is a loose surface layer of soil which could easily be washed away with the run-off water unless some protection is provided early. In this respect mulching has the advantage over the establishment of cover crops because mulch could be applied immediately after planting to give a suitable cover to protect the soil. The application of mulch in young tea plantations have also been shown to conserve soil moisture, reduce weed growth and increase the survival of plants during dry periods in addition to reducing soil erosion. (Manipura, Somaratne & Jayasooriya 1969; Manipura 1971).

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