African Journal of Biotechnology Vol. 6 (24), pp. 2803-2806, 17 December, 2007
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2007 Academic Journals

Full Length Research Paper

Spatial distribution of N, P and K in major yam soils of southeastern Nigeria

G. O. Chukwu[1], M. I. S. Ezenwa[2], A. O. Osunde[2] and R. Asiedu[3]

[1]National Root Crops Research Institute, Umudike P.M.B.7006, Umuahia, Abia State, Nigeria.
[2]Department of Soil Science, Federal University of Technology, Minna, Niger State, Nigeria.
[3]International Institute of Tropical Agriculture, Ibadan, Nigeria.

Accepted 25 January, 2007

Pedometrics, the application of numerical techniques to describe soil attributes and enhance objectivity in soil-related decision making, was applied to soil samples from 149 geo-referenced locations in yam growing area of southeastern Nigeria. Geostatistical technique was applied using Krigin to estimate soil parameters from unsampled sites. Results revealed multi-nutrient deficiencies of N, P, and K in the area. The magnitude of deficiency is N > K > P. Pragmatically, 4.19, 2.59 and 1.76 m ha are deficient in total N, exchangeable K and available P, respectively. This could guide soil nutrient management decision for sustainable yam production in the area.

Key words: Pedometrics, geostatistics, krigin, primary nutrients, southeastern Nigeria.

INTRODUCTION

Soil as a natural system mediates the energy and material fluxes at the earths' surface. It is characterized by uncertainties, inexactness and ambiguity (Webster, 2000). Nevertheless, information about spatial distribution of soil attributes in a given area is an essential part of land surface requirements for environmental purposes, agriculture and other land uses. The emergence of a generation of soil geostatisticians has facilitated quantitative pedology, whereby the extent and magnitude of spatial distribution of soil data could be estimated with a high degree of accuracy. This is a pragmatic approach to making pedological information more useful to non-specialists and facilitates research negotiations between pedologists and stakeholders in soil resources management.

Pedometrics is a neologism which refers to the application of numerical techniques in pedological studies (Webster, 1994). Bouma (1997) listed geostatistics, remote sensing, geographical information system (GIS), landscape modeling, fuzzy set theory and automated measurements, as quantitative technologies applicable in pedological science. Geostatistics is the application of regionalized variable theory to predict the value of a soil parameter from unsampled locations (Heuvelink and Webster, 2001), using the values obtained from sampled locations. Krigin is a geostatistical tool that accounts for spatial dimension of soil parameters at unsampled locations (Oliver, 1987).

Yam is the most important staple carbohydrate food, in the socio-cultural setting of southeastern Nigerians. Its production, storage and processing (cooking) are associated with cosmo-vision and annual festivals (Chukwu and Chukwu, 2002). N, P, and K are primary nutrients most commonly demanded by yam, as well as other crops, in plant nutrition. This explains why most compound fertilizers, and fertilizer requirements for yam are based on N, P and K. Although maps showing N, P and K status of Nigerian soils exist (Enwezor et al., 1990), none expressed the abundance or deficiency of the nutrients in quantitative terms. The trust of the present study was to quantitatively delineate spatial distribution of N, P and K in major yam soils of southeastern Nigeria.

*Corresponding authors E-mail: goddychukwu2003@yahoo.com.

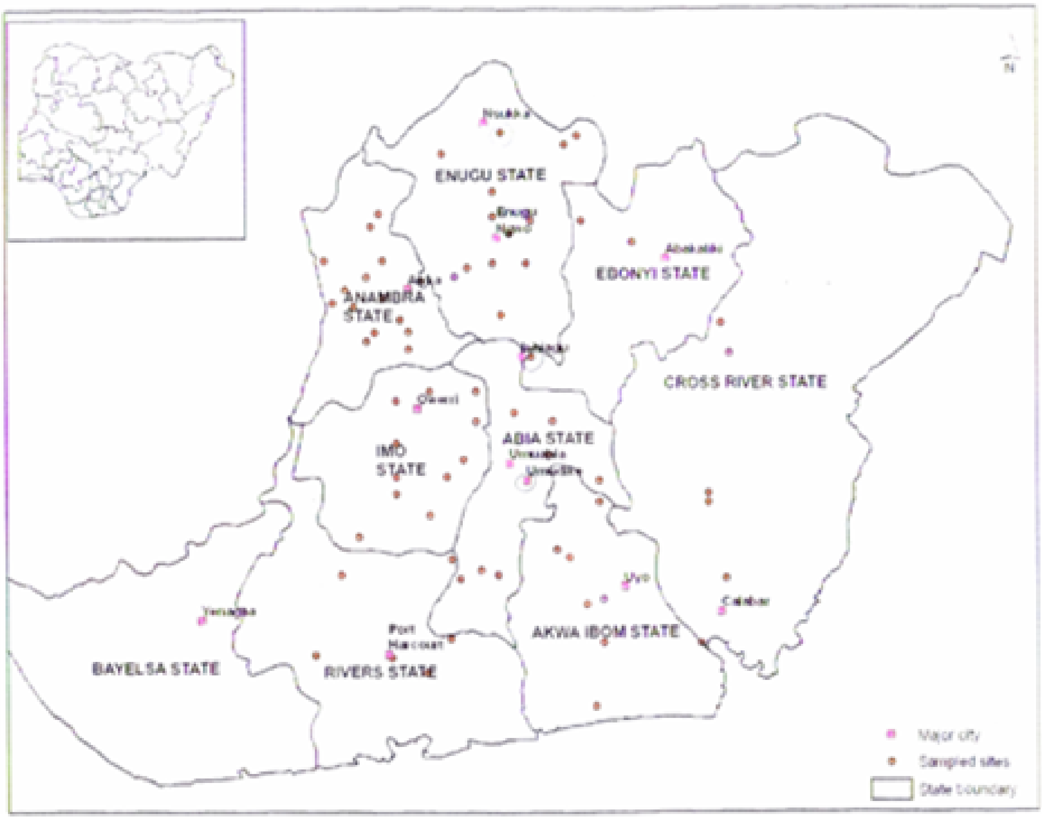

Figure 1. Sampling Points for Spatial Analysis.

MATERIAL AND METHOD

Field work and laboratory analysis

Free survey was adopted in collecting soil samples at 0 - 20 cm depth from 149 geo-referenced locations (Figure 1), using geographical positioning system (GPS). The soil samples were processed by air-drying, crushing gently with a wooden roller and sieving with a 2 mm sieve. Sub-samples of the 2 mm sieved soil samples were ground in a mortar with a piston and sieved to pass through 0.5 mm sieve. The 2 mm sieved samples were used to determine exchangeable K and available P, while the 0.5 mm sieved soil was used to determine total N. Exchangeable K was analysed by extraction with I N NH_4OAc solution followed by flame photometry. Total N was determined by the micro-kjedhal wet oxidation method (Bremner, 1965). Available P was determined using Bray and Kurt (1945) method.

Geostatistical analysis

Soil map of southeastern Nigeria obtained from the Federal Department of Agricultural Land Resources, Owerri, was digitized and used as a base map. With the aid of GIS, soil variables (N, P and K) were subjected to exploratory analysis. It involved checking for normality as viewed from the displayed histograms, as well as calculating the Kurtosis, and skewness. A data set with Kurtosis of three and zero skewness was adjudged normally distributed and need no transformation. Few out-liers were eliminated from the data set before non-normally distributed data were transformed. The GIS has the ability to select appropriate transformation method for each data set.

Variogram analysis was performed on the data by calculating experimental variograms and fitting appropriate variogram models to the data, using in-built Krigin tool in the GIS. The experimental variogram was calculated by averaging one-half the difference squared of z-values over all parts of the observations with specified separation distance according to Oliver (1987).

$$Y(h) \quad = \quad ½\, M(h) \sum_{i=1}^{M(h)} \left\{ (Z(Xi + h) - Z(Xi) \right\}^2$$

Where M = Number of comparisons at lag h; (h = 20 m), Z(xi) and Z(xi+h) = values of the variables at any two places separated by lag h.

Prediction of soil properties from the unsampled locations, involved linear summation of weighted observations within a given neighborhood, based on Krigin technique (Heuvelink and Weaster, 2001), thus;

$$Z^* (x_o) = \sum_{i=1}^{N} wiz\ (Xi)$$

z = value of soil parameter of interest; Xi = sampled location; Wi = weight associated with each $z(X_i)$; N = number of the closest neighbouring sampled data points used for summation and $Z^* (X_0)$ = estimate of Z at unsampled location Xo.

Variogram models were fitted to the data set using in-built mechanism in the GIS, by comparing various models until the one that matched the experimental variogram was found. Variogram models that best describe the experimental variogram models of the soil parameters are shown in Table 1.

Table 1. Method of transformation and variogram models of N, P, and K in yam soils of southeastern Nigeria.

Parameter	Method of transformation	Variogram mode
Total N	Arcsine	Guassian
Available P	Log	Hole effect
Exchangeable K	Log	Rational Quadratic

RESULTS AND DISCUSSION

Spatial distribution of N, P and K are delineated in Figures 2, 3 and 4. The area showed multi-nutrient deficiencies of the primary nutrients, in the magnitude of total N > exchangeable K > available P.

Total N

Figure 2 indicates that over 90.0% of the area, equivalent to 4.20 million hectares (m ha), are deficient in total N. The mean value of total N is below the critical level (0.15%) required for sustainable yam production (Chukwu et al., 2005). However, about two percent of the area (0.084 m ha) are medium in N, having total N ranging from 0.15 – 0.20%. The small proportion occurs at the northwest of Enugu/Anambra States axis bordered by alluvial parent material.

Available P

Figure 3 shows spatial distribution of available P in the soils. Most of the areas (1.77 m ha) located about longitude 6°N and above are deficient in available P (< 15.0 mg kg^{-1}). The soils occur in northern Abia, Anambra, and Cross River states. Virtually, over 90.0% of Ebonyi and Enugu States soils suffer severe P deficiency. However, the south-western part of the study area covering over 80.0% of Imo and Akwa Ibom States are high in available P (≥ 25.0 mg kg^{-1}).

Exchangeable K

Spatial distribution of exchangeable K in the soil is quantitively delineated in Figure 4. About 60.0% of the area (2.60 m ha) are low in exchangeable K (< 0.20 cmol(+)kg^{-1}). Over 80.0% of soils in Abia, Imo and Anambra States are low in exchangeable K. However, about 26.6% of the study area (1.14 m ha), in northeastern Abia State, northern Akwa Ibom State and Cross River States are medium in exchangeable K (0.2 – 0.4 cmol(+)kg^{-1}). The medium K zone also covers about 80% of soils in Enugu and Ebonyi States. About 12.7% (0.55 m ha) of the soils located around Ebonyi/Cross River States axis, are high in exchangeable K (≥ 0.4 cmol(+)kg^{-1}).

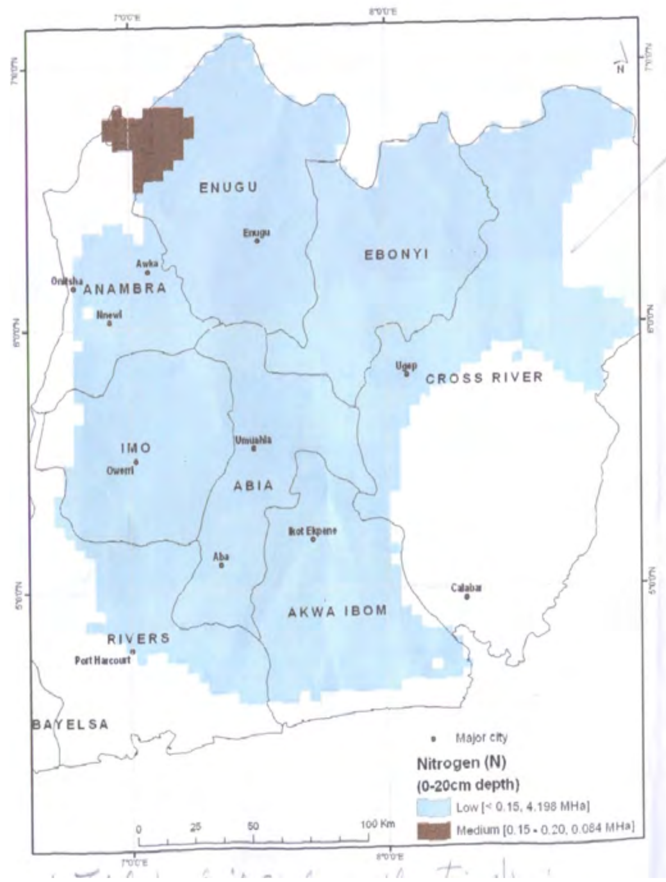

Figure 2. Total N in major yam soils of southeastern Nigeria

The area covered by this study is typical of the acid sands underlain, predominantly, by lithologic materials ranging from coastal plain sands, sandstone and shale or a mixture of shale and sandstone. As a consequence, the lithologies of the soils constitute materials that had undergone cycles of weathering and erosion before deposition (Ojanuga et al., 1981). They, therefore, contain less weatherable minerals. The area is subjected to annual and seasonal bush burning, which occurs about November through February. Burning, deprives the soil of natural organic matter input from vegetation and exposes the soils to erosive impact of heavy annual precipitation (1,500.00 - > 2,000.00 mm) in the area. This aggravates leaching due to the coarse nature of the soils. There is high demographic pressure in the area necessitating unavoidable pressure on the land, in quest for food and money, with a consequential reduction in fallow periods (Chukwu, 1997). These factors explain the multi-nutrient deficiencies of the primary nutrients observed.

Conclusion

The delineated spatial distribution of the primary nutrients (N, P and K) in the area will guide soil management stra-

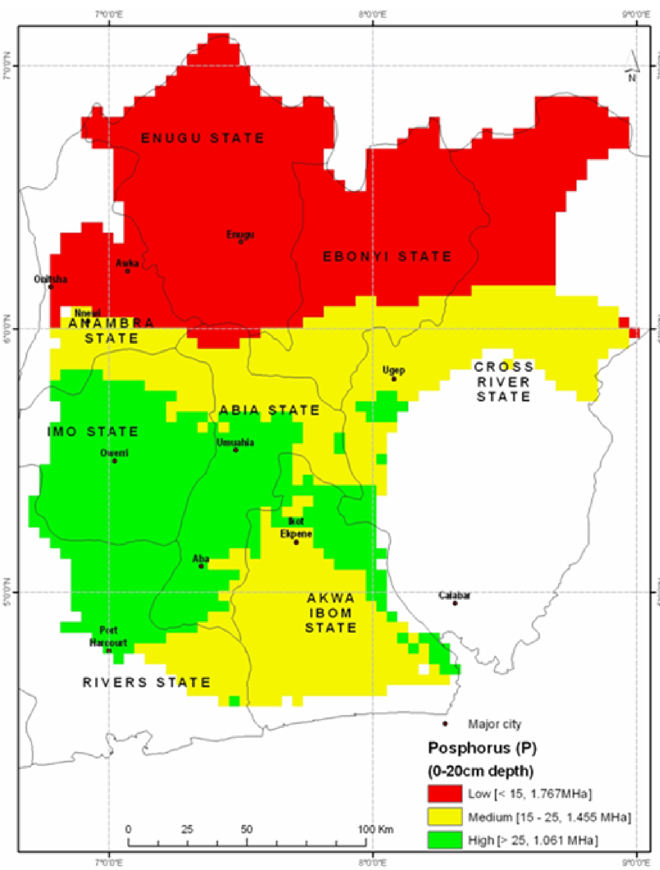

Figure 3. Available P in major yam soils of southeastern Nigeria

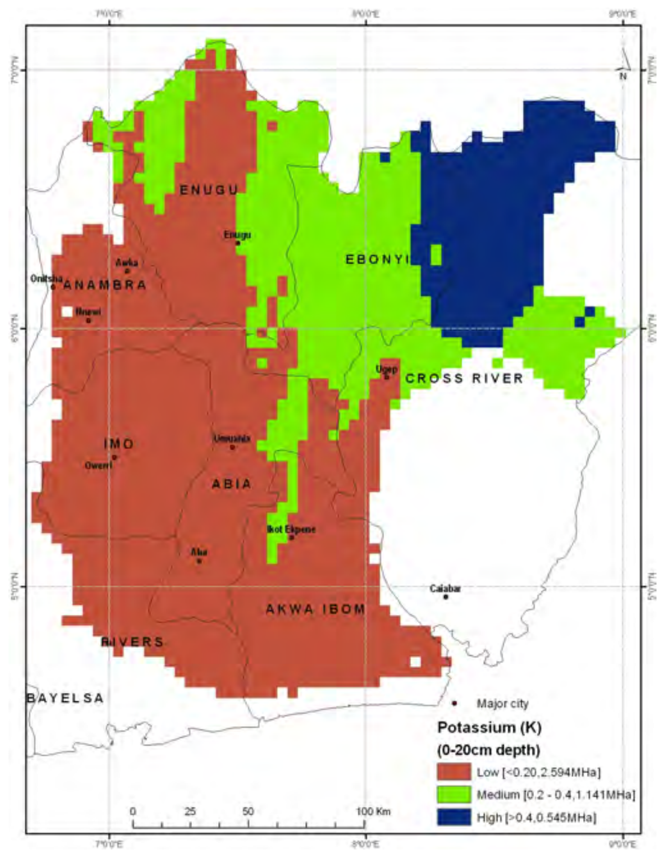

Figure 4. Exchangeable K in major yam soils of southeastern Nigeria

tegies, in terms of choice of land, fertilizer, as well as quantity of fertilizer inputs needed to boost and sustain yam production in the area.

ACKNOWLEDGEMENTS

We wish to express our gratitude to International Fund for Agricultural Development (IFAD) Rome, for funding this study and the Executive Director, National Root Crops Research Institute, Umudike, for his kind permission to execute and publish it.

REFERENCES

Bouma J (1997). The role of quantitative approaches in soil science when interacting with stakeholder Geoderma 78: 1-12.

Bray RH, Kurtz LT (1945). Determination of total, organic and available forms of phosphorus in soil. Soil Sci., 59: 225-229.

Bremner JM (1965). Total Nitrogen. In Methods of Soil Analysis Part 2. Black CA, Evans DD, White JL, Ensminger LE, Clark FE (ed). Am. Soc. Agron., 9: 149- 178.

Chukwu GO (1997). Conserving uplands through sloping agricultural land technology. Proceedings Forestry Association of Nigeria, Conference, Ibadan, pp. 293-298.

Chukwu GO, Ezenwa MIS, Osunde AO, Asiedu R (2005). Soil suitability evaluation of an alluvial chronosequence for yam production in southeastern Nigeria. J. Sustain. Agric. Environ. 7(2): 241-247.

Chukwu GO, Chukwu KE (2002). Cosmovision and folk science in yam production. Proceedings 26 Annual Conference, Agricultural Society of Nigeria. Fed. Univ. of Tech., Owerri, pp. 125-129.

Enwezor WO, Ohiri AC, Opuwaribo EE, Udo JE (1990). A review of fertilizer use on crops in southeastern zone of Nigeria. Federal Ministry of Agriculture and Natural Resources, Lagos, 2: 49-100.

Heuvelink GBM, Webster R (2001). Modeling soil variation: past present and future. Geoderma 100: 29-301.

Ojanuga AG, Lekwa G, Akamigbo FOR (1981). Survey, classification and genesis of 'acid sands' In: 'Acid Sands' of Southeastern Nigeria. Soil Science Society of Nigeria, Special Monograph 1: 1-18.

Oliver MA (1987). Geostatistics and its application to soil science. Soil Use and Management 3(1): 8-20.

Webster W (2000). Is soil variation random? Geoderma 97: 149-163.

Webster W (1994). The development of pedometrics. Geoderma 62: 1-15.