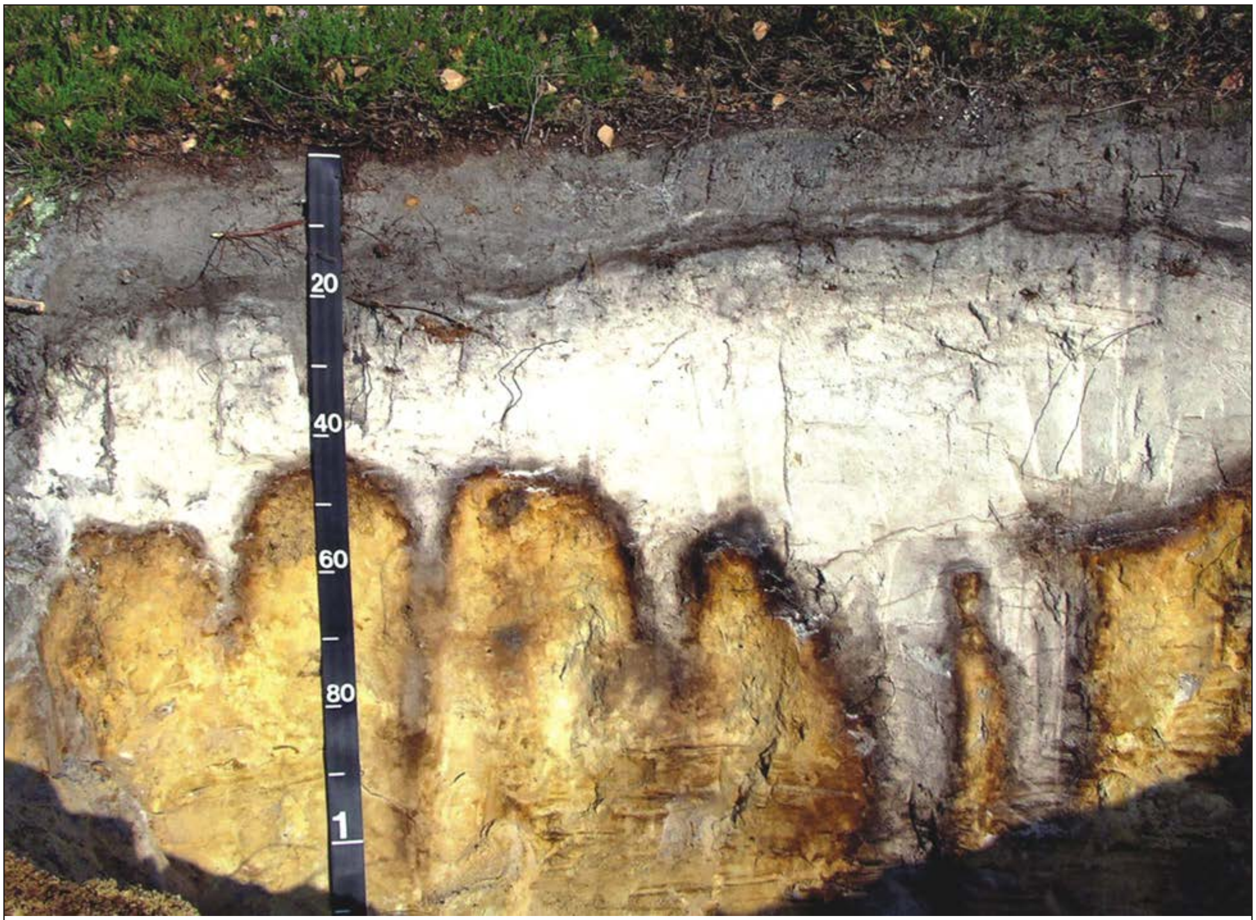

International Journal of
Soil Science

ISSN 1816-4978

Academic
Journals Inc.

www.academicjournals.com

International Journal of Soil Science 2 (1): 62-68, 2007
ISSN 1816-4978

Soil-Chemical Properties as Affected by Yam/Cassava/Landrace Legumes Intercropping Systems in Owerri Ultisols Southeastern Nigeria

I.I. Ibeawuchi
Department of Crop Science and Technology,
Federal University of Technology, P.M.B. 1526, Owerri, Nigeria

Abstract: Soils with low N when planted with legumes or legumes in association with tuber/root crops helped to increase N-fixation. Biological nitrogen fixation may be the only means by which N supply to plants can be increased in tropical farm lands since yam/cassava based intercropping with landrace legumes left behind substantial amounts of N after a cropping season especially when initial soil N is low. Intercropping and even sole cropping resulted in increased organic matter content of the soil and higher quantities are expected when the litters are incorporated into the soil and there is total decay. There is Phosphorous (P) decline in plots with tuber/root crops as they take up large quantities of P from the soil. Also, there was a decline in soil basic cations calcium (Ca) magnesium (Mg) and potassium (K) in tuber/legume crop mixture. This is viewed as being temporary since the decay of litters and roots of these crops thereafter will boost the soil reserve as a result of humus complexes, which will release most of the lost nutrients back to the soil. Tuber/legume crop mixture increased soil pH. Soil chemical properties in terms of macro, meso and micro nutrients after a cropping period depends on the type of crops planted and cropping systems used.

Key words: Soil chemical properties, yam/cassava/landrace legumes based, intercropping systems

INTRODUCTION

The soils of Owerri are ultisols, formed from coastal plain sands and are low in mineral reserve and in fertility (Eshett, 1993). This study on soil chemical properties as affected by yam/cassava /landrace legumes mixture in Owerri Southeastern Nigeria was conducted with a view to understanding the role and contributions of such intercropping systems in enhancing the fertility of ultisols for sustainable crop production.

In field crop production, the macro, meso and micro elements play different roles but plants need more of macro elements than others. The macro elements makeup about 99% of plants diet of which N, P and K account for 60% and are definitely the big 3 of soil fertility in terms of quantity needed and likelihood of deficiencies (David, 1986). The assessment of these and the basic cations and soil pH before and after a cropping period will help give an insight of the soil fertility balance in a yam/cassava/landrace legumes mixture. This became necessary to help the farmer understand the fertility status of the soil (ultisols) after a cropping phase, since chemical fertilizers whose use is now constrained owing to its prohibitive cost and limited availability (Ibeawuchi, 2003; Lal and Kang, 1982). This research is expected to benefit the farmer as intercropping is the main farming practice in the humid tropics and fits their climatic conditions and ecological considerations. Therefore, understanding the soil chemical properties with respect to N, P, K, Ca Mg and pH of ultisols is fundamental in food crop production and can play a leading role in soil fertility management.

Intercropping systems limits soil losses and run-off and provides a nearly continuous soil cover thus preventing it from the direct impact of the rains (Kurt, 1984; Gomez and Gomez, 1986). Intercropping also produces a dense and diversified root system and this reduces leaching of nutrients (Ibeawuchi and Ofoh, 2000). According to Ibeawuchi and Ofoh (2003) the combination of base-crops and legumes generally increased soil phosphorus, soil organic matter and soil pH, while soil nitrogen and potassium were reduced. Also, Okigbo and Lal (1979) reported that relatively simple intercropping system as maize/cassava can increase the CEC (Cation Exchange Capacity) and pH as well as increase Mn content in the soil.

In general therefore, sustainability of the soil using landrace legumes in yam-cassava based intercropping systems is the center of this study.

MATERIALS AND METHODS

The experiment was conducted in 2001and repeated in 2002 cropping season at the Teaching and Research farm of the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri Nigeria, located between latitude 5° 23′ 8.7″ N and longitude 6°. 59′ 39. 4″ E., which is in the tropical rainforest zone of Southeastern Nigeria. The areas has a minimum and maximum annual ambient temperatures of 20 and 32°C, respectively and mean annual rainfall of 2500 mm (Ibeawuchi, 2004).

The soils have been developed from deep unconsolidated marine sediments of Pleistocene age, often known as coasted plain sands and classified as Ultisols with low mineral reserve and are therefore low in fertility (Eshett, 1993). The experimental site was under fallow for 2 years and it was previously cropped with cassava and maize to which no fertilizer was applied. At the beginning of the research in March 2001, the soil had 0.06% N, 5.20 Cmol kg^{-1} P, 1.54% OM, 0.62 Cmol kg^{-1} Mg, 1.52 Cmol kg^{-1} Ca, 0.60 Cmol kg^{-1} K and a pH of 4.45 (water).

Planting Materials

Three land race legumes were used namely: African yam bean-*Sphenostylis sternocarpa*; Lima bean-*Phaseolus lunatus*; and the velvet bean-*Mucuna pruriens* var. utilis. Mucuna grows in the wild but the black seed were collected from the SAAT gene bank while lima bean and African yam bean were bought from the rural markets in Owerri agricultural zone. Other planting materials include cassava - (TMS 30555); Seed yams (white) obiaeturugo-local cultivar; TZSR yellow maize. Cassava cuttings and maize were bought from the Imo Agricultural Development Project Headquarters Okigwe Road, Owerri while the seed yams were bought from a yam farmer at Ohozara in Ebonyi State Nigeria. For the repeat of the experiment, seeds of the land race legumes, maize seeds, seed yams and cassava cuttings harvest were got from the previous plantings.

Land Preparation

For the two years of the research work, land preparation was done manually with machetes, spades and rakes since minimum tillage was used. The dry trash was later packed and removed from the site. The field was thereafter marked out for planting. The experiment was laid out in a randomized complete block design replicated 3 times. Each plot measured 3×4 m with 1 m between plots and 2 m between blocks and 1m experimental guard areas. The treatments includ sole crops and their combinations as follows:

Yam/Maize Based

- Yam/Maize/Mucuna (Y/M/Mp)
- Yam/Maize/Lima (Y/M/L).
- Yam/Maize/African Yambean (Y/M/Ayb).
- Yam/Maize, (Y/M).

Cassava/Maize Based

- Cassava/Maize/Mucuna (C/M/Mp)
- Cassava/Maize/Lima (C/M/L)
- Cassava/Maize/African Yambean (C/M/Ayb)
- Cassava/Maize (C/M)

Yam/Maize/Cassava Based

- Yam/Maize/Mucuna (Y/M/ Cassava Mp).
- Yam/Maize/Cassava/Lima (Y/M/C/L)
- Yam/Maize/Cassava/African Yambean (Y/M/C/Ayb)
- Yam/Maize/Cassava (Y/M/C)

Sole Cropping

- Yam (Y)
- Cassava (C)
- Mucuna (Mp)
- Lima bean (L)
- African yambean (Ayb), (Ibeawuchi, 2004)

Planting and Spacing

Two seeds of each landrace legume were planted 2-3 cm deep and spaced 50×50 cm. These were later thinned down to 1 plant per hole after emergence giving 20,000 plants per hectare for sole and intercropped plots of each legume.

Two maize seeds were planted per hole at a depth of 2-5 cm at 1×1 m spacing. This was later thinned down after germination and emergence to 1 plant per stand giving 10,000 plants per hectare.

Yam

Dioscorea rotundata (white) obiaeturugo, seed yams weighing 200-300 g were planted 1 per hole measuring 30×30×30 cm at a spacing of 1×per hectare.

Cassava

(TMS 30555) cuttings measuring 20 cm long were planted on flat at 1×1 m spacing giving a plant population of 10,000 plants ha^{-1}.

Soil Samples

At the beginning of the experiment, soil samples were randomly collected with soil auger at a plough layer of 0-20 cm from different spots of the experimental field. The soil samples were bulked and analysed. Also, at the end of each experiment soil samples were collected with soil auger from each plot and samples from plots carrying the same treatments were bulked and analyzed.

Soil pH was determined in distilled water at 1:2.5 soil: water-solution ratio using the Beckman zeromatic pH meter.

Organic Matter (OM) was determined by the modified Walkley and Black method (Nelson and Sommers, 1982).

Nitrogen (N) was determined by the modified micro-kjeldahl digestion method. Available Phosphorus (P) and exchangeable potassium (K) were determined by the Bray II method and the flame photometry, respectively. Atomic Absorption Spectrophotometry (AAS) determined calcium (Ca) and Magnesium (Mg).

The data collected were collated and statistically analyzed using the Megastat, developed by Microsoft Excel (2000) and SPSS (2004) packages. Wahua (1999) was also used to help in data analysis and interpretation.

RESULTS AND DISCUSSION

Table 1 shows the soil chemical analysis before and after the experiment in 2001. Soil samples from all plots with cassava were collected and analyzed in the preceding years 2002 for 2001 cropping and 2003 for the year 2002 cropping. The result shows that there were increases in soil residual N in all the plots with the landrace legumes after the 2001 cropping. Plots with sole legume-Mucuna, Lima and African yam bean-had higher increases in residual soil N than those in the mixture. The result showed increased soil P after the 2002 cropping. Plots with lima bean either as sole or in mixture had higher increases in the soil residual P than others while those in plots of sole or mixture non legume crops decreased. The result shows a general increase in soil organic matter (OM) after 2001 cropping. Except for sole yam, sole cassava and Cassava/Maize mixture in 2001, all mixtures resulted in increased soil organic matter. Residual soil Mg declined after the 2001 cropping in all plots except in yam/maize/lima crop mixture that had +36% increases. The result shows that after the 2001cropping, increases in soil Ca were observed. Except in yam/maize/mucuna/ (+28%) yam/ maize/lima (+54%) other plots with sole or crop mixture resulted to decrease in soil residual Ca. The result shows that after the 2001 cropping, there was a general decline in soil residual K except in yam/maize/cassava/ mucuna with +7% increase. There was a general increase in soil pH (water) ranging from +1% in Y/M/L, Y/M/C/Ayb and sole Lima, respectively to +9% in Y/M/C crop mixture.

Table 1: Soil Chemical analysis before and after the experiment in 2001

Soil samples Depth: 0-20 cm	Total N (%)	P (Cmol/kg)	OM (%)	Mg (Cmol/kg)	Ca (Cmol/kg)	K (Cmol/kg)	pH (water)
Before experiment	0.06	5.2	1.54	0.62	1.56	0.60	4.45
After experiment							
Cropping systems	%Δ	%Δ	%Δ	%Δ	%Δ	%Δ	%Δ
Yam/Maize/Mucuna	0.14+133	6.00+15	2.34+52	0.61-2	2.00+28	0.34-43	4.61+4
Yam/Maize/Lima	0.11+83	8.28+59	2.47+60	0.84+36	2.40+54	0.21-65	4.48+1
Yam/Maize/African yam bean	0.13+117	6.30+21	2.39+55	0.61 -2	1.46 - 6	0.31-48	4.66+5
Yam/Maize	0.03+50	4.99-4	1.24+20	0.39-37	1.46 -6	0.22-63	4.55+2
Cassava/Maize/Mucuna	0.18+200	6.82+27	1.74+13	0.55-11	1.51 -3	0.25-58	4.53+2
Cassava/Maize/Lima	0.13+117	8.23+58	1.93+25	0.58 -7	1.53 -2	0.21-65	4.54+2
Cassava/Maize/African yam bean	0.16+167	6.42+24	1.78+16	0.58- 7	1.51 -3	0.21-65	4.54+2
Cassava/Maize	0.03+50	5.75+11	1.13-27	0.62 0	1.51 -3	0.11-82	4.53+2
Yam/Maize/Cassava/Mucuna	0.10+67	5.88+13	1.74+13	0.55 -11	1.43 -8	0.39-35	4.58+3
Yam/Maize/Cassava/Lima	0.09+50	7.64+47	1.74+13	0.51 -18	1.59 +2	0.64+7	4.56+3
Yam/Maize/Cassava/Ayb	0.09+50	5.78+11	2.25+45	0.51 -18	1.53 -2	0.36-40	4.51+1
Yam/Maize/Cassava	0.02-67	5.20 0	1.14-26	0.59 -5	1.47 -6	0.24-60	4.49+9
Yam	0.06 0	5.06-3	1.11-28	0.59 -5	1.47 -6	0.16-73	4.56+5
Cassava	0.04-33	5.20 0	1.49-03	0.60-3	1.51 -3	0.11-82	4.54+2
Maize	0.02-67	5.10-2	1.16-25	0.61 -2	1.51 -3	0.15-75	4.53+2
Mucuna pruriens	0.33+450	6.49+25	2.26+47	0.57-8	1.44 -8	0.59 -2	4.55+2
Lima beans	0.24+300	8.61+66	2.37+54	0.61 -2	1.51 -3	0.58 -3	4.51+1
African yam bean	0.28+367	6.88+32	2.35+53	0.52 -16	1.56 0	0.6 0	4.48+1

NB: %Δ = Percentage change, (+) = Increase, (-) = Decrease

Table 2: Soil Chemical analysis before and after the experiment in 2002

Soil samples Depth: 0-20 cm	Total N (%)	P (Cmol/kg)	OM (%)	Mg (Cmol/kg)	Ca (Cmol/kg)	K (Cmol/kg)	pH (water)
Before experiment	0.09	5.76	2.62	0.83	1.3	0.48	4.49
After experiment							
Cropping systems	%Δ	%Δ	%Δ	%Δ	%Δ	%Δ	%Δ
Yam/Maize/Mucuna	0.16+78	4.95-14	2.99+14	0.86+4	1.39+7	0.42-13	4.63+3
Yam/Maize/Lima	0.13+44	4.92+3	2.68+2	0.89+7	1.38+6	0.36-25	4.58+2
Yam/Maize/African yam bean	0.14+56	4.87-18	2.78+6	0.85+2	1.32+2	0.39-19	4.59+2
Yam/Maize	0.05-44	3.64-37	2.71+3	0.45-46	0.97-25	0.31-35	4.55+2
Cassava/Maize/Mucuna	0.19+11	5.88+2	2.85+9	0.89+7	1.28-2	0.38-21	4.61+3
Cassava/Maize/Lima	0.14+56	5.84+1	2.99+10	0.88+6	1.29-1	0.41-15	4.56+2
Cassava/Maize/African yam bean	0.16+78	5.86+2	2.88+4s	0.88+6	1.30 0	0.41-15	4.59+2
Cassava/Maize	0.04-56	5.81+9	1.22+4	0.58-30	1.06-19	0.36-25	4.57+2
Yam/Maize/Cassava/Mucuna	0.16+78	4.39-24	2.96+13	0.87+5	1.35+4	0.35-27	4.58+2
Yam/Maize/Cassava/Lima	0.12+33	5.74+3	2.77+6	0.88+6	1.33+2	0.34-29	4.54+1
Yam/Maize/Cassava/Ayb	0.15+67	4.81-17	2.79+7	0.87+5	1.32+2	0.34-29	4.61+3
Yam/Maize/Cassava	0.07-22	3.64-37	2.72+4	0.65-22	0.97-25	0.34-29	4.53+1
Yam	0.05-44	3.64-37	2.67+2	0.45-46	0.97-25	0.31-35	4.52+1
Cassava	0.04-56	3.37-42	2.67+2	0.39-53	0.84-35	0.29-40	4.52+1
Maize	0.02-78	3.74-35	2.64+1	0.27-68	0.65-50	0.21-56	4.52+1
Mucuna puriens	0.19+111	4.98-14	2.73+4	0.79-5	1.31+1	0.39-19	4.53+1
Lima beans	0.16+78	6.72+17	2.67+2	0.81-2	1.30 0	0.31-35	4.55+2
African yam bean	0.17+89	4.88-15	2.64+1	0.79-5	1.30 0	0.39-19	4.52+1

NB: %Δ = Percentage change, (+) = Increase, (-) = Decrease

Table 2 shows the soil chemical properties before and after the experiment in 2003. The result shows that there were increases in soil N in all plots with the landrace legume after the 2002 cropping. However, there was higher residual soil N in 2001 than in 2002 cropping. All plots without landrace legume declined in soil N. These was a +450, +300 and +360% increases, respectively in sole mucuna, lima bean and African yam bean in 2001 as against +111, +78 and +89%, respectively in mucuna, lima bean and African yam bean in 2002.

The result shows that under yam-based crop mixture, soil residual P decreased in Y/M/Mp (-14%) Y/M/Ayb (-16%) and Y/M (-37%) and increased only in Y/M/L by +3%. There was a general increase in all cassava-based crop mixture ranging from +1% in Y/M/L to +9% in cassava/maize. Under Yam/Cassava-based crop mixture soil P increased only in Y/M/D/L by +3% and not while under sole cropping sole Lima increased by +17%, other plots witnessed decreases. The result shows a general increase in soil OM after the 2002 cropping unlike the 2001 cropping where some plots decreased in OM. However, the increases after the 2001 cropping were higher than that observed after the 2002 cropping. Soil Mg decreased only in yam/maize by -46% under yam-based mixture while other plots increased. Under cassava-based cropping system, there were increases except in cassava/maize (-30%). Furthermore, the result shows that in yam/cassava-based crop mixture soil Mg decreased only in yam/maize/cassava by -22% while the other plots increased. In the sole plot cropping, residual soil Mg decreased from -2% in sole Lima to -68% in sole maize. The result shows that soil Ca increased after the 2002 cropping in yam-based crop mixture. There were increases in Y/M/Mp(+7%), Y/M/L (+6%) and Y/M/Ayb (+2%) while yam/maize decreased by -25%. Under cassava-based crop mixture soil Ca decreased from -19% in cassava/maize to -2% in C/M/L. The Yam/Cassava-based crop mixtures showed that residual soil Ca increased in Y/M/C/Mp,Y/M/C/L and Y/M/C/Ayb while it decreased in Y/M/C by -25%. The plots with sole Mucuna increased by +1% while sole African yam bean and sole Lima bean neither increased nor decreased. The sole non legume crop plots declined in soil Ca ranging from -50% in sole maize to -25% in sole yam. The result shows that all plots declined in soil K after the 2002 cropping. Also, the result showed a general increase in soil pH (water) after the 2002 cropping.

DISCUSSION

After the experiment, the quantity of N left in the soil in 2001 was higher than that in 2002 in all plots of sole cropping system. This observation may suggest that although grain legumes require large qualities of N (Kurt, 1984) they can satisfy most of their own needs by symbiotic N-fixation and leave behind substantial amounts especially when the initial soil N was low. This is the case of 2001 cropping with initial soil N of 0.06% as against 0.09 in 2002. However, % total soil N increased in all plots with the land-race legumes and decreased in plots without legume association. This report disagreed with that by Ibeawuchi and Ofoh (2003) that soil N declined in plots with maize/cassava /groundnut/African yam bean mixtures but rather agreed with the results by Agboola and Fayemi (1972) that the tropical legume fix large quantities of N in crop mixtures with maize. The decline of soil N in plots without legumes indicates that inter-cropping systems increased the removal of soil nutrient (Kurt, 1984) where legumes are absent. However most root crops like yam has moderate soil N needs (David, 1986). Due to diversified root systems in intercropping the N that would have been lost before through leaching were trapped by these diverse root systems.

The decline of soil P in plots with tuber/root crops indicates that they take up large amounts of P from the soil. This view agreed with that by Onwueme (1978), Ustimenko-Bakumovsky (1983), David (1986) and Onwueme and Sinha (1991) that tuber / root crops take up more P and K from the soil more than any other crop species. However, the low P in plots with tuber/legume mixture could indicate that plant litter and left over which serve as reservoir of most nutrients have not fully decomposed to release nutrients which will include P(Ibeawuchi, 2004). This agreed with the result by Ibeawuchi and Ofoh (2003) that decayed litters in crop mixture form humus and organic acids that form complexes with Iron (Fe) and Aluminum (Al) thus reducing considerably the ability of the soil to tie up P hence making it available in the soil. Although P fixation is common in Ultisols, the decayed leaves and plant roots will help produce enough organic acids and humus to release the soil P. from being held in the soil thus making the tie-up temporary.

The intercropping and sole cropping systems resulted in increased organic matter content of the soil. Although, litter decay had not taken place completely, it was expected that more organic matter might be released from tuber/legume cropping systems if decay is completed. However, the incorporation of these litters into the soil in the next planting will increase both soil N and others elements including OM.

The decline of Mg, Ca and K in the soil where tuber/legume mixture had been planted could be attributed to the increased nutrient decline prevalent in intercropping systems (Kurt, 1984). However, soil K was particularly reduced in most plots with tuber/root crops suggesting that these crop species take up high quantities of K from the soil (Ustimenko-Bakumovsky (1983), David (1986) and Onwueme and Sinha (1991). The low K content of the soil may be as a result of parent material since only soils formed of volcanic origin tend to be high in K (David, 1986).

The increase in soil pH in this trial in both 2001 and 2002 suggest that intercropping help to improve soil pH. This observation agreed with the report by Okigbo and Lal (1979) who reported that intercropping maize/cassava improved the soil CEC, soil pH and soil Mn. It means therefore that there is much we can understand in the merits of tuber/legume association because of its complex nature in the farm ecology.

CONCLUSION

One of the limiting factors in crop production is low soil fertility. In low soil fertility, intercropping tubers/root crops with legumes especially landraces is advocated. There is an organized replacement process of nutrients in intercropping systems yet to be understood. It is expected that soil nutrients should seriously deplete under intercropping systems but the reverse is the case. Soils planted with legumes or in association with other crops should be planted the following year with cereals component crops to reap the full befits or planting legumes in a cropping system. Farmers are advised to use African yam bean and lima bean in their intercropping and mucuna as relay crop when maize had been harvested and yam or other crops fully established to avoid shading of which mucuna is a culprit.

ACKNOWLEDGMENTS

I acknowledge Messrs. C.I. Akaerue, the chief laboratory technologist and Mr. Simon Nti a principal laboratory technologist of School of Agriculture and Agricultual Technology Laboratory, Federal University of Technology, Owerrri and Chief Laboratory Technologist of the Department of Soil Science undergraduate laboratory, Faculty of Agriculture, University of Nigeria, Nsukka for their efforts in analyzing all my soil samples.

REFERENCES

Agboola, A.A. and A.A.A. Fayemi, 1972. Fixation and extraction of nitrogen by tropical legumes. Agron. J., 64: 409-412.

Agron.Monograph 9Madison W.I, ASA and SSSA, 1982: 581-594.

David, L., 1986. Soils, Crops and Frtilizer Use; A field manual for Development workers. United States Peace Corps, Information Collection and Exchange, pp: 93-285.

Eshett, E.T., 1993. Wetlands and ecotones studies on land water. National Institute of Ecology, New Delhi and International Scientific Publications, New Delhi, pp: 232-234.

Gomez, A.A. and K.A. Gomez, 1986. Multiple cropping in the humid tropics of Asia. IDRC 176e pp: 1-165.

Ibeawuchi, I.I. and M.C. Ofoh, 2000. Productivity of Maize/Cassava/Food legume Mixtures in Southeastern Nigeria. J. Agric. Rural Dev., 1: 1-9.

Ibeawuchi, I.I., 2003. Effect of four organic manure types on the yield and yield components of fantasia pepper (*Capsicum annum* L.) in southeastern Nigeria J. Sci. Business Agric. (JoSBAG) 4th Quarter 2003, pp: 25-29.

Ibeawuchi, I.I. and M.C. Ofoh, 2003. Effects of maize/cassava/food legume mixtures in soil nutrient status and weed control. Bionature, 23: 59-64.

Ibeawuchi, I.I., 2004. The Effect of Landrace Legumes on the productivity of tuber based cropping systems of S/E Nigeria Ph.D Thesis, pp: 1-133.

Kurt, G.S., 1984. Intercropping in tropical smallholder agriculture with special reference to West Africa GTZ., pp: 1-233.

Lal, R. and B.T. Kang, 1982. Fertilizers and Soil Amendments. Prentice Hill Inc. Englewood Cliffs USA., pp: 250.

Micro Soft Excel Package, 2000. Microsoft Inc. USA

Nelson, D.W. and L.E. Sommas, 1982. Total Carbon, Organic Carbon and Organic Matter. Page, A.L. *et al*., (Eds.), Methods of Soil Analysis Part 2, 2nd Edn.

Okigbo, B.N. and R. Lal, 1979. Soil fertility maintenance and conservation for improved agrofoerstry systems in humid tropics. ICRAF., pp: 41-47.

Onwueme, L.C., 1978. The Tropical Root Crops. Chidiester. John Wiley.

Onwueme, I.C. and T.D. Sinha, 1991. Field Crop Production in the tropical Africa CTA. Ede Netherlands. pp: 1-319.

Statistical Package for Social Scientists (SPSS) (2004). SPSS Inc. Northern Michigan Avenue-Chicago. Version 11.

Ustimenko-Bakumovsky, G.V., 1983. Plant Growing in the Tropics and Sub Tropics MIR Publishers. Moscow, pp: 28-264.

Wahua, T.A.T., 1999 Applied Statistics for Scientific Studies, pp: 140-145.