Soil organic carbon and the hydrology of rubber soil versus forest soil: a depth resolved linear regression analysis

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Abstract:
The large demand for rubber has resulted in the conversion of large tracts of natural forests into rubber plantations, particularly in South East Asia. Here we report a depth resolved study of the correlation between soil organic matter (SOM) content and soil moisture content. At intermediate depths ~ *0.2 – 1.1* m, in the mean, the SOM content of rubber soils is greater than that in contiguous forest soils (Mann-Whitney *U* test $p < .05$). The soil water content however, was higher for forest soil (Mann-Whitney *U* test $p < .05$) for depths up to *1.4* m. A depth resolved regression analysis showed that the linear relation between soil water content and SOM content differ between rubber soils and forest soils (Chow test $p < .05$). Particularly, up to depths ~*0.8* m, the correlation is positive for forest soils while for rubber soils it is negative. Above this depth the relation is in the mean flat for forest soils.

Keywords:
Forest soil; Rubber soil; Soil organic matter; Hydrology

1. Introduction:

The impact of land use / land cover (LULC) change from natural forest to rubber plantations has often been explored, considering the important roles tropical forests play in regulating weather and climate patterns at both regional as well as global scales (see [1] and references therein). On the other hand, change over to cultivation of *Hevea brasiliensis* has been reported as leading to zero flow, water table draw down and dry season water shortages [2] in rubber growing regions. Rubber trees have been called water pumps due to enhanced evapotranspiration loses from rubber plantations. However, quantitative and qualitative understanding of the vertical profile of hydrologically relevant physical properties of the soil is important in modelling infiltration and estimating runoff (see for example details of the HYDRUS code: www.ars.usda.gov), and hence merit study.

2. Methodology:

Data on core samples from *100* rubber plantations and *21* forests / sacred groves contiguous with the rubber plantations, were used in the study (Data courtesy [3]). The samples were all from the south western coast of peninsular India; particularly from the narrow region between the Arabian sea and the Western Ghats, from Kanyakumari to Shivamogga. The soil moisture content and the soil organic matter content were estimated for all the core samples. The value obtained for each sample was assigned to the mean depth of the sample. The median value of the soil water content, for samples lying within various ranges of their mean depth was determined. Results show a higher soil water content for forest soil compared to rubber soil. The Mann-Whitney *U* test was done, on the data for various depth ranges, to check for any significant difference in the mean values. A similar exercise was done for the data on soil organic matter content. In this case, SOM for rubber soil was higher compared to that for forest soil; the results are statistically significant for intermediate depths. Depth resolved linear regression analysis was done for obtaining a linear relationship between soil water content and SOM. Chow test was done to check the nature of the correlation between soil water content and SOM, between rubber soils and forest soils.

3. Result:

The results of the Mann-Whitney *U* test for any significant difference between the means for soil water content and SOM, between rubber and forest soils, are given in tables 1 and 2 below. In all cases the distribution of the data was reported as approximately normal.

Table 1

Mean depth (cm)	U	z-score	p	ρ	Median WR	Median WF
5	273.5	-4.64058	<.01	0.159942	0.2162	0.3332
10	489.5	-4.61084	<.01	0.193478	0.2239	0.3264
30	429.5	-4.24319	<.01	0.204524	0.2305	0.3065
50	334	-2.94815	<.01	0.265501	0.2452	0.2926
70	417.5	-2.08742	<.05	0.336422	0.2709	0.3197
95	488	-2.84715	<.01	0.293976	0.2679	0.3125
125	345	-2.61336	<.01	0.294118	0.2922	0.3383
145	259	-1.71165	0.08726	0.352381	0.3061	0.3288

Table 2

Mean depth (cm)	U	z-score	p	ρ	Median SOMR	Median SOMF
5	273.5	-4.64058	0.3125	0.425731	0.0549	0.0509
10	489.5	-4.61084	0.4654	0.451383	0.0543	0.05135
30	429.5	-4.24319	0.0232	0.341905	0.0343	0.03228
50	334	-2.94815	0.0426	0.339428	0.0239	0.02045
70	417.5	-2.08742	0.01	0.298147	0.0178	0.01281
95	488	-2.84715	0.01	0.283735	0.0138	0.01019
125	345	-2.61336	0.1	0.372549	0.0099	0.00866
145	259	-1.71165	0.87288	0.485714	0.0083	0.00775

Here, Median WR refers to the median value for the water content of the sample of rubber soil, WF that for forest soil, SOMR that for the SOM content of rubber soil and SOMF that for forest soil.

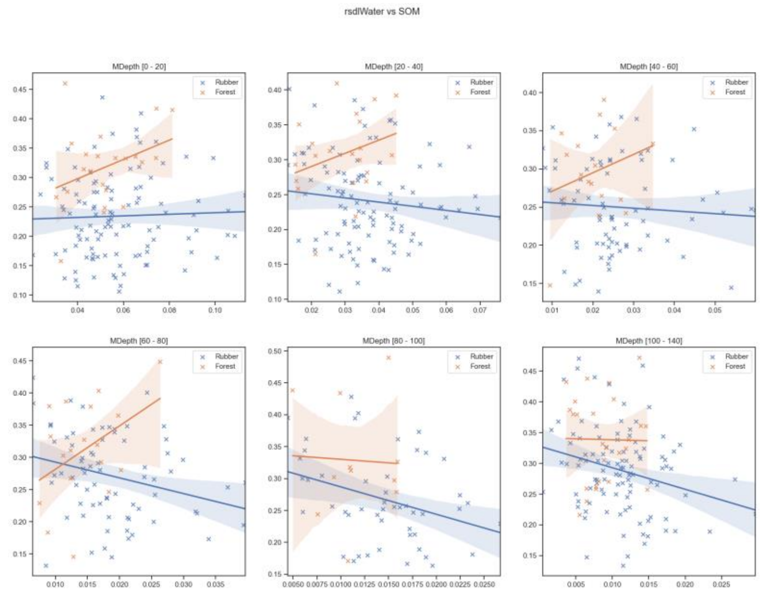

Fig 1. Linear relation between soil water content and SOM within the indicated ranges of the mean depth of the samples.

The results of the Chow test for the depth range *0 – 20* cm yield $F(2, 129) = 14.314$ where, $F_{critical} = 4.786$ for $p < .01$. Fig 1 shows the graphs of the linear regression relation between soil water content and SOM for the indicated ranges in mean depth of the samples. The slopes run opposite to each other up to depths ~*0.8* m.

4. Discussion and Conclusion:

The importance of soil organic matter, as a key factor that makes soil drought resistant, is often emphasized (see for example [4]). Here we report, for rubber soils, an anti-correlation between soil water content and soil organic matter content, that is counter to expectations. This contrary property of rubber soils could also be contributing to the negative impact of rubber plantations on the water security of the hosting region. A more detailed study and specific analysis is under way.

References:

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