ASSESSMENT OF FERTILITY STATUS OF SHER-E-BANGLA AGRICULTURAL UNIVERSITY FARM SOILS

A Thesis

By

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CERTIFICATE

This is to certify that the thesis entitled " ASSESSMENT OF FERTILITY STATUS OF SHER-E-BANGLA AGRICULTURAL UNIVERSITY FARM SOILS" submitted to the DEPARTMENT OF SOIL SCIENCE, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in SOIL SCIENCE, embodies the results of a piece of bonafide research work carried out by MD. MERAZUL ISLAM , Registration No. 11-04691, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

Dated:

Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED PARENTS

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ABBREVIATIONS AND ACRONYMS

AEZ = Agro-Ecological Zone

@ = At the rate of

Agric. = Agriculture

Agril. = Agricultural

BARC = Bangladesh Agricultural Research Council

BARI = Bangladesh Agricultural Research Institute

BBS = Bangladesh Bureau of Statistics

BAU = Bangladesh Agricultural University

BRRI = Bangladesh Rice Research Institute

CEC = Cation Exchange Capacity

EC = Electrical Conductivity

et al **= And Others**

FAO = Food and Agricultural Organization

IFDC = International Fertilizer Development Corporation

IARI = Indian Agricultural Research Institute

JNKVV = Jawaharlal Nehru Krishi Vishwa Vidyalaya

M. Sc. (Ag) = Master of Science in Agriculture

M. Sc. = Master of Science

Sci. = Science

Soc. = Society

SRDI = Soil Resources Development Institute

USDA United States Department of Agriculture

UNDP = United Nation Development Program

U.K. = United Kingdom

UNESCO = United Nation Educational Scientific and Cultural Organization

USA = United States of America

Viz. = Namely

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CHAPTER I

INTRODUCTION

Soil fertility is the capacity of soil that enables it to provide essential nutrient elements in adequate quantities and proportions for the growth of specified crops. It is the inherent capacity of soil. To be fertile, soil needs macronutrients, which include nitrogen, potassium and phosphorous,along with micronutrients, such as sulfur, chlorine, copper, manganese, molybdenum, boron, iron, cobalt, magnesium, zinc and chlorine. It must contain organic matter and optimum pH value. The soil must also contain micro and macro-organisms and it must be well drained (Rahman and Azam, 1988).

Soil fertility is the quality of soil that enables it to provide compounds or elements in adequate amounts and in proper balance for the growth of plants when other growth factors like light, moisture, temperature and the physical conditions of the soils are favourable. So, fertility is the potential nutrient status of a soil to produce crops. As plants have evolved in different climates and on different soils, they have different needs for the essential nutrients and different tolerance to the toxic elements. As such, a soil can be fertile for one plant and at the same time be unfertile for another plant. On the other hand soil productivity is a measure of the soils ability to produce a particular crop or sequence of crops under a specified management system. Soil fertility in modern-day agriculture is a part of a dynamic system. Nutrients are constantly being used in the forms of plant and animal products. Unfortunately, others can be lost by leaching or erosion. Moreover nutrients like phosphorus and potassium can be tied up by certain soil clays. Organic matter and soil organisms immobilize and then release nutrients throughout time. So, to improve agricultural production, nutrient balance might be relatively stable. (Thomas *et al.*, 2000).

The process by which the content of plants essential macro and micro nutrients, electrical conductivity (EC), soil reaction (soil pH) etc are measured and finally nutrient status can be known from the soil samples is called soil chemical analysis. It also helps to determine the relationship between soil reaction and nutrient availability. Chemical analysis of soil is one of the scientific method by which we can easily understand the nutrient status of soil before plantation and helps to apply proper amount of manures and fertilizers for crop production (Jackson, 1997). This approach should also be used for Sher-e-Bangla Agricultural University farm soils for the successful crop cultivation.

The farm soils are being used for extensive agricultural research in recent years. But there is no systematic published information on the fertility status of the soils of the university farm. Therefore it appears difficulties for the formulation of proper nutrient dose in conducting research programs on SAU farm soils. Moreover it is particularly important for the balanced use of fertilizers for different crops in these soils. In this context it is necessary to asses physical and chemical properties of the SAU farm soils to provide ba sic information needed in conducting pertinent research in agriculture. From this point of view, the present study was undertaken with the following objectives.

Objectives:

I. To evaluate physical parameters such as soil texture , particle density, Bulk density of soils.

II. To asses chemical properties (soil pH, cation exchange capacity , organic carbon) and nutrient status(total Nitrogen, available Phosphorus, Potassium, Sulphur, Zinc ,Copper, Iron, and Manganese) of the farms.

CHAPTER II

REVIEW OF LITERATURE

In successful crop production soil physical and chemical properties might be the first concern. This chapter has presents a comprehensive review of literature related to the physical and chemical properties of SAU farm soils which belong to the Tejgaon series under the Agro Ecological Zone (AEZ-28) known as Madhupur Tract. It was felt essential to review the similar research works carried out on the Tejgaon series under the Madhupur Tract (AEZ-28). A brief discussion of available literature on the above properties of the SAU farm soils is presented below.

2.1 Physical characteristics of soil

2.1.1 Soil texture

Soil texture refers to sand, silt and clay composition in combination with gravel and larger-material content. Clay content is particularly influential on soil behavior due to a high retention capacity for nutrients and water. Texture influences many physical aspects of soil behavior. Available water capacity increases with silt and more importantly, clay content. Nutrient-retention capacity tends to follow the same relationship. Plant growth, and many uses which rely on soil, tends to favor medium textured soils, such as loam and sandy loam. A balance in air and water-holdling characteristics within medium-textured soils are largely responsible for this. Textural designations are also used to describe soils. The main ones are sand, silt, clay, and loam. The non technical terms "lightness" and "heaviness" refer to soil texture. "Heavy soils" are high in clay and other fine particles; "light soils" are low in clay and high in sand and other coarse particles.

The coarse materials such as sands and gravels are usually composed of many small paiticles cemented together either chemically or by a matrix material. These are ' relatively firmly and present only a single outer surface. The physical and chemical properties of these coarse materials do not differ greatly from those of their parent materials. Silt particles, which are smaller than sand particles, are more or less unweathered, but their surfaces are coated with a clayey matter. The properties of silt are therefore somewhat intermediate between those of sand and clay.

The clays, the smallest of the soil particles, show distinct chemical and physical properties. Clays are colloidal, viscous and gelatinous when moist but hard and cohesive when dry. Their structure can only be seen with an electron microscope. Clays are composed of particles called micelles, which are formed from the parent materials by a crystallization process; they are not merely finely divided rock. The micelles are sheet like (laminar), with internal as well as external surfaces, and tend to be held together by chemical linkages or ions between the plates. Their tremendous surface area relative to

Their volume is one of their most significant features.

Akhter (2005) conducted an experiment in the SAU farm soils and found that the value of sand, silt and clay were 40 %, 40 % and 20 % respectively and the texture of SAU farm soils was loam.

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the value of sand, silt and clay were 27%, 43.% and 30% respectively and the texture of SAU farm soils was clay loam.

Jahan (2006) observed that the percentage of sand, silt and clay were 38.9%, 36.4.% and 24.66% respectively and the texture of SAU farm soils was loam.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils found that the percentage of sand, silt and clay were 49%, 38.% and 18% respectively and the texture of SAU farm soils was loam.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils found that the percentage of sand, silt and clay were 38 %, 35.% and 27%, and the texture of SAU farm soils was clay loam.

Fatima, (2007) reported that SAU farm soils contain 30% sand, 45.% silt and 25 % clay representing loam texture.

Karim (2007) reported that SAU farm soils contain 25%, sand, 41.% silt and 34% clay representing loam texture.

Kawosar (2007) observed that the percentage of sand, silt and clay were 26 %, 45.% and 29 % respectively and the texture of SAU farm soils was clay loam.

2.1.2 Soil density

Particle and bulk density are find useful in several soil and water management aspects e.g. drainage, irrigation and compaction. Some of the research findings on soil densities are cited here.

2.1.2.1 Particle density

Akhter (2005) conducted an experiment in the SAU farm soils and found that the value of Particle density varied from 2.40 to 2.50 g/cc.

Jahan (2006) studied some plots of SAU found that the that the value of particle density varied from 2.36 to 2.54 g/cc.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils found that value of particle density varied from 2.37 to 2.52 g/cc.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils found that the value of particle density varied from 2.39 to 2.51 g/cc.

Fatima (2007) studied some plots of SAU farm soils found that the value of particle density varied from 2.41 to 2.53 g/cc.

Karim (2007) conducted an experiment in some plots of the SAU farm soils and found that the value of particle density varied from 2.38 to 2.54 g/cc.

Kawosar (2007) observed some plots of SAU farm soils found that the value of particle density varied from 2.37 to 2.54 g/cc..

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the value of particle density varied from 2.42 to 2.53 g/cc.

Joshua and Rahman (1983) in a study in the Ganges River Floodplain soil reported that the silt loam soil had particle density between 2.67 to 2.70 g/cm where as the particle density of clay soil varied from 2.63 to 2.70 g/cc

Haque (1988) observed that the particle density of 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm depth of the Old Madhupur Floodplain Soil varied from 2.63 to 2.70 g/cc.

Hossain (1989) observed that the particle density varied from 2.49 to 2.67 g/cm in Ghatail series, 2.40 to 2.78 g/cm in Sonatola series and 2.34 to 2.63 g/cc in Nunni series.

Chowdhuiy (1990) reported that the particle density values of Sonatola series varied from 2.40 to 2.50 g/cc in Melandaha series from 2.45 to 2.65 g/cc in Kendua series from 2.45 to 2.61 g/cc and that of Tarakanda series from 2.40 to 2.60 g/cc The highest particle density of 2.65 g/cc was found at 45-60 cm depth of Melandaha series and the lowest value of 2.40 g/cc was observed at 15-30 cm depth in Sonatola series and 0-15 cm depth in Tarakanda series.

Chowdhury (1992) reported that the particle density values of Old Brahmaputra Floodplain Soil varied from 2.40 to 2.56 g/cc and Madhupur Tract Soil from 2.32 to 2.48 g/cc under different cropping patterns at different depths where tractor tillage operation was used. He also reported that the particle density values of Old Brahmaputra Floodplain Soil varied from 2.42 to 2.53 g/cc and Madhupur Tract Soil from 2.42 to 2.54 g/cc under some cropping patterns and depths under traditional tillage operation.

Hannan (1995) reported that the particle density of Madhupur Tract, Brahmaputra Alluvium and Barind Tract varied from 2.56 to 2.72 g/cc No definite order in the changes of particle density values with increasing depth of all profiles was found.

Khan *et al*. (1998) observed that the particle density of Benchmark soils ranged from 2.50 to 2.71 g/cc in the Floodplain soils of Bangladesh. Also observed that the particle density was higher in the subsurface than in the surface horizon which might due to comparatively higher content of organic matter in the surface horizon.

Fakir (1998) observed that the particle density varied from 2.41 to 2.66 g/cc in ten selected soils series of Bangladesh.

Mondal (1998) observed that the particle density values varied depth wise from 2.33 to 2.65 g/cm and also found that it was increased with depth.

2.1.2.2 Bulk density

Akhter (2005) conducted an experiment in the SAU farm soils and found that the value of bulk density varied from 1.21 to 1.31 gm/cc.

Jahan (2006) observed that some plots of SAU had the bulk density varied from 1.22 to 1.42 gm/cc.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that value of bulk density varied from 1.24 to 1.39 gm/cc.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the value of bulk density varied from 1.21 to 1.49 gm/cc.

Fatima (2007) observed some plots of SAU farm soils and found that the value of bulk density varied from 1.25 to 1.46 gm/cc.

Karim (2007) conducted an experiment in some plots of the SAU farm soils and found that the value of bulk density varied from 1.22 to 1.42 gm/cc.

Kawosar (2007) found that the value of bulk density of some SAU soils varied from 1.24 to 1.45 gm/cc.

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the value of bulk density varied from 1.23 to 1.48 gm/cc..

Brady (1988) stated that the bulk density values of clay, clay loam and silt loam soils normally ranged from 1.0 to 1.60 g/cm while that of sands and sandy soil ranged from 1.20 to 1.80 gm/cc.

Haque (1988) observed that the bulk density of 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm depth of the Old Brahmaputra Floodplain soils ranged from 1.36 to 1.48 gm/cc.

Hill (1990) conducted that reduced tillage generally had higher bulk density (1.64- 1.81 gm/cc. in sandy loam soil at 15-30 cm depth.

Chenkual and Achaiya (1990) showed that the bulk density increased from 6cm to downward. They also observed that higher bulk density reduced rate of water infiltration.

Matin and Uddin (1994) reported that the soil bulk density was higher due to tillage by country plough over power tiller. They also found that the bulk density was increased significantly with increasing soil depth.

Fakir (1998) observed that the bulk density ranged from 1.32 to 1.62 gm/cc.in ten selected soil series of Bangladesh and also found that the bulk density increased with the increase of depth and the highest bulk density was found at 30-45 cm depths in Sonatola series.

Mondal (1998) observed that the bulk density values ranged from 1.16 to 1.66 gm/cc.

Khan *et al.* (1998) observed that the bulk density of Benchmark soils ranged from 1.18 to 1.67 gm/cc in the Floodplain soils of Bangladesh and also observed that bulk density values were comparatively higher in the Gangetic Alluvium Soils than in the Brahmaputra and Tista Alluvium Soils.

2.2 Chemical properties of soils

The chemical properties mainly deal with the chemical composition of the soil materials and indicate the nature and extent of weathering and stage of development of soils. These properties give an idea about the nutritional status of soils.

2.2.1 Soil reaction (pH)

Soil pH is the negative logarithm of the hydrogen ion activity (concentration) of a soil. (Brady and Well, 2005).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and mean pH value was 6.4 g/l.

Jahan (2006) observed some plots of SAU found that mean value of Soil pH was 5.56 g/l.

Hossain (2006) conducted an experiment in some plots of SAU farm soils found that mean value of soil pH was 5. 6 g/l.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils found that the range of soil pH was 4.5 to 5 g/l.

Roy (2006) conducted an experiment in some plots of SAU farm soils found that the mean value of soil pH was 5.50 g/l.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils found that the mean value of soil pH was 5.53 g/l.

Fatima (2007) observed some plots of SAU farm soils found that the value of soil pH was 7.1

Zafreen (2007) observed some plots of SAU farm soils found that the mean value of soil pH was 5.5 g/l.

Karim . (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of soil pH was 5.7 g/l.

Kawosar (2007) observed some plots of SAU farm soils found that the mean value of soil pH was 5.6 g/l.

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of soil pH was 5.6 g/l.

Rashid (2007) observed some plots of SAU farm soils found that the mean value of soil pH was 5.90 g/l.

Haque (2008) observed some plots of SAU farm soils found that the range of Soil pH was 5.46 to 5.61 g/l.

Nasrin . (2009) conducted an experiment in some plots of the SAU farm soils found that the mean value of Soil pH was 5.6 g/l.

12 topsoil samples of Sonatala soil group (including Sonatala and Kendua series) and 20 topsoil samples of Silmandi soil group (including Silmandi and Lokdeo series) of Purbadhala thana, and found that soil pH ranged from 4.2 to 7.0 and 4.2 to 7.8

respectively (SRDI, 1990a).) Soil pH of Tejgaon, Khulna, Khilgaon, Sonatala and Silmondi series was 5.4, 5.4, 5.2, 5.6 and 5.8 respectively. (SRDI, 1990b They also reported that the variation of pH of top soil of Brahmaputra alluvium were not so different. pH range of 42 topsoil samples of Silmandi soil group (Silmandi and Lokdeo series) varied from 4.9 to 6.3 in Nandail thana. It also found that the topsoil of Sonatala soil group (Sonatala, Kendua and Ishwargonj) had pH values between 5.4 to 6.0. The pH of top soils (0-15 cm) and sub soils (15-30 cm) of Lokdeo series ranged from 6.0-6.4 and 5.7-6.4 respectively. The pH of top soils and sub soils of Sonatala series varied from 5.4-6.3 and 5.5 to 6.3 respectively (SRDI, 1990c).

BARC (1987) noted that the pH values of top soils of soil series Tejgaon, Khulna, Khilgaon, Sonatala and Silmondi were 5.4, 5.4, 5.2, 5.6 and 5.8 respectively.

pH of Tejgaon and Gangachara series was classified as acidic (pH 5.0 and 5.6 respectively) and Gopalpur as slightly alkaline (pH 7.7) (Begum and Islam, 1987). McConnell *et al.* (1988) reported that soil formed under high rainfall condition were more acid than those formed under acid condition. They reported that N fertilizers speed up the rate of acidity development in soils. They also stated that except in lower rainfall areas percent acidity generally increased with depth.

Haque *et al.* (1988) in a study observed that the pH of surface soil of the old Brahmaputra, Flood Plain Soil was near neutral and it was little higher in deeper layers.

Chowdhury *et al.* (1990) reported that pH of Sonatala, Melandaha, Kendua and Tarakanda series ranged from 6.8 to 7.2, 6.6 to 7.1, 6.7 to 7.2 and 6.6 to 6.8, respectively. 18 samples of Sonatala series and 12 samples of Silmandi series, showed that soil pH varied from 5.5 to 7.2 and 5.8 to 7.1, respectively, in Jamalpur sadar thana (SRDI, 1991).

2.2.2 Organic carbon

It is commonly believed that the soils of tropics have lower organic matter content than soils of the temperate region (Bartholomew, 1972). The red colour of many soils in the tropics, high temperatures and high rainfall are among the reactions cited in support of this generalization.

Jahan (2006) studied plots of SAU farm soils and found that the mean value of organic carbon was 0.82%.

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of organic carbon was 0.45%.

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of organic carbon was 0.81%.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of organic carbon was 0..69 %.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of organic carbon was 0.47 % .

Fatima (2007) observed some plots of SAU farm soils and found that the mean value of organic carbon was 0.62%.

Zafreen (2007) studied some plots of SAU farm soils and 0.82% mean organic carbon was found.

Karim (2007) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 0.49% was found.

Haque (2008) studied some plots of SAU farm soils and 0.48% mean organic carbon was found.

Roy (2006) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 0.82% was found.

Kawosar (2007) studied some plots of SAU farm soils and 0.45% mean organic carbon was found.

Islam (2007) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 2.15% was found.

Nazrul (2007) studied some plots of SAU farm soils and 0.47 % mean organic carbon was found.

Mostafa (2007) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 0.81% was found.

Shoukat (2007) studied some plots of SAU farm soils and 0.83% mean organic carbon was found.

Asaduzzaman (2007) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 1.47% was found.

Ahmed (2007) studied some plots of SAU farm soils and 1.56% mean organic carbon was found.

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 0.45% was found.

Akhter (2005) studied some plots of SAU farm soils and 0.82% mean organic carbon was found.

Rashid (2007) conducted an experiment in some plots of the SAU farm soils and the mean value of organic carbon 0.22% was found. Organic carbon content of Bangladesh Agricultural University Farm Soils (Sonatala series) of Mymensingh ranged from 0.44 to

1.30% in the top soils (Department of Soil Survey of Bangladesh, 1979). Department of Soil Survey of Bangladesh (1975) reported that organic carbon of topsoil and sub-soil of Sonatala series were 0.52% and 0.05% respectively. They further found that the organic carbon content of topsoil and sub-soil of Silmondi series were 1.31% and 0.46% respectively. They also reported that the organic carbon contents of topsoil and sub-soil of Ghatail series were 1.69 % and 0.197% respectively. The organic carbon content of top soils of series Tejgaon, Kalma, Khilgaon, Sonatala and Silmondi were 0.39%, 0.78%, 1.68%, 1.15% and 0.97% respectively (BARC, 1987). Haque *et al.* (1988) reported that the organic carbon content of topsoils of Lokdeo series ranged from 0.49 to 1.10 % and in sub-soils from 0.35 to 0.91%. They further noted that in Sonatala series the organic carbon content of topsoils and subsoils Was 0.28 to 0.98% and 0.15 to 0.62 % respectively. Bhuiyan (1988) analyzed some samples of Bangladesh soil and found that the organic carbon content of different soil series of Bangladesh ranged from 0.497 to 2.58 %, mean value being 1.09 %. Organic carbon content decreased with depth in all the profiles with its content ranging from 0.30 to 1.58% (Sood and Kanwar, 1986). Tajamannan *et al.* (1979) found that the organic carbon content decreased with depth. Begum and Islam (1987) worked with three soil series and reported that the organic matter content of all the three soils was low (1.3 to 1.6%). Prihar *et al.* (1985) observed that in addition to supplying nutrients, organic matter promoted soil aggregation. They also noted that under submergence, however, it helped to create a reduced zone that favoured rice growth and generally increased water holding capacities of mineral soils.

Department of Soil Survey (1979) found that the organic carbon contents in the topsoil of Sonatala and Silmandi series were 0.52 and 1.31%, respectively.

Organic carbon content of topsoil of Sonatala and Silmandi series were 0.66 % and 0.73%, respectively in Shibpur thana. BARC (1987). BARC (1982) reported that the organic carbon content of top soils of series Tejgaon, Kalma, Khilgaon, Sonatala and Silmandi under Shivpur upazilla were 0.39%, 0.78%, 1.68%, 0.97% and 0.73% respectively.

Bhuiyan (1987) reported 0.57, 1.38 and 1.26 % organic carbon in the Noncalcareous Alluvium, Grey Floodplain and Noncalcareous Dark Grey Floodplain soil types, respectively.

SRDI (1990a) on the basis of topsoil study on 12 samples of Sonatala soil group (including Sonatala and Kendua series) and 20 samples of Silmandi soil group (including Silmandi and Lokdeo series) of Purbadhala found that average organic carbon were 0.75 % in Sonatala, and 0.28 % in Silmandi soil group. SRDI (1990b) found that the range and average values of organic carbon content in 42 topsoil samples of Silmandi soil group (Silmandi and Lokdeo series) were 0.23 to 1.56 % and 1.05 %, respectively in Nandail thana. It also found that the Sonatala soil group (Sonatala, Kendua and Ishwargonj) contained similar amount of organic carbon having average of 0.96 %.

(SRDI, 1991b) analyzed 18 samples of Sonatala series and 12 samples of Silmandi series and reported that average organic carbon contents were 0.95 % and 1.21 %, respectively, in Jamalpur Sadar thana (SRDI, 1991a). In Kendua thana, the average contents of organic matter were found to be 1.25 % in Sonatala soil group (including Sonatala, Kendua, Ishwargonj and Tarakanda series) and 1.16 % in Silmandi soil group (including Silmandi and Lokdeo series)

2.2.3 Cation exchange capacity (CEC)

Cation exchange phenomena are the most important properties of soils. Cation exchange phenomena are considered as an index of soil fertility as well as soil quality. It plays an important role in the genetic processes of soils.

Akhter (2005) conducted an experiment in the SAU farm soils and found that the range of cation exchange capacity was 13.3 to 22.29 (cmol/kg).

Jahan (2006) studied some plots of SAU found that the range of cation exchange capacity was 11.23 to 29.12 (cmol/kg).

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils found that the range of cation exchange capacity was 15.58 to 24.45 cmol/kg.

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils found that the range of cation exchange capacity was 13.39 to 31.15 (cmol/kg).

Fatima (2007) observed some plots of SAU farm soils found that the range of cation exchange capacity was 14.42 to 28.32 (cmol/kg).

Zafreen (2007) observed some plots of SAU farm soils found that the range of cation exchange capacity was 11.23 to 24.32 (cmol/kg).

Karim (2007) conducted an experiment in some plots of the SAU farm soils and found that the range of cation exchange capacity was 14.23 to 29.32 (cmol/kg).

Kawosar (2007) observed some plots of SAU farm soils found that the range of cation exchange was 12.55 to 31.3 (cmol/kg).

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the range of cation exchange capacity was 13.25 to 30.47 (cmol/kg).

Gupta and Misra (1970) reported that the cation exchange capacity of some soils from Gwalior ranged from 11.4 to 21.3 cmol/kg soil having textures from clay to sandy loam.

SRDI Staff (1965-86) reported that the CEC of the top soil of most of the Brahmaputra Floodplain area having less than 2 percent organic matter ranged from 9 - cmol/kg soil.

The CEC of sub soils was usually slightly higher ranging from 10 - 28 cmol/kg of soil. The values of CEC slightly increased with depth due to their increased clay content.

Chatterjee and Dalal (1976) reported that the CEC value of some soils from Bihar and West Bengal decreased with depth from 4.1 to 10.2 me / 100 g soil.

Thawale *et al.* (1991) found that the CEC of the soils of an Agricultural Farm at Swangi ranged from 35.7 to 62.8 me/lOOg soils indicating occurrence of montmorillomtic type of clay minerals.

Chowdhury (1992) observed that cation exchange capacity of soils decrease with increasing depth of soils. In Old Brabmaputra Floodplain Soil cation exchange capacity varied from 3.44 to 9.27 cmol/kg soil.

Walia and Chamuah (1992) reported that the vertical distribution of cation exchange capacity (CEC) of the flood affected soils of Brahmaputra valley showed an irregular trend.

Mondal (1998) observed that the cation exchange capacity (CEC) values varied from 4.35 to 17.39 cmol/kg soil of the Bangladesh Agricultural University (BAU) Agricultural Farm and also found that the cation exchange capacity (CEC) values were relatively higher at the surface layer but decreased with depth.

2.2.4 Total Nitrogen

The total nitrogen content of soils ranges from <0.02% in subsoils to >2.5% in peats; the surface layer of most cultivated soils contains between 0.06 and 0.5% N.

Jahan (2006) studied some plots of SAU farm soils and 0.05% of total nitrogen was observed.

Hossain (2006) conducted an experiment in some plots of SAU farm soils and 0.03% of total nitrogen was found .

Uddin (2006) studied some plots of SAU farm soils and 0.076% of total nitrogen was observed.

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and 0.06 % of total nitrogen was found .

Chowdhury (2006) studied some plots of SAU farm soils and 0.043% of total nitrogen was observed.

Fatima (2007) conducted an experiment in some plots of SAU farm soils and 0.054% of total nitrogen was found .

Zafreen (2007) studied some plots of SAU farm soils and 0.05% of total nitrogen was observed.

Karim (2007) conducted an experiment in some plots of SAU farm soils and 0.03% of total nitrogen was found .

Haque (2008) studied some plots of SAU farm soils and 0.41% of total nitrogen was observed.

Roy (2006) conducted an experiment in some plots of SAU farm soils and 0.03% of total nitrogen was found .

Kawosar (2007) studied some plots of SAU farm soils and 0.07% of total nitrogen was observed.

Islam (2007) conducted an experiment in some plots of SAU farm soils and 0.1629 % of total nitrogen was found .

Rashid (2007) studied some plots of SAU farm soils and 0.0187% of total nitrogen was observed.

Nazrul (2007) conducted an experiment in some plots of SAU farm soils and 0.0143 % of total nitrogen was found .

Mostofa (2007) studied some plots of SAU farm soils and 0.076 % of total nitrogen was observed.

Shoukat (2006) conducted an experiment in some plots of SAU farm soils and 0.072 % of total nitrogen was found.

Asaduzzaman (2006) studied some plots of SAU farm soils and 0.0791 % of total nitrogen was observed.

Ahmed (2007) conducted an experiment in some plots of SAU farm soils and 0.03 % of total nitrogen was found.

Nasrin (2009) studied some plots of SAU farm soils and 0.057% of total nitrogen was observed.

Akhter (2005) conducted an experiment in some plots of SAU farm soils and 0.07% of total nitrogen was found.

Bangladesh soils like other tropical and sub-tropical soils have long been categorized as poor in fertility because of low nitrogen supply (Islam, 1983). He also reported that the nitrogen content of the hilly regions of the north-east and east were relatively high (0.10 to 0.12%) as compared with that of the floodplain and terrace soils (0.02 to 0.09) %

The nutritional status of Bangladesh soils varies greatly. Total Nitrogen ranged from 0.04 to 0.42% (Rahman, 1988). Haque (1988) reported that total N content of Brahmaputra alluvial soils of Mymensingh ranged from 0.06 to 0.10% in the surface and 0.02- 0.08% in sub-surface layers. Portch and Islam (1984) reported that most of the soils of

Bangladesh contained N below critical level. Bhuiyan (1988) worked with 40 soil samples of Bangladesh and stated that the total N content of Bangladesh soils ranged from 0.05 to 0.22%.

Dohnke and Blume (1986) made a chemical analysis of seventeen Bangladesh soils and found that all the soil were deficient in nitrogen content (0.03 to 0.21%).

Department of Soil Survey (1979) reported that the nitrogen content of Bangladesh Agricultural University Farm Soils ranged from 0.06 to 0.13% in the top soil of the ridges. They further reported that total N content decreased gradually with depth.

The range and average values of NH_4-N content in 42 topsoil samples of Silmandi soil group (Silmandi and Lokdeo series) were 8 to 22 and 15 ppm, respectively, In Nandail thana. It also found that the Sonatala soil group (Sonatala, Kendua and Ishwargonj) contained 14 ppm NH_4-N on an average with a range of 8 to 18 ppm (SRDI, 1990). SRDI (1991), from a study with 18 samples of Sonatala series and 12 samples of Silmandi series, reported that average NH_4-N contents were 24 and 35 ppm, respectively, in Jamalpur Sadar thana.

In Kendua thana, the average contents of NH_4-N were found to be 13 ppm in Sonatala soil group (including Sonatala, Kendua, Ishwargonj and Tarakanda series) and 16 ppm in Silmandi soil group (including Silmandi and Lokdeo series) as reported by SRDI (1991). In this study, 19 topsoil samples were analyzed in case of Sonatala group and 34 topsoil samples were analyzed from Silmandi group.

2.2.5 Available Phosphorus

Phosphorus is essential to all living organisms and appears to be the second limiting factor in the mineral nutrition of crops. It is present in soil in both organic and inorganic forms. Inorganic forms of P include mainly phosphate compounds of Ca, Fe and Al. Plant absorbs P from soil solution in the form of $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-} ions. The solubility of inorganic phosphorus depends upon soil condition especially soil condition related to soil pH and the degree of availability to plants depends upon the solubility or dissociation of phosphate compounds. Organic phosphorus may be mineralized to available forms by the activities of soil microorganisms through the decomposition processes.

Phosphorus has many vital functions in photosynthesis and the plant utilization of sugars and starches that are produced for growth. It also plays an important role in the transfer of energy in plants (Chandra, 1973).

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available phosphorus was 20 ($mgkg^{-1}$)

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available phosphorus was ($mgkg^{-1}$).

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available phosphorus was 12.50 ($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available phosphorus was 18.60 ($mgkg^{-1}$).

Fatima (2007) observed some plots of SAU farm soils and found that that the mean value of available phosphorus was 10.46 ($mgkg^{-1}$).

Zafreen (2007) observed some plots of SAU farm soils and found that the mean value of available phosphorus was 18 ($mgkg^{-1}$).

Karim (2007) conducted an experiment in some plots of the SAU farm soils and and found that the mean value of of available phosphorus was 23 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that that the mean value of of available phosphorus was 21 ($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of available phosphorus was 22 ($mgkg^{-1}$).

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of of available phosphorus was 22.08 ($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available phosphorus was 31.21 ($mgkg^{-1}$).

Rashid (2007) observed some plots of SAU farm soils and found that that the mean value of available phosphorus was 58.8 ($mgkg^{-1}$).

Nazrul (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available phosphorus was 22.01 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available phosphorus content was 22.09 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available phosphorus was 41.93 ($mgkg^{-1}$).

Asaduzzaman (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available phosphorus was 15.86 ($mgkg^{-1}$).

Ahmed (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available phosphorus was 20 ($mgkg^{-1}$).

Nasrin . (2009) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available phosphorus was 20 ($mgkg^{-1}$).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of available phosphorus was 18.49 ($mgkg^{-1}$).Talati *et al.* (1975) stated that available phosphorus was found different at different locations and at different profiles.

Phosphorus is generally considered second most limiting crop nutrient after Nitrogen. It is one of the major constraints for successful production of upland crops in Bangladesh (Islam, 1983). Begum and Islam (1987) worked with three soil series of Bangladesh and reported that Tejgaon series contained a good amount of P (27 ppm), whereas Gangachara and Gopalpur series were deficient in P (7and 5 ppm respectively).

Available phosphorus content of Noagaon soil was 8 ppm which was below critical level and that of Kazirshmla soil was 16 ppm that was above critical level (Haque and Eaqub, 1988).

Portch and Islam (1984) reported that 41% soils of Bangladesh contained P below critical level and 35% below optimum level. They also reported that soil test average and range values for P were 12.8 and 5 to 23 ppm respectively in Chhiatta series. They further stated that in Sonatala series average range values were 13 and 2 to 32 ppm respectively. Eaqub and Zaman (1987) observed that the available phosphorus content of Sonatala and Silmandi were 14 ppm and 16 ppm respectively.

BARC (1987) reported that the available phosphorus content of Shibpur Upazila of series Teigaon, Kalma, Khilgaon, Sonatala and Silmandi was 7, 6, 7, 39 and 29 ppm respectively. It was mentioned that the phosphorus content of Tejgaon, Kalma and Khilagaon were below critical level and that of Sonatala and Silmandi were above critical level.

Bhuiyan (1988) observed that the available phosphorus of different soil series of Bangladesh ranged from 2.2 to 14 ppm with a mean value of 12.2 ppm.

The average content of available P in Kendua thana was found to be 31 ppm in Sonatala soil group (including Sonatala, Kendua, Ishwargonj and Tarakanda series) and 27 ppm in Silmandi soil group (including Silmandi and Lokdeo series) as reported by (SRDI, 1991a). SRDI (1990a) reported analyzing 12 topsoil samples of Sonatala soil group including Sonatala and Kendua series) and 20 topsoil samples of Silmandi soil group (including Silmandi and Lokdeo series) of Purbadhala thana and reported that average contents of available phosphorus as 21 ppm in Sonatala and 9 ppm in Silmandi soil group. SRDI (1990b) also found that the range and average values of available P content in 42 samples of Silmandi soil group (Silmandi and Lokdeo series) were 5 to 50 and 14 ppm, respectively, in Nandail thana. Again the Sonatala soil group (Sonatala, Kendua and Ishwargonj) contained 11 ppm available P on an average with a range of 6 to 20 ppm as mentioned in the same report.

2.2.6 Exchangeable Potassium

Potassium is very common in nature through it never occurs in elemental forms. K is a structural element of many soil minerals. A large portion of K in soils is present as a part of the crystalline structure of primary minerals and secondary minerals such as feldspars, micas and micaceous minerals of the clay fraction. A small portion (40 to 600ppm) is found in exchangeable ions and an extremely small part (1 to 10ppm) is present as soluble salt. The average K content of the earth's crust is 2-3%.

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of exchangeable potassium content was 0.10 (meq/100g soil).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of exchangeable potassium content was 0.15 (meq/100g soil).

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of exchangeable potassium content was 0.10 (meq/100g soil).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of exchangeable potassium content was 0.11 (meq/100g soil).

Fatima (2007) observed some plots of SAU farm soils and found that that the mean value of exchangeable potassium content was 0.27(meq/100g soil).

Zafreen (2007) observed some plots of SAU farm soils and found that that the mean value of exchangeable potassium content was 0.212(meq/100g soil).

Karim (2007) conducted an experiment in some plots of the SAU farm soils and and found that the mean value of of exchangeable potassium content was 0.11(meq/100g soil)

.Haque (2008) observed some plots of SAU farm soils and found that that the mean value of exchangeable potassium content was 0.42(meq/100g soil).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of exchangeable potassium content was 0.15(meq/100g soil).

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of of exchangeable potassium content was 0.285(meq/100g soil).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of exchangeable potassium content was 0.108 (meq/100g soil).

Rashid (2007) observed some plots of SAU farm soils and found that the mean value of of exchangeable potassium content was 0.16(meq/100g soil).

Nazrul (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of exchangeable potassium content was 0.177(meq/100g soil).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of exchangeable potassium content was 0.15 (meq/100g soil).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of exchangeable potassium content was 0.108 (meq/100g soil).

Asaduzzaman (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of exchangeable potassium content was 0.163(meq/100g soil)

Ahmed (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of exchangeable potassium content was 0.10(meq/100g soil).

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the mean value of exchangeable potassium content was 0.172(meq/100g soil)

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of exchangeable potassium content was 0.07(meq/100g soil)

Islam *et al.* (1974) worked with soils of Bangladesh and found that on an average about 0.51 % of total potassium of Bangladesh soils was in exchangeable form and a very negligible amount of 0.05% was in water soluble form. Marshall (1947) stated that the availability of potassium depends on primary minerals, secondary clay minerals, organic matter, potassic fertilizer etc. present in the soil.

Potassium is one of macro nutrients which is involved in the uptake of other nutrient elements such as Ca, N and P; since there is a close relationship between potassium and other nutrient elements (Kyuma. 1978 ; Islam *et al.,* 1985). Bhuiyan (1988) worked on different soil series of Bangladesh and reported that the exchangeable potassium ranged from 39 to 132.6 ppm with a mean value of 72.2 ppm. Portch and Islam (1984) reported that 75% soils of Bangladesh contained potassium below critical level and 17% below optimum level. They also reported that Chhiata series contained 0.1 to 0.36 meq $100g^{-1}$ soil exchangeable k. In Sonatala series they found that average and range values of potassium were 0.06 and 0.03 to 0.1 meq $100g^{-1}$ soil respectively.

Continuous cropping without potassium application was found to decrease the content of available potassium appreciably and increases the influence of potassium progressively

(Ghosh and Biswas, 1978). Ghelani (1985) reported that the availability of potassium content was more at lower depth than in the surface layer.

The magnitude of the exchangeable potassium values greatly differed from place to place within a short distance (Karim *et al.* 1980). Begum and Islam (1987) found that the Tejgaon soil series representing terrace soil and Gangachora series representing floodplain soils were deficient in potassium (0.19 and 0.18 meq $100g^{-1}$ respectively). They also reported that Gopalpur soil series representing Rajshahi soil contained potassium somewhat at critical level.

Eaqub and Zaman (1987) observed that the available potassium contents of Sonatala and Silmandi series were 0.06 and 0.15 meq $100g^{-1}$ respectively. BARC (1985) studied two soil series and reported that the available potassium status of Sonatala and Ghatail series was 121.21 and 82.11 ppm respectively. Haque and Eaqub (1988) reported that the potassium content of Noagaon soil was 0.1 meq $100g^{-1}$ and that of Kazirshimla soil was 0.15 meq $100g^{-1}$. They also reported that the soils contained potassium below the critical level. BARC (1987) reported that the available potassium content of Shibpur upazilla in soil series Tejgaon., Kalma, Khilgaon, Sonatala, and Silmandi was 0.31, 0.31, 0.29, 0.39 and 0.48 meq 100 mg^{-1} respectively. They commented that potassium content of these series was high falling above the critical level (0.20 meq 100 mg^{-1}).

Ahmed *et al.* (1973) worked with two soils of Bangladesh and reported that potassium fixation was minimal at the surface layer of new alluvium soil. They also observed that the intensity of potassium fixation progressively increased with time and directly related with the amount of clay in the soil. Eaqub and Islam (1982) reported that potassium is the third major nutrient element deficient in most of our soils. Previously, there was a general impression that Bangladesh soils have sufficient potassium and there is no need for any potash fertilizer application. However, due to intensification of agriculture in recent years, a well-spread response to add potash has been observed.

Mian and Eaqub (1981) found that exchangeable potassium content of Sonatala series was 0.10 meq 100 g^{-1} soil.

BARC (1987) reported that available potassium content was 0.39 and 0.48 meq 100g^{-1} soil in Sonatala and Silmandi series respectively in Shibpur thana.

SRDI (1990a) reported analyzing 12 topsoil samples of Sonatala soil group (including Sonatala and Kendua series) and 20 samples of Silmandi soil group (including Silmandi and Lokdeo series) of Purbadhala thana that average contents of available potassium was 0.33 meq 100 g^{-1} in Sonatala and 0.30 meq 100 g^{-1} in Silmandi soil group. SRDI (1990b) found that the range and average values of available potassium content in 42 samples of Silmandi soil group (Silmandi and Lokdeo series) were 0.20 to 0.52 and 0.40 meq 100 g^{-1} respectively in Nandail thana. It also found that the Sonatala soil group (Sonatala, Kendua and Ishwargonj) contained 0.40 meq 100 g^{-1} available potassium on an average with a range of 0.33 to 0.54 meq 100 g^{-1}.

SRDI (1991a), from a study with 18 samples of Sonatala series and 12 samples of Silmandi series, reported that average available potassium content were 0.29 and 0.30 meq 100 g^{-1} respectively in Jamalpur Sadar thana.

In Kendua thana, the average contents of available potassium were found to be 0.14 meq 100 g^{-1} in Sonatala soil group (Including Sonatala, Kendua, Ishwargonj and Tarakanda series) and 0.28 meq 100 g^{-1} in Silmandi soil group (including Silmandi and Lokdeo series) as reported by SRDI (1991b).

2.2.7 Available Sulphur

Sulphur is essential for the nodulation in legumes. It plays a role in the development of chlorophyll (Kulandai *et al.,* 1975). Islam (1977) reported that the adequate sulphur present in the soil was not available to plants because of reduction of sulphate to sulphide. Pointing sulphur deficiency the authors commented that increase in rice yield as a result of sulphur application was attributed mainly to the correction of sulphur deficiency in soil.

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available sulphur content was 45 ($mgkg^{-1}$).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available sulphur content was 25.96 ($mgkg^{-1}$).

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available sulphur content was 8.0 ($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available sulphur content was 11($mgkg^{-1}$).

Fatima (2007) observed some plots of SAU farm soils and found that that the mean value of available sulphur content was 18 ($mgkg^{-1}$).

Zafreen (2007) observed some plots of SAU farm soils and found that the mean value of available sulphur content was 16 ($mgkg^{-1}$).

Karim (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available sulphur content was 46 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that the mean value of available sulphur content was 221 ($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of available sulphur content was 16 ($mgkg^{-1}$).

Kawosar (2007) observed some plots of SAU farm soils and found that that the mean value of available sulphur content was 25.98 ($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available sulphur content was 20.42 ($mgkg^{-1}$).

Rashid (2007) observed some plots of SAU farm soils and found that the mean value of of available sulphur content was 20.77 ($mgkg^{-1}$).

Nazrul (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available sulphur content was 24.05 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available sulphur content was 25.98 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available sulphur content was 20.79 ($mgkg^{-1}$).

Asaduzzaman (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available sulphur content was 30.53 ($mgkg^{-1}$).

Ahmed (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available sulphur content was 45 ($mgkg^{-1}$).

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available sulphur content was 36.07 ($mgkg^{-1}$).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of available sulphur content was 20.82 ($mgkg^{-1}$).

Portch and Islam (1984) reported that the soil test average and range values for sulphur in soil were 11.4 and 4 to 38 ppm respectively in Chhiata series. In Sonatala series, they found average and range values of sulphur in soil were 17 and 6 to 52 ppm respectively. They also reported that 68% soils of Bangladesh contained sulphur below critical level and 14% below optimum level.

Total sulphur content of 17 soil series representing 8 districts and 16 general soil types varied between 14.4 (Tejgaon) and 83.9 (Harta) ppm with an average of 34.8 ppm. (Islam *et al.,* 1986). Eaqub and Zaman (1987) observed that the available sulphur contents of Sonatala series and Silmandi series were 8 ppm and 14 ppm respectively. Bhuiyan (1988) stated that the mean value of available sulphur of different series of Bangladesh was 16.8 ppm. Begum and Islam (1987) worked with three soil series of Bangladesh and reported that soils were deficient in S, the values of sulphur varied from 4 to 9 ppm.

Haque and Eaqub (1988) worked with two soils and reported that the soils of Noagaon was deficient in sulphur (10 ppm) and the sulphur content of Kazirshimla soil was just at critical level (14 ppm).

Portch and Islam (1984) studied 63 soil samples following the Agro Services International Methodology and found that 14, 21 and 68 percent of the soil samples were below the critical level for Ca, Mg and S, respectively. They further reported that the available sulphur content in Sonatala soil series and the varied from 6 to 52 ppm, with a mean value of 17 ppm.

SRDI (1990a) reported analyzing 12 topsoil samples of Sonatala soil group (including Sonatala and Kendua series) and 20 topsoil samples of Silmandi soil group (including Silmandi and Lokdeo series) of Purbadhala thana that average contents of Ca, Mg and sulphur were 3.0 m.e. 100 g^{-1}, 0.8 meq. 100 $g^{-1}$and 4 ppm in Sonatala, and 4.0 meq 100 g^{-1}, 0.9 meq 100 g^{-1} and 5 ppm in Silmandi soil group, respectively. SRDI (1990b), from a topsoil study with 2 samples of Sonatala soil group (including Sonatala and Kendua series) and 40 samples of Silmandi soil group (including Silmandi and Lokdeo series), reported that average Ca contents were 5.1 and 6.8 meq 100 g^{-1} soil, average Mg contents were 1.9 and 2.3 meq 100 g^{-1} soil and average sulphur contents were 13 and 13 ppm, respectively, for the two soil groups in Trishal thana. SRDI (1990c) found that the range values of Ca and Mg contents in 42 topsoil samples of Silmandi soil group (Silmandi and Lokdeo series) were 1.4 to 11.8 and 0.5 to 7.6 meq 100 g^{-1} respectively, while the sulphur content varied from 7 to 55 ppm in Nandail thana. It also found that the Sonatala soil group (Sonatala, Kendua and Ishwargonj) samples contained 6.3 meq 100 g^{-1} Ca, 1.9 meq 100 g^{-1} Mg and 20 ppm sulphur on an average.

Hossain (1978) analyzed a large number of soils from farmer's field in BRRI project area and found that the available sulphur content was below 10 ppm.

Sulphur deficiency in some rice soils of Bangladesh, occurring generally on submerged soil.(Jahiruddin *et al.*, 1981). In Kendua thana, the average contents of Ca and Mg were found to be 4.4 and 1.1 meq 100 g^{-1}, respectively, in Sonatala soil group (including Sonatala, Kendua, Ishwargonj and Tarakanda series) as reported by SRDI (1991a). It also found that in case of Silmandi soil group (including Silmandi and Lokdeo series) average contents of the above mentioned secondary nutrients were 4.5 and 1.2 meq $100g^{-1}$ respectively. It further reported that average contents of available sulphur were 10 and 18 ppm in Sonatala and Silmandi soil groups, respectively. In this study, 19 topsoil samples were analyzed in case of Sonatala group and 34 top soil samples were analyzed from Silmandi group. SRDI (1991b), from a study with 18 samples of Sonatala series and 12 samples of Silmandi series, reported that average Ca contents were 3.2 and 3.4 meq 100 g^{-1} soil, average Mg contents were 0.8 and 0.9 meq 100 g^{-1} soil and average sulphur contents were 11 and 13 ppm respectively, for the two soil series in Jamalpur Sadar thana.

Sulphur is absorbed by plant roots almost excessively as the sulphate ion ($S0_4^{--}$). Some SO_2 is absorbed through plant leaves and utilized by plant. Sulphur is present in equal or lesser amounts than P is such plant as wheat, corn, beans and potatoes but in large amounts in alfalfa, cabbage and turnips (Tisdale and Nelson, 1995).

2.2.8 Available Zinc

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available zinc content was 1.94 ($mgkg^{-1}$).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available zinc content was 3.31 ($mgkg^{-1}$).

Bhuiyan (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available zinc content was 1.2 ($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available zinc content was 3.39 ($mgkg^{-1}$).

Fatima (2007) observed some plots of SAU farm soils and found that the mean value of available zinc content was 1.84 ($mgkg^{-1}$).

Zafreen (2007) observed some plots of SAU farm soils and found that that the mean value of available zinc content was 1.682($mgkg^{-1}$).

Karim (2007) conducted an experiment in some plots of the SAU farm soils and and found that the mean value of of available zinc content was 1.516 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that that the mean value of available zinc content was 3.31($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of available zinc content was 1.716 ($mgkg^{-1}$).

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of available zinc content was 3.32 ($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available zinc content was 20.42 ($mgkg^{-1}$).

Rashid (2007) observed some plots of SAU farm soils and found that the mean value of available zinc content was 6.58 ($mgkg^{-1}$).

Nazrul (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available zinc content was 3.32 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available zinc content was 3.31 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available zinc content was 1.489 ($mgkg^{-1}$).

Asaduzzaman (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available zinc content was 1.548 ($mgkg^{-1}$).

Ahmed (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available zinc content was 1.618 ($mgkg^{-1}$).

Nasrin (2009) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available zinc content was 1.882 ($mgkg^{-1}$).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of available zinc content was 1.680 ($mgkg^{-1}$).

Portch and Islam (1984) reported that soil test average and range values for zinc were 1.5 and 0.8 to 2.2 ppm, respectively in chhiata series. In Sonatala series, they reported that average and range values of zinc were 16.3 and 0.8-76.7 ppm respectively.

Zinc is involved in chlorophyll formation but nothing is definitely known. It is also found to play a role in leaf development (Kulandai and Monickam, 1975). Jahiruddin *et al.* (1981) worked with some soils of Bangladesh and reported zinc deficiency in some rice soils, occurring generally in submerged soils. Dohnke and Blume (1986) worked with 17 rice soils of Bangladesh and observed that the available zinc content of the soils ranged from 0.2 to 2.7 ppm.

Begum and Islam (1987) reported that the Gangachara and Gopalpur soil series of Bangladesh were deficient in zinc. They also reported that the zinc content of Tejgaon soil series was above the critical level.

BARC (1987) reported that the available zinc content of Shibpur upazila soil series of Tejgaon, Kalma, Khilgaon, Sonatala and Silmandi were 2.4, 3.0, 2.8, 1.2 and 1.1 ppm respectively. They commented that the available zinc content of in Sonatala and Silmandi was below the critical level (2.0 ppm) but other series was above critical level.

Haque and Eaqub (1988) reported that the soils of Kazirshimla was deficient in zinc content which contained only 1 ppm zinc , whereas Noagaon soil contained zinc slightly above the critical level containing 2.2 ppm available zinc . Islam (1988) reported that 70% soils of Bangladesh contained zinc below the critical level and 14% below optimum level.

2.2.9 Available Copper

Fatima (2007) observed some plots of SAU farm soils and found that that the mean value of available copper content was 1.6 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that the mean value of available copper content was 3.56 ($mgkg^{-1}$).

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of available copper content was 3.54 ($mgkg^{-1}$).

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available copper content was 0.313 ($mgkg^{-1}$).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available copper content was 0.175($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available copper content was 0.66 ($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of available copper content was 0.6884 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available copper content was 3.54 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available copper content was 3.56 ($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available copper content was 3.54 ($mgkg^{-1}$).

2.2.10 Available Iron

Fatima (2007) observed some plots of SAU farm soils and found that the mean value of available Iron content was 14 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that the mean value of available Iron content was 262.9 ($mgkg^{-1}$).

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of available Iron content was 254 ($mgkg^{-1}$).

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Iron content was 8.798 ($mgkg^{-1}$).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Iron content was 21.56 ($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Iron content was 22.64 ($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available Iron content was 221 ($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of of available Iron content was 12.85 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of of available Iron content was 262.6 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available Iron content was 262.9 ($mgkg^{-1}$).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Iron content was 229 ($mgkg^{-1}$).

2.2.11 Available Manganese

Fatima (2007) observed some plots of SAU farm soils and found that the mean value of available Manganese content was 3.68 ($mgkg^{-1}$).

Haque (2008) observed some plots of SAU farm soils and found that the mean value of available Manganese content was 1.63 ($mgkg^{-1}$)..

Kawosar (2007) observed some plots of SAU farm soils and found that the mean value of available Manganese content was 1.74 ($mgkg^{-1}$).

Hossain (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Manganese content was 2.025 ($mgkg^{-1}$).

Uddin (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Manganese content was 3.77 ($mgkg^{-1}$).

Chowdhury (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Manganese content was 3.52($mgkg^{-1}$).

Islam (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available Manganese content was 1.73 ($mgkg^{-1}$).

Roy (2006) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Manganese content was 1.46 ($mgkg^{-1}$).

Shoukat (2006) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available Manganese content was 1.89 ($mgkg^{-1}$).

Mostofa (2007) conducted an experiment in some plots of the SAU farm soils and found that the mean value of available Manganese content was 1.87 ($mgkg^{-1}$).

Akhter (2005) conducted an experiment in some plots of SAU farm soils and found that the mean value of available Manganese content was 1.64($mgkg^{-1}$).

CHAPTER III

MATERIALS AND METHODS

3.1 Sampling location and sampling procedure

The map of SAU farm was collected from farm office(Fig 1). There were 54 plots in the farm, From each plot, 2 representative samples- one from the depth 0-15 cm and other from the depth 15-30 cm were taken from Red Brown Terrace soils of the farm division of Sher-e-Bangla Agricultural University, Dhaka. Soil of the experimental field belongs to the Tejgaon series under the Agro Ecological Zone, Madhupur Tract (AEZ-28).

Representative soil samples were collected from May 20 to May 28, 2011 and prepared to represent the each land type of different parts for laboratory analyses following the instructions outlined by Philippine Council for Agriculture and Resources Research (PCARR), 1980.

The soil samples were collected through augar following random method.Following the same procedure another 270 primary samples were collected from the sub soil (15-30 cm) depth. Which formed 54 composite samples. In total, 108 working samples were prepared for laboratory analyses.

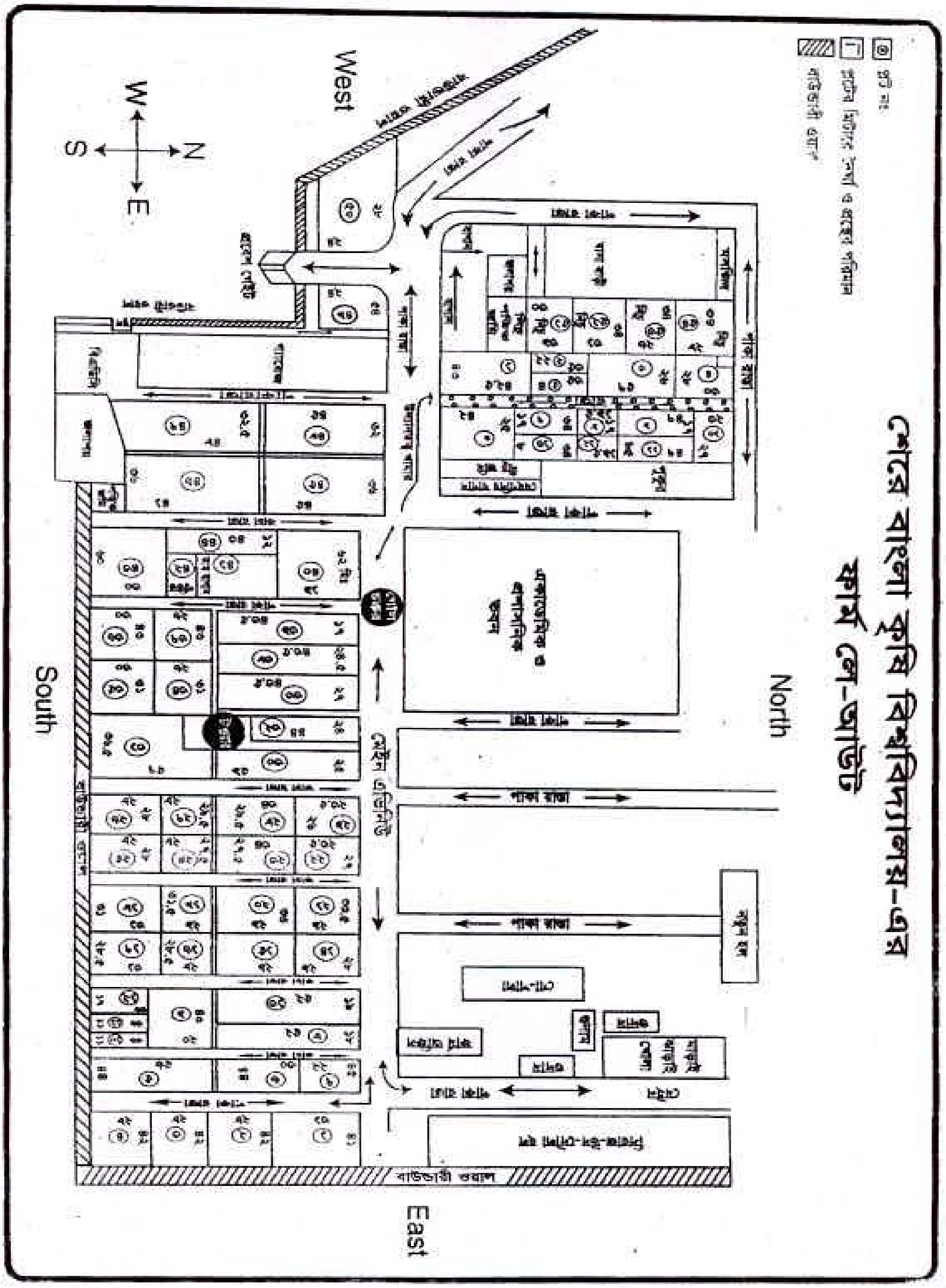

FIG : Layout of SAU farm soils.

3.1.1 Methods of analysis of soil physical properties

The methods followed to measure the different physical properties of the collected soil samples are given below:

3.1.2 Soil texture

Detem of Soil texture was detemined out by hydrometer method as outlined by Bouyoucos (1927). Fifty grams of oven dry soil from each sampling depth was taken separately in a dispersion cup and 100 ml of 5 percent calgon solution was added into each cup of about 2.5 cm from the top. The suspension was then stirred with electrical stirrer for 10 minutes. The contents of each dispersion cup were then transferred to one litre sedimentation cylinder separately and distilled water was added to make the volume up to the mark. A rubber cork was placed on the mouth of the cylinder and the cylinder was inverted several times until the whole soil mass appeared in the suspension. The cylinder was set upright and the hydrometer readings were taken 2 times at 40 seconds and 2 hours of sedimentation. The correction of hydrometer reading was made as the hydrometer was calibrated at 68° F. The percentage of sand, silt and clay were calculated as follows:

Calculation:

$$\% \text{ (Silt + Clay)} = \frac{\text{Corrected 40 seconds hydrometer reading}}{\text{Weight of oven dry soil}} \times 100$$

$$\% \text{ Clay} = \frac{\text{Corrected 2 hours hydrometer reading}}{\text{Weight of oven dry soil}} \times 100$$

% Sand = 100 - % (Silt +Clay)
% Silt = % (Silt +Clay) -% Clay
(C.H.R = Corrected hydrometer reading, W = Weight of oven dried soil)
The textural classes of soil phase determined for different depths by plotting the results on triangular diagram designed by Marshall (1947) following USDA (19'75) system.

3.1.3 Particle density

Particle density of soil was determined by volumetric flask method (Black, 1965).

$$\text{Particle density (g/cc)} = \frac{\text{Wt. of oven dried soil in g}}{\text{Volume of soil particles in cc}}$$

3.1.4 Bulk density

Bulk density of soil (0-15 cm depth) was determined by the help of a core sampler made of metal cylinders of known volume. The soil samples were collected from each sampling site with the help of a core sampler up to 15 cm depth. Then the samples were dried at 105°C in an oven until constant weights were attained. The oven dry weight of soil samples of known volume were taken to calculate the bulk density as follows:

$$\text{Bulk density (g/cc)} = \frac{\text{Wt. of oven dried soil in g}}{\text{Total volume of soil in cc}}$$

3.2 Analysis of soil chemical properties

3.2.1 Determination of soil pH

Soil pH of the collected soil samples were determined by glass electrode pH meter as described by Ghosh and Biswas (1978). Ten gram of air-dried soils were taken in a beaker and 25 ml. of distilled water was added. The suspension was stirred well for about 30 minutes and allowed to stand for about half an hour. The electrode was immersed into the partly settled soil suspension and pH was measured.

3.2.2 Determination of organic carbon

The percent of organic carbon of soil was determined by wet oxidation method (Page *et al* 1982). In this method wet oxidation of organic carbon was done with potassium dichromate and conc. sulphuric acid. Then titrated with ferrous sulphate using diphenylamine indicator. The amount of organic matter content in each individual soil sample can be determined by multiplying the percent organic carbon with the Van Bemmelen Factor, 1.73 (Page, 1982).

3.2.3 Determination of Cation exchange capacity

Cation exchange capacity is a measure of exchangeable bases and soil acidity at some specific soil pH. The exchangeable bases and acidity neutralize negative charges arising from permanent charges due to isomorphic substitution in clays, or pH-dependent charges from hydroxyl groups on clay and oxides or carboxyl groups on soil organic matter. A common method for determining CEC uses 1 M ammonium acetate (NH_4OAc) at pH 7 (neutral NH_4OAc) and is a standard method used for soil surveys by the Natural Resource Conservation Service (Burt, 2004; Carter et al., 2008; Sumner and Miller, 1996). An advantage of CEC measured at a constant pH of 7 is elimination of CEC variability due to differences in soil pH. Thus, comparisons of CEC can occur across varied soil types and lime applications.

<u>CEC and base saturation with neutral NH_4OAc</u>

Equipment and Apparatus

1. 250 mL beaker
2. Balance to weigh to the nearest 0.01 gm
3. 7.0 cm Buchner funnel
4. Filter paper (7 cm Whatman #1 or #42)
5. 250 mL suction flask connected to vacuum pump
6. 250 mL volumetric flasks
7. Balance, stir plate, stir bars and container for reagents
8. Apparatus and instrumentation for NH_4^+ analysis. Apparatus and instrumentation for Ca^{2+}, Mg^{2+}, K^+, and Na^+ analyses.

Reagents

1. 1 M NH_4OAc at pH 7.00.

Following are directions for making 10 L of this reagent. Multiply quantities by appropriate values for making larger or smaller volumes.

Make the solution in a fume hood to avoid breathing vapors of ammonia and acetic acid. Add 580 mL of glacial acetic acid (99.5%) to approximately 5 L of water. Add 680 mL of concentrated ammonium hydroxide (58% NH4OH). Add water to yield a volume of approximately 1900 mL. Adjust pH to 7.00 with dropwise additions of either ammonium hydroxide or acetic acid. Dilute to 10 L.

2. Ethyl alcohol (95%).

3. 1 M KCl.

Following is a procedure for making 10 L of this reagent.

Multiply quantities by appropriate values for making different volumes. Dissolve 745 g KCl in about 8 L of water. Dilute to 10 L.

Procedures

1. Weighing 10 grams of air-dried soil ground to less than 2 mm and place into a 250 ml beaker.

2. After adding 25 mL of NH4OAc to the soil. Refrain from mixing the beaker in a circular fashion to avoid soil wicking onto the sides of the beaker. Cover and let set overnight.

3. For each sample, preparing a 7 cm Buchner funnel by fitting it with a 7 cm Whatman #42 filter paper. Wet the filter with a minimum amount of NH4OAc. Insert the funnel into a 250 ml suction flask. Turn on vacuum pump to seat the moistened filter. Stir and transfer the soil-NH4OAc mixture into the filter.

4. Measuring approximately 75 mL NH4OAc for each sample into a plastic squirt bottle with one bottle for each sample. Use about 10 mL of the NH4OAc in the bottle to transfer all of the soil to the Buchner funnel.

5. By Covering the soil with a 7.0 cm Whatman #1 filter paper to keep the soil moist between leachings.

6. Leaching the soil 5 to 7 times with 10 to 15 ml increments of NH4OAc. Do not let the soil dry between leachings.

7. Transfering the leachate to a 250 mL volumetric and bring to volume with 1 M NH4OAc. Analyze the solution for Ca, Mg, K, and Na using atomic absorption spectrophotometry, flame emission spectrophotometry, or inductively coupled plasma spectrophotometry.

8. By remove excess NH4OAc in the soil, leach the soil with ethanol. Leach the soil with about 25 mL portions of ethanol five to six times for a total volume of about 150 mL.

9. After removing adsorbed NH_4 in the soil, leach the soil with 1 M KCl. Leach the soil with about 25 mL portions of 1 M KCl four to five times for a total volume of about 125 mL.

10. Transfering the leachate to a 250 mL volumetric flask and bring to volume using 1 M KCl. Analyze the solution for NH4 concentration using colorimetry, distillation, or ion-selective electrode potentiometry.

Calculations

1. If mg/L of NH4-N is quantified in the leachate, use the following to calculate CEC.

CEC (cmolc/kg) = (mg NH4-N / L) (0.25 L / 10 g soil) (1 meq NH4-N / 14 mg NH4-N) x 100

If mg/L of NH4 is quantified in the leachate use 18 mg NH4 instead of 14 mg NH4-N.

2. Calculate exchangeable bases (Ca, Mg, K, and Na) in meq/100 g as follows.

Ca (cmolc/kg) = (mg Ca / L) (0.25 L / 10 g soil) (2 meq Ca / 40.1 mg Ca) x 100

Mg (cmolc/kg) = (mg Mg / L) (0.25 L / 10 g soil) (2 meq Mg / 24.3 mg Mg) x 100

K (cmolc/kg) = (mg K / L) (0.25 L / 10 g soil) (1 meq K / 39.1 mg K) x 100

Na (cmolc/kg) = (mg Na / L) (0.25 L / 10 g soil) (1 meq Na / 23.0 mg Na) x 100

3. Calculate exchangeable acidity in meq/100 g as follows.

Acidity (cmolc/kg) = CEC – (Ca + Mg + K + Na)

4. Calculate percent base saturation as follows.

% base saturation = (Ca + Mg + K + Na) / CEC x 100

5. The Soil Science Society of America accepts cmolc/kg as the unit for CEC, exchangeable bases, and exchangeable acidity (ASA, CSSA, SSSA, 1998). A more common unit used for these values is meq/100 g. The units of cmolc/kg or meq/100 g are interchangeable since 1 meq/100 g = 1 cmolc/kg.

3.2.4 Determination of total nitrogen

Procedure

Take 1 gm soil sample in a microkjeldahl flask. Add 1.1 g catalyst mixture in each digestion tube in order to raise the boiling temperature of the digestion mixture and to shorten the digestion time. Then add 10 ml concentrated H_2SO_4 and swirl the flask gently so as to bring the dry sample to come in contact with the reagents. Add 2.0-2.5 ml 30% H_2O_2 prior to high temperature digestion to destroy organic material and to minimize foaming. Then heat the flask continuously at 360-410^oC temperature for 1 hr or more till the liquid is clear (the color of the soil turn grayish white). The sample should be observed very closely at this point, as the contents of the tube may start to foam and rise up to the top of the tube. If there is excessive foaming the samples can be lifted from the heating unit to let the foaming to subside. After completion of digestion, allow the flask to cool and add 20 ml water (slowly, and with shaking) then filter the repeated washing and make volume up to 50 ml. Transfer 10 ml of digest solution to the distillation chamber. Add 10 ml of H_3BO_3 indicator solution to a 250 ml conical flask which is marked to indicate a volume of 50 ml and place the flask under the condenser outlet of the distillation apparatus so that the delivery end dips in the acid. Add sufficient amount of 10N-NaOH solution in the container connecting with distillation apparatus. Note that water runs through the condenser of distillation apparatus. Collect the distillate in the conical flask by switch operating the distillation apparatus. Remove the conical flask and wash the delivery outlet of the distillation apparatus with distilled water. Titrate the distillate against 0.01 N H_2SO_4. The color change of the end point from green to pink. Record the amount of 0.01N H_2SO_4 solution required to neutralize the ammonium borate in which the distillate is collected. Run a blank experiment simultaneously using all the chemicals except soil.

The amount of N was calculated using the following formula:

$$\% N = \frac{(B-T) \times N \times 0.014}{w} \times 100$$

Where, B = Amount in mL of 0.1N NaOH solution required in blank titration

T = Amount in mL of 0.1N NaOH solution required in true (soil sample) titration

N = Actual strength of 0.1N NaOH solution

w = Oven dry weight of supplied soil sample

3.2.5 Determination of phosphorus

Phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ at pH 8.5 (Olsen et al, 1954). Both alkaline and neutral soils contain calcium phosphate. When this soil was treated with 0.5 M $NaHCO_3$, $CaCO_3$ is precipitate and phosphate ions are available in the soil solution. An acid molybdate solution containing orthophosphate ion forms a phosphomolybdate complex, which can be reduced to Mo blue colour by reducing agents like ascorbic acid. The intensity of this blue colour in solution depends on the concentration of available soil P in solution. The absorbance of solution is determined by means of a double beam spectrometer with an 890 nm wavelength. (Smeller, 1978).

3.2.6 Determination of exchangeable potassium

Ammonium acetate extraction method:

The available K in soil is the sum of the exchangeable and water soluble K, that is, the total K extracted by neutral 1N Ammonium Acetate. As an index of K availability for rapidly growing annual and perennial agronomic and vegetable crops, the exchangeable K is perhaps best expressed as a quantity, such as ppm, lbs per 2,000,000 lbs, or meq. per 100g. However, with some other crops, such as tree crops, the exchangeable K is perhaps best calculated as a percentage of the cation exchange capacity.

Equipments:

i. Centrifuge tube (50 mL)
ii. Pyrex bottle
iii. Volumetric flask (100 mL)
iv. Flame photometer
v. pH meter.
vi. Centrifuge.

Procedure

i. By Placeing 10 g. of soil (use 5 g if the soil contains 500 ppm extractable K) in a 50 ml. centrifuge tube.
ii. After that Added 25 ml. of NH_4OAc (pH 7.0).
iii. Shaking well the tube for 10 minutes.
iv. Next centrifuge the tube until the supernatant liquid is clear.
v. Transfering the supernatant liquid into a 100 ml volumetric flask.

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i. Centrifuge tube (50 mL)
ii. Pyrex bottle
iii. Volumetric flask (100 mL)
iv. Flame photometer
v. pH meter.
vi. Centrifuge.

Procedure

i. By Placeing 10 g. of soil (use 5 g if the soil contains 500 ppm extractable K) in a 50 ml. centrifuge tube.
ii. After that Added 25 ml. of NH_4OAc (pH 7.0).
iii. Shaking well the tube for 10 minutes.
iv. Next centrifuge the tube until the supernatant liquid is clear.
v. Transfering the supernatant liquid into a 100 ml volumetric flask.

vi. Made three additional extractions in the same manner. (Repeat the procedure thrice.)

vii. Diluted the combined extracts to 100 ml with more NH_4OAc.

viii. Then Mixed the solution.

Next determine K on a flame photometer by comparing the emission with standards made in NH_4Ac containing O, 10, 20, 40, 60, 80 and 100 ppm K. The NH_4OAc extract can be put directly into most flame photometers if care is taken to avoid solid particles that may clod the atomizer. If solid particles appear in the extract, filter a small portion of the extract using whatman No. 40 or equivalent quality filter paper before putting the solution into the flame photometer.

3.2.7 Determination of sulphur

Sulphur was determined by terbidimetric method with the help of spectrophotometer. Five (5.0) g soil was taken in a dry conical flask. Then 25 ml sulphur extracting solution was added. These were shaken for 30 minutes on an orbital shaker. The content was filtered in a dry conical flask.

Ten (10) ml. soil filtrate was pipetted in a conical flask. 10-ml acid seed solution was added. Five ml terbidimetric reagent was added. These were shaken frequently during 20 minutes. The absorbance on a spectrophotometer at 420-nm wavelength was measured. (Tresa *et al.*, 1999).

3.2.8 Determination of zinc, copper , iron, and manganese

Principle :

DTPA (Diethylene Triamine Penta Acetic acid) is a chelating agent. The chelating chemical (DTPA) combines with free metal (Zn, Fe, Cu, Mn) ions to form organo-metallic complexes in solution, thereby reducing the activity of the metals in the solution. In response, the metal ions desorb from the surfaces or dissolve from the labile solid phases to replenish the activity of free metal ions. Thus the amount accumulated is proportional to the intensity and capacity of the soil to replenish free ions in solution. Thus, the amount of micronutrients extracted by DTPA indicates their availability to crops. The extracting solution is buffered at pH 7.3 by Tri Ethanol Amine (TEA) to stabilize the pH and $CaCl_2$ is added to prevent the dissolution of $CaCO_3$ which may cause excessive extraction of the micronutrients. These conditions permit to dissolve the right amount of Zn, Fe, Cu, Mn in solution.

The dissolved micronutrients in the extract are then measured by Atomic Absorption Spectrophotometer (AAS), wherein the extracted sample is first converted into an atomic vapour, usually by a flame, and irradiated by the metal being sought. The absorption of radiated light by the vapourized sample is related to the concentration of the desired metal in it.

Procedure:

Ten gram of soil is weighed in a conical flask and 20 mL of the extracting solution is added. It is shaken continuously for 2 hours, preferably on a horizontal shaker and filtered through Whatman 42 filter paper. The filtrate is used for taking readings in Atomic Absorption Spectrophotometer.

3.2.9 Data analysis

The recorded data on different soil physical and chemical properties were analysed by Statistical Package for the Social Sciences (SPSS), Version- 12.0.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Physical characteristics:

The physical characteristics of soil are very useful criteria in the land use and management.Some of these properties were studied in the field as well as in the laboratory and presented with relevant discussion.

4.1.1 Particle size distribution and soil texture:

Particle-size analysis of soil was done by Hydrometer method. The results on particle size distribution of soils are presented in tables 4.1 and 4.2

The textural classes of SAU farm soils was loam both at 0 to 15 cm and 15 to 30cm soil depths. Loam textures of these soils indicate that they are suitable for rice and crop cultivation. Brammer (1971) reported that the texture of Bangladesh soils changes from coarse to fine along the north-south direction.

The mean values of sand, silt and clay at 0 to 15 cm soil depths were found 31.129%, 43.269 and 25.615 in SAU farm soils. The highest value of sand, silt and clay were found 39.42% ,58.4 % and 35.96% at 0-15 cm soil depths in SAU farm soils. The lowest value of sand, silt and clay were found 14.76% ,30.58% and 19.07% at 0-15 cm soil depths. (Table 4.1).

The mean value of sand, silt and clay at 15 to 30cm soil depths found to be 32.36%, 42.40°/o and 25.452% respectively in SAU farm soils. The highest value of sand, silt and clay were 40.16% , 53.92% and 46.87% respectively and The lowest value of sand, silt and clay were found 21% , 29.53 % and 16.61 % respectively at 15 to 30cm soil depths in SAU farm soils. (Table 4.2).

It appears from the results in Table 4.1 and 4.2 that the silt and clay fractions of SAU farm soils were relatively higher in the surface layer than the subsurface layer while the sand content showed verse trend of clay and silt in respect of depths. These variations in sand, silt and clay contents of different depths might be due to the movement of the clay and colloidal size particles through percolated water from the upper layers to the lower layers. During the rainy season the flowing water carried finer soil particles (clay) from the upper surface and deposits in the lower surface (15-30 cm depths) that resulted higher clay contents.

Loam soils are very good for agricultural use (Weir, 1989). They can easily be kept in a state of good tilth that is conducive to a rapid germination of seeds and to easy penetration of roots. Water drains through this soil with random and yet considerable water is retained by this soil for plant use. These soils are highly productive if skillfully managed.

4.1.2 Particle density

The results of particle density of soil have been presented in Table 4.1 and 4.2 The particle density of the studied soil at 0 to 15 cm depths in SAU farm soils varied from 2.35 to 2.51 g/cm and the mean value was 2.41g/cm. The particle density at 15 to 30cm soil depths varied from 2.37 to 2.54 g/cc where the mean value is 2.44 g/cc in SAU farm soils.

The particle density of surface soil (0-15) cm and sub surface soil 15-30 cm with standard deviation and CV % are presented in Table 4.1 and 4.2 respectively.

In general the surface layer had low particle density than to the subsurface layer due to the variations of organic matter and mineral content in the subsurface layer. The highest value of particle density was recorded (2.51 g/cc) in the surface layer and the lowest value of particle density was found to be (2.35 g/cc) (Table 4.1).

The increase in particle density in the sub-surface layer might be due to soil compaction and low organic carbon content. The weathered mineral elements were leached out from the surface layer and deposited in the sub-surface layer due to continuous cultural practices. Hossain and Idris (1976) observed similar trend results.

However, the gradual increase in particle density with increasing depths in all the studied SAU farm soils might be mainly associated with the decrease of organic matter with increasing depths (Table 4.4) and accumulation of minerals from the surface layer due to the long continued leaching with percolated rain.

4.1.3 Bulk density

Bulk density is the mass weight per unit volume of dry soil. The bulk density of soil is a variable parameter. It varies due to the content of organic matter, texture, structure, state of packing and on total pore space.

The results of bulk density of soil are presented in table 4.1 The Bulk density of the studied soil at 0 to 15 cm depths in SAU farm soils varied from 1.25 to 1.56 g/cc .

The bulk density of surface soil (0-15) cm with standard deviation and CV % are presented in Table 4.1 .

The lower values of bulk density in the surface layer were attributed to the higher content of organic matter in comparison to the lower depths. Besides, frequent cultivation and other cultural practices made the soil loose and finer which ultimately contributed to the low density in surface layer (0-15 cm depth). The bulk density is normally decreased as the mineral soil becomes finer in texture. The bulk density values for sand and sandy loam soils varied from 1.2 to 1.7 g/cm (Miller *et al.*, 1958).

4. 2.1.Physical properties of soil analysis

Table 4.1. Physical properties of soil for 0 to 15 cm soil depth

Plot no	Particle size			Textural name	Particle density g/cc	Bulk density g/cc
	%sand	%silt	%clay			
Plot no 1	30.21	40.4	29.75	Clay Loam	2.41	1.4
Plot no 2	35.05	33.72	31.23	Clay Loam	2.42	1.54
Plot no 3	33.44	33.68	27.76	Clay Loam	2.402	1.46
Plot no 4	35.09	39.09	25.82	Loam	2.392	1.48
Plot no 5	36.03	38.06	25.91	Loam	2.411	1.49
Plot no 6	39.42	35.52	25.06	Loam	2.422	1.56
Plot no 7	31.16	43.66	25.18	Loam	2.432	1.39
Plot no 8	27.64	46.6	25.76	Loam	2. 344	1.36
Plot no 9	31.72	46.11	22.17	Loam	2.394	1.39
Plot no 10	33.62	42.6	23.78	Loam	2.362	1.36
Plot no 11	37.62	43.31	19.07	Loam	2.424	1.49
Plot no 12	27.55	51.3	21.15	Silt Loam	2.45	1.32
Plot no 13	33.21	44.07	22.72	Loam	2. 38	1.41
Plot no 14	30.24	44	25.76	Loam	2.37	1.42
Plot no 15	35.12	38.77	26.11	Loam	2.412	1.46
Plot no 16	36.14	40.14	23.72	Loam	2. 391	1.51
Plot no 17	28.32	47.55	24.13	Loam	2. 4	1.33
Plot no 18	27.18	51.73	21.09	Silt Loam	2.44	1.28
Plot no 19	33.21	42.38	24.41	Loam	2. 391	1.41
Plot no 20	35.37	41.44	23.19	Loam	2. 380	1.52
Plot no 21	31.38	44.36	24.26	Loam	2.392	1.38
Plot no 22	31.04	43.75	25.21	Loam	2.41	1.37
Plot no 23	32.63	43.18	24.19	Loam	2.42	1.4
Plot no 24	34.27	42.58	23.15	Loam	2.431	1.46
Plot no 25	32.84	44	23.16	Loam	2.39	1.41
Plot no 26	30.72	44.27	25.01	Loam	2.36	1.4
Plot no 27	34.29	44.55	21.16	Loam	2. 35	1.49
Plot no 28	35.42	42.29	22.29	Loam	2. 411	1.53
Plot no 29	36.02	39.23	24.75	Loam	2. 372	1.55
Plot no 30	32.52	41.11	26.37	Loam	2.351	1.44
Plot no 31	30.84	45.4	23.76	Loam	2.354	1.39
Plot no 32	31.81	44.08	24.11	Loam	2.37	1.38
Plot no 33	34.44	43.29	22.27	Loam	2.383	1.5
Plot no 34	35.11	39.59	25.3	Loam	2.4121	1.51
Plot no 35	36.25	30.58	33.17	Clay Loam	2.42	1.54
Plot no 36	32.77	45.4	21.83	Loam	2.362	1.41
Plot no 37	36.21	41.07	26.72	Loam	2.39	1.54
Plot no 38	26.84	47.4	25.76	Loam	2.424	1.33

Table 4.1. continued						
Plot no	Particle size			Textural name	Particle density	Bulk density
	%sand	%silt	%clay			
Plot no 39	34.22	43.1	22.68	Loam	2.41	1.47
Plot no 40	30.82	46.02	23.16	Loam	2.3912	1.37
Plot no 41	30.24	44	25.76	Loam	2.366	1.36
Plot no 42	30.11	36	33.89	Clay Loam	2.433	1.34
Plot no 43	29.31	45.51	25.18	Loam	2.3821	1.33
Plot no 44	32.26	42	25.74	Loam	2.394	1.39
Plot no 45	33.21	40.51	26.28	Loam	2.4	1.42
Plot no 46	20.64	46	33.36	Clay Loam	2.43	1.32
Plot no 47	25.61	46.02	28.37	Clay Loam	2.4241	1.34
Plot no 48	23.59	48.2	28.21	Clay Loam	2.435	1.31
Plot no 49	31.12	43.07	25.18	Loam	2.4127	1.45
Plot no 50	32.03	41.79	26.18	Loam	2.41	1.42
Plot no 51	14.76	51.13	34.11	Silty Clay Loam	2.51	1.26
Plot no 52	23.64	51.13	26.96	Loam	2.394	1.3
Plot no 53	21	43.4	35.96	Clay Loam	2.423	1.29
Plot no 54	15.64	58.4	25.96	Silt Loam	2.45	1.25
Range	14.7	30.6	19.07		2.35	1.25
	to	to	to	to	to	To
	39.4	58.4	35.96		2.51	1.56
Mean	31.13	43.3	25.62	Loam	2.41	1.41
SD	5.05	4.8	3.51		0.03	0.08
CV %	16.2	11.03	13.7		1.26	5..67

Source: Characteristics of experimental soil is analyzed in the laboratory of Soil Science Department SAU Dhaka.

Table 4.2. Physical properties of soil for 15 to 30 cm depth

Plot no	Particle size			Textural name	Particle density g/cc
	%sand	%silt	%clay		
Plot no I	36.21	40.07	24.72	Loam	2.374
Plot no 2	40.16	38.03	21.81	Loam	2. 393
Plot no 3	34.3	40.11	25.59	Loam	2. 41
Plot no 4	34.24	38	27.76	Clay Loam	2.46
Plot no 5	37.38	44.1	25.5	Loam	2.43
Plot no 6	34.06	42.2	23.74	Loam	2.44
Plot no 7	33.64	44.6	21.76	Loam	2.452
Plot no 8	29.67	46.27	23.76	Loam	2. 441
Plot no 9	33.84	42. 37	23.79	Loam	2. 424
Plot no 10	29. 34	48.7	21.96	Loam	2.453
Plot no 11	32.6	43.25	24.15	Loam	2.431
Plot no 12	29.47	53.92	16.61	Silt Loam	2.472
Plot no 13	34.14	44.16	21.7	Loam	2. 41
Plot no 14	34.42	44	21.58	Loam	2.402
Plot no 15	35.51	41.86	22.63	Loam	2.383
Plot no 16	31. 38	38.97	29.65	Clay Loam	2. 454
Plot no 17	30. 39	45.48	24.13	Loam	2. 411
Plot no 18	32.24	49.4	18.36	Loam	2.473
Plot no 19	34.31	41.4	24.29	Loam	2. 4
Plot no 20	36.21	39.5	24.29	Loam	2. 364
Plot no 21	33.45	45.17	21.38	Loam	2. 447
Plot no 22	32.68	44.96	22. 36	Loam	2.432
Plot no 23	38.16	38.47	23. 37	Loam	2.387
Plot no 24	36.1	41.54	22.36	Loam	2.396
Plot no 25	34.84	36	29.16	Clay Loam	2. 36
Plot no 26	36.73	40.17	23.1	Loam	2.412
plot no 27	37.82	41.04	21.14	Loam	2. 410
Plot no 28	32.25	44.02	23.73	Loam	2. 445
Plot no 29	28.81	48.1	23.09	Loam	2. 470
Plot no 30	32.11	46.22	21.67	Loam	2.449
Plot no 31	33.83	45.52	20.65	Loam	2.435
Plot no 32	32.18	46. 38	21.44	Loam	2.447
Plot no 33	30.08	40.49	29.43	Loam	2. 4
Plot no 34	36.84	35.4	27.76	Clay Loam	2.454
Plot no 35	36.25	30.58	33.17	Clay Loam	2.481

Table 4.2 continued

Plot no	Particle size			Textural name	Particle density g/cc
	%sand	%silt	%clay		
Plot no 36	30.92	43.73	25. 35	Loam	2.417
Plot no 37	32.46	37.4	30.14	Clay Loam	2.44
Plot no 38	31.15	44.04	24.81	Loam	2.42
Plot no 39	35. 3	40.6	24.1	Loam	2. 401
Plot no 40	28.84	47.4	23.76	Loam	2.46
Plot no 41	32. 35	38.49	29.16	Clay Loam	2.472
Plot no 42	36.19	37	26.81	Loam	2.365
Plot no 43	33.51	43.25	23.24	Loam	2.426
Plot no 44	35.12	40.87	24.01	Loam	2. 432
Plot no 45	32.41	37. 38	30.21	Clay Loam	2.464
Plot no 46	29.61	46.29	24.1	Loam	2.419
Plot no 47	27.56	46.53	25.81	Loam	2.431
Plot no 48	23.65	46.02	30. 33	Clay Loam	2.473
Plot no 49	28.1	45.4	26.5	Loam	2.445
Plot no 50	27.6	42.52	29.88	Clay Loam	2.465
Plot no 51	21.64	47.4	30.96	Clay Loam	2.461
Plot no 52	27.72	46.87	25.41	Loam	2.448
Plot no 53	21	37.4	40.96	Clay	2.534
Plot no 54	23.65	29.53	46.87	Clay	2.54
Range	21	29.53	16.61		2.365
	to	to	to	to	To
	40.16	53.92	46.87		2.543
Mean	32.4	42.4	25.5	Loam	2.44
SD	4.2	4.6	5.1		0.04
CV %	13.03	10.8	20.03		**1.53**

Source: Characteristics of experimental soil is analyzed in the laboratory of Soil Science Department SAU Dhaka.

4.3 Chemical characteristics

4.3.1 Soil pH

The pH' value indicates whether any soil is acidic, alkaline or neutral. It plays a very important role in grouping the soils into different reaction classes. It has a profound influence on many factors connected with the suitability of a soil for agricultural use and hence special importance has been given to it.

The pH' value at 0 to 15cm soil depths varied from 4.9 to 8.06 g/l where the mean value is 6.28 In SAU farm soils. The pH of the collected soil sample at 15 to 30 cm depths in SAU farm soils varied from 4.87 to 7.41 g/l and the mean value was 6.11 g/l.

The pH of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in (Table 4.3 and 4.4) respectively.

The pH' value in SAU farm soils under the present investigation varied widely. the - surface layer and the sub-surface layer therefore, soils were highly acidic soil to medium alkaline.

It might be possible because of nitrogenous fertilizers were used in the -surface layer . Soils become acidic when considerable portions of the exchangeable cations are hydrogen ions and various forms of hydrated aluminium. As water containing hydrogen cations from various weak acids (such as carbonic and organic acids) moves through the soil, some of the hydrogen cations replace absorbed exchangeable cations, such as Ca^{++}, Mg^{++}, K^{+} and Na^{+} ; then water carries the removed cations deep into the soil profile or into the ground water. Michael (1978).

The low pH value may also be indicative of the low cation exchange capacity which is a notable feature of these soils. It is low near the surface and gradually increases with the increase of soil depth.

This increase of pH with depth is a common feature in many of the seasonally flooded soils of Bangladesh (Muzib et a!. 1969; Brammer, 1971, Matin and Uddin 1994). This increase has been attributed to the alternate oxidation and reduction conditions in the tidal flooded, poorly drained soils (Ponnamperuma, 1985). In the subsoil zone the soluble bases have only restricted movement where the internal drainage is poor.

As a result, the pH in the subsoils tends to remain at a higher level as compared to that in the surface soils.

4.3.2 Organic carbon

The results on organic carbon content of soils are shown in (Table 4.3). Organic matter is the life of soil as it is the store house of all plant nutrients. It is responsible for influencing the physical and chemical properties of soils. Role of organic matter in improvement of soil structure, water and nutrient holding capacities in light soils, release of available nutrients from native sources, control of soil erosion and supply of food and energy for beneficial soil microbes are well established facts (Islam, 1995).

Results of the organic carbon content in the studied SAU farm soils at 0 to 15 cm depths ranged from 0.247 to 2.15 with a mean value of 0.75 % (Table -4.3).

The organic carbon content of SAU farm soils at 15 to 30cm soil depth varied from 0.209 to 0.97 % and mean value 0.53% .(Table 4.4).

The organic carbon of surface soil (0-15) cm and sub surface soil 15-30 cm with standard deviation and CV % are presented in Table 4.3 and 4.4 respectively.

The organic carbon content was higher in the surface soil and decreased with increasing depths in all studied soils. Sood and Kanwar (1986), Anwar (1993) and Sahoo et *al.* (1995), also observed similar decreasing trend of results. This variation might be possibly for addition of organic matter in the surface layer and presence of compact plough pan in the sub-surface layer. The highest amount of organic carbon content 2.15% was found in the studied soils at 0 to 15 cm and the lowest value 0.21 % was observed at 15 to 30cm soil depth. (Table 4.4). As such , the studied soils hold low amount of organic matter

(BARC, 2005). Besides higher population of micro-organisms and plant residues also contributed to the higher organic carbon status in the surface layer (Islam et a!. 1993). The organic matter content in the studied soil showed a general tendency of decrease with depth . Organic carbon has a close relation with the nutrient availability of a soil. In our soil the low level of organic carbon might be due to higher oxidation rate of plant and animal residues by relatively higher temperatures. Soil organic carbon status can be enriched by adding cow dung, compost and through green manuring.

4.3.3 Cation exchange capacity (CEC)

Cation exchange capacity (CEC) refers to sum total of all exchangeable cations that a soil can adsorb at pH 7' The CEC is very important property of soils for predicting their exchangeable base, quantity types of clay minerals and their nutrient holding capacity (Landon, 1991). It also plays a vital role in determining the trend and type of fertility status of soils (Buol *et al* 1980). The weathering stage of soils or in other words their maturity can also be conveniently determined or predicted by their cation exchange capacity.

The cation exchange capacities of soils are presented in table 4.3 and 4.4. The cation exchange capacity of the soils of SAU farm soils at 0 to 15 soil depths ranged from 11.84 to 31.39 (cmol/kg) soil with a mean value of 16.70 (cmol/kg) soils (Table-4.3).

The cation exchange capacity of the soils under the present investigation of SAU farm soils at 15 to 30 cm depths ranged from 13.17 to 23.31 (cmol/kg) soil and mean value 16.53 (cmol/kg) soils (Table-4.4).

The cation exchange capacity of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in Table 4.3 and 4.4 respectively.

The highest 31.39 (cmol/kg) of cation exchange capacity was found SAU farm soils at 0 to 15 cm depth and the lowest 13.17 (cmol/kg) value was observed at 15 to 30 cm soil depth. (Table 4.3).

Cation exchange capacity of soils decreased with the increasing of soil depth in all the plots studied.

The values of cation exchange capacity of surface soilis higher than that of subsurface soil because of relatively high clay and organic carbon contents of the surface soil and of low clay and organic carbon contents of the subsurface soil so the cation exchange capacity values were relatively low in subsurface soil . The cation exchange capacity (CEC) values in all locations indicated that they decreased considerably with the increase in soil depth. This denotes that comparatively higher chemical activity in surface layer. Cation exchange capacity (CEC) of soils are influenced by a number of factors which may be enumerated as organic matter, clay content, free ion oxides etc. (Campbell and Calridge, 1975).

Landox (1991), who noted that the CEC was significantly correlated with clay and organic matter, but clay, was the bigger contributor in mineral soils.

4.3.4 Total Nitrogen

Total nitrogen contents of studied soils are shown in Table 4.3 and 4.4. The total nitrogen of the studied soil at 0 to 15 cm depths in SAU farm soils varied from 0.019% to 0.163% and the mean value was 0.057% . The total nitrogen at 15 to 30cm soil depths varied from 0.014 % to 0.079 % where the mean value is 0.04 in SAU farm soils.

The total nitrogen of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in Table 4.3 and 4.4 respectively.

The highest 0.163% total nitrogen was found SAU farm soils at 0 to 15 cm depth and the lowest 0.014 % was observed at 15 to 30 cm soil depth, which indicated low nitrogen content, (Appendix III) it was also supported by Umeda and Yamada (1980.)

Department of Soil Survey of Bangladesh (1979) stated that higher level of nitrogen may be due to free or nonsymbiotic N fixation. Specific types of microorganisms exist independently in soils and in water, convert nitrogen (N_2) into body tissue nitrogen form and then release it for plant use when they die and are decomposed.

4.3.5 Available phosphorous

The total available phosphorus at 0 to 15 cm soil depths varied from 17.64($mgkg^{-1}$) to 31.21($mgkg^{-1}$) where the mean value is 22.01($mgkg^{-1}$).(Table 4.3).

The phosphorus concentration of collected soil samples of SAU farm soils at 15 to 30cm depths found to vary from 15.86 to 41.93 ($mgkg^{-1}$) with an average 22.22 ($mgkg^{-1}$) (Table 4.4).

The studied soil can be interpreted as medium in respect of available phosphorus. (Appendix III) .Chowdhury (1992) also found similar trend of result.

The total available phosphorus of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in Table 4.3 and 4.4 respectively.

Bhuiyan (1988) observed that the available phosphorus of different soil series of Bangladesh ranged from 2.2 to 14 ppm, which was a good agreement with this study.

4.3.6 Exchangeable potassium

The potassium content of collected soil sample at 0 to 15 cm soil depths was within the range of 0. 123 meq $100g^{-1}$ to 0.212 meq $100g^{-1}$ with an average of 0.151meq $100g^{-1}$ (Table 4.3) , The potassium concentration of collected soil samples of SAU farm soils at 15 to 30cm depths found to vary from 0.108 to 0.285 meq $100g^{-1}$ soil with an average value of 0.152 soil meq $100g^{-1}$ (Table 4.4) which indicated low level of potassium, (Appendix III), Haque and Eaqub (1988) also reported low k in terrace soil of Bangladesh. The availability of potassium depends on primary minerals, secondary clay minerals, organic matter, potassic fertilizer etc. reported by Ghelani (1985) and Kemmler (1980).

The exchangeable Potassium of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in Table 4.3 and 4.4 respectively.

The exchangeable K contents in the soils under study indicates that these soils are not deficient in potassium and little application of potassic fertilizer will be needed for good growth of crops. The distribution of exchangeable K showed no significant variation.

Sharpley (1989) found that determination of both exchangeable and $HN0_3$ extractable K gave a better indication of the potential K supplying power of soils from a study with 102 soils of 10 orders. Potassium is an essential element for crops. Sometimes plant cannot uptake K from soil when it remains fixed with clay minerals.

4.3.7 Chemical properties of soil and nutrient analysis

Table 4.3 Chemical properties of soil for 0 to 15 cm soil depth						
Plot no	pH	CEC (cmol/kg)	% Organic carbon	Total N (%)	P (mgkg^{-1})	K (meq/100g soil)
Plot no 1	6.03	17.19	0.704	0.0533	24.79	0.168
Plot no 2	6.18	14.51	0.970	0.0735	23.92	0.175
Plot no 3	5.24	16.87	1.199	0.0908	24.29	0.163
Plot no 4	6.1	18.53	0.514	0.0389	23.07	0.156
Plot no 5	6.29	17.47	0.714	0.0524	21.31	0.144
Plot no 6	6.65	15.84	1.084	0.0822	22.64	0.162
lot no 7	6.08	14.51	0.552	0.0418	23.15	0.154
Plot no 8	6.45	15.84	0.780	0.0591	19.43	0.132
Plot no 9	6.94	15.69	0.400	0.0307	18.23	0.138
Plot no 10	6.65	14.59	0.628	0.0476	21.48	0.144
Plot no 11	6.95	15.48	0.856	0.0649	17.64	0.129
Plot no 12	6.6	11.84	0.545	0.0415	19.43	0.132
Plot no 13	6.76	14.49	0.639	0.0509	20.37	0.147
Plot no 14	6.86	14.68	0.683	0.0521	22.27	0.159
Plot no 15	7.52	15.84	0.970	0.0735	19.43	0.139
Plot no 16	6.95	14.89	0.932	0.0706	21.53	0.149
Plot no 17	8.06	14.51	0.639	0.0511	20.13	0.143
Plot no 18	7.41	12.27	1.122	0.0851	19.96	0.136
Plot no 19	7.67	16.23	0.932	0.0713	23.54	0.212
Plot no 20	7.49	16.29	0.742	0.0562	21.75	0.148
Plot no 21	7.57	12.44	0.742	0.0573	19.36	0.136
Plot no 22	6.97	14.95	0.514	0.0389	17.96	0.133
Plot no 23	7.04	14.19	0.552	0.0423	21.75	0.148
Plot no 24	5.61	15.07	0.780	0.0594	19.56	0.135
Plot no 25	5.89	19.44	0.628	0.0476	20.68	0.141
Plot no 26	6.43	15.74	1.427	0.1081	22.46	0.152
Plot no 27	6.3	12.77	0.666	0.0529	18.89	0.128
Plot no 28	5.46	14.11	1.199	0.0919	18.51	0.137
Plot no 29	5.86	15.49	0.247	0.0187	20.62	0.145
Plot no 30	7.32	12.77	0.716	0.0586	18.89	0.2
Plot no 31	4.98	13.18	0.818	0.062	21.49	0.142

Table 4.3 continued						
Plot no	pH	CEC (cmol/kg)	% Organic carbon	Total N (%)	P ($mgkg^{-1}$)	K (meq/100g soil)
Plot no 32	7.29	13.74	2.15	0.1629	31.21	0.125
Plot no 33	6.87	18.51	0.476	0.0375	21.29	0.147
Plot no 34	7.14	17.57	0.704	0.0533	19.43	0.131
Plot no 35	5.18	18.36	0.438	0.0332	24.79	0.168
Plot no 36	4.95	17.45	0.856	0.0649	21.74	0.143
Plot no 37	7.27	19.84	0.473	0.0361	23.14	0.157
Plot no 38	6.76	17.36	0.456	0.0359	23.64	0.153
Plot no 39	5.03	17.11	0.724	0.0533	19.43	0.132
Plot no 40	5.6	15.85	0.932	0.0704	21.84	0.152
Plot no 41	5.93	18.51	1.503	0.1139	23.56	0.156
Plot no 42	4.93	18.31	0.627	0.0466	26.57	0.182
Plot no 43	4.96	19.88	0.285	0.0216	23.33	0.156
Plot no 44	6.75	15.81	0.590	0.0447	23.43	0.151
Plot no 45	5.71	19.26	0.704	0.0533	21.54	0.145
Plot no 46	5.59	14.91	0.479	0.036	25.32	0.172
Plot no 47	5.54	17.37	0.438	0.0332	25.12	0.173
Plot no 48	4.9	20.24	0.856	0.0649	25.37	0.182
Plot no 49	7.16	17.22	0.476	0.036	21.75	0.148
Plot no 50	4.94	19.31	0.712	0.0187	24.07	0.163
Plot no 51	4.94	20.64	1.122	0.0851	29.43	0.123
Plot no 52	5.52	17.97	0.628	0.0476	24.07	0.163
Plot no 53	5.11	27.31	0.742	0.0562	17.64	0.212
Plot no 54	6.61	31.39	0.247	0.0562	22.29	0.151
Range	4.9	11.84	0.247	0.0187	17.64	0.123
	to	to	to	to	to	to
	8.1	31.39	2.15	0.1629	31.21	0.212
Mean	6.3	16.697	0.750	0.057	22.01	0.1511
SD	0.89	3.345	0.33	0.025	2.76	0.0179
CV %	14.2	20.0	44.	43.85	12.54	11.85

Source: Characteristics of experimental soil is analyzed in the laboratory of Soil Science Department SAU and (SRDI), Farmgate, Dhaka

Table 4.4 Chemical properties of soil for 15 to 30 cm soil depth

Plot no	pH	CEC (cmol/kg)	% Organic carbon	Total N (%)	P ($mgkg^{-1}$)	K (meq/100g soil)
Plot no 1	6.08	18.51	0.552	0.0418	23	0.156
Plot no 2	5.81	17.38	0.856	0.0649	19.43	0.132
Plot no 3	5.15	18.43	0.97	0.0735	15.86	0.143
Plot no 4	6.24	17.17	0.438	0.0332	24.74	0.168
Plot no 5	6.5	15.84	0.415	0.0303	23.13	0.151
Plot no 6	6.64	17.24	0.402	0.0313	21.23	0.144
Plot no 7	6.24	16.17	0.411	0.0342	19.43	0.138
Plot no 8	6.56	14.51	0.628	0.0476	20.92	0.122
Plot no 9	6.88	15.41	0.323	0.0245	21.42	0.112
Plot no 10	6.58	15.84	0.421	0.0319	19.43	0.121
Plot no 11	6.7	13.17	0.833	0.0791	20.58	0.149
Plot no 12	6.51	14.51	0.472	0.0369	22.79	0.153
Plot no 13	6.76	15.84	0.323	0.0245	19.43	0.123
Plot no 14	7.04	17.64	0.335	0.0257	19.77	0.165
Plot no 15	6.79	14.51	0.780	0.0591	21.02	0.153
Plot no 16	6.95	15.84	0.932	0.0706	21.53	0.146
Plot no 17	7.41	16.44	0.361	0.0274	19.27	0.285
Plot no 18	6.76	14.91	0.704	0.0533	16.39	0.111
Plot no 19	7.02	17.57	0.818	0.0622	21.75	0.148
Plot no 20	7.03	16.24	0.400	0.0334	21.14	0.157
Plot no 21	7.11	14.91	0.419	0.0312	16.39	0.117
Plot no 22	6.73	15.53	0.327	0.0247	19.96	0.136
Plot no 23	5.99	16.24	0.361	0.0274	19.72	0.138
Plot no 24	5.54	14.91	0.425	0.0373	19.15	0.13
Plot no 25	5.83	15.44	0.319	0.0225	26.04	0.177
Plot no 26	6.28	16.63	0.552	0.0418	20.68	0.147
Plot no 27	6.91	14.11	0.668	0.0501	17.11	0.119
Plot no 28	5.46	15.31	0.361	0.0271	18.89	0.128
Plot no 29	5.98	15.94	0.514	0.0389	20.43	0.149
Plot no 30	6.92	14.41	0.346	0.0247	17.03	0.117
Plot no 31	4.98	15.84	0.656	0.0508	17.64	0.122
Plot no 32	7.2	13.17	0.818	0.0629	17.18	0.154
Plot no 33	6.33	15.84	0.408	0.0377	24.43	0.151
Plot no 34	6.77	14.51	0.326	0.0235	24.37	0.163
Plot no 35	5.13	18.56	0.313	0.0233	24.11	0.144

Table 4.4 continued

Plot no	pH	CEC (cmol/kg)	% Organic carbon	Total N (%)	P (mgkg^{-1})	K (meq/100g soil)
Plot no 36	4.97	15.84	0.363	0.0274	23.14	0.108
Plot no 37	6.47	17.27	0.209	0.0159	26.57	0.18
Plot no 38	5.36	16.97	0.476	0.0363	22.64	0.156
Plot no 39	4.96	15.54	0.437	0.0143	22.79	0.159
Plot no 40	4.87	15.74	0.932	0.0476	21.11	0.141
Plot no 41	6.07	17.37	0.894	0.0678	24.79	0.167
Plot no 42	5.91	19.84	0.848	0.0618	24.03	0.163
Plot no 43	4.88	16.67	0.285	0.0366	26.57	0.172
Plot no 44	6.22	18.07	0.638	0.0511	21.54	0.142
Plot no 45	5.57	15.84	0.435	0.0332	21.03	0.189
Plot no 46	5.23	18.91	0.247	0.0177	19.92	0.136
Plot no 47	5.39	17.30	0.283	0.0216	23.51	0.168
Plot no 48	4.91	18.91	0.552	0.0418	27.11	0.184
Plot no 49	7.33	16.24	0.477	0.0365	41.93	0.161
Plot no 50	4.89	17.93	0.552	0.0428	25.82	0.166
Plot no 51	4.91	21.97	0.780	0.0591	27.64	0.188
Plot no 52	5.54	17.80	0.483	0.0360	24.07	0.163
Plot no 53	5.03	23.31	0.628	0.0476	36.57	0.248
Plot no 54	6.5	16.64	0.704	0.0533	23.51	0.285
Range	4.87	13.17	0.209	0.0143	15.86	0.108
	to	to	to	to	to	to
	7.41	23.31	0.97	0.0791	41.93	0.285
Mean	6.11	16.53	.53	0.04	22.22	0.15
SD	0.78	1.89	0.21	0.02	4.47	0.03
CV %	12.77	11.43	39.62	40	20.11	20.39

Source: Characteristics of experimental soil is analyzed in the laboratory of Soil Science Department SAU and (SRDI), Farmgate, Dhaka

Table 4.5 Chemical properties of soil for 0 to 15 cm soil depth

Plot no	S ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)
Plot no 1	15.08	1.612	0.4996	18.14	3.023
Plot no 2	20.79	1.715	0.6884	19.26	3.21
Plot no 3	25.68	1.619	0.8509	21.17	3.012
Plot no 4	11.01	1.722	0.3648	19.13	3.22
Plot no 5	15.44	1.412	0.4958	18.56	3.27
Plot no 6	23.24	1.532	0.7693	18.03	3.034
Plot no 7	11.82	1.582	0.3917	17.8	2.963
Plot no 8	16.71	1.486	0.5535	16.67	2.779
Plot no 9	8.561	1.587	0.2839	17.33	2.955
Plot no 10	13.45	1.68	0.4457	18.92	3.154
Plot no 11	18.34	1.882	0.6075	17.84	3.529
Plot no 12	11.82	1.382	0.3917	15.55	2.591
Plot no 13	14.27	1.615	0.4726	18.59	3.029
Plot no 14	14.24	1.514	0.4832	17.01	2.835
Plot no 15	20.79	1.711	0.6812	19.28	3.234
Plot no 16	19.98	1.819	0.6614	20.39	3.398
Plot no 17	14.23	0.787	0.1753	8.798	2.648
Plot no 18	24.05	1.313	0.7963	14.76	2.46
Plot no 19	19.98	1.518	0.6619	16.29	2.835
Plot no 20	15.9	1.413	0.5266	15.88	2.648
Plot no 21	36.07	1.618	0.5387	18.14	3.023
Plot no 22	11.55	1.513	0.3648	17.08	2.835
Plot no 23	11.87	1.625	0.3917	18.11	3.047
Plot no 24	16.71	1.733	0.5531	19.17	3.323
Plot no 25	13.45	1.642	0.4476	18.4	3.079
Plot no 26	30.57	1.511	1.0127	17.38	2.891
Plot no 27	14.27	1.725	0.4721	19.6	3.266
Plot no 28	25.68	1.882	0.8509	17.37	2.891
Plot no 29	15.3	1.349	0.4729	15.17	2.516
Plot no 30	14.27	1.537	0.4726	17.3	2.833
Plot no 31	17.53	1.548	0.5805	17.33	2.491
Plot no 32	36.07	1.539	0.3108	17.67	2.596
Plot no 33	10.19	1.443	0.3378	16.22	2.704
Plot no 34	15.08	1.449	0.4996	17.39	2.891
Plot no 35	9.376	1.398	1.5258	16.21	2.732

Table 4.5 continued

Plot no	S ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)
Plot no 36	18.34	1.496	0.6075	17.29	2.896
Plot no 37	10.19	1.577	0.3374	17.14	2.823
Plot no 38	10.77	1.339	0.3379	15.16	2.516
Plot no 39	15.08	1.741	0.4955	19.6	3.266
Plot no 40	19.98	1.562	0.6614	17.35	2.567
Plot no 41	32.21	1.509	1.0666	17.07	2.835
Plot no 42	5.3	1.774	0.4457	19.21	3.277
Plot no 43	6.115	1.413	0.2023	15.85	2.648
Plot no 44	12.64	1.645	0.4187	18.17	3.023
Plot no 45	15.87	1.822	0.4996	20.36	3.398
Plot no 46	10.19	1.186	0.3378	13.38	2.216
Plot no 47	9.376	1.285	0.3108	14.42	2.404
Plot no 48	18.34	1.193	0.6075	13.49	1.463
Plot no 49	10.19	1.482	0.3378	16.63	2.779
Plot no 50	15.9	1.548	0.5266	17.82	2.961
Plot no 51	24.05	1.417	0.7963	9.923	2.297
Plot no 52	13.45	1.181	0.4457	13.34	2.216
Plot no 53	15.9	1.082	0.5266	12.17	2.029
Plot no 54	13.45	0.882	0.2023	15.86	1.654
Range	5.3	0.787	0.1753	8.798	1.463
	to	to	to	to	to
	36.07	1.882	1.5258	21.17	3.529
Mean	16.11	1.50	0.53	16.98	2.82
SD	6.19	0.22	0.27	2.42	0.41
CV %	38.43	14.29	50.28	15.52	14.61

Source: Characteristics of experimental soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

Table 4.6 Chemical **properties** of soil for 15 to 30 cm soil depth

Plot	S ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)
Plot no 1	11.82	1.812	0.3917	20.39	3.398
Plot no 2	18.34	2.012	0.6075	17.35	3.773
Plot no 3	7.746	1.714	0.6884	19.26	3.21
Plot no 4	9.376	1.716	0.3108	19.44	3.11
Plot no 5	8.121	1.512	0.2839	17.01	2.835
Plot no 6	8.263	1.725	0.2831	18.29	3.12
Plot no 7	9.344	1.682	0.3133	18.93	3.154
Plot no 8	13.45	1.483	0.4457	16.67	2.779
Plot no 9	6.93	1.684	0.2292	18.44	3.157
Plot no 10	8.561	1.489	0.2855	16.67	2.779
Plot no 11	8.543	1.516	0.2873	18.56	3.154
Plot no 12	10.19	1.583	0.3378	17.8	2.966
Plot no 13	6.77	1.717	0.2291	19.27	3.17
Plot no 14	6.76	1.721	0.2262	19.08	3.19
Plot no 15	16.71	1.623	0.5535	18.14	3.023
Plot no 16	19.98	1.818	0.6614	20.22	3.04
Plot no 17	2079	0.782	0.2554	12.17	2.835
Plot no 18	15.08	1.643	0.4987	18.12	3.015
Plot no 19	17.53	1.722	0.5805	19.26	3.06
Plot no 20	8.561	1.752	0.5243	19.11	3.18
Plot no 21	8.561	1.543	0.2839	19.21	3.22
Plot no 22	6.93	1.633	0.2293	18.17	3.021
Plot no 23	7.432	1.454	0.2567	19	3.11
Plot no 24	8.566	1.816	0.2839	20.15	3.394
Plot no 25	6.93	1.232	0.2297	19.62	3.264
Plot no 26	11.82	1.841	0.3917	20.72	3.453
Plot no 27	14.27	1.865	0.4726	20.77	3.433
Plot no 28	7.746	1.632	0.2568	18.47	3.074
Plot no 29	11.01	1.442	0.3648	16.22	2.704
Plot no 30	6.964	1.649	0.2276	18.33	3.079
Plot no 31	14.27	1.746	0.4756	19.23	3.266
Plot no 32	17.53	1.641	0.1483	18.47	3.054
Plot no 33	8.51	1.548	0.2841	17.35	2.891

Table 4.6 continued					
Plot	S ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)
Plot no 34	6.87	1.866	0.2277	20.72	3.456
Plot no 35	6.55	1.342	0.2254	15.1	2.516
Plot no 36	7.746	1.344	0.2562	22.64	2.891
Plot no 37	13.45	1.447	0.1483	16.22	2.701
Plot no 38	10.19	1.434	0.3378	16.22	2.644
Plot no 39	8.588	1.623	0.2815	18.47	3.079
Plot no 40	4.484	1.465	0.4457	16.22	2.025
Plot no 41	19.22	1.631	0.6345	18.14	3.013
Plot no 42	19.12	1.817	0.6332	20.39	3.398
Plot no 43	8.567	1.515	0.2023	17.01	2.835
Plot no 44	14.21	1.713	0.4726	19.26	3.27
Plot no 45	9.345	1.815	0.3108	18.14	3.022
Plot no 46	5.3	1.382	0.1753	15.55	2.587
Plot no 47	6.115	1.385	0.2077	15.55	2.59
Plot no 48	11.82	1.182	0.3917	13.3	2.216
Plot no 49	10.33	1.384	0.3378	15.55	2.591
Plot no 50	10.65	1.381	0.3344	15.55	2.491
Plot no 51	16.71	1.082	0.5535	17.01	2.027
Plot no 52	10.44	1.365	0.3379	15.55	2.391
Plot no 53	13.45	1.034	0.4423	12.17	2.543
Plot no 54	15.08	1.515	0.4956	13.3	2.214
Range	4.484	0.782	0.5805	12.17	2.025
	to	To	to	to	to
	20.79	2.012	0.6884	22.64	3.773
Mean	10.96	1.56	0.366	17.81	2.95
SD	4.25	0.231	0.142	2.187	0.37
CV %	38.78	14.8	38.79	12.28	12.54

Source: Characteristics of experimental soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

4.3.8 Available sulphur

The available sulphur contents of soils showed at 0 to 15 cm depths in SAU farm soils varied from 5.3 to 36.07(mgkg^{-1}) and the mean value was 16.11 (mgkg^{-1}) (Table 4.5) . The available sulphur contents of soils at 15 to 30cm depths varied from 4.48 to 20.79 (mgkg^{-1}) where the mean value 10.96 (mgkg^{-1}) (Table 4.6)

The available sulphur of surface soil (0-15) cm and sub surface soil (15-30) cm with standard deviation and CV % are presented in Table 4.5 and 4.6 respectively.

The available sulphur contents of soils showed wide variation among different depths and places . Generally the available sulphur content was higher in the surface soil and decreased slightly in the sub-surface soil. In addition to others principle source of this nutrient in soils is organic matter whose status also decreased with increasing depths showing very close relation with these nutrients. (Table-4.6).

The available sulphur content of soil also showed decreasing trend with increasing soil depths. Our observation supported by Islam (1983) who reported that the sulphur deficiency in Bangladesh soil is becoming wide spread and acute. Our results are also supported by Chowdhury (1992) who reported that the available sulphur of soil decreased with increasing of soil depth and the available sulphur of Old Brahmaputra Floodplain Soil varied from 4.00 to 20.00 ppm.

High level of sulphur might be due to the presence of sulphur in irrigation waters (up to 7.7 (mg kg^{-1}) and also due to relatively high organic matter content of the soil along with higher percentage of clay content (up to 33.20% clay) that are responsible for retaining the higher proportion of sulphur. The application of sulphur fertilizer for intensive crop production might also be one of the causes of increasing soil sulphur in soil. Islam (1977)

4.3.9 Available Zinc

The available zinc contents of studied soils at 0 to 15 cm depth varied from 0.787 to 1.882 ($mgkg^{-1}$) and the mean value was 1.504 ($mgkg^{-1}$) (Table 4.5).The available zinc contents of soils at 15 to 30cm depths varied from 0.782 ($mgkg^{-1}$) to 2.012 ($mgkg^{-1}$) where the mean value was 1.56 ($mgkg^{-1}$) (Table 4.6).

In surface soils, The available zinc contents of soils at 0 to 15 cm soil depths , the standard deviation and the co-efficient of variation percentage was 0.215 & 14.29 respectively (Table4.5) & subsurface soils, at 15 to 30cm soil depths the standard deviation, and the co-efficient of variation percentage was 0.231 and 14.80 respectively (Table 4.6).

Jahiruddin (1990), reported that the availability of Zn^{++} increases with decreased soil pH.

4.2.10 Available Copper

The Copper content of collected soil sample at 0 to 15 cm soil depths was within the range of 0.1753 ($mgkg^{-1}$) to 1.5258 $mgkg^{-1}$ with an average of 0.53($mgkg^{-1}$) (Table 4.5) , The Copper concentration of collected soil samples of SAU farm soils at 15 to 30cm depth found to vary from 0.1483 to 0.6884($mgkg^{-1}$) soil with an average 0.37 ($mgkg^{-1}$) soil (Table 4.6)

In surface soils, (0 to 15 cm)The Copper content of collected soil sample at 0 to 15 cm soil depths the standard deviation and the co-efficient of variation percentage was 0.2679 & 50.28 respectively (Table4.5) & subsurface at 15 to 30cm, soil depths the standard deviation, and the co-efficient of variation percentage was 0.14 and 38.79 respectively (Table4.6).

4.3.11 Available Iron

Iron contents of soils are shown in T able 4.4. The Iron contents of the studied soil at 0 to 15 cm depths in SAU farm soils varied from 8.798 to 21.17 ($mgkg^{-1}$) and the mean value was 16.98(mgkg^{-1}) (Table 4.5) . The Iron contents at 15 to 30cm soil depth varied from 12.17 to 22.64 (mgkg^{-1}) where the mean value was 17.81 (mgkg^{-1}) in SAU farm soils. (Table 4.6)

In surface soils Iron contents of soils are at 0 to 15 cm soil depths the standard deviation and the co-efficient of variation percentage was 2.42 and 15.52 respectively (Table 4.5). and subsurface soils at 15 to 30cm soil depths the standard deviation, and the co-efficient of variation percentage was 2.19 and 12.28 respectively (Table 4.6).

4.3.12 Manganese

The Manganese content of collected soil sample at (0 to 15) cm soil depths was within the range of 1.463 to 3.529 mgkg^{-1} with an average of 2.82 (mgkg^{-1}) (Table 4.5) , The Copper concentration of collected soil samples of SAU farm soils at 15 to 30cm depth found to vary from 2.025 to 3.773 (mgkg^{-1}) soil with an average 2.95 (mgkg^{-1}) (Table 4.6).

In surface soils The Manganese content of collected soil sample at 0 to 15 cm soil depths, the standard deviation and the co-efficient of variation percentage was 0.41 and 14.61 respectively (Table 4.5) & subsurface soils at 15 to 30cm soil depths the standard deviation, and the co-efficient of variation percentage was 0.37 and 12.54 respectively (Table 4.6)

CHAPTER V
SUMMARY AND CONCLUSION

The study was made to analyse the soil Physical properties, chemical properties and soil (0-15cm) fertility of SAU farm soils. In this purpose 54 representative soil samples (0-15cm) and(15-30cm) were collected from Red Brown Terrace soils of the farm division of Sher-e-Bangla Agricultural University, Dhaka.

Soil of the experimental field belongs to the Tejgaon series under the Agro Ecological Zone, Madhupur Tract (AEZ-28). The soil samples were collected through augar following random method. In this method 0-15 cm depth of 270 primary samples were collected randomly and by aggregating 5 samples, one composite sample was formed. In this way, 54 composite samples were formed. Similarly 270 primary samples were collected randomly from the subsoil (15-30 cm) and by aggregating 5 samples, one composite sample was formed. Thus 108 working samples were prepared for laboratory analyses and at the regional laboratory of Soil Resources Development Institute (SRDI), Dhaka.

The texture of the surface soil(0-15cm) depth varied from loam to clay loam and that of subsurface soil (15-30 cm) ranged from loam to clay. However the texture of the studied soils was mostly loam. It appears from the results in (Table 4.1 and 4.2) that the silt and clay fractions of SAU farm soils were relatively higher in the surface layer than the subsurface layer. The particles density of surface layer (0-15cm) varied from 2.351 to 2.51(g/cc) and that of subsurface layer (15-30 cm) from 2.365 to 2.543 (g/cc). In general the surface layer had low particle density than to the subsurface layer . The increase in particle density in the sub-surface layer might be due to soil compaction and low organic carbon content. The bulk density of surface layer (0-15cm) varied from 1.25 to 1.56 (g/cc). The bulk density is normally decreased as the mineral soil becomes finer in texture. The pH of surface soil (0-15cm) varied from 4.9 to 8.06 (g/l) and that of subsurface layer (15-30 cm) from 4.87 to 7.41(g/l). The soils were acidic to Slightly alkaline. It might be possible because of nitrogenous fertilizers were used in the -surface layer .The cation exchange capacity of surface soil (0-15cm) ranged from 11.84 to 31.39 (cmol/kg) and that of subsurface layer (15-30 cm) from 13.17 to 23.31(cmol/kg). The low pH value may also be indicative of the low cation exchange capacity which is a notable feature of these soils .The values of cation exchange capacity of surface soils higher than that of subsurface soil because of relatively high clay and organic carbon contents of the surface soil . The organic carbon content of surface soil (0-15cm) varied from 0.247 to 2.15 % and that of subsurface layer (15-30 cm) from 0.21 to 0.97 %. The organic carbon content was higher in the surface soil and decreased with increasing depths in all studied soils. This variation might be possibly for addition of organic matter in the surface layer and presence of compact plough pan in the sub-surface layer .The total nitrogen content of surface soil (0-15cm) varied from 0.0187 to 0.1629 % and that of subsurface layer (15-30 cm) from 0.0143 to 0.0791 %. which indicated low nitrogen content. The available phosphorus content of surface soil (0-15cm) varied from 17.64 to 31.21 (mgkg-1) and that of subsurface layer (15-30 cm) from 15.86 to 41.93(mgkg-1). The studied soil can be interpreted as medium in respect of available phosphorus. The available potasium content of surface soil (0-15cm) varied from 0.123 to 0.212 (meq/100g soil) and that of subsurface layer (15-30 cm) from 0.108 to 0.285 (meq/100g soil). which indicated low level of potassium. The available sulphur content of surface soil (0-15cm) varied from 5.3 to 36.07 (mgkg-1) and that of subsurface layer (15-30 cm) from 4.484 to 20.79 (mgkg-1). The available sulphur contents of soils showed wide variation among different depths and places . Generally the available sulphur content was higher in the surface soil and decreased slightly in the sub-surface soil. The available sulphur content of soil also showed decreasing trend with increasing soil depths. The available zinc content of surface soil (0-15cm) varied from 0.787 to 1.882 (mgkg-1) and that of subsurface layer (15-30 cm) from 0.782 to 2.012 (mgkg-1). the availability of Zn^{++} increases with decreased soil pH. The available Copper concentration of surface soil (0-15cm) varied from 0.1753 to 1.5258 (mgkg-1) and subsurface layer (15-30 cm) from 0.1483 to 0.6884 (mgkg-1). The available Iron content of surface soil (0-15cm) varied from 8.798 to 21.17 (mgkg-1) and that of subsurface layer (15-30 cm) from 12.17 to 22.64 (mgkg-1). The available Manganese content of surface soil (0-15cm) varied from 1.463 to 3.529 (mgkg-1) and that of subsurface layer (15-30 cm) from 2.025 to 3.773 (mgkg-1). From the above discussion the organic carbon status of SAU farm soils was low, total nitrogen content was low, the available phosphorus content was medium, exchangeable potasium content was low, available sulphur content was medium, available zinc content was low . As a result it is clearly understandable that the fertility status of SAU farm soils are low but this soil may be highly productive if skillfully managed.

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APPENDICES

Appendix I. Soil characteristics based on pH

Category/Classification	pH Range
Highly acidic	4.5 or less
Acidic	4.5-5.5
Slightly acidic	5.6-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-8.4
Alkaline	8.5-9.0
Highly alkaline	9.0 or more

Source: Bhumi O Mrittika Sampod Nirdwshika, 2008

Appendix II. Soil fertility status based on organic matter

Classification/Categories	Range (O.M. %)
Very low	1.0 or less
Low	1.0-1.7
Medium	1.7-3.4
High	3.4-5.5
Very high	5.5 or more

Source: Bhumi O Mrittika Sampod Nirdwshika, 2008

Appendix III.Soil fertility level based on different nutrient elements.

Name of Element	Level of Nutrient		
	Low	Medium	Optimum
Total Nitrogen (%)	0.18	0.181-0.270	0.271-0.360
Phosphorus($\mu g\ g^{-1}$)	12	13-25	26-75
Sulphur($\mu g\ g^{-1}$)	12	13-25	26-75
Zinc($\mu g\ g^{-1}$)	2	2.1-4.0	4.1-18
Potassium (meq $100g^{-1}$)	0.2	0.21-0.40	0.41-1.50

Source: Bhumi O Mrittika Sampod Nirdwshika, 2008