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ASSESSMENT OF SOIL PHYSICO-CHEMICAL PROPERTIES OF SHONGA IRRIGATION SCHEME FOR IRRIGATED AGRICULTURE

by

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Abstract
Continuous agricultural practices have impacts on soil properties and these impacts may be negative on soil, crop and groundwater quality. This could be as a result of the quality of water used, method of application and the nature of the soil viz the physical and chemical composition of the soil. The physical and chemical characteristics of soil at Shonga irrigation scheme were evaluated to assess the fertility and productivity status of the soils. Five soil samples were collected from different locations at soil depth of 30cm in the study area using soil auger. A random sampling method was used to sample soil and the soil samples were taken to the laboratory for chemical and physical analysis. Physical analysis results showed that the soil of the study area was sandy loam; the available soil moisture contents obtained is low for 0-10cm, 10-20cm and 20-30cm crop rooting depths. The low percent of soil moisture ranged from 1.05 to 1.12%. The particle density, soil bulk density and porosity were 2.63g/cm^3, 1.62 g/ cm^3 and 38.4% respectively. Chemical analysis results revealed that the value of soil pH lies in the alkaline side and it ranged from 7.80 to 8.81. The organic carbon ranges from 0.52to 0.72% of the entire soil nutrients relating to soil fertility and is available in medium proportion of organi carbon. Electrical Conductivity (EC) values ranges from 0.50 to 0.73dSm^{-1} and all the soil samples have lower EC values. Available potassium content ranges from 125.31 to 630.15kg/ha with the majority of the soil samples in the study show high available potassium. Nitrogen which is an essential plant nutrient for growth of plant canopy is low in all soil samples. The available phosphorous content of the soil is high which ranged from 15.11to 54.13kg/ha Therefore, it is essential to give attention to proper monitoring of the soil condition of the farm land in order to prevent soil deterioration. It was recommended that For efficient production output, manure or compost should be applied in appropriate proportion to stabilize and correct nutrient deficiency in the soil, periodical test has to be conducted to

ascertain any changes in values obtained and careful selection of crop and management alternatives is required if full yield potential is to be achieved.

Keywords: Soil Physico-Chemical, Properties, Shonga irrigation Scheme & Irrigated Agriculture.

Introduction

The continuous use of soil for agricultural activity without careful quality assessment and monitoring will rise to accumulation of salts on the soil and consequently affects the crops potential yield. A salinity problem exists if salt accumulation in the crop root zone to a concentration that causes a loss in yield. Salts in soil reduce water availability to the crop to such an extent that yield is affected. A relatively high sodium or low calcium content of soil reduces the rate at which irrigation water enters soil to such an extent that sufficient water cannot be infiltrated to supply the crop adequately from one irrigation event to the next or infiltrates too slowly to supply the crop with sufficient water to maintain acceptable yields. Certain ions such as sodium, chloride and boron from the soil accumulate in a sensitive crop to concentrations high enough to cause crop damage and reduce yields (FAO, 1994). Soil salinity is a major environmental factor limiting the productivity of agricultural lands. It causes land degradation and affects food production (Sharma and Rao, 1998). This problem is reducing agricultural productivity and also putting far reaching impacts on the livelihood strategies of small scale farmers (Tanwir*et al.*, 2003).

In addition to its direct impact on plants, salinity creates a sodic soil whose structure is much less stable than before and is quite vulnerable to structural decline. Excessive nutrients reduce yield and unsightly deposits on fruit or leaves due to overhead sprinkler irrigation with high bicarbonate water, water containing gypsum or high in iron and various abnormalities often associated with an unusual pH of the water (FAO, 1994). Some soil properties are good indicators of soil quality as they contribute to biological, physical and chemical properties of the soil. These include cation exchange capacity(CEC), soil organic matter (OM) and organic carbon (OC), exchangeable sodium percentage (ESP), electrical conductivity (EC), salinity and sodicity status, calcium (Ca) and magnesium (Mg) mineral nutrients (Adejumobi*et al.*, 2014). However, soil physical properties include Particle size distribution (soil texture), available soil moisture content, soil bulk density, particle density and soil porosity. Soils in the tropics have been reported to be low in nutrients. Nitrogen is an important and commonly deficient nutrient element in tropical soils and it is the primary element of concern in vegetable production. In order to ameliorate nutrient depleted soils, inorganic fertilizer has been used by farmers (Ojo*et al*., 2015).

Global drive for sustainable agriculture systems involves optimizing agricultural resources to satisfy human needs and at the same time maintaining the quality of the environment and conserving natural resources (FAO, 1998). The success of soil management to achieve productivity and maintain soil fertility depends on the understanding of how the soil responds to agricultural use and practices (Negassa and Gebrekidan, 2004).

It is therefore necessary to carry out soil sampling and analysis of physical and chemical properties of soil at the Shonga irrigation scheme located in the flood plain of River

Niger between Shonga and Tada in Edu Local Government Area of Kwara State, Nigeria to ascertain the quality status of the soil for sustainable agricultural production and for proper monitoring and dealing with fluctuation of the scheme soil quality.

Location of the Study Area

The Shonga irrigation scheme is located in the flood plain of River Niger between Shonga and Tada in Edu Local Government Area of Kwara State (Figure 1). The North Eastern side and boundary lies within Longitude 5^0 06' E and 5^0 11' E while the South Eastern boundary lies approximately between 5^0 05' E and 9^0 06' N and; 5^0 11' E and 9^0 03' N. This area is traditionally known for rice cultivation. The project is designed to lift water directly from River Niger through a network of canals. Consequently, twelve 24-inch hydro-flow pumps of low heads and high volume suitable for lift-and-gravity irrigation were installed on the bank of River Niger. Seven-kilometer main canals and 192km distribution channels have been established in this area while 32,000 ha of cultivable land have been cleared for both irrigation and rain-fed farming activities. This is expandable to 5000ha at full operation but the authority needs N960million. So far only 250ha is put to active irrigation activity (LNRBDA, 2010).

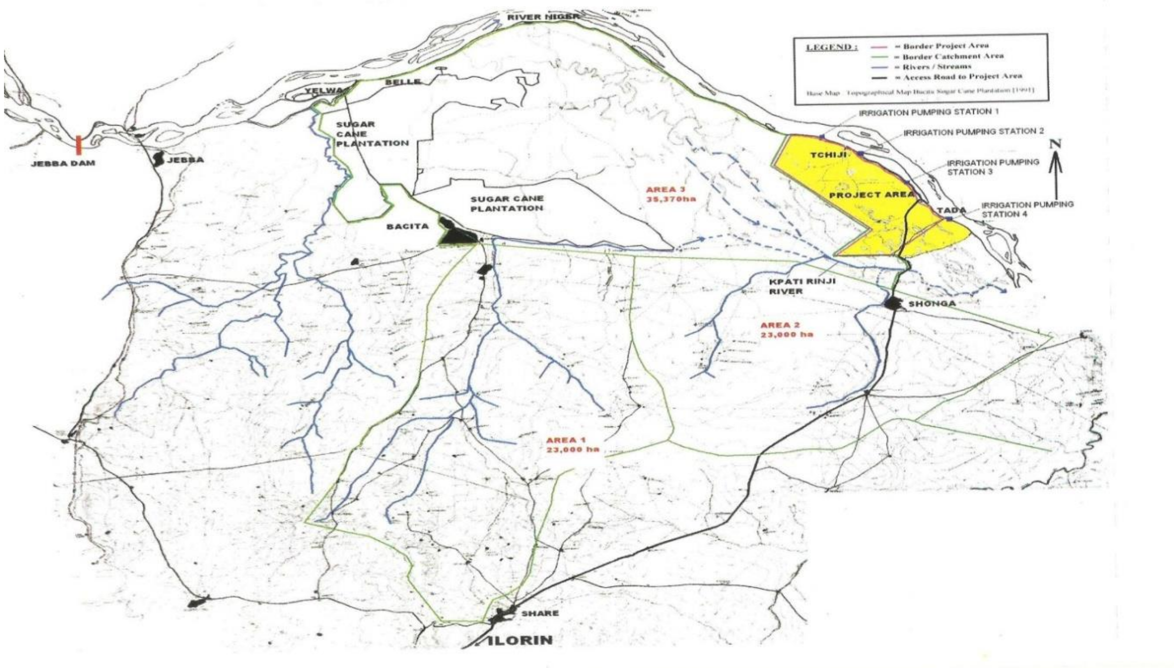

Figure 1: Map of the Study area
Source: Construction Products Nigeria Limited (CPN 2000)

Soil Sampling Method

Five soil samples were collected randomly from different locations at soil depth of 30cm in the study area using soil auger. The soil samples were taken into polythene bags and labeled accordingly. The collected soil samples were air dried, gently crushed and sieved through 2 mm mesh for laboratory analysis. The undisturbed soil samples were collected using core cutters and sealed immediately on both edges with candle wax melted on the field to prevent loss of moisture. These soil samples were taken to the laboratory for chemical and physical analysis.

Soil Chemical Analysis

The following methods were employed for soil chemical analysis:

(i) Soil pH was determined by pH meter in soil-water and soil-KCL filtrates.

(ii) CEC was determined titrimetrically following sequential leaching with ammonium acetate, 95% ethanol, potassium chloride and distillate collected over 2%.

(iii) Exchangeable sodium percentage (ESP) was observed by dividing total exchangeable sodium by the cation exchange capacity multiplied by 100.

(iv) Organic carbon (OC) expressed in percentage was determined using Walkley-Black wet digestion method.

(v) Organic Matter (OM) in percentage was done by calculation: OM = OC x 1.723.

(vi) Calcium and Magnesium were determined using Atomic Absorption Spectrophotometer.

Physical Analysis

The following methods were employed for soil physical analysis:

(i) The particle size analysis was done by hydrometer method employing sodium

(ii) hexametaphosphate [Na $(HPO_4)_6$] calgon as the dispersing agent.

(iii) The available soil moisture content was determined using a digital moisture analyser.

(iv) Soil bulk density was determined by employed a core method. Particle density was used with bulk density to calculate soil porosity.

Results of Soil Chemical Analysis

The results of the soil chemical analysis are presented in Table 1 and in Figure 2 to 7.

Table 1: Results of Chemical Analysis

S/N	Parameters	A	B	C	D	E
1.	pH	8.55	8.81	7.60	7.92	8.10
2.	Organic carbon (%)	0.62	0.71	0.72	0.65	0.52
3.	Available Nitrogen (kg/ha)	241.0	252.40	252.68	230.5	140.0
4.	Available Phosphorus (kg/ha)	31.15	54.13	50.09	28.12	15.11
5.	Available Potassium (kg/ha)	125.31	321.20	248.15	630.15	128.15
6.	Electrical Conductivity (dSm^{-1})	0.73	0.58	0.55	0.50	0.60

Soil pH

Soil pH measures the relative concentration of hydrogen ion in the soil water solution. The value of pH showed lies in the alkaline side which are greater than 7 as shown in Figure 2.Alkalinity is a measure of saline or salt affected soil. If pH is less than 6.0 then soil type is acidic also if the soil pH range from 6-8.5 its type is normal soil, but greater than 8.5 then it is said to be alkaline type of soil (Hert *et al.*,1999).

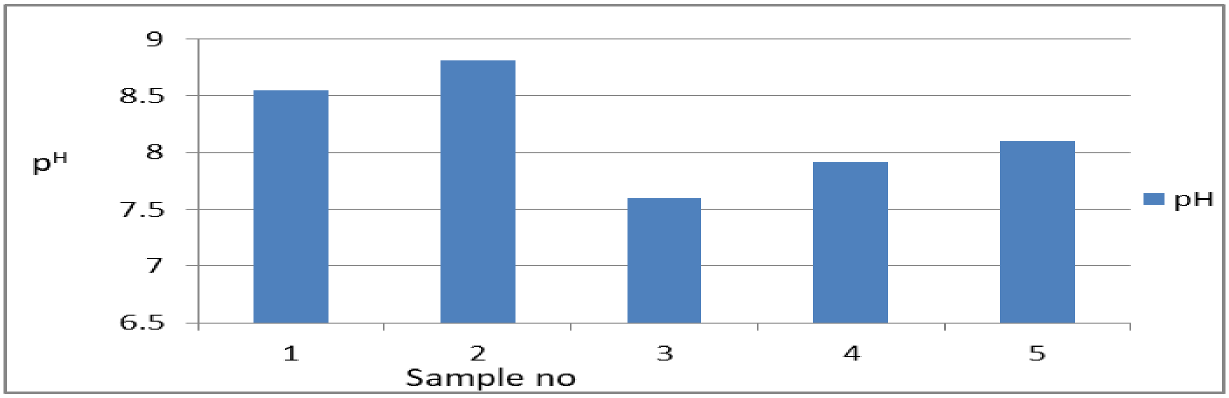

Figure2: Soil pH indicator against sample no.

Organic carbon

The organic matter is an important of the soil that contributes to soil fertility. Soil organic carbon is the basis of soil fertility. It release nutrient for plant growth. Increasing soil organic carbon improves soil health and fertility (Johnston*et al.*, 2008). The organic carbon ranges from 0.52to 0.72% as shown in Figure 3 and is available in medium proportion of organic carbon.

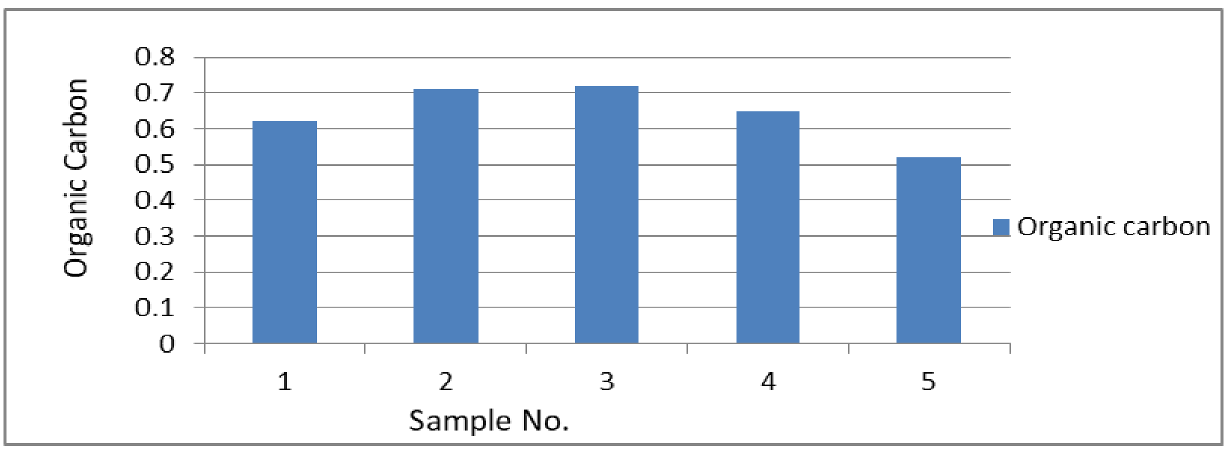

Figure3: Organic carbon against sample no.

Electrical Conductivity

Electrical conductivity (EC) is very important property of the soil. It indicates total soluble salt content of the soils. The value of conductivity is the measure of ions present in the soil sample. During this process the cations of the clay/colloidal matter are exchanged in equivalent quantities with the cations of soil and salt solutions. This process of exchanges of cation of soil and salt solution is known as cation exchange. Example of cations include Ca, Mg, Na, K and anions are; CO_3, HCO_3 and PO_4. The conductivity values can be varying with chemical properties of soil. If EC is less than 4 soil type is normal. From this study, EC values ranges from 0.50 to 0.73dSm^{-1} as shown in Figure 4.All soil samples have lower EC values.

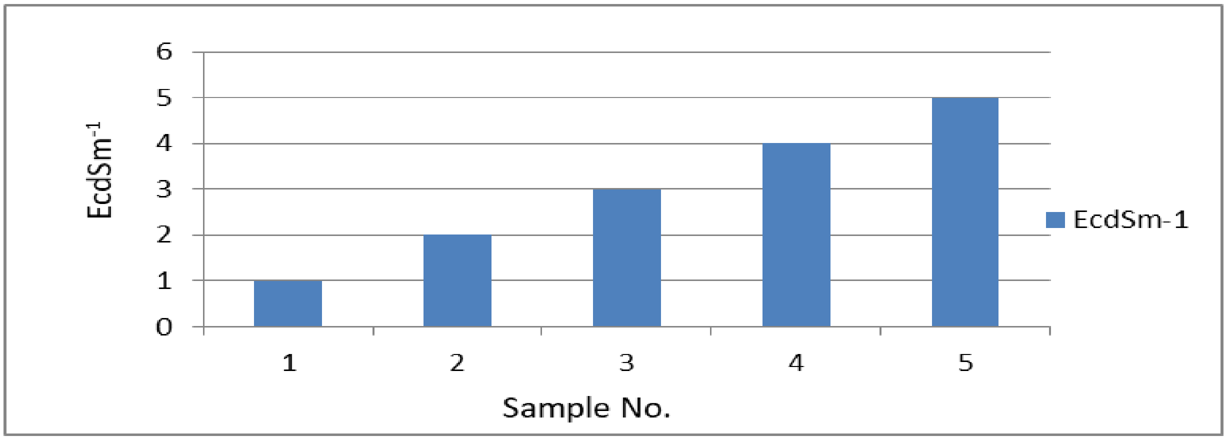

Figure4: Electrical conductivity against sample no.

Potassium

Potassium plays an important role in different physiological processes of plants. Potassium is a major nutrient for the production of superior quality crop. Its main role is catalytic in nature. Available potassium content ranges from 125.31 to 630.15kg/ha as shown in Figure 5. Majority of the soil samples in this study show high available potassium. Therefore, soil of the study area contained high to medium available potassium (Somwanshi*et al.*, 1999).

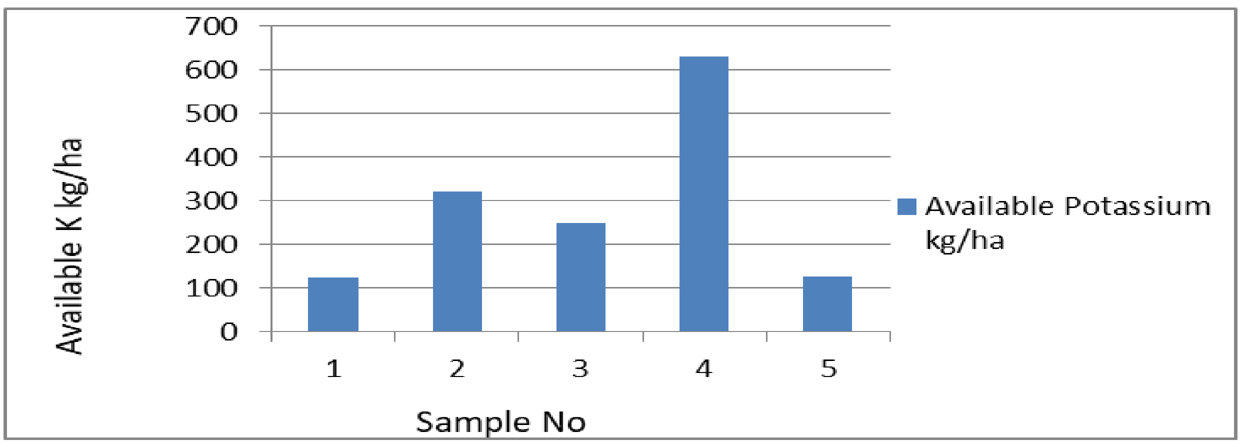

Figure5: Potassium against sample no.

Nitrogen

The Nitrogen is an essential plant nutrient for growth of plant canopy. Deficiency of nitrogen shows stunted growth development of yellowish green leaves and also deduces protein content and yields. As indicated in Figure 6, Nitrogen is low in all soil samples.

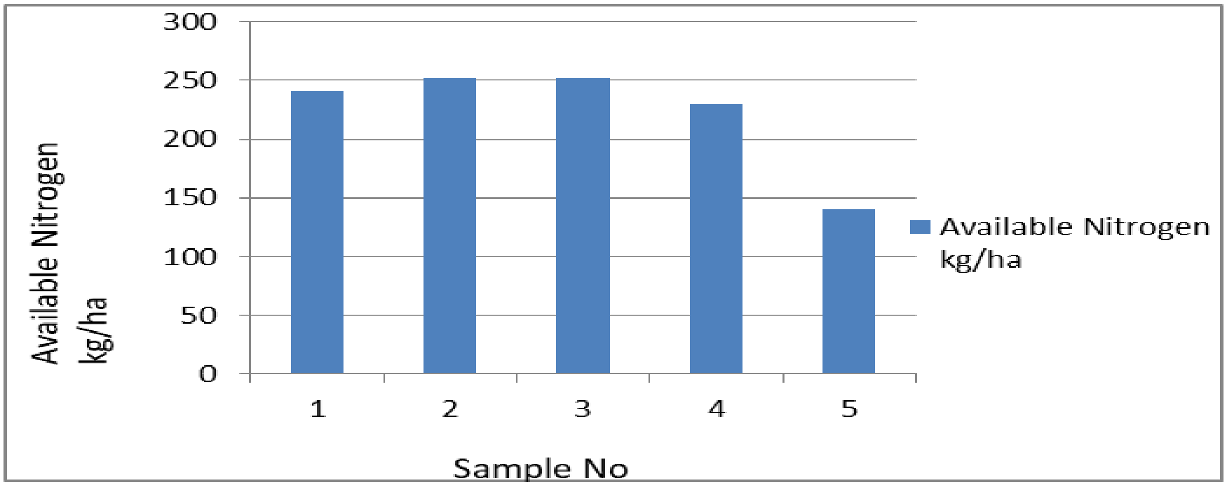

Figure6:Nitrogen against sample no.

Phosphorous

Phosphorous is called the master key element in soil quality. It is a most important element in every living cell. It is essential for growth, cell division root growth and elongation seed and fruity development and early ripening (Kachhave and More, 1982). Also it helps in energy storage and transfer. In this study, soil phosphorous ranges15.11 to 54.13kg/ha as indicated in Figure 7.

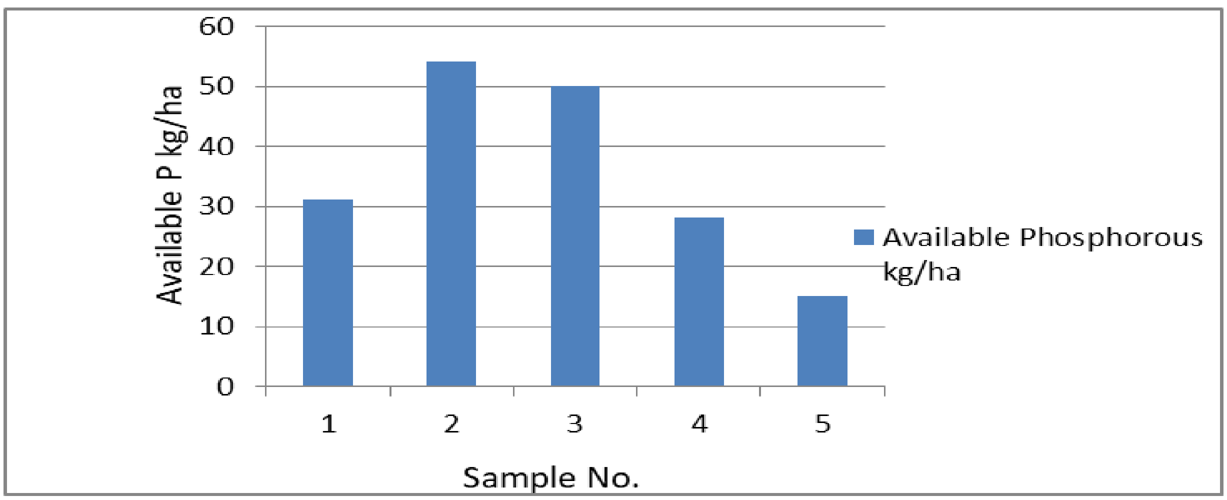

Figure7: Phosphorous against sample no.

Results of Physical Analysis

The parameters evaluated for soil physical properties include soil texture, moisture content, porosity and bulk density. Results of the soil particle size analysis revealed that soil in the study area is sandy loam, using USDA textural classification triangle chart. This indicates that the soil is generally very light-textured with sand percentage averaging more than 75% and loam is 25%. The particle size distribution of the soils is shown in Table 2. Therefore, the soils appear moderately suitable for agricultural production, but may be drought prone.

Table 2: Average particle size distribution of the soil

S/N	Depth(cm)	Sand(%)	Silt(%)	Clay(%)	Textural class (USDA)
1	0-10	71	12	17	Sandy Loam
2	10-20	69	16	15	Sandy Loam
3	20-30	76	12	12	Sandy Loam

The available soil moisture contents obtained is low for 0-10cm, 10-20cm and 20-30cm crop rooting depths. The low percent of soil moisture ranged from 1.05 to 1.12% and it is an indication that enough moisture is not readily available to support plant growth which may reduce crop yield. The field capacity, permanent wilting point and available water content are called the soil moisture characteristics. Soil moisture content is a portion of water which is easily extracted by the plant and it is about 75% of available water in the soil (FAO, 1985).

Bulk density was determined by measuring the mass of soil in a cylinder of known volume. Cylinder's inside volume is equal to soil volume. After pushing the soil out of cylinder, it was dried in oven at 105^0C until it reaches a constant weight. The bulk density was calculated by dividing the oven-dry mass by cylinder volume. Soil porosity in a soil consists of that portion of the soil volume not occupied by solid particles, either mineral or organic. It was calculated by dividing the volume of voids (pore space), by the volume of solids (soil particles). Thus;

(1) Cylinder volume ($Vc) = \Pi r^2 h$

$= (3.142)\ (2.06\ cm^2)\ (10.16)$

$= 135.45\ cm^3$

(2) Volume of water displaced by soil $(Vws) =$ $9.5\ cm^3$

(3) Particle density

$$(\rho s) = \frac{Massofsoilsamplepassedthroughsieve(Ms)}{Volumeofwaterdisplacedbysoil(Vws)}$$

$$= \frac{25}{9.5}$$

$=2.63 g/cm^3$

(4) Bulk density

$$(\rho b) = \frac{Massofoven-driedsoil\,(Mds)}{VolumeofCylinder\,(Vc)}$$

$$= \frac{218.9}{135.45}$$

$= 1.62 g/ cm^3$

(5) Soil Porosity

$$(\ell s) = 1 - \frac{Bulkdensity}{Particledensity} x100$$

$$= 1 - \frac{1.62}{2.63} x100$$

$=38.4\%$

Conclusions

The following conclusions were drawn from the study:

(i) The soil of the study area is predominantly sandy loam and the soil has high value of low soil moisture content.

(ii) In this study, the soil bulk density, soil porosity and particle density are 1.62g/ cm^3, 38.4% and 2.63g/cm^3respectively.

(iii)Conclusively from study area, the soil sample show medium proportion of organic carbon.

(iv)The higher nutrient fertility status in irrigation fields might be associated with intensive cultivation of crops.

(vii) Classification criteria in the study area showed normal soil pH.

(viii) The majority of soil samples low status of available phosphorous was found in all soil samples the generated nutrient status information can serve as an effective tool for farmers and policy makers in adoption of site specific nutrient management practices.

Recommendations

The following recommendations were drawn from conclusions:

(i) For efficient production output, manure or compost should be applied in appropriate proportion to stabilize and correct nutrient deficiency in the soil.

(ii) Periodical test has to be conducted to ascertain any changes in values obtained.

(iii) Careful selection of crop and management alternatives is required if full yield potential is to be achieved.

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