

THE INFLUENCE OF METHODS OF WEED MANAGEMENT IN TEA ON THE SURFACE LAYER SOIL PROPERTIES OF AN ULTISOL

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The effect of two methods of weed control namely (i) chemical and (ii) manual (with a weed scraper) on some soil physical and chemical properties were studied in a long term experiment. It was found that chemical weed control was superior to manual weed control with respect to changes in soil physical and chemical properties such as total pore space, per cent aggregation, water retention, total available water, texture, organic carbon, CEC and percentage total nitrogen.

INTRODUCTION

Most of the tea plantations in Sri Lanka are on ultisols on slopy terrain ranging from 10 to 15 per cent. Nearly three-quarter of the total extent is under seed tea. The inherent poor spread of low 'jat' seed tea planted on many estates, wide spacing (0.9 m X 0.9 m or 1.2 m X 0.9 m) used, type of planting (up and down the slopes) and failure to regularly replace dead tea bushes are some of the factors that have contributed to poor soil cover in mature tea fields. There is, in addition, the inevitable soil exposure for a period of three to six months once in two to four years when most of the canopy is removed by pruning. As a result, weeds thrive in the vacant patches ; in addition, high levels of N applied to tea also contribute to heavy weed growth. These weeds apart from competing for water, nutrients and light can also harbour pests and diseases. Weed control is practised routinely in all tea plantations. Earlier, weed control was done manually with a weed scraper which disturbs the soil and leaves a loose layer of top soil which can be easily washed away in the run off water by the high intensity rainfall experienced (Holland and Joachim, 1933 ; Hasselo and Sikurajapathy, 1965). The loss of top soil results in the loss of soil fertility (Sandanam, Krishnapillai and Sabaratnam, 1978). There is considerable evidence to show that there is deterioration of soil physical and chemical properties by cultivation (Bulfin and Gleason, 1967 ; Skidmore, Carstensod and Baubury, 1975 ; Somapala and Willatt, 1982). However, at present weed control is practised largely by spraying herbicides to kill weeds. The use of herbicides (no cultivation) does not deteriorate soil physical properties on a long term basis and is beneficial under tropical conditions (Carry and Evans, 1972 ; Aina, 1979). The present study was undertaken as there is no information available on the effect of weed control operations, whether manual or chemical, on soil physical and chemical properties in an ultisol under tea.

MATERIALS AND METHODS

The investigation was carried out in a mature vegetatively propagated tea field adjacent to the laboratories of the Tea Research Institute of Sri Lanka, Ratnapura (30 m AMSL, latitude 6° 41' N, longitude 80° 24' E). The soil in this study belongs to the ultisol group (US soil taxonomy). Kaolinite is the major clay mineral present. This field, had been weeded manually for three years prior to commencement of treatments. In August 1983, this field was demarcated into two equal plots (each 0.125 ha in extent). In one plot weed control was done chemically (Treatment A) by spraying herbicides at 6–9 weekly intervals depending on the weed flora: Paraquat (20% a.i.) was sprayed at the rate of 1.1 l ha⁻¹, and 2,4-D (80% a.i.) at the rate of 1.25 kg ha⁻¹. The herbicides were applied using a hand operated compressed air sprayer with brass floodjet nozzles at a volume of 600 l ha⁻¹. In the other plot, clean weed control was done manually (Treatment B) at 6–9 weekly intervals using weed scrapers. The weed scraper is an L shaped implement with a metallic blade about 3–5 cm wide, 6–8 cm long and attached to a wooden handle, 30 cm long. Scraper weeding involves the removal of weeds with roots by a scraping action on the soil surface with the above implement. Soil properties were studied in April 1985—four weeks after the last weed control treatments were applied.

Soil properties studied and techniques employed

Infiltration rate was measured with a double ring cylinder infiltrometer (Haise *et al.*, 1956). At each site five measurements were taken at random. Other physical properties were determined with soil at 0–15 cm depth. Water retention characteristics were determined with 10 core samples taken randomly from each site. The core samples were saturated and the saturated water content was noted. Water retention at lower suction (less than 0.1 Bar) was determined using hanging water column and higher suctions (greater than 0.1 Bar and less than 15 Bars) were determined by pressure plate apparatus (Vimocil, 1965). Bulk density was determined according to the core method of Blake (1965). To determine the total pore space, particle density was taken as 2.65 g cm⁻³.

Macropore space is considered to be the difference between the total pore space and the percentage volumetric water content at 100 cm water suction. Macropore space as a percentage of total pore space was estimated using the relationship $100(TPS - \Theta)/TPS$ where TPS is the total pore space and Θ is the volumetric water content at 100 cm water suction, since a pore size of 1.5×10^{-2} mm corresponding to 100 cm water suction is frequently chosen for separating 'large' pores from 'small' pores (Marshall, 1959). With the composite samples collected from 0–15 cm depth (about 10 kg from each site), (i) soil textural analysis (Gee and Bauder, 1979) and (ii) percentage aggregation (USDA Handbook No. 60) were done in triplicate. Also, the (2mm) sieved samples were analysed in triplicate for the following :

- (i) pH (1 : 2.5, soil : water)
- (ii) Borax extractable phosphorus (Jackson, 1967)
- (iii) Organic carbon (Walkley and Black, 1934)
- (iv) Cation exchange capacity (Jackson, 1967)
- (v) Ammonium chloride extractable K⁺ (Jackson, 1967)
- (vi) Total nitrogen (Jackson, 1967)

The results were statistically analysed using the unpaired *t*-test.

RESULTS AND DISCUSSION

The various soil physical and chemical properties measured in the two treatments A and B are presented in Tables 1 and 2 respectively.

The particle size distribution showed more sand and less clay on the top 15 cm in the manually weeded (i.e. cultivated) area. The increase in coarseness may be due to highly erosive rainfall which favours the removal of finer particles from the breakdown of soil aggregates by raindrop impact on the exposed top soil (Aina, 1979; Sandanam and Ananthacumaraswamy, 1982).

The herbicide treated area (Treatment A) had significantly low dry bulk density than that of manually weeded area (Treatment B). Also, the percentage of soil aggregation was substantially higher in the herbicide treated area. This can be ascribed to the higher organic matter content (Table 2) of the soil, which favours granulation. In addition, probably higher microbial population contributes to the increased aggregation. The high intensity rainfall coupled with low structural stability and less cover on the soil surface therefore will result in higher bulk density in the manually weeded area. The herbicide treated plots had higher total pore space (TPS) whereas the manually weeded area had higher macropore space (at 100 cm water suction). Higher saturated water content and higher pore space in the herbicide treated area were due to improved soil structure and percentage aggregation by higher organic matter content. Apparently, higher macropore space and higher macropore space as a percentage of TPS in the manually weeded area was due to breaking of hardened or compact surface by weed scrapers four weeks prior to measurements being taken. This is likely to have a considerable effect temporarily at any rate towards the increased intake of water. The breaking up of such material has the effect of enlarging the opening resulting in the higher macropore space found in the manually weeded area (Bennett, 1939). The ability of the soil surface to transmit fluid depends upon macropore space which is related to its texture and structure plus any cracking in the surface layers. The higher macropore space of manually weeded area is in conformity with the higher saturation infiltration rate of the soil (Table 1, Fig. 1). Generally, shortly after cultivation most soils contain an abundance of larger pores (Skidmore *et al.*, 1975 ; Sandanam and Ananthacumaraswamy, 1982).

TABLE 1 — *Physical properties*

Treatment	Soil texture				Bulk Density (g cm ⁻³)	Saturation Infiltration Rate (cm h ⁻¹)	% Saturated water content (cm ⁻³ cm ⁻³)
	Gravel %	Sand (%)	Silt (%)	Clay (%)			
A	20.61	46.71	18.98	13.70	1.34	35.4	48.45
B	21.74	53.58	15.09	9.59	1.45	40.8	44.51
	NS	*	*	*	*	*	*

Treatment	% Total Pore Space (TPS)	Pore Space Macro	Macro Pore Space as % of TPS	% Aggregation	Total Available Water (cm/15cm)
B	45.28	23.05	54.29	14.0	0.75
	*	*	*	*	*

* Significant at 5% level A : Chemical Weeding B : Manual Weeding

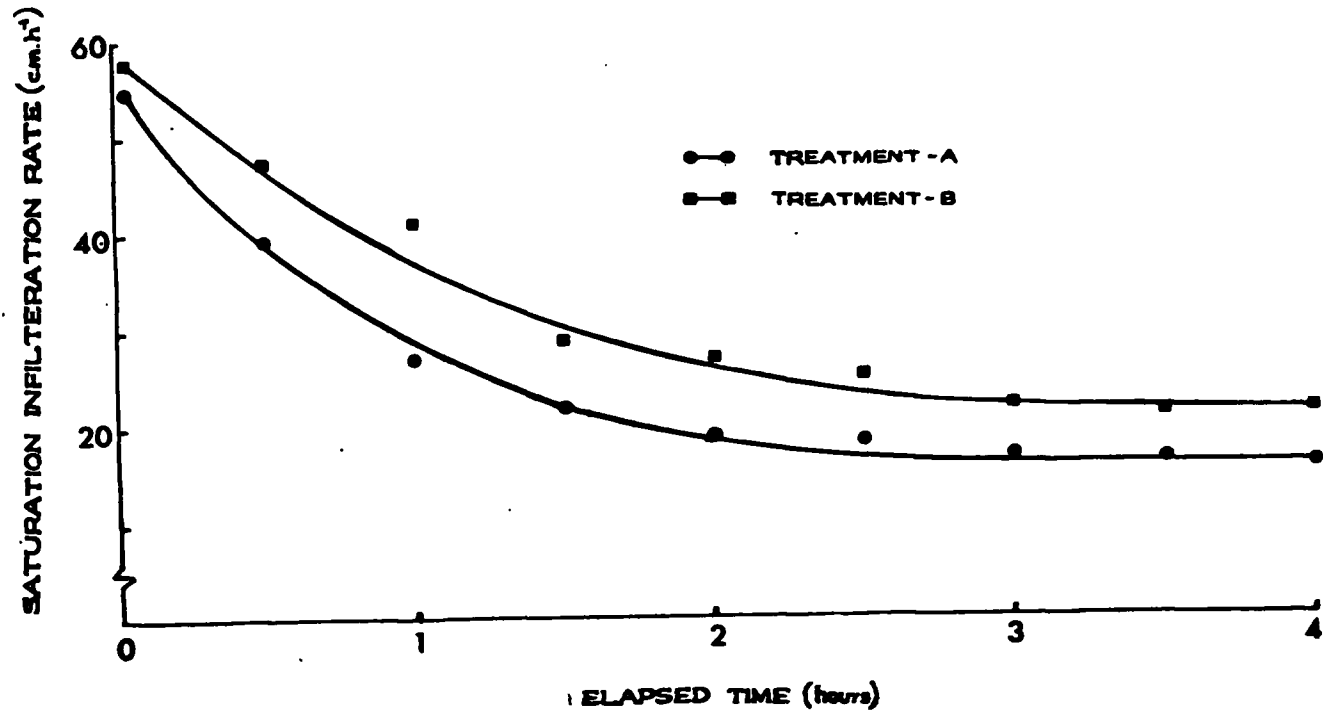


Fig. 1 — Infiltration rates under chemical (Treatment A) and manual (Treatment B) weeding.

In the soil moisture characteristic curve (Fig. 2) the herbicide treated area (Treatment A) showed higher moisture retention capacities and total available water than that of the manually weeded area. The difference in moisture retention capacities and total available water can be attributed to changes in organic matter content and to difference in texture. Total available water (TAW) was significantly higher for the herbicide treated area suggesting that higher silt and clay contents also contribute to the increased TAW, in addition to organic matter content (Sandanam and Ananthacumaraswamy, 1982).

TABLE 2 — Chemical properties

Treatment	pH	%Organic Carbon	CEC m.eq.%	Total Nitrogen%	Potassium (ppm)	Phosphorus (ppm)	C/N ratio
A	5.25	3.9	6.22	0.114	44	26	34.2
B	5.50	0.9	4.63	0.062	40	24	14.5
	NS	*	*	*	NS	NS	*

* Significant at 5% level A : Chemical Weeding B : Manual Weeding

Of the chemical properties studied, the most striking difference was found in the organic carbon content which is significantly lower in the manually weeded area. The removal of weeds by scraping and transporting it out of the field results in depletion of the organic carbon content of the soil. The loose layer of soil formed by scraping can be easily washed away by erosive rain which also results in depletion of organic carbon content. Further, the relatively higher temperature in the exposed soil surface also favours increased oxidation of organic carbon contributed by leaf fall and root activity of tea. On the other hand, in the herbicide treated area, in addition to leaf fall and root activity, the weeds killed by the herbicides are allowed to decompose *in situ*, thus contributing to the enrichment of the organic carbon content of the soil. The significantly lower CEC of the manually weeded area is due to the decrease in percentage clay and organic matter content (Mahaney, 1979), and not to lower pH as a higher pH was recorded in this instance. Of the major nutrients studied, the only marked difference is in the nitrogen content of the soil. The lower nitrogen content of the manually weeded area is due to lower organic carbon content of the soil (Aina, 1979). In the case of herbicide treated area, the decomposed weeds also contributed to the enrichment in nitrogen content of the soil. The difference in pH can be attributed to differences in the organic matter content of the soils. In the herbicide treated area, higher organic carbon content, probably increased the concentration of organic acids. The decrease in pH in the herbicide treated area was apparently caused by release of H⁺ ions from the undissociated organic acid groups through coupling with aluminium of the kaolinitic clay (Khanna and Stevenson, 1962). Nitrate formation, during mineralization of organic matter, could also contribute to increased acidity. It has been shown that residues with higher C/N ratio decrease pH (Sivapalan, Fernando and Thenabadu, 1985).

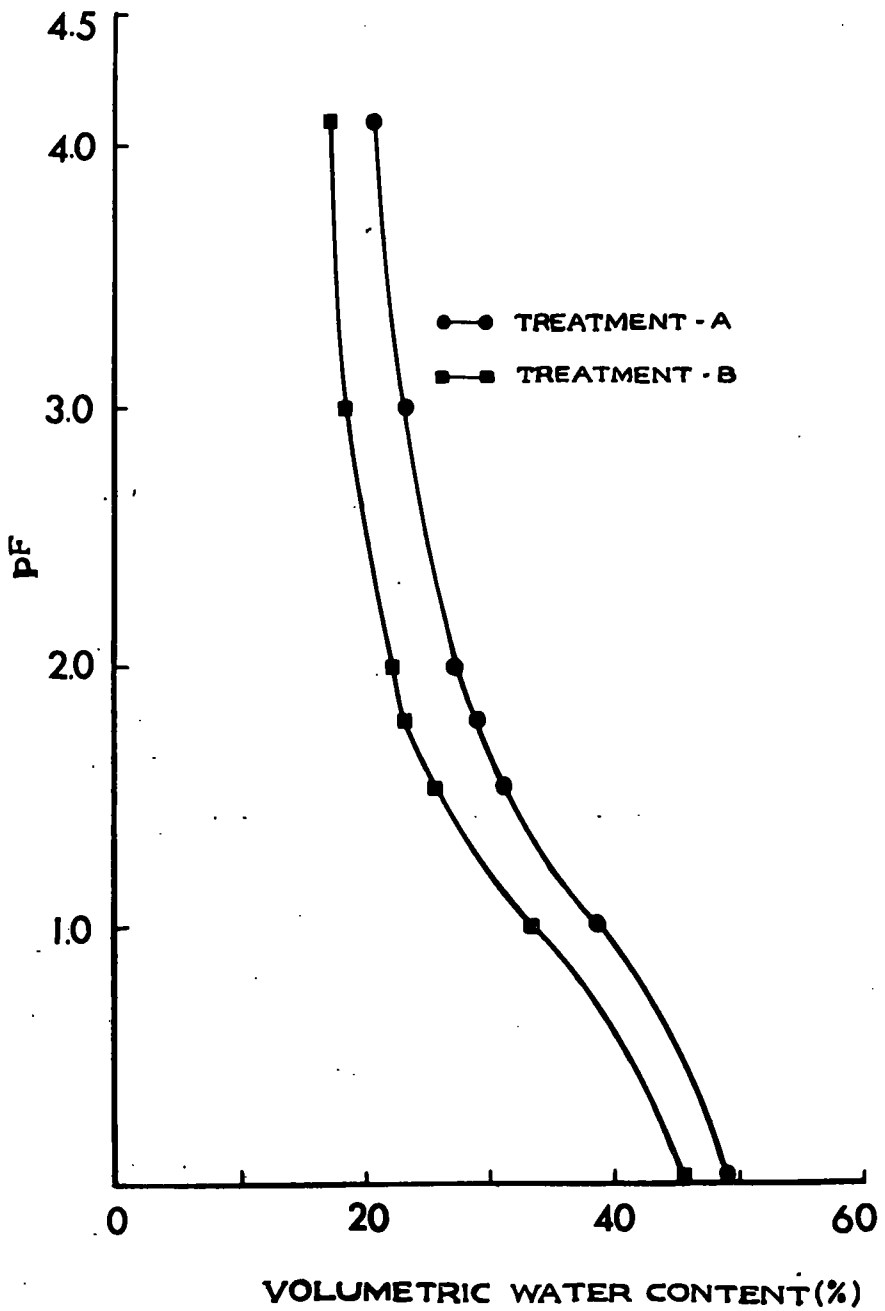


Fig. 2 — Water retention curves of the soil under chemical (Treatment A) and manual (Treatment B) weeding.

CONCLUSION

These results indicate that marked changes in soil physical and chemical properties could be brought about by the type of soil management. In the ultisol under consideration, the soil treated with herbicides for 2 years had higher organic carbon content, percentage aggregation, total pore space and water retention capacity. In the soil under manual weeding with the scraper, there was a decrease in silt and clay fractions, lower CEC and N content. These findings clearly show that there are marked changes in soil properties between the two systems of weed control. It is shown that the changes associated with the use of herbicides results in conditions presumed to be more suited for better plant growth.

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