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RESEARCH ARTICLE

Effects of land use and management practices on quantitative changes of soil carbohydrates

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Abstract: Soil carbohydrates (SC) are important parameters in determining soil fertility in different land uses, particularly in the tropics. There are no tropical studies reported so far on the effect of heterogeneneous land uses on the concentration of SC. Therefore, SC under 13 different land uses including forests and adjacent cultivated lands in Sri Lanka were studied. Soil litter (SL) and soil organic C fractions were evaluated for availability of SC. The study showed that SL is the main factor determining SC composition. Positive relationships between SL and carbohydrates of plant origin (CPO) indicated that SL is the major source of carbohydrates in cultivated lands. Negative relationships were observed between SL and carbohydrates of microbial origin (CMO) in forests. Although the vegetation structure differs, the forests did not show much variation in SC, as soil disturbances, which lead to differences in decomposition rates were minimal or absent. However, the soil management practices among the cultivated lands were highly variable and hence induced significant variations in SC by changing the litter decomposition processes. Intensive soil tillage, agrochemical use and low biomass return reduced the SC to a significant level as shown in potato and tea soils. Three carbohydrates, namely arabinose, xylose and glucose, were not detected in potato cultivation, while ribose and glucose were not detected in tea plantation. The concentration of the other carbohydrates was restricted to the range of 0.12 – 1.75 x 10^{-6} g kg soil^{-1} in tea.

High biomass return and minimum soil tillage in rubber and coconut plantations respectively increased the SC to 48.6 and 57.79 x 10^{-6} g kg soil^{-1} being comparable to their adjacent forests. By comparing SC of forests and the adjacent cultivated lands, both having similar climatic conditions and soil types, the study confirmed that differences in land management practices affected SC concentration. This study provides important guidelines for selecting better land management practices in tropical ecosystems for sustaining soil fertility through SC management.

Keywords: Cultivated lands, forests, soil carbohydrates, soil litter, soil organic carbon.

INTRODUCTION

Carbohydrates play an important role in the terrestrial carbon cycle. Soil structure formation and supply of energy for soil micro-organisms are the main processes that are governed by soil carbohydrates. Fungal and bacterial polysaccharides may play an important role in soil structure formation (Hu *et al*., 1995).

Carbohydrates derived from various sources are usually considered as readily degradable compounds in soil (Allard, 2006). They are degraded microbially to metabolizable substances, which are the most readily available food for soil organisms (Larre-Larrouy *et al*., 2004). Soil microbial activities depend mainly on carbohydrates as energy sources. Plant-derived sugars, especially pentose polymers (arabinose and xylose) serve as the major source of energy and C for soil micro-organisms. In turn, micro-organisms synthesize primarily hexose polymers (i.e., galactose, mannose, fucose and rhamnose) and release them into the soil (Murayama, 1948; Cheshire, 1979; Moers *et al*., 1990). The most prominent carbohydrate monomers in soils of forest and pasture are glucose, galactose, mannose and arabinose (Glaser *et al*., 2000). Glucose is the most abundant sugar in soils (Nacro *et al*., 2005). Although carbohydrates play an important role in soil organic matter (SOM) dynamics in tropical soils, only few studies have been conducted in this area. The only available data are those on savannah soils in Congo and Senegal (Larré-Larrouy & Feller, 1997; Sall *et al*., 2002), native grasslands and forest soils in Costa Rica (Guggenberger & Zech, 1999) and forest and savannah soils in Congo and Brazil (Kouakoua *et al*., 1999).

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In order to understand SOM dynamics, it is important to study the quantity and composition of soil carbohydrates (SC), which originate from both plant debris and microbial activity. The content of SC is reported to be low in tropical soils and represent only 3% of total organic C in tropical forest soils and 7% of total organic C in tropical grassland soils (Nacro *et al.,* 2004). This is a typical feature of tropical soils.

The SC content is lower (0.01 g kg soil^{-1}) in the surface soil layer (0-5 cm) owing to the faster microbial degradation at high temperatures compared to the concentration (0.03 g kg soil^{-1}) in the 5-15 cm soil layer (Amelung *et al*., 1999; Fallahzade & Hajabbasi, 2011). High rainfall could also induce leaching of polysaccharides to the subsoil (Rodionov *et al*., 1999).

The SC, the labile pool of SOM, is affected mostly by land use changes (Guggenberger *et al*., 1995). Prolonged cultivation may result in decline in SOM and cause changes in the composition of soil carbohydrates (Larre-Larrouy *et al*., 2004). Cultivation also affects the proportion of soil C present as carbohydrates in the soil aggregates (Larre-Larrouy *et al*., 2004). Nacro *et al*. (2005) have reported that neither vegetation nor soil controls SC dynamics and that the most likely factor has been found to be the tropical climate, which drives rapid decomposition of carbohydrates. These results have come from a limited number of studies and so far there are no studies that report on variability of SC in relation to a range of heterogeneous land uses.

Therefore, natural forests and the adjacent cultivated lands were evaluated for SC with a view to assess the impact of land management on these tropical ecosystems. The different soil organic matter fractions (soil litter and soil organic C) and their contribution to the availability of SC was also investigated.

METHODS AND MATERIALS

Field sites**:** Soil samples were collected from sites subjected to 13 different land uses located within the main climatic regions of Sri Lanka (5º 54' N - 9º 52' N latitudes and 79º 39' E - 81º 53' E longitudes). Detailed information of the study sites are given in Tables 1 & 2.

The study sites included 6 forest types classified (National Atlas of Sri Lanka, 1988) as semi evergreen, moist monsoon, dry monsoon, montane, dry mixed evergreen, and 2 tropical wet evergreen forests; 7 croplands (tea, rubber, coconut, export agricultural crops pepper, cardamom and cocoa), potato as well as home gardens and chenas; where slashburn and cultivation are practised.

Twenty composite soil samples from random sites were collected from 0-30 cm depths at each site, after removal of soil surface litter because the major proportion of SOM can be sampled from this depth (Ratnayake, 2006). Each composite sample comprised 3 soil cores. Soils were air-dried and passed through a 2 mm sieve. Gravel and organic debris retained on the sieve were removed. These soils were again sieved to < 0.15 mm to obtain a fine fraction. All soil analyses (except those pertaining to results in Table 1) were performed using this fine fraction.

Determination of SC content**:** The SC was determined by using the method of Amelung *et al*. (1996). Individual sugars were released from SC by treatment with 4 M trifluoroacetic acid at 105 ^{0}C for 4 h. The resulting monosaccharides were then converted into alditol acetate derivatives by using acetylation as the derivatisation procedure. Reference alditol acetates of rhamnose, fucose, ribose, arabinose, xylose, mannose, galactose, and glucose were used as standards. These derivatives were then separated on a Shimadzu GC-9AM gas chromatograph (Japan) equipped with a hydrogen flame ionization detector. Separation of the monosaccharide units was achieved with a SPB 1701 fused silica capillary column. The carrier gas was Helium and the total flow rate was 80 mL min^{-1}.

Determination of SL content**:** The soil litter content was measured using a modified weight loss on ignition method (Ratnayake *et al*., 2007).

Soil organic C content**:** The carbon content was measured calorimetrically (Baker, 1976). A Potassium dichromate solution was used to oxidize organic C in acidic medium. The amount of oxidized C in the sample was measured by determining the amount of chromic acid produced during the oxidation. The colour intensity was measured spectrophotometrically.

Statistical analysis**:** The comparison of soil carbohydrates of sites subject to different land uses was done by using the generalized linear model (GLM) and Tukey's (HSD) test (SAS, 1996). The t-test was carried out to compare SC of the natural forests and the adjacent cultivated lands. The relationships between concentrations of different sugars with SL and organic C were established through correlation and regression analyses (SAS, 1996). The relationships between concentrations of different sugars with climatic parameters (rain fall, temperature and elevation) were also established through correlation and regression analyses (SAS, 1996). Sugar concentrations were transformed to logarithmic scale [$\log_{10}$ (x + 1)].

Table 1: Detailed information of the field sites studied

Ecosystem	ELE (m)	MAR (mm)	MAT (^0C)	Soil great group[19]	Soil pH	Soil organic matter (g kg^{-1})	Soil total N (g kg^{-1})	Soil total P (g kg^{-1})
Forests								
Tropical wet evergreen (WL)	1000	5000	25	Haplic Acrisols	4.57	40.5	2.7	0.4
Tropical semi evergreen (IM)	700	2500	24.8	Cambisols	6.13	41.0	1.6	0.5
Moist monsoon (IU)	1300	2500	22	Chromic Luvisols	6.98	47.9	2.3	0.4
Dry monsoon (IL)	221	2000	27.4	Haplic Acrisols	6.08	27.9	1.1	0.1
Montane (WU)	2000	2500	15	Haplic Acrisols	5.74	72.6	3.7	0.4
Dry mixed evergreen (DL)	300	1400	28.4	Chromic Luvisols	6.87	15.9	2.3	0.5
Tropical wet evergreen (WM)	600	3300	20	Rhodic Nitisols	6.37	35.8	2.9	0.5
Cultivated lands								
Rubber (WL)	1000	5000	25	Haplic Acrisols	4.63	33.0	1.9	0.5
Export agricultural crops (IM)	700	2500	24.8	Cambisols	5.64	20.7	0.7	0.6
Potato farm (IU)	1300	2500	22	Chromic Luvisols	6.07	37.8	2.2	0.6
Coconut (IL)	221	2000	27.4	Haplic Acrisols	5.19	21.9	1.1	0.3
Tea (WU)	2000	2500	15	Haplic Acrisols	5.06	35.6	0.5	0.7
Chena (DL)	300	1400	28.4	Chromic Luvisols	6.71	14.2	1.6	0.4
Home garden (WM)	600	3300	20	Rhodic Nitisols	6.00	27.8	1.7	0.6

ELE- Elevation; MAR- Mean annual rainfall; MAT- Mean annual temperature;

Climatic regions: WL- Wet Zone low country; IM- Intermediate Zone mid country; IU- Intermediate Zone up country; IL- Intermediate Zone low country; WU- Wet Zone up country; DL- dry Zone low country; WM- Wet Zone mid country.

Table 2: Some soil management practices adopted in the cultivated lands

Site	Crop type	Fertilizer (kg ha^{-1})			Number of applications (year $^{-1}$)			Soil digging/forking (Number of times year $^{-1}$)
		N	P	K	Fertilizer	Pesticide	Herbicide	
Rubber	Perennial tree	20	20	60	1	NC	2	2
Export agricultural crops	Perennial tree	120-250	140-200	95-150	4	NC	NA	4
Potato farm	Annual[a]	210	50	300	6	6	2	4
Coconut	Perennial tree	140	90	330	1	NC	1	NA
Tea	Perennial tree	240	30	60	3-6	2	4	4
Chena	Annual	NA	NA	NA	NA	NA	NA	NA
Home garden	Perennial trees, annuals	NA	NA	NA	OM	NA	NA	4

[a] 2 crops annually; NC- not common; OM- organic manure; NA- not applied

RESULTS

Regression analysis showed that the SL content was positively related to the soil carbohydrates of plant origin, arabinose and xylose (CPO) in the cultivated lands (Figure 1). However, the SL contents of forests is negatively related to the soil carbohydrates of microbial origin, ramnose, fucose and ribose (CMO) (Figure 2). No significant relationships were found between soil organic C contents and the different SC ($p > 0.05$) in land subjected to different uses.

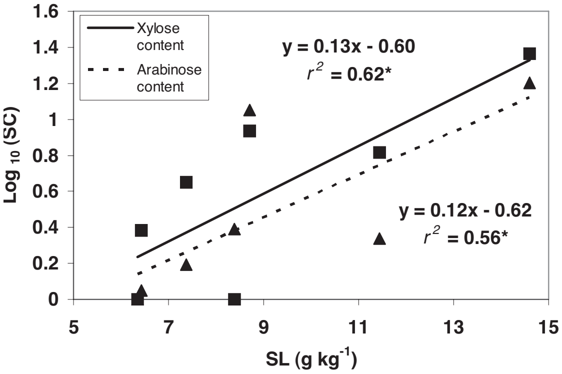

Figure 1: Relationships between the soil litter (SL) content and soil carbohydrate (SC) contents, (a) xylose (■) and (b) arabinose (▲) in lands cultivated with different crops (tea, rubber, coconut, export agricultural crops, home garden, potato and chena). Each data point in the figure represents a mean of 20 composite soil samples per site. * significant at $p < 0.05$.

Table 3 shows the concentrations of carbohydrates and their variance among the land under different uses. The different types of forests did not show much variation in SC. Unlike the forests, carbohydrate contents in cultivated lands were significantly different among sites (Table 3). It was also noted that some of the sugars were not detected in cultivated lands other than in coconut plantations where all the sugars were present. Rhamnose and fucose contents showed the highest variation among the cultivated lands. Xylose and arabinose contents were significantly high in rubber and coconut plantations (Table 3). Xylose content was significantly high in the home garden as well. The concentration of xylose and arabinose were lowest in tea plantation. Both these sugars were not detected in sites under potato cultivation. The concentration of CMO was comparatively high in coconut and rubber plantations. The lowest concentration of CMO was found in tea soil. Ribose and glucose were not detected in tea soil. Glucose was not detected at sites where potato was cultivated. Most of the carbohydrates were not detected in export agricultural crop plantations (Table 3).

All carbohydrates tested were present in the soils of moist monsoon, dry monsoon, montane and dry mixed evergreen forests. In tropical wet evergreen and semi evergreen forest soils arabinose, glucose and galactose were not detected (Table 3). The concentrations of plant-derived carbohydrates were significantly high in dry monsoon forest soils (xylose and arabinose) and dry mixed evergreen forest soils (xylose) (Table 3). The soils from other forests, semi evergreen, moist monsoon, montane and tropical wet evergreen did not show any significant variations in the concentration of plant-derived sugars.

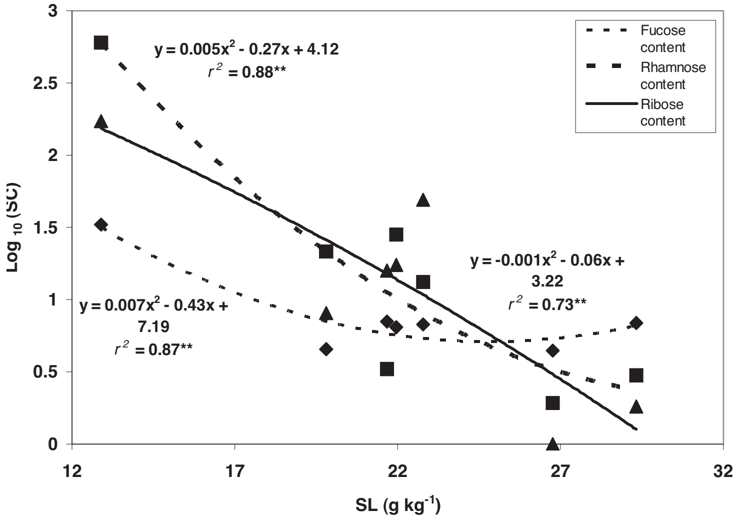

Figure 2: Relationships between the soil litter (SL) content and soil carbohydrate (SC) content, (a) rhamnose (■), (b) ribose (▲), (c) fucose (♦) in 7 major forest types [tropical wet evergreen (2 forests), semi evergreen, moist monsoon, dry monsoon, montane and dry mixed evergreen]. Each data point in the figure represents a mean of 20 composite soil samples per site. ** significant at $p < 0.01$.

Table 3: Concentrations of soil carbohydrates in sites subjected to different land uses

Ecosystem	Carbohydrates of plant origin (x 10^{-6} g kg soil^{-1})		Carbohydrates of microbial origin (x 10^{-6} g kg soil^{-1})					
	Arabinose	Xylose	Rhamnose	Fucose	Ribose	Manose	Galactose	Glucose
Forests								
Tropical wet evergreen (WL)	2.69b	3.52b	5.83b	1.99b	4.24b	4.63b	38.06b	ND
Tropical semi evergreen (IM)	ND	1.44b	3.44b	0.93b	3.20b	6.96	ND	ND
Moist monsoon (IU)	14.25b	2.24b	32.13a	598a	182a	374a	1818a	911a
Dry monsoon (IL)	96.65a	22.2a	5.76b	12.27b	50.3b	33.03b	92.52b	19.5b8
Montane (WU)	1.98b	8.69b	3.52b	20.57b	13.44b	19.94b	22.82b	7.52b
Dry mixed evergreen (DL)	2.86b	17.15a	5.44b	27.16b	18.29b	9.63b	0.44b	1.14b
Tropical wet evergreen	4.82b	2.63b	6.04b	2.30b	16.21b	2.88b	0.48b	7.44b
CV (%)	114	124	71	78	68	81	128	133
Cultivated lands								
Rubber (WL)	10.23a	7.58a	48.86a	34.64a	42.5a	26.0c	ND	31.65a
Export agricultural crops (IM)	1.45b	ND	1.99e	ND	ND	ND	ND	5.68b
Potato farm (IU)	ND	ND	5.95c	7.95c	1.03c	37.6b	130a	ND
Coconut (IL)	14.98a	22.19a	36.45b	1.69d	29.40b	51.28a	57.79b	7.79b
Tea (WU)	0.192d	1.42b	1.75e	0.49e	ND	1.41d	0.12c	ND
Chena (DL)	1.18b	5.54b	4.25c	12.41b	17.52b	3.04d	ND	1.94c
Home garden	0.534c	21.24a	3.17d	0.98e	16.14b	ND	ND	2.5c
CV (%)	47	47	36	66	89	94	178	138

Values in the same column followed by the same letter are not significantly different at $p < 0.05$. ND- not detected.

Table 4: Concentrations of soil carbohydrates in the natural forest and the adjacent cultivated lands

Ecosystem		Carbohydrates of plant origin ($x\ 10^{-6}$ g kg soil^{-1})		Carbohydrates of microbial in origin ($x\ 10^{-6}$ g kg soil^{-1})					
		Arabinose	Xylose	Rhamnose	Fucose	Ribose	Manose	Galactose	Glucose
Tropical wet evergreen		2.69 (0.73)	3.52 (1.17)	5.83 (1.64)	1.99 (0.67)	4.24 (1.49)	4.63 (2.57)	38.06 (21.12)	ND
Rubber		10.23 (2.04)	7.58 (1.69)	48.86 (10.7)	34.64 (7.16)	42.5 (10.4)	26.0 (6.69)	ND	31.65 (6.87)
	Difference	54**	4.06**	43.03**	32.65**	38.26**	21.37	-	-
Semi evergreen		ND	1.44 (0.31)	3.44 (0.58)	0.93 (5.52)	3.20 (0.71)	6.96 (3.77)	ND	ND
Export agricultural crops		1.45 (0.32)	ND	1.99 (0.26)	ND	ND	ND	ND	5.68 (1.26)
	Difference	-	-	1.45	-	-	-	-	-
Moist monsoon		14.25 (0.74)	2.24 (2.09)	32.13 (0.18)	598 (0.26)	182 (1.94)	374 (0.52	1818 (12.41)	911 (10.04)
Potato farm		ND	ND	5.95 (0.72)	7.95 (0.02)	1.03 (0.23)	37.6 (9.46)	130 (26.14)	ND
	Difference	-	-	21.18	590.05	0.79	336.1	1688	-
Dry monsoon		96.65 (4.27)	22.20 (9.81)	5.76 (1.63)	12.27 (3.75)	50.3 (11.2)	33.03 (6.77)	92.52 (21.94)	19.58 (4.78)
Coconut		14.98 (3.05)	22.19 (2.86)	36.45 (8.19)	1.69 (0.48)	29.40 (6.48)	51.28 (5.72)	57.79 (18.72)	7.79 (4.17)
	Difference	81.67	0.01	30.69	10.58	20.9	18.25	34.73	11.79
Montane		1.98 (0.11)	8.69 (3.41)	3.52 (0.25)	20.57 (5.59)	13.44 (0.25)	19.94 (3.04)	22.82 (1.6)	7.52 (0.54)
Tea		0.192 (.068)	1.42 (.0.69)	1.75 (.0.31)	0.49 (.0.27)	ND	1.41 (.0.56)	0.12 (.0.01)	ND
	Difference	1.78	7.21	1.77	20.08	-	18.53	22.7	-
Dry mixed evergreen		2.86 (2.26)	17.15 (14.57)	5.44 (0.90)	27.16 (2.97)	18.29 (5.49)	9.63 (1.27)	0.44 (0.39)	1.14 (0.61)
Chena		1.18 (0.62)	5.54 (1.92)	4.25 (0.76)	12.41 (2.78)	17.52 (.6.18)	3.04 (0.24)	ND	1.94 (0.68)
	Difference	1.68	11.61	1.19	14.75	0.77	6.59*	-	0.8
Tropical wet evergreen		4.82 (1.98)	2.63 (0.98)	6.04 (1.91)	2.30 (0.72)	16.21 (6.11)	2.88 (0.57)	0.48 (0.12)	7.44 (2.66)
Home garden		5.34 (0.24)	21.24 (1.41)	3.17 (0.58)	0.98 (0.19)	16.14 (4.28)	ND	ND	2.5 (0.95)
	Difference	0.52	18.61**	2.87**	1.32**	0.07	-	-	4.94

Values within parentheses are standard errors. ** significant at $p < 0.01$, * significant at $p < 0.05$, ND- not detected.

The concentrations of CMO were significantly high in the moist monsoon forest soils. The other forest soils did not show any variations in the concentration of CMO.

Table 4 shows the concentration of carbohydrates in soils and the differences between natural forests and the adjacent cultivated lands. CPO, arabinose and xylose were significantly high in rubber plantation soils compared to the adjacent tropical wet evergreen forest soils. CMO, rhamnose, fucose and ribose contents were also significantly high in rubber plantation soils. Glucose was present in detectable quantities in rubber plantation soils, but was not detected in the adjacent forest soils. Dry monsoon forest soils had a significantly high amount of arabinose compared to the adjacent coconut plantation soils. The xylose content was comparable in the dry monsoon forest soils and coconut plantation soils. The xylose content was significantly high (21.24 x 10^{-6} g kg soil^{-1}) in home garden soils (Table 4). Mannose content was significantly high in montane forest soils (19.94 x 10^{-6} g kg soil^{-1}) and in dry mixed evergreen forest soils (9.63 x 10^{-6} g kg soil^{-1}) compared to the concentrations in their corresponding cultivated land soils (1.41; 3.04 x 10^{-6} g kg soil^{-1}) (Table 3).

Correlation and regression analysis of soil carbohydrate contents and climatic parameters showed that glucose content in soil of cultivated lands was correlated significantly with elevation (r = 0.73; $p < 0.05$). Significant negative correlation was observed between rainfall and xylose content (r = 0.76; $p<0.05$) of the forests soils. A marginally significant relationship was observed between rainfall and soil fucose content (r= 0.68; $p< 0.05$).

DISCUSSION

Positive relationships between SL and CPO (arabinose and xylose) indicate that SL is the major source of the carbohydrates in cultivated lands (Cheshire, 1979; Kouakoua *et al*., 1999). In cultivated lands, litter incorporation into the soil generally enhances the amount of plant-derived sugars (Solomon *et al*., 2000). However, in the forests, soil carbohydrates deplete due to mineralization processes during litter humification with high microbial activities compared to the cultivated lands (Guggenberger *et al*., 1994). In cultivated lands, crop residues serve as the major source of SL whereas in forest soils, litter fall serves as their major source of SL.

The negative relationships between SL and soil CMO (rhamnose, fucose, mannose and ribose) may be due to high SL accumulation under low moisture levels and hence lower rates of decomposition. This is an interesting observation for further studies. It has been shown that when there is a high SL content, microbial respiration is found to be high in forest ecosystems (Tangtrakarnpong & Vityakon, 2002; Templer *et al*., 2005).

The carbohydrate contents were significantly high in rubber plantation soils (7.58 – 48.86 x 10^{-6} g kg soil^{-1}) as SL content increased with heavy litter fall (FAO, 2001). Minimum soil tillage in tree crop plantations (rubber and coconut) reduce the rate of decomposition and thereby increase the SC. Low biomass return may have reduced the concentration of carbohydrates in tea soils (0.12- 1.75 x 10^{-6} g kg soil^{-1}). Further, the heavy use of agrochemicals reduces the decomposition processes by lowering the microbial activities, which in turn reduce the concentration of CMO as observed in tea soils. Although there were low biomass retention and high soil disturbances in home gardens, the application of manure may have increased the carbohydrate content (Solomon *et al*., 2000). The CPO were not detected in potato soils probably due to the very low biomass return, intensive soil tillage practices and high use of agrochemicals for annual crops. Heavy soil erosion could have further reduced the carbohydrate content *via* leaching (Rodionov *et al*., 1999). Although export agricultural plantations are tree crop plantations, they showed a very low concentration of SC as the soil tillage and fertilizer applications are high compared to the other tree crops.

Rapid decomposition of CPO under the tropical climate favours the formation of CMO as observed in moist monsoon forest soils (Nacro *et al*., 2004; Amelung *et al*., 1999) where the temperature and rainfall is found to be optimum for microbial growth (Piao *et al*., 2000). The abundance of CMO in moist monsoon forest soils indicate high microbial activity in the soil, and rapid decomposition of organic matter favoured by the temperature and the elevation.The significant negative correlation between rainfall and the soil sugars has indicated that there could be a leaching of sugars with high rainfall (Rodionov *et al*., 1999). Reduced microbial activities under low temperature with the increase of elevation may have resulted in the positive correlation between elevation and soil glucose content (Amelung *et al*., 1999).

In warm climates, the labile soils carbohydrates decompose more rapidly, as micro-organisms mineralise their hexoses before they accumulate (Amelung *et al*., 1999) and the lowest amounts of microbial derived sugars, glucose (1.14 x 10^{-6} g kg soil^{-1}) and galactose (0.44 x 10^{-6} g kg soil^{-1}) were observed in dry mixed evergreen forest soils where temperature was found to be the highest compared to the other sites. The deciduous nature of dry forests may have increased the SL content and thereby increasing the availability of CPO in dry monsoon and dry mixed evergreen forests soils.

Forests with different vegetation structure did not show much variation in SC, as there were no soil disturbances that result in differences in decomposition rates. However, the soil management practices in the cultivated lands are highly variable and may induce significant variations in SC possibly by changing the litter decomposition processes (Solomon *et al*., 2000). This was further confirmed by the significant differences in SC observed between forests and the adjacent cultivated lands under the same climatic conditions.

This study confirms that the variability of SC in tropical ecosystems is governed mainly by the differences in SL content. In addition, different land use and management practices in cultivated lands influence the SC dynamics. Thus, SC, an important SOM fraction, can be improved by improving land management in tropical ecosystems. This study provides some important information that could be used to prepare guidelines on sustainable land management practices in tropical ecosystems.

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