Effects of Compounded Soil Amendments on Yield of Cassava, Sweet Potato and Yam Tuber Crops in Owerri, South-eastern Nigeria

Ofor, Marian Onomerhievurhoyen[1*], Unamma, Anthony Odera[2], Opara, Patrick Ifeanyi[3], Ihediohanma, Ngozi Chidinma and Nwokeji, Ephraim Maduka[1]

1. Department of Crop Science and Technology, Federal University of Technology Owerri, P.M.B 1526 Owerri, Imo State, Nigeria
2. Department of Physical Science Education, Imo State University, P.M.B. 1001 Owerri, Imo State, Nigeria
3. Federal University of Technology International School P.M.B 1526 Owerri, P.M.B 1526 Owerri, Imo State, Nigeria
4. Department of Food Science and Technology, Federal University of Technology Owerri, P.M.B 1526 Owerri, Imo State, Nigeria

mariofor2002@yahoo.com; patoparaife@yahoo.com

Abstract: Field experiments were carried out to study the effects of soil amendment, namely, 25percent burnt palm bunches (ash) and 75percent poultry manure on root crops. Treatments comprised four (4) soil amendment rates (0, 3, 6, and 9t/ha) and three (3) families of root crops viz; *Dioscorea rotundata* Poir cv. TDr 89/02665, *Ipomoea batatas* and *Manihot esculenta* Crantz cv. TMS 30555., arranged in randomized complete block design with three replications and in a factorial arrangement. The soil amendments were applied before planting arrangement. The soil analysis results before and after planting showed that there was marked improvement in soil K from 0.03 to 0.51 mg/l00g soil and pH from 5.86 to 6.50 as a result of soil amendment application. As a stimulatory source which induces shoot proliferation, soil amendment reduced the number of days to 50% sprouting from 33 to 29days. Cassava recorded the highest number of roots per plot (32.25) while soil amendment rate of 6t/ha gave the highest number of roots (27 per plot). Cassava yield (12.91t/ha) was significantly higher than yam yield (1l.41t/ha) and potato (7.84t/ha). Soil amendment rates of 6t/ha produced the highest yield (12.91t/ha) as it had greater assimilate allocation to the roots, than other rates which had nutrient imbalance and less nutrient availability.

[Ofor, Marian Onomerhievurhoyen, Unamma, Anthony Odera, Opara, Patrick Ifeanyi, Ihediohanma, Ngozi Chidinma and Nwokeji, Ephraim Maduka. **Effects of Compounded Soil Amendments on Yield of Cassava, Sweet Potato and Yam Tuber Crops in Owerri, South-eastern Nigeria.** *Researcher* 2015;7(1):81-88]. (ISSN: 1553-9865). http://www.sciencepub.net/researcher. 13

Key words: soils, amendments, compounded, tuber crops, organic

1. Introduction

Tuber crops are crops in which the underground storage organ is either an enlarged stem or root. In many tropical and sub-tropical countries, tuber crops constitute a major and relatively cheap source of food, particularly carbohydrates which are a source of energy to man and his livestock. Tuber crops also provide raw materials to many of our industries e.g. the starch industry. The important tuber crops in Nigeria and some of the West African countries include yam, cassava, cocoyam and sweet potato.

According to Ohiri and Ezumah (1990), in Southeastern Nigeria, soil acidity is a problem hindering proper agricultural production, since most of the crops grown are susceptible to dangerous effects of acidic soils. The acidic nature of the soils in Southeastern Nigeria has been attributed to their parent material, leaching and degradation in soil physical properties. To reduce or make the soil less acidic, it is common practice to apply lime to agricultural soil. However, the unavailability and high cost of liming materials necessitated this research into low cost, affordable and adoptable organic liming materials. Nonconventional liming materials such as plant ash are suitable alternatives to conventional liming materials like CaO and $Ca(OH)_2$, due to their affordability and availability, in addition to their ability to reduce soil acidity. Ojeniyi and Adeniyan (2005); and Igbokwe (1980) found that yield of vegetable crops and nutrient content were improved by plant ash in South-eastern Nigeria.

Similarly, Olayinka (1990) reported that acidity was reduced in soils amended with plant ash. Omijeh *et al* (2011) indicated that plant ash has a great potential of reducing acidic accumulation in tuber production, because it helps to increase pH, availability, caution and yield. At Agbani in Enugu, Southeastern Nigeria, farmers apply various kinds of non-conventional liming materials like palm bunch ash and saw dust ash including wood ash, in different sites without specific recommendations, due to lack of research work. The desire to determine appropriate rates of non-conventional liming materials that will increase the pH of soils for cultivation is therefore the main thrust of this research.

2. Materials and Methods

2.1 Area of Study

The experiment was conducted at the Teaching and Research Farm, Federal University of Technology, Owerri, Latitude 5^0 20^0N and Longitudes 07^0 02^0E in the humid tropics. This area is between 80-90m above sea level with average maximum annual temperature of 28^0C to 31^0C with minimum of 20^0C, annual rainfall range of 1200 to 3600 mm and the vegetation is tropical rain forest. The soil is a highly leached ultisol, with unique properties. It's generally sandy, acidic and of loss nutrient reserve, with a high degree of erodability; and the hydrology is governed by Otamiri River (Onweremadu, 2006).

2.2 Soil Sampling and Analysis

Soil samples were randomly collected from the experimental site to the depth of 0.15cm using soil auger before tillage operation and after harvesting. The soil samples were bulked and a composite sample was obtained, air dried and passed through a 2mm diameter sieve. The samples were subjected to laboratory analysis for the determination of physical and chemical properties of the soil. The results are as shown in Tables 1-9.

2.3 Treatments and Experimental Design

Two factors, namely three (3) root crops (yam, potato and cassava); and four (4) soil amendment rates were combined to obtain twelve treatment combinations. Factor B consisted of soil amendment rates at four levels, namely 0t/ha, 3t/ha, 6t/ha and 9t/ha, with each level consisting of 25% burnt palm bunch (ash) and 75% poultry manure. The three levels of factor A and four levels of factor B were combined to obtain the following treatments combination:-

Yam + 0t/ha (control)
Yam + 3t/ha (0.75ash +2.25 manure)
Yam + 6t/ha (1.5 ash +5 manure)
Yam + 9t/ha (2.25 ash + 6.75 manure)
Potato + 0t/ha (control)
Potato + 3t/ha (0.75ash +2.25 manure)
Potato + 6t/ha (1.5 ash +4.5 manure)
Potato + 9t/ha (2.25 ash +6.75 manure)
Cassava + 0t/ha (control)
Cassava + 3t/ha (0.75ash+2.25 manure)
Cassava + 6t/ha (1.5 ash+4.5 manure)
Cassava + 9t/ha (2.22 ash + 6.75 manure)

The root crops used for the experiment were all obtained from National Root Crops Research Institute, Umudike (NRCRI). They include; *Dioscorea rotundata* Poir cv. TDr 89/02665, *Ipomoea batatas* and *Manihot esculenta* Crantz cv. TMS 30555. All data collected were subjected to statistical analysis using the Genstat (2007) edition.

3. Result Analysis

The soil nutrient status before cropping was analyzed. On the average, the total nitrogen (N) was 0.048%; available phosphorus (P) was 8.10 ppm; exchangeable potassium (K) = 0.03 meg/l00g; pH 5.86; organic Carbon (C) was 0.1728%; and ECEC = 1.11 meg/100g, on surface soil (0-15cm) before planting. There were changes in soil nutrient status after harvesting and the changes were significant for some nutrients.

From Table 1, number of days to 50% sprouting of root crops varied significantly with yam, sweet potato and cassava. Yam significantly recorded the highest number of days to sprouting (40 days) while the least number of days to sprouting was observed in sweet potato (24 days). It was observed that it took cassava 27days to attain 50% sprouting. Soil amendment on the other hand did not affect number of days to 50% sprouting. However, plants that received 0t/ha soil amendment took longest time (33 days) to attain 50% sprouting earlier (29days). The coefficient of variation (CV) estimate obtained was low (13.2%) for the number of days to 50% sprouting.

The effect of soil amendment and root crops on plant height/vine length of root crops at 2,4 and 6 MAS, as presented in Table 2, indicates that at 2 MAS, yam had the longest vine length (113.2cm), followed by sweet potato (92.8cm). However, cassava recorded the shortest plant height with the mean valve of 56.8cm. With respect to soil amendment, plant height/vine length values increased as soil amendment rates increased. The longest plant length/vine (94.3cm) was recorded at plots that received 9t/ha soil amendment. Plots treated with soil amendments at 0t/ha gave the shortest (81.2cm) plant height/vine length.

At 4 MAS, the results showed that sweet potato recorded the longest vine length (l79.8cm) while cassava had the shortest plant height (99.8cm). However, the effect of soil amendments on root crops indicate that plots treated with 3t/ha gave the shortest plant height/vine length (147.3cm). Longest plant height/vine length (160.7cm) was obtained in plots treated with 6t/ha soil amendment.

At 6 MAS, effect of root crops showed that sweet potato had the longest vine (255.1cm) followed by yam (199.3cm). Cassava had the shortest plant height (151.4cm). The result from the effect of soil amendment indicates that the result followed the same trend as in 4MAS with 6t/ha recording the longest plant height/vine length (217.4cm); but the control (0t/ha) gave the shortest plant height/vine length (185.1cm). The CV value at 6 MAS was 10.5%, compared to the values at 2 MAS and 4 MAS, with CV values of 14.2 and 11.9% respectively.

Table 1: Effect of soil amendment rates and type of root crops on number of days to 50% sprouting

Soil Amendment Rates	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	43.33	25.00	28.00	32.11
0.75 ash + 2.25 manure (3t/ha)	37.33	24.33	26.00	29.22
1.5 ash + 4.5 manure (6t/ha)	40.33	23.00	25.33	29.56
2.25 ash + 6.75 manure (9t/ha)	35.67	23.67	25.67	28.33
Mean	39.17	24.00	26.25	

C.V (%) = 13.2
LSD $_{(0.05)}$ for Soil Amendment= N.S
LSD $_{(0.05)}$ for Root Crop = 3.34
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S
MAS = Months after Sprouting

Table 2: Effect of Soil Amendment rates on plant height/vine length of Roots Crops (cm) at 2, 4 and 6 MAS

Soil Amendment Rates (2 MAS)	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	110.0	82.7	51.0	81.2
0.75 ash + 2.25 manure (3t/ha)	109.3	93.7	58.7	87.8
1.5 ash + 4.5 manure (6t/ha)	105.7	98.7	59.0	87.8
2.25 ash + 6.75 manure (9t/ha)	127.7	96.7	58.7	94.3
Mean	113.2	92.8	56.8	

C.V (%) = 14.2
LSD $_{(0.05)}$ for Soil Amendment = N.S
LSD $_{(0.05)}$ for Root Crop = 10.56
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

Soil Amendment Rates (4 MAS)	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	173.0	179.0	103.7	151.9
0.75 ash + 2.25 manure (3t/ha)	173.7	168.0	101.0	147.3
1.5 ash + 4.5 manure (6t/ha)	175.7	201.0	105.3	160.7
2.25 ash + 6.75 manure (9t/ha)	153.7	201.0	89.0	154.6
Mean	173.8	179.8	99.8	

C.V (%) = 11.9
LSD $_{(0.05)}$ for Soil Amendment = N.S
LSD $_{(0.05)}$ for Root Crop = 15.53
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

Soil Amendment Rates (6 MAS)	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	192.7	2.350	127.7	185.1
0.75 ash + 2.25 manure (3t/ha)	195.0	244.0	151.7	196.9
1.5 ash + 4.5 manure (6t/ha)	206.3	274.3	171.7	217.4
2.25 ash + 6.75 manure (9t/ha)	203.3	267.0	154.7	208.3
Mean	199.3	255.1	151.4	

C.V (%) = 10.5
LSD $_{(0.05)}$ for Soil Amendment 20.72
LSD $_{(0.05)}$ for Root Crop = 17.95
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

In Table 3, effect of soil amendment rates and root crops shows that of the root crops evaluated, cassava recorded the highest number of roots per plot (32.25). Yam on the other hand gave the least number of roots per plot (18.33). With the effect of soil amendment rates, plots treated with 6t/ha had the highest number of roots per plot (27); this was followed by plots that received 3t/ha (24.67). Expectedly, the plots whose soil amendment rates was 0t/ha (control) recorded the least number of roots per plot. The trait studied above had low CV values (114%).

Table 4 which shows the effect of soil amendment rates and root crops on root girth indicates that with respect to root crop effect, yam had the biggest girth sizes (20.93cm) followed by sweet potato (19.8cm). However, smallest root girth size was obtained cassava (12.35cm). Soil amendment rates also differed significantly with the plots that received 6t/ha having recorded the biggest girth size (20.49cm). Incidentally plots treated with 0t/ha (control) and 9t/ha soil amendment rates had the smallest girth size with the mean values of 15.29 and 15.62cm respectively. However, the coefficient of variation estimates show that root girth had moderately high CV (22%).

Table 5 indicates that the effect of soil amendment rates and root crops on yield of roots per plant did not differ significantly among each other. All the plots treated with different rates of soil amendment produced almost the same yield of roots per plant except the plots treated with 6t/ha which had the highest yield of roots per plant (1.23kg). Conversely, the root crops differed significantly with cassava recording the highest yield of roots per plant (1.30kg). This is followed by yam with yield of 1.16kg while the lowest yield of roots per plant was obtained in sweet potato (0.81kg). The CV was moderate with a value of 17.9%.

Table 6 shows the effect of soil amendment rates and root crops on the yield per plot of the root crops studied. Cassava recorded the highest yielded (10.32kg) per plot. On the other hand, yam gave the second highest yield per plot (6.05kg) per plot. When compared the effect of soil amendment rates on yield per plots, it was discovered that the highest yield (10.44kg) was obtained from the plots treated with 6t/ha. 3 and 9t/ha soil amendment rates produced yield of 8.60 and 8.40kg of root respectively. Lowest yield (7.2kg) was obtained in the check plots (0t/ha). The CV estimates is however moderate (l8.1%).

Table 7 showed the effect of soil amendment rates and root crop yield per hectare (t/ha) of roots. The root crops yield per hectare varied significantly with yam, sweet potato and cassava. Cassava however, significantly produced the highest yield per hectare (12.91t/ha). This is followed by yam which gave a yield output of 11.4t/ha while sweet potato recorded the lowest yield per hectare (7.87t/ha). Soil amendment rates also differed significantly with control (0t/ha) producing the lowest yield per hectare (9.09t/ha). Yield obtained from plots treated with 3 and 9t/ha soil amendment rates did not differ from each other with each giving a yield output of 10.71 and 10.17t/ha respectively. Highest yield however, was recorded on plots that received 6t/ha (12.94t/ha). The CV obtained was 19.5%.

Table 3: Effect of Soil Amendment Rates and Root Crops on the Number of Roots per Plot

Soil Amendment Rates	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	12.33	11.00	31.00	18.11
0.75 ash + 2.25 manure (3t/ha)	22.67	19.33	32.00	24.67
1.5 ash + 4.5manure (6t/ha)	23.33	23.33	34.33	27.00
2.25 ash + 6.75manure (9t/ha)	15.00	21.00	31.67	22.56
Mean	18.33	18.67	32.25	

C.V (%) = 11.4
$LSD_{(0.05)}$ for Soil Amendment = 2.56
$LSD_{(0.05)}$ for Root Crop = 2.22
$LSD_{(0.05)}$ for Soil Amendment x Root Crops = 4.44

Table 4: Effect of Soil Amendment Rates and Root Crops on Root Girth (cm)

Soil Amendment Rates (4 MAS)	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	17.70	18.63	9.53	15.29
0.75 ash + 2.25 manure (3t/ha)	23.70	21.80	13.30	19.37
1.5 ash + 4.5manure (6t/ha)	25.03	21.82	14.40	20.49
2.25 ash + 6.75manure (9t/ha)	17.97	16.93	11.97	15.62
Mean	20.93	19.80	12.35	

C.V (%) = 22.0
LSD $_{(0.05)}$ for Soil Amendment = 3.80
LSD $_{(0.05)}$ for Root Crop = 3.29
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

Table 5: Effects of Soil Amendment Rates and Root Crops on Roots Yield per Plant (Kg)

Soil amendment rates	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	1.13	0.67	1.27	1.02
0.75 ash + 2.25 manure (3t/ha)	1.13	0.77	1.33	1.08
1.5 ash + 4.5manure (6t/ha)	1.30	0.97	1.43	1.23
2.25 ash + 6.75manure (9t/ha)	1.07	0.83	1.17	1.02
Mean	1.16	0.81	1.30	

C.V (%) = 17.9
LSD (0.05) for soil amendment N.S
LSD (0.05) for root crop = 0.17
LSD (0.05) for soil amendment x root crops = N.S

Table 6: Effect of Soil Amendment Rates and Roots Crops on Yield per Plot of Roots (kg)

Soil amendment rates	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	8.20	4.35	9.07	7. 20
0.75 ash + 2.25 manure (3t/ha)	9.67	5.81	10.33	8.60
1.5 ash + 4.5manure (6t/ha)	11.83	6.81	12.57	10.44
2.25 ash + 6.75manure (9t/ha)	8.73	7.12	9.33	8.40
Mean	9.61	6.05	10.32	

C.V (%) = 18.1
LSD $_{(0.05)}$ for Soil Amendment 1.54
LSD $_{(0.05)}$ for Root Crop = 1.33
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

Table 7: Effect of Soil Amendment Rates and Root Crop Yield per Hectare (t/ha) of Roots

Soil Amendment Rates	Yam	Sweet potato	Cassava	Mean
Control (0t/ha)	10.26	5.67	11.33	9. 09
0.75 ash + 2.25 manure (3t/ha)	12.08	7.10	12.93	10.71
1.5 ash + 4.5manure (6t/ha)	14.13	9.00	15.70	12.94
2.25 ash + 6.75manure (9t/ha)	9.14	9.70	11.67	10.17
Mean	11.41	7.87	12.91	

C.V (%) = 17.5
LSD $_{(0.05)}$ for Soil Amendment = 1.84
LSD $_{(0.05)}$ for Root Crop = 1.59
LSD $_{(0.05)}$ for Soil Amendment x Root Crops = N.S

4. Discussion

The main advantage of organic fertilizer (poultry manure) is their contribution to soil organic matter content rather than as nutrient source. The main nutrient applied through organic fertilizers is nitrogen but much of this nitrogen is lost making it necessary to incorporate ash to boost other nutrient components, especially the K availability which is required for ample tuberization (FAO, 1992). However, continued use of poultry manure has been shown to reduce acidity and increase the exchangeable cations and CEC (cation exchange capacity). In addition to macro-nutrients, poultry manure adds micronutrients which increases yield of micro-nutrient deficient soil (Bache and Heathcote, 1989). Returning or addition of burnt plant remains (ash) have been demonstrated by Jones (1976) to slow down the rate of development of acidity and conservation of top soil exchangeable K which is essential for tuber development.

Consequently, a pre-planting soil test revealed a moderate (5.86) pH value of the soil and very low K availability. However, the post planting soil test results which revealed an increase in the pH (6.5) is as a result of burnt palm bunches (ash) that was incorporated into the manure. This is in agreement with Charles (2010) who reports that the increase in soil pH results from the application of lime (ash). He believed that ash reduces soil acidity (increase ions into water and carbon dioxide (CO_2). Also the increase in K, results from the addition of burnt palm bunches. This again supports the earlier findings made by Wilson and Kang (1981) which stated that burnt palm bunches (ash) contains a high proportion of K.

The highly significant differences obtained in most of the agronomic traits and the level of variability among the root crops observed in this study indicates that enough specie variability exist among the root crops. Number of days to sprouting was generally observed to decrease with an increasing rate the soil amendment materials. This implied that the soil amendment materials acted as external stimulatory source such as mineral nutrients during the pre-sprouting stage. Hence shoot growth (proliferation) was enhanced by soil amendment supplementation, a result which accords with reports by Mantel and Hugo (1989) on shoot cultures of the same species *Dioscorea alata* cv Oriental Lisbon.

The plant height/vine length obtained at 0t/ha, 3t/ha, 6t/ha and 9t/ha, with highest length at 6t/ha than at 0t/ha, 3t/ha and 9t/ha, implies that the use of soil amendment rate at these three levels is better than non-use. Application of manure enhances vegetative growth which is associated with an increase in the vine length as the soil amendment rates increased. This agrees with the report of Kamprath *et al*., (1982).

Root length and girth which was observed to increase as the levels of soil amendment increases but diminished at 9t/ha soil amendment could however; be as a result of induced nutrient deficiencies. This supports the view of Enwezor *et al*., (1989) which maintained that when one nutrient is present in excessive quantity (excess 2.25 t/ha ash content in 9t/ha soil amendment) in the soil, it limits the uptake of other element which could have been used for carbohydrate accumulation. Uguru (1996), however argued that when different nutrients are applied together, they interact either positively to growth and yield or negatively to depress crop. The results recorded from roots yield reverted that at lower and optimum rates of soil amendment, more roots are produced per unit of amendment applied to the soil. But at highest soil amendment rate, the law of diminishing returns sets in. This is in accordance with the findings of Samuelson and Nordhaus (2001), which states that adding more than one factor of production, while holding all others constant will at some point yield lower per unit return. Smith and Palmer (1970) on the other hand reports that soil amendments promote root growth, increase the chlorophyll content and photosynthesis of leaves; thereby promoting the photosynthetic materials to transfer to the tuber root and increase the yield and carbohydrate content of roots. Consequently, soil amendments exert its effects by mobilizing more metabolites to tuber formation and growth.

However, the effect of soil amendment rates on number of root crops indicates that Nitrogen (N), phosphorus (P) and Potassium (K) are more likely to limit root crop yield than other nutrients. Calcium and magnesium may be limiting at a pH of 5 or lower. Incidentally, the low roots yield obtained at the highest soil amendment rate i.e. 9t/ha, was attributed to excessive burnt palm bunch (2.25 t/ha ash) application which had led to nutrient imbalance, thus depressing the number of roots. This is supported by Jones (1976); Jones and Stockinger (1976), whose reports suggests that nutrient imbalance can interfere with pollination or efficient transfer of photosynthesis to the roots resulting in reduction in number of roots. Within the range of soil amendment levels used, number of roots in all four treatments was almost similar (Table 7). The results showed that manure, in combination with a low or optimum level of burnt palm bunch (ash), exerted a positive influence on root number proliferation but this effect diminished with increasing levels of burnt palm bunch (ash). This also agrees with the findings of Ammirato (1982) on yam tissue cultures, the level (1.5t/ha ash) at 6t/ha soil amendment rates was optimal for good basal root proliferation.

Conclusion and Recommendations

As in most parts of tropical Africa, the traditional method of maintaining soil fertility and root crops productivity in Nigeria has, hitherto, been the bush-fallow system whereby arable land is allowed revert to fallow after 3- 4 years of continuous cultivation. This evolved out of exigencies and the degree of regeneration of soil fertility which is generally dependent on the length of the follow period. However, with agriculture becoming more and more intensive, coupled with the introduction of high yielding and more nutrient demanding root crops, it became obvious that the available nutrient status, in view of growing human population cannot meet the current demand for root crops production. Root crops however, are a heavy user of nutrient. Therefore, nutrients assimilated from the soil by crops; lost through leaching and erosion; fixed or immobilized, should be replaced to ensure optimum root crop performance.

As deep feeders, the nutrients must be present in available form in the soil. One reason root crop yield remains low in Nigeria is because of inadequate use of K-fertilizers, as most soils available for root crops growing are no longer virgin; at best, they are being cleared from a short period of fallow; and after a season, most of the nutrients are exhausted. For such soils to support a good crop, additional potassium (k) based fertility is required. Because large amounts of K are absorbed from the root zone in the production of root crops, it is classified as a macronutrient. Nigerian soils can supply some K for root crop production, but this supply is not adequate. The application of ash (burnt palm bunch) to the soil can affect biological, chemical and physical properties of the soil. Similarly, the increase in soil pH resulting from the application of ash provided a more favourable environment for soil microbiological activity which increases the rate of release of plant nutrients.

This trial revealed that the use of ash (burnt palm bunch) at the rate of 1.5 t/ha in combination with adequate manure rate of 4.5 t/ha as a soil amendment source gave the best yield than maximum ash rate of 2.25 t/ha and manure rate of 6.75 t/ha. The poor growth of root crops in trial with maximum ash rate was attributed to the induced micronutrient deficiencies as a result of excessive ash application; while the low yield of roots in the trail with maximum poultry manure rate was attributed to the effect of law of diminishing returns. This study showed soil amendment rates that are important in determining the best yield of root crops in south eastern Nigeria. These findings should increase our knowledge of the agronomy of these crops and can be useful to the agronomist. It could now be possible to reasonably predict yield at different levels of soil amendments. The prediction may be useful to large and small scale farmers and should therefore, be subjected to further research to verify the results.

It is recommended that farmers and those interested in farming should apply soil amendment as expressed in this research work with the following reasons:-

i. Roots/tuber crops cultivated on plots with soil amendment rate of 6 tons/hectare have higher yields than those with lower rates
ii. It is economic to adopt this particular mode of soil amendments as it has low cost per unit of plant food.
iii. It requires less storage space
iv. It has low transport cost
v. It has less labour in handling
vi. It can be produced in large quantities for farmers of similar crops in the region.
vii. Soil amendments has direct effect on the plant growth and on the humus content of the soil and so it is easier to improve its physical and the microbial properties and activities of the soil.

Correspondences to:
Ofor, Marian Onomerhievurhoyen
Department of Crop Science and Technology,
Federal University of Technology Owerri,
P.M.B 1526 Owerri, Imo State, Nigeria
Email:mariofor2002@yahoo.com

Opara, Patrick Ifeanyi
Federal University of Technology
International School,
P.M.B 1526 Owerri, Imo State, Nigeria
Telephone: +2348037670333
Email:patoparaife@yahoo.com

References

1. Ammirato, P.V. Growth and Morphogenesis in culture of the monocot yam, Dioscorea; In Plant Tissue Culture, A. Fujiwara Maruzen (ed.), 1982: Tokyo, Japan. Pp 169-170.
2. Bache, B. W. and R.G. Heathcote. Long-term effect of fertilizers and phosphate supply to plant from some Nigerian soils. *Journal of Agric. Studies*, 1989: 74; 282-290.
3. Charles, C.M. Extension Agronomic Research Bulletin. Auburn University, U.S.A. 2010: Vol. 2; 2-4.
4. Enwezor, W.O., Udo, F. and Usoroh, N. J. Fertilizer use and management practices for crops in Nigeria (Series No. 2). Bobma Publishers, Ibadan, 1989: Pp 10-12.
5. Food and Agriculture Organization of the United Nations (FAO). Sustainable Development and the Environment; FAO policies and actions. Stockholm, Rio 1992: Rome, Italy.

6. Genstat Discovery, 3rd edition. Laws agricultural trust, 2007: Rothamsed Experimental State Uk.
7. Igbokwe, M.C. Nitrogen requirement of corn in a newly cleared loamy sand soil at Uyo Nigeria: The effect of Nitrogen and liming materials. In: Nitrogen cycling in West African Ecosystems (ed. Rosswall T.), 1980: pp 275- 283.
8. Jones, M. Planting time studies on roots and tubers at Samara Nigeria: 1970-1973, 1976: Samaru Misc paper 58.
9. Jones, M.I. and Stockinger, K.R. (1976): Effect of fertilizer on exchangeable cation ratios and crop nutrition in northern Nigeria. *Expl. Agric*. 12:49-59.
10. Kamprath, E.O., Moll, R.H. and Rodrigue, N. (1982): Effect of fertilizer and recurrent selection on performance of hybrid populations of corn. Agronomy Journal, Madison, WI. 74:955-958.
11. Mantell, S.H. and Hugo, S.A. Effect of photoperiod, Medium strength, in organic Ammoniurn, sucrose and cytokinin on root shoot and micro tuber development in shoot culture of *Dioscorea alata* and *Dioscorea bulbifera* .Yams: Plant Cell, Tissue and Organ Culture, 1989:16:23-27.
12. Ohiri, A.c. and Ezumah, H.C. Tillage effects on Cassava (*Manihot esculenta*) production and some soil properties. *Soil Tillage*, 1990:17, 221 – 229.
13. Ojeniyi, S.O. and Adeniyan, O.N. Effect of poultry manure, NPK 15:12:12 and combination of their reduced levels on maize growth and soil chemical properties. *Niger. J. Soil Sci.*, 2005: 15; 34 – 41.
14. Olayinka, A. Effects of poultry manure and Corn straw on Soil chemical properties. *Ife Journal of Agriculture*, 1990: 2; 36 – 44.
15. Omijeh, J.E., Adegbehin and Omeke, J.O. Herbage Dynamics and Soils of two different sites of *Calotropis procera* (Ait) R.Br. (Asclepiadaeceae) in the Northern Guinea Savanna zone of Nigeria. *Int. Journal of Agric. and Rural Development*, 2011: Vol. 14 (2), pp. 687.
16. Onweremadu, E.U. Assessment of mined soils in Erosion degraded farmlands in Southeastern Nigeria. *Estud Biol*., 2006: 28; 59 – 67.
17. Samuelson and Nordhaces, Microeconomics 17th ed. McGraw Hill., 2001: Pp. 110.
18. Smith, O.E. and Palmer, C.E. Cytokinin induced tuber formation on stolons of *Solenum tuberosum*. *Physiologia Plant*, 1970: 23, 199.
19. Uguru, M. I. Crop Production: Techniques and practice. Fulladu Publishing Company, Nsukka, 1996: Pp. 21.
20. Wilson, J.E. and Kang, B.T. Effect of mound size and fertilizer on white guinea yam in southern Nigeria. *Plant and soil*, 1981: 61, 319-327.

1/22/2015