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INFLUENCE OF LONG TERM CULTURAL OPERATIONS ON PHYSICAL AND WATER RETENTION CHARACTERS OF A RED SANDY LOAM SOIL*

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ABSTRACT

The effects of long term manurial-cum-cultural practices, imposed since 1919 and modified in 1972, on physical and water retention properties of a red sandy loam soil planted to coconut, were studied. The treatments like forking basins after inorganic fertilization, no tillage and no manuring, and tillage with organic and inorganic fertilization, showed an improvement in water holding capacity, bulk density, estimated porosity and available water capacity over the treatment of tillage alone when tested for their cumulation effect during 1982. More or less a similar trend was observed for water retained at various tensions. However, the treatments like forking basins after inorganic fertilization, no tillage and no manuring and tillage with organic and inorganic fertilization had an edge over other treatments. The data revealed that minimum disturbance of soil by way of forking after inorganic fertilization helped in maintaining better physical environment in basins of coconut palms over other treatments.

Cultural operations are known to influence the physical and water retention characters of a soil. Manifestation of the changes becomes more pronounced when these operations are carried out over a long period of time in soils where perennial crops are grown. Effects of various cultural operations and amendments on soil environment and plant growth have adequately been reviewed (Prihar, 1982). Menon and Pandalai (1960) have reported instances of better performances of coconut palms with regular cultivation over no tillage and Ramanandan and Pillai (1974) attributed it to higher nutrient availability as a result of cultivation of soils. Tillage requirements of the tropical soils under different agro-ecological systems for optimum physical conditions have been documented (Lal and Kang, 1982).

The present investigation deals with the effect of various treatments in a long term manurial-cum-cultural trial started in 1919 and modified in 1972, on some physical parameters and water retention characters of a red sandy loam soil planted to coconut. The experimental site is located at the Central Plantation Crops Research Institute, Kasaragod, Kerala, India.

MATERIAL AND METHODS

The Experiment

A long term observational trial had been in progress with three treatments (plots) viz., tillage and manuring, tillage alone, and no tillage and no manuring since 1919. These plots were sub-divided in 1972 to accomodate six treatments viz., tillage and inorganic fertilization

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with green forest leaves (TI), tillage and inorganic fertilization (T2), application of inorganic fertilizers and forking in (T3), tillage alone (T4), no tillage and no manuring but herbicidal weed control (T5) and no tillage and no manuring (T6). This experiment was utilized for generating the present information. The plots were underplanted in 1967. The modified treatments were improved in such a way that three plots continued to receive the original treatments. The first three treatments received 500 g N, 320 g P_2O_5 and 1,200 g K_2O per palm per year as per standard practice. In addition, treatment T1 received 50 kg green forest leaves per palm per year. The herbicide treatment in T5 consisted of the application of a mixture of Grammaxone (1, 1-dimethyl-4, 4-bipyridilum dichloride) plus Fernoxone (2, 4-dichlorophenoxy-acetic acid). The no tillage and no manure plot served as the absolute control. The tillage included two ploughings after heavy monsoon rains.

Soil

The soil type under the experiment is a red sandy loam (sand 88.0, silt 1.0 and clay 11 0 per cent for surface with marginal variations in the profile) with pH, 5.3; organic carbon, 0.14 per cent; available phosphorus, 52 kg P_2C_5/ha; and available potassium, 52 kg K_2O/ha.

Soil Sampling

Soil samples from different treatments were collected from the basins of first generation palms as well as underplanted palms of the experiment. Under each treatment, three palm sites were sampled, each at three depths (0–30, 30–60 and 60–90 cm) and at four locations around the palm to get a composite sample. The samples were air dried and 2 mm fraction was used for analysis.

Analysis

The fine earth samples were analysed for organic carbon by following the procedure outlined by Walkley and Black (Jackson, 1967). Water holding capacity, bulk density and particle density were determined by the usual methods. Porosity was computed from particle and bulk density values.

For soil water retention in the disturbed soil samples in duplicate were determined by pressure plate and pressure membrane apparatus at 0.1, 0.3, 1.0, 3.0, 5.0, 10.0 and 15.0 bar tensions.

For the purpose of statistical analysis, the samples collected from the basins of first generation and underplanted palms were considered as replicates. In addition, the data were subjected to Duncan's Multiple Range test to evaluate statistical significance.

RESULTS AND DISCUSSION

Organic Carbon Status

Significant effects were not observed on the organic carbon status of the soil (Table 1). However, a continued application of cover of a limited amount of organic matter through green forest leaves (T1) and through natural weed growth (T6) over years revealed marginal increase in the organic carbon in the respective treatments. The organic carbon value was the highest at 0–90 cm depth

TABLE 1
Influence of long-term cultural treatments on some physical parameters

Treatment/Depth	Organic carbon (%)	Water holding capacity (% by wt.)	Bulk density (g/cm³)	Particle density (g/cm³)	Estimated porosity (%)	Available water capacity (g/100 g)	
						0.1–15 bars	0.3–15 bars
T1—Tillage+organic+inorganic fertilizer	0.33	32.18[ab]	1.39[ab]	2.59	46.62[ab]	5.44[bc]	2.91[ab]
T2—Tillage+inorganic fertilizer	0.24	32.38[ab]	1.39[ab]	2.63	47.13[ab]	4.81[ab]	2.85[ab]
T3—Forking basins+inorganic fertilizer	0.24	34.60[b]	1.37[a]	2.63	47.90[a]	6.00[c]	3.36[b]
T4—Tillage alone	0.24	29.57[a]	1.44	2.60	44.88[c]	5.12[bc]	2.30[a]
T5—No tillage+herbicidal weed control	0.28	31.93[ab]	1.41[b]	2.61	46.06[bc]	5.86[bc]	3.17[b]
T6—No tillage	0.41	35.73[b]	1.37[ab]	2 61	47.42[ab]	4.02[a]	2.60[a]
C. D. at 5%	NS	3.58	0.03	NS	1.29	1.00	0.58
0–30 cm	0 47	32.16	1.42	2.61	45.50	4.88	3.08
30–60 cm	0.24	31.99	1.41	2.60	46.17	5.25	2.52
60–90 cm	0.15	34.05	1.35	2.61	48.33	5.51	3.00
C. D. at 5%	0.10	NS	0.02	NS	1.92	NS	0.41

[a], [b] and [c] supercripts denote differences based on Duncan's Multiple Range Test.

in T6 (0.41%) as compared to the rest of the treatments where the values ranged from 0.24 to 0.33 per cent. However, the surface layer had higher values of organic carbon in T6 (0.82%) followed by T1 (0.49%) and T5 (0.46%) over other treatments (0.32–0.37%). The increase in organic carbon in no tillage and no manuring (T6) treatment can be attributed to the intensive weed growth (mostly grasses) and their recycling for years. This can be accounted for *in situ* formation of organic matter with and without the intervention of soil microflora (Martin, 1977). Irrespective of the treatment effects, the organic carbon showed a decreasing trend with increase in depth of soil. The drop in the organic carbon contents was more sharp from surface downwards in the untilled soil than in the tilled ones as also observed by Juo and Lal (1979).

Physical Properties

Tillage alone (T4) resulted in the lowest water holding capacity (29.57%) and porosity (44.88%) and the highest bulk density (1.44 g cm^{-3}). Agboola (1982) observed that the bulk density of the soil was more in the tilled plots. The treatments, forking basins after inorganic fertilization (T3) and no tillage and no manuring (T6) with water holding capacity of 34.60 and 35.73 per cent, respectively, differed significantly from tillage alone (T4). Similar significant differences for the treatments were recorded for bulk density and porosity values; the lowest bulk density (1.37 g cm^{-3}) and the highest porosity (47.90%) were exhibited by the treatment forking basins after inorganic fertilization (T3). Comparison of tillage with organic and inorganic fertilization (T1) and tillage with inorganic fertilization (T2) revealed that application of green forest leaves over years could not bring out changes in these characters. When T3 and T4 were compared, it was observed that limited disturbance of these soils by way of forking helped to create better physical environment in presence of inorganic fertilization. In general, minimum or no tillage of these light soils helped to maintain better physical environment. Low (1972) also observed marked differences in physical properties of even a clayey soil kept under permanent grass and arable crops for almost a century.

The available water capacity (water retained between 0.3 and 15 bars) showed significant differences among the treatments ranging from 2.30 (T4) to 3.36 per cent (T3). The available water capacity in treatments T1, T3 and T5 was significantly different from T4. When available water capacity between 0.1 and 15 bars was considered, T3 showed the highest and T6 the lowest value. The results indicated that tillage alongwith organic and inorganic fertilization (T1) helped in increasing the available water capacity (0.3–15 bars) of the soil as compared to tillage alone (T4); even though the increase in organic carbon was not significant in the former. This behaviour possibly be accounted for the more vigorous root growth owing to addition of fertilizers which in turn continuously replaced the decomposed organic matter and kept the soil arrangement salutary for higher available water.

However, no tillage and no manuring (T6) with the highest organic carbon (0.82% in 0–30 cm depth) has not been able to influence this property significantly though it was on a par with T1 and T5 which differed from T4. The above effect coupled with low available water capacity (0.1–15 bars) may be due to high water retention observed at 15 bars in T6 over other treatments except in T1. These results warrant investigation on the nature of organic matter produced under different treatments and its effect on these properties.

Water Retention Characters

In the absence of gradational treatments, effect of two treatments at a time was compared. The results of 90 cm profile have been given in Table 2 and those for surface and sub-soil in Figures 1 to 6. Comparison of T1 and T2 (Fig. 1) revealed that, in the former, besides the tillage plus inorganic fertilization, the addition of organic matter has been able to increase water retention more or less at all the tensions tried in the surface as well as sub-soil; even though the increase in available water capacity was

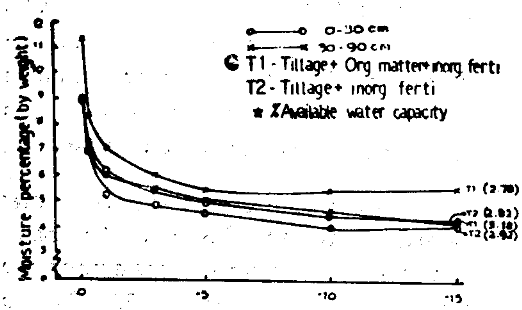

Fig. 1. Influence of organic mater on water retention

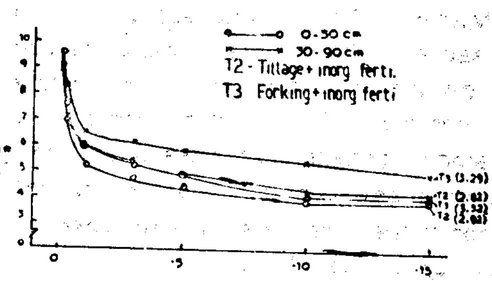

Fig.2. Influence of limited tillage on water retention

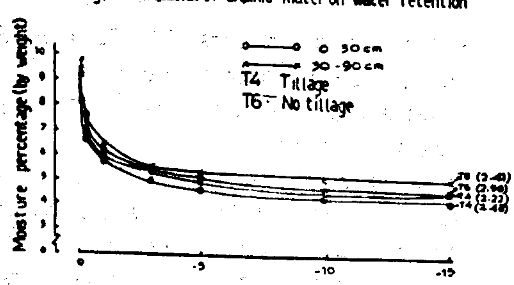

Fig.3. Influence of no tillage on water retention

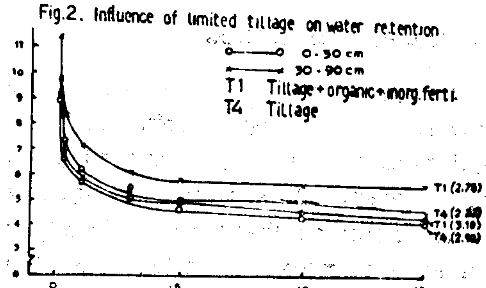

Fig 4 - Influence of organic and inorganic-ferti

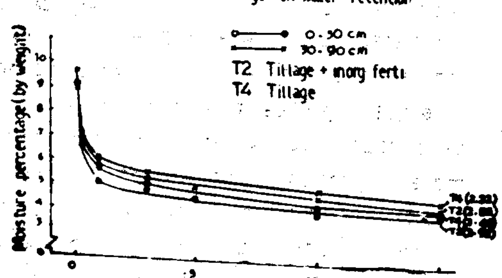

Fig 5. Influence of inorganic ferti on water retention

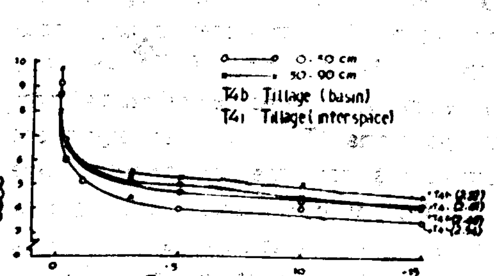

Fig.6. Influence of basin on water retention

TABLE 2

Influence of long-term cultural treatments on water retention characters

Treatment/Depth	Water retained at bars						
	0.1	0.3	1.0	3.0	5.0	10.0	15.0
T1—Tillage+organic+ inorganic fertilizer	10.53[bc]	8.05[c]	6.78[c]	5.89[b]	5.54[b]	5.09	5.14[c]
T2—Tillage+inorganic fertilizer	9.00[a]	7.04[ab]	5.68[a]	5.28[a]	4.84[a]	4.47	4.20[a]
T3—Forking basins+ inorganic fertilizer	10.71[c]	8.07[c]	6.34[bc]	5.86[b]	5.50[b]	5.03	4.71[bc]
T4—Tillage alone	9.25[ab]	6.73[a]	5.74[a]	5.17[a]	4.78	4.79	4.40[ab]
T5—No tillage+herbicidal weed control	10.55[bc]	7.86[c]	6.29[b]	5.55[ab]	5.03[ab]	4.80	4.69[b]
T6—No tillage	8.89[a]	7.47[bc]	6.29[b]	5.49[ab]	5.23[ab]	4.79	4.87[c]
C. D. at 5%	1.04	0.61	0.47	0.42	0.56	NS	0.43
0–30 cm	9.11	7.33	5.91	5.33	4.78	4.31	4.25
30–60 cm	10.05	7.34	5.89	5.44	5.24	4.80	4.80
60–90 cm	10.45	7.94	6.75	5.84	5.43	5.38	4.94
C. D. at 5%	0.73	0.43	0.33	0.36	0.40	0.53	0.30

[a], [b] and [c] supercripts denote differences based on Duncan's Multiple Range Test.

marginal in surface samples. The results in Fig. 2 showed that when tillage was replaced with forking the basins, the minimum soil disturbance, the water retained at different tensions has significantly increased. Comparison of no tillage and no manure (T6) with tillage alone (T4) revealed that in the former water retained at 0.3, 1.0 and 15.0 bars was significantly higher for the entire profile (Table 2). Similarly, higher water retention and higher available water capacity were recorded in surface and sub-soil independently (Fig. 3). Comparison of T4 with T1 (Fig. 4) and T2 (Fig. 5) has clearly brought out the beneficial effect of application of inorganic fertilizer alongwith organic fertilizers as compared to inorganic fertilizers alone in tilled plots. The results (Table 2) indicated that the water retention characters of no tillage and no manuring plots (with and without herbicides) were on a par with tillage alongwith organic and inorganic fertilization. The differences in water retention between basins (organic carbon 0.24%) and interspaces (0.15%–data not given in table) indicated the beneficial effect of rhizodeposition (Martin, 1977) in the former (Fig. 6).

The results of the present investigation show that in light soils minimum or no tillage results in better physical environment than tillage alone. Only when tillage is accompanied by addition of organic matter and inorganic fertilizers, that the improvement in physical parameters of soil can be compared to minimum or no tillage treatments. On the whole the data indicated that minimum tillage or growing a cover crop with proper inorganic nutrition, to replace the grass, may provide the optimum soil physical conditions in monocropping of coconut. This supports the original concept of minimum or no tillage. Lal and Kang (1982) also advocated minimum or no tillage under humid/sub-humid conditions for optimising soil physical environment for crop growth.

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