Physical Properties of The Irrigable Lowland Rice Soils of Ebonyi South-East Nigeria

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Abstract
Since the mid-1980s, rice consumption has increased in Nigeria at an average annual rate of 11 %, of which only 3 % can be explained by population growth. The remainder represents a shift in diet towards rice at the expense of other coarse grains. Physical properties of the irrigable lowland soils of Ebonyi southeast Nigeria was investigated to determine their suitability for irrigated rice production. The state was divided into three agricultural zones of North, Central and the southern zones. Soil samples were collected from 0-30 cm soil depth with a core sampler attached to a soil auger. A total of 200 soil samples were collected from each zone using transverse method and analyzed for the selected physical properties. The laboratory results were analyzed to determine means and percentages and compared with known standards set by Landon for tropical soils. The results revealed that the North had the best physical properties for lowland rice production followed by the southern zone and lastly the central zone. Increased lowland production is advice for the Northern zone all things being equal.
Key words: Irrigability, Irrigation, Rice, Tropics, ,

1.0. Introduction

Rice is the most popular cereal crop in Nigeria. Rice was once reserved for ceremonial occasions in the Nigerian diet. The popularity of rice is derived partly from the rising level of income and the relative convenience with which it can be processed and preserved (Ekpe, 2010). The FAO, (1999) reported that an estimated 2.1 million tons of rice is consumed annually in the country. This figure is likely to have increased since the past 16 years. With increasing urbanization, it is to be expected that the importance of rice would increase. This is largely due to the fact that rice is preferred by urban population, which is increasing faster than the whole national population as a result of higher rate of urbanization (NPC, 2002).

Nigeria is a major rice producer in West Africa and was rated the region's largest rice producer in 1990. Rice cultivation is widespread throughout Nigeria with most of the rice grown in the Eastern and Middle belts of the country (WARDA, 1996).

Based on the above increasing demand for rice, the total area presently under cultivation across the country is comparatively small. Local production is further constrained by poor soil physical properties, low or inadequate agricultural inputs, improper management techniques, declining available farm labour and lack of adequate water control techniques, among other factors (Ekpe, 2010). 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 by hectare across the country may even be lower in Ebonyi State of Nigeria, the Study area of this research. Ebonyi State has a total land area of 7,087,120 hectares.. About 40 % of this landmass is clayey and situated predominately in the lowland or fadama areas of the state. 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 (Ekpe, 2010). It was based on the above facts that an investigation to assess the adequacy or otherwise of the physical properties of the soil of the Ebonyi state lowland soils for rice production was embarked upon.

2.0 Materials and Methods

2.1 Site Description

Ebonyi 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 100 km, while from north to south (Edda – Effium) is over 120 km. The rainfall pattern is bimodal with peaks in July and September. Total mean annual rainfall ranged from 1,700 – 2,000 mm with 70 % relative humidity during the dry season. The people are predominantly farmers with petty trading activities and a 4 large rice mills are located round the state making it local rice mill hub in Nigeria.

2.2 Field 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. 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 a set of soil sample was collected yearly for two years. Two hundred (200) undisturbed soil samples were randomly collected from each village in each zone yearly for two years using a core sampler attached a soil auger. The undisturbed samples were used to determine some selected physical properties of the soil.

2.3 Soil Sampling

2.3.1 Laboratory Analysis of soil samples

Soil samples were analyzed for Particle size distribution according to the Bouyoucos (1951) hydrometer method using sodium hexametaphosphate as a dispersing agent and the texture was read out using textural class calculator and correlated with textural triangle. Bulk density was determined by the method of Blake and Hartage (1965) and the formula is presented in equation 1and correlated using bulk density calculator.

$$Bd = \frac{w}{v} \text{..........................Equ.1}$$

in which Bd = bulk density
W = mass of oven dry soil
V = volume of soil

Total porosity was by calculation according to the formula in equation 2.

$$TP = 1 - \frac{Bd}{pd} \times \frac{100}{1} \text{....................Equ.2}$$

Where : Tp is Total porosity,
Bd is Bulk density and
Pd is Particle density taken as 2.65 $mg.kg^{-1}$

Hydraulic conductivity was determined using the constant head method as described by AOAC (1990). The hydraulic conductivity calculated using the formula in equation 3.

2.4 Methods of Data Analysis

The raw data emanating from the laboratory analysis was analyzed for means and per cent ages according to Gomez and Gomez (1986). The soil physical properties were interpreted according to Landon, (1991) and collaborated with textural class and bulk density calculators.

3.0 Results and Discussion

3.1 Soil Texture

Table 1 shows the physical properties of lowland Soils in Ebonyi State. The lowland soils of the Northern zone of Ebonyi were Clay loamy with about 408.47 $g.kg^{-1}$ sand, 250.00 $g.kg^{-1}$ silt and 350.60$g.kg^{-1}$ clay (at 0-30 cm soil depth) while those of the central zone were sandy loamy (730.33 $g.kg^{-1}$ sand, 150.07 $g.kg^{-1}$ silt and 119.60 $g.kg^{-1}$ clay).The Southern zone lowland soils are sandy loam (590.33 $g.kg^{-1}$ sand, 230.60 $g.kg^{-1}$ silt and 179.07 $g.kg^{-1}$ clay). The soils of higher clay content (North and Southern zones) are the most ideal for rice production. Mineral particles in soil range widely in size from large stones to minute clay fragments. The proportion of various size particles has a major impact on soil physical, chemical and biological properties. Hence the description and characterization of soil texture is of primary importance to farmers.

Location	Bd mg.kg^{-1}	Tp %	Hc cm/hr	Sand	Silt g/kg	Clay	Texture
Northern Zone lowland	1.33	49.81	3.56	408.5	240.9	350.6	Clay Loam
Central Zone	1.51	43.02	1.23	730.3	150.1	119.6	Sandy Loam
Southern Zone	1.46	44.91	2.44	590.3	230.6	179.1	Sandy Loam
Standard	1.65	38.0	0.6-2.0	250.00	180.00	570.00	Clay Loam

Legend:
Bd = bulk density ; Tp = Total porosity ;Hc = Hydraulic Conductivity

Table 2: Soil Textural Classification according to USDA and ISSS Systems

Soil Separates	Particle Diameter	
	USDA	ISSS
Very coarse sandy	2.00 – 1.00	> 2.0
Coarse Sand	1.00 – 0.50	0.2-2.0
Medium Sand	0.50 – 0.25	NC
Fine Sand	0.25 – 0.10	0.20-0.02
Silt	0.05 – 0.002	0.02-0.002
Clay	< 0.002	< 0.002

NC = Not Classified. Adopted from Landon, 1991

3.2 Buk Density

The bulk density of Ebiaunuhu lowland soil showed 1.33 mg.kg^{-1}. This value may be due to the high clay, silt and low sand content. The Ogboji and Akaeze lowland soils showed 1.51 and 1.46 mg.kg^{-1} bulk density. From the rating of bulk density, they are in the textural class of loamy, sandy loam and sandy clay loam for Ebiaunuhu, Ogboji and Akaeze lowland soils respectively. Bulk density is suggestive of easy of root penetration. This resistance varies with soil depth. This value of bulk density is ideal for rice production. Soil bulk density is defined as the mass per unit volume of the entire soil, including the total pore space, i.e. the space occupied by the combination of solids and pore space (Earr & Henderson,1986). Bulk density (BD) or apparent specific gravity is the mass of unit volume of a soil measured in mg.kg^{-1}. It is measured using an oven dry soil sample of mass (W) and volume (V): Under good management, bulk density will tend to reduce until equilibrium value is reached for a given soil and cropping situation. Bulk density is simply an indication of the general status of the soil in physical terms. The bulk density of clays, clay loam and silt loam surface soils normally range from 1.00 to 1.60 g. cm^{-3} while variations of 1.20 to 1.80 g.cm^{-3} is common in sands and sandy loams. (Webster and Wilson, 1980,).

3.3 Total Porosity

The total porosity of the soils ranged from 43.02 and 444.91 and 49.81 per cent in Ebiaunuhu and Ogboji to Akaeze, respectively. Ebiaunuhu lowland soil is more porous than the Ogboji and Akaeze lowland soils. Water movement into and within the Ebiaunuhu lowland soil will be better than in the other two soils. The most ideal TP is

Table 3: Soil permeability classes

Classification	Infiltration Rate ($cm.hr^{-1}$)
Very slow	less than 0.06
Slow	0.06 – 0.2
Moderately Slow	0.2 – 0.6
Moderate	0.6 – 2.0
Moderately rapid	2.0 – 6.0
Rapid	6.0 – 20.0
Very rapid	greater than 20.0

Adopted from Landon, 1991

Soil permeability is a measure of the ability of air and water to move through the soil. The size, shape, and continuity of the pore spaces, which in turn are dependent on the soil bulk density, structure and texture, influence permeability (Thomas *et al*.,1996).

4.0 Conclusion

The most suitable lowland soil in Ebonyi State for rice production is located at the Northern zone with its clay loamy soil. This is due to the higher occurrence of clay soil in that zone. The next soils good for lowland rice production is located at the villages in the Southern zone of Ebonyi of which the largest producer of lowland/ swamp rice is Edda. The Ebonyi Central ranks third in its lowland soil physical properties suitability. This is because Ebonyi Central has very low clay content (an important textural class for lowland soils).

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