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Effect of tillage and organics on soil physical properties of sorghum (Var. Co 26) in an alfisol having subsoil hard pan at shallow depth

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Abstract : Effect of tillage practices and organics on physical properties at different depths in an Alfisol having sub soil hard pan at shallow depth was studied in the field experiment with sorghum as the test crop. The bulk density of the soil reduced significantly due to chiseling and this effect was more pronounced in 15-30 and 30-45 cm depths, where the bulk density steeply reduced from 1.82 to 1.58 Mg m^{-3}. Application of either farm yard manure or composted coir pith @ 12.5 t ha^{-1} appreciably reduced the bulk density over control and their effects were found to be comparable. A steep increase in hydraulic conductivity was observed due to chiseling in 15 - 30 cm depth (0.32 to 2.78 cm h^{-1}). No perceptible change was observed in the surface layer due to different tillage practices. The applied organics had a marked favourable effect on the hydraulic conductivity of the surface soil and on the pore size distribution. The pore size distribution of the soil also indicated the positive influence of chiseling in all the depths. *(Key Words : Tillage, Organics, Bulk density, Hydraulic conductivity, Pore size distribution, Sorghum)*

Among the various soil physical constraints, subsoil hard pan at shallow depth is the one which limits the crop growth to a greater extent. Normally, the problem occurs in red soil area due to illuviation of clay in the sub soil horizon coupled with cementing action of oxides of iron and alumina and calcium carbonate. Since red soil occupies sixty two per cent of the total Geographical area of Tamil Nadu and totally 5,218 sq. km is affected by this problem in Coimbatore, Madurai and North Arcot districts alone (Basker *et al.* 1995). It lowers the infiltration and percolation rates, nutrient movement and free air transport within the soil profile as well as the contribution of subsoil fertility to crop growth is hampered (Garcia *et al.* 1988). To overcome this problem, the chisel ploughing to a depth of 45 - 50 cm at 0.5 m interval criss cross was found to be effective. However, the tillage effect is expected to depend up on the crop growth and season. When sub soil occurs in red soils at shallow depth of low fertility, due to root restriction, nutrients in the surface soil are exhausted exorbitantly thus leading to further deterioration of the soil. The present study was, therefore undertaken to evaluate the extent of influence of tillage practices and organics on soil physical properties at different depths.

Materials and Methods

A field experiment was conducted during 1995 - 96, to study the direct effect of tillage and organics in a sandy clay loam (Pichanur series - Typic Haplustalf), reddish brown soil having subsoil hard pan at shallow depth (at 15 cm) in the farmer's field at Nachipalayam village of Madukkarai block of Coimbatore district, Tamil Nadu, India. The undisturbed soil samples collected from three depths *viz.* 0-15, 15-30 and 30-45 cm were subjected to various physical properties.

Physical properties of initial soil samples at different depths

Depth (cm)	Bulk density (Mg m^{-3})	Hydraulic conductivity (cm h^{-1})	Capillary porosity (%)	Non capillary porosity (%)	Total porosity (%)	Infiltration rate (cm h^{-1})
0 - 15	1.45	2.38	35.26	12.08	47.34	0.62
15 - 30	1.81	0.30	32.44	7.96	40.40	-
30 - 45	1.84	0.34	33.68	8.04	41072	

The results showed that the bulk density was 1.45 Mg m^{-3} in surface layer, whereas the bulk density was much higher in second (1.81 Mg m^{-3}) and third layers (1.84 mg m^{-3}). Contrary to this, the hydraulic conductivity was very high in surface layer (2.38 cm h^{-1}) compared to second and third depths (0.30 and 0.34 cm h^{-1}). The pore space was found to be higher in top layer compared to subsoil layers, The infiltration rate was found to be 0.62 cm h^{-1}. The soil was tested to be neutral in reaction pH 7.1; EC:0.42 dSm^{-1}; Organic carbon : 0.21%. The $KMnO_4$ oxidasable N, Olsen- P and NH_4 OAl-K status of the soil was 142, 7.3 and 112 kg ha^{-1} respectively. The iron and aluminium oxides were found to be high.

The following treatments were imposed in a split plot design and the 27 treatment combinations were replicated thrice. The main plot treatments (type of tillage) *viz.*, T_1 Country ploughing twice T_2 - Mould board ploughing twice ; T_3 - Chisel ploughing once + country ploughing twice; Source of organics *viz.*, M_1 - No organics M_2 - Farm yard manure @ 12.5 t ha^{-1} M_3 - Composted coir pith @ 12.5 t ha^{-1}. The sub plot treatments were N_1 - Nitrogen -, N_2 - 75 % of the recommended N; N_3 - 100 % of the recommended N. At the time seeding, 50 % of N, full dose of P and K in the form of urea, single super phosphate and muriate of potash respectively were applied basally. The remaining half the dose of N was top dressed on 45 days after sowing. The farm yard manure and composted coir pith were applied basally and incorporated thoroughly in the top soil @ 12.5 t ha^{-1} as per the treatment schedule 15 days before sowing.

The undisturbed core samples were collected at 45 and 90 days after sowing and at harvest in 3 depths *viz.*, 0-15 cm (D_1), 15-30 cm (D_2) and 30-45 cm (D_3) to monitor the changes in the physical properties of the soil and the data collected were subjected to statistical scrutiny (Panse and Sukhatme, 1978).

Results and Discussion

Bulk Density (Table 1)

The bulk density values of the core samples collected on 45 Days After Sowing (DAS) revealed that the lowest bulk density of 1.54 Mg m^{-3} was registered in the chiseled plots which was significantly lower than other tillage treatments. The highest bulk density (1.67 Mg m^{-3}) was observed in country ploughing treatment. Among depths, significantly higher bulk densities were recorded in subsoil layers than in surface soil. The interaction effect of T x D showed that chiseled plots registered lesser bulk density values in second and third depths compared to other tillage treatments. As far as the surface soil is concerned, the values were comparable.

The results of bulk density on 90 DAS and at post harvest stage revealed the same trend as that of the bulk density values of 45 DAS. The bulk density values were significantly lower in second and third depths under chiseled plots, whereas the bulk densities were on par in these depths in other tillage treatments. However, in surface layer all the tillage treatments behaved similarly.

Irrespective of tillage treatments, the surface layer registered significantly lower bulk density values. In second depth, the bulk density values were significantly lower due to chiseling, whereas the other two tillage treatments did not alter the bulk density in subsurface layers.

Among the organics tried, composted coir pith and farm yard manure decreased the bulk density of the surface soil. This finding is in line with the findings of Anderson *et al.* (1990) who reported a reduction of bulk density due to continuous application of farm yard manure alone and in combination with inorganics (Mahimairaja *et al.*,1986). In the present study. however the bulk density in the subsurface layers were not influenced due to application of organic manures *viz.*, farm yard manure and composted coir pith. This might probably due to the incorporation of organic manure only in the top layer prior to sowing. Irrespective of the stage of crop, the interaction effect of manures with tillage was not significant.

Hydraulic conductivity (Table 2)

The hydraulic conductivity values of the core samples collected on 45 DAS indicated that chiseling increased the hydraulic conductivity value to 2.189 cm h^{-1} which is significantly superior than the other two tillage treatments. The organics *viz.* composted coir pith and farm yard manure at 12.5 t ha^{-1} also significantly improved the hydraulic conductivity compared to control.

In second depth, the chiseled plots recorded significantly higher values than the other two tillage treatments. The results of hydraulic

Table 1. Effect of tillage and organics on the bulk density of soil at different depths (Mg m^{-3}) at 45, 90 DAS and at harvest (sorghum)

Treatments	T_1				T_2				T_3				Grand Mean
Depth (cm)	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	
At 45 DAS													
0 - 15 cm	1.440	1.395	1.410	1.415	1.430	1.370	L.370	1.390	1.405	1.360	1.380	1.382	1.39P
15 - 30 cm	1.855	1.835	1.850	1.847	1.755	1,780	1.740	1.758	1.580	1.535	1. 530	1.548	1.718
30 - 45 cm	1.740	1.745	1.750	1.750	1.745	1.750	1.750	1.748	1.685	1.695	1.680	1.687	1.730
Mean	1.678	1.668	1.670	1.672	1.643	1.633	1.620	1.632	1.557	1.530	1.530	1.539	
At 90 DAS													
0 - 15 cm	1.415	1.360	1.360	1.378	1.435	1.360	1.350	1.382	1.430	1.355	1.365	1.383	1.381
15 - 30 cm	1.870	1.860	1.865	1.865	1.790	1.775	1.810	1.792	1.605	1.585	1.645	1.602	1.753
30 - 45 cm	1.745	1.730	1.705	1.727	1.715	1.745	1.745	1.735	1.655	1.665	1.675	1.665	1.709
Mean	1.677	1.650	1.643	1.647	1.647	1.627	1.635	1.636	1.636	1.563	.535	1.552	1.550
At harvest													
0 - 15 cm	1.455	1.395	1.375	1,408	1.455	1.425	1.395	1.425	1.435	1.390	1.385	1.403	1.412
15 - 30 cm	1.865	1.845	1.875	1,862	1.840	1.845	1.845	1.843	1.670	1.660	1.685	1.672	1.792
30 - 45 cm	1.750	1.760	1.765	1,758	1.785	1.760	1.775	1.773	1.735	1.720	1.725	1.727	1.753
Mean	1.69071	.667	1.672	1,676	L693	1.677	1.672	1.681	1.613	1.590	1.598		

	45 DAS					90 DAS					At harvest				
	T	M	D	T *on* D	D *on* T	T	M	D	T *on* D	D *on* T	T	M	D	T *on* D	D *on* T
SEd	0.014	-	0.012	0.022	0.0200	0.018	-	0.016	0.029	0.027	0.009	-	0.018	0.026	0.030
CD (0.05)	0.033	NS	0.024	0.048	0.042	0.041	NS	0.033	0.062	0.057	0.021	NS	0.037	0.056	0.064

Table 2 Effect of tillage and organics on the hydraulic conductivity (cm h^{-1}) at 45, 90 DAS and at harvest (sorghum).

Treatments	T_1				T_2				T_3				Grand Mean
Depth (cm)	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	
At 45 DAS													
0-15	2.6000	3.510	3.505	3.205	2.800	3.540	3.680	3.340	2.890	3.535	3.600	3.342	3.296
15 - 30	.0390	0.380	0.385	0.385	0.370	0.330	0.350	0.350	2.440	2.940	2.850	2.743	1.159
30 - 45	0.510	0.495	0.510	0.505	0.505	0.470	0.505	0.49'1	0.505	0.485	0.455	0.482	0.493
Mean	1.167	1.462	1.467	1.365	1.225	1.447	1.512	1.394	1.945	2.320	1.302	2.189	
At 90 DAS													
0-15	2.220	3.320	3.345	2.962	2.310	3.280	3.390	2.993	2.260	3.530	3.520	3.103	3.019
15 - 30	0.320	0.335	0.340	0.332	0.340	0.320	0.340	0.333	2.000	2.080	2.135	2.072	0.912
30 - 45	0.405	0.390	0.370	0.388	0.380	0.390	0.400	0.390	9.365	0.380	0.395	0.380	0.368
Mean	0.982	1.348	1.352	1.227	1.010	1.330	1.337	1.239	1.542	1.997	2.017	1.852	
At harvest													
0-15	1.950	3.150	0.100	2.7'13	2.060	3.220	0.250	2.843	2.085	3.423	3.315	2.Q42	2.839
15 - 30	0.350	0.355	0.355	0.347	0.335	0.385	0.325	0.348	1.720	2.000	1.970	1.897	0.864
30 - 45	0.410	0.380	0.380	0.390	0.355	0.385	0.360	0.367	0.365	0.350	0.370	0.362	0.373
Mean	0.903	1.272	1.157	0.917	1.330	1.312	1.186	1.290	1.925	1.885	1.733		

45DAS	T	M	D	TonD	DonT	MonT	DonT
SEd	0.085	0.085	0.074	0.135	0.129	0.135	O.129
CD (0.05)	0.178	0.178	0.158	0.295	0.270	0.295	0.270

90DAS	T	M	D	TonD	DonT	MonT	DonT
SEd	0.064	0.064	0.051	0,094	0.091	0.094	0.091
CD (0.05)	0.142	0.142	0.112	0.208	0.181	0.208	0.181

At harvest	T	M	D	TonD	DonT	MonT	DonT
SEd	0.0414	0.044	0.041	0.074	0.064		
CD (0.05)	0.102	0.102	0.083	0.152	0.131	0.152	0.131

Table 3. Effect of tillage and organics on the porosity (per cent) at 45, 90 DAS and at harvest (sorghum)

Treatments	T_1				T_2				T_3				Grand Mean
Depth (cm)	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	
At 45 DAS													
0 - 15	48.06	51.08	51.69	50.28	48.62	51.47	52.41	50.83	47.93	51.78	52.31	50.67	50.59
15 - 30	39.61	39.44	39.42	39.49	41.45	41.54	41.76	41.58	45.52	46.66	46.49	46.22	42.43
30 - 45	41.70	41.42	41.80	41.64	41.24	40.72	40.58	40.85	44.65	44.61	44.39	44.55	42.34
Mean	43.12	43.98	43.30	43.80	43.77	44.58	44.92	44.42	46.03	47.68	47.73	47.15	
At 90 DAS													
0 -15	46.82	50.25	50.90	49.32	47.14	51.17	50.65	49.65	45.40	50.58	51.47	49.15	49.37
15 - 30	39.15	40.06	38.94	39.38	40.93	41.16	41.60	41.23	44.94	45.80	46.08	45.61	42.07
30 - 45	40.81	40.36	40.72	40.63	40.52	40.83	40.12	40.49	42.98	42.63	42.80	43.47	41.52
Mean	42.26	42.56	43.52	43.11	42.86	44.39	44.12	43.79	44.44	46.67	47.12	46.07	
At harvest													
0 - 15	45.06	48.28	49.67	47.67	45.20	49.62	49.81	48.21	46.90	49.56	48.37	48.37	48.08
15 - 30	39.60	39.67	19.11	39.46	39.88	39.26	40.20	39.78	44.01	40. 17	43 .64	43.64	40.96
30 - 45	41.01.	39.98	40.6'3	40.54	40.36	40.57	40.59	40.50	41.58	42.00	41.93	41.93	40.99
Mean	41.89	42.64	43.14	42.56	41.82	43.15	43.53	42.83	44.16	44.91	44.86	44.65	

	45DAS							90DAS							At harvest						
	T	M	D	TonD	DonT	MonT	DonT	T	M	D	TonD	DonT	MonT	DonT	T	M	D	TonD	DonT	MonT	DonT
SEd	0.30	0.30	0.32	0.55	0.56	0.55	0.56	0.40	0.40	0.30	0.58	0.51	0.58	0.51	0.32	0.32	0.27	0.49	0.46	0.49	0.46
CD (0.05)	0.70	0.70	0.68	1.19	1.18	1.19	1.18	0.92	0.92	0.62	1.7	1.08	1.27	1.08	0.73	0.73	0.56	1.08	0.97	1.08	0.97

conductivity of soil samples on 90 DAS and at post harvest stages revealed a similar trend as that of the results of hydraulic conductivity on 45 DAS. The interaction of T x D indicated that irrespective of tillage treatments, the surface layer registered the highest value. In chiseled plots, the hydraulic conductivity was significantly higher in second depth (15-30 cm) than in third depth. The first and third depths were on par with each other.

A significant increase in hydraulic conductivity was observed in subsoil due to chiseling. The initial hydraulic conductivity of 0.3 cm h^{-1} in the second layer (15-30 cm) drastically increased to 2.78 cm h^{-1} immediately after chiseling. It got slightly reduced to 2.74 cm h^{-1} on 45 DAS, 2.07 cm h^{-1} on 90 DAS and 1.90 cm h^{-1} at post harvest stage of sorghum crop. This trend again confirmed the earlier conclusions on the effect of irrigation or rainfall on the resettling of clay and sesquioxides.

Porosity (Table 3)

The statistical scrutiny of the data on total porosity at all stages revealed that chiseling increased the total porosity markedly than in other two tillage treatments. Organic manuring at the rate of 12.5 t ha^{-1} found to increase the total porosity compared to control. The effect was comparable among composted coir pith and farm yard manure treatments. The top layer was found to have significantly higher total porosity than the subsurface layers. The interaction effect was also found to be significant with respect to T x D and M x D. The T x D interaction showed that irrespective of the tillage treatments, the total porosity was found to be significantly higher in first layer followed by second depth. The lowest value was observed in the third depth.

The pore size distribution of the soil at different depths indicated that there was a positive influence due to chiseling at all the depths, whereas the effect was observed only in the surface layer due to other tillage treatments. As in the case of bulk density and hydraulic conductivity, the poresize distribution also attained its original value at the end of the residual crop due to the reasons attributed earlier (Gupta and Abrol, 1993). Application of organics favourably influenced the pore size distribution of the surface soil (Bharadwaj and Omanwar, 1992). However, the effect was not observed in subsurface layers possibly due to the incorporation of organic manures only in the top layer prior to sowing.

Thus it can be concluded from these results that the effect of chiseling was stupendous followed by two country ploughing in improving the soil physical properties *viz.*, bulk density, hydraulic conductivity and pore size distribution particularly by shattering the sub surface layers, thereby providing a conducive physical environment for better movement of water, nutrients better foraging of roots to deeper layers facilitating for effective mining of nutrients from deeper layers thus culminating in higher N uptake and grain yield of sorghum.

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