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# SOIL FERTILITY STATUS OF IUBAT'S AGRICULTURAL RESEARCH STATION, RAJENDRAPUR, GAZIPUR

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## ABSTRACT

Twenty two soil samples (11 from 0-15cm and 11 from 15-30cm depths) were collected from IUBAT's Rajendrapur Agricultural Research Station, Gazipur covering two depths and six sites representing (I) vegetables, pulses and other crops, (II) wheat, rice and vegetable growing zone, (III) forest area, (IV) fruit growing zone, (V) maize cultivated area and (VI) lowland for boro cultivated area (Table 3-4). The soils were dried at IUBAT lab-2, ground, sieved and properly labeled. Twelve physical and chemical properties were studied at Humbold Soil Testing lab. BAU, Mymensingh. The morphological characteristics/description of the eleven representative soils is reported in Table 4. The soil properties studied covered textural classes (sand, silt and clay contents), particle density, pH, organic carbon, organic matter, N, P, K, S, EC, $HCO_3$, Na and Ca contents. The soils were acidic (pH 5.49-6.01) light-red, brown, loamy types (loam, clay loam, silt loam, sandy loam etc.), organic carbon (0.637-1.950%), organic matter (1.102-3.374%), particle density (2.406 to 2.69gmcm$^{-3}$, total N (0.072-0.187%), P (2.209-36.93ppm), K (0.104-0.209meq/100gm), S (10.14-43.00ppm), EC (33-164µS/cm), $HCO_3$ (126-305ppm), Na (0.123-0.185meq/100g) and Ca (0.370-0.617meq/100gm). Minor variations of soil properties were recorded from soil to soil and surface (0-15cm) and sub-surface (15cm) depths where standard deviations (SD, minor values) confirmed the low variations of the results. As the soils are acidic with mostly forest vegetation where proper management system through various green manuring, and other manuring by various practices are essential for 2-5 years for developing sound land for growing of most agricultural crops for larger productions.

**Key words:** Soil fertility, physical and chemical properties of soils, nutrient contents, management.

## Introduction

A universal concept "No soil no crop, no crop no food and no food no life" clearly and properly explain the importance of soil fertility. Soil, fertility is the capacity of soils to supply adequate/proper nutrients to crops. Practically, it is the inactive form of soil productivity i.e. a soil may be fertile but may or may not be productive. Through field and lab. analysis of soils under various conditions fertility can be confirmed. Polluted, hazardous and some problematic soils are not the fertile soils. Usually, all productive (growing of crops and vegetables) soils are the fertile soils but not all fertile soils are productive. Climate, rainfall, temperature, vegetation, drought, cyclone/tornato, erosion disasters etc. influences the soil fertility. Fertility is the originality of soils that rarely be changed naturally but through growing/improving of productive capacity-then fertility changes too. For studying of crop production works in the field usually basic studies of soil properties or soil fertility situation is important for all researchers where more than thousands of research works were done/completed with BAU soils by the MS and PhD students/researchers or different project works of the teachers in 1972-2023 where most of the these/reports are available at Univ. library. Sattar (CV) handled more than 100 soil fertility works for basic soil properties for supporting of main research and here 22 references (1-22) are listed dealing with fertility, productivity and other capacity and/or properties of soils. For proper crop growth, crop yield and food security soil fertility knowledge in important.

Fertility deals with mostly the physical and chemical properties of soils, where Sattar (1972)[1-3] studied fertility status of 4 soils for his M.Sc. (Ag). Thesis (4 articles published in India J. Soil Sci./India J. Agril. Sci.) including physical and chemical properties of 20 general soils of Bangladesh in 1973-74. BINA (1985)[4] described the fertility situations of some soils of Jamalpur like as pH (4.8-7.5), organic matter (0.4-3.0%), Ca (4.3-16 me/100g), Mg (0.15-8.4me/100g), K (0.56-0.86 me/100g), S (1-72ppm), Zn (1-6ppm), B

(0.1-10ppm) and the ranges were recorded from soils of Kustia were pH (5.3-8.1), organic matter (0.4-2.3%), C a(6.6-20.8me/100g), Mg (1.42-5.35me/100g), S (0.05-11.2ppm), Zn (0.5-0.6ppm) and B (0.04-3.32ppm). Sattar (1988)[8-9] handled 25-49 soil samples and the ranges of chemical properties are listed in Table 1 where standard deviation (SD) showed the variations of ranges of the results (minor to medium). Regarding soil fertility conditions and using of fertilizers BARC (1985)[13] developed guidebook covering on critical, low, medium and optimum levels of nutrients/fertility conditions and then using the necessary amounts of fertilizers against each nutrient (Table 2). Soil Resources Development Institute (SRDI), Dhaka published Upazila level of books covering fertility status and nutrient requirements to every union and/or village in 2000s and they are widely used regarding handling of fertility to the farmers field. They are also using soil sampling kits for helping soil fertility test and fertilizer doses for respective field of the farmers at village levels. Fertility largely helps for guiding the requirements of fertilizers to the particular area/field for better yield of crops. In the present study, the fertility status of six (I-VI) categories of 11 soils at 2-depths was established at IUBAT's Agricultural Research Station (ARS) at Rajendrapur, Gazipur. As the soils and soil properties are variable so further related research is important covering 50 or more soils of the region.

Table 1. Evaluation, observation and analysis of the nutrient elements for crop fields in Bangladesh (Sattar, 1988)[8]

| Sl. No. | Nutrient elements | Ranges | Average | Standard deviation SD | Results handled (samples) |
|---|---|---|---|---|---|
| 1. | pH vaues | 5.8-7.9 | 5.93 | 1.016 | 49 |
| 2. | Organic matter (%) | 0.8-6.85 | 1.52 | 1.059 | 42 |
| 3. | Total-N (%) | 0.05-1.20 | 0.25 | 0.289 | 22 |
| 4. | $NH_4$-N(ppm) | 2.0-49.0 | 21.16 | 13.334 | 19 |
| 5. | $NO_3$-N(ppm) | 2.2-11.1 | 6.76 | 2.839 | 14 |
| 6. | Ca (me/100g) | 1.9-19.8 | 8.16 | 6.962 | 33 |
| 7. | Mg (me/100g) | 0.3-8.44 | 2.54 | 1.581 | 33 |
| 8. | K (me/100g) | 0.01-0.86 | 0.26 | 0.213 | 33 |
| 9. | P (ppm) | 2.0-62.0 | 13.88 | 8.707 | 25 |
| 10. | S (ppm) | 1.0-75.0 | 9.02 | 14.382 | 27 |
| 11. | B (ppm) | 0.10-120.0 | 6.49 | 26.041 | 20 |
| 12. | Cu (ppm) | 1.0-27.0 | 4.77 | 2.114 | 27 |
| 13. | Fe (ppm) | 22.0-374.0 | 130.19 | 102.446 | 27 |
| 14. | Mn (ppm) | 4.6-105.0 | 29.39 | 21.331 | 27 |
| 15. | Zn (ppm) | 0.7-6.0 | 1.87 | 1.279 | 27 |
| 16. | Mo (ppm) | 0.05-0.58 | 0.26 | 0.174 | 17 |

Table 2. Critical, low, medium and optimum levels of nutrient elements in crop field soils (BARC, 1985)[13]

| Sl. No. | Nutrient elements | Critical levels | Low | Medium range | Optimum range |
|---|---|---|---|---|---|
| 1. | N (µg/ml) | 75 | 75 | 76-150 | 151-300 |
| 2. | P (µg/ml) | 12 | 10 | 13-25 | 35-75 |
| 3. | S (µg/ml) | 12 | 12 | 13-25 | 26-75 |
| 4. | B (µg/ml) | 0.3 | 0.2 | 0.81-0.50 | 0.51-40 |
| 5. | K (me/100g) | 0.2 | 0.2 | 0.21-0.40 | 0.41-1.5 |
| 6. | Mg (me/100g) | 0.8 | 0.8 | 0.81-2.0 | 2.1-9.0 |
| 7. | Ca (me/100g) | 2 | 2 | 2.1-4.0 | 4.1-18 |
| 8. | Zn (µg/ml) | 2 | 2 | 2.1-4.0 | 4.1-18 |
| 9. | Cu (µg/ml) | 1 | 1 | 1.1-3.0 | 3.1-10 |
| 10. | Mn (µg/ml) | 5 | 5 | 5.1-10 | 11-50 |
| 11. | Fe (µg/ml) | 20 | 20 | 21-40 | 41-200 |

The following factors directly and/or indirectly influence/affect the fertility status/conditions of the soil environment of Bangladesh (Sattar, 1988): (1) high or low temperature, (2) severe rainfall, (3) flooding or severe long time water logging, (4) northwestern winds, (5) soil erosion by wind, water and human activities, (6) cyclone disaster, (7) soil moisture condition, (8) clay content, (9) using of irrigation water,

(10) river-bank erosion, (11) river sedimentation, (12) HYV of crops, (13) poor crop rotation, (14) severe fertilizer and pesticide applications, (15) burning of crop residues, (16) poor reserving/saving of crop residues, (17) types of crops/plants, (18) poor organic matter content, (19) poor using of manuring, (20) grazing of animals, (21) cutting of surface soil, (22) methods of fertilizer applications, (23) seasonal variations, (24) poor/lack of proper microbial actions/functions, (25) varietal performances, (26) deforestation, (27) poor farming i.e. subdivision and fragmentation of land, (28) climate changes/variations, (29) severe pollution and degradation of land, (30) rise/increasing of heavy metal contaminations, (31) soil pH and salinity situations, (32) growth/rise of human settlement, (33) urban sanitation, (34) poor taking care of soil health, (35) huge waste disposal in crop field, (36) growth of industry and industrial effluents to the crop fields, (37) lack or poor soil fertility management practices, (38) natural drought, (39) poor or lack of intercultural operation to the crops, (40) high salinity.

## Materials and Methods

Six categories (I-VI) of 11 soil samples were collected covering 4 from vegetable, pulses and fruit garden area, (I) 3 from wheat, rice, vegetable growing area, (II) 1 from forest zone, (III) 1-fruit gardening/growing area, (IV) 1-maize field and (V) 1-from low land (VI) of boro rice field (Table 3-4). Each soil sample was collected by Auger at 0-15cm and 15-30cm depths, packed well, carried at IUBAT campus soil science lab-2, dried at room temperature, ground well and then sieved and packed properly with labelling. Soil fertility covering some physical (sand, silt, clay and textural types, particle density) and chemical (pH, organic carbon, N, P, K, S, EC, $HCO_3$, Na and Ca contents were determined by regular standard methods (Sattar and Rahman, 1987)[2] at Humboldt Soil Testing lab., Dept. of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh.

Table 3. Crops and vegetation of the study area

| Area category | Soil sample No. | | Crops and/or vegetation |
|---|---|---|---|
| | No. | Depths (cm) | |
| I. | 1, 2, 3, 4 | 0-15; 15-30 | Vegetables, pulses, grasses, jackfruit plants |
| II. | 5, 6, 7 | 0-15; 15-30 | Wheat, rice, vegetables |
| III. | 8 | 0-15; 15-30 | Forest plants-sal, segun, tal, bamboo, wild grasses, banana |
| IV. | 9 | 0-15; 15-30 | Jackfruit, lemon, mango, grasses, banana |
| V. | 10 | 0-15; 15-30 | Maize, ginger, wild grases, anas, termaric |
| VI. | 11 | 0-15; 15-30 | Lowland, waterlogging, boro rice, amon rice |

Table 4. Soil sampling records and the morphological description

| Sl No. | Observations/information recorded | | Description/evaluations |
|---|---|---|---|
| 1. | Soil sampling location | : | IUBAT's ARS at Rajendrapur, Gazipur |
| 2. | General soil type | : | Shallaw red brown soils/red brown terrace soils |
| 3. | Topography | : | Slighty high land, high land |
| 4. | Vegetation | : | Wheat, rice, pulses, grasses, forest plants, jackfruits, banana, mango, bamboo, ginger |
| 5. | Drainage/site drainage | : | Well drained |
| 6. | Sampling depths | : | 0-15 cm and 15-30 cm |
| 7. | Collection technique | : | By Augur |
| 8. | Date of collection | : | May 2023 |
| 9. | Collected by | : | 3rd semester Agriculture students of IUBAT, Dhaka (2 students and author) |
| 10. | Number of samples collected | : | 11 samples, 0-15 cm depth; 11 samples, 15-30 cm depth |

## Results and Discussion

The fertility status covering some physical and chemical properties of six categories/sampling areas (I-VI) representing soil samples (11) each at two depth (0-15cm and 15-30cm) are discussed here in Tables 5-9.

**I. Soil fertility in relation to physical properties of soils**

Physical properties covered soil colour, land type and particle density (Table 5) including
Textural classes (% sand, silt and clay contents) (Table 6) are studied at 0-15 cm and 15-30cm depths.

1. **Land type:** Except group/category VI-sample No. 11 (lowland), the other soil regions (No. 1-10) covered high land like as forest land/forest vegetation i.e. high land for most crops.

2. **Soil colour:** As the soils are acidic red types so most of the soils (No. 1-10) are shallow/light red or shallow red brown in colour. Colour dominancy reduced at lower depths. Low land soils are brown in colour (Table 5).

3. **Particle density:** At surface soil particle density varied from 2.257-2.691gm$^{-3}$ with an average of 2.492gm$^{-3}$ and 2.406-2.786gm$^{-3}$ with the average value of 2.541gm$^{-3}$ respectively. Particle density of 11 surface and 11 sub-surface soils showed nearly, similar values including soils at lowland (No. 11) with slightly higher at sub-surface soils. The standard deviation of 0.112(0-15cm) and 0.102(15-30cm) showed very minor variations of the results in surface and sub-surface soils (Table 5). Particle density of organic soils were less than 2.00gm$^{-3}$ and mineral soils 2.65-2.75gm$^{-3}$ and soils of Bangladesh 2.00-2.65gm$^{-3}$ (Sattar, 2022)[22].

Table 5. Soil physical properties

| Area categories | Sample No. | Sampling depths (cm) | Land type | Soil colour | Particle density gm/cm |
|---|---|---|---|---|---|
| I. | 1. | 0-15 | High | Red-shallow light | 2.492 |
| | | 15-30 | High | Red-shallow light | 2.406 |
| | 2. | 0-15 | High | Red-shallow light | 2.504 |
| | | 15-30 | High | Red-shallow light | 2.571 |
| | 3. | 0-15 | High | Light-red brown | 2.520 |
| | | 15-30 | High | Light-red brown | 2.588 |
| | 4. | 0-15 | High | Red brown | 2.444 |
| | | 15-30 | High | Shallow red brown | 2.468 |
| II. | 5. | 0-15 | High | Light red | 2.691 |
| | | 15-30 | High | Light red | 2.638 |
| III. | 6. | 0-15 | High | Medium red (average) | 2.550 |
| | | 15-30 | High | Low red | 2.560 |
| IV. | 7. | 0-15 | High | Red brown | 2.251 |
| | | 15-30 | High | Light red brown | 2.507 |
| V. | 8. | 0-15 | High | Shallow red | 2.647 |
| | | 15-30 | High | Shallow red (light) | 2.488 |
| VI. | 9. | 0-15 | High | Red brown | 2.468 |
| | | 15-30 | High | Low red brown | 2.786 |
| | 10. | 0-15 | High | Red brown | 2.405 |
| | | 15-30 | High | Deep red brown | 2.427 |
| | 11. | 0-15 | Low | Light brown | 2.427 |
| | | 15-30 | Low | Light brown | 2.510 |
| | 0-15cm | $\bar{x}$ (Average value) | | | 2.492 |
| | | SD (Standard deviation) | | | 0.112 |
| | 15-30cm | $\bar{x}$ | | | 2.541 |
| | | SD | | | 0.102 |

$\bar{x}$ = average; SD = Standard deviation

4. **Textural classes:** Table 6 showed the % sand, silt and clay contents and the textural classes of 11 soils each at 2 depths i.e. 22 soils from six areas/categories (I-VI). Sand content varied 33-52% at surface and 31-53% at sub-surface with the average ($\bar{x}$) and standard deviation (SD) of $\bar{x}$ 40.364% (surface) an $\bar{x}$ = 41.455% (sub-surface SD=6.880 surface, 0-15cm depth; 8.50 sub-surface 15-30depth). Sand contents were nearly uniform at two-depth and there SD values showed slight variations. Again, silt content at surface and sub-surface soil ranged 34-50% and 38-48% with average of $\bar{x}$ =42.636% and 42.273 and standard deviations of SD = 4.978 and 3.078, respectively. Clay particle varied 07-26% at top soils with $\bar{x}$ values of 17% and SD of 7.084 and 07-27% at sub-soil (15-30cm depth) with $\bar{x}$ values 16% and SD of 8.623. The textural types of surface soils were recorded to loam, clay loam, silt loam, sandy loam and that of sub-surface soils to clay loam, loam, and sandy loam types (Table 6).

Table 6. Sand, silt and clay contents and the textural classes of soils at 2-depths

| Area categories | Sample No. | Sampling depths (cm) | Sand (%) | Silt (%) | Clay (%) | Textural classes |
|---|---|---|---|---|---|---|
| I. | 1. | 0-15 | 33 | 46 | 21 | Loam |
| | | 15-30 | 35 | 38 | 27 | Clay loam |
| | 2. | 0-15 | 39 | 40 | 21 | Loam |
| | | 15-30 | 33 | 42 | 25 | Loam |
| | 3. | 0-15 | 33 | 40 | 27 | Clay loam |
| | | 15-30 | 39 | 48 | 13 | Loam |
| | 4. | 0-15 | 37 | 50 | 13 | Silt loam |
| | | 15-30 | 31 | 42 | 27 | Clay loam |
| II. | 5. | 0-15 | 39 | 38 | 23 | Loam |
| | | 15-30 | 53 | 40 | 07 | Sandy loam |
| | 6. | 0-15 | 52 | 39 | 09 | Loam |
| | | 15-30 | 52 | 41 | 07 | Loam |
| | 7. | 0-15 | 53 | 40 | 07 | Sandy loam |
| | | 15-30 | 53 | 40 | 07 | Sandy loam |
| III. | 8. | 0-15 | 39 | 34 | 27 | Clay loam |
| | | 15-30 | 43 | 48 | 09 | Loam |
| IV. | 9. | 0-15 | 47 | 46 | 07 | Loam |
| | | 15-30 | 49 | 44 | 07 | Loam |
| V. | 10. | 0-15 | 39 | 46 | 15 | Loam |
| | | 15-30 | 31 | 42 | 24 | Clay loam |
| VI. | 11. | 0-15 | 33 | 50 | 17 | Silt loam |
| | | 15-30 | 37 | 40 | 23 | loam |
| | 0-15cm | $\bar{x}$ | 40.364 | 42.636 | 17 | |
| | | SD | 6.880 | 4.978 | 7.084 | |
| | 15-30cm | $\bar{x}$ | 41.455 | 42.273 | 16 | |
| | | SD | 8.50 | 3.078 | 8.623 | |

$\bar{x}$ = average; SD = Standard deviation

**II. Soil fertility in relation to chemical properties of soils**

Soil fertility in relation to chemical properties of soils were studied soil pH, organic carbon, organic matter, N, P, K, S, EC, $HCO_3$, Na and Ca contents in soils and the results are reported in Table 7-9.

1. **Soil pH:** Soil pH values of surface soils varied 5.52-6.01 and sub-surface soils 5.49-6.00 with $\bar{x}$ values of 5.695 and 5.702 and SD values of 0.147 and 0.152, respectively. All 11-soils were moderatly acidic where variations were minor/small and similar resluts were observed from the sub-surface (15-30cm depth) soils. According to pH values soils are good for forest plants and 50-70% good for crops and vegetable cultivation where sustainable soil management practices can be applied for building of soil life as good productive ones (Table 7).

2. **Soil organic carbon and soil organic matter:** Soil organic matter is very much important as it is called the store house of plant nutrients. Here soil organic carbon is determined by Walkley and Black method and that is multiplied by 1.73 for organic matter contents. Usually, most Bangladesh soils contain <2% of soil organic matter where 1.5-2% can be treated as good soil with adequate nutrients. Here organic matter content recorded 1.354-3.257% ($\bar{x}$ =1.811; SD = 0.717) at 0-15 cm (top soil) depth and 1.228-3.374% ($\bar{x}$ =1.796; SD = 0.613) at lower depths (Table 7). Usually, mostly surface soils showed slightly higher amount of organic matter and this is because of more and more decomposition of leaves of forest plants and other grasses, bushes available in the regions. Organic matter status showed that most soils are fertile but because of the proper managements the productive capacity is low.

Table 7. pH, organic carbon and organic matter contents of the soils at two depths

| Area categories | Sample No. | Sampling depths (cm) | pH values | Organic carbon content (%) | Organic matter content (%) |
|---|---|---|---|---|---|
| I. | 1. | 0-15 | 5.80 | 0.820 | 1.419 |
| | | 15-30 | 5.85 | 1.950 | 3.374 |
| | 2. | 0-15 | 5.66 | 0.967 | 1.673 |
| | | 15-30 | 5.76 | 1.113 | 1.925 |
| | 3. | 0-15 | 5.68 | 1.920 | 3.322 |
| | | 15-30 | 5.78 | 0.773 | 1.337 |
| | 4. | 0-15 | 5.76 | 0.783 | 1.354 |
| | | 15-30 | 5.52 | 0.710 | 1.228 |
| II. | 5. | 0-15 | 5.50 | 0.784 | 1.356 |
| | | 15-30 | 5.49 | 1.187 | 2.053 |
| | 6. | 0-15 | 5.77 | 0.637 | 1.102 |
| | | 15-30 | 6.00 | 0.783 | 1.732 |
| | 7. | 0-15 | 5.80 | 0.967 | 1.672 |
| | | 15-30 | 5.71 | 0.930 | 1.608 |
| III. | 8. | 0-15 | 5.52 | 0.967 | 1.673 |
| | | 15-30 | 5.61 | 1.040 | 1.799 |
| IV. | 9. | 0-15 | 6.01 | 0.930 | 1.609 |
| | | 15-30 | 5.84 | 0.673 | 1.164 |
| V. | 10. | 0-15 | 5.62 | 0.857 | 1.483 |
| | | 15-30 | 5.57 | 1.333 | 2.307 |
| VI. | 11. | 0-15 | 5.52 | 1.883 | 3.257 |
| | | 15-30 | 5.59 | 0.710 | 1.228 |
| | 0-15cm | $\bar{x}$ | 5.695 | 1.047 | 1.811 |
| | | SD | 0.147 | 0.414 | 0.717 |
| | 15-30cm | $\bar{x}$ | 5.702 | 1.018 | 1.796 |
| | | SD | 0.152 | 0.362 | 0.613 |

$\bar{x}$ = average; SD = Standard deviation

3. **Total-nitrogen (N) contents:** A variable N content was recorded at surface (0.067-0.162%; $\bar{x}$ =0.096%; SD = 0.033) and sub-surface (0.072-0.187%; $\bar{x}$ =0.095%; SD = 0.032) soils. Except few cases most of the samples showed N content almost similar. In general, sub-surface soils produced a slightly high content of N than those of surface soils. Soils showed normal N contents.

4. **Phosphorus (P) content:** P contents of 11 soils of six sites (I-VI) varied widely although they were the normal ranges at surface soils (2.699-35.85ppm) with an average of 14.50($\bar{x}$) and SD of 9.262. At lower depth (15-30cm), P contents measured 2.209-36.93ppm with the average value ($\bar{x}$) of 14.285 and SD of 10.237. Sub-surface soils (15-30cm depth) showed high P contents than those of top soils (0-15m) SD values showed slightly high variations of P contents in 11 top and 11 subsurface soils (Table 8).

Table 8. NPKS contents in soils at two-depths

| Area categories | Sample No. | Sampling depths (cm) | Total-N (%) | P (ppm) | K (meq/100gm) | S (ppm) |
|---|---|---|---|---|---|---|
| I. | 1. | 0-15 | 0.084 | 2.699 | 0.195 | 10.14 |
| | | 15-30 | 0.187 | 2.209 | 0.209 | 18.57 |
| | 2. | 0-15 | 0.092 | 20.190 | 0.146 | 19.93 |
| | | 15-30 | 0.102 | 13.71 | 0.153 | 30.00 |
| | 3. | 0-15 | 0.164 | 7.127 | 0.146 | 20.72 |
| | | 15-30 | 0.080 | 15.22 | 0.125 | 20.00 |
| | 4. | 0-15 | 0.071 | 20.19 | 0.125 | 12.86 |
| | | 15-30 | 0.074 | 14.68 | 0.125 | 43.00 |
| II. | 5. | 0-15 | 0.072 | 19.97 | 0.104 | 27.86 |
| | | 15-30 | 0.089 | 13.17 | 0.118 | 21.79 |
| | 6. | 0-15 | 0.067 | 8.21 | 0.125 | 18.98 |
| | | 15-30 | 0.072 | 6.80 | 0.160 | 45.36 |
| | 7. | 0-15 | 0.089 | 35.85 | 0.209 | 23.93 |
| | | 15-30 | 0.084 | 36.93 | 0.216 | 18.14 |
| III. | 8. | 0-15 | 0.089 | 5.01 | 0.202 | 21.79 |
| | | 15-30 | 0.094 | 12.31 | 0.230 | 23.22 |
| IV. | 9. | 0-15 | 0.089 | 9.179 | 0.153 | 20.00 |
| | | 15-30 | 0.072 | 30.99 | 0.209 | 22.86 |
| V. | 10. | 0-15 | 0.078 | 20.30 | 0.174 | 24.64 |
| | | 15-30 | 0.122 | 5.72 | 0.153 | 26.07 |
| VI. | 11. | 0-15 | 0.162 | 10.15 | 0.181 | 26.43 |
| | | 15-30 | 0.074 | 5.39 | 0.202 | 29.29 |
| | 0-15cm | $\bar{x}$ | 0.096 | 14.5 | 0.16 | 20.667 |
| | | SD | 0.033 | 9.262 | 0.033 | 5.121 |
| | 15-30cm | $\bar{x}$ | 0.095 | 14.285 | 0.173 | 27.118 |
| | | SD | 0.032 | 10.237 | 0.039 | 8.869 |

$\bar{x}$ = average; SD = Standard deviation

5. **Potassium (K) content:** Optimum level of K contents were recorded from most soils 0.104-0.209me/100g at top surface and 0.125-0.230 me/100g from lower depth (subsurface) soils. K recorded to slightly high content at subsurface ($\bar{x}$ =0.173; SD=0.039) than those of surface ($\bar{x}$ =0.16; SD=0.033) soils. Soils may rarely show K problems where sound management might solve it (Table 8).

6. **Sulphur (S) content:** S showed sound soil fertility in the study region (I-VI), and never produce S deficiency to crops. Protection of soil life and management is important. S variations recorded to top soil (10-15cm) 10.14-26.07 ppm with the average value of 20.657($\bar{x}$) where SD of 5.121 showed minor variations within 11 soils. Soils at lower depths recorded to S contents 18.14-43.00% with $\bar{x}$ =27.118 and SD=8.886. SD values showed minor variations within 11 soils. Soil fertility related to S-an essential macro/major nutrient is important in relation to crop/plant growth, development, flowering and fruiting the crops (Table 8).

7. **EC status in soils:** Soil related to EC is important for identify the acidity salinity and/or alkalinity in soils where EC measured in surface soils varied 33-156 µS/cm ($\bar{x}$ =67.727 µS/cm; SD=32.897) but at lower depths (15-30cm), the EC ranged 40-164 µS/cm ($\bar{x}$ =62.545; SD=34.310). EC levels were largely higher at sub-surface soils than those of top soils (Table 9). SD values showed wide variations of EC within 11 soils of top and 11 of sub soils. Practically, EC had minor salinity influence on soil environment.

8. **Bicarbonate status (content) in soils:** The $HCO_3$ contents of 11 soils covering 2-depths covered 22 soils of six categories (I-VI) recorded to 214-397ppm with the averages ($\bar{x}$) of 247.727ppm and SD of 73.422 but at lower depths (15-30m), $HCO_3$ measured 126-366 ppm with $\bar{x}$ =216.727 ppm and SD=63.784. SD values produced high variation of $HCO_3$ (Table 9).

9. **Sodium (Na) content in soils:** Na is required by some of the plants/crops but not generally treated as essential elements/nutrients and even there is no standard for low, medium or high level of Na concentration for dealing with soil fertility scale. Here recorded Na for 11 soils varied 0.123-0.216meq/100g with average ($\bar{x}$) of 0.163meq/100g and SD 0.027 at top soils and 0.123-0.185 meq/100g ($\bar{x}$ =0.146 meq/100g; SD=0.020). Most soils showed Na content higher at lower depths than those of top soils (Table 9). SD values confirmed minor variations with the 11 soils at both depths.

10. **Soil fertility in relation to calcium (Ca) content in soils:** Eleven soils of six categories (I-VI) showed nearly same amount of Ca at both depths where surface soil showed 0.370-0.555meq/100gm with $\bar{x}$ of 0.448 and SD of 0.070 and similarly at sub-surface, the ranges recorded 0.370-0.617 meq/100g ($\bar{x}$ =0.460; SD = 0.076). Soils showed medium categories of Ca content in soils for production of crops. Ca-bearing fertilizer or liming can be applied for improving the acidity and quality of soils for better crop production of most crops.

Table 9. EC, $HCO_3$, Na and Ca contents of the soils at two depths

| Area categories | Sample No. | Sampling depths | EC (μS/cm) | $HCO_3$ (ppm) | Na (ppm) | Ca (meq/100gm) |
|---|---|---|---|---|---|---|
| I. | 1. | 0-15 | 58 | 214 | 0.216 | 0.493 |
| | | 15-30 | 48 | 366 | 0.144 | 0.493 |
| | 2. | 0-15 | 68 | 214 | 0.144 | 0.493 |
| | | 15-30 | 54 | 214 | 0.164 | 0.493 |
| | 3. | 0-15 | 48 | 275 | 0.123 | 0.493 |
| | | 15-30 | 73 | 183 | 0.123 | 0.370 |
| | 4. | 0-15 | 47 | 305 | 0.144 | 0.370 |
| | | 15-30 | 40 | 183 | 0.123 | 0.432 |
| II. | 5. | 0-15 | 59 | 244 | 0.164 | 0.370 |
| | | 15-30 | 43 | 126 | 0.164 | 0.432 |
| | 6. | 0-15 | 50 | 397 | 0.144 | 0.370 |
| | | 15-30 | 51 | 244 | 0.123 | 0.370 |
| | 7. | 0-15 | 156 | 183 | 0.164 | 0.555 |
| | | 15-30 | 78 | 183 | 0.185 | 0.617 |
| III. | 8. | 0-15 | 33 | 183 | 0.185 | 0.432 |
| | | 15-30 | 164 | 183 | 0.144 | 0.555 |
| IV. | 9. | 0-15 | 57 | 366 | 0.144 | 0.432 |
| | | 15-30 | 54 | 214 | 0.144 | 0.492 |
| V. | 10. | 0-15 | 106 | 183 | 0.164 | 0.370 |
| | | 15-30 | 46 | 183 | 0.123 | 0.370 |
| VI. | 11. | 0-15 | 63 | 183 | 0.206 | 0.555 |
| | | 15-30 | 37 | 305 | 0.164 | 0.432 |
| | 0-15cm | $\bar{X}$ | 67.727 | 249.727 | 0.163 | 0.448 |
| | | SD | 32.897 | 73.422 | 0.027 | 0.070 |
| | 15-30cm | $\bar{X}$ | 62.545 | 216.727 | 0.146 | 0.460 |
| | | SD | 34.310 | 63.784 | 0.020 | 0.076 |

$\bar{X}$ = average; SD = Standard deviation

## Conclusion

It can be concluded that the fertility conditions of the soils of area/region is quite good. Soils are slighty acidic with low productive capacity. Through regular crop production, proper crop rotation and sound manuring and management would be helpful to develop as good productive land as well as sound agricultural crop research based campus/station.

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