Growth and Nutrient Uptake of Maize (*Zea mays* L.) amended with Compost-Enriched Palm Kernel Cake

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Abstract

Organic waste materials are used for improving soil health and crop yields. Enrichment of organic waste materials with palm kernel cake could increase soil nutrient content. Pot experiments were conducted in a screenhouse at Kwara State University, Malete, Ilorin, Nigeria during the 2015 planting season to examine the effect of NPK fertilizer and different rates of compost combined with palm kernel cake (PKC) on growth, dry matter yield and nutrient uptake of maize. The experiment involved eight treatments: Sunshine Grade B+PKC at 2, 4. 6 t/ha, Aleshinloye Grade B+PKC at 2, 4. 6 t/ha, NPK at 60 kg N/ha and Control (No fertilizer addition). The treatments were laid out in a completely randomized design (CRD) with three replicates. The parameters taken on growth and yield parameters were plant height (cm), number of leaves, stem girth (mm) and dry matter yield (g/pot). Maize plants grew better ($P<0.05$) with the application of NPK fertilizer at first planting. The use of organic fertilizers; Sunshine Grade B+PKC at 4 t/ha and Aleshinloye Grade B+PKC at 4 t/ha had greater positive effects on growth and nutrient uptake of maize at second planting. Sunshine Grade B+PKC at 4 t/ha significantly ($P<0.05$) improved the dry matter yield of maize by 62% during first planting and by 66% during second planting compared with the control. The combination of Sunshine Grade B+PKC at 4 t/ha and Aleshinloye Grade B+PKC at 4 t/ha could serve as alternative to mineral fertilizer for the production of maize with the additional advantage of enhancing better waste management.

Keywords: Dry matter yield, Maize, Nutrient uptake, Organic waste, Palm kernel cake.

Introduction

Maize (*Zea mays* L) is an important cereal crop in the humid and sub humid tropics; the crop which is an important source of carbohydrate (70.4%) is consumed by man in various ways. The grains are used in the manufacturing of alcohol, starch, and corn oil, while the stalk is used to make paper cardboard. It provides valuable roughages for dairy and beef cattle and constitutes a high proportion of the concentrate in livestock feeds (Ogundare *et al*., 2012,). Maize production in Nigeria has increased tremendously over the years especially in North Central Nigeria. About 2 – 3 million hectares of land are cropped to maize in Nigeria annually (FFD, 2002) resulting in the production of 5.4 million metric tons of maize (Tarfa *et al*., 2001). Despite the increase in production level, higher production level is still attainable except for the low fertility status of Nigerian soils. Tropical soils are beset with the problems of acidity, low nutrient contents, nutrient imbalance and erosion (Olowoake *et al*., 2013). The fragile nature of the soil, coupled with overuse of most arable crop lands as a result of continuous cropping has made it mandatory to apply fertilizer to the soils.

Organic wastes have been used as a source of plant nutrients for centuries. Organic waste materials were used as sole nutrient source for crop production before the advent of chemical fertilizers. Over time, however, the use of

organic waste material in farming was reduced significantly due to discovery of chemical fertilizer which is a ready source of plant nutrients. High population growth rate, rapid urbanization and mechanization forced farming communities to totally rely on chemical fertilizers. Inorganic fertilizer or petroleum based fertilizer for soil improvement and crop production is known as conventional farming method. The major limitation to the usage of chemical fertilizer is due to the adverse effect they have on plants such as poor plant quality, disease susceptibility and environmental pollution (Adeoluwa and Adeogun 2010). The use of inorganic fertilizer input is further constrained by unavailability of the right type of inorganic fertilizer at the right time coupled with high cost and lack of technical know-how (Chude, 1999). This had diverted the attention of agronomists towards making use of organic nutrients (organic manures as well as organic wastes) for improving soil fertility and increase crop production (Somani and Totawat, 1996).

Integrated approaches that sustain both agriculture and environment and maintain the long term ecological balance of the soil ecosystem are needed to reduce high cost of production and environmental pollution (Zahir *et al*., 2007).The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide. Several sources of organic materials and residues abound in Nigeria which can be processed, packaged and made available as branded organic fertilizer at a cheaper rate for home gardening, horticulture and farming as a whole (Olowoake and Adeoye, 2010; Olowoake *et al.,* 2013). Many experiments have also been conducted on the use of compost in combination with mineral fertilizer (Adeoye *et al*., 2008; Olowoake and Ojo 2014; Okubena-Dipeolu 2015 and Zhang *et al*., 2016).

Palm kernel cake, the by-product after extraction of oil, is normally used for the production of animal feeds. However, in most part of Nigeria the cake is sometimes used as fuel for cooking and fuel source in industry. The management of palm kernel wastes is a serious environmental problem in many Nigerian cities as it is produced in large amounts by a vibrant industry and mostly not properly disposed of which causes environmental problems. Using them as fuel is creates environmental issues and alternative methods of utilization are preferred.

This study was therefore carried out to investigate the efficacy of compost supplemented with palm kernel cake on improving the growth, nutrient uptake and dry matter accumulation of maize as well as its residual effect.

Materials and Methods

Two-phased pot experiments were conducted in the screenhouse of the College of Agriculture, Kwara State University, (Latitude 8^0 71$^{'}$N and Longitude 4^0 44$^{'}$E) Malete, during the 2015 planting season. The fertilizers used include; Aleshinloye Grade B (un-amended compost) produced from Aleshinloye fertilizer plant, Ibadan, Oyo State Nigeria. Sunshine Grade B (un-amended compost) a commercial organic fertilizers developed by Ondo State Government of Nigeria, Palm kernel cake (PKC) and NPK 15-15-15. The nutrient analysis of the Palm kernel cake (PKC) and composted materials; Aleshinloye Grade B and *Sunshine Grade B* are summarized in Table 1. Twenty four 4-litre plastic pots were filled with 5.5 kg of soil. The soil used for this experiment was a composite of surface soil (0-15 cm depth) collected from the Kwara State University Teaching and Research Farm, Malete, Kwara State, Nigeria. *Physico*-chemical analysis of the experimental soil used

in the screenhouse was carried out before the experiment. The sandy loam texture soils were collected at a depth of 0-15 cm, air-dried and passed through a 2 mm sieve. Chemical and physical properties were determined in the laboratory. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1951) and the soil pH was determined in 0.01M $CaCl_2$. Soil organic carbon and the total N were evaluated by the Walkey and Black (1963) method and the micro-Kjeldahl digestion method (Bremmer and Mulvaney, 1982), respectively. Available P was extracted by the method of Bray and Kurtz (1945), while exchangeable bases (Ca, Mg, K and Na) were extracted with neutral 1M NH_4OAc at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with using Perken-Elemer Atomic Absorption Spectrophotometer Model 305 B as described in A.O.A.C. (1992). Micronutrients were extracted with 0.1 EDTA and determined using atomic absorption spectrophotometer (Table 2).

The experiment was laid out in a completely randomized design (CRD) with three replications. The treatments used were;

1. Control (No fertilizer).
2. 50% Aleshinloye *Grade* B + 50% PKC- 2.0 t/ha (5.5 g)
3. 50% Aleshinloye *Grade* B + 50% PKC- 4.0 t/ha (11 g)
4. 50% Aleshinloye Grade B + 50% PKC- 6.0 t/ha (16.5 g)
5. 50% Sunshine Grade B + 50% PKC- 2.0 t /ha (5.5 g)
6. *50% Sunshine Grade B* + 50% PKC- 4.0 t /ha (11 g)
7. *50% Sunshine* Grade B +50% PKC- 6.0 t /ha (16.5 g)
8. NPK 15 –15-15 -60kgN /ha (1.1 g)

The compost supplemented with de-oiled palm kernel cake treatments were thoroughly mixed with soil in a plastic pot. Maize, *Zea mays* (L) variety TZSR-Y was used as the test crop. NPK 15-15-15 fertilizer was applied at the rate of 60 kgN/ha (Aduloju and Abdumalik, 2013) for the optimum growth of maize. The organic sources were applied a week before planting while the mineral fertilizer was applied two weeks after planting (Olowoake and Lawal, 2016). Four seeds were planted in each pot, but later thinned to two after germination. Plants were watered daily and weeding was also carried out as required. The plants were observed for six weeks after which they were harvested and analyzed for N, P and K contents based on the procedures described by Okalebo *et al.* (1993).

Data on plant height, number of leaves and stem girth were collected fortnightly. At six weeks after planting (WAP) maize plants were harvested from the ground level, oven dried at 70°C to a constant weight; and the weight was recorded as dry matter yield. The second experiment was set up to investigate the residual effects of compost supplemented with palm

Table 1: Composition of Major nutrients in Aleshinloye Grade B, Sunshine *Grade B* and Palm kernel de-oiled cake evaluated for cultivation of maize.

	Nutrient (%)		
Organic fertilizer	**N**	**P**	**K**
*Aleshinloye Grade B	1.2	0.8	2.9
**Sunshine Grade B	3.5	1.0	2.5
Palm kernel deoiled cake	2.5	0.15	0.58

Source:*Aleshinloye Fertilizer Company, Ibadan, Nigeria and ** Ondo State Government (2012)

kernel cake on the dry matter yield and nutrient uptake of maize. Maize variety TZSR-Y was re-seeded. The experiment was repeated without any fertilizer application at the second planting. Watering and weeding were carried out throughout the experimental period. The experiment was terminated at six weeks after planting (6 WAP). The plant parts were analyzed for nutrient concentration N, P, K (Okalebo *et al*., 1993). Nutrient uptake was determined by multiplying total dry matter yield (g) with nutrient content (%) (Anand and Guinto, 2017). The data collected were subjected to statistical analysis of variance (ANOVA) and significant differences among the treatment means were evaluated using Duncan's Multiple Range Test (DMRT) at 5 % probability level.

Table 2: Physical-chemical properties of experimental soil

Particulars	Soil Value
pH	6.7
Org. C (gkg^{-1})	6.84
Total N (gkg^{-1})	3.1
P Mehlich ($mgkg^{-1}$)	9.3
Exchangeable Acidity (c mol kg^{-1})	0.30
Exchangeable H+	0.30
Mg	4.54
Ca	19.8
Na	0.78
K	1.52
Extractable micronutrients (c mol kg^{-1})	
Cu	3.69
Mn	124.0
Fe	229.0
Zn	1.24
Physical composition (%)	
Sand	75.8
Silt	13.4
Clay	10.8
Textural class	Sandy loam

Results

Soil Analysis

The physico-chemical properties of the experimental soil revealed that the soil was slightly acidic and of sandy loam texture (Table 2).

Plant height, number of leaves and stem girth as affected by minerals and organic fertilizers

The plant height and number of leaves of the maize plants were significantly ($P<0.05$) increased with the application of organic fertilizer and NPK in both cropping cycles (Table 3) and were significantly higher ($P<0.05$) when compared with the control.

At 2, 4, and 6 WAP, maize plants in the 60 kgN/ha of NPK treatment were taller than those of other treatments by 24-40%, 11-34% and 7-33%, respectively. The control treatment consistently produced the shortest maize plant height. Application of NPK enhanced plant height compared with the application of enriched compost in the first trial. At the second cropping, maize plant height also differed significantly ($P<0.05$) at all weeks after planting among the fertilizer treatments (Table 3). Higher significant ($P<0.05$) maize plant heights observed at the second trials were obtained from application of Aleshinloye Grade B and Sunshine Grade B composts amended with PKC at 2 and 4 t/ha . These were maintained from 2 to 6 week after planting.

In first trial the number of leaves per plant differed significantly ($P<0.05$) among the different fertilizer treatments (Table 3). At 2, 4 and 6 weeks after planting, there was no significant difference among the fertilizers treatments. All the fertilized pots had higher number of leaves per plant than the control treatment. At 4 and 6 WAP, NPK pot had 1.4-

27% and 8- 34% more number of leaves than others. In the second trial all the fertilized pots had higher number of leaves per plant than the control treatment. At 4 and 6 WAP, application of Aleshinloye Grade B + PKC produced more leaves than NPK. The number of leaves per plant differed significantly (P<0.05) among the fertilizer treatments at 6 weeks after planting (Table 3). The control treatment consistently produced the least number of leaves per plant. Also at 6 WAP, the number of leaves in the Aleshinloye Grade B + PKC pot at 6 t/ha superseded other treatments by 1.3- 38%.

Stem girth at 2, 4 and 6 WAP differed significantly (Table 4) among the different fertilizer treatments. In first trial stem girth in the 60 kgN/ha of NPK pot was bigger than in other treatments at 2, 4 and 6 WAP by 3- 28%, 26- 50% and 17- 47%, respectively. The lowest stem girth was produced by the control treatment. Maize plant stem girth differed significantly (P<0.05) among fertilizer treatments in second trial. At 2, 4 and 6 weeks after planting the application of Sunshine Grade B +PKC at 4 and 6 t/ha, resulted in significantly higher stem girth than NPK while the control consistently had the smallest stem girth. The application of Sunshine Grade B + PKC at 6 weeks after planting produced significantly better stem girth than other compost treatment enriched with PKC.

Table 3: Growth parameters of maize as influenced by the application of different fertilizer types during the first and second planting in the screenhouse.

		Plant height (cm) WAP			Number of leaves WAP		
Treatment	Rate	2	4	6	2	4	6
		First cropping					
Control	0 t/ ha	15.2c	21.3d	30.8d	4.0b	5.3b	6.8d
Aleshinloye Grade B + PKC	2.0 t /ha	20.9b	26.3c	37.5c	5.0a	6.7a	8.2c
Aleshinloye Grade B + PKC	4.0 t /ha	21.3b	26.3c	38.5c	5.3a	6.8a	8.4c
Aleshinloye Grade B + PKC	6.0 t /ha	22.3b	28.0b	41.5b	5.3a	7.0a	9.3a
Sunshine Grade B+ PKC	2.0 t /ha	20.2b	26.3c	37.7c	5.0a	6.7a	8.2c
Sunshine Grade B+ PKC	4.0 t /ha	20.2b	26.4c	39.1c	5.1a	6.8a	8.5c
Sunshine Grade B+ PKC	6.0 t /ha	21.2b	28.5b	42.5b	5.2a	7.2a	9.5b
NPK 15 –15-15	60 kgN/ha	25.2a	32.0a	45.8a	5.3a	7.3a	10.3a
		Second cropping					
Control	0 t/ ha	5.9b	8.5d	12.3d	3.0b	4.5b	4.9c
Aleshinloye Grade B + PKC	2.0 t /ha	6.1b	12.7c	17.2c	4.5a	5.5a	5.8b
Aleshinloye Grade B + PKC	4.0 t /ha	7.8a	15.6a	20.0a	4.0a	6.0a	7.7a
Aleshinloye Grade B + PKC	6.0 t /ha	8.9a	16.5a	20.3a	4.0a	6.0a	7.9a
Sunshine Grade B+ PKC	2.0 t /ha	7.0a	13.8c	17.5c	3.7a	5.7a	5.2b
Sunshine Grade B+ PKC	4.0 t /ha	7.8a	16.7a	21.9a	3.8a	5.8a	7.7a
Sunshine Grade B+ PKC	6.0 t /ha	7.5a	16.9a	21.5a	3.8a	5.7a	7.8a
NPK 15 –15-15	60 kgN/ha	7.2a	14.4b	18.9b	4.0a	5.9a	5.8b

Means having the same letter within the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. PKC- Palm kernel cake

Table 4: Stem girth of maize as influenced by fertilizer types during the first and second cropping in the screenhouse

Treatment		Stem girth (mm)		
	Rate	2	4	6
		First cropping		
Control	0 t/ ha	2.70b	3.46d	4.0d
Aleshinloye Grade B + PKC	2.0 t /ha	3.33a	4.26c	5.08c
Aleshinloye Grade B + PKC	4.0 t /ha	3.29a	4.42c	5.31c
Aleshinloye Grade B + PKC	6.0 t /ha	3.59a	5.14b	6.20b
Sunshine Grade B+ PKC	2.0 t /ha	3.31a	4.38c	4.59c
Sunshine Grade B+ PKC	4.0 t /ha	3.61a	4.40c	5.01c
Sunshine Grade B+ PKC	6.0 t /ha	3.51a	5.08b	6.04b
NPK 15 –15-15	60 kgN/ha	3.74a	6.98a	7.51a
		Second cropping		
Control	0 t/ ha	1.09d	1.59d	3.21d
Aleshinloye Grade B + PKC	2.0 t /ha	1.37	3.05c	4.02c
Aleshinloye Grade B + PKC	4.0 t /ha	2.31a	4.29a	5.92a
Aleshinloye Grade B + PKC	6.0 t /ha	2.35a	4.35a	5.92a
Sunshine Grade B+ PKC	2.0 t /ha	1.39c	3.07c	4.21c
Sunshine Grade B+ PKC	4.0 t /ha	2.39a	4.19a	6.05a
Sunshine Grade B+ PKC	6.0 t /ha	2.39a	4.04a	5.87a
NPK 15 –15-15	60 kgN/ha	1.97b	3.95b	4.69b

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. PKC = Palm kernel cake

Dry shoot weight and nutrient uptake by maize

Table 5 shows that there was no significant ($P<0.05$) difference in the dry shoot weight of maize plants among the fertilizer treatments in first trial. The dry shoot weight in the NPK and Aleshinloye Grade B + PKC at 4 and 6 t/ha pot was larger than other treatments by 2-25%. The control treatment produced the smallest dry shoot weight. Dry shoot weight was significantly ($P<0.05$) influenced by the fertilizer treatments in second trial (Table 5). The Sunshine Grade B + PKC treatment at 4 and 6 t/ha produced the highest dry shoot weight while the control treatment had the smallest weight. Generally, all the compost treatments enriched with PKC produced higher dry shoot weight than application of 60 kgN/ha NPK (15:15:15) fertilizer.

Nutrient uptake of N, P, and K in maize plants differed significantly ($P<0.05$) among the different fertilizer treatments during the first and second trial (Table 5). For the N uptake, the highest value of 5.55 mg N / pot was observed in plants treated with NPK fertilizer and was significantly ($P<0.05$) higher than the values of other treatments including control. P uptake values show that NPK had highest value (2.89 mg P / pot). K uptake had the values of 23.69 mg K / pot from the treatment NPK 60

kgN/ha. However, Sunshine Grade B+ PKC at 2 t/ha had the lowest value of 11.91 mg K / pot among the treatment applications.

During the second trial, the uptake of N by maize plant shows that treatment 6.0 t /ha Aleshinloye Grade B + PKC had the highest uptake values of 3.83 mg N / pot, this value was significantly ($P< 0.05$) different from NPK, 2.0 t/ha Aleshinloye Grade B + PKC , 2.0 t/ha Sunshine Grade B + PKC and control. The treatments Aleshinloye Grade B + PKC and Sunshine Grade B+PKC both at 4.0 t/ha had the highest uptake values of 2.19 mg P / pot, this values was not significantly ($P<0.05$) different from 6.0 t / ha Aleshinloye Grade B + PKC and Sunshine Grade B+PKC at 6.0 t / ha. Also, K values of Aleshinloye Grade B +PKC (5.26 mg K) was significantly different from NPK. However, control had the lowest value of 1.61 mg K / pot.

Discussion

The soil was generally low in total N, and P. Thus, the soil required fertilizers or soil amendment to improve its fertility. The total N content, 3.1 g/kg, of experimental soil was below the critical level of 4.3 g kg^{-1} (Aduloju, 2004), while the available P of 9.3 mg kg^{-1} was below the critical level of 10-16mg kg^{-1} (Adeoye and Agboola, 1985). The K status of the soil which

Table 5: Dry shoot weight and nutrient uptake by maize as influenced by application of fertilizer types during the first and second cropping in the screenhouse

Treatments	Rate	Dry shoot weight (g)	Nutrient uptake mg/pot		
			N	P	K
		First cropping			
Control	0 t/ ha	4.0b	1.15d	0.93d	10.63d
Aleshinloye Grade B + PKC	2.0 t /ha	5.0a	2.67c	1.97c	16.79b
Aleshinloye Grade B + PKC	4.0 t /ha	5.3a	3.10c	1.92c	16.97b
Aleshinloye Grade B + PKC	6.0 t /ha	5.3a	4.50b	2.58b	18.75b
Sunshine Grade B+ PKC	2.0 t /ha	5.0a	2.45c	1.95c	11.91c
Sunshine Grade B+ PKC	4.0 t /ha	5.1a	2.43c	2.00c	16.35b
Sunshine Grade B+ PKC	6.0 t /ha	5.2a	4.60b	2.66b	19.88b
NPK 15 –15-15	60 kgN/ha	5.3a	5.55a	2.89a	23.69a
		Second cropping			
Control	0 t/ ha	3.0c	1.48d	0.76d	1.61d
Aleshinloye Grade B + PKC	2.0 t /ha	4.5a	2.39c	0.95c	2.56c
Aleshinloye Grade B + PKC	4.0 t /ha	4.0a	3.35a	2.19a	5.26a
Aleshinloye Grade B + PKC	6.0 t /ha	4.0a	3.83a	2.09a	5.22a
Sunshine Grade B+ PKC	2.0 t /ha	3.7a	2.79b	0.91c	3.69b
Sunshine Grade B+ PKC	4.0 t /ha	3.8a	3.47a	2.19a	5.15a
Sunshine Grade B+ PKC	6.0 t /ha	3.8a	3.48a	2.07a	5.17a
NPK 15 –15-15	60 kgN/ha	3.4b	2.57b	1.30b	3.52b

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level. PKC- Palm kernel cake

is 1.52 cmol/kg was higher than the critical level of 0.2 cmol kg^{-1} (Adeoye, 1986). Therefore, indicating that the soil may be poor in nutrients. The values of maize plant height, stem girth and number of leaves were observed to be low in the pot without any fertilizer treatment when comapared to composts enriched with PKC and NPK fertilizer treatments respectively. This might be as a result of low nutrients status of the soil especially N and P. The high values of plant height and number of leaves of maize plant grown in the pot treated with NPK 15:15:15 fertilizer over Aleshinloye Grade B and Sunshine Grade B during the first cropping might be as a result of the quicker release of N, P and K which are the major nutrients required by crop for vegetative growth, seed and root development. This observation is in line with the findings of Olowoake (2014) that mineral fertilizers quickly release their nutrients to the soil than organic wastes.

The residual fertilizer treatments from Aleshinloye Grade B + PKC and Sunshine Grade B + PKC at 4 t/ha treatment having better plant height, number of leaves and stem girth compared to other treatments in this investigation could be as a result of better nutrient mineralization with time of application. This is in line with the report of several authors Gabrielle *et al*. (2004), Olowoake (2014) and Ayanfeoluwa (2015) that organic fertilizers are characterized with slow release of nutrients, which leads to reduction in soil nutrient loss.

The significant increase in total dry shoot weight over control treatment during the first trial could be due to the fact that nutrient are readily released from inorganic fertilizer than from organic fertilizer because organic fertilizer has to undergo mineralization before the nutrients are made available for maize plant to use. A similar result was obtained by Adeoye *et al*. (2001) when he reported that, maize was able to utilize the readily available nutrient from mineral fertilizer for its growth and development.

The highest N and K uptake obtained by the NPK treatment at first planting was as a result of the product of the concentration of Nitrogen, potassium and dry matter yield. This was in agreement with Olowoake and Adeoye (2010) findings that accumulation of N, P and K in maize is similar to the dry matter yield obtained.

Conclusion

The residual study showed that the use of compost supplemented with palm kernel cake fertilizer resulted to significantly higher maize growth, dry matter yield and nutrient uptake compared to NPK and control treatments. An application rate of 4 tonnes per hectare of Aleshinloye Grade B compost + PKC and Sunshine Grade B +PKC led to higher dry shoot weight and nutrient uptake of maize than using NPK 15-15-15 at second planting. Thus, for enhanced performance of maize in the test soil; application of a combination of compost and palm kernel cake could be an alternative to mineral fertilizer.

References

Adeoluwa, O.O. and Adeogun, O. O. (2010). Evaluation of feather as organic fertilizers on Amaranthus (*Amaranthuscaudatus*). In: Proceedings of 1st Technical workshop on Organic Agriculture Conference 6-8 September, 2010, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. pp.16-19.

Adeoye, G. O. and Agboola, A. A. (1985). Critical levels for soil pH, available P, K, Zn and Mn and maize ear leaf content of P, Cu and Mn on sedimentary soils of southwestern Nigeria. *Fertilizer Research* 6(1): 65-67.

Adeoye, G.O., Sridhar, M.K.C., and Ipinmoroti, R.

R. (2001). Potassium recovery from farm waste for crop growth. *Soil Science and Plant Analysis* 32(15, 16):2347-2358.

Adeoye, G.O., Sridhar, M.K.C., AdeOluwa, O.O., Oyekunle, M., Makinde, E.A., and Olowoake, A. A. (2008). Comparative Evaluation of Organo-mineral fertilizer (OMF) and Mineral Fertilizer (NPK) on yield and quality of maize (*Zea mays* (L) Moench). *Nigeria Journal Soil Science* 18: 141-147.

Adeoye, G.O. (1986). Comparative studies of some extractants for sedimentary soil of South Western Nigeria. Ph.D. Thesis, University of Ibadan, Ibadan. 201pp

Aduloju, M. O. and Abdulmalik, T. O. (2013). Effect of Zinc and N-P-K application on Phosphorus and Zinc uptake by maize (*Zea mays* L.) on an Alfisol. *Global Journal of Bioscience and Biotechnology* 2(4): 496-499.

Aduloju, M.O. (2004). Acid Extractable Micronutrients (Mn and Zn) in Selected soils of vegetables producing Areas of Kwara State, Nigeria. *Nigeria Journal of Horticultural Science* 9:116-199.

Anand, S. and Guinto, D.F. (2017). Dry matter accumulation, nutrient uptake, nutrient use efficiency of two improved cultivars of Taro (*Colocasia esculenta*) under screenhouse conditions in Samoa. *Journal of Agriculture and Ecology Research International* 11(4) : 1-11.

AyanfeOluwa O. O. E., AdeOluwa, O.O., and Aduramigba-Modupe, V. O. (*2015).* Residual Fertilizer Value of OBD-plus Compost for Maize (*Zea mays*) Production. *International Journal of Plant and Soil Science 6(3):* 162-167.

A.O.A.C. Official methods of analysis of the association of official analytical chemists (1992). Official Methods of Analysis, A.O.A.C. Washington D.C., U.S.A. 1359p.

Bouyoucos, G.H. (1951). A calibration of the hydrometer for the making mechanical analysis of soil. *Agronomy journal.* 43: 434-438.

Bray, R.H. and Kurtz, L.T. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science.* 59: 39-45.

Bremner, J. M. and Mulvaney, C. S. (1982). Nitrogen total. In: Methods of Soil Analysis Part 2. (eds. A.L. Page, R.H. Miller and D.R. Kenney). SSSA. Madison. USA. pp. 595-624.

Chude, V.O. (1999). Perspectives on fertilizer use in the 21st century. Book of abstracts, Soil Science Society of Nigeria Benin, 1999. 25th Annual Conf. Held at precious Palm Royal Hotel from 21st –25th Nov, 1999.

Federal Fertilizer Department (FFD) (2002). Fertilizer Use and Management Practices for Crops in Nigeria. In: E.A.Aduayi, V.O.Chude, B.A. Adebusuyi and S.O.Olayiwola (eds.) Fertilizer Use and Management Practices for Crops in Nigeria. A co-publication of the Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development and National Programme on Food Security Abuja, Nigeria.

Gabrielle, B., Da-Silveira, J., Hovot S., and Francou, C. (2004). Simulating urban compost waste effects on carbon and nitrogen dynamics using biochemical index. *Journal of Environmental Quality* 33:2333-2342.

Ogundare, K., Agele, S., and Aiyelari, P. (2012). Organic amendment of an ultisol: effects on soil properties, growth, and yield of maize in Southern Guinea savanna zone of Nigeria. International *Journal of Recycling of Organic Waste in Agriculture,* 1(11): 1-7.

Okalebo, J.R., Gathua, K.W., and Woomer. P. L. (1993). Laboratory method of soil and plant analysis: a working manual. Tropical Soil Biology and Fertility Programme (TSBF), Nairobi, Kenya.88pp.

Okubena-Dipeolu, E. A. (2015). Effects of organic, organomineral and NPK fertilizer treatments on the sensory evaluation of *Amaranthus cruentus* soup in Ikorodu and LASU. *American Journal of Research Communication* 3 (2): 67-75.

Olowoake, A. A (2014). Influence of organic, mineral and organomineral fertilizers on growth, yield and soil properties in grain amaranth (*Amaranthus cruentus.* L) *Journal of organics* 1(1): 39-47.

Olowoake, A.A. and Adeoye, G.O. (2010). Comparative efficacy of NPK fertilizer and composted organic residues on growth, nutrient absorption and dry matter accumulation in

maize. *International Journal of Organic Agriculture Research and Development 2:* 43-53.

Olowoake A. A. and Lawal, O.I. (2016). Effect of organomineral and NPK fertilizer application on growth and yield of grain amaranth (*Amaranthus cruentus* L.) *Tropical Agriculture* 93(2):139-146.

Olowoake, A. A. and Ojo, J.A. (2014). Effect of fertilizer types on the growth and yield of *Amaranthus caudatus* in Ilorin, Southern Guinea Savanna Zone of Nigeria. *Advances in Agriculture* 3(4): 121-125.

Olowoake, A. A., Idowu, E.O., and Adeoye, G. O. (2013). Comparative effect of conventional fertilizers and organic fertilizers in pepper production (*Capsicum frutescens*). *International Journal of Organic Agriculture Research and Development 8:* 1-9.

Somani, L.L., and Totawat, K. L. (1996). Soil conditioners and amendments. Agrotech publication Academy, Udaipur. 1st edition. pp. 28 – 160.

Tarfa, B.D., Uyobisere, E.O., Chude, V.O., Raji, B.A., and Yaro, D.T. (2001): Effect of the complementary use of foliage of *Azadirachta indica, Parkia biglobosa and* NPK on yield and nutrients uptake of maize in a savanna soil. *Nigerian Journal of Soil research* 2: 43- 50.

Walkey, A. and A.I. Black (1934). An examination of the Degtjareff method for determining soils organic matter and proposed modification of the chronic acid titration method. *Soil Science* 37: 29-38.

Zahir, Z. A., Naveed, M., Zafar, M.I., Rehman, H. S., Arshad, M., and Khalid, M. (2007). Evaluation of composted organic waste enriched with nitrogen and l-tryptophan for improving growth and yield of wheat (*Triticum aestivum*.). *Pakistan Journal of botany* 39(5): 1739-1749.

Zhang, Y., Caihua L., Yanwei, W., Yimin, H., Peter C., Zhang, J., and Xiaolin, L. (2016). Maize yield and soil fertility with combined use of compost and inorganic fertilizers on a calcareous soil on the North China Plain. *Soil and Tillage Research* 155: 85–94.