PHYSIO- CHEMICAL PROPERTIES OF SOIL AND ITS INFLUENCE ON CROP YIELD OF OKE-OYI IRRIGATION SCHEME, NIGERIA

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Abstract - *Irrigation is an important factor that determines crop yield and growth due to its association with many factors of plant environment that influence its growth development. Soil quality analysis for irrigation at Oke-Oyi phase II & III irrigation scheme of the Lower Niger River Basin Development Authority (LNRBDA), Kwara State, Nigeria were carried out. This study determined the cause(s) of low yield of selected crops grown on phase II and III of the scheme between the years 2015 to 2017.*

Soil samples were randomly taken at depths of 0-20 cm, 20-60 cm and 60-100 cm from the operating land in Phase II and III. The soil samples were taken to the laboratory for chemical and physical analysis.

Physical analysis results indicated that: the soil of both phase had sandy loam texture; soil moisture contents of 1.08%, 1.05%, 1.12% and 1.09% (phase II) and1.17%, 1.35%,1.02% and 1.76% (phase III) , infiltration capacities (K) 0.00956 cm/s to 0.0104 cm/s and 0.00876 cm/s to 0.0216cm/s for phase II and III respectively. Chemical analysis results revealed that: soil pH was moderately to slightly acidic (5.30 to 6.8 7) for phase II and moderately acidic (5.72 to 5.88) for phase III, the average organic carbon were 0.142-0.267% phase II and 0.0860-0.1151% phase III respectively; available phosphorous content of 20.276 to 28.342mg/l phase II and 19.296 to 30.242 mg/l phase III; Exchangeable Sodium Percentage (ESP), 5.90 to 10.0% phase II and 6.80 to 9.02% phase III; Sodium Adsorption Ratio (SAR) 0.10 to 0.32 meg/l phase II and 0.09 me/l to 0.10 me/l for phase III. In 2015, rice yield decreased from 4000 kg to 3600 kg per hectare for in 2016 and subsequently, decreased to 3300kg per hectare in 2017(phase II). Garden egg yield decreased from 5.2 Ton/ha in 2015 to 4.60 Ton/ha in 2016 and subsequently decreased to 4.00 Ton/ha in 2017(phase III). The decrease in the crop yield between 2015 and 2017 in phase II and III may be due to the increase in exchangeable bases in the soil. Crop yield data collected were subjected to analysis of variance (ANOVA) from the ANOVA results it was concluded that yields of maize, pepper, garden egg and water melon are significant ($P < 0.05$) while that of rice and okro are insignificant ($P > 0.05$).

Therefore, there is a need for proper monitoring of the soil condition in the both phase in order to prevent further deterioration since reduction in crop yields have been observed from 2015 to 2017 growing period.

Keywords – Crop yield, Soil quality, Irrigation, Soil samples and Operating land

1. INTRODUCTION

Irrigation is an important determinant of crop yield and growth because it is associated with many factors of plant environment, which influence growth and development (1). There is a rapid expansion of irrigation schemes in Nigeria due to increase in population and hence the need for additional food supply. The needs to feed and improve the standard of living of the ever-increasing human population led to the introduction of the irrigation schemes. This has facilitated the cultivation of the same land twice or more in a year and has improved the farmer's standard of living economically (2). 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 (3).

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 (4). Irrigation agriculture could have adverse effects on soil chemical properties, fertility and sustainable productivity if not well monitored. The chemical properties of a soil give a strong indication of its fertility.

Therefore, continued use of soil for irrigation activity in the study area without careful quality assessment and monitoring has given rise to accumulation of salts on the soil and consequently affects the crops potential yield. The aim of the study is to determine the cause(s) of low yield of selected crops grown on phase II and III of the scheme between the years 2015 to 2017.

2. MATERIALS AND METHODS

The study was conducted in Oke-Oyi irrigation project of Lower Niger River Basin Development Authority (LNRBDA) situated at Ilorin-East LGA of Kwara State, Nigeria. Oke-Oyi is the head quarter of Ilorin East Local Government Area of Kwara State, which is about 25 km away from Ilorin town along old Ilorin-Jebba Road. The irrigation project site is located between the latitude; 08° 37.322' N and 08° 37.781'N, and Longitude; 04° 45.893'E and 04° 46.027'E of Greenwich Meridian. The total surface area of the irrigation project site is 50 hectares of land which was divided into Phase II (30ha) and Phase III (20ha). Phase II is used for cultivation of arable crops such as Okra, Maize, and Rice with surface area of 12.5ha, 10ha, and 7.5ha, respectively and phase III is used for cultivation of arable crops such as Watermelon, Pepper and Garden egg with surface area of 3 ha, 5 ha and 12 ha, respectively. Both phases were small-medium irrigation schemes and basin irrigation system which were used to supply water to the field from the rectangular weir located at the adjacent side of the scheme.

2.1 Soil Sampling

Soil samples were taken from sixteen different locations on the irrigated section and four places in the non-irrigated section on the field making a total 60 samples at three depth intervals (0-20, 20-60 and 60-100cm) for phase II and phase III respectively. Chemical and physical analysis of Soil samples collected were determined using (5) laboratory soil standards. The parameters determined were; particle size analysis was done by hydrometer method, (i) The soil pH by using glass electrode pH meter in soil-water and soil-KCL filtrates.

(ii) The exchangeable cations by flame analyser after extraction with neutral ammonium acetate.
(iii) Exchangeable sodium percentage (ESP) was determined using ammonium acetate (NH_4OAC) method. (iv)Available phosphorus by Bray I method. (v) Organic carbon using Walkey Black method, involving oxidation of organic matter with potassium chromate and sulphuric acid. From the organic carbon data, organic matter content was then calculated. Crop yields data collected were subjected to One-way analysis of variance to compare the yield with the FAO standards.

3.0 RESULTS AND DISCUSSIONS

3.1 Physical Analysis

Results of the soil particle size analysis revealed that soil in the study areas, phase II and phase III are sandy loam, using textural classification triangle chart. This indicated that the soil of phase II is generally very light-textured with sand percentage averaging more than 75% and loam is 25% and that the soil of phase III is generally very light-textured with sand percentage averaging more than 79% and loam is 21%. Therefore, for phase II, the soils appear moderately suitable for irrigation, but may be drought prone and for phase III, the soils appear moderately suitable for irrigation.(6).

The results of the available soil moisture contents obtained for East, West, South and Northern sides of phase II and phase III were; 1.08%, 1.05%, 1.12% and 1.09%, and 1.17%, 1.35%, 1.02% and 1.76%, respectively.

The values of infiltration capacities (K) were generally high and varied from 0.00956cm/s to 0.0104cm/s for phase varied from 0.00876cm/s to 0.0216cm/s. According to (7) a coarse sandy soil with (K) value of 10^{-2} cm/s would lose water at the enormous rate of nearly 10m/day while a fine loam soil with a (K) value of 10^{-4} cm/sec would lose only about 10 cm/day. The soils in the study area were dominantly sandy loam texture and show high transmission of water and moderate water holding capacity, well drained and suitable for irrigation (8).

3.2 Chemical analysis

The results of the selected average soil chemical properties of phase II and III are presented in Table 1. The soil pH on the field was moderately to slightly acidic for phase II and moderately acidic for phase III, as given by (9) ranged from 5.30 to 6.87 and from 5.72 to 5.88 for phase II and phase III respectively. According to United State Department of Agriculture (USDA), too high or too low soil pH leads to deficiency of many nutrients, decline in microbial activities, decrease in crop yield and deterioration of soil health. Therefore, the soil of the study area is thus suitable for crop growth.

The organic carbon gives a direct measure of available nitrogen of the soil. The average organic carbon in phase II ranged from 0.142-0.267% and phase III ranged from 0.0860-0.1151% of the entire soil nutrients relating to soil fertility. (10) Stated that organic carbon for the soil is considered high if it is within the range of 0.96-1.08%. It is observed from table 1 that the level of organic carbon has decreased from surface depth(0-20cm) to the second depth (20-60cm)and sharply increased from second depth (20-60cm) to third depth (60-100cm) of the soil for phase II and that the level of organic carbon has generally decreased from 0.09 to 0.12% for phase III which may be due to lack of return of enough crop residues common to the farmers in the study area. This shows that irrigation has negative effect on the soil organic content.

Table 1.0: Average soil chemical properties of phase II and phase III

PHASE II				PHASE III		
Parameters	0-20 (cm)	20-60 (cm)	60-100 (cm)	0-20 (cm)	20-60 (cm)	60-100 (cm)
Ph	6.52	5.3	6.87	5.72	5.77	5.88
Mg++(me/l)	1.36	1.16	2.26	2.06	1.29	2.78
Ca++ (me/l)	5.25	4.36	6.22	4.29	4.99	6.05
Na+ (me/l)	0.25	0.16	0.65	0.18	0.17	0.21
N (me/l)	1.04	0.18	1.15	0.22	1.07	0.32
K (me/l)	0.23	1.26	0.18	1.06	0.29	1.15
OC (%)	0.23	0.14	0.27	0.12	0.11	0.09
OM (%)	0.17	0.16	0.13	0.2	0.19	0.15
P (mg/l)	28.34	26.06	20.28	30.24	24.07	19.29
ESP (%)	10	9.11	5.9	9.02	8.01	6.8
CEC (me/l)	5.34	4.76	5.52	4.75	4.83	4.62
SAR (meg/l)	0.14	0.1	0.32	0.1	0.09	0.1

Phosphorus is an essential element classified as a macro-nutrient because of the relatively large amount required by plants (11). Available phosphorous content of the soil at phase II is high ranged from 20.276 to 28.342mg/kg. Available phosphorous content of the soil at phase III ranged from 19.296 to 30.242 mg/l. The level of phosphorous content of the soil is high and may be due to moderate organic matter content, parent material and degree of weathering. However, the soil at phase II and phase III will be good for crop that requires much phosphorus.

Sodium, which determines the sodicity status of a soil is generally low and ranged from 0.156 to 0.653me/l for phase II and ranged from 0.1722 to 0.2.83me/l. It is observed from Table 1 that the level of sodium for phase II and phase III slightly decreased from soil surface depth (0-20cm) downward to the second depth (20-60cm) and also slightly increased to the third depth (60-100cm). The low sodium level in the soils indicates a non-sodic status of the soils and thus good for irrigation (12).

Exchangeable sodium percentage (ESP) gives the measure of the potential sodium problem and is the percentage of sodium ions out of the total base cations ($Ca2+$, $Mg2+$, $K+$ and $Na+$) (13).ESP value of the soil in phase II ranged from 5.90 to 10.0%, ESP value of the soil in phase III ranged from 6.80 to 9.02% as shown in Fig. However, the ESP value has not exceeded 10% which could result to problem on the soil. The implication of a high ESP value on the soil is soil deterioration or damage and unhealthy soil condition as stated by (13).

The calcium in the soil of the study area of phase II is generally moderate and ranged from 4.36 – 6.22 me/l and ranged from 4.29-6.05me/l. It can be deduced from the result shown in figure 4. That there is an appreciable increase in the calcium level. This increase could be related to the increase in pH observed which in tending towards moderately acidic. It indicates that irrigation has lead to increase in calcium level of the soils in phase II and phase III.

Magnesium ranged from 1.16 – 2.26 me/l and been the dominant cation in phase II and ranged from 1.29 – 2.775 /l in phase III respectively. Magnesium level decrease from soil surface depth (0-20 cm) to the second depth (20-60 cm) and increase sharply from the second depth to the third depth (60-100 cm) for phase II and phase III. This increase could be as a result of high magnesium content of irrigation water used for both phases. Magnesium is one of the secondary macronutrient required by plant, it deficiency causes leaf yellowing with brilliant tints (14).

Potasium (K) of the soil is moderate for phase II and phase III ranging from 0.23 to 1.26me/ for phase II and from 0.29 to 1.15me/l for phase III respectively. The average value of potasium is 1.175me/l, decline in potasium level from 0-20 cm to 60 cm and subsequently increased to 100 cm soil depth. The value of K that eventually rised from second depth can yield 100% without application of fertilizer (15).

Sodium Adsorption Ratio (SAR) is calculated from the Na, Ca, and Mg reported in me/l and the value is ranged from 0.14 to 0.10me/l for phase II and it ranged from 0.09 to 0.10 for phase III. The level of SAR decreased from 0-20 cm to 20-60 cm soil depth and subsequently increased from second depth (20-60 cm) to 60-100 cm soil depth, The SAR values obtained were generally below 13 meq/l$^{1/2}$ which indicated that the soil of the lands are normal for the growth of crops and the soil structure was in good condition for proper yield.

3.3 Effect of soil chemical properties on crop yield

It is observed among the three crops planted in the study area (figure 2), that Rice had the highest yield of 4.0 ton/ha followed by maize with 1.1 ton/ha and okra with 3.1 ton/ha for Phase II while Garden egg had the highest yield of 5.20 ton/ha followed by watermelon with 3.91 ton/ha while peper had the least yield of 3.1 ton/ha for phase III. Rice yield decreased from 4.0 ton/ha in 2015 to 3.6 ton/ha in 2016 and subsequently decreased to 3.3 ton/ha in 2017 for phase II and Garden egg yield decreased from 5.2 ton/ha in 2015 to 4.60 ton/ha in 2016 and then decreased to 4.00 ton/ha in 2017 for phase III. The decrease in the crop yield between 2015 and 2017 may be due to the increase in exchangeable bases, in the soil such as phosphorous, magnesium, potassium and sodium, in the soil. Maize and Okro (phase II) and watermelon and pepper (phase III) yields decreased slightly from 2015 to 2017 as compared to rice (phase II) and pepper (phase III) yields respectively. This indicate that there is not much effect of chemical properties on Maize and Okro as compared to Rice which has been affected by increased in chemical content of the soil in phase II, there is a slight negative effect due to chemical properties on the yield of both Watermelon and Pepper in phase III.

Comparing this with FAO crop yield standards the yields for the crop in both phase II and phase III are lower than the FAO crop yield standards for each respective crops (figure 1.0). However the one way analysis of variance of the crop yields and FAO standard as presented in Table 4.1 indicates that the yields of maize, pepper, garden egg and watermelon are significant while yields of rice and okro are insignificant of 95% level of significance with respect to the FAO standard.

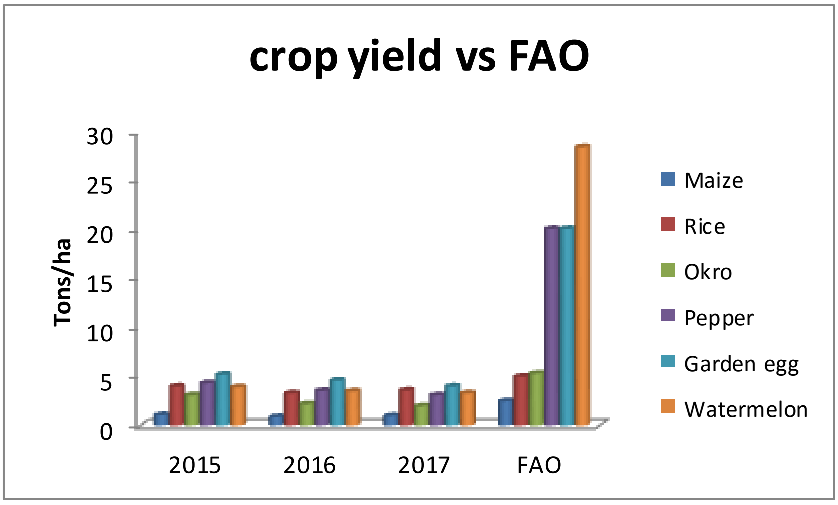

Figure 1.0 Crop yield in tonnes per hectare

Table 4.1 Analysis of Variance for crop yield with FAO Standard

ANOVA

	Sum of squares	Degree of freedom	Mean Square	F	Significant
Maize Crop					
Between groups	1.688	1	1.688	168.750	0.006
Within Groups	0.20	2	0.010		
Total	1.708	3			

Rice Crop Between groups Within Groups Total	 1.401 0.247 1.648	 1 2 3	 1.401 0.123	 11.358	 0.078
Okro Crop Between groups Within Groups Total	 6.163 0.687 6.850	 1 2 3	 6.163 0.343	 17.951	 0.51
Pepper Crop Between groups Within Groups Total	 200.165 0.772 200.937	 1 2 3	 200.165 0.386	 518.249	 0.002
Garden Egg Between groups Within Groups Total	 177.870 0.720 178.590	 1 2 3	 177.870 0.360	 494.083	 0.002
Watermelon Between groups Within Groups Total	 462.397 0.193 462.590	 1 2 3	 462.397 0.097	 4781.765	 0.000

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