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Comparative evaluation of physical properties in soils of orange orchard and bushy forest in chittagong hill tracts, Banglandesh

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Abstract: The physical properties of soil on two hill slopes of 35% and 55% in orange orchard cultivated by the *Mro* tribe of Chittagong Hill Tracts (CHTs) were evaluated and compared with those of bushy hill forests. Soil samples were collected from three different depths (0-5 cm, 5-15 cm and 15-30 cm), digging three profiles in each land use for determining moisture content, organic matter content and particle density. Maximum water holding capacity, field capacity, dry and moist bulk density and porosity were determined only for the surface soils. Moisture content at all the soil depths was significantly higher ($p \leq 0.05$) in orange orchard than in forest on both the slopes. Orange orchard contained lower mean soil organic matter than forest on 55% slope, while it contained higher values on 35% slope compared to forest. The highest value of the above two properties was found at surface soil in both the land uses on both the slopes, decreasing with the increase of soil depth. On both the slopes maximum water holding capacity and porosity of surface soil and particle density at all soil depths were lower in orange orchard compared to those in forest. Field capacity values of surface soil did not show consistency in trend for the differences between the two land uses on both the slopes. Bulk density value of moist and dry surface soil was higher in orange orchard than in forest on both the hill slopes.

Keywords: Orange orchard; Bushy forests; Physical property, Slope; Chittagong Hill Tracts

Introduction

In immemorial times, the human beings started their days from the forests and caves of hilly regions. As their population started increasing, the primitive dwellers began to clear forests and hills for their inhabitation and agriculture. Fruit production for human consumption began with the harvesting of wild stands from hills and forests. Today fruits are also cultivated frequently in the hilly and mountainous regions of the world (Gautam *et al*. 2004). Fruits are also found to be grown either wild or cultivated in the hills of Bangladesh. Hills make up one-fifth of the world's landscape and home to at least one-tenth of the world's people (Denniston 1995). High north-south striking hill ranges occupy wholly the district of Chittagong and Chittagong Hill Tracts (CHTs) of Bangladesh representing major hilly region in the country. The CHTs region constitutes 76% of the total hilly region of Bangladesh of which 90% of the area is hilly, 4% covered by villages, rivers and marshes and 6% only suitable for intensive agriculture (Khisa 1997). There are ethnic people in all the 64 districts of Bangladesh; however, they are concentrated in north and northeastern borders, north central region and the entire area of greater CHTs (Khan 1998). Twelve tribes were recorded in the CHTs among whom the *Mro* or *Murung* is the ancient one (Lewin 1869; Roy 1996). Hutchinson (1906) described them as the true aboriginal tribe of the CHTs who has certain peculiar customs that divide them very distinctly from the other tribes.

With the rapid increase of population and limited land resources, many countries throughout the world are facing acute problems of lands for food production. It instigates the people to convert the forestland into agricultural, horticultural and many other kinds of land uses. Such activities result in the depletion of the existing forests throughout the world, especially in Asian countries. The *Mro* tribes who live on the hilltops of deep forests in the CHTs are found to be the consumers of 28 various fruits ranging from the smallest Bethul (*Calamus* spp.) to the gigantic Kanthal (*Artocarpus heterophyllus*), most of which are harbored in the hill forests (Miah and Chowdhury 2004), where more than 50 species of edible fruit trees were found (Khisa 1998). Moreover, about half (50%) of the rich farmers (annual income Tk. >15000.00) and one-third (33.3%) of the medium farmers (annual income Tk. 10000.00- Tk. 15000.00) were found to be engaged in horticultural practices, though their primary occupation is fully concentrated on shifting cultivation (Chowdhury and Miah 2004). They usually grow orange trees in the bushy hill forests of the CHTs and it is hypothesized that such cultivation exerts an impact on the soil environment of the respective micro-

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climatic region. Taking this hypothesis into consideration, physical analysis of soil in both the orange orchard and forests was carried out to evaluate the status of certain physical properties.

Materials and Methods

Selection of soil sampling sites

Two paired sites, one on 55% slope and the other on 35% slope, were selected in orange growing area at Thanchi upazilla (sub-district) of Bandarban district under CHTs. In each pair, one part represented orange orchard and the other bushy hill forest, being adjacently located on similar slope to avoid initial variation in soil properties between the two, due to topographic differences. Soils were sampled from each of the four sites during dry season from the last week of March to the first week of April 2005. Soil samples were collected from three profiles in each part at a depth of 0–5 cm (surface soil), 5–15 cm and 15–30 cm. The slope of the sampling sites was determined with the help of Abney's Level.

Soil sample preparation

In the laboratory, collected moist soil samples were firstly sieved through 10 mm mesh sieve to remove gravel, small stones and coarse roots and then passed through 2 mm sieve. Then the sieved samples were dried under room temperature. Some samples were dried in an oven at 105 °C for 8 h.

Determination of physical properties

Soil samples were analyzed chemically to determine the bulk density, organic matter, moisture content, field capacity, porosity, maximum water holding capacity (WHC) and particle density by conventional methods of soil chemical analysis. While studying soil profile, 4 profiles were studied for differentiation of soil horizons by digging at right angles and with the help of conventional methods. The data were then analyzed statistically and arranged systematically.

Results and Discussion

Differences in soil profile characteristics between orange orchard and forest

On the surface soil of orchard litter fall was scarce because of persistent leaves of orange trees. The surface soil was also covered with undergrowth for which the soil remained moist and earthworm activities were frequent. This soil was compact due to repeated and intensive management by the owner. In the orchard soil color of 0–5 cm depth was distinctly different from that of 5–15 cm depth. Soil of 0–5 cm depth was dark brown, while 5–15 cm depth brown in color.

On the forest surface soil litters were scatteredly distributed over the ground. This layer was not compact and had no earthworm activity. Soil of 0–5 cm depth in the color and structure was distinctly different from that of the 5–15 cm. Soil of 0–5 cm was dark brown, while 5–15 cm brown in color. Further, soil of 0–5 cm was sub-angular blocky, while soil in depth of 5–15 cm granular crumb in structure.

It can be concluded from the above description that orange orchard was different from forest in absence of litter, presence of undergrowth and earthworm activities, compactness (Wilde 1958; Pritchett and Fisher 1987) etc.

Table 1. Moisture contents (%) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Land use	
		Orange orchard	Forest
55	0-5	22.67 ± 1.94*	16.20 ± 1.93
	5-15	20.07 ± 1.10*	12.20 ± 3.33
	15-30	19.60 ± 1.40*	9.47 ± 4.90
	Mean	20.78*	12.62
35	0-5	18.53 ± 3.13	17.07 ± 2.30
	5-15	17.87 ± 2.25	15.67 ± 3.82
	15-30	16.87 ± 2.00	15.87 ± 4.69
	Mean	17.76*	16.20

Each value is the mean of three replicated samples ± SD.

* The values are significant ($p \leq 0.05$).

Soil moisture contents

On 55% and 35% hill slopes, moisture contents in all the soil depths were significantly higher ($p \leq 0.05$) in orange orchard than in forest (Table 1). Moreover, mean soil moisture contents at all the depths were significantly higher in orange orchard than in forest on both the slopes. Irrespective of soil depth and hill slopes, moisture contents in orange orchard ranged from 16.87% to 22.67% and those values in forest ranged from 9.47% to 17.07%. Moisture content in soil gradually decreased in general with the increase of the depth in both the land uses on both the slopes, except in 15–30 cm depth in forest on 35% slope, where moisture content increased slightly than that of 5–15 cm depth. The evidence of decreasing moisture content with the increase in soil depth was also revealed by Haque (1997), who compared the moisture content between agricultural soils and forest soils.

Bulk density

Bulk density value of moist surface soil in orange orchard was significantly higher ($p \leq 0.05$) than that in forest on both the hill slopes (Table 2). The difference in bulk density in dry soil was larger in orange orchard than forest. Although this kind of study is not available, Singh *et al*. (2001) found highest bulk density in both degraded and slightly degraded land compared to undisturbed site. Rolfe and Boggess (1973) found significantly lower bulk density in a pine plantation compared to an old-field soil.

Table 2. Bulk density of moist and dry soil (g/cc), particle density (g/cc) and porosity (%) of surface soil on 55% and 35% slopes in orange orchard and forest

Slope (%)	Parameter	Land use	
		Orange orchard	Forest
55	Moist bulk density	1.86 ± 0.09*	1.80 ± 0.09
	Dry bulk density	1.48 ± 0.08	1.47 ± 0.06
	Particle density	2.06 ± 0.08	2.10 ± 0.05
	Porosity	28.23 ± 1.25	30.25 ± 3.24
35	Moist bulk density	1.81 ± 0.12	1.75 ± 0.19
	Dry bulk density	1.53 ± 0.14	1.39 ± 0.15
	Particle density	2.10 ± 0.05	1.99 ± 0.17
	Porosity	27.33 ± 5.15	30.25 ± 1.78

Each value is the mean of three replicated samples ± SD.

* The values are significant ($p \leq 0.05$).

On 55% hill slope, the moist and dry bulk density values were 1.86 g/cc and 1.48 g/cc, respectively in orange orchard, while these values were 1.80g/cc and 1.47 g/cc in forest. On 35% slope, the moist and dry bulk density was 1.81 g/cc and 1.53 g/cc in orange orchard and these values were 1.75 g/cc and 1.39 g/cc in forest. The existence of lower bulk density in forest soil was also evident from Rolfe and Boggess (1973) as well as Pritchett and Fisher (1987). They argued that it was lower in forest soil due to increased burrowing activity of soil fauna and higher organic matter contents. Similar occurrence was also observed in the studied forest floor rather than in orange orchard.

Porosity

Porosity of surface soil was lower in orange orchard compared to forest on both the slopes (Table 2), which may be caused by the compactness managed repeatedly and intensively by the owner. This finding is similar to other researchers (e.g., Singh *et al*. 2001; Mongia and Bondopadyay 1994). Porosity in orange orchard on 55% slope was 28.23%, which was slightly higher than the value (27.33%) on 35% slope, while porosity in forest was the same (30.25%) on both the slopes.

Particle density

On both the slopes particle density of soils at all the depths was lower in orange orchard compared to that in forest (Table 3). In orange orchard irrespective of soil depth and slopes, particle density at surface soil ranged from 2.06 g/cc to 2.10 g/cc in comparison with the density in forest range from 1.99 g/cc to 2.10 g/cc. The particle density values significantly decreased with the increase in soil depth on 55% slope, while on 35% slope although its values decreased with the increase in soil depth, the differences were not significant.

Table 3. Particle density (g/cc) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Particle density (g/cc)	
		Orange orchard	Forest
55	0-5	2.06 ± 0.08*	2.10 ± 0.05
	5-15	1.92 ± 0.13*	1.92 ± 0.12
	15-30	1.88 ± 0.13*	1.89 ± 0.08
	Mean	1.95*	1.97
35	0-5	2.10 ± 0.05	1.99 ± 0.17
	5-15	1.82 ± 0.18	1.89 ± 0.14
	15-30	1.70 ± 0.25	1.88 ± 0.16
	Mean	1.87	1.92

Each value is the mean of three replicated samples ± SD.
* The values are significant ($p \leq 0.05$).

Table 4. Maximum water holding capacity (%) and field capacity (%) of surface soil on 55% and 35% slopes in orange orchard and forest

Slope (%)	Parameter	Land use	
		Orange orchard	Forest
55	Maximum water holding capacity	22.10 ± 1.37	24.43 ± 1.64
	Field capacity	15.15 ± 0.23	13.38 ± 0.58
35	Maximum water holding capacity	21.16 ± 3.96	25.07 ± 3.26
	Field capacity	10.88 ± 2.06	14.74 ± 1.06

Each value is the mean of three replicated samples ± SD.

Maximum water holding capacity

On both the slopes maximum water holding capacity of surface soil was lower in orange orchard than in forest (Table 4). This result suggests that orchard floor was subjected to repeated and intensive management by the owner making it compact, and in effect, maximum water holding capacity of the surface soil decreased. Similar trend was also reported by many other researchers (e.g., Singh *et al*. 2001; Mongia and Bondopadhyay 1994). Hossain and Chowdhury (1984) found that water holding capacity in plantation soils increased with the age of the plantations. Within orange orchard, maximum water holding capacity was higher on 55% slope than on 35% slope but in forest the value was lower on 55% slope than on 35% slope.

Field capacity

Field capacity values of surface soil did not show consistency in trend for the differences between the two land uses on both the slopes (Table 4). On 55% slope, field capacity in orange orchard was higher than that in forest, but on 35% slope, the value was lower in orange orchard than in forest. The field capacity in orchard was higher on 55% slope and lower on 35% slope compared to corresponding forest values. Field capacity values in orange orchard were 15.15% on 55% slope and 10.88% on 35% slope, respectively, while the values in forest were 13.38% on 55% slope and 14.74% on 35% slope, respectively.

Organic matter concentration in soil

Table 5 shows organic matter concentration in soil in both the orange orchard and forest. The highest value of organic matter was found at surface soil in both the land uses. The content of organic matter was lower in orange orchard than in forest on 55% slope, while it was higher on 35% slope compared to forest. The organic matter on both the slopes decreased with the increase of soil depth. A number of studies (Zingg 1940; Hudson 1957; Roose 1980; Evans 1981; Morgan 1986) support that the rate of soil erosion increases with the rise of slope, which ultimately causes the loss of organic matter in the hilly soils.

Table 5. Organic matter contents (%) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Organic matter contents (%)	
		Orange orchard	Forest
55	0-5	3.65 ± 0.17*	3.65 ± 1.17
	5-15	3.15 ± 0.17	3.65 ± 1.25
	15-30	2.93 ± 0.10*	2.70 ± 0.67
	Mean	3.24	3.33
35	0-5	4.04 ± 0.54	4.09 ± 0.54
	5-15	3.81 ± 0.29	3.65 ± 0.34
	15-30	3.48 ± 0.17*	3.26 ± 0.35
	Mean	3.78	3.67

Each value is the mean of three replicated samples ± SD.
* The values are significant ($p \leq 0.05$).

The values of organic matter concentration at surface soil were the same in both land uses on 55% slope. On 35% slope, its value at surface soil was higher in forest than in orange orchard like (especially or such as) organic carbon. In forest, the values both in 0–5 cm and 5–15 cm depths were the same (3.65%) on 55% slope.

On both slopes the organic matter concentrations varied with the increase in soil depth within land uses. On 55% slope, there was significant difference in organic matter between 0–5 cm and 5–15 cm depths as well as between 0–5 cm and 15–30 cm depths. On 35% slope significant difference in the concentration was found only between 0–5 cm and 15–30 cm depths.

Conclusion

Certain physical properties of the bushy forest soils in the CHTs were increased after bringing them under horticulture with the cultivation of orange, while the other properties were decreased. There, the *Mro* tribe begins growing orange trees as the secondary occupation though shifting cultivation, the local primary occupation is considered as subsistence economy. The lower values of porosity and maximum water holding capacity of the surface soil in orange orchard was the result of compactness due to repeated and intensive management by the owner. Conversely, higher value of bulk density in the orange orchard proved the decreased burrowing activity of soil fauna and lower organic matter contents. In the present study, the impact of orange cultivation on physical properties of existing hill forest soils was explored only partially. Further study needs to be carried out to evaluate the impact of orange cultivation on more physical, chemical and biological properties of the soil in the CHTs. It would be helpful for policy makers to decide whether to cultivate orange and/or other kinds of fruit tree species or not in the bushy forests of CHTs to uplift the socio-economic conditions and living standard of the forest dwellers on the one hand, especially the *Mro*, the most undeveloped tribe of Bangladesh, and to improve the soil condition on the other hand.

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