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SOIL FERTILITY STATUS OF SOME OF THE INTENSIVE CROP GROWING AREAS UNDER MAJOR AGRO-ECOLOGICAL ZONES OF BANGLADESH

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Abstract

Laboratory studies on soil fertility evaluation was carried out across major agro-ecological zones (AEZs) of Bangladesh to know the nutrient status of soils and to relate those with soil properties like pH, organic matter, CEC, and clay content. Thirty five composite soil samples were collected from intensive crop growing sites, which covered 17 AEZs of Bangladesh. After proper processing, the samples were analyzed for texture, pH, organic carbon, CEC, exchangeable cations (K, Ca, Mg and Na), total N, available P and S following standard methods. The textural class of the soils collected from AEZ 12 and 13 appeared to be mostly clay. Clay loam soil was found in AEZ 4, 8, 9, 11, 25 and 28. Loamy soil was seen in AEZ 1 while AEZ 22, 23 and 29 were mostly sandy textured. The results revealed that 65.7% of the tested soil was acidic while 25.7% was alkaline in nature. All the tested soils showed lower pH_{KCl} compared to pH_{H2O} thus possessed negative charge. About 68.6% of the collected soils contained low (1.10-1.70%) level of organic matter, 25.7% soils retained it at medium level (1.71-2.40) and 5.7% soils at very low level (<1.0%). All the tested soils appeared to be deficient (< 0.12%) in nitrogen content. 68.6% soil samples had the low level of available P while only 8.6% retained it an optimum amount. About 80% of the tested soils contained low level of available S (7.9-14.7 mg kg^{-1}) although coastal regions soils hold higher amount of available S. High CEC (20-38 cmol kg^{-1}) was found in clay rich soils of AEZ 10, 11, 12, and 13. Study revealed that 40% of the collected soils were very low, 31.4% were low, 8.6% each of medium and optimum, and 11.4% contained high level of exchangeable K. The calcareous soils (AEZ 10, 11, 12 and 13) contained very high level of Ca. Non calcareous soils also showed fairly good level of Ca content except AEZ 1, 3, 23 and 29. Sandy textured soils of greater Dinajpur, Rangpur, Moulvibazar showed lower level of exchangeable Mg. About 86% of the tested soils had the lower (< 2%) potassium saturation percentage (KSP), which needs K application for sustainable crop production. Estimate showed that 44% variability for CEC may be attributed by clay content and the relationship was significant ($p = 0.05$). Again, 50.4 and 65.6% variability in exchangeable K and Mg, respectively may be governed by clay content of the soils, while such relationship for Ca was non-significant. CEC may contribute 62.2, 92.3 and 83.9% variability for exchangeable K, Ca and Mg content in soils, respectively. The fertility status of most of the studied soils (except AEZ

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10, 12, 13 and to some extent 11) appeared to be low to very low, which demand judicious management in order to achieve food security and to conserve the soil fertility.

Keywords: Soil fertility, agro-ecological zones, texture, organic matter, cation exchange capacity

Introduction

Even though Bangladesh is a small country, but it has wide variation and complexity of soils due to diverse nature of physiography, parent materials, land type, drainage conditions and agro ecology. Depending on these aspects, the country has been divided into 30 agro ecological zones (AEZ), which varied greatly in respect of area, land and soil, climate, and cropping intensity (FAO-UNDP, 1988). Some AEZs are very potential for crop agriculture and nutrient supplying capacity but some are being depleted due to intensive cropping.

Increasing cropping to meet the demands for food for a swelling population has led to mining out the inherent plant nutrients from the crop fields thereby fertility status of the soils severely declined in Bangladesh over the years (Ali *et al*., 1997 and Khan *et al*., 2008). The use of chemical fertilizers as the supplemental source has been increasing steadily but these are not applied in balanced proportion. Of the total fertilizer used in the country, urea alone constituted about 75% (FRG, 2012). Previous study indicated that about 60% cultivable land of Bangladesh is deficient in N, P and K (Miah *et al*., 2008). Moreover, organic matter content in country's soils is low, the majority being below the thresh hold level (1.5%) and it was gradually depleted by 5 to 36% during the period of 1967-1995 (Ali *et al*., 1997). Islam (2008) mentioned that organic matter content in Bangladesh soils is generally around 1% in most and around 2% in few soils. Sulfur deficiency in Bangladesh soils is supposed to be increased gradually due to increased use of high analysis S free fertilizers over the years, higher removal by HYV crops, prolonged submergence for rice cultivation and low level of organic matter. Soils are being disturbed vigorously through tillage operation like plowing, puddling, laddering and so on, leading to higher rate of decomposition of organic matter.

The fertility status of Bangladesh soils is not available widely. The systematic work in this regard is very scarce. The information in this regard available so far is mostly old one. Soil fertility is a dynamic phenomenon and the magnitude of change depends on how intensively the land is used, nutrients are added and removed by the crops. It is, therefore, felt necessary for the evaluation of the fertility status of Bangladesh soils to update and make information available to the scientists, extension personnel, students as well as policy makers for the judicious management of soil resources for achieving food security ensuring better soil health for sustainability. Keeping this view in mind, the present studies were undertaken across major agro-ecological zones (AEZs) of Bangladesh in order to know the nutrient status of soils and to relate those with soil properties like pH, organic matter, CEC, exchangeable bases and clay content.

Materials and Method

Sites: Soil collection sites were selected mostly on the basis of the cropping intensity of the region covering major agro ecological zones (AEZs) of Bangladesh. The soil sampling sites are shown in Fig.1 representing the Map of the country.

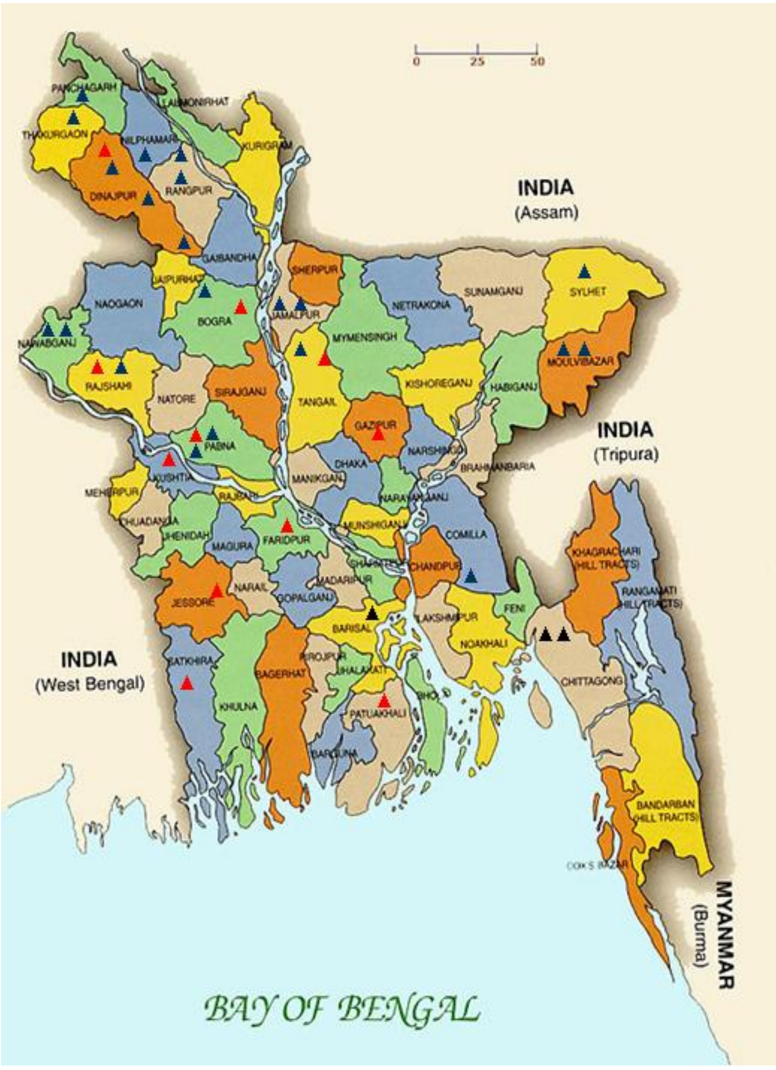

Fig. 1 Map showing the soil sampling sites representing major AEZ of Bangladesh ∆ Indicates sampling sites.

Table 1. Location, geographical position and major crops and cropping patterns of the soil sampling sites

Sl. No	Location	Geographical position	AEZ	*Soil taxonomy	*Soil Series	*Physiographic unit	Cropping pattern
1	Atwari, Panchagarh	N 26^{o} 13' 347″ E 88^{o} 26' 020″	1	Haplambrepts	Baliadangi	Old Himalayan Piedmont Plain	Potato-Mungbean-T. aman
2	Thakurgaon Sadar	N 26^{o} 04' 745″ E 88^{o} 30' 707″	1	Ustochrepts	Amnura	Old Himalayan Piedmont Plain	Boro-Fallow-T. aman
3	Birgonj, Dinajpur*	N 25^{o} 53' 197″ E 88^{o} 37' 498″	1	Albaquept	Amnura	Old Himalayan Piedmont Plain	Potato/Maize-T. aman
4	Kaharole, Dinajpur	N 25^{o} 48' 903″ E 88^{o} 39' 854″	1	Albaquept	Amnura	Old Himalayan Piedmont Plain	China Boro-T. aman
5	Dinajpur Sadar, Dinajpur	N 25^{o} 42' 848″ E 88^{o} 39' 731″	1	Albaquept	Amnura	Old Himalayan Piedmont Plain	Boro-T. aman
6	Fulbari, Dinajpur	N 25^{o} 29' 416″ E 88^{o} 57' 923″	1	Albaquept	Amnura	Old Himalayan Piedmont Plain	Boro fallow-T. aman
7	Kamarpukur, Nilphamari	N 25^{o} 47' 118″ E 88^{o}56'069″	3	Fluvaquents	Gangachara	Tista Floodplain	Boro-T. aman
8	Gangachara, Rangpur	N 25^{o} 50' 051″ E 89^{o}14' 292″	3	Haplaquepts	Gangachara	Tista Floodplain	Aus-T.aman
9	Rangpur Sadar	N 25^{o} 41' 759″ E 89^{o} 16' 070″	3	Haplaquepts	Palashbari	Tista Floodplain	Boro-T. aman
10	Sonatola, Bogra*	N 25^{o} 01' 651″ E 89^{o} 27' 054″	4	Albaquept	Palashbari	Karatoya Bangali Floodplain	Boro-T. aman
11	Shibgonj, Bogra	N 24^{o} 58' 656″ E 89^{o} 20' 191″	25	Albaquept	Akdala	Barind Tract	Onion- GM-T. aman
12	Salimpur (Ishurdi), Pabna*	N 24^{o} 06' 014″ E 89^{o} 05' 539″	11	Eutrochrepts	Sara	Ganges River Floodplain	Lentil/Chickpea-Banana-Fallow

Table 1. Cont'd.

Sl. No	Location	Geographical position	AEZ	*Soil taxonomy	*Soil Series	*Physiographic unit	Cropping pattern
13	Pakuria (Ishurdi), Pabna	N 24^{o} 02' 592″ E 89^{o} 04' 497″	11	Fluvaquents	Ishurdi	Ganges River Floodplain	Boro-T. aman
14	RARS (Ishurdi), Pabna	N 24^{o} 07' 315″ E 89^{o} 04' 591″	11	Eutrochrepts	Ishurdi	Ganges River Floodplain	Wheat-Mungbean-T. aman
15	Bheramara, Kushtia*	N 24^{o} 04' 633″ E 88^{o} 59' 453″	11	Eutrochrepts	Sara	Ganges River Floodplain	Maize-T. aman
16	Jessore Sadar, Jessore*	N 23^{o} 10' 458″ E 89^{o} 17' 732″	11	Haplaquepts	Gopalpur	Ganges River Floodplain	Vegetables/ pulse-T. aman
17	Godagari, Rajshahi (HL)*	N 24^{o} 28' 987″ E 88^{o} 29' 990″	26	Eutrochrepts	Nachol	Barind Tract	Mustard/Chickpea – T. aman
18	Godagari, Rajshahi (LL)	N 24^{o} 28' 912″ E 88^{o} 29' 980″	26	Ustochrepts	Amnura	Barind Tract (Grey valley)	Boro-T. aman
19	Chapai Nawabgonj Sadar	N 24^{o} 35' 555″ E 88^{o} 16' 759″	26	Haplaquepts	Nachol	Ganges River Floodplain	General cultivation
20	Barogharia, Chapai Nawabgonj	N 24^{o} 37' 074″ E 88^{o}14'892″	10	Haplaquepts	Amnura	Ganges River Floodplain	Boro-T. aman
21	Kanaipur, Faridpur*	N 23^{o} 30' 832″ E 89^{o} 46'845″	12	Eutrochrepts	Gopalpur	Ganges River Floodplain	Onion/wheat-Boro-T. aman
22	Benerpota, Satkhira*	N 22^{o} 44′ 888″ E 89^{o} 06′ 361″	13	Haplaquepts	Barisal	Ganges Tidal Floodplain	Research field
23	Babuganj, Barisal	N 22^{o} 42' E 90^{o}23'	13	Haplaquepts	Barisal	Ganges Tidal Floodplain	Aus- T. aman
24	Mirzagonj, Patuakhali*	N 22^{o} 25′ 589″ E 90^{o} 13′ 631″	13	Haplaquepts	Jhalokhati	Ganges Tidal Floodplain	Aus-T. aman
25	Yugitola, Gazipur*	N 23^{o} 58' 911″ E 90^{o} 24' 388″	28	Aeric Haplaquepts	Chhiata	Madhupur Tract	Aus-T. aman

Table 1. Cont'd.

Sl. No	Location	Geographical position	AEZ	*Soil taxonomy	*Soil Series	*Physiographic unit	Cropping pattern
26	Madhupur, Tangail*	N 24° 37' 060″ E 90° 05' 385″	28	Haplaquepts	Silmondi	Madhupur Tract	Pineapple-Papaya-Turmeric
27	Gopalpur, Tangail	-	8	Haplaquepts	Sonatala	Brahmaputra – Jamuna Floodplain	Mustard-Boro-T. aman
28	Jamalpur Sadar, Jamalpur	N 24° 54' 372″ E 89° 55' 086″	9	Haplaquepts	Jamalpur	Brahmaputra – Jamuna Floodplain	Potato- Boro-T. aman
29	West Ramnagar, Jamalpur	N 24° 54' 104″ E 89° 54' 766″	9	Haplaquepts	Sonatala	Brahmaputra – Jamuna Floodplain	Mustard/chilli-Boro-T. aman
30	Akbarpur, Moulvibazar	N 24° 24' E 91° 37'	29	Haplaquepts	Balagonj	Northern and Eastern Piedmont Plain	Aus -T. aman
31	RARS (Akbarpur), Moulvibazar	N 24° 24' E 91° 37'	22	Haplaquepts	Goainghat	Northern and Eastern Piedmont Plain	Citrus orchard
32	Khadim Nagor, Sylhet	-	20	Eutrochrepts	Monu	Surma-Kushiara Floodplain	T. aman
33	Chandina, Comilla	-	16	Aeric Haplaquepts	Debidwar	Meghna River Floodplain	Mustard-fallow-B. Aman
34	Hathazari, Chittagong	N 22° 30' 958″ E 91° 47' 535″	23	Ustochrepts	Mirsarai	Chittagong Coastal Plain	Chilli-fallow-T.aman
35	RARS (Hathazari), Chittagonj	N 22° 30' 186″ E 91° 47' 678″	23	Ustochrepts	Mirsarai	Chittagong Coastal Plain	Maize-legume-T. aman

*****Included for the sake of study

Soils: The collected soils represented 19 series, which covered 21districts and 17 AEZs of Bangladesh. The location, geographical position, agro-ecological zones, soil taxonomy, soil series, physiographic units and major cropping patterns of the sampling sites are presented in Table 1.

Collection, preparation and analysis of soils: Five soil samples (0-15 cm) were collected from each of the selected sites and mixed together thoroughly to make a composite sample. Soils were mostly collected from farmers' field to get the representative sample of the locality during February - April 2009. Collected composite soil samples (35) were brought to the Soil Science Laboratory, BARI, Gazipur and air dried and ground to pass through 20 mesh sieve. The samples were then analyzed for texture, pH, organic carbon, CEC, exchangeable cations (K, Ca, Mg, Na), total N, available P and available S following standard laboratory methods as stated below.

Analytical methods: Mechanical analysis of soils was done by hydrometer method (Bouyoucos, 1962) and the textural class was determined from Marshall's triangular co-ordinate following USDA system. A glass electrode pH meter calibrated with buffer pH 7.0 and 4.0 measured the pH of the soil suspension maintaining soil: water ratio of 1:2.5 (Page *et al*., 1982). The pH_{KCl} was determined by stirring 10 g soil in 25 ml of 1.0 M KCl solution in a similar manner of pH_{H2O} determination. The difference between the pH in KCl and that in water gave the value of Δ pH.

$$\Delta\, pH = pH_{KCl} - pH_{H2O}$$

The value of the Δ pH indicates the surface charge characteristics. A positive value of Δ pH symbolizes positive surface charge while the negative value denotes negative surface charge. Cation exchange capacity of the soil was determined by Schollenberger (1980) method. Organic carbon was determined by wet oxidation method as described by Walkley and Black (1935) and the organic matter content was estimated by multiplying the percent organic carbon with the Van Bemmelen factor 1.73. Total N content of soil was determined following micro Kjeldhal method (Bremmer and Mulvancy, 1982). For the determination of available P, Bray 1 method (Bray and Kurtz, 1945) was used for acid soils while Olsen method (Olsen, 1982) was followed for neutral and alkaline soils. The filtrate was analyzed for P following Murphy and Riley (1962) method. Available S was determined by extracting the soil sample with 0.15 % $CaCl_2$ solution as described by Page *et al.* (1982). The reading was taken using UV visible Spectrophotometer (Varian Model 50 Conc.) at 720 nm and 420 nm wavelength for P and S, respectively. Exchangeable bases (K, Ca, Mg and Na) were extracted with 1 M NH_4OAc solution (pH = 7) (Thomas, 1982). In case of exchangeable K, the reading was taken directly using AAS (Chemito AA 203) at 766.5 nm wavelength. For Ca, 2 ml aliquot was diluted with 1 ml of La_2O_3 and 7 ml of distilled water and then reading was taken using AAS (Chemito AA 203). In case Mg and Na, 1 ml aliquot was diluted with 9 ml of distilled water and reading was taken using the same AAS.

Statistical analysis: The data were statistically analyzed for mean, range, standard deviation, standard error following the methods of descriptive statistics. Regression analysis was also done to observe the relationship between desired soil properties.

Results and Discussion

The experimental soils varied widely in texture, pH, organic matter and essential plant nutrients like nitrogen, phosphorus, potassium, and sulfur content (Tables 2 and 3). Moreover, cation exchange capacity (CEC) and basic cation contents also varied greatly (Table 4).

Soil particles and textural class

Sand particle (2.00-0.05 mm) of the collected soils varied from 22-72% (Table 2) where the highest sand content was recorded in Balagonj Sandy Loam (Soil No. 30) at Akbarpur, Moulvibazar under AEZ 22. The lowest sand content (22%) was found in Sonatola Clay Loam (Soil No. 29) at West Ramnagar, Jamalpur under AEZ 9. In general, AEZ 1, 3, 22, 23 and 29 showed higher sand particles and AEZ 10, 11, 12 and 13 contains lower sand particles. The rest of the AEZs under this study contain moderate level of sand (30-49%).

The second category soil particle, silt (0.05-0.002 mm) also varied widely (16-50%) among the studied soils (Table 2). The highest silt content (50%) was obtained from Amnura Silt Loam (Soil No. 20) at Barogharia, Chapai Nowabgonj under AEZ 10. The higher (35-40%) silt content was found in Soil No. 6, 14, 15, 19, 23, 28 and 33 across different AEZs as presented in Table 2. The moderate (30-34%) amount of silt content was recorded in Soil No. 2, 8, 9, 13, 16, 24 and 28 while rest of the soils contained low amount (<30%) of silt particle. Thus silt content varied among the collected soils irrespective of AEZs.

The clay (<0.002 mm) content of the tested soils varied from 12 to 64 % (Table 2) where the highest result was found in Barisal Clay (Soil No. 22) at Benerpota, Satkhira sunder AEZ 13. Soils collected from Bogra, Pabna, Jessore, Tangail and Gazipur had medium amount (30-34%) of clay. The lower amount of clay (17-29%) was recorded from the soils of Rangpur, Dinajpur and Chittagong (AEZ 23). The lowest clay (12%) content was found in Balagonj Sandy Loam (Soil No. 30) at Akbarpur, Moulvibazar under AEZ 29.

Thus textural class of soils collected from Faridpur (AEZ 12), Satkhira and Patuakhali (AEZ 13) was clay (Table 2). Clay loam soil was found in Barind, Rajshahi (AEZ 26), Jamalpur (AEZ 9) Tangai (AEZ 8 and 28), Bogra (AEZ 4 and 25) and Barisal (AEZ 13). The soils sampled from AEZ 11 (Pabna, Kushtia and Jessore) were mostly clay loam and loam. The collected soils of greater Dinajpur (AEZ 1) appeared to be either loam or sandy clay loam. The soils collected from Moulvibazar (AEZ 22, 29) and Chittagong (AEZ 23) were sandy textured (Table 2).

Table 2. Soil particles and textural class of studied soils of Bangladesh

Sl. No.	Name of the Soil	Location	AEZ	Soil particles (%)			Textural Class
				Sand	Silt	Clay	
1	Baliadangi SCL*	Atwari, Panchagarh	1	59	22	19	Sandy clay loam
2	Amnura loam	Thakurgaon Sadar	1	43	34	23	Loam
3	Amnura loam	Birgonj, Dinajpur	1	49	28	23	Loam
4	Amnura SCL	Kaharole, Dinajpur	1	57	21	22	Sandy clay loam
5	Amnura SCL	Dinajpur Sadar	1	63	20	17	Sandy clay loam
6	Amnura loam	Fulbari, Dinajpur	1	39	38	23	Loam
7	Gangachara loam	Kamarpukur, Nilphamari	3	37	27	40	Clay loam
8	Gangachara SCL	Gangachara, Rangpur	3	51	27	22	Sandy clay loam
9	Palashbari loam	Rangpur Sadar	3	47	33	20	Loam
10	Palashbari clay loam	Sonatala, Bogra	4	38	32	30	Clay loam
11	Akdala clay loam	Shibgonj, Bogra	25	40	26	34	Clay loam
12	Sara loam	Salimpur (Ishurdi), Pabna	11	29	44	27	Loam
13	Ishurdi loam	Pakuria (Ishurdi), Pabna	11	49	32	19	Loam
14	Ishurdi clay loam	RARS (Ishurdi), Pabna	11	33	35	32	Clay loam
15	Sara loam	Bheramara, Kushtia	11	39	38	23	Loam
16	Gopalpur clay loam	Jessore Sadar, Jessore	11	37	31	32	Clay loam
17	Nachol loam	Godagari, Rajshahi (HL)	26	37	38	25	Loam
18	Amnura clay loam	Godagari, Rajshahi (LL)	26	35	26	39	Clay loam
19	Nachol loam	Chapai Nawabganj Sadar	26	39	36	25	Loam
20	Amnura silt loam	Barogharia, Chapai Nawabganj	10	25	50	25	Silt loam
21	Gopalpur clay	Kanaipur, Faridpur	12	23	15	62	Clay
22	Barishal clay	Benerpota, Satkhira	13	24	12	64	Clay
23	Barishal clay loam	Babuganj, Barisal	13	30	38	32	Clay loam

Table 2. Cont'd.

Sl. No.	Name of the Soil	Location	AEZ	Soil particles (%)			Textural Class
				Sand	Silt	Clay	
24	Jhalokathi clay	Mirzaganj, Patuakhali	13	24	34	42	Clay
25	Chhiata loam	Yugitola, Gazipur	28	33	41	26	Loam
26	Silmondi clay loam	Madhupur, Tangail	28	26	44	30	Clay loam
27	Sonatola clay loam	Gopalpur, Tangail	8	44	24	32	Clay loam
28	Jamalpur clay loam	Jamalpur Sadar, Jamalpur	9	38	32	20	Clay loam
29	Sonatola clay loam	West Ramnagar, Jamalpur	9	22	40	38	Clay loam
30	Balagonj sandy loam	Akbarpur, Moulvibazar	22	72	16	12	Sandy loam
31	Goainghat SCL	RARS (Akbarpur), Moulvibazar	29	60	18	22	Sandy clay loam
32	Monu SCL	Khadim Nagor, Sylhet	20	47	27	26	Sandy clay loam
33	Debidwar loam	Chandina, Comilla	16	38	38	24	Loam
34	Mirsarai SCL	Hathazari, Chittagong	23	52	28	20	Sandy clay loam
35	Mirsarai SCL	RARS (Hathazari), Chittagong	23	50	29	21	Sandy clay loam
SE (±)				2.09	1.49	1.87	
STD				12.36	8.82	11.06	
Range				22-72	12-50	12-64	

SCL = Sandy clay loam

AEZ 1 = Old Himalayan Piedmont plain; AEZ 3 = Tista Meander Floodplain; AEZ 4 = Karotoya Bangali Floodplain: AEZ 8 = Young Brahmaputra and Jamuna Floodplain

AEZ 9 = Old Brahmaputra Floodplain; AEZ 10 = Active Ganges Floodplain; AEZ 11 = High Ganges River Floodplain; AEZ 12 =Low Ganges River Floodplain

AEZ 13 = Ganges Tidal Floodplain ; AEZ 16 = Middle Meghna River Floodplain;AEZ 20 = Eastern Surma Kushiara Floodplain; AEZ 22 = Northern and Eastern Piedmont Plains

AEZ 23 = Chittagong Coastal Plains; AEZ 25 = Level Barind Tract;AEZ 26 = High Barind Tract ; AEZ 28 = Madhupur Tract; AEZ 29 = Northern and Eastern Hills

Soil pH and charge characteristics

Soil pH_{H2O} was moderately alkaline (8.0-8.3) in AEZ 11 except Gopalpur clay loam at Jessore (pH 7.5) where the highest value was observed in Sara loam and Ishurdi clay loam at Pabna and lowest in Sara loam at Bheramara, Kushtia (Soil No. 15). Strongly acid soil (pH 4.7-5.5) was found in AEZs 1, 3, 20, 22, 23, 28 and 29 where the highest result was found both in Gangachara Sandy Clay Loam at Ranpur (Soil No. 8) under AEZ 3, Balagonj Sandy Loam at Moulvibazar (Soil No. 30) under AEZ 22 and the lowest in Goainghat Sandy Clay Loam at Akbarpur (Soil No. 31) under AEZ 29. The tested soils of greater Dinajpur (AEZ 1), Barind region of Rajshahi (AEZ 26), Gazipur (AEZ 28), Madhupur of Tangail (AEZ 28) and Chittagong (AEZ 23) appeared to be strongly acidic in nature (Table 3). The results revealed that 65.7% of the tested soil was acidic while 25.7% was alkaline in nature.

Soil pH_{KCl} showed slightly lower value in all the cases, however, the magnitude of difference between pH_{H2O} and pH_{KCl} varied from 0.6 to 1.8 unit (Table 3) where the highest negative value was observed in Gopalpur Clay Loam Soil at Jessore (Soil No. 16) and the lowest value in Silmondi Clay Loam at Madhupur, Tangail (Soil No. 26) indicating the strength of negative charge characteristics of the tested soils. Since all the tested soils had lower pH_{KCl} compared to pH_{H2O}, essentially, all of them possess negative charge on the surface of the soil particles.

Organic matter

The tested soils varied widely in organic matter content (Table 3). About 68.6% of the collected soils contained low (1.10-1.70%) level of organic matter, 25.7% soils retained it at medium level (1.71-3.40) and 5.7% soils showed it at very low (<1.0%) level. The highest organic matter content (2.40%) was found in Monu Sandy Clay Loam (Soil No. 32) at Khadim Nagor, Sylhet under AEZ 20 followed by Goainghut Sandy Clay Loam (Soil No. 31) at Akbarpur Moulvibazar under AEZ 29 and Barisal Clay at Benerpota, Shatkhira (Soil No. 22) under AEZ 13 and may be interpreted to be medium in status. The lowest organic matter (0.88 %) was observed in Barisal Clay Loam (Soil No. 23) at Babuganj, Barisal under AEZ 13, which was closest to the Debidwar Loam (Soil No. 33) at Chandina, Comilla under AEZ 16 and can be regarded as very low in category. Islam (2008) mentioned that organic matter content in Bangladesh soils is generally around 1% in most and around 2% in few soils. But a productive mineral soil should have at least 2.5% organic matter (Rijpma and Jahiruddin, 2004). Ali *et al*. (1997) reported that organic matter content in soils gradually depleted by 5-36% during the period of 1967-1995.

Table 3. Soil pH, charge characteristics, organic carbon, nitrogen, phosphorus and sulphur fertility of major soils of Bangladesh

Soil No.	Name of the Soil	Location	AEZ	pH (H_2O)	pH (KCl)	Δ pH	Organic matter (%)	Total-N (%)	Available	
									P (mg kg^{-1})	S (mg kg^{-1})
1	Baliadangi SCL*	Atwari, Panchagarh	1	5.0	4.1	-0.9	1.90	0.103	8.4 L	13.6
2	Amnura loam	Thakurgaon Sadar	1	5.5	4.2	-1.3	1.53	0.082	5.5 L	10.4
3	Amnura loam	Birgonj, Dinajpur	1	5.2	4.1	-1.1	1.48	0.078	7.0 L	8.3
4	Amnura SCL	Kaharole, Dinajpur	1	5.6	4.2	-1.4	1.67	0.088	6.0 L	7.9
5	Amnura SCL	Dinajpur Sadar	1	5.2	4.1	-1.1	1.57	0.083	10.5 L	14.6
6	Amnura loam	Fulbari, Dinajpur	1	5.4	4.1	-1.3	1.64	0.082	9.0 L	12.5
7	Gangachara loam	Kamarpukur, Nilphamari	3	5.4	4.1	-1.3	1.93	0.102	8.9 L	12.9
8	Gangachara SCL	Gangachara, Rangpur	3	5.5	4.2	-1.3	1.59	0.084	6.0L	11.9
9	Palashbari loam	Rangpur Sadar	3	5.8	4.4	-1.3	1.31	0.070	6.3L	8.5
10	Palashbari clay loam	Sonatala, Bogra	4	6.2	4.8	-1.4	1.86	0.098	11.9 M	13.1
11	Akdala clay loam	Shibgonj, Bogra	25	5.9	4.7	-1.2	1.36	0.072	10.3 L	10.1
12	Sara loam	Salimpur (Ishurdi), Pabna	11	8.3	7.0	-1.3	1.05	0.055	16.1 M	12.2
13	Ishurdi loam	Pakuria (Ishurdi), Pabna	11	8.2	7.5	-0.7	1.64	0.087	8.5 L	9.9
14	Ishurdi clay loam	RARS (Ishurdi), Pabna	11	8.3	7.4	-0.9	1.29	0.069	13.0 L	16.9
15	Sara loam	Bheramara, Kushtia	11	8.0	7.4	-0.7	1.10	0.058	8.9 L	8.5
16	Gopalpur clay loam	Jessore Sadar, Jessore	11	7.5	5.7	-1.8	1.07	0.056	12.9 L	8.8
17	Nachol loam	Godagari, Rajshahi (HL)	26	5.1	3.8	-1.3	1.09	0.058	12.1 L	11.4
18	Amnura clay loam	Godagari, Rajshahi (LL)	26	7.3	5.9	-1.4	1.50	0.080	12.9 L	9.0
19	Nachol loam	Chapai Nawabganj Sadar	26	7.8	6.8	-1.0	1.52	0.080	17.4 M	14.7
20	Amnura silt loam	Barogharia, Chapai Nawabganj	10	7.6	6.3	-1.2	1.36	0.072	18.4 M	10.2
21	Gopalpur clay	Kanaipur, Faridpur	12	7.4	6.2	-1.2	1.97	0.104	16.5 M	11.5
22	Barishal clay	Benerpota, Satkhira	13	7.8	6.5	-1.3	2.09	0.111	24.0 O	48.3
23	Barishal clay loam	Babuganj, Barisal	13	7.1	6.0	-1.1	0.88	0.049	20.0 M	31.7

Table 3. Cont'd.

Soil No.	Name of the Soil	Location	AEZ	pH (H_2O)	pH (KCl)	Δ pH	Organic matter (%)	Total-N (%)	Available	
									P (mg kg^{-1})	S (mg kg^{-1})
24	Jhalokathi clay	Mirzaganj, Patuakhali	13	7.1	5.8	-1.4	1.84	0.098	25.8 O	42.8
25	Chhiata loam	Yugitola, Gazipur	28	5.3	4.0	-1.3	1.69	0.089	6.1 L	10.5
26	Silmondi clay loam	Madhupur, Tangail	28	5.3	4.8	-0.6	1.26	0.066	6.6 L	13.2
27	Sonatola clay loam	Gopalpur, Tangail	8	6.2	4.8	-1.4	2.00	0.106	9.8 L	10.9
28	Jamalpur clay loam	Jamalpur Sadar, Jamalpur	9	6.3	4.7	-1.6	1.24	0.065	18.1 O	11.6
29	Sonatola clay loam	West Ramnagar, Jamalpur	9	6.4	5.0	-1.3	1.71	0.091	14.1 M	9.1
30	Balagonj sandy loam	Akbarpur, Moulvibazar	22	5.5	4.3	-1.2	1.28	0.068	6.2 L	10.6
31	Goainghat SCL	RARS (Akbarpur), Moulvibazar	29	4.7	3.7	-1.0	2.10	0.117	5.0 VL	9.9
32	Monu SCL	Khadim Nagor, Sylhet	20	5.3	4.1	-1.2	2.40	0.128	6.3 L	23.3
33	Debidwar loam	Chandina, Comilla	16	5.9	4.7	-1.2	0.98	0.052	10.9 M	22.4
34	Mirsarai SCL	Hathazari, Chittagong	23	5.3	4.0	-1.3	1.47	0.071	5.5 L	14.3
35	Mirsarai SCL	RARS (Hathazari), Chittagong	23	5.2	4.0	-1.2	1.24	0.066	6.3 L	15.8
SE (±)				0.187	0.195	0.040	0.061	0.003		
STD				1.104	1.154	0.237	0.361	0.020		
Range				4.7-8.3	3.7-7.4	-	0.88-2.40	0.049-0.128		

Table 4. Contents of exchangeable bases in studied soils of Bangladesh

Sl. No.	Name of the Soil	Location	AEZ	CEC (cmol kg^{-1})	Exchangeable bases (meq 100 g^{-1}soil)				KSP (%)
					K	Ca	Mg	Na	
1	Baliadangi SCL*	Atwari, Panchagarh	1	6.4	0.14	2.13	1.31	0.25	2.19
2	Amnura loam	Thakurgaon Sadar	1	4.4	0.06	1.45	1.16	0.21	1.35
3	Amnura loam	Birgonj, Dinajpur	1	5.1	0.05	2.14	1.37	0.27	0.98
4	Amnura SCL	Kaharole, Dinajpur	1	5.1	0.07	1.98	1.08	0.26	1.36
5	Amnura SCL	Dinajpur Sadar	1	5.4	0.06	1.58	1.43	0.26	1.12
6	Amnura loam	Fulbari, Dinajpur	1	7.1	0.06	2.33	1.89	0.28	0.84
7	Gangachara loam	Kamarpukur, Nilphamari	3	12.5	0.25	4.35	2.96	0.43	2.00
8	Gangachara SCL	Gangachara, Rangpur	3	5.5	0.24	2.06	0.90	0.36	4.38
9	Palashbari loam	Rangpur Sadar	3	6.9	0.13	2.97	1.31	0.31	1.87
10	Palashbari clay loam	Sonatala, Bogra	4	12.7	0.06	6.16	4.60	0.34	0.47
11	Akdala clay loam	Shibgonj, Bogra	25	13.6	0.14	4.59	4.17	0.49	1.03
12	Sara loam	Salimpur (Ishurdi), Pabna	11	27.4	0.30	21.83	3.91	0.23	1.09
13	Ishurdi loam	Pakuria (Ishurdi), Pabna	11	17.3	0.11	11.51	3.96	0.31	0.64
14	Ishurdi clay loam	RARS (Ishurdi), Pabna	11	30.2	0.21	19.67	7.78	0.47	0.69
15	Sara loam	Bheramara, Kushtia	11	25.1	0.14	20.05	2.96	0.29	0.56
16	Gopalpur clay loam	Jessore Sadar, Jessore	11	22.4	0.12	14.04	5.41	0.23	0.54
17	Nachol loam	Godagari, Rajshahi (HL)	26	10.1	0.12	3.60	3.00	0.24	1.19
18	Amnura clay loam	Godagari, Rajshahi (LL)	26	24.5	0.26	11.27	7.91	0.90	1.06
19	Nachol loam	Chapai Nawabganj Sadar	26	26.2	0.33	18.26	4.25	0.22	1.26

Table 4. Cont'd.

Sl. No.	Name of the Soil	Location	AEZ	CEC (cmol kg^{-1})	Exchangeable bases (meq 100 g^{-1}soil)				KSP (%)
					K	Ca	Mg	Na	
20	Amnura silt loam	Barogharia, Chapai Nawabganj	10	39.8	0.52	24.53	10.49	0.37	1.25
21	Gopalpur clay	Kanaipur, Faridpur	12	36.3	0.52	22.80	11.39	0.44	1.43
22	Barishal clay	Benerpota, Satkhira	13	38.7	0.65	23.05	13.66	1.84	1.68
23	Barishal clay loam	Babuganj, Barisal	13	14.0	0.10	6.21	4.55	0.48	0.71
24	Jhalokathi clay	Mirzaganj, Patuakhali	13	24.5	0.40	10.04	7.72	0.43	1.63
25	Chhiata loam	Yugitola, Gazipur	28	6.7	0.09	3.12	2.13	0.27	1.34
26	Silmondi clay loam	Madhupur, Tangail	28	9.2	0.28	3.77	2.63	0.20	3.04
27	Sonatola clay loam	Gopalpur, Tangail	8	20.1	0.08	8.12	6.07	0.22	0.40
28	Jamalpur clay loam	Jamalpur Sadar, Jamalpur	9	14.0	0.05	5.77	4.13	0.24	0.36
29	Sonatola clay loam	West Ramnagar, Jamalpur	9	19.1	0.08	7.96	5.84	0.23	0.42
30	Balagonj sandy loam	Akbarpur, Moulvibazar	22	4.6	0.07	1.67	1.08	0.17	1.52
31	Goainghat SCL	RARS (Akbarpur), Moulvibazar	29	5.7	0.07	2.13	0.86	0.19	1.23
32	Monu SCL	Khadim Nagor, Sylhet	20	6.7	0.07	2.52	1.41	0.22	1.05
33	Debidwar loam	Chandina, Comilla	16	15.4	0.11	4.87	4.41	1.21	0.72
34	Mirsarai SCL	Hathazari, Chittagong	23	6.4	0.07	2.04	1.88	0.41	1.09
35	Mirsarai SCL	RARS (Hathazari), Chittagong	23	5.2	0.11	1.56	1.25	0.28	2.13
SE (±)				1.79	0.026	1.274	0.541	0.055	0.135
STD				10.56	0.151	7.536	3.201	0.324	0.796
Range				4.4-39.8	0.05-0.65	1.45-24.53	0.86-13.66	0.17-1.84	0.36-4.38

Nitrogen

Total-N content in soils varied greatly among different AEZs although almost all the tested soils appeared to be deficient (< 0.12%) in nitrogen content (Table 3). Like organic matter, the highest total N (0.128%) was recorded from Monu Sandy Clay Loam (Soil No. 32) at Khadim Nagor, Sylhet under AEZ 20. The lowest total N (0.049%) was recorded from Barisal Clay Loam (Soil No. 23) at Babuganj, Barisal under AEZ 13, which was followed by Debidwar Loam (Soil No. 33) at Chandina, Comilla under AEZ 16 and Sara Loam (Soil No. 22) at Ishurdi, Pabna under AEZ 11. As such soil total –N status may not be categorized as higher or lower on the basis of AEZs but it was found higher where organic matter content was also higher. Portch and Islam (1984) studied 63 soil samples from different regions of Bangladesh and found that 100% of them were deficient in N. Moslehuddin (1993) also found N deficiency in Old Brahmaputra floodplain soil.

Available phosphorus

The available P content also varied among the tested soils to a great margin (Table 3). The highest available P (25.8 mg kg^{-1}) was found in Jhalokathi Clay (Soil No.24) at Mirzagonj, Patuakhali under AEZ 13, which was closely followed (24.0 mg kg^{-1}) by Barisal Clay (Soil No. 22) at Benerpota, Satkhira under the same AEZ. The lowest available P (5 mg kg^{-1}) was obtained from strongly acidic soil of Moulavibazar (AEZ 29). Soils of Faridpur, Jamalpur, Jessore, Pabna, Chapainawabgonj, Rajshahi, and Barisal showed optimum amount available P. The rest of the studied soils were deficient in available P content. It was appeared that, 68.6% of the studied soils had the low level of available P, 22.9% showed medium level while 8.6% soils retained it an optimum amount. The fixation of P in acid soils might be the major reason for low available P. Moslehuddin *et al*. (1997) reported deficiency of available P in calcareous soils of Ganges floodplain and acidic soils of terrace and hill areas. Portch and Islam (1984) found that 41% of soils contained P below the critical level while 35% were below the optimum level.

Available Sulphur

The tested soils varied greatly in respect of available S across different AEZs (Table 3). The highest available S (48.3 mg kg^{-1}) was recorded in Barisal Clay (Soil No. 22) at Benerpota Satkhira soil, which was almost similar (42.8 mg kg^{-1}) to that of Jhalakathi Clay at Mirzagonj, Patuakhali. It revealed that coastal regions soils hold higher amount of available S. The optimum (31.7 mg kg^{-1}) level of S was observed in Barisal Clay Loam Soil (Soil No. 23) at Babuganj, Barisal under AEZ 13, which was followed (23.3 mg kg^{-1}) by Monu Sandy Clay Loam (Soil No 32) at KhadimNagor, Sylhet under AEZ 20. However, about 80%

soils contained low level of available S (7.9-14.7 mg kg $^{-1}$). Clay textured organic matter rich soils contained relatively higher amount of available S than sandy textured one. Portch and Islam (1984) found that 68% of the studied soils were below the critical level for S. Bhuiyan (1991) reported that about 4 million ha of land was potentially deficient in S.

Cation exchange capacity (CEC)

The CEC of the tested soils varied from 4.4 - 39.8 cmol kg^{-1} (Table 4). The highest CEC (39.8 cmol kg^{-1}) was recorded in Amnura Silt Loam (Soil No.20) at Barogharia, Chapai Nowabgonj under AEZ 10, which was followed (38.7 cmol kg^{-1}) by Barisal Clay (Soil No. 22) at Benerpota, Shatkhira under AEZ 13 and Gopalpur Clay (Soil No. 21) under AEZ 12. Moderate CEC (10-19 cmol kg^{-1}) was observed in AEZ 3 (Kamarpukur, Nilphamari), AEZ 4 (Sonatola, Bogra), AEZ 9 (Jamalpur Sadar), AEZ 13 (Babuganj, Barisal), AEZ 16 (Chandina, Comilla) and high land of Nachol Loam at Godagari, Rajshahi under AEZ 26. The low CEC (4.6-9.2 cmol kg^{-1}) was found in AEZ 22, 29 (Akbarpur, Moulvibazar), AEZ 20 (Khadim Nagor, Sylhet), AEZ 23 (Hathazari, Chittagong), AEZ 28 (Tangail, Gazipur), AEZ 3 (Rangpur) and AEZ 1 (Dinajpur and Panchagarh). Higher clay and organic matter content might have resulted in higher CEC in soil. The soil low in clay, organic matter and exchangeable bases found to hold low CEC. Harpstead *et al*. (2001) also reported that very sandy soils are at the low CEC while very clayey soils may have higher CEC.

Exchangeable bases

Exchangeable bases (K, Ca, Mg and Na) showed a wide variation in soils (Table 4). The exchangeable K content of the collected soils varied from 0.054 to 0.653 meq 100 g^{-1} showing the highest value in Barisal Clay at Benerpota, Satkhira under AEZ 13 and the lowest in Amnura Loam at Birgonj, Dinajpur under AEZ 1. The soils of Dinajpur (AEZ 1), Rangpur (AEZ 3), Bogra (AEZ 4), Akbarpur (AEZ 29 and AEZ 22), Sylhet (AEZ 20), Jamalpur (AEZ 9), Tangail (AEZ 8) and Chittagong (AEZ 23) were very low (< 0.09 meq 100 g^{-1}) in exchangeable K. The high level of K (0.361 – 0.45 meq 100 g^{-1}) was found in Jhalokathi Clay at Mirzagonj, Patuakhali (AEZ 13). The very high level of K (> 0.451 meq 100 g^{-1}) was of course recorded in Gopalpur Clay at Kanaipur Faridpur (AEZ 12), Amnura Silt Loam at Barogharia, Chapai Nawabganj (AEZ 10) and Barishal Clay at Benerpota Satkhira (AEZ 13). Study revealed that 40% of the collected soils were very low, 31.4% were low, 8.6% each of medium and optimum, and 11.4% contained high level of exchangeable K. The result indicated that about 72% soils fall in either very low or low category in respect of exchangeable K status, which might be a great concern in achieving yield sustainability and maintaining K fertility in Bangladesh agriculture. Islam *et al*. (1992) reported that about 50% of the cultivable areas of Bangladesh found to be low in exchangeable K, 30% areas medium and the rest 20% areas (mostly in southern saline areas) were high to very high level of exchangeable K.

The content of exchangeable Ca of the tested soils varied from 1.45 to 24.53 meq 100 g^{-1} where the highest result was observed in Amnura Silt Loam at Barogharia Chapai Nowabgonj (AEZ 10), which was closely followed by Barisal Clay at Benerpota, Satkhira, Gopalpur Clay at Kanaipur, Faridpur, Sara Loam at Salimpur, Pabna and also Sara Loam at Bheramara, Kushtia. Exchangeable calcium content was also found very high in Gopalpur Clay Loam at Jessore, Jhalokathi Clay at Mirzagonj, Patuakhali, Sonatola Clay Loam at Ram Nagor, Jamalpur and Gopalpur Tangail (Table 4). The lower Ca content was found in greater Dinajpur (mostly Amnura Loam), Rangpur (Gangachara SCL and Polashbari Loam) and Hathazari (Mirersarai SCL), which were actually either, at par or very few were just below the critical level (2.0 meq 100 g^{-1}). The calcareous soils (AEZ 10, 11, 12 and 13) obviously contained very high level of Ca. But non calcareous soils also showed fairly good level of Ca content except sandy textured soils (AEZ 1, 3, 23 and 29). Therefore, most of the studied soils were rich in calcium content.

The exchangeable Mg content varied from 0.86 to 13.66 meq 100 g^{-1} (Table 4). The highest Mg was found in Barisal Clay at Benerpota, Satkhira, which was followed by Gopalpur Clay at Faridpur and Amnura Silt Loam at Barogharia, Chapai Nawabganj. The soils collected from Rajshahi, Pabna, Jessore, Patuakhali, Tangail and Jamalpur also showed high level of exchangeable Mg. But sandy textured soil of greater Dinajpur, Rangpur, Moulvibazar showed lower level of exchangeable Mg. Magnesium was found to be deficient in the coarse-textured soils of Old Himalayan piedmont plain, Brown hill soils, and Grey floodplain soils of the northern part of the country (Islam *et al.*, 1992). The reason behind less prevalence of Ca deficiency in comparison to Mg may be that Ca is automatically added to the soil as a part of P- and S-fertilizers.

The exchangeable Na content also varied widely among the tested soils (Table 4). The highest Na content (1.84 meq 100 g^{-1}) was found in Barisal Clay at Benerpota, Satkhira and the lowest (0.17 meq 100 g^{-1}) in Balagonj Sandy Loam at Akbarpur, Moulvibazar under AEZ 22. The content of Na for rest of the soils was 0.2 to 0.5 meq 100 g^{-1}. As Satkhira region is salt affected, that might be the major region for higher Na content in Barisal Clay Soil at Benerpota.

Potassium saturation percentage (KSP) varied from 0.36 to 4.38% (Table 4). The critical lower limit of the basic cation saturation ration (BCSR) was assumed to be 2% (McLean, 1977). In this concept, 30 soil samples out of 35 had KSP less than 2%. Gangachara SCL at Gangachara, Rangpur showed the highest KSP (4.38%), which was followed (3.04%) by Silmondi Clay Loam at Madhupur, Tangail (AEZ 28). Baliadangi SCL at Atwari, Panchagarh, Gangachara Loam at Kamarpukur, Nilphamari (AEZ 3) and Mireasarai SCL at Hathazari, exerted 2.19, 2.00 and 2.13% KSP, respectively. According to the McLean (1977), soils containing less than 2% K saturation, needs K application. However, Abedin *et al*. (1991) found no benefit of K application to wheat in calcareous soil following BCSR concept. Again, Kopittke and Menzies (2007) disregarded the BCSR concept of K application based on their extensive review.

Functional Relationship

A significant ($p = 0.05$) positive linear relationship was observed between soil pH and available phosphorus (Fig. 2). The coefficient of determination of the regression equation was ($R^2 = 0.4287^*$), which implies that available P of the tested soils governed by soil pH by 42.9% cases and that was statistically significant. The relationship between organic matter and total nitrogen appeared to be highly significant ($p < 0.01$), which revealed that total N content in soils was mostly dependent on organic matter content. The higher R^2 value 0.991** indicated that 99% variability in total-N content in soils could be explained by organic matter content (Fig. 3). The relationship between CEC and clay content of the studied soils appeared to be statistically significant ($p = 0.05$). The R^2 value of the regression equation was 0.44*, which implies that 44% variability for CEC could be attributed by clay content (Fig. 4). The relationship between exchangeable Na with clay was non-significant ($R^2 = 0.341^{ns}$), while exchangeable K showed significant relationship ($p = 0.01$) with clay content (Fig. 5). Estimate showed that 50.4% variability in exchangeable K may be governed by clay content of the soils. But clay content did not influence exchangeable Ca content in studied soils significantly ($R^2 = 0.2914$). In contrary, a significant ($p < 0.01$) positive linear relationship was observed between clay content and exchangeable Mg. Regression equation showed that 65.6% variability in exchangeable Mg may be governed by clay content in soils (Fig. 6). Cation exchange capacity (CEC) gave significant positive linear relationship with exchangeable K, Ca and Mg but such relationship with Na was non-significant (Fig. 7 and 8). CEC may explain 62.2, 92.3 and 83.9% variability for exchangeable K, Ca and Mg content in soils, respectively. Higher the CEC there is a greater possibility of the exchangeable base content in soils except Na. The studied soils were mostly non-saline which might be the major reason for the poor relationship with Na.

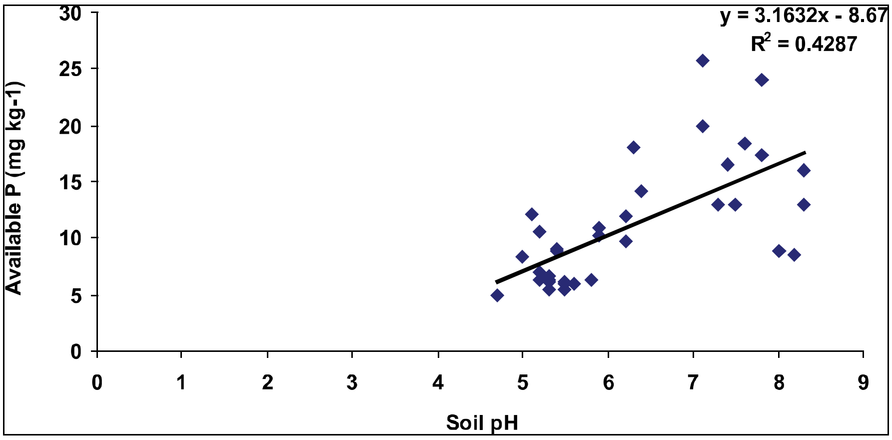

Fig. 2. Relationship between pH and available P of the collected soil samples.

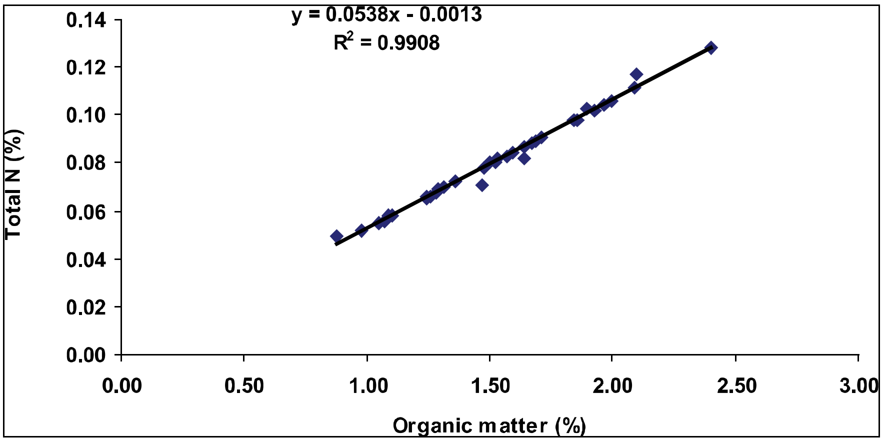

Fig. 3. Relationship between organic matter and total N content of the collected soils.

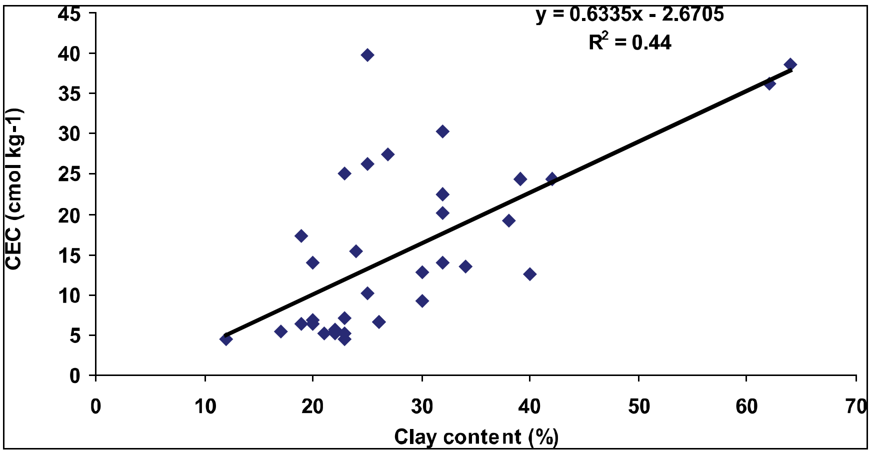

Fig. 4. Relationship between clay content and CEC of the collected soils.

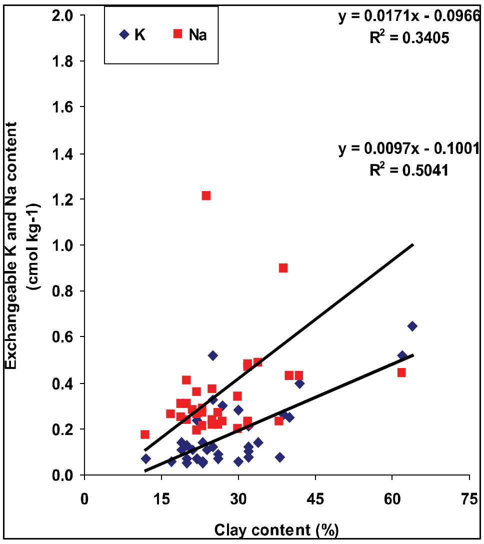

Fig. 5. Relationship between clay content with exchangeable K and Na of the collected soils.

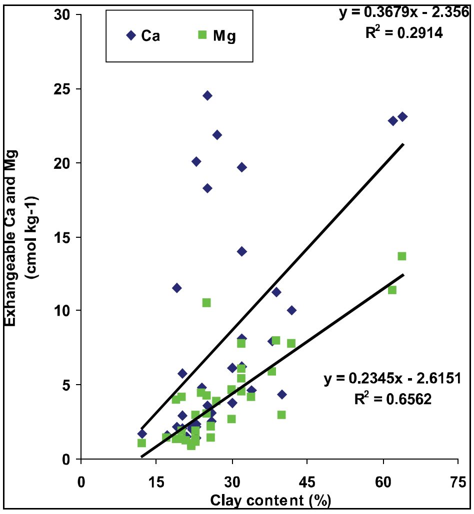

Fig. 6. Relationship between clay content with exchangeable Ca and Mg of the collected soils.

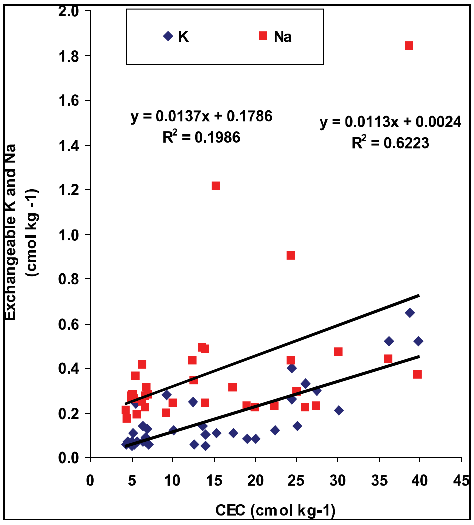

Fig. 7. Relationship between CEC with exchangeable K and Na of the collected soils.

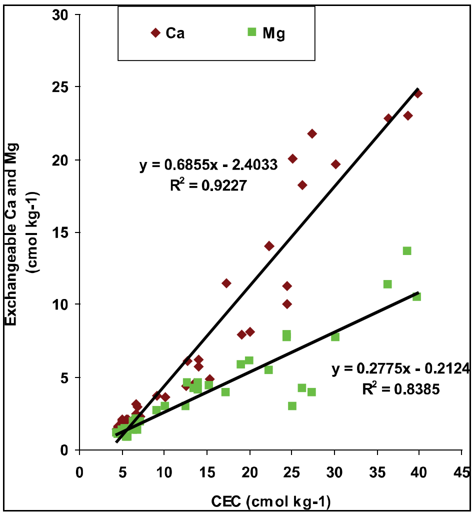

Fig. 8. Relationship between CEC with exchangeable Ca and Mg of the collected soils.

Conclusion

Studied soils varied widely in texture, pH, CEC, organic matter and essential plant nutrient elements. Sand dominated loamy textured soils were found in northern region while soils of north eastern and south eastern part except coastal belt was mostly sandy textured. The middle part of the country was dominated by clay loam soil. The soils of south-western coastal belt appeared to be clay textured. The majority of the tested soils found to be acidic in nature. Organic matter status appeared to be remarkably low. Nitrogen deficiency was found in all soils. Available P and S contents were mostly low. Exchangeable K content was low to very low except clay rich soils of Ganges floodplain and Ganges tidal floodplain regions. The calcareous soils contained very high level of Ca. But non calcareous soils also retained fairly good level of exchangeable Ca except sandy textured ones. Magnesium deficiency was found in sandy textured soils but rest of the soils hold optimum to high level of exchangeable Mg. Thus the fertility status of most of the Bangladesh soils (except AEZ 10, 12, 13 and to some extent 11) appeared to be low to very low, which demand judicious management in order to achieve food security and to maintain the soil fertility.

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