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Evaluation of Physicochemical properties of Irrigated Soil

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Abstract
Physical and chemical properties of irrigated soils were evaluated using standard methods. Soil properties varied according to farm. Moisture levels were low (1.00 ± 0.00 - 2.15 ± 0.01%). pH varied from slightly acidic (6.33 ± 0.08) to slightly alkaline (7.40 ± 0.06), and was within the range for optimum growth for plants.CEC ranged from 5.05 ± 1.00 to 17.73 ± 0.03 cmol/kg, and was within the range for most soils. OM contents (14.08 ± 0.10 - 24.37± 0.41%) were high in all the farms. Nitrogen (0.01 ± 0.00 - 0.09 ± 0.00 mg/kg) and phosphorus (0.09 ± 0.00 - 1.78 ± 0.01 mg/kg) contents were low and high respectively. Ca^{2+} concentration varied from 0.42 ± 0.05 to 5.64 ± 0.04 mg/kg. Mg^{2+} levels (1.81 ± 0.02 - 3.62 ± 0.01mg/kg) were below the optimum range for soils. Clay (8-24%) and sand (64-82%) contents were relatively high. Irrigated soils were classified as sandy loamy. Significant and positive correlations ($p \leq 0.05$) occurred for pH, OM and CEC.
Key words: physical, chemical, properties, irrigation, soil

1. Introduction

Soil is a complex system comprised of minerals, soil organic matter (SOM), water, and air (Visha et al., 2009; Hector, 2011). Soil quality includes mutually interactive attributes of physical, chemical and biological properties, which affect many processes in the soil that make it suitable for agricultural practices and other purpose (Rakesh et al., 2012).

The physicochemical properties soils play important roles in vegetation development. Soil texture and acidity affects the absorption and accumulation of mineral elements by plants and thus play a very important role in vegetation establishment and development at such sites (Mamun et al., 2011; Triphati andMisra, 2012).

Soil pH is the H^+ ions in the soil pores, which is in dynamic equilibrium with the predominantly charged surfaces of soil particles (Alloway, 1997; Tukura et al., 2009; Snober et al., 2011). pH value of soil is influenced by the type of parent materials from which the soil was formed and is affected by rainfall, due to leaching of basic nutrients such as Ca^{2+} and Mg^{2+} from the soil, and their replacement by acidic elements, such as Al^{3+} and Fe^{2+} (Michael and Aguin, 2010). pH greatly affects trace metal complexation, either through solubility equilibria or due to complexation by soluble and surface ligands (Tukura et al., 2012).

SOM is active in the binding of native and tecnogenic trace metals, and is of importance in the transportation of metallic ions in soils, sediments and waters, as chelates of various stabilities, and in supplying these ions to plants in soils (Robin and James, 2003; Motuzova et al., 2008, Rash et al., 2012). SOM is around 2-5% of the total soil mass and plays an important role in regulating water-holding capacity of the soil and its ion-exchange capacity (Stackhouse and Benson, 1988). Lignin is the main components of plants that contribute to SOM in the form of humic substances which are classified as humic, fulvic and humin acids (Connel, 1997; Alina and Henyk, 2000).

CEC is a measure of the amount of cations which the soil can absorb or hold (Ayidnalp and Marinova, 2003). Soil particles and OM are negatively charged resulting in the attraction of the positive cations (Na^+, Ca^{2+}, Mg^{2+}, H^+ and NH_4^+) in the soil (Alloway, 1997). The CEC on most soils range from 5 to 35 meq/100g depending upon the soil type, amount or combinations of clay minerals (Kabata-Pendias, 2004). Soils with high CEC generally have higher levels of clay and OM. CEC is responsible for exchangeable cations such as Ca^{2+}, Mg^{2+}, and K^+, which are readily available for plant uptake; and cations adsorbed to exchange sites are more resistant to leaching, or downward movement in soils with water (Mamun et al., 2011).

Ca^{2+} and Mg^{2+} are secondary nutrients which are required in relatively smaller but in appreciable quantities. Ca^{2+}deficiencies are rare when the soil pH is adequate (Snober et al., 2011). Mg^{2+} is a constituent of chlorophyll and chromosome. Optimum Mg^{2+} levels in soil normally range from 100 to 250 ppm (Mamun et al., 2011). Na^+ indicates the degree of which the soil exchange sites are saturated with Na^+. Exchangeable Na^+ greater than 2.5% may cause adverse physical and chemical conditions to develop in the soil that may prevent plant growth. High levels of exchangeable Na^+ affect soil permeability and may be toxic to sensitive plants (Mc Cauley et al., 2005).

Nitrogen, phosphorus and potassium are three major or primary nutrients which are require in large quantities by plants (Rai et al., 2012). Soil phosphorus is available in very low amounts to plants since most of the total soil phosphorus is tied up in insoluble compounds, and its availability depends on the soil pH (Rai et al., 2011; Snober et al., 2011). K^+ in soil may exist in unavailable, slowly available (exchangeable), and available forms (in solution). The exchangeable form becomes available when the K^+ in solution is removed by the crops (Ijaz et al., 2006).

Physicochemical properties of soil are complex, often non-linearly related, and spatially and temporally dynamic (Rakesh et al., 2012). Many researches on soil physicochemical parameters have been conducted around the world (Iwugbue et al., 2006; Hector et al., 2011; Snober et al., 2011; Rai et al., 2012) but information on the physical and chemical properties of irrigated soil along the bank of Mada River are limited. The objective of this study is to evaluate the physical and chemical properties of soil samples collected from three irrigated farmlands along the bank of Mada River.

2. Materials and Methods

2.1 Sample collection and preparation

Twenty sub-soil samples were collected at a depth of 1-10cm, using a hand trowel, from each of the three irrigated farmlands along the bank of Mada River, and then combined to form a homogenized composite sample of each farmland. The homogenised samples were air dried for seven days, grind in a clean mortar and pestle and sieved to pass through a 2mm alumina mesh, then preserved in washed clean plastic bottles for analysis (Buszewski et al., 2000; Nomeda, 2004).

2.2 Sample analysis

Available phosphorus in soil was extracted by using the Bray and Kartz method. The extract was estimated colorimetrically following the blue color method using ascorbic acid and extract was analyzed by a spectrophotometer at 882 nm (Mamun et al., 2011), available potassium and sodium in soil was determined by flame photometric method after the soil was extracted with 1M ammonium acetate at pH 7, After removing the excessive ammonium, the soil was extracted with 100 g L^{-1} NaCl solution and the supernatant was used to determine the Cation Exchange Capacity (CEC) using the Kjeldahl distillation and titration method ((Akbar et al., 2011). Exchangeable cations (calcium and magnesium) of soil samples were determined by classical routine method by complexometeric titration using EDTA as described in Huq and Alam (2005). Total nitrogen of soil samples were determined by Kjeldahl's method following concentrated sulfuric acid (H_2SO_4) digestion as suggested by Jackson (1962). Particle size analysis was done by Hydrometer method, percentage of moisture present in the air dried soil was determined by drying method (Allen et al., 1974). Textural classes were determined by Marshall's Triangular Co-ordinates, as designed by the USDA (1951).

3. Results and Discussion

Physicochemical parameter results are presented in Table 1. Soil moisture content was low (1.00±0.00 - 2.15±0.01). The highest moisture content was obtained at farm B. Plant becomes stressed if water level is low. pH(H_2O) values indicated that soils at farm A (6.48 ±0.10) and Farm B (6.92±0.08) were slightly acidic, and slightly alkaline (7.40±0.06) for farm C. pH($CaCl_2$) for all the farms was slightly acidic. The soil pH values are within the range for optimum plant growth and in agreement with the values reported by Vishal et al. (2009), however, lower than the values reported by Rai et al. (2011). OM content varied according to farm. The lowest and highest OM values were recorded at farms B and A respectively, which might be attributed to variation in the level of debris deposited on each of the farmland during rainy season as result of flood. CEC was highest at Farm C (17.73±0.03cmol/kg) and lowest at Farm B (5.05±1.00 cmol/kg). Clay along with SOM accounts for a great percentage of the total cation exchange site (Ayodele et al., 2008; Rakesh et al., 2012). Nitrogen is an essential constituent of metabolically active compounds such as amino acids, proteins, enzymes and some non-proteinous compounds (Rai et al., 2011). Total nitrogen levels were low in all the farms (0.01±0. 00 - 0.09±00 mg/kg). Phosphorus plays an important role in energy transformations and metabolic processes in plants (Rai et al.2011). The highest phosphorus level was recorded at Farm A (71.78 ±0.05 mg/kg), and the lowest at farm B (34.55±5.55 mg/kg).

Results for the exchangeable bases (Table 2) indicated that K^+ level at farm A (0.32±0.02 mg/kg) was the lowest and the highest concentration at farm B (0.19± 0.01 mg/kg). K^+ soil content was low. K^+ is essential for photosynthesis, for protein synthesis, for starch formation and for the translocation of sugars. Only small fraction of total K is held in exchangeable form, while the rest remains in fixed or non-exchangeable form (Snober et al., 2011). Na^+ varied from 0.43±0.01 mg/kg to 041±0.01 mg/kg. Exchangeable Na^+ greater than 2.5% may cause adverse physical and chemical conditions to develop in the soil that may prevent plant growth. High levels of exchangeable Na^+ affect soil permeability and may be toxic to sensitive plants (Mamun et al., 2011). Mg^{2+} in soil varied in the order Farm C > Farm A > Farm B. Mg^{2+}plays a catalytic role as an activator of a number of enzymes, most of which are concerned with carbohydrate metabolism (Snober et al., 2011). Mg^{2+} contents were below the optimum range (100 - 250 ppm).The highest and lowest concentrations of Ca^{2+} were recorded at farms A and C respectively.

Particle size results are presented in Table 3. Relative proportion of different sizes of soil particles is an important physical parameter to determine soil texture. Soil texture has an extremely significant influence on the physical and mechanical behaviors of the soil (Rai et al., 2011). Silt content was highest at Farm A (12%) and

was the same at Farms B and C. The values of clay varied significantly across the farms. The highest clay level (24%) was recorded at Farm A and the lowest (8%) at Farm C. Clay and SOM influence the CEC of soil. Sand levels varied between 64% and 82%. The textural classification was sandy loamy for all the farms. This is expected as soil texture is mainly inherited from the soil forming material (Ayodele et al, 2008).
Physicochemical parameters were correlated and results presented in Table 4. pH, OM and CEC correlated strongly, and correlations with other parameters were also strong, except for CEC with silt (0.4988).which was weak. Correlation between the parameters and clay generally ranged from weak to moderately strong (0.3700 – 0.5892), except with OM which was strong (0.7382). The relatively strong to near perfect correlation of pH and OM with other parameters indicated that these parameters may influence each other and the other parameters.

4. Conclusion

Physical and chemical properties of the soils differed according to farm. Soil pH varied from slightly acidic to slightly alkaline, and was within the range for optimum growth of plants.CEC was within the range for most soils. OM contents were high in all the farms and ranged from 14.08 ± 0.10% to 24.37 ± 0.41%. Nitrogen and phosphorus levels were generally low. Exchangeable bases were low. Mg^{2+} content was below the optimum range for soils. Silt (12%), clay (24%) and sand (64 %) levels were highest at Farm A. Clay (8-24%) and Sand (64-82%) contents were relatively high in all the farms. Textural classification of the soils indicated that the soils were sandy loamy. Correlations were strongly positive for pH, OM and CEC with other soil properties, indicating similar mechanisms.

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Table 1. Physicochemical properties of irrigated soils

Site	Moist.(%)	OM (%)	pH(H_2O)	pH($CaCl_2$)	CEC (cmol/kg)	N (mg/kg)	P (mg/kg)
Farm A	1.00±0.00	24.37±0.41	6.48±0.10	6.33±0.08	5.05±1.00	0.01±0.00	71.78±0.00
Farm B	2.15± 0.00	14.08±0.10	6.92±0.08	6.40±0.09	6.50±0.03	0.09±0.00	34.55±5.80
Farm C	1.22±0.00	16.23±5.01	7.40±0.06	6.88±0.10	17.73±0.03	0.02±0.00	43.73±0.04

Table 2. Levels (mg/kg) of exchangeable bases in irrigated soils

Site	K^+	Na^+	Ca^{2+}	Mg^{2+}
1	0.317 ± 0.02	0.43 ± 0.01	5.64 ± 0.01	2.72 ± 0.02
2	0.192 ± 0.01	0.41 ± 0.01	2.53 ± 0.01	1.81 ± 0.02
3	0.189 ± 0.01	0.42 ± 0.0	0.42 ± 0.05	3.62 ± 0.01

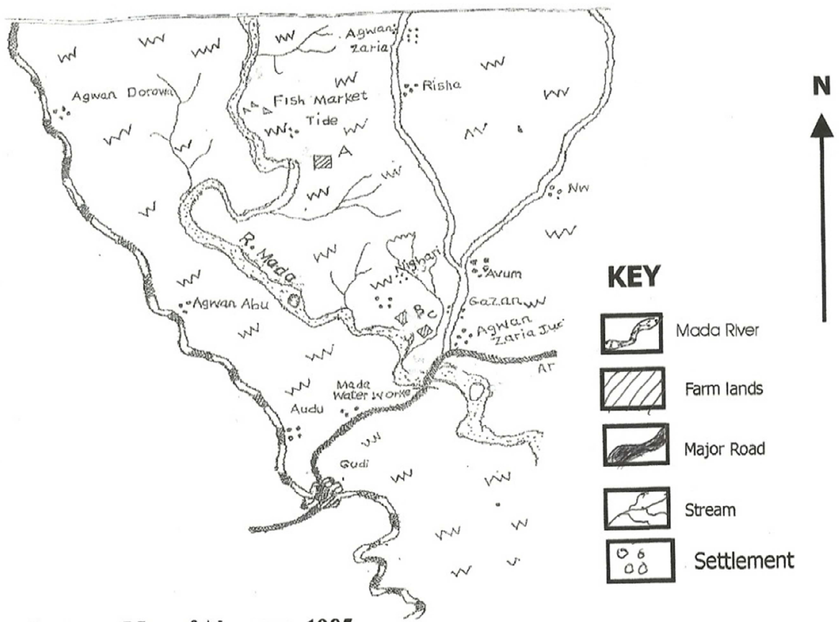
Table 3. Particle size distribution and textural analysis of irrigated soils

Site	Silt (%)	Clay (%)	Sand (%)	Textural class (USDA)
1	12	24	64	Sandy loamy
2	10	12	78	Sandy loamy
3	10	8	82	Sandy loamy

Table 4. Correlation analysis of irrigated soil physicochemical parameters

	pH	OM	CEC	P	N	Ca^{2+}	Mg^{2+}	Na^{+}	Silt	Clay	Sand
pH	1	0.9295	0.9152	0.8800	0.9332	0.8317	0.7810	0.9900	0.8596	0.5283	0.7390
OM		1	0.9159	0.8732	0.7731	0.6880	0.8755	0.9475	0.7862	0.7382	0.6397
CEC			1	0.9858	0.8468	0.8947	0.9011	0.9511	0.7420	0.4988	0.7615
P				1	0.7848	0.5722	0.9340	0.9212	0.6695	0.4725	0.8011
N					1	0.9818	0.5577	0.8925	0.7611	0.3222	0.7710
Ca2+						1	0.6510	0.8310	0.6412	0.4427	0.7720
Mg2+							1	0.8620	0.6465	0.5892	0.6787
Na+								1	0.8438	0.5567	0.7581
Silt									1	0.3700	0.3290
Clay										1	0.3222
Sand											1

Significant at $p \leq 0.05$



Source: Map of Akwanga, 1985.
Fig. 1: Mada River showing irrigated farmlands

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