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Assessment of Fertility Status of Irrigated Lowland Rice Growing Soils of Ebonyi South-East Nigeria

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Abstract A study to assess soil fertility status was conducted in the lowland rice growing soils of Ebonyi South-East Nigeria situated within latitude 60 41, N and longitude 80 51 E, and 104.40 m above sea level. The assessment covered all the villages that produce rice in the three major rice producing zones of Ebonyi state with Ebiaunuhu, Ogboji and Akaeze representing Ebonyi North, Central and South zones respectively. Soil samples were collected from the rice growing lowland zones at 0-30cm depth using soil auger attached to a core sampler. A total of 250 soil samples were collected from each of the 100 hectare lowland soils of the zones and analyzed for chemical fertility indicators. The data was analyzed for means and percentages and the results were ranked using fertility standard according to Landon. The results revealed that total nitrogen, organic matter and cation exchange capacity were in low in all the zones while P was adequate in all the zones and K was high for the soils studied. Calcium concentration was high in the north but low in the central and southern zones. The soils require good input of N-fertilizer and organic matter to boost CEC and therefore increase the yield of rice in these lowland soils of Ebonyi State.

Keywords Ebonyi, Fertility, Irrigable, Lowland Soil, Rice

1. Introduction

In Nigeria, rice was once reserved for ceremonial occasions, but with rising incomes and the relative convenience with which it can be processed and preserved (Onwuchekwa,1988) the popularity of rice has increased to the point where it has become the most popular cereal crop in Nigeria. With increasing urbanization (NPC, 2002), it is to be expected that the importance of rice will increase. This represents good news for farmers, because rice has high positive income elasticity and is replacing tuber and root crops as well as other grains (maize, millet and sorghum) as the most important foodstuff for a significant proportion of the population (Filanni, 1980). Despite this increasing demand for rice, the total area presently under cultivation across the country is comparatively small. Local production is further constrained by low/inadequate agricultural inputs, improper management techniques, declining available farm labour and lack of adequate water control techniques, among other factors (WARDA, 1996). In 2000, for example, only about 6.3% of the total area cultivated to the various crops in the country was put under rice production. The overall comparatively low rice production hectarage across the country may even be lower in Ebonyi State of Nigeria, the Case Study State of this research work. The country has, on occasions, resorted to importation of rice to augment local production. The federal Government of Nigeria has as a result addressed increasing rice production needs through various development plans and projects, banned the importation of rice but instead of increasing the local production rather increased the cost of the of smuggled rice geometrically .To address this problem the joint research studies of the National Cereal Research Institute (NCRI) Badaggi and the International Institute of Tropical Agriculture (I.I.T.A.), Ibadan have recommended a total of 43 rice varieties for the various rice growing areas of Nigeria. These rice varieties have potential yield of 2-7 tons paddy per hectare and are not only of good quality but are resistant to most pests and diseases (I.I.T.A, 1995). This is aimed at achieving much higher yield per hectare compared to the present average yield of 2 tons per hectare. With some of these improved varieties farmer may be encouraged to add many more hectares of the available potential rice land to rice production across the country. This is particularly true for Ebonyi State of Nigeria.

Ebonyi State has a total land area of 7,087,120 hectares. About 40% of this landmass is clayey and situate

predominately in the lowland/fadama areas of the state (Ekpe *et al* 2015). About 80% of the lowland soils are clayey with strong grey and brown mottles below a dark humus surface horizon (Ituma, 1980), and are suitable for rice production both under rainfed and irrigated conditions. The full utilization of this area for rice production could yield as high as 300,000.0 metric tons of rice per annum (FAO, 1984 cited by Ekpe et al., 2014). Efforts to achieve food security and higher cash income (returns) for the rural farmers could be directed towards increasing production of rice through proper soil fertility assessment and irrigation practices.

2. Materials and Methods

2.1. Site Description

Ebony State is located between latitude 6^0 4^1, N and longitude 8^0 5^1 E, and 104.40 m above sea level. The State is bounded on the west by Enugu State and northwest by Benue State. It shares boundaries with Cross River, Imo and Abia states. The state has 7,087.12 Sq. km of land area. The longest distance from east to west (Akaeze - Izzi) is more than 100km, while from north to south (Edda – Effium) is over 120km. For the purpose of this study, the state was divided into three Agricultural zones; the Northern zone with headquarter at Ebiaunuhu, central zone with headquarter at Onueke and southern zone with headquarters at Akaeze. Each zone has concentration of major rice producing areas.

2.2. Northern and Central Zones

The mean annual rainfall of the two zones for the 2003 and 2004 base years was 1613.80 mm from about 88 rain days, distributed bimodally with May/June and August/September showing the highest peaks. The maximum and minimum temperatures within the same period were 30.48 and 23.47℃ repressively. The relative humidity ranged from 32.20-90.93% with a mean of 67.78%. The areas are situated in the derived Savannah zone of Nigeria characterized by sparse vegetation with native trees less than 5m in height. The tree varieties are mostly *Acacia nilotica*, desert palm and neem trees with planted vegetation made up of Gmelina trees. The grass species include Calaponium *mucunoid, Andropogunium gyanus* and Elephant grass.

The soil has an underlying parent material consisting of shales inter-bedded with sand and limestone. Marine formations also exist together with shales, known to be good aquifers (Kowal and Kassan, 1978.) The soils textural class is clay loam, fairly drained with gravely subsoil in some locations especially the uplands adjacent to lowland areas (U.S.D.A., 1988).

2.3. Southern Zone

The mean annual rainfall of this zone for the 2003 and 2004 base years was 1466.32mm obtained from 87 rain days with a fairly defined peak rain period of 6 months from April to September. The maximum and minimum temperatures were 32.18 and 17.40^{o}C respectively while the relative humidity ranged from 50-87% and a mean of 68.42%. Parts of this zone around Edda lie within the high rainfall zone of Nigeria. The soil textural class of this zone is sandy loam.

2.4. Soil Sampling

All the villages in the zones mapped out for irrigation project by National Programme on Food Security (NPFS) were selected for soil sampling. In each village two sets of soil samples were collected yearly. Each set of the soil samples was obtained at 0-30 cm depth from an area of 40 hectares. Two hundred and fifty (250) soil samples were obtained on the whole using the grid method (I.I.T.A, 1979). Each set of these samples was bulked, dried at room temperature, mixed and ground thoroughly, and passed through a 0.2mm sieve. From the bulked samples, twenty (20) representative samples were collected from each zone, each year for two years.

3. Laboratory Analysis of Soil Samples

Soil samples were analyzed for pH in 1:2.5 soil water solution; total nitrogen was determined using the macro-kjeldahl procedure described by Jackson (1958) and sited by Ekpe *et al* 2010; Available phosphorus was determined using Bray2 solution (Bray and Kurtz, 1945); percent organic matter was determined walkly and Black (19) and the value was corrected to organic carbon by multiplying the percent organic matter with a factor of 1.724 ;the exchangeable bases potassium(K),calcium(Ca) and sodium(Na) were determined by extracting with 1 N ammonium acetate; the amount of K, Ca, and Na in the filtrate were determined using Corning flame photometer with appropriate filter, and Mg determined using a Perkin-Elmer atomic absorption spectrometer (Tel and Rao,1982);CEC was determined by distillation with NH_4OAC according to IITA,(1979).

Data Analysis and Statistics

For purposes of this research only the primary data were collected from results of soil analysis. The two year data were analyzed for means and percentages according to Gomez and Gomez, (1984) and the fertility status determined by comparing the data with Landon, 1991 and FAO (2010) soil fertility standards for rice production.

Table 1. Chemical properties of selected Lowland soils in Ebonyi State

Location	pH	%OM	CEC Cmol/100g	TN %	AP Cmol/100g	Exch.K Cmol/100g	Na Cmol/100g	Ca Cmol/100g	Mg Cmol/100g	%BS
Ebiaunuhu	5.66	2.71	17.2	0.20	30.25	0.21	2.26	8.8	1.93	142.15
Ogboji	5.26	2.94	18.0	0.073	29.45	0.14	2.31	0.86	1.0	136.44
Akaeze	4.95	2.85	15.6	0.17	27.06	0.22	2.26	0.85	0.35	154.29
FAO Limits	6.5-8.5	4-20	0.5-10	0.2-1.0	>22	0.2-4.0	250-400	200-400	0.2	>6.0

4. Results

4.1. The Chemical Properties of the Lowland Soils

The results of the analysis of the chemical properties of the lowland soils of Ebonyi State are presented in Table 1. The soil of Ebiaunuhu and Akeze has high pH levels of 5.66 and 5.26 respectively while the Ogboji soil was more acidic with pH of 4.95. Generally, rice crops can tolerate soil pH range of 4.5-9.0. The result further revealed that the soils have mean values of 0.20%, 0.073% and 0.17% total nitrogen for North (Ebiaunuhu), Central (Ogboji) and South (Akaeze) Zones respectively. The values of available phosphorus for the selected soils in the three zones were 30.25 Cmol/100g, 29.45 Cmol/100g and 27.06 Cmol/100g soil for Ebiaunuhu, Ogboji and Akaeze lowland soils respectively. Exchangeable Potassium (K) in the selected lowland soils in Ebiaunuhu was 0,12 C-mol/100g while the value was 0.14 C-mol/100g in Ogboji and Akaeze lowland was 0.22 C-mol/100g. The data on percent organic matter content of the sampled sites showed mean organic value of 2.71, 2.94 and 2.85 per cent for Ebianuhu, Ogboji and Akaeze lowland soils respectively. The cation exchange capacity (CEC) values of soils of the three zones were 17.20-mg/100g soil for the Ebiaunuhu while the Ogboji had 18.0 mg/100g and the Akaeze had 15.60 mg/100g soil. The result of the soil analysis for sodium, calcium and magnesium in the sampled sites throughout the state showed that sodium (Na) level in the soils were 2.26, 2.31, and 2.26 C-mol/100g soil for Ebiaunuhu, Ogboji and Akaeze lowland soils respectively. The mean Magnesium (Mg) values were 1.93, 1.0 and 1.35 mg cm^{-3} for North, central and Southern soils respectively, while the mean average values of Calcium were 8.8, 0.86 and 8.8 Cmol/100g soil for the North, Central and Southern zones respectively.

4.2. Soil Fertility Rating of Ebonyi Lowland Soils

The general rating of 8 (Ca, Mg, K, CEC, BS, TN, AP,O/M) selected soil parameters important in rice production indicated that CEC was high in the northern and southern agroecological zones while Ca, Mg and O/M were low in all the soils. Other parameters were in the medium to high fertility classes. Available P was in very high fertility class (Table 2).

Table 2. General rating of eight selected fertility indices in the three locations studied according to Enwezor *et.al* 1989)

Fertility Parameters	Agro-Ecological Zone	of Ebonyi State	
	North	Central	South
Ca^{2+}	High	Low	Low
Mg^{2+}	High	High	High
K^{+}	Medium	Low	Medium
CEC	High	Low	High
BS	High	High	High
TN	Medium	Very Low	Low
AP	Very High	Very High	Very High
OM	Low	Low	Low

5. Discussions

Ebiaunuhu had 0.20% TN, Ogboji 0.073 and Akaeze 0.17. Ebianunhu lowland soil was in the medium rating for total N, and Ogboji and Akaeze were within the low rating class (FAO/UNESCO, 1973). Total nitrogen in tropical soils is generally low. The zones require nitrogen fertilizer for improved yield of rice crops since the crop is a high consumer of nitrogen. The order of total nitrogen in the zones are Ebiaunuhu >Akaeze>Ogboji.

The values of available phosphorus (P) for the selected soils in the three zones are high and the phosphorus content of the Ebonyi State lowland soils was adjudged as adequate.

The value of available Potassium (k) in the central zone was 0.14 Cmol/100g. This value was low. Therefore, there will be high response to K fertilizer in the zone, while available k in the southern zone represented by Akaeze was 0.22. This is high and therefore the soil would not require the input of k-fertilizer for rice production unless applied as a starter dose.

The mean OM was 2.71, 2.94 and 2.85 per cent for Ebianuhu, Ogboji and Akaeze lowland soils respectively. The percent OM was low. The present level of OM in the study area cannot support the production of rice without human intervention such as the application of organic matter and fertilizers (MÜller-Samann, and Kotisch, 1987). The trend of the quantity of organic matter in these soils are in the following sequence Ogboji > Akaeze > Ebiaunuhu.

The cation exchange capacity (CEC) of the three zones is 17.20 mg/100g soil for the Northern zone while the Central has 18.0 mg/100g and the South 15.60 mg/100g soil. From the result, there is high level of cation exchange capacity in the soils. In these soils attempt should be made to sustain the high CEC values through good soil management practices (adequate organic matter incorporation, etc).

Sodium (Na) levels in the soils were 2.26, 2.31, and 2.26 Cmol/100g for Ebiaunuhu, Ogboji and Akaeze lowland soils respectively. Magnesium (Mg) levels were 1.93, 1.0 and 1.35 mg cm^{-3} for Ebiaunuhu, Ogboji and Akaeze lowland soils respectively. The levels of sodium and magnesium in the soils were sufficient for intensive production of rice. Since lowland rice production benefit from broken structure to encourage water retention, the high Na will benefit lowland irrigated rice production in the study area.

The average level of calcium in the soils for Ebianunhu, Ogboji and Akaeze lowland soils were 8.8, 0.86 and 8.8 Cmol/100g soil respectively. There was low calcium content in Ogboji lowland soils. This is about 1000% less than in all the other soils in the state. The Ebiaunuhu and Akaeze lowland soils have adequate levels of calcium that does guarantee zero application of this element in the soils within the next few years.

6. Conclusions

The soils of Ebonyi state are potentially suitable for increased rice production with adequate management.

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