The Environmentalist, 21, 153–159, 2001

Nutrient requirements for the growth of waterleaf (*Talinum triangulare*) in Uyo metropolis, Nigeria

IMOH E. UKPONG* and JULIA O. MOSES
Department of Geography and Regional Planning, University of Uyo, PMB 1017, Uyo, Akwa Ibom State, Nigeria

Summary. The all-season vegetable known as waterleaf (*Talinum triangulare*) is extensively grown in Nigeria's metropolistan market gardens. This paper examines the soil compositions of some of the cultivation areas for this crop to determine the impacts of its very intensive repetitive cultivation. In general, the regular application of organic manures and mineral fertilizers has maintained the fertility status of the market garden soils. Multiple regression analysis indicated that base saturation, available phosphorus and organic matter were the most significant determinants to variations in crop production.

Keywords: fertilizers, waterleaf, nutrients, Nigeria

Introduction

In the last 20–30 years, the areas around most cities in Nigeria have been used for intensive market gardening. This has been due to the rapid growth in population which has led to a sustained demand for vegetables. In the south-eastern States of Nigeria the concentration has been on the cultivation of waterleaf (*Talinum triangulare*), a highly desirable vegetable crop which is sold in urban markets and other areas surrounding the cities. In addition to rapid population growth, competition from other urban land uses has led to a decrease in land availability. Intensive continuous cultivation of soils around these metropolitan areas has resulted.

It is obvious that as the plant growth makes continuous demands on the soil properties, intensive cultivation has the potential of reducing the soil quality. Large amounts of biomass are harvested away from the site without recycling. Authors who have studied the impacts of such intensive agricultural methods in tropical countries include Juo and Lal (1977), Areola (1980), Ogbigbesan and Amalu (1985), Russel (1987), Ikeorgu and Odurukew (1990), Aweto and Ogurie (1992), Aweto and Ishola (1995), and Aweto (1995). In Nigeria and elsewhere in the tropics, studies have indicated that intensive cultivation without regular fertilizer application brings about a decline in soil quality and a reduction in productivity (Lombin, 1986).

In Nigeria, soil quality is traditionally maintained through the practice of bush fallow (land rotation), but the rate of fertility restoration depends on the length of the fallow and the fallow vegetation composition. There has been a reduction in fallow duration from a period of 10 to 20 years to one of 3 to 5 years which has affected fertility restoration. According to Agboola (1979), this change has resulted from population pressures on land and socio-economic pressure, with its consequent reduction in land availability.

With the reduction in fallow duration it has become necessary to restore the lost nutrients and enhance soil sustainability by the application of mineral fertilizers and organic manure. Simple application of fertilizers, however, may not be enough because different crops require specific nutrients and the way the soil resources are utilized determines the crop yield. Since

*Dr Imoh Ukpong (corresponding author) and Julia Moses are members of staff in the Department of Geography and Regional Planning at the University of Uyo.

crop production is a complex interaction between the environment, soil parameters and nutrient dynamics, the soil must be studied in terms of productivity potentials, and organic matter management for sustainable use (Agboola, 1986). It is important to understand the environment—crop relationships and the nutrient requirements of crops. In addition, the adoption of soil management techniques to conserve and enhance soil fertility and nutrients appears crucial to the long term productivity of tropical soils used for intensive market gardening.

The study area involved Uyo metropolis (Figure 1), the capital of Akwa Ibom State of Nigeria. This urban area lies on latitude 4°59′N and longitude 7°54′E, and covers an area of approximately 35 km^2.

The population of Uyo grew from 743 in 1931, to 75332 in 1983 (UMIP, 1988). Currently, however, Uyo has a population of 2.12 million (Ikhuoria and Ezeka, 1997). The relief of Uyo varies from gently sloping to monotonous countryside with no area higher than 61 m. Uyo is situated on the plains of the Cross River, with a geological foundation of unconsolidated alluvial sands and young sedimentary rocks. The main drainage is through a valley which contains many small perennial streams. The climate is sub-equatorial, with a mean annual rainfall of 2500 mm.

With a land-man ratio of 1 km^2: 281 persons, Akwa Ibom State ranks high compared with many States in Nigeria and the population is growing at a rate of 3.0 percent p.a. (Ikhuoria and Ezeka, 1997). This situation has necessitated intensive landuse and continuous cropping has become a common practice. Consequently, fallow durations have been drastically reduced more especially in the urban peripheries. According to Woomer and Swift (1994), the fertility of many tropical soils, particularly those of smallholder farmers is regulated by key biological processes and organic resources available to the farmers. Too often, these processes are not understood well enough by the farmers and agriculturalists to be placed in a soil management context.

Failure to understand the complexities of soil fertility has resulted in a lack of well integrated management strategies. The local farmers who produce the bulk of agricultural products do not understand the environment-crop relationships or the nutrient requirements of the crops which they grow. For this reason, agricultural productivity has tended to be low. A consequence of this is increasing food shortages in the country.

The aim of this paper is to examine the soils in a metropolitan environment with a view to investigating their relationships for the sustainable production of all-season vegetable crop, waterleaf (*Talinum triangulare*) Figs. 2–5. The objectives were to identify the soil properties that substantially influence the growth rate and productivity of the crop in the context of current soil management practices.

Methods of study

Intensive market gardening is practised in five major areas in Uyo metropolis. From each of these areas ten cultivated plots, each measuring a half hectare were chosen for data collection, using the stratified random sampling method. With a soil auger, ten surface soil samples (0–15 cm) were taken randomly from each of the ten sample plots and bulked to a total of fifty soil samples. These were air-dried before laboratory analysis. In order to eliminate catenary effects, all soil samples were taken from flat areas where the slope could not have influenced the soil content or structure. Two very long-term uncultivated sample plots located in the same environment as the cultivated sites were also chosen as controls for soil measurements. The approach of sampling the soil at a uniform predetermined depth was necessitated by the desire to ensure comparability between the results.

Soil particle size was determined using the hydrometer method of Boyoucous (1962), exchangeable cations were extracted in neutral ammonium acetate followed by determination of Ca, Mg and K by atomic absorption and Na by flame photometry. Cation exchange capacity was determined by the sum total of exchangeable cations method (IITA, 1990), organic matter by the Walkley and Black wet oxidation method, nitrogen by the macro-djehldahl digestion method and phosphorus using the Bray No. 1 method (Jackson, 1970). Exchange acidity was determined according to Mclean (1965); electrical conductivity was measured with a conductivity meter and soil pH in a 1:2 soil-to-water ratio, using a glass electrode.

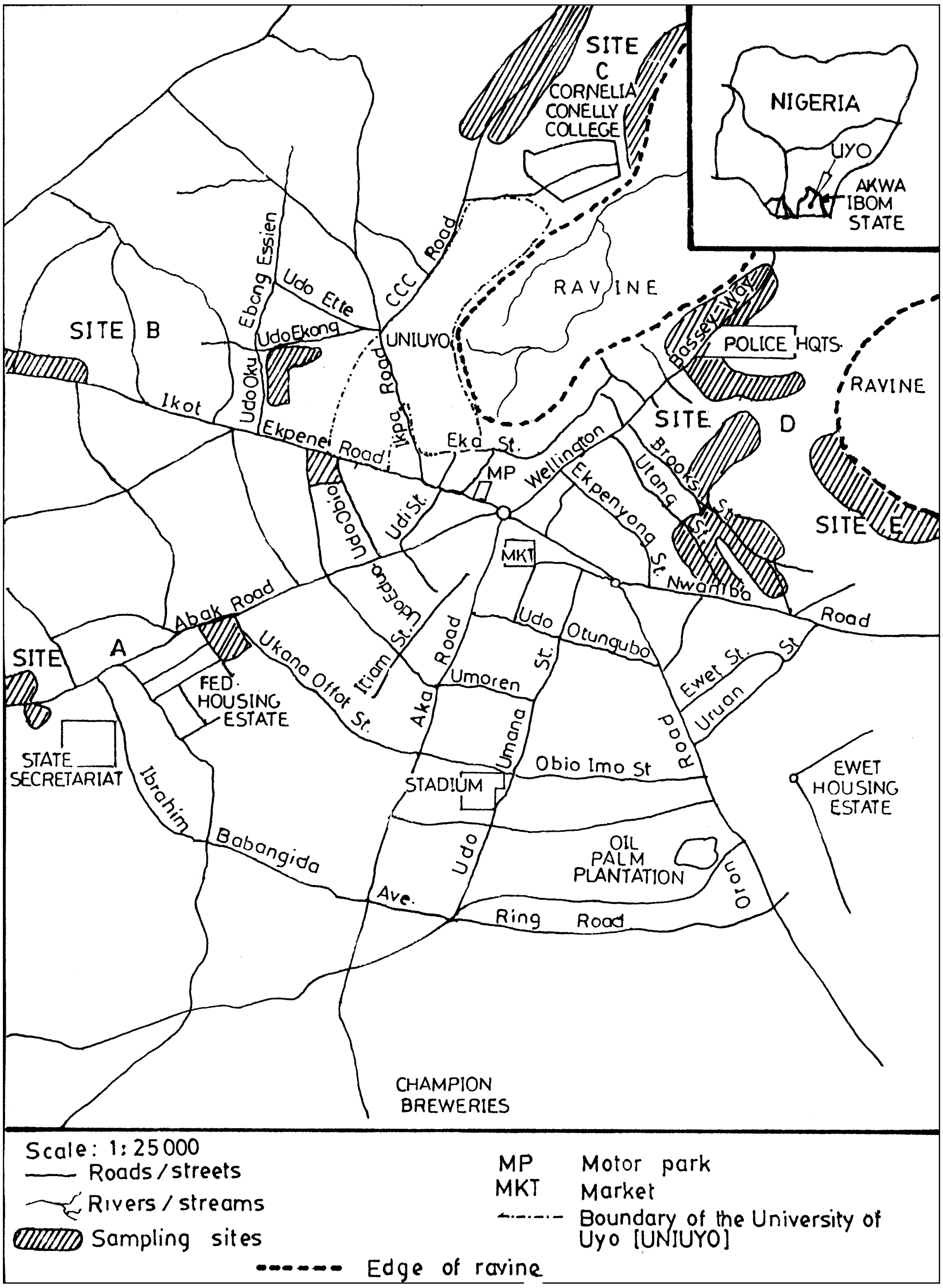

Figure 1. Map of Uyo metropolis showing study sites A–E. *In-set:* Nigeria showing the location of Uyo metropolis in Akwa Ibom State.

The vegetable was harvested in 0.5 m^2 units randomly selected within the same sample plots from which the soil samples were obtained. A total of fifty 0.5 m^2 units were sampled for the analysis. The following measures of crop productivity were obtained: weight of the standing crop, stem, root and leaf weight. Stem and leaf length, leaf width and leaf area were also measured. The density of plants per sampling unit was also obtained for the analysis. In order to determine the effects

Figure 2. Waterleaf (*T. triangulare*) bed about to be planted, Uyo metropolis.

Figure 4. Harvesting of waterleaf. Basins are used as measures of quantity.

of variation in soil properties on crop productivity, standard statistical methods were utilized.

Results and discussion

The physical and chemical properties of the market garden soils and uncultivated control plot soils are shown in Table 1. Both the cultivated and the control soils contained a high proportion of sand and to a large extent, they were similar in texture. Soil texture was apparently not influenced greatly by soil use. In both domains, sand accounted for over 80 percent by weight. However, the level of clay was higher in the cultivated topsoil than in the control soils. This relatively high clay content might have resulted from greater earthworm activity, for this was noticeably common in the market garden plots. As the land being utilized was usually cleared manually, the physical status of the soil was conserved. This is unlike mechanical clearing which may destroy the top soil (Lal, 1986). According to Tisdale and Nelson (1975) and Sanchez (1976), long term fertilizer application often results in improved soil physical status.

Calcium values were higher in the cultivated soils than the control soils. This was attributed to the organic fertilizers which had been applied. These were usually poultry droppings. Tisdale and Nelson (1975) maintain that calcium is the most significant nutrient in poultry dung. In addition, magnesium and sodium were higher in the market garden soils than the control soils, perhaps

Figure 3. A bed of waterleaf (*T. triangulare*) reaching maturity.

Figure 5. Head transport is used to carry waterleaf to market, Uyo metropolis.

Table 1. Properties of cultivated garden soils (0–15 cm) and control plots (0–15 cm), taken from the area of Uyo metropolis, Nigeria

Soil properties	Waterleaf garden soils Mean ± standard deviation	Uncultivated control soils Mean ± standard deviation
Sand	76.69 ± 1.86	91.7 ± 1.92
Silt	8.47 ± 1.14	4.8 ± 2.49
Clay	11.91 ± 0.95	4.4 ± 0.89
Calcium (meq/100 g)	7.59 ± 1.86	1.08 ± 0.41
Magnesium (meq/100 g)	3.29 ± 0.97	0.29 ± 0.22
Sodium (meq/100 g)	0.23 ± 0.03	0.10 ± 0.03
Potassium (meq/100 g)	0.12 ± 0.05	0.14 ± 0.12
Cation exchange capacity (meq/100 g)	12.39 ± 2.73	4.11 ± 0.70
pH	5.87 ± 0.21	4.99 ± 0.22
Organic matter (%)	3.48 ± 0.26	2.62 ± 0.62
Total nitrogen (%)	0.16 ± 0.03	0.30 ± 0.33
Available phosphorus (mg/kg)	208.42 ± 65.76	202.63 ± 70.63
Base saturation (%)	88.74 ± 4.60	42.92 ± 12.41
Exchange acidity (meq/100 g)	1.14 ± 0.23	1.32 ± 0.16

due to the effect of chemical fertilizer application. However, the cation exchange capacity level in the market garden soils was well below the value which Young (1976) believed was required for high soil fertility. The cation exchange capacity for the control soil was also relatively low, although satisfactory according to the criteria of Sanchez (1976).

Total nitrogen was higher in the control soils than the cultivated soils because of volatilisation of nitrogen from the topsoils of the market gardens. Available phosphorus contents were high and comparable in both soils. The accumulation of phosphorus in the cultivated soils could also be due to long term application of inorganic, phosphate fertilizers. According to Cruickshank (1972), many forms of phosphorus are not very soluble in water. Aweto and Ayuba (1993) also discovered high levels of phosphorus in a continuously cultivated sub-Sahelian soil near Maiduguri. pH was higher in the market garden soils, indicating a lower acidity level than the control soils, probably due to the liming effect of regular fertilizer applications.

Standard multiple regression procedures revealed that, with the exception of leaf width, the soil physical properties were not particularly significant in determining variation in crop productivity measurements. Those soil variables which were retained in the multiple regression equations, which accounted for 45 percent or more of the total variance in the crop productivity indicators, are shown in Table 2.

The most frequently occuring parameters were base saturation, available phosphorus and organic matter. These appeared to be the major soil properties that determined the variations in crop yield. This indicates that for the sustainable cultivation of waterleaf (*T. triangulare*), there has to be an adequate supply of the indicated nutrients, with emphasis on phosphorus and base saturation levels. Table 3 indicates that a combination of soil properties accounted for the variation in several productivity measures of the crop. For example, variation in stem weight was accounted for by available phosphorus, potassium, nitrogen and pH, while leaf area which is perhaps the most desirable property of *T. triangulare* was determined by available phosphorus, organic matter and base saturation. Leaf width was determined by soil texture and a combination of nutrients, *e.g.* available phosphorus, organic matter, potassium, total nitrogen and sodium (although sodium is a minor essential for plant growth).

Table 2. Percentage contribution of independent variables in seven multiple regressions to the total variance of the crop productivity analysis

Independent variables	Stem weight	Leaf length	Leaf width	Leaf area	AGB*	Total occurrences
Base saturation	—	28.3	—	19.8	30.4	5
Available Phosphorus	21.5	10.5	15.2	12.4	—	4
Organic matter	—	6.4	12.3	9.4	—	3
Potassium	16.3	—	9.4	—	18.2	3
Sodium	—	4.0	—	4.0	—	3
pH	10.4	—	—	—	4.9	2
Nitrogen	7.5	—	4.3	—	—	2
Sand	—	—	3.8	—	—	1
Silt	—	—	2.2	—	—	1
Clay	—	—	3.5	—	—	1
Total variance%	55.7	49.2	50.7	45.6	53.5	

*AGB = above ground biomass (leaf weight + stem weight).

Table 3. Predictive multiple regression equations based on the performance of the crop properties for *T. triangulare* on soil variables*

Crop variables	Predictive multiple regression equations
Stem weight	y = 2891.16 − 0.22 (Av.P) − 381.25 (N) −93.1 (K) + 9.24 (pH) ± 22.1 (R^2 = 55.70%)
Leaf length	y = −54.84 + 4.38 (Av.P) − 0.41 (om) +4.78 (Na) − 0.10 (BS) ± 0.49 (R^2 = 49.19%)
Leaf width	y = −63.63 − 0.30 (om) + 0.6 (clay) +0.65 (sand) − 0.65 (silt) + 3.19 (Na) +2.16 (Av.P) + 0.49 (N) ± 0.29 (R^2 = 30.71%)
Leaf area	y = −118.71 + 9.45 (Av.P) − 0.83 (om) −0.25 (BS) ± 1.07 (R^2 = 45.57%)
Above ground biomass (stem + leaf weights)	y = 1732.49 − 9.12 (BS) + 16.35 (pH) −125.98 (K) ± 37.93 (R^2 = 53.53%)

*Av.P = available phosphorus, N = nitrogen, K = potassium, Na = sodium, BS = base saturation, om = organic matter.

Conclusions

Following 30 years of continuous cultivation of waterleaf around Uyo metropolis, it was observed that the cultivated soils were higher in nutrient status than the soils in uncultivated control plots. There are indications that urban market garden soils are relatively well managed, more so than in the peripheral, intensively cultivated subsistence farms where poor yields have been reported (Ukpong, 1997). In Uyo metropolis, intensive and continuous cultivation of *T. triangulare* may have depleted the soil nutrients, but the losses are constantly replenished by organic manures and inorganic fertilizers. Regular application of these fertilizers has tended to improve the quality of the cultivated soils. The levels of nutrients in control soils indicate that generally, soils of the study area, once the vegetation is removed, are of marginal fertility and their relationship to crop demands should be established before the soils are put into intensive use.

References

Agboola, A.A. (1979) Soils of the Nigeria forest zone and their response to cultivation. In (Okali, D.U.U., eds.) *The Nigerian Rainforest Ecosystem—Proceedings of the Man and Biosphere Workshop on the Nigerian Rainforest Ecosystem*. University of Ibadan, Nigeria.

Agboola, A.A. (1986) Planning for food production in Nigeria without planning for soil fertility management and evaluation In (Chaude, V.O., ed.) *Proceedings of the 4th Annual Conference of the Soil Science Society of Nigeria*, Makurdi, 19–23rd October, Makurdi. Soil Science Society of Nigeria.

Areola, O. (1980) Some issues and prblems of studying savana fallows. *African Environment* **15**, 51–62.

Aweto, A.O. (1995) Organic carbon dimnution and estimates of carbon dioxide release from plantation soil. *The Environmentalist* **15**, 10–15.

Aweto, A.O. and Ogurie, G. (1992) Impact of intensive market gardening on the nutrient status of hydromorphic soil in the Ojo area of Lagos metropolis, Nigeria. *The Environmentalist* **12**, 223–30.

Aweto, A.O. and Ayuba, H.K. (1993) Effect of continuous cultivation with animal manuring on a sub-Sahelian soil near Maiduguri, north-eastern Nigeria. *Biological Agriculture and Horticulture* **19**, 343–52.

Aweto, A.O. and Ishola, M.A. (1995) The impact of Cashew (*Anacardium occidentate*) on forest soil. *Experimental Agriculture* **30**, 337–41.

Boyoucous, G.J. (1962) Estimation of colloidal materials in soils. *Science* **64**, 632.

Cruickshank, J.G. (1972) *Soil Geography*. Newton Abbot, David and Charles.

IITA (1990) International Institute for Tropical Agriculture, 1990 Manual Series. Ibadan, Nigeria.

Ikeorgu, J.E.G and Odurukwe, S.O. (1990) increasing the productivity of cassava/maize intercrops with groundnuts (*Arachis hypogea*). *Journal of Tropical Agriculture* **67**, 165–68.

Ikhouria, I.A. and Ezeka, E.N. (1997) Cartographic issues in census of population in Nigeria. In (Ikhuoria, I.A. and Isi, A., eds.) *Cartography and Geographic Information System for Sustainable Development*, p. 97.

Jackson, M.L. (1970) *Soil Chemical Analysis*, Englewood Cliffs, New York: Prentice Hall.

Juo, A.S.R. and Lal, R. (1977) The effect of continuous cultivation on the chemical and physical properties of an afisol in the tropics. *Plant and Soil* **47**, 567–84.

Lal, R. (1986) Different methods of clearing land for agricultural purposes in the tropics. In (Lal, R. Sanchez, P.A. and Cummings, R.W., eds.) *Land Clearing and Development in the Tropics*, pp. 55–67. Rotterdam: A.A. Balkema.

Lombin, G. (1986) Soil Science, In (Youdeowei A., Ezedinma, F.O.C. and Onazi, O.C., eds.) *Introduction to Tropical Agricult*., pp. 84–87, London: Longman.

Mclean, E.O. (1965) Aluminium, In (Black, C.A., ed.) *Method of Soil Analysis*, Madison, Wisconsin: American Society of Agronomy.

Ogbigbesan, G.O. and Amalu, U.C. (1985) Impact of longterm landuse with fertilizer application on the soil properties of a commerical cassava farm. In (Sobule, R.A. and Udo, E.J., eds.) *Soil Fertility, Soil Tilth and Post Clearing Land Degradation in the Humid Tropics*, pp. 234–47. Ibadan: Soil Science Society of Nigeria.

Russel, C.E. (1987) Plantation forestry, the Jari project, Para, Brazil. In (Jordan, C. F., ed.) *The Amazonian Ecosystem Disturbance and Recovery*, pp. 76–89, New York: Springer-Verlag.

Sanchez, P.A. (1976) *Properties and Management of Soils in the Tropics*. New York: John Wiley and Sons.

Tisdale, S.L. and Nelson, W.L. (1975) *Soil Fertility and Fertilizers*. London: Collier Macmilland Publishers.

Ukpong, I.E. (1997) Nutrient build-up in bush fallow soils and its implication to subsistent agriculture in Akwa Ibom State, Nigeria. *Ibom Journal of Social Issues* **4**, 82–89.

UMIP (1988) Uyo Masterplan, Interdesign Partnership, Uyo, Nigeria; Government of Akwa Ibom State.

Woomer, P.L. and Swift, M.J. (1994) “Preface,” In (Woomer, P.L. and Swift, M.J., eds.) *The Biological Management of Tropical Soil Fertility*. London: John Wiley and Sons.

Young, A. (1976) *Tropical Soil and Soil Survey*, Cambridge: Cambridge University Press.