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SOIL FERTILITY STATUS OF SOME ORCHARDS IN THE CHITTAGONG HILL TRACTS

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ABSTRACT

Properties of some soils of banana, jackfruit and pineapple orchards of different locations in the Chittagong Hill Tracts were studied. Soil samples were analyzed for particle size distribution, texture, pH, organic matter, total nitrogen, available P and 1*N* NH_4OAc extractable K^+, Ca^{2+} and Mg^{2+}. Particle size distributions were 76-87% sand, 2-12% silt and 10-15% clay. The textural classes of the soils varied from loamy sand to sandy loam. Soil pH, organic matter, total N and available P varied from 4.62 to 5.47, 1.66 to 2.58%, 0.11 to 0.18%, and 0.48 to 5.56 mg kg^{-1}, respectively. These properties varied significantly within the sites in all types of orchard except total N in pineapple orchard. 1*N* NH_4OAc extractable K^+, Ca^{2+} and Mg^{2+} ranged from 0.20 to 0.69 cmol kg^{-1}, 2.00 to 3.18 cmol kg^{-1} and 0.72 to 1.61 cmol kg^{-1}, respectively. A significant variation in exchangeable K^+, Ca^{2+} and Mg^{2+} was observed among the sites in all types of orchard.

Key words: Orchard, organic matter, total N, available P.

INTRODUCTION

Soil fertility management issues are becoming critical for the productivity of the land, particularly in the hills of Bangladesh. The increasing population pressure in the hills of Bangladesh stresses the environment and threatens the agricultural productivity and consequently the food security. The sustainability of hill agriculture depends how farmers manage, protect and utilize their farm and forest resources (Basnyat, 1995). Shifting cultivation, overgrazing, and overuse of marginal land are contributing to the loss of soil-fertility (Regmi, 1999). The inhabitants in the Chittagong Hill Tracts (CHT) that lies in southeastern part of the country have diversified life style with unique cultural heritage of each community. In addition to shifting cultivation, orchard cultivation is also the major agricultural practice in their food acquiring system since 1860 (Khan and Khisha, 1970). Due to tropical and subtropical climate, a variety of fruits and vegetables are grown in our country. Particularly, the distinctive climatic conditions in the Chittagong region provide a great diversity and variety for fruit production. The major fruits grown in the Chittagong Hill Tracts include mango, jackfruit, litchi, guava, banana, papaya, pineapple, watermelon, lime and lemon (Uddin et al., 2016). Fruits are highly valued in human diet mainly for vitamins and minerals. Fruits in Bangladesh cover an area of 242.8 thousand hectares with

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a total production of 10.91 lakh metric tons (BBS, 2012). Fruit contributes 10% income of the national economy and fruit cultivation covers 1-2% land of the total cultivable land of Bangladesh (Mondal *et al.*, 2011).

Poor soil fertility and substandard management are to blame for low yields and poor fruit quality that are major hurdles to overcome for a large number of production areas. Insufficient information on the soil fertility status results in poor fertilization strategy in these areas. The identification and correction of critical soil fertility factors is one of the major efforts towards improving fruits yield and quality. Although orchard cultivation is a great concern on the perspective of land and vegetation conservation in the southeastern hilly watersheds of Bangladesh, only a few studies have been done on the impact of orchard cultivation on the environment (Kibria et al., 2011). This paper outlines a soil fertility investigation involving the three prominent orchard fruit production in south-eastern part of Bangladesh.

MATERIALS AND METHODS

Study area

The study area covered three hilly districts e.g. Rangamati, Khagrachari and Bandarban. Eleven different sites were selected from six locations for auguring (0-15 cm deep) and taking soil samples (Figure 1). There were variable numbers of sites in the locations depending on the orchard cultivations and variability of slope and soil conditions. In order to study the properties of the soils under different orchard cultivation of Chittagong Hill Tracts (CHT), thirty three soil samples were collected from the selected sites of these regions. Among these soil samples, there were five banana cultivation sites, three jackfruit cultivation sites and three pineapple cultivation sites. A brief description of the locations and sites are presented below.

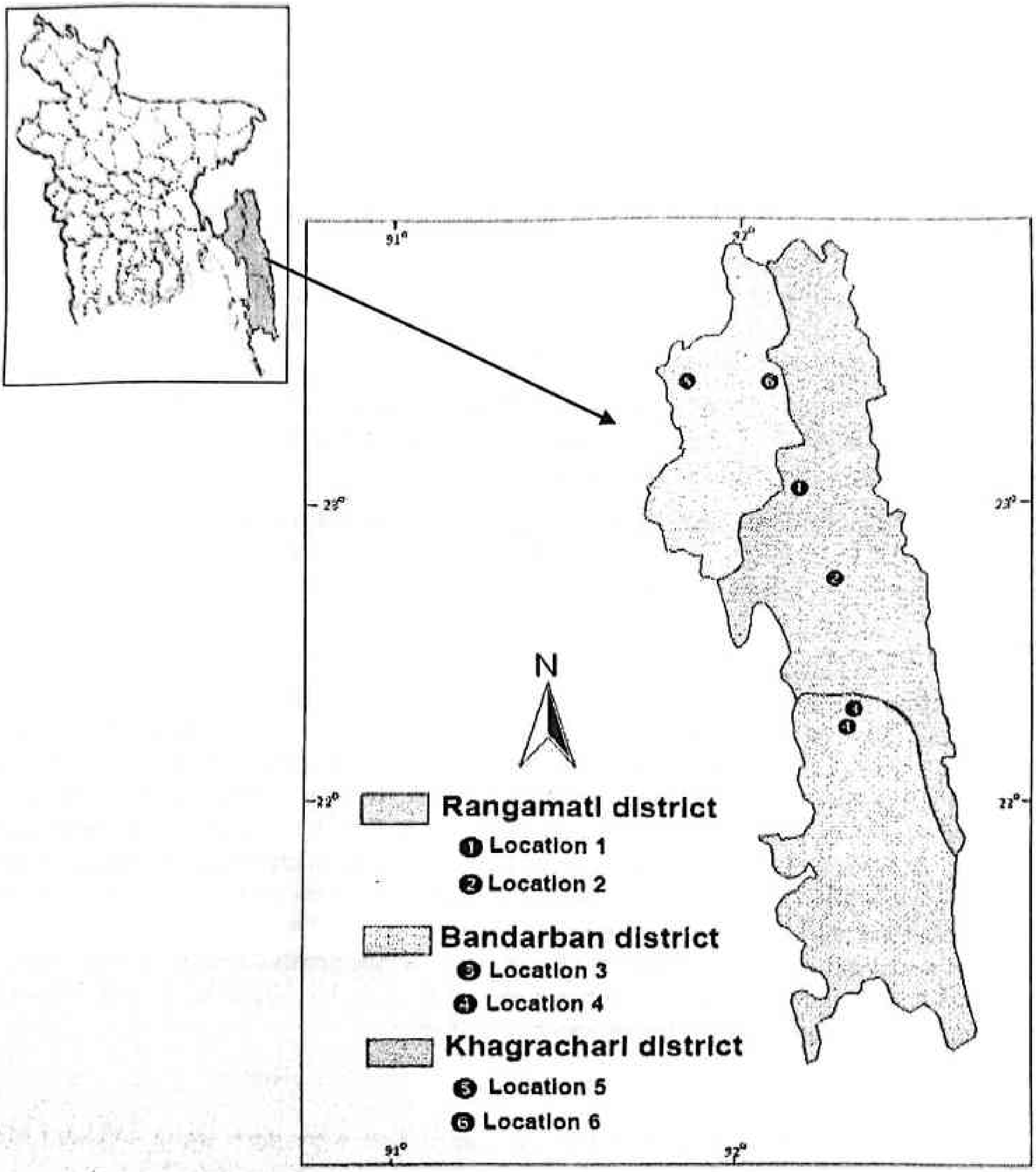

Figure 1 Locations of the study area

Location -1: Vandaritila: Vandaritila is located in Rangmati district at the geographical position of 22° 39′ 191′′ N and 92^0 08′ 630′′ E. Two sites, both with banana cultivation, were selected for collection of soil samples in this location.

Location -2: Digolibak: Digolibak is located in Rangamati district at the geographical position of 22^0 40′ 862′′ N and 92^0 11′ 33′′ E. Two sites were taken in this location for collection of soil samples. The sites were cultivated with jackfruit and pineapple, respectively.

Location -3: Getsimonipara: Getsimonipara is located in Bandarban district at the geographical position of 22^0 11′ 605′′ N and 92^0 14′ 380′′ E. Three sites were selected for collection of soil samples from this location- one site for jackfruit and two sites for pineapple cultivation.

Location -4: Mrolongpara: Mrolongpara is located in Bandarban district at the geographical position of 22^0 12′ 272′′ N and 92^0 16′ 190′′ E. Two sites were taken for collection of soil samples. In the both sites banana was cultivated.

Location -5: Alutila: Alutila is located in Khagrachari district with the geographical position of 23^0 04′ 687′′ N and 91^0 56′ 070′′ E. One site was taken for the collection of soil samples. Jack fruit was cultivated in this site.

Location -6: Golabari: Golabari is located in Khagrachari district with the geographical position of 23^0 05′ 535′′ N and 91^0 57′ 822′′ E. One site was taken for collection of soil samples. In this site banana was cultivated.

Soil sampling and Analysis

Samples from surface soil (0-15 cm) were collected from the hill top, mid-slope and foot hill of each site, taken in polythene bags, marked well and carried to the laboratory for analysis. Particle size distribution and soil textural classes were determined by Hydrometer method (Day, 1965). Soil pH was measured by an electronic pH meter from a soil-water suspension at a ratio of 1:2.5. Organic carbon was determined by Wet-oxidation method of Walkley and Black (1934). Total nitrogen was determined by micro-Kjeldahl digestion and distillation method (Jackson, 1973). Available phosphorus was extracted by ammonium fluoride-hydrochloric acid (Bray and Kurtz-2) and determined according to the Ascorbic acid blue color method (Jackson, 1973) by using a Spectrophotometer. Exchangeable potassium, calcium and magnesium were extracted with 1*N* NH_4OAC at pH 7.0 and determined by an Atomic Absorption Spectrophotometer.

Statistical Analysis

Analysis of variance and Duncan's Multiple Range Test were done using software MS EXCEL and SPSS version 12.

RESULTS AND DISCUSSION

The percentage of sand, silt and clay in soils of different sites of banana orchard varied from 76 to 85, 5 to 12 and 10 to 13, respectively. The soils varied from loamy sand to sandy loam in texture. Sand, silt and clay content of soils were 76 -87, 2-11 and 11-15%, respectively in the different sites of jackfruit orchard. The textural classes of the soils varied from loamy sand to sandy loam. In different sites of pineapple orchard, the percentage of sand, silt and clay ranged from 75 to 81, 6 to 12 and 11 to 14, respectively. The textural class of the soils was sandy loam.

Soil pH varied significantly within the sites from 5.13 to 5.37, 4.87 to 5.33 and 4.62 to 5.47 in banana, jackfruit and pineapple orchard, respectively (Table 1). In banana orchards, soil pH among the slope position was significantly different at Vandaritila-2 and Mrolongpara-2 sites (Table 2). pH was significantly lower in hill top soil than that in foot hill soil. Soil pH among the slope positions in jackfruit orchard was significantly different at Digolibak and Alutila but not at Gatsimonipara (Table 3). In pineapple orchards, soil pH varied significantly within the slope positions at Digolibak and Gatsimonipara-1 site. At Digolibak, the highest pH was found in hill top position while in foot hill position at Gatsimonipara-1 site (Table 4).

TABLE1. CHEMICAL PROPERTIES OF DIFFERENT ORCHARD SOILS IN SOME SITES OF THE CHITTAGONG HILL TRACTS

Site	pH	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	1*N* NH_4OAc Extractable cation (cmol kg^{-1})		
					K^+	Ca^{2+}	Mg^{2+}
Banana Orchard							
Vandaritila 1	5.23ab	1.89bc	0.12b	5.37a	0.34c	3.10a	1.21b
Vandaritila 2	5.20ab	2.16b	0.14b	1.77b	0.46bc	3.02a	0.95c
Mrolongpara 1	5.13b	2.58a	0.17a	5.56a	0.58a	2.60b	1.50a
Mrolongpara 2	5.37a	2.75a	0.18a	2.73b	0.41bc	2.52b	1.35ab
Golabari	5.23ab	1.66c	0.11b	0.48c	0.49ab	2.56b	1.47a
Jackfruit Orchard							
Digolibak	4.87b	1.54c	0.11c	9.89a	0.46b	2.42b	0.90b
Gatsimonipara	5.23a	2.42a	0.16a	2.74b	0.69a	2.29b	1.42a
Alutila	5.33a	2.0b	0.13b	1.80b	0.44b	2.94a	0.96b
Pineapple orchard							
Digolibak	4.62c	2.06b	0.12a	3.56a	0.20c	2.0b	0.72c
Gatsimonipara-1	5.47a	2.21b	0.15a	1.58c	0.49b	3.05a	1.61a
Gatsimonipara-2	5.10b	2.47a	0.17a	2.20b	0.66a	3.18a	1.42b

Figures in the column having the same letter(s) did not differ significantly ($p \leq 0.05$).
Each value is a mean of values of three slope positions.

TABLE 2 CHEMICAL PROPERTIES OF BANANA ORCHARD SOILS IN DIFFERENT SLOPES OF SOME SITES OF THE CHITTAGONG HILL TRACTS

Site	Slope Position	Slope	pH	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	1*N* NH_4OAc Extractable cation (cmol kg^{-1})		
							K^+	Ca^{2+}	Mg^{2+}
Vandaritila 1	Hill top	22°	5.30a	1.98a	0.14a	10.27a	0.34a	3.75a	1.25a
	Mid-slope	35°	5.30a	1.93a	0.14a	2.79c	0.33a	2.81b	1.12b
	Foot hill	21°	5.10a	1.77b	0.12a	3.05b	0.35a	2.75c	1.25a
Vandaritila 2	Hill top	16°	5.0b	1.77c	0.12b	1.50b	0.59a	2.50c	0.85b
	Mid-slope	20°	5.20ab	2.25b	0.14a	1.34c	0.36b	2.80b	0.75c
	Foot hill	12°	5.40a	2.45a	0.15a	2.48a	0.42b	3.75a	1.25a
Mrolongpara 1	Hill top	18°	5.10a	2.79a	0.20a	8.21a	0.51c	2.91b	1.62a
	Mid-slope	15°	5.20a	2.73a	0.17ab	4.70b	0.67a	2.88a	1.63a
	Foot hill	8°	5.10a	2.21b	0.15b	3.77c	0.57b	2.11c	1.25b
Mrolongpara 2	Hill top	15°	5.10b	3.04a	0.20a	2.43b	0.52a	2.10b	1.31b
	Mid-slope	25°	5.50a	3.13a	0.20a	3.72a	0.45b	2.72a	1.50a
	Foot hill	20°	5.50a	2.08b	0.13b	2.04c	0.25c	2.75a	1.23c
Golabari	Top	32°	5.20a	1.89a	0.13a	0.18c	0.32b	2.42c	1.75a
	Middle	30°	5.30a	1.62b	0.11b	0.23b	0.30b	2.58b	1.40b
	Valley	35°	5.20a	1.46c	0.10b	1.03a	0.86a	2.67a	1.25c

Figures in the column having the same letter(s) did not differ significantly ($p \leq 0.05$).

TABLE 3. CHEMICAL PROPERTIES OF JACKFRUIT ORCHARD SOILS IN DIFFERENT SLOPES OF SOME SITES OF THE CHITTAGONG HILL TRACTS

Site	Slope Position	Slope	pH	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	1*N* NH_4OAc Extractable cation (cmol kg^{-1})		
							K^+	Ca^{2+}	Mg^{2+}
Digolibak	Hill top	7°	5.0a	1.65a	0.12a	6.45b	0.32c	2.50a	0.98a
	Mid-slope	8°	4.50b	1.50b	0.10b	4.59c	0.58a	2.25b	0.84b
	Foot hill	15°	5.10a	1.46b	0.09b	18.57a	0.49b	2.50a	0.87b
Gatsimonipara	Hill top	15°	5.40a	2.48a	0.14a	4.31a	0.76a	2.25b	1.25b
	Mid-slope	20°	5.10a	2.29b	0.16a	2.53b	0.59b	2.11c	1.25b
	Foot hill	20°	5.20a	2.48a	0.17a	1.39c	0.72a	2.52a	1.75a
Alutila	Hill top	15°	5.50a	2.37a	0.15a	2.48a	0.47a	2.89b	1.25a
	Mid-slope	17°	5.30b	2.20b	0.14a	1.57b	0.46ab	2.80c	0.79b
	Foot hill	22°	5.20b	1.44c	0.10b	1.34c	0.40b	3.13a	0.83b

Figures in the column having the same letter(s) did not differ significantly ($p \leq 0.05$).

TABLE 4 CHEMICAL PROPERTIES OF PINEAPPLE ORCHARD SOILS IN DIFFERENT SLOPES OF SOME SITES OF THE CHITTAGONG HILL TRACTS

Site	Slope Position	Slope	pH	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	1*N* NH_4OAc Extractable cation (cmol kg^{-1})		
							K^+	Ca^{2+}	Mg^{2+}
Digolibak	Hill top	10°	4.80a	2.12b	0.14a	4.16a	0.25a	2.76a	0.75a
	Mid-slope	14°	4.60ab	2.29a	0.15a	3.67b	0.16b	1.50c	0.73a
	Foot hill	18°	4.47b	1.77c	0.06b	2.84c	0.20b	1.75b	0.69a
Gatsimonipara-1	Hill top	30°	5.30b	2.48a	0.17a	1.55b	0.44b	2.50c	1.50b
	Mid-slope	35°	5.60b	2.20b	0.15a	1.39c	0.52a	3.75a	1.82a
	Foot hill	40°	5.50a	1.94c	0.14a	1.81a	0.50a	2.89b	1.52b
Gatsimonipara-2	Hill top	30°	5.20a	2.58a	0.19a	2.74a	0.72a	3.02b	1.25b
	Mid-slope	28°	5.10a	2.34c	0.16a	1.37c	0.67b	3.62a	1.75a
	Foot hill	25°	5.00a	2.49b	0.17a	2.50b	0.58c	2.89c	1.25b

Figures in the column having the same letter(s) did not differ significantly ($p \leq 0.05$).

Organic matter content of soil in different sites of banana, jackfruit and pineapple orchard varied from 1.66 to 2.75 %, 1.54 to 2.42 % and 2.06 to 2.47 %, respectively (Table 1). A significant variation in organic matter content of soil was observed among the sites within an orchard. In jackfruit orchard, Gatsimonipara contained significantly higher amount of organic matter than Digolibak and Alutila. Organic matter content of soil among slope positions also varied significantly at all the sites in each kind of orchard. (Tables 2-4). Generally, at hill top soil contained higher amounts of organic matter than mid-slope and foot hill soil.

In different sites of banana, jackfruit and pineapple orchard mean total nitrogen content of surface soil varied from 0.11 to 0.18 %, 0.11 to 0.16 % and 0.12 to 0.17, respectively (Table 1). Total N content of surface soil differed significantly among the sites in banana and jackfruit orchard but not in pineapple orchard. Total N concentration in surface soil differed significantly among slope position in all the sites of banana orchard except Vandaritila-1 site. In most sites, the highest N concentration was found in hill top soil (Table 2). In jackfruit and pineapple orchards at Gatsimonipara, N concentration in surface soil did not vary significantly among the slope positions (Table 3 and 4).

Mean available P content of surface soil was in the range of 0.48 to 5.56 mg kg^{-1}, 1.80 to 9.89 mg kg^{-1} and 1.58 to 3.56 mg kg^{-1} in different sites of banana, jackfruit and pineapple orchard respectively (Table 1). A significant variation in mean available P concentration in surface soil was observed among the sites. Among the slope positions, available P concentration in surface soil also varied significantly at all sites in every kind of orchard (Table 2). Hill top soil contained significantly higher amount of available P than mid-slope and foot hill soil at Vandaritila-1 and Mrolongpara-1 sites of banana orchard, Gatsimonipara site in jackfruit orchard (Table 3), and Digolibak and Gatsimonipara-2 sites in pineapple orchard (Table 4). On the contrary, foot hill soil contained significantly higher amount of available P than mid-slope and hill top soil at Vandaritila-2 and Golabari sites of banana orchard, Digolibak and Alutila sites in jackfruit orchard, and Gatsimonipara-1 site in pineapple orchard.

1*N* NH_4OAc extractable K^+ content of surface soil of different sites ranged from 0.34 to 0.58 cmol kg^{-1} in banana orchard, 0.44 to 0.69 cmol kg^{-1} in jack fruit orchard and 0.20 to 0.66 cmol kg^{-1} in pine apple orchard (Table 1). 1*N* NH_4OAc extractable K^+ content of soil significantly differed among the sites in all fruit orchards. 1*N* NH_4OAc extractable K^+ in soil significantly varied among the slope position at all the sites except Vandaritila-1 in banana orchard (Table 2). However, there was no definite trend of variation in 1*N* NH_4OAc extractable K^+ with the slope position.

In different sites of banana, jackfruit and pineapple orchard mean 1*N* NH_4OAc extractable Ca^{2+}content of surface soil ranged from 2.52 to 3.10 cmol kg^{-1}, 2.29 to 2.94 cmol kg^{-1} and 2.0 to 3.18 cmol kg^{-1} respectively (Table 1). In all fruit orchards, 1*N* NH_4OAc extractable Ca^{2+} content of soil significantly varied among the sites. A significant variation in 1*N* NH_4OAc extractable Ca^{2+} of surface soil was also observed among the slope position at all sites. At most of the sites in banana and jackfruit orchards, the highest Ca^{2+} content was found in foot hill soil (Table 2 and 3).

Mean 1*N* NH_4OAc extractable Mg^{2+} content of surface soil in different sites of banana, jackfruit and pineapple orchard varied from 0.95 to 1.50 cmol kg^{-1}, 0.90 to 1.42 cmol kg^{-1} and 0.72 to 1.61 cmol kg^{-1}, respectively (Table 1). 1*N* NH_4OAc extractable Mg^{2+} content of soil significantly varied among the sites in all fruit orchards. Within the sites, 1*N* NH_4OAc extractable Mg^{2+} content of surface soil varied significantly among the slope positions except in pineapple orchard at Digolibak. In most of the sites, hill top soil contained the highest amount of 1*N* NH_4OAc extractable Mg^{2+}. 1*N* NH_4OAc extractable Mg^{2+} gradually decreased from hill top to foot hill in banana orchard at Golabari and pineapple orchard at Digolibak (Table 2 and 3).

According to classification of soils on the basis of soil reaction (BARC, 2012), the studied soils are strongly to moderately acidic. The soils are generally poor in organic matter and nutrients. As compared to standard values for agricultural soils of the country, the present values may be considered to be low to moderate. The average organic matter content of Bangladesh soils is less than 1%. However, some of the studied soils had organic matter higher than 2% that might have developed from the luxuriant past forest vegetation. The differences in natural fertility, variation in cultural practices and applied N fertilizers might cause the variation in N contents. According to the quantitative standards suggested by Jackson (1962), for soil N all soils are high in total N contents. Similar to N, there was much variation in soil available P. The available phosphorus in Bangladesh soils could be considered between low and medium (BARC 2012). In the present study, available P content of the soils was in the low range in all sites. On the basis of standards for P (deficient <3.0 mg kg^{-1}, low range 3.0-4.0 mg kg^{-1}, satisfactory range 5.0-7.0 mg kg^{-1} and high range >8.0 mg kg^{-1}) laid down by Watanabe and Olsen (1965), most of the soils were deficient in and some had low level of available P. Only 12% of the soils had sufficient available P for normal plant growth. About 0.12 cmol kg^{-1} of NH_4OAc extractable K is considered the critical limit for Bangladesh soils. The present exchangeable K values are mostly above the critical level.

Banana tolerates a wide range of soil acidity, pH 5.5–7.5 is optimal (Scot et al., 2006). Fertility of soil is very important for successful cultivation, as banana is a heavy feeder. Banana is a quick growing and exhaustive crop for nutrient requirement for its growth. In hilly areas and homesteads, banana is being grown without any fertilizer. Though there is a recommendation of fertilizer application in banana, the farmers do not usually follow. Only the commercial scale farmers use it. Most of the growers use high amount of phosphate and urea but low potash (Islam and Hoque, 2003). Banana crop is a heavy potassium (K) feeder in comparison to many other crops and it has to be taken into account when a fertilization program is planned. Banana is being grown in Chittagong Hill Tracts from very long time without prior evaluation of the site conditions. The slope and drainage conditions of the sites are ideal. Depth and fertility of soils of most of the present sites are also satisfactory. Still, adequate fertilizer application and other management practices are needed.

Jackfruit grows best in well drained, deep soils of moderate fertility but tolerates a wide range of soils including shallow limestone, sand, and rocky substrates. The tree does not tolerate water stagnation or poor drainage (Elevitch and Manner, 2006). If the roots touch stagnant water, the tree fails to bear fruit, or it may die. The tree can grow in light and medium textured soils (sands, sandy loams, loams, and sandy clay loams). It requires free drainage. The tree tolerates moderately acid to neutral soils (pH 5.0–7.5) (Elevitch and Manner, 2006). It performs best on deep well drained alluvial, sandy or clay loam soils with pH 6.0-7.5. Properties of soils of the present sites are satisfactory.

Pineapples grow and produce best where the soil is well drained and with pH range of 4.5 to 5.5. The predominant soil types are clay loam, clay, and clay soils of the valleys, hills and mountains. Pineapples thrive best in a sandy loam, mildly acid soil of medium fertility. They tolerate drought remarkably well, but adequate soil moisture is necessary for good fruit production (Malo and Compbell., 1994). Thus, fine textured, slightly to moderately sloping, strongly to moderately acidic fertile soils of the Chittagong Hill Tracts are ideal for pineapple cultivation. However, planting pineapples along the slope must be restricted to avoid severe soil erosion.

The findings of present research work give an indication of an urgent need of long term fertility management program and monitoring for sustainability of fruit orchards of the Chittagong Hill Tracts.

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