EFFECT OF SOIL QUALITY ON RICE (Oryza sativa) CULTIVATION IN SELECTED LOWLAND AREAS OF KEBBI STATE, NIGERIA.

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ABSTRACT

Rice is one of the most important staple foods consumed in almost every household in Nigeria. With Nigeria's ever growing population and the need to increase food production, it has become necessary to focus attention on the medium necessary to increase rice production. This study was conducted to assess soil quality of lowland areas in Kebbi State where rice is majorly cultivated. Soil samples were analyzed following the standard procedures. Result obtained was observed to be sandy loam in texture, organic C (0.25gkg^{-1}) was observed to be low and that might be due to poor vegetation and excessive grazing in the area. The obtained values for other parameters were total nitrogen (0.08gkg^{-1}), available phosphorus (0.62mgkg^{-1}), potassium (0.27cmol(+)kg^{-1}), Calcium (0.59cmol(+)kg^{-1}) and Magnesium (0.77 cmol(+)kg^{-1}). Based on the inherent concentrations of these elements, high quantities of these elements would be required to achieve. Based on the concentrations of pH(6.3), EC (0.15(µS/cm) and ESP 2.31%, the soil is free from salinity and sodicity problems and could therefore be used for the production of rice under good management practices.

Keywords: Soil quality, lowland, kebbi state and rice productions

1.0. INTRODUCTION

Rice is the second most widely consumed cereal in the world next to wheat (Prabha *et al., 2018*). It is the staple food for two thirds of the world's population. Rice remains a very important constituent of the Nigerian diet and its importation makes an important share of Nigerian agricultural imports (Ogundele and Okoruwa 2006).

Rice contains 80% carbohydrates, 7-8% protein, 3% fat, and 3% fibre (Prabha *et al., 2018*). In recent time, demand for rice is increasing in Nigeria at faster rate than in other West African Countries (FAO, 2000). According to Akanji (1998) who inferred that the increasing demand for rice in Nigeria was partly due to explosion in population, rapid urbanization, increased income levels following the discovery of crude oil and ease of preparation. Although the country is the largest producer of rice in West Africa, yet it accounted for up to 20% of sub-Sahara Africa's rice imports for domestic consumptions (Omotola and Ikechukwu, 2006).

Federal Ministry of Agriculture and Rural Development [FMARD], 2016) put the estimated demand for rice in Nigeria to be about 6.3million tons, while supply was 2.3 million tons, thus, creating a serious gap that was expected to be made-up for by importation and this was valued at over $1 billion/annum. However, recent ban on rice importation suggests that Nigeria will henceforth, supply all its demand and for this to happen, the country must double its production capacity and equally address the challenges facing the rice cultivation particularly, those associated with soil quality.

Soils on which rice are cultivated are as varied as the climatic regime to which the crop is exposed: soil texture ranges from sand to clay, pH from 3 to 10; organic matter contents from 1 to 50%; salt content from almost 0 to 1%, and nutrient availability from acute deficiencies to surplus (De Datta, 1981; Talpur, *et al.*, 2013). Intensive cultivation or continuous cropping involving exhaustive high yielding varieties of rice and other crops, has led to heavy withdrawal of micro and macro nutrients from the soil; imbalanced and discriminate use of chemical fertilizers has resulted in deterioration of soil health (John et al., 2001). Gangwar and Ram (2005) reported increase in macro nutrients such as nitrogen, phosphorus, potassium and sulphur content in cropping sequences involving vegetable, pea, green gram. According to United Nations University Institute of Advanced Studies (UNU-IAS, 2008), degradation of natural resources reduces the productivity. Sanchez (2010) emphasized on the development of high yielding crop varieties with little attention given to the ecology on which the plant survives. He suggested that crop yields in Africa could be tripled through proper management of the soil environment. Ladaha (2003) also reported that long-term fertilization effects on crop yield and soil fertility changes.

Increase in rice production is necessary, because it has a great potential to play a crucial role in contributing to food and nutritional security, income generation, poverty alleviation and socio-economic growth of Nigeria (Gona and Ishaya, 2019). Increased production can easily be achieved in the country since one of the most original features of rice is the fact that it can

be grown under different environmental conditions particularly from the point of view of water supply.
The average yield of upland and lowland rainfed rice in Nigeria is 1.8 t/ha–1, while that of the irrigation system is 3.0 t/ha–1 [PCU 2002]. This is very low when compared to 3.0 t/ha–1 from upland and lowland systems and 7.0 t/ha–1 from irrigation systems in Côte d'Ivoire and Senegal (Ogundele, Okoruwa 2006; WARDA, NISER 2001).

In order to increase rice production, it is important to evaluate soil quality. Therefore, this study was conducted to directly assess soil quality induced by management practices in rice field of lowland areas in selected local government areas of Kebbi State.

3.0 MATERIALS AND METHODS

THE STUDY AREA

The Study covers of four local government areas of the state, namely, Bunza ($12^0$05'3.98"N, $4^0$01'16.00"E), Jega (12^0 13'19.88"N, 4^0 22'46.67"E), Kalgo ($12^0$17'0.56"N, $4^0$06'3.17"E) and Maiyama($12^0$04'56.10"N, $4^0$22'8.65"E) local government areas. Kebbi State is situated in the extreme north-western part of Nigeria between Latitudes 10º06' to 13º10'N and Longitudes 3º0' to 6º 03' E at an altitude of about 200 meters above sea level, in the Sudan savannah agro-ecological zone (KARDA, 1998). The climate of the area is semi-arid with an average annual rainfall of about 500-650mm, the relative humidity ranges from 21-47% and 51-92% during the dry and rainy seasons, respectively. Temperature ranges from 20-30^{0}C during the dry cold season and 27-41^{0}C during the hot season. The main sources of water for irrigation at the study area are the tube wells and the Gindi River. The crops that are commonly grown in the area include cereal crops, such as rice, maize, guinea corn and wheat. Vegetable crops like tomatoes, pepper, lettuce and spinach are also grown in the area.

COLLECTION OF SOIL SAMPLE

Four local government areas were covered for the purpose of this study. From each local government area, soil samples were collected in two (2) lowland areas in triplicate form at a depth of 0-15cm being the rooting depth of most of the cereal crops grown in the area using a soil auger (Adegbite *et al.*, 2018). The soil samples were put in a clean and well labeled plastic bag and taken to laboratory for preparation and analysis. The samples were air dried and gently crushed using porcelain pestle and mortar and sieved through 2mm sieve for laboratory analysis.

SOIL ANALYTICAL METHODS

The processed soil samples were analyzed for various physical and chemical properties following the procedures as described by (Page et al., 1982). The particle size analysis was carried out by the (Bouyoucos, 1951) hydrometer method as modified by Day, 1965. The

texture was determined on the USDA textural triangle. Organic carbon was determined by (Walkley and Black 1934) wet combustion method (CF 1.33). Total nitrogen was determined by macro-Kjeldahl digestion and distillation method. Available phosphorus was obtained by the use of Bray-1 method (0.025 N HCl + 0.03N NH4F) as described by Bray and Kurz, 1945). Cation exchange capacity was determined by ammonium saturation method as described by (Chapman, 1965). Potassium (K) and sodium (Na) concentrations in solution were determined by flame photometry (Uriyo and Singh (1974). Calcium (Ca) and magnesium (Mg) were determined by EDTA titration method as described by (Stewart, 1974). The soil pH was determined using pH meter in a 1:2 soil water mixture as recommended by Alberta Saskart Chewan and Mannitaba Provisional Laboratory (ASCMPL, 1988). Electrical conductivity (EC) was also determined in a 1:2 soil water ratio at 25ºC on a conductivity meter. The result was multiplied by a conversion factor of 2.063 (ASCMPL, 1988) to obtain the saturation extract. The exchangeable sodium percentage ESP was calculated as follows:- Where Na+ and CEC were in cmol (+)kg-1 of soil. Base saturation was obtained by summation of the values of basic exchangeable cations. Percentage base saturation on the other hand was determined by using the formula below;

$$\frac{\text{Exchangeable } Na^{+}}{\text{CEC}} \times \frac{100}{1}$$

Where Na^{+} and CEC were in cmol (+)$kg^{-1}$of soil.

Statistical Analyses

The data obtained were analysed using descriptive statistics and expressed as tables (Augie, *et al.*, 2020).

RESULT

Table 1: Table: Mean particle size distribution and texture of the soils of the study area.

LGA	%sand	%silt	%clay	Texture
Jega	65.33	16.88	17.79	SL
Kalgo	69.12	19.97	10.92	SL
Maiyama	70.44	17.33	12.23	SL
Bunza	52.98	26.17	20.85	SCL
Mean	64.46	20.09	15.45	SL
Range	52.98-70.44	16.88-26.17	10.92-20.85	

Table 2: Soil quality assessment with respect to fertility status of the study area

Local government Areas	Organic Carbon ((g/kg-^{1})	Total Nitrogen (g/kg^{-1})	Available P (g/kg^{-1})	Potassium K (cmol(+)kg^{-1})
Jega	0.19	0.07	0.65	0.36
Kalgo	0.22	0.07	0.59	0.24
Maiyama	0.24	0.08	0.61	0.21
Bunza	0.33	0.08	0.61	0.25
Overall mean	0.25	0.08	0.62	0.27
Range	0.19-0.33	0.07-0.08	0.59-0.65	0.21-036

Table 3: Quality assessment with respect to exchangeable cations of the study area

Local government	Calcium Ca (Cmol/kg)	Magnesium Mg (Cmol/kg)	Sodium Na (Cmol/kg)	Cation Exchange capacity CEC (cmol/kg)
Jega	0.57	0.89	0.14	1.96
Kalgo	0.56	0.63	0.23	1.66
Maiyama	0.52	0.67	0.28	1.68
Bunza	0.73	0.88	0.31	2.17
Overall mean	0.59	0.77	0.24	1.88
Range	0.52-0.73	0.63-0.89	0.14-0.24	1.66-2.17

Table 4: Soil Quality assessment with respect to Salinity/sodicity of the study area according to USDA classification of salt affected soils

LGA	pH	EC (dsm^{-1})	ESP (%)
Jega	6.5	0.23	7.14
Kalgo	6.3	0.15	13.86
Maiyama	6.4	0.07	16.67
Bunza	5.9	0.13	14.28
Overall mean	6.3	0.15	12.99
Range	5.9-6.5	0.07-0.23	7.14-14.28

DISCUSSION

The relative proportion of sand, silt and clay of a soil determine its texture. The texture of a soil influences its physical and chemical properties such as water holding capacity, cations exchange, pH and so on. The result from this study (Table 1) shows that the relative proportions of sand, silt and clay of the soils of the study area were 64.47%, 20.09%, 15.44%, respectively. This indicated that the dominant texture of the soil was sandy loam. The result was similar to the report by Singh *et al.* (2002) that the dominant texture of the irrigated fadama soils in Sokoto State was sandy loam. Similarly, this result also agrees with the earlier findings of Augie *et al.*, 2020 who opined that the dominant texture of the University Fadama Farm located at Jega is predominantly sandy loam. Based on the physical attributes of this textural class, the soil could be used for the production of rice under good management practices. Out of the four sampling areas, only soil of Bunza indicated sandy clay loam with mean particle size distribution of 52.98% sand, 26.17% silt and 20.85% clay particles. This is in agreement with the findings of Olaleye, 1998 and Augie 2020b who found high amount of clay and silt in soil of Yauri and attributed it to why rice is cultivated in high volumes in that area.

Organic carbon is an indicator of organic matter content in the soil. It is a potential source of essential plant nutrients and it also plays an important role in influencing the physical and chemical properties of the soil. Table 2 shows that organic carbon content of the soils of the study area ranged from 0.19-0.33g/kg with an overall mean value of 0.25g/kg-^{1}. Based on the rating scale given by Esu (1991), the soil could be rated as low in organic carbon. This result is in agreement which the findings of Singh 1991a who reported low organic C for fadama soil in Kebbi State. Similarly, Kozah 1997; Sanda *et al*., 2014 reported low organic C for soil in Rafin Yaki valley in Bedi Village of Zuru and low organic C in floodplains of Jega all in Kebbi state. Low organic C might be attributed to constant use of land all year round and constant removal of rice straw to feed cattle in the area. The highest organic carbon of 0.33gkg^{-1} was observed in Bunza and it might be due to intense vegetation in the area.

The study revealed that the total nitrogen of the study area as shown in Table 2 ranged from 0.07-0.08g/kg with an overall mean value of 0.08g/kg. Based on the rating scale given by Esu

(1991), the total nitrogen was low. The values were similar to the values 0.08-0.29g/kg obtained for well drained top soils in savannah region of Nigeria (Jones, 1973). The values were also similar with obtained values of 0.01-0.065g/kg for fadama soils in Kebbi State Singh (1999b). Similarly, Singh (1999a) observed that 12-65% of the lowland soils in Kebbi State were found to have low total N content. He reported that it ranged between 0.1 and 0.2g kg-1. The low total N content in the soils may be attributed to removal of crop residue on farmlands and low application of organic residues for crop cultivation coupled with low vegetative cover for returning organic matter to the soil (Augie, *et al.*, 2020).

Furthermore, table 2 shows that the content of available phosphorus of the study area ranged from 0.59-0.65mg/kg with an overall mean of 0.62mg/kg. These figures are higher than the ranges of 0.01-0.03mg/kg, 0.001-0.007mg/kg, 0.01-0.07mg/kg reported for soils around River Rima, River Sokoto and around Goronyo dam respectively (Singh and Tsoho 2001) but lower compared to Singh, 1999b with a value of 2.2 g/kg. Available P values in the study area were found to be low considering the values for available P ratings given by Esu (1991) which set P values of less than 10 mg kg-1 in the low category rating for available P.

The content of the exchangeable potassium of the soils analyzed for the area as shown in Table 3, ranged from 0.21-0.36 cmol/kg with an overall mean value of 0.27 cmol/kg. This K value of 0.27 cmol/kg was similar to the mean value of 0.25cmol/kg reported for fadama soils of Sokoto Rima River (Singh *et al*, 1996). Based on the rating scale given by Esu (1991), the soil could be rated as high in potassium.

The result for Ca was shown in Table 2 which indicated that the Ca ranged from 0.52-0.73cmol/kg with overall mean value of 0.59 Cmol/kg. The Ca content of study areas were observed to be low based on the rating of Adepetu *et al.*, 1979. Based on the report by SFMS (2013) that rice requires 27kg of Ca/ha and an inherent Ca concentration of 0.59cmol (+)kg^{-1} (11.8kg/ha), 15.2kg/ha of Ca could be added to supplement the deficient quantities.

The values for Mg ranged from 0.63-0.89 (mean, 0.77cmol (+)kg^{-1} in the soil of the study area. These values were similar to 0.32-0.99 (mean 0.80)Cmol/kg as reported by Singh (1999b) for soil in Sokoto Rima River Basin. Based on the Mg requirement of rice (23kg/ha) as given by SFMS (2013) and the inherent Mg content of the soil of the study area 0.77cmol(+)kg^{-1} (15.4kg/ha), 7.6kg of Mg would be required to supplement the deficient quantities.

The sodium (Na) values obtained as indicated in Table 3 ranged from 0.23-0.4 cmol/kg with an overall mean of 0.31cmol/kg. Singh and Tsoho (2001) reported similar Na^+ value of 0.3-0.5cmol/kg for soils around lakes in Sokoto State. Based on the rating scale in given by Esu (1991), the soils of the study area could be ranked as medium to high in Na^+. Excess concentration of potassium in the soil is detrimental to both soil and the growing crops and therefore, the farmers in the area could be advised to ensure proper tillage to facilitate leaching of Na^+ so as to prevent its further accumulation to the detrimental level.

The obtained values for CEC from this research ranged 12.76-13.8cmol/kg with an overall mean value of 13.23cmol/kg as shown in Table 4. The obtained values were also higher than 3-8Cmol/kg as reported by Jones and Wild (1975) for savannah soil, but lower than 6.39-14.64Cmol/kg CEC given by Singh (1997b) for Sokoto Rima basin soils. High CEC value of 13.23Cmol(+)kg^{-1} indicated higher concentrations of exchangeable bases in the soil of the study area.

Electrical conductivity (EC), exchangeable sodium percentage (ESP) and soil pH are the indicators of salinity and sodicity status of a soil. Soil pH of the study areas shows that is thes were slightly acidic.

As per this study, the results in Table 4 revealed that, the EC (dsm^{-1}), ESP (%) and pH ranged from 0.07-0.23, 1.8-2.99 and 5.9-6.5 with mean values of 0.5, 2.31 and 6.3, respectively. Based on the concentrations of these parameters, the soil could be considered as free from problems of salinity and sodicity and therefore good for the production of rice and good management practices.

CONCLUSION AND RECOMMENDATIONS

The result of this study shows that the soils of the study areas were low in fertility and therefore accounts for the low yield of rice in study area and the state (Kebbi Satet) at large. Although Marginal fertility is a characteristic of many tropical soils, mainly because of the high rate at which organic matter is lost, high rate of leaching, highly weathered minerals and low organic input (Yagodin, 1984). This could also be due to cultural practices that resulted in over utilization of the land, transiting from rain-fed to irrigated agriculture for many years now.

It is therefore important to augment the poor soil quality with appropriate management practices such as complimentary use of both organic and inorganic fertilizers to maximize the potentials of the lowland areas for rice cultivation.

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