Original Research Article

Assessment of Physico-Chemical Properties of Tada Shonga Irrigation Scheme Soil

ABSTRACT

This research was conducted to analyze the soil physico-chemical properties of Shonga Irrigation Scheme to ascertain its suitability for rice production. Disturbed soil samples were collected from the 0–15 and 15–30 cm soil layers in five identified areas in the irrigation scheme. The samples were sent to the Soil laboratory of the Lower Niger River Basin for physical and chemical analysis. Most of the soils were strongly acidic to moderately acidic with pH values ranging between 4.8 and 5.7. The organic carbon and organic matter ranged from 0.13 to 0.19% and 0.03 and 0.32%, respectively which implies low fertility. Calcium values ranged between 2.1 and 3.75 cmol/kg, with the low values related to the soil pH status. Magnesium values averaged 2.48 and 1.95 cmol/kg in the top and lower soil layers, respectively. Exchangeable Acidity (EA) values ranged between 0.20 and 3.40 cmol/kg in the surface horizon and between 0.2 and 5.4 cmol/kg in the sub-surface horizons. Available phosphorus had an average of 40.05 and 23.14 ppm in the surface and sub surface soil layers, respectively. Analysis of variance techniques was used for significant differences within chemical properties. For all tests, a threshold of P=.05 was used to define statistical significance. Soil pH and available phosphorus were within the recommended land suitability requirement for rice cultivation. Organic carbon, organic matter, calcium and magnesium were not within the recommended range for rice production. Organic carbon and organic matter can be supplied through the incorporation of organic manure.

Keywords: Soil Properties, Irrigation, Irrigation Scheme, Soil Samples

1. INTRODUCTION

Globally, the increase in population has resulted into an increase in global food demand [1]. Hence, food security has become a major global problem. In overcoming this problem, water and soil resources have been under increasing pressure. This has led to the intensification of agricultural land and changing of land use [2]. Alternative strategies to meet the global food demand as well as to maximally utilize the limited land and water resources needs to be put into consideration. Irrigation provides one such solution by opening up more lands for crop production. Irrigation technology makes it possible for food to be produced throughout the whole year even in the absence of rain [3]. But irrigation is not without its challenges. Problems such as alkalization, acidification, salinization and waterlogging could be generated from irrigation and thereby make it unsustainable [4].

The continuous use of soils may lead to changes in its physico-chemical properties, influencing both their interaction with the environment and their ability to produce crops. Thus physico-chemical deterioration remains the greatest threat to irrigated agriculture[5]. Irrigated arable land is estimated to be around 301Mha worldwide [6]. Without periodic assessment and monitoring, the soil under irrigation operations could be adversely affected and eventually lead to a decrease in crop yield. Therefore this study was carried out to assess the soil physico-chemical properties of Shonga Irrigation Scheme.

2. METHODOLOGY

2.1 Description of the study area

The study area was located in Tada Shonga Irrigation Scheme, a distance of 110 km northeast of Ilorin in Edu Local Government Area of Kwara State, Nigeria. Its geographical coordinate is latitude 9° 1' 0" N North and longitude 5° 9' 0" East (Fig. 1). The Tada Shonga Irrigation Scheme is operated by the Lower Niger River Basin Development Authority (LNRBDA). The climate in Tada Shonga irrigation sites is tropical continental with pronounced wet and dry seasons and steady high temperatures. The maximum rainfall in the area is during September and drops to zero in December. Its rainy season lasts for about 218 days, it usually starts in April and ends in October [7]. The Tada Shonga Irrigation Project, which is conceived as a pilot public-private partnership, has a proposed gross area of 3000 hectares for the irrigation scheme which 2000ha is been utilized for rice production with a surface irrigation system. The scheme is designed as a lift irrigation system, involving the direct lifting of water from the River Niger and delivery through a network of canals.

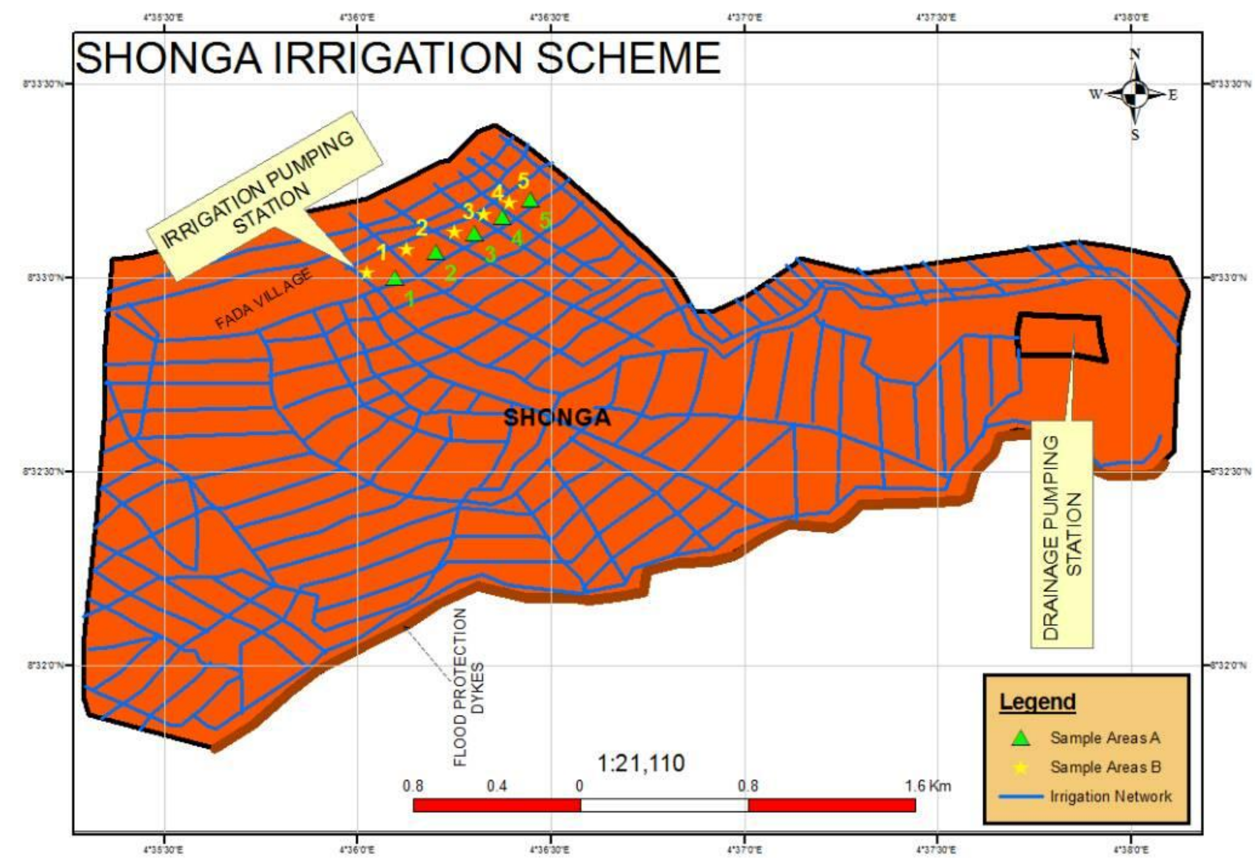

Fig. 1: Location of the Tada-Shonga Irrigation Scheme

Source: [7]

2.2 Sample Collection

Disturbed soil samples were collected at five locations within the irrigation scheme. Soil samples were collected from the 0–15 and 15–30 cm soil layers at each sampling point with the aid of a soil auger. Random sampling approach by following a zig-zag pattern across the field was used in collecting soil samples at different sampling points at the required depths. The collected soil samples were packed in different polythene bags to prevent atmospheric influences. The samples were sent to the laboratory of the Lower Niger River Basin for physical and chemical analysis.

2.3 Soil Sample Analysis

Soil samples were analyzed according to the USDA textural classes[8]. Physical properties of interest in soil analyses include texture, while chemical properties of concern include pH, organic carbon (OC) and organic matter (OM), exchangeable acidity (EA), exchangeable cations–calcium (Ca) and magnesium (Mg) and available phosphorus (AP). Mechanical analysis of soil was done by the Bouyoucous or hydrometer method [9] by sieve and sedimentation analysis; corresponding textural classes were determined.

2.4 Statistical Analysis

Data were statistically analyzed for variance (ANOVA) using the SPSS (v. 20) statistical package. A threshold of P =.05 was used to define statistical significance.

3. RESULTS AND DISCUSSION

3.1 Soil Textural Analysis

The soil textural class for M1 was loam in both soil layers. M2 soil was clay loam for both the topsoil and subsoil. M3 and M4 had different soil types in the topsoil and subsoil. M3 was clay loam in the topsoil and silty clay loam in the subsoil. M4 was silty clay loam in the topsoil and clay loam in the subsoil. M5 had both soil layers as clay loam. Clay loam has been reported to be most suited for rice production [10]

Table 1. Soil Textural Classification of Tada Shonga Irrigation Scheme

Sample Unit	Sample Depth	Sand (%)	Silt (%)	Clay (%)	Textural Class
M1A1	0 – 15	26	44	30	Loam
M1A2	15 – 30	28	54	18	Loam
M2A1	0 – 15	28	32	40	Clay Loam
M2A2	15 – 30	26	32	42	Clay Loam
M3A1	0 – 15	18	46	36	Clay Loam
M3A2	15 – 30	16	44	40	Silty Clay Loam
M4A1	0 – 15	20	48	32	Silty Clay Loam
M4A2	15 – 30	28	44	28	Clay Loam
M5A1	0 – 15	32	36	32	Clay Loam
M5A2	15 – 30	22	46	32	Clay Loam

M1-M5 represents the sampling points
A1 represents the sampling depths (0 – 15 cm)

A2 represents the sampling depths (15 – 30 cm)

3.2 Chemical Properties Analysis

The results of the selected soil chemical properties are presented in Figure 2. The soil pH ranged between 4.8 and 5.7 in the surface layer, and 5.0 to 5.5 in the sub-surface soil layer from the five sampling points. The average pH in the 0–15 cm surface soil layer was 5.24 while the sub-surface soil layer recorded 5.3. Soil pH characterizes the chemical environment of the soil and may be used as a guide to the suitability of soils for various pasture and crop species. Soil pH is also an indicator of the chemical processes that occur in the soil and is a guide to likely deficiencies and/or toxicities [11]. According to the classification by [12], the soil pH range in the soil samples indicates a very strongly acidic to moderately acidic soil reaction. The relative acidity of the soil samples may be due to the leaching of basic cations, leaving the topsoil acidic as the soils were under irrigation, or due to crop uptake. The soil pH of Tada Shonga Irrgation Scheme falls within the recommended range for rice production (3.1 – 5.3) as stated by [10]. Therefore as regards pH, the five sampling locations of the scheme are suitable for rice cultivation.

Organic Carbon (OC) of the soil samples ranged from 0.13 to 0.19%. OC gives a direct measure of available nitrogen in the soil. Organic carbon for the soil is considered adequate if it is within the range of 0.20 – 21.0% for rice cultivation [10]. Hence OC of the soil samples was considered low.

Organic matter (OM) had values between 0.23 and 0.32% in the topsoil and values between 0.03 and 0.3% in the subsoil layer. An average value of 0.28% was recorded in the 0–15 cm depth and reduced to 0.22% at depth 15–30 cm. The OM of the scheme falls below the soil recommended range (0.34–36%) for rice cultivation [10]. The low SOM values in this irrigation site may be due to carbon loss as CO_2 as a result of yearly conventional tillage and removal of crop residue, causing immobilization of soil nutrients. The application of organic manure can help to improve the soil OM content.

Calcium (Ca) values ranged between 2.1 and 3.75 cmol/kg (average of 3.2 cmol/kg) for 0 – 15 cm soil layer and between 2.4 and 3.4 cmol/kg (average of 3.11 cmol/kg) for the 15 – 20 cm soil layer. Apart from sampling locations M2A1 and M5A2, the soil Ca values fall outside the recommended range (2.70 – 0.85 cmol/kg) for rice cultivation [10]. The low Ca could be related to the soil pH status. Acidic soils are usually calcium deficient, indicating that Ca-based fertilizer would be required to reverse this result so that the beneficial use of calcium in the soil including structure stabilization and combating soil acidity would be possible [13].

Magnesium (Mg) values were in the range 0.5–4.35 cmol/kg in the surface soil; and 0.4–3.3 cmol/kg in the sub-surface soil layer. The average Mg value was higher in the surface layer (2.48 cmol/kg) as compared to the sub-surface layer (1.95 cmol/kg). The Mg values of the scheme soil were not within the recommended range (0.84–0.10 cmol/kg) [12] for rice cultivation. Further application of magnesium is not necessary since the value of the current data is adequate for the soil.

Exchangeable Acidity (EA) values ranged between 0.20 and 3.40 cmol/kg in the surface layers and between 0.2 and 5.4 in the sub-surface layers.

The available Phosphorus (AvP) had values ranging from 11.03 to 108.41 ppm, with an average value of 40.05 ppm in the 0–15 cm soil layer. At the 15–30 cm soil layer, AvP values were between 14.4 and 33.08 ppm, with an average value of 23.14 ppm. The AvP in the soil of the scheme (except M4A1) is within the acceptable range (8.60–83.0 ppm) for rice cultivation [10].

ANOVA for statistical variance are presented in Table 2. There were no significant differences ($p > .05$) in the results between the two soil layers for all chemical properties considered.

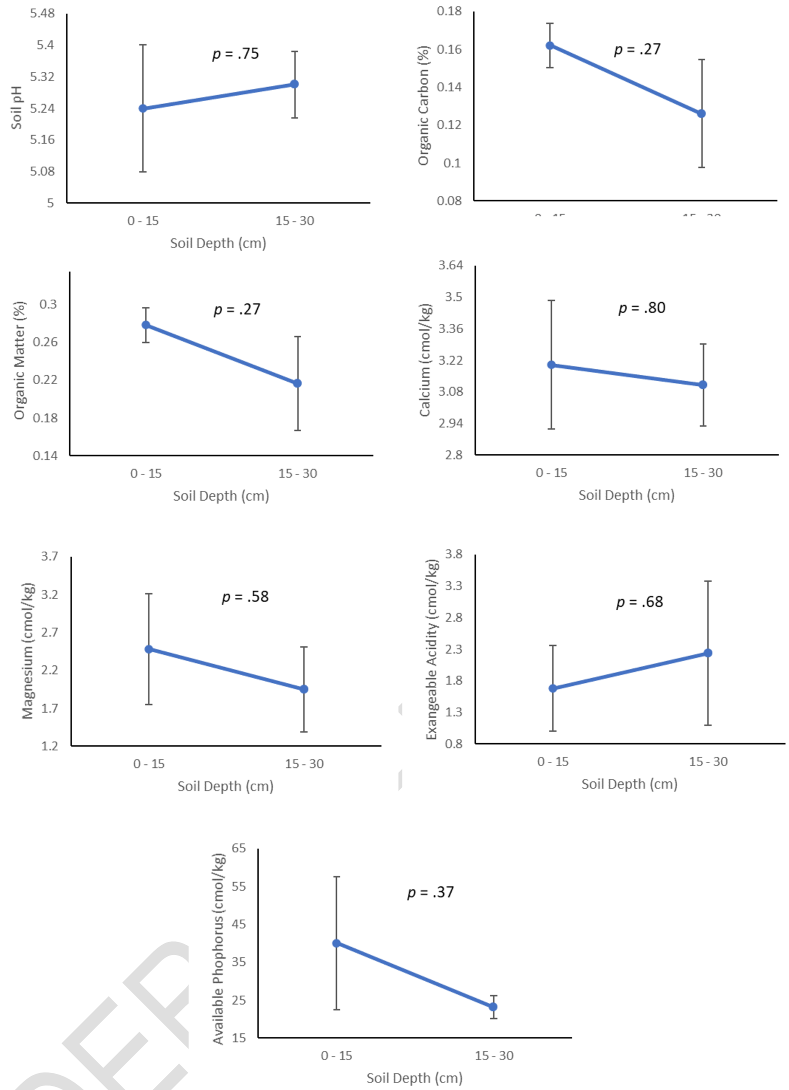

Fig. 2. Soil Chemical Analysis of Tada Shonga Irrigation Scheme

Table 2: Analysis of Variance of Selected Chemical Properties

Chemical Properties		Sum of Squares	df	Mean Square	F	Sig.
Organic Carbon	Between Groups	.003	1	0.003	1.379	0.274
	Within Groups	.019	8	0.002		
	Total	.022	9			
Organic Matter	Between Groups	.010	1	0.010	1.383	0.273
	Within Groups	.056	8	0.007		
	Total	.065	9			
pH	Between Groups	.009	1	0.009	0.110	0.748
	Within Groups	.652	8	0.082		
	Total	.661	9			
Ca	Between Groups	.020	1	0.020	0.071	0.797
	Within Groups	2.292	8	0.287		
	Total	2.312	9			
Mg	Between Groups	.702	1	0.702	0.331	0.581
	Within Groups	16.988	8	2.124		
	Total	17.690	9			
EA	Between Groups	.784	1	0.784	0.179	0.683
	Within Groups	35.040	8	4.380		
	Total	35.824	9			
AvP	Between Groups	713.349	1	713.349	0.899	0.371
	Within Groups	6348.507	8	793.563		
	Total	7061.856	9			

4. CONCLUSION

Physico-chemical properties of Shonga irrigation scheme soil were assessed. Soil pH and available phosphorus were within the recommended land suitability requirement for rice cultivation. Organic carbon, organic matter, calcium and magnesium fell outside the recommended range for rice production. Organic carbon and organic matter can be supplied through the incorporation of organic manure.

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