

## AN ASSESSMENT OF THE SUITABILITY OF FIVE GRAMINACEOUS SPECIES FOR SOIL RECONDITIONING BEFORE REPLANTING TEA

### 2. EFFECT OF SPECIES ON SOME SOIL PHYSICAL AND CHEMICAL PROPERTIES

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In five experiments conducted in three tea growing districts to evaluate the effect of soil reconditioning before replanting tea with five graminaceous species, measurements were made of infiltration rate, hydraulic conductivity, water retention characteristics, nutrient status, organic carbon status and particle size distribution. Infiltration rate varied with location and species used for soil reconditioning. In general all the species tested increased infiltration rate compared to that under old seedling tea. One species (Guinea grass) when used for the dual purpose of soil reconditioning and raising fodder did not affect infiltration rate. Organic carbon status alone did not reflect the addition of top and root residues. In two experiments where water retention at 0.1bar and 15bar were evaluated Guatemala grass appeared to increase it. Particle size distribution was affected in one experiment probably due to soil erosion following uprooting tea. Nutrient status determined at the end of the reconditioning period in one experiment did not show any marked change due to treatments.

### INTRODUCTION

The previous publications in this series (Sandanam *et al*, 1982) examined the effects of five graminaceous species, tested for soil reconditioning before replanting, on their contribution to the soil in terms of shoot and root residues. This paper examines the effect of these species on some soil physical properties. Grasses in general are known to improve soil physical properties (Martin, 1944; Low, 1955; Clarke, Greenland and Quirk, 1967), and the beneficial effect of Guatemala grass roots in aggregation in tea soils has also been reported (Tolhurst, 1959). Although such benefits from grasses are reported to be short lived in tropical soils (Pereira, Chenery and Mills, 1954), the immediate benefits do help in the establishment of young tea plants by increasing the water holding capacity, improving aeration etc. It is therefore necessary that the species used for soil reconditioning should be capable of improving soil physical properties if they are to be effective in improving soil conditions. Even in soils infested with nematodes it is reported that damage to young tea by nematodes is more severe in gravelly and heavy ill drained soils and that young tea could overcome the damage by nematodes if it could produce roots at a rate faster than the rate at which they are damaged (Kerr and Vythilingam, 1966). This further emphasizes the need for improvement in soil physical properties for early establishment of young tea. Although the previous paper reported the extent of addition of organic residues from the different species tested the effect of such additions could have differential effects on soil physical properties. This paper therefore examines the effect of growing these species on infiltration rates, nutrient and organic carbon status and water retention characteristics.

TABLE 1 — *Equilibrium Infiltration Rate (cm hr<sup>-1</sup>)*

<i>Treatments</i>	<i>St Coombs</i>	<i>Galphilla</i>	<i>Little Valley</i>	<i>Cannavarella</i>	<i>Ury</i>	<i>Average of 5 estates</i>	<i>Saturated hydraulic conductivity (St Coombs) cm/hr</i>
Old tea	6.8	16.8	15.7	40.8	28.5	21.7	39.9
Guatemala grass	47.0	56.4	93.0	54.8	84.0	67.0	62.0
Mana grass	48.5	55.2	41.7	73.2	111.0	65.0	80.9
Guinea Grass (mulch)	72.6	21.6	46.8	60.0	93.0	58.8	79.4
Guinea grass (fodder)	21.9	13.2	38.4	31.2	30.0	26.9	22.3
Sugar cane	—	54.0	67.0	133.4	60.6	78.6	—
Eragrostis	53.8	—	—	—	—	53.8	59.9

\*Each value is an average from two determinations

## MATERIALS AND METHODS

The details of species tested, the design and lay out of the experiments, the locations and other details are given in Paper I of this series (Sandanam *et al*, 1982). At the end of 1½ years of soil reconditioning infiltration rates were determined in plots in one block in each experiment. In each plot measurements were made, in duplicate, and according to the method outlined by Haise *et al* (1956) using double ring cylinder infiltrometers (diameter 30.5 cm). Water retention characteristics were determined using core samples, (diameter 5.35 cm and height 6.0 cm). Water retention at 0.1 bar was estimated using hanging water columns and that at 15 bar using a pressure plate/membrane apparatus. Bulk density, used for conversion of gravimetric to volumetric water content was determined according to the method of Blake (1965) using cores measuring 5.35 cm in diameter and 6.0 cm in height. Particle size analysis was carried out by the pipette method as outlined by Day (1965). Organic carbon was determined by the method of Walkley and Black (1934). Infiltration rates were measured in all the experiments, water retention characteristics, bulk density and organic carbon content were determined only for the St Coombs experiment. Saturated hydraulic conductivity, for the St Coombs soil, was measured by the constant head method of Klute (1965). Total N was determined by the Kjeldahl method, available P was extracted with borax-sulphuric acid mixture adjusted to pH 1.5 and determined by molybdenum blue method. Exchangeable K was extracted with 1N NH<sub>4</sub> Cl and determined by flame photometry.

## RESULTS AND DISCUSSION

The previous paper in this series reported the extent of tops and root residues contributed by the different species tested for soil reconditioning and it was evident from the results that this varied among locations and among the species. The results presented here in Figures 1-5 and Table 1 shows that all the species used increased infiltration rate as compared with that in soil under old tea. Rain water on reaching the soil surface partly enters the soil and part of it could run off the surface depending on many factors. The rate at which water enters the soil is termed infiltration rate (Baver, 1956) and this rate depends on (a) surface conditions and the amount of protection available against the impact of rain, (b) internal characteristics of the soil mass, including pore size, depth of permeable portion, degree of swelling of clay colloids, content of organic matter and degree of aggregation, (c) duration of rainfall and (d) the antecedent moisture conditions (Musgrave, 1955). It is also well recognized that lower the infiltration rate higher the run off and consequently higher the soil erosion. In young tea, since most of the soil surface remains exposed during the first two years the dangers of soil erosion is high (Sandanam and Rajasingham, 1982) if the soil is not in the proper state to absorb most of the rain that falls on it. Thus the influence of the soil reconditioning crop on the rate of infiltration assumes great importance. Usually fields with high infiltration rate and large field moisture capacity support vegetation best (Horton, 1933). It is to be noted that the infiltration measurements were made at the end of about 1½ years after planting the soil reconditioning species and before the tea in "no reconditioning" treatments was uprooted. Therefore the results for "No reconditioning" treatment reflects the condition of soil under old tea for many years. The surface soil under tea is generally compacted due to frequent treading by labour in the process of harvesting and performance of other cultural operations and therefore the infiltration rate could be expected to be low. It could be argued that during the process of uprooting old tea and during the subsequent "deep-forking" the soil could have been loosened to a large measure resulting in higher infiltration rates in the reconditioned plots. But, Figures 1-5 and Table 1 indicate that the rates are not similar in all the reconditioned plots, there being

wide differences between species. These differences therefore reflect the efficiency of improvement in structural condition of the soil to aid infiltration. At St Coombs Guinea grass (mulched) showed the highest equilibrium infiltration rate. This was followed by *Eragrostis*, Mana and Guatemala grass which gave similar rates. The plot under Guinea grass used for fodder and that under tea gave the lowest infiltration rates. In Galphilla plots under Guatemala, Mana and Sugar cane showed comparatively high rates (54-56 cm hr<sup>-1</sup>) whereas in the plots under Guinea grass and tea showed low rates (13-21 cm hr<sup>-1</sup>). In little Valley Estate the differences were very wide. Guatemala grass plots showed high infiltration rates (93 cm hr<sup>-1</sup>), followed by Sugar cane (67 cm hr<sup>-1</sup>), Guinea and Mana grass plots were intermediate (38-46 cm hr<sup>-1</sup>) and the plot with old tea showed a low rate (15 cm hr<sup>-1</sup>). In the Uva district where the soils are relatively more sandy the species differed in their effect on infiltration. Thus at Ury Group plots with Mana, Guatemala and Guinea (mulch) grass showed high rates (84-111 cm hr<sup>-1</sup>) that under Sugar cane showed 60 cm hr<sup>-1</sup> and the plots under Guinea for fodder and old tea showed 28-40 cm hr<sup>-1</sup>. In Cannavarella, however, plots under Sugar cane showed the highest rate 133 cm hr<sup>-1</sup>, those under Mana, Guatemala and Guinea grass showed intermediate rates (54-73 cm hr<sup>-1</sup>) and those under Guinea grass for fodder and tea showed the lower rates (28-30 cm hr<sup>-1</sup>). It is also clear from Table 1 that the soils in the Uva district had inherently higher infiltration rates even under old tea than that in the Mid country or Up country, the lowest rate being that in the clayey Up country soil. Taking all the experiments together an average rate of infiltration was calculated and is given in the 6th column in Table 1. It appears from these figures that all the species tested improved infiltration rate substantially. However, when Guinea grass was used for the purpose of obtaining fodder as well, the improvement was marginal or nil thus emphasizing that it is not desirable to combine soil reconditioning with fodder production with this grass. Sugar cane, of course, substantially improved infiltration but the growth and yield of tea in soil reconditioned with this species has to be evaluated since its contribution in the form of root residues was lower compared with that from the other species. It is also to be noted that the rate of initial entry of water into the soil was higher in most instances with Guatemala grass, Mana grass, Sugar cane and Guinea grass (mulched) (Figs. 1-5). This perhaps reflects the better surface condition of the soil created by these species. Guinea grass (fodder) and tea plots in most cases showed also a low initial intake rate. *Eragrostis*, although tested only in one experiment showed a fairly high infiltration rate. The high initial intake rate is generally associated with dry soils (Tisdall, 1951). Since it could be expected that the soil moisture status in any one location would have been similar in all the plots at the time the measurements were made the differences in the initial intake rate among the plots with different species could be attributed (a) to different luxuriance of growth by the different species thereby creating differences in moisture extraction from the soil leading to differential moisture status or to the differences in thickness of the mulch layer that had accumulated as a result of addition of loppings. It is known that crop residues generally increase infiltration rate (Duley and Russel, 1939). This is supported by the fact that plots under old tea and that under Guinea grass taken away for fodder consistently showed lower initial intake rate compared with the plots under other species.

The organic carbon content (Table 2) in the plots under different treatments, determined only at St Coombs showed an interesting trend. The highest organic carbon content (11%) was in the plot under old tea. In all the other plots it ranged from 3-4%. This indicates the severity of soil disturbance that had taken place in the process of uprooting and deep forking and points out that this loss cannot be made up fully by soil reconditioning. It therefore appears desirable to minimise the severe soil upheaval during uprooting, deep-forking and levelling periods. There were only marginal differences in organic matter content in surface layer (0-15 cm)

in plots under the different species. It may be questioned as to why, after 1½ years of growing grasses, the organic carbon content was so low in these plots, although tonnes of leaf and root residues per hectare have gone into the soil. The reason is perhaps due to the fact that surface litter and root residues are excluded from analysis since these are removed by sieving the soil before analysis. Such an effect was recognized by Tolhurst (1959) who pointed out that a straight forward chemical analysis for total organic carbon content after soil reconditioning will be of little value as a practical tool for estimating the progress of reconditioning. Thus the percentage carbon does not reflect the benefit derived during the 1½ years of soil reconditioning but it could be a yard stick in the long term after the residues are humified. The nutrient content in the plots did not show any marked differences (Table 2).

The saturated hydraulic conductivity, determined with core samples in the laboratory (Table 1) confirm the effect on intake rates discussed earlier. The low values in the plots under Guinea grass grown for fodder and that under old tea and the high values in plots with other species suggest an improvement in structure and pore space relationships in the reconditioned plots.

TABLE 2 — *Nutrient status and % organic carbon in 0-15 cm soil layer at the end of soil reconditioning period at St Coombs*

<i>Treatments</i>	<i>N (%)</i>	<i>P (ppm)</i>	<i>K (m. eq. %)</i>	<i>Ca (m. eq. %)</i>	<i>Organic carbon %</i>
Guatemala grass	0.44	30.5	0.44	0.63	3.36
Mana grass	0.44	30.5	0.47	0.70	3.98
Guinea grass (fodder)	0.44	25.0	0.34	0.54	4.11
Guinea grass (mulch)	0.45	30.5	0.38	0.60	4.31
Eragrostis	0.41	27.0	0.40	0.59	3.33
Old tea	0.47	41.9	0.46	0.68	11.00

TABLE 3 — *Water retention v/v %*

<i>Species</i>	<i>St Coombs</i>			<i>Galphilla</i>		
	<i>at 0.1 bar</i>	<i>at 15 bar</i>	<i>AWC cm/30 cm</i>	<i>at 0.1 bar</i>	<i>at 15 bar</i>	<i>AWC cm/30 cm</i>
Guatemala grass	43.92	28.44	4.64	37.83	27.29	3.16
Mana grass	47.11	31.94	4.55	33.46	25.48	2.39
Guinea grass (fodder)	36.31	24.07	3.67	33.93	24.67	2.77
Guinea grass (mulch)	40.42	27.37	3.91	34.54	24.68	2.96
Eragrostis	43.16	30.77	3.71	—	—	—
Sugar cane	—	—	—	33.79	25.00	2.64

TABLE 4 — Particle size distribution at St Coombs and Galphilla Estate

	St Coombs			Galphilla		
	% sand	% silt	% clay	% sand	% silt	% clay
Guatemala grass	20.10	22.40	47.50	40.80	15.71	43.49
Mana grass	25.00	23.80	51.21	31.60	18.80	49.60
Sugar cane	—	—	—	40.00	17.70	42.30
Guinea grass (mulch)	20.01	28.04	51.95	42.60	19.18	38.22
Guinea grass (fodder)	33.93	19.19	46.88	36.00	24.08	39.92
Eragrostis	36.41	26.19	47.40	—	—	—
Old tea	31.81	20.33	47.87	28.60	20.85	50.55

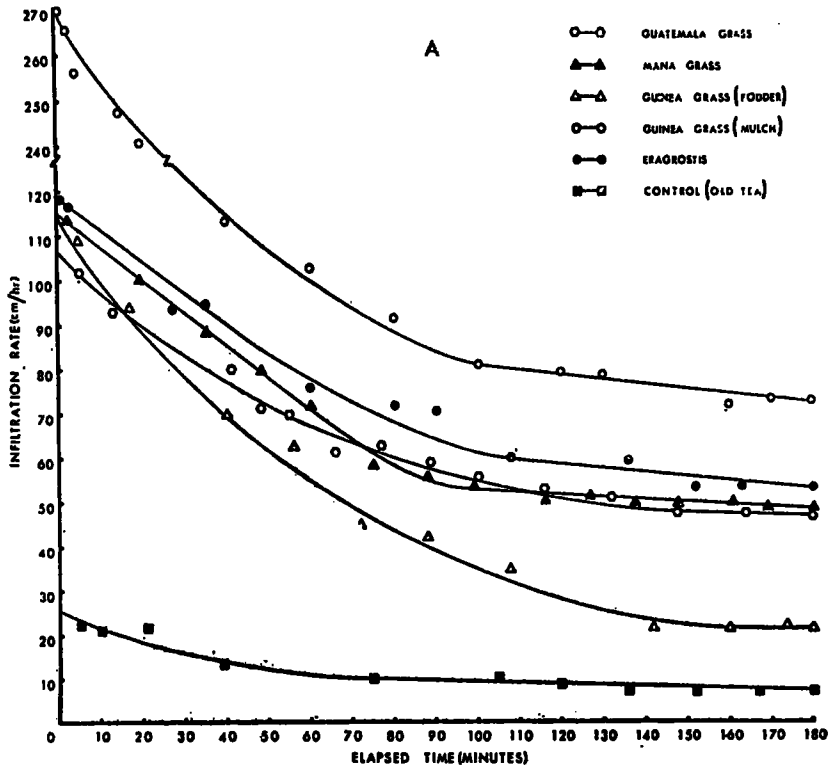


Fig. 1. — Infiltration rates under different treatments at St Coombs

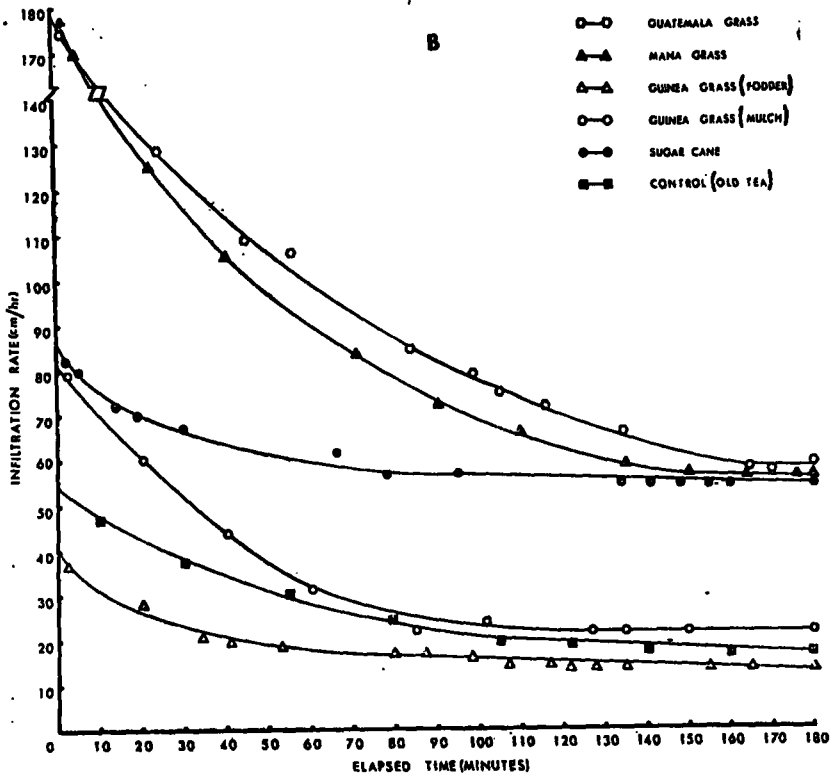


Fig. 2. — Infiltration rates under different treatments at Galphilla

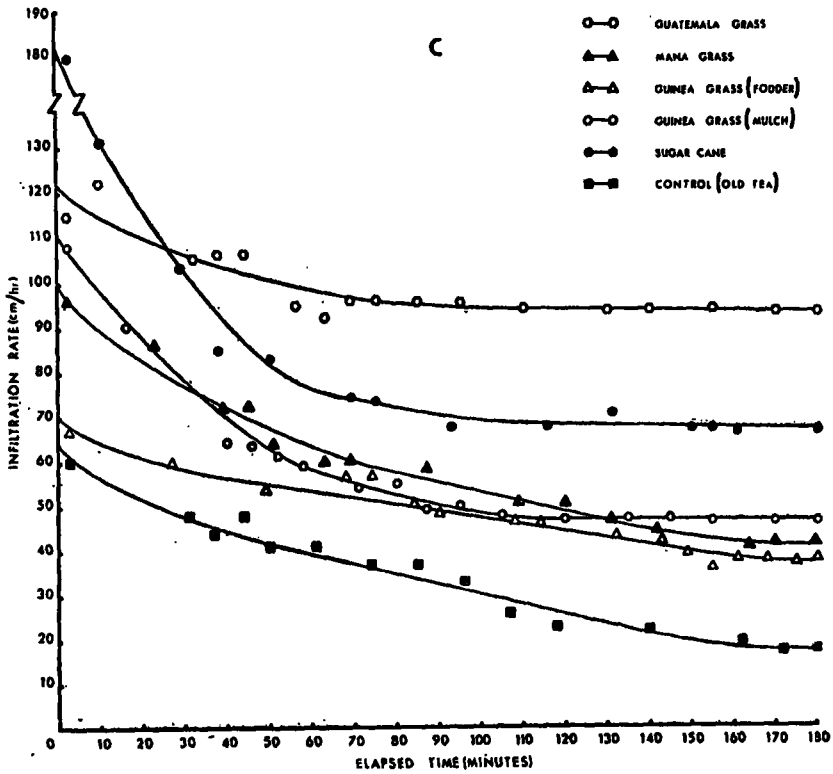


Fig. 3. — Infiltration rates under different treatments at Little Valley

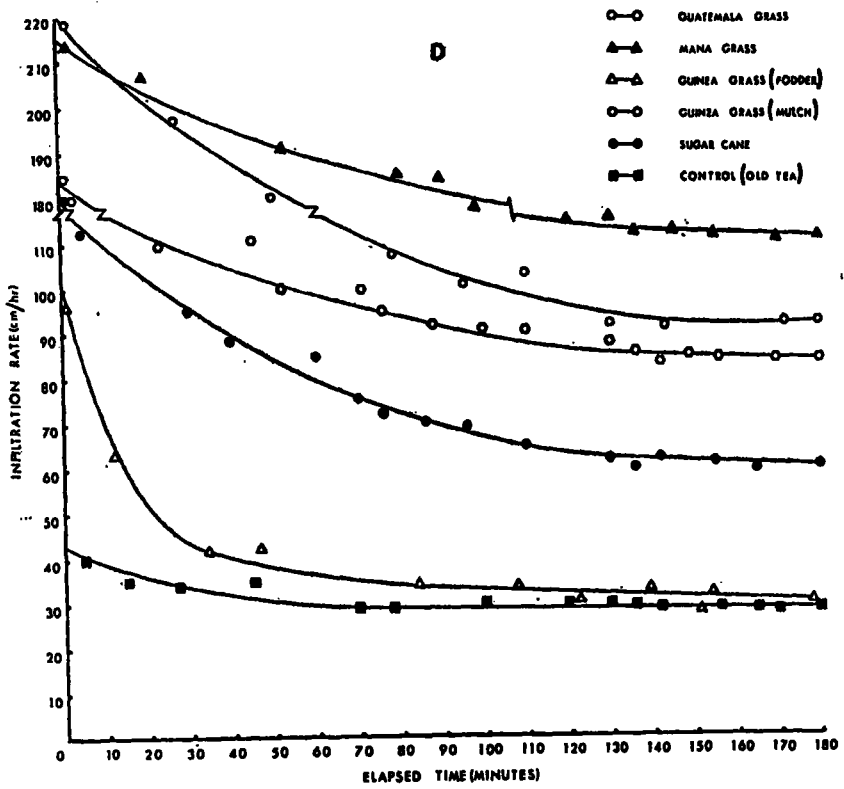


Fig. 4. — Infiltration rates under different treatments at URY

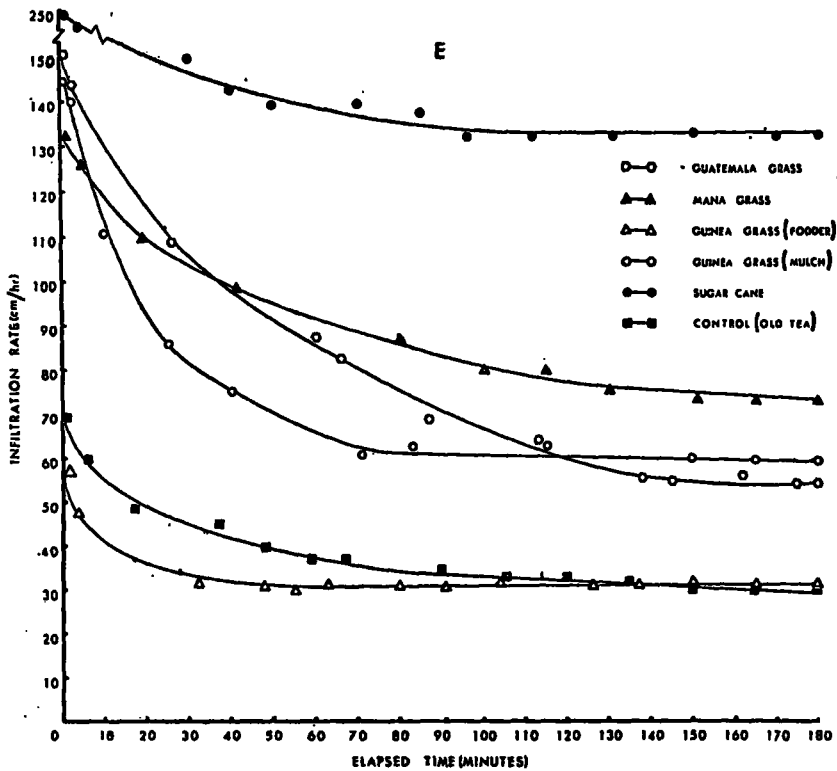
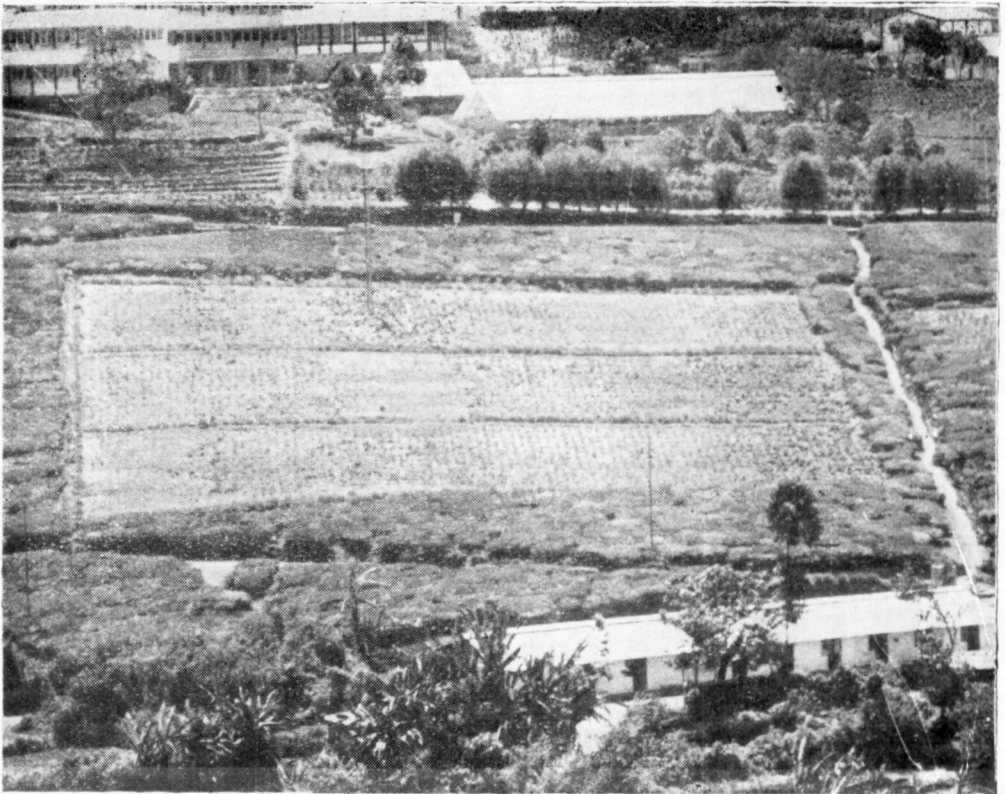


Fig. 5. — Infiltration rates under different treatments at Camavarella



*Fig. 6. — Plots with the different Soil reconditioning Species. (Please note “no soil reconditioning plots” with old tea in the left Block)*

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*Fig. 7. — Reconditioned plots planted with tea (Please note the poor growth of tea in “no Reconditioning plots” compare with Fig. 6)*

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Table 3 gives the water retention at 0.1 bar (Field Capacity) and at 15 bar (Permanent Wilting Point) tensions. From the volumetric water content at these suctions the Available Water Capacity (AWC) were calculated. It appears from Table 4 that at St Coombs the plots under Guatemala grass and Mana grass had a slightly higher AWC. At Galphilla, however, AWC was higher in plots with Guatemala grass than in the plots with the other species.

Table 4 gives the particle size distribution in the different treatments at St Coombs and Galphilla Estates. Particle size distribution could change in favour of sand due to the downward eluviation of silt and clay and erosion which favours the removal of finer particles from the top soil (Aina, 1979). The data presented here appears to indicate that at St Coombs the differences in particle size distribution between plots with old tea and that with reconditioning grasses are not marked. However, at Galphilla where the rain is more erosive, and the soil more erodible, soil exposure after uprooting old tea and until the soil reconditioning grass fully establishes and covers the soil has led to erosion as reflected by an increase in percentage sand and a reduction in percentage silt and/or clay.

The ultimate criterion of the benefits derived from soil reconditioning is to be evaluated in terms of the growth of the young tea that is planted after such soil reconditioning. If Fig. 6 and 7 are compared it will be very clear that the tea in the "No reconditioning" plots is weak and has not established properly, thus emphasizing the desirability of reconditioning. The differences between the species tested is not very clear from the plates. Having observed that soil reconditioning is indispensable for early successful establishment of young tea the choice of species should be governed by the extent of root and top residues returned to the soil and the consequent improvement in organic matter and physical properties of the soil. An additional advantage gained from soil reconditioning is that areas, where soil conditions are so poor that tea in any case will not thrive, can be identified based on the growth of the reconditioning crop and these areas can either be given additional ameliorative treatments or micro-diversified into fuel clearings.

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