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STUDIES ON SOIL PHYSICAL, CHEMICAL AND MICROBIOLOGICAL PROPERTIES UNDER COMPACTED AND NON-COMPACTED TEA SOILS OF SOUTH BANK

Ishan Kr Phukan and Arup Baruah

Soils Department, Tocklai Tea Research Institute, Jorhat – 785 008, Assam

Abstract: Soil compaction is one of the major problems restricting tea productivity in some areas of N.E. India. It has restricted the productivity at a very low level in some tea estates. Results of analysis carried out on soil samples collected from compacted and non-compacted sections from seven tea estates from South Bank indicated that, non-compacted soil maintained lower bulk density, higher organic carbon, clay content and microbial load over compacted soil. Other properties viz., pH, available nutrients did not show any definite trend under these two soil conditions.

Keywords: Soil compaction, soil properties, tea productivity, tea estates, south bank, bulk density, organic carbon, clay content, microbial load, available nutrients.

Introduction

Compaction is the process of densifying a soil mechanically and influencing the physical properties of the soil. Physical properties influence all biological and many chemical processes in the soil (J. Kuht and E. Reintam, 2004). Soil compaction is one of the major problems restricting productivity in many areas of North East India. It has restricted the productivity at a very low level in many tea estates. The physical properties of soil affect growth and development of tea roots and indirectly affect tea productivity. The soils that support tea are liable to be relatively compacted over the years due to intensive leaching and continuous trampling by pluckers and therefore need special attention. Tea roots are sensitive to high mechanical impedance and lack of aeration in soil. The worst hit tea growing areas of NE India with problem of soil compaction are in South Bank in Sonari, Nazira and Golaghat districts where yield has been stagnating at around 1200-1300 Kg/ha. S. K. Dutta *et al* (1971) reported that tea planted in compacted soils and otherwise having poor physical condition, normally fails to produce satisfactory growth. Role of soil physical properties for increasing productivity of different crops have been emphasized by many scientists (C. Dakshinamurthy and B. P. Ghildyal, 1976; T. Satyanarayana and B. P. Ghildyal, 1970; O. Babalola and R. Lal, 1977). There is complete lack of data (or literature reports) regarding the physical, chemical

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and microbiological properties of soil under compacted (Comp) and non-compacted (Ncomp) sections of tea estates. Therefore, this study aimed to investigate of some selected soil physical, chemical and microbiological parameters of Comp and Ncomp soils of mature tea sections (15-25 years) under different tea estates of South Bank where compaction is a major problem.

Materials and Methods

Seven tea estates located on the Southern Bank of Brahmaputra were selected for the present study. At each estate two different locations (sections) were selected on the basis of soil compaction (Comp) and no-compaction (Ncomp). Profiles (Photograph 1) were dug out down to a depth of 45 cm; undisturbed core and block samples were collected from each of these profiles at an interval of 15 cm. They were analysed for bulk density following undisturbed core method (G. R. Blake and K. H. Hartge, 1986) and water stable aggregates by using Yoder's wet sieving technique (R. Yoder, 1936). Using the same samples pH, organic carbon (Org C), soil available potash (Av. K_2O) and phosphate (Av. P_2O_5) were estimated following standard methodology (M. L. Jackson, 1973; C. A. Black, 1965). Soil microbial load (total bacteria, fungus, actinomycetes and phosphate solubilizing bacteria) was also estimated following the procedure of B. S. Sidhu *et al* (2007). Soil samples were analysed for their mechanical separates as described by C. A. Black (1965). Yield data of tea under these sections was also collected from the tea estates. The name of the tea estates are given in Table 1.

Statistical Analysis

All the data of soil were statistically analyzed to draw conclusion of significance by using the methods prescribed by V.G. Panse and P. V. Sukhatme (1967). The test of significance was carried out at 5% level of significance by referring to 'F' table values.

Results and Discussion

The texture of the soil was silt loam in all the sections of the tea estates under study and no differences were observed in textural class of different depth studied. Increasing compaction in the sub-soil layers with increasing depth was mainly attributed to the presence of increasing percentages of silt plus clay fractions together with soluble iron compounds in the mechanical make up of sub-soils. Data on mechanical analysis indicated higher silt plus clay content in Comp section as compared to Ncomp section throughout the soil profile in all the tea estates (Figure 1a-1g). Highest content of silt + clay was recorded in 15-30 cm depth in all the Comp sections. The structural indices represented by water stable aggregates (WSA) showed significant variations under Comp and Ncomp situations. Soils under all the Ncomp sections were found to be associated with greater aggregate stability (>2-0.5 mm) as compared to Comp sections (Table 2).

The indices of bulk density in the compacted soil were unfavourable in all measured soil depths. Bulk density, an indicator of compaction, under compacted soil was significantly higher over non-compacted soil in all the tea estates. In Comp and Ncomp sections bulk density, in 0-15 cm soil depth, varied from 1.44 to 1.54 Mgm^{-3} and from 1.32 to 1.38 Mgm^{-3} respectively (Table 3 and Figure 2). This trend was noticed up to 45 cm depth. Lower bulk density in Ncomp sections might be due to good structure of soil and high organic matter content of soil (M. A. N. Anikwe, 2000). Highest bulk density was recorded from Mackypore tea estate. Bulk density increased with increase in depth in all profiles indicating higher compaction in lower horizons. Profile study also indicated very hard and compacted soil beyond 15 cm depth under compacted sections. Present investigation showed that heavy leaching of silt plus clay fractions together with soluble iron compounds under heavy rainfall conditions and fluctuations of water table near to the surface layers during monsoon were mainly responsible for compaction or denser packing of soils at lower horizon. Similar observation was reported by R. L. Daddow and G. E. Warrington (1983).

Data on organic carbon indicated that all the non-compacted sections maintained higher oxidizable Org C over compacted sections up to 30 cm depth. But beyond 30 cm it was statistically at par (Figure 3). Higher organic carbon in Ncomp sections is indicative of addition of organic manures and better organic matter management in these sections. Levels of pH were not significantly affected by the process of compaction and non-compaction and did not indicate any definite trend upto 30 cm depth. However, the soil pH below 30 cm depth was found to be much higher in compacted sections especially under highly water logged/water saturated soil (Table 4). Soil available K_2O did not show any definite trend between compacted and non compacted soil sections. However, available P_2O_5 was found to be higher in Comp sections as compared to Ncomp sections in higher number of tea estates especially in water logged sections (Figure 4). This might be due to reversion of insoluble ferric phosphate in acidic tea soil to more soluble ferrous phosphate as a result of changes in redox potential (W. H. Patrick and I. C. Mahapatra, 1968; G. Rubio *et al*, 1997; I. R. Phillips, 1998).

Soil compaction was able to reduce the biomass of soil microbiota. The populations of soil aerobic bacteria, fungi, actinomycetes and PSB was higher in low density soils (Ncomp sections) as compared to Comp sections in all the tea estates (Table 5), presumably due to the favourable soil physical conditions and more substrates provided by plant roots. This finding is in consistent with the results reported by M. M. Landina and I. L. Klevenskaya (1985) and D. L. Smeltzer *et al* (1986) that soil compaction decreased microbial numbers.

Data procured from the corresponding tea estates revealed that productivity (KMTH) of non-compacted soil sections were higher as compared to compacted soil sections (Table 6). I. Piero *et al* (2014) reported that degradation of soil structure through compaction was the main factor resulting in observed declined productivity (quantitatively and qualitatively)

Conclusion

The present study showed that soil compaction had a significant effect on physical, chemical and microbiological properties of soil under long term mono-cropping in mature tea. In such tea areas, enrichment of soil organic matter and improvement of soil physical properties need special attention and practices like recommended rotational cultivation practices viz., forking, deep hoeing etc followed by addition of organic manures and surface mulching, retention of tea pruning litters, addition of quality organic manure and liming materials like dolomite if pH is low, particularly in the year of pruning is suggested.

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Table 1: Name of sampled tea estates

Garden Name	Abbreviation	Location	Soil texture
Ghilladhary	Ghil	Jamuguri, Golaghat	Silt loam
Khongia	Khong	Demow, Sivasagar	Silt loam
Mokrung	Mokrn	Furkating, Golaghat	Silt loam
Gelaky	Gelky	Nazira, Sivasagar	Silt loam
Dufflating	Duff	Titabor, Jorhat	Silt loam
Aideobari	Aidb	Teokghat, Sonari, Sivasaga	Silt loam
Meckeypore	Mecky	Nazira, Sivasagar	Silt loam

Table 2. Total water stable aggregates under Comp and Ncomp sections

Tea Estate	Depth (cm)					
	0-15		15-30		30-45	
	Comp	Ncomp	Comp	Ncomp	Comp	Ncomp
Ghil	62.30	73.25	57.34	67.31	47.34	53.98
Khong	62.32	76.23	57.58	63.99	48.29	52.24
Mokrn	69.97	74.79	56.84	68.52	46.84	58.52
Gelky	70.92	80.39	56.07	60.82	48.83	50.79
Duff	67.73	81.18	56.66	65.65	46.66	55.65
Aidb	65.81	73.51	61.21	67.44	51.16	57.32
Mecky	60.77	83.30	52.96	73.51	44.82	63.48
CD (0.05)	4.79		4.19		5.61	

Table 3. Bulk density under Comp and Ncomp sections in different tea estates

Tea Estate	Bulk density (g/cc)					
	Depth (cm)					
	0-15		15-30		30-45	
	Comp	Ncomp	Comp	Ncomp	Comp	Ncomp
Ghil	1.52	1.38	1.56	1.40	1.56	1.41
Khong	1.44	1.32	1.53	1.47	1.54	1.48
Mokrn	1.46	1.37	1.51	1.41	1.52	1.42
Gelky	1.47	1.38	1.51	1.41	1.52	1.41
Duff	1.45	1.38	1.49	1.40	1.48	1.41
Aidb	1.45	1.36	1.50	1.42	1.51	1.42
Mecky	1.54	1.38	1.58	1.42	1.58	1.43
CD (0.05)	0.05		0.03		0.04	

Table 4. Soil pH status under comp and Ncomp conditions

Tea Estate	Soil pH					
	Depth (cm)					
	0-15		15-30		30-45	
	Comp	Ncomp	Comp	Ncomp	Comp	Ncomp
Ghil	4.76	4.66	4.82	4.78	5.56	5.03
Khong	4.97	4.86	4.98	4.86	5.63	4.90
Mokrn	4.71	4.63	4.73	4.63	5.73	4.92
Gelky	4.79	4.72	4.80	4.73	5.77	4.82
Duff	4.76	4.71	4.89	4.73	4.95	4.77
Aidb	4.68	4.55	4.79	4.60	6.15	4.77
Mecky	5.03	4.88	5.27	5.05	6.22	5.08
CD (0.05)	0.11		0.09		0.10	

Table 5. Mean distribution of soil microbes

Microbes (cfu/g X 10^5)/g	Comp	Ncomp
Bacteria	8.9	20.3
Fungi	9.8	16.1
Actinomycetes	1.9	2.1
PSB	ND*	0.25

ND: Not detected

Table 6. Yield of tea under Comp and Ncomp sections

Rea estate	Soil status	KMTH*
Ghiladhari	Comp	1623
	Ncomp	2048
Khungia	Comp	917
	Ncomp	3512
Mokrung	Comp	1265
	Ncomp	1862
Gelaky	Comp	964
	Ncomp	1226
Dufflatinga	Comp	1961
	Ncomp	2356
Aideobari	Comp	1700
	Ncomp	2600
Meckypore	Comp	1216
	Ncomp	1613

*KMTH: Kg made tea per ha

Photograph 1. Profile study in Mokrung tea estate during the progress of the

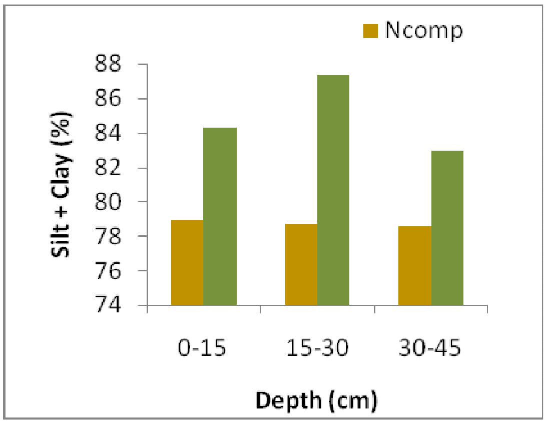

Figure 1a:Ghiladhary TE

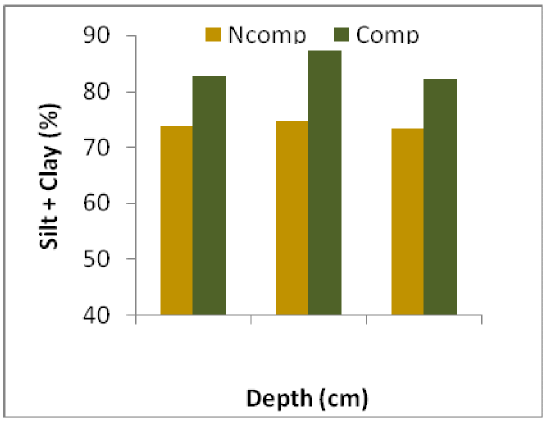

Figure 1b. Khungia TE

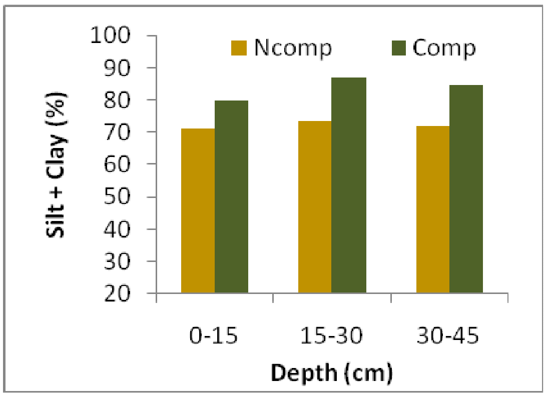

Figure 1c. Mokrong TE

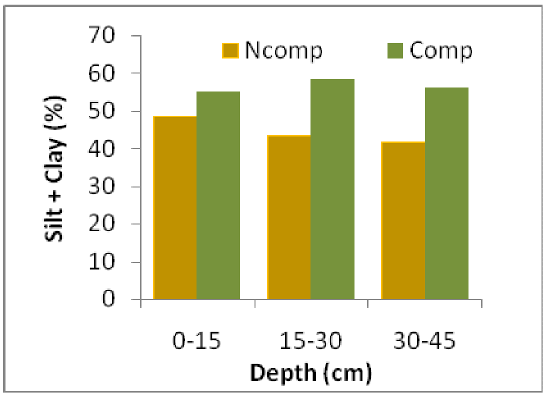

Figure 1d. Galeky TE

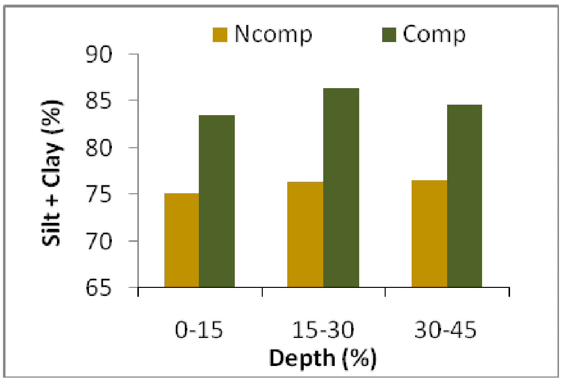

Figure 1e: Duflatinga TE

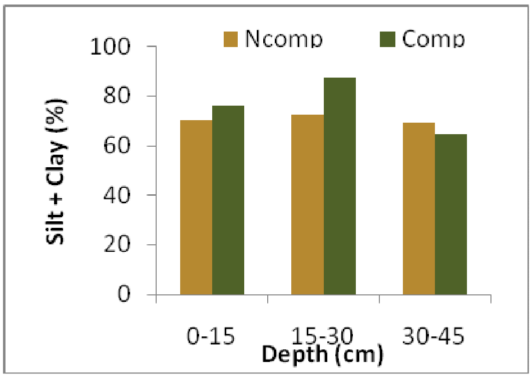

Figure 1f. Aideobari TE

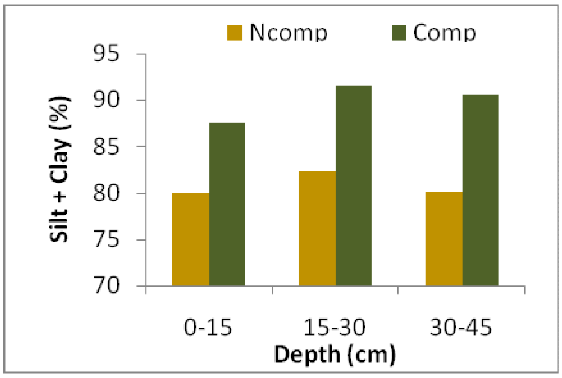

Figure 1g: Mackeypore TE

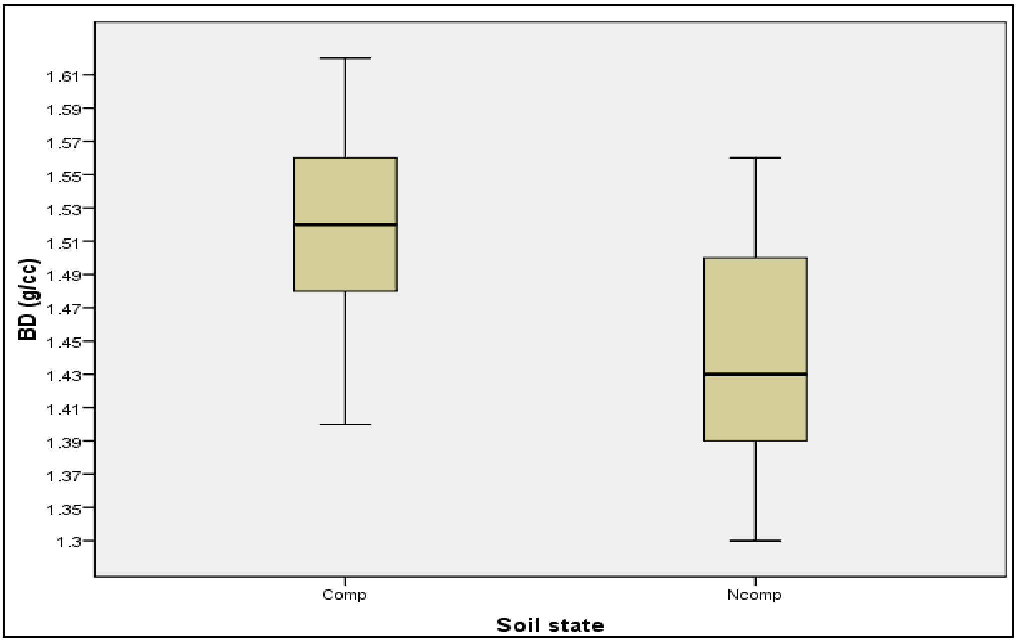

Figure 2. Bulk density under Comp and Ncomp sections (irrespective of treatments)

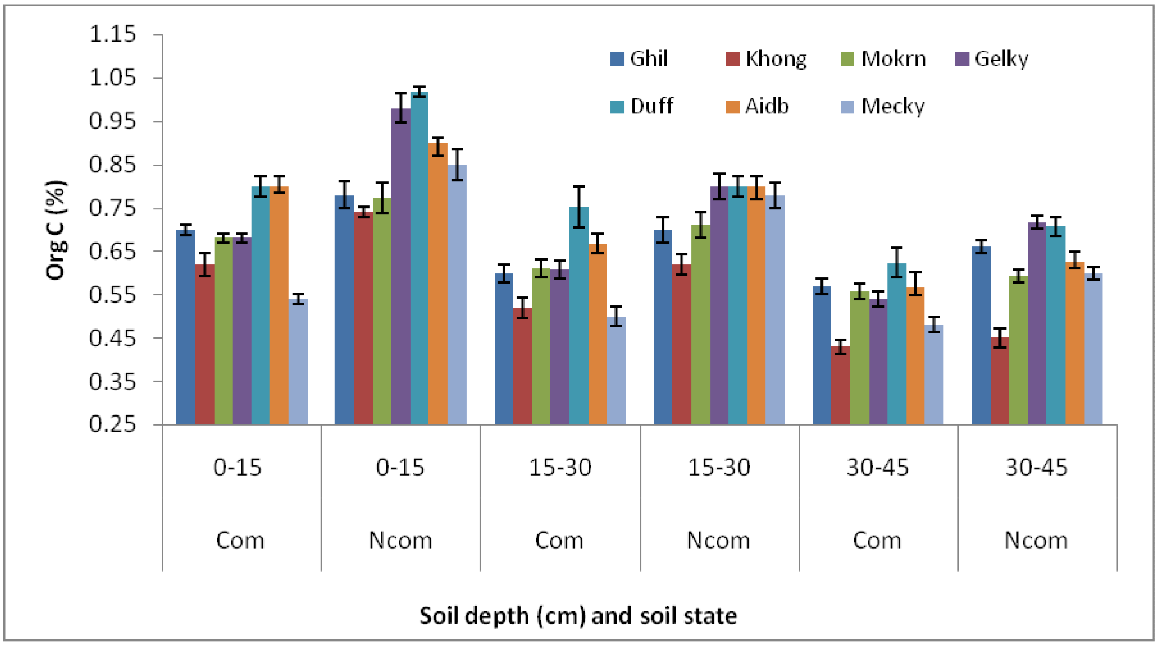

Figure 3. Variation of organic Carbon with depth

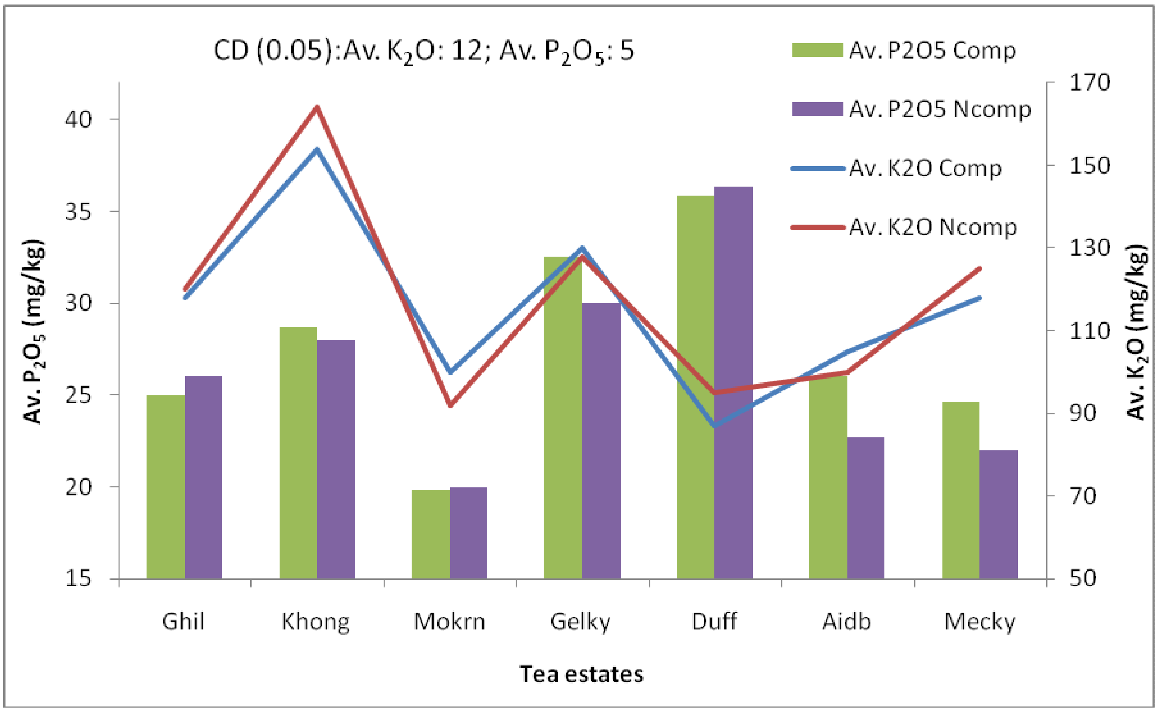

Figure 4. Status of Av. P_2O_5 and Av. K_2O under Comp and Ncomp sections