



Contents lists available at opensci.com

E-ISSN: 2776-7205

Applied Research in Science and Technology

DOI: 10.33292/areste.v6i1.139

Journal homepage: <https://areste.org/index.php/oai>



Response of Fluted Pumpkin (*Telfairia occidentalis* Hook. F) to Wood Ash Rates in An Ultisol, Southeastern Nigeria

Janet Oliver Orji¹, Angus Onwudiwe Ikeh¹, and Alice Nnenna Amanze²

¹Department of Crop Science, Faculty of Agriculture, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria

²Department of Agricultural Extension, Faculty of Agriculture, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria

*Correspondence: E-mail: janet.orji@uaes.edu.ng

ARTICLE INFO

Article History:

Received 3 July 2025

Revised 28 August 2025

Accepted 9 September 2025

Published 1 May 2026

Keywords:

Fluted pumpkin,

Foliar,

Pod yield,

Wood ash.

ABSTRACT

Background: Fluted pumpkin is a major leafy vegetable widely cultivated and consumed in Nigeria and other rainforest ecological zones of West and Central Africa. The cultivation of this crop faces challenges due to the low soil fertility of the ultisols found in southeastern Nigeria, making it difficult for farmers in the region to achieve bumper harvests of both foliage and pods.

Aims: The experiment aimed to evaluate the response of fluted pumpkin (*Telfaria occidentalis* Hook. F) to varying rates of wood ash application in an ultisol soils. This study seeks to determine the optimal wood ash level that improves soil fertility and enhances the growth and yield of fluted pumpkin, thereby providing sustainable agricultural practices for farmers in southeastern Nigeria.

Methods: The field experiment was conducted to evaluate the effect of wood ash application on growth and yield of fluted pumpkin (*Telfaria occidentalis* Hook. F). The experimental treatments were four wood (dried oil palm rachis) ash rates; 0, 2, 4 and 6 t/ha. The treatment was laid in a randomized complete block design, replicated four times.

Results: The results showed that the application of wood ash enhanced growth and yield of fluted pumpkin. The treatment of 6t/ha wood ash produced 19.71 t/ha foliar yield. The treatment of 4t/ha produced 18.63 t/ha foliar yield. The least foliar yield, 8.81 t/ha was recorded in the control treatment. Comparing the number of pods per plant, the treatment of 6t/ha wood ash produced significant number of pods per plant; 3.60, followed by 3.43 fluted pumpkin pods per plant recorded in the treatment of 4t/ha wood ash. The least number of pods per plant; 1.12 was recorded in the control treatment. The treatment that received 6t/ha oil palm rachis ash (OPRA) produced 26.81 t/ha pod, followed by 25.01 t/ha recorded in 4t/ha wood ash rate. The least pod yield; 7.44 t/ha was recorded in the control treatment. The study revealed that application of wood ash to fluted pumpkin could assist farmers in achieving bumper harvest in the study area. Farmer in the study area should adopt the application of 4t/ha of wood ash to fluted pumpkin.

To cite this article: Orji, J. O., Ikeh, A. O., Amanzemanze, A. N. (2026). Response of fluted pumpkin (*Telfaria occidentalis* Hook. F) to wood ash rates in an ultisol, Southeastern Nigeria. *Applied Research in Science and Technology*, 6(1), 1–9.

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1. Introduction

One of the significant frontiers that can greatly contribute to global food security is the expansive humid tropical region, where soils have the potential for arable crop production (Buol *et al.*, 2011; Ikeh *et al.*, 2016). Unfortunately, many of these soils are acidic, specifically Oxisols and Ultisols, which are characterized by low base status and often result in poor crop growth and yields. This issue arises from the high concentration of hydrogen ions (H^+) in the soil solution, which adversely affects the availability and uptake of several essential metallic ions. Consequently, deficiencies in calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), and molybdenum (Mo) occur, while elements such as aluminium (Al), iron (Fe), and manganese (Mn) are present in excessive amounts (Ibia & Udo, 2019).

Furthermore, clay, aluminum (Al), and iron (Fe) ions and their oxides convert both native and applied phosphorus (P) into insoluble forms through various fixation processes (Brady & Weil, 2002). In Nigeria, Ultisols are predominantly found in the southern regions, where the parent materials of Coastal Plain Sands and the excessive rainfall contribute to the formation of highly weathered and leached soils. These soils typically exhibit low organic matter content and cation exchange capacity, which reflect a mineralogy characterized by kaolinitic and low-activity clay minerals composed of Fe and Al oxides (Juo & Wilding, 1996). A significant challenge is addressing acid soil infertility, as evidenced by low nutrient levels (deficiencies) and nutrient imbalances. Developing practical management systems that farmers can adopt is essential for achieving reasonable and sustained high crop yields (Ayodele & Shittu, 2014; Ikeh *et al.*, 2017).

Ultisols dominate southeastern Nigeria (over 70% of the land) and are highly weathered, acidic, nutrient-poor, with low cation exchange capacity, and formed on parent materials such as Coastal Plain Sands. These soils are crucial to the region's humid tropical agriculture, but their inherent poor-quality leads to challenges such as erosion and nutrient depletion, necessitating careful management (Onweremadu, 2007; Ibia, 2005). The ultisols of southeastern Nigeria are highly weathered and leached soils formed on Coastal Plain Sands under an excessive rainfall regime (Ayodele & Shittu, 2014).

In the soils of southeastern Nigeria, the application of mineral fertilizers has decreased soil pH, leading to unstable, unproductive soil conditions. Despite the environmentally detrimental and ecologically unsound characteristics of inorganic fertilizers in Ultisols, there is still a significant shortage of these fertilizers in the region. As a result, it has become essential to explore locally available alternatives (Sampson *et al.*, 2025). Research by Akpan *et al.* (2024) suggests that using wood ash as an organic fertilizer, in combination with lime, can improve crop yields and enhance soil health compared with traditional inorganic fertilizers.

Fluted pumpkin (*Telfaria Occidentalis* Hook. F.) is an indigenous vegetable consumed in Nigeria. It is a leafy vegetable that belongs to the family Cucurbitaceae. Fluted pumpkin is one of the important leafy Vegetables in Nigeria, grown and consumed in rural and urban areas. In Nigeria, the young shoots and leaves of the plant are primarily used in soups as a source of vegetables and herbal medicine. The fruit could be boiled and eaten or fermented and used to prepare local seasoning known as ogiri among the Igbo tribes of southeastern Nigeria. The seeds are rich in protein and fat and therefore can contribute to a well-balanced diet. It is a crop of nutritional and commercial importance in southern Nigeria. Nutritionally, it is grown mainly for its leaves and edible seed because they contribute to good health by providing inexpensive sources of minerals and vitamins needed to supplement people's diets, which are mainly carbohydrates. Commercially, the production serves as a major source of income to the farmers and their households because it can give high yield per unit area of land and hence generate high income (Idem *et al.*, 2012).

One of the major problems limiting crop production, including fluted pumpkin, is soil fertility (Akata *et al.*, 2025). This has so far been checked by applying plant nutrients to the soil, either in organic or inorganic form. Soil fertility is a critical factor in plant growth and yield. Traditional agricultural practices often use organic fertilizers to enhance soil nutrient levels and improve crop performance. Among the various organic amendments available, wood ash has attracted attention for its high mineral content and potential to improve soil properties.

Wood ash contains calcium, which strengthens cell walls and improves the overall structural integrity of plants. This is particularly beneficial for fluted pumpkin, as it helps the plant develop strong vines and fruits that are less susceptible to diseases and pests. The high phosphorus content in wood ash also promotes root development, leading to stronger, more resilient plants. Phosphorus is essential for energy transfer and root establishment, and this can be particularly important in the early stages of pumpkin growth (Ikeh *et al.*, 2023).

According to Akata *et al.* (2016) & Ikeh *et al.* (2023), the application of wood ash enhances crop growth and yields in acidic soils due to the addition of nutrients and its capacity to neutralize acidity, which may result from fertilizer usage, by reducing aluminum solubility (Ikeh *et al.*, 2016). A study by Ikeh *et al.* (2025a) demonstrated that incorporating organic manure into the soil in a groundnut trail shifts the pH from acidic to nearly neutral within four months. Furthermore, the use of wood ash as a liming agent boasts a high acid-neutralizing capacity in soils, attributed to the formation of hydroxides and carbonates during combustion and conditioning processes (Holmberg & Claesson, 2001). Wood ash has been shown to enhance microbial activity and alter community composition, with significant implications for microbial processes and nutrient cycling (Olubode *et al.*, 2017). Olubode *et al.* (2017) reported that wood ash can effectively be used for the amelioration of acidic soils instead of liming and further stated that the utilization of wood ash in soybean, which is available in huge amounts, may partially replace expensive soil conditioners and fertilizers.

The research gap in the current literature on the use of wood ash as a soil amendment centers on its specific effects on the growth and yield of fluted pumpkin (*Telfairia occidentalis*) across various soil types and environmental conditions. While existing studies have highlighted the general benefits of wood ash for improving soil health and reducing reliance on synthetic fertilizers, there is limited empirical evidence on the optimal application rates and frequencies for fluted pumpkin cultivation.

Furthermore, much of the research focuses on the biochemical composition of wood ash and its effects on a broad range of crops, omitting detailed studies specifically targeting fluted pumpkin. As fluted pumpkin is a vital vegetable crop for many smallholder farmers in Nigeria and West Africa, understanding the nuances of how wood ash influences its growth, yield, and overall productivity under varying agronomic practices is essential. *The novelty of this research is the determination of the optimal oil palm rachis wood ash application rate for enhancing fluted pumpkin productivity and ameliorating Ultisol fertility constraints in southeastern Nigeria.*

Additionally, there is a need to explore the long-term effects of wood ash application on soil health in sustainable farming systems. Investigating these parameters can provide valuable insights into optimizing the use of wood ash, helping farmers make informed decisions that enhance crop production while ensuring environmental sustainability. By addressing this research gap, future studies can offer tailored recommendations for farmers, potentially leading to improved agricultural practices and economic outcomes for those cultivating fluted pumpkin.

2. Methods

2.1 Study Site

This experiment was conducted at the Teaching and Research Farm of the University of Agriculture and Environmental Sciences, Umuagwo, Imo State. The study was carried out in Umuagwo, Ohaji-Egbema, South-east Nigeria (latitude 5° 15' N and longitude 6° 58' E). The soils were derived from

coastal plain sands (Benin formation). Ohaji-Egbema is situated in the humid tropics with a total mean annual rainfall of about 2500 mm and an annual temperature range of 26-30°C (NIMET, 2014). Physiographically, the area's landscape is a low-lying plain, with almost no part of the town exceeding 65 m above sea level. In both locations, the prevailing slope was gentle, averaging about 1%. The original vegetation was rainforest, which has been depleted by human activities, primarily agriculture and deforestation. The major socio-economic activity of the area is farming. Soil fertility regeneration is through bush-following, while slash-and-burn is the major land-clearing technique. The experimental site was previously used for groundnut and maize intercrop.

2.2 Experimental Design

The experimental treatments were wood ash (oil palm rachis ash) rates (0, 2, 4, and 6 t/ha). The experiment design used was a randomized complete block design (RCBD). The treatments were replicated four times. The experimental site occupied an area of 24 m × 22 m (528 m²). Each plot was 4m x 3m (12 m²). Each replication has 4 plots, for a total of 16. Each plot was separated with other by 1.5m spacing, while each block was separated by a 2 m pathway.

2.3 Soil Sampling

Composite soil samples were collected with the aid of a soil auger, before planting and at harvest, at two soil depths: 0-15 cm. The soil samples were collected in polythene bags, labeled, air-dried, crushed, and sieved through a 2.0 mm mesh for physico-chemical analysis.

2.4 Soil Analysis

The following soil physico-chemical properties were determined (i) Soil pH: Soil pH was determined in water 1:2 (soil: water ratio) using a pH meter with glass electrode (Bates, 1954). (ii) Total Nitrogen: Total nitrogen in the soil was determined by micro-Kjeldahl digestion and the distillation method (Ibia & Udo, 2009). (iii) Organic Matter: Organic matter content of the soil was determined by the dichromate wet oxidation method of Walkley and Black (1934). (iv) Available Phosphorus: Available P in the soil was determined by Bray-1 method (Bray and Kurtz, 1945). (v) Exchangeable Cations: Exchangeable cations were extracted with neutral NH₄ OAC. Calcium and magnesium were determined in the extract by EDTA titration (Jackson, 1962), while potassium and sodium were determined using flame photometer.

2.5 Agronomic Practices

- i) Land preparation: The experimental site was manually prepared by slashing, raking, and marking out with measuring tapes, rope, and pegs. Ridges of 5m x 5m were made with spades and native cultivating hoes that are predominantly used with the farming systems of southeastern Nigeria.
- ii) Planting: The planting was done in the first week of April, 2024. The fluted pumpkin seeds, sourced from Eke Umuagwo Community Market were planted on the crests of the seedbeds of 4m x 3m. A total of three (3) seeds were planted at a spacing of 1m x 1m and later thinned down to two seeds at two weeks after planting (WAP).
- iii) Wash Application: Wood ash as organic soil amendments were incorporated into the soil during land preparation on a treatment basis.
- iv) Weeding: Manual weeding was carried out using a native weeding hoe at 3 and 9WAP.
- v) Harvesting: Foliage harvesting was done at fortnightly while pod harvesting was at seven (7) months after planting (MAP), when the plant attained 100% senescence.

The following growth and yield parameters were assessed:

- vi) Data Collection and Analysis
 - a) Vine length: Vine length was measured at 2, 4, 6, and 8 weeks after planting (WAP) with aid of measuring tape. The measurement was from the base to the terminal bud in centimeter.

- b) Number of leaves per Plant: Number of leaves per plant was determined by counting all the functional leaves from the five (5) tagged fluted pumpkin in a plot.
- c) Number of Pods per Plant: The number of pods per plant was determined by counting the total number of pods attached to each stand.
- d) Pod Yield (t/ha) was determined with a top load weighing balance. The weight in kilograms was converted to tonnes per hectare.

2.6 Statistical Analysis

Data collected on the growth and yield were subjected to analysis of variance (ANOVA), and treatment means separated using the least significant difference (LSD) (P= 0.05) as described in [Steel et al. \(1997\)](#).

3. Results

3.1 Chemical Composition of Oil Palm Rachis Ash

The chemical composition of oil palm rachis ash is presented in Table 1. The ash pH was 11.36, and total N was 0.06%. The Ca, Na, K and Mg values were 41.33, 5.01, 10.63 and 5.71 cmol/kg, respectively. The P-available concentration was 14.82 mg/kg.

Table 1. Chemical composition of oil palm rachis ash

Nutrients	Unit	Values
Soil pH		11.36
Total N	%	0.06
Ca	cmol/kg	41.33
Na	cmol/kg	5.01
K	cmol/kg	10.63
Mg	cmol/kg	5.71
Available P	mg/kg	14.82

3.2 Soil Physico-chemical Properties of the Experimental Field Before and After Planting

The physico-chemical properties of the soil at the experimental site, before and after planting, are summarized in table 2 and table 3. The results indicate that the initial soil pH was 5.50, which increased to 6.20 with the application of 2 t/ha of wood ash and further to 8.43 with 6 t/ha of wood ash at harvest. The organic matter content and exchangeable bases exhibited a similar trend. The initial calcium content was recorded at 2.11 cmol/kg, increasing to 3.23 cmol/kg after the application of 6t/ha of wood ash. Across all soil nutrients assessed, the lowest value at harvest was recorded in the control treatment.

The particle size analysis revealed a consistent pattern, with sand being the dominant particle size, followed by clay, before silt. The result showed that the treatment of 6t/ha wood ash had a lower sandy percentage with a higher percentage of silt content at harvest.

Table 2. Soil chemical properties of the experimental field before and after planting

Wood Ash Rate (t/ha)	Soil pH	Organic Matter (%)	Total N (%)	Ca (cmol/kg)	Na (cmol/kg)	K (cmol/kg)	Mg (cmol/kg)	Available P (mg/kg)
	5.5 ^d	1.93 ^c	0.07 ^b	2.11 ^c	0.15 ^c	0.86 ^c	1.33 ^c	32.26 ^c
0	5.5 ^d	1.55 ^d	0.06 ^b	1.97 ^d	0.13 ^d	0.71 ^d	0.92 ^d	29.33 ^d
2	6.2 ^c	2.01 ^b	0.07 ^b	2.33 ^b	0.14 ^c	0.99 ^b	1.45 ^b	34.23 ^b
4	7.6 ^b	2.28 ^a	0.07 ^b	3.16 ^a	0.17 ^b	1.01 ^a	1.62 ^a	35.12 ^a
6	8.43 ^a	2.39 ^a	0.08 ^a	3.23 ^a	0.19 ^a	1.01 ^a	1.70 ^a	35.33 ^a

LSD	0.53	0.27	0.008	0.27	0.019	0.094	0.19	1.33
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Table 3. Soil particle size of the experimental field before and after planting

Wood Ash Rate (t/ha)	Sand (%)	Silt (%)	Clay (%)
	83.3 ^a	7.78 ^d	8.92 ^b
0	83.26 ^a	7.55 ^c	9.19 ^a
2	83.5 ^a	7.39 ^c	9.11 ^a
4	83.4 ^a	7.47 ^c	9.13 ^a
6	82.5 ^b	8.8 ^a	8.7 ^c
LSD	0.27	0.19	0.20

3.2 Vine Length of Fluted Pumpkin as Influenced by Wood Ash Rates

The impact of wood ash on the length of fluted pumpkin vines is summarized in Table 4. The results indicated a significant difference ($p < 0.05$) at 4, 6, and 8 weeks after planting (WAP). Specifically, an increase in wood ash levels led to a rise in vine length. The treatment involving 6 tons of wood ash per hectare demonstrated notable vine lengths of 20.33 cm, 44.38 cm, 70.23 cm, and 78.13 cm at 4, 6, and 8 WAP, respectively. The control treatment (no soil amendment) recorded the shortest vine lengths of 9.22 cm, 15.99 cm, 22.99 cm, and 25.44 cm during the same periods.

Table 4. Vine length of fluted pumpkin as influenced by wood ash rates

Treatments	Weeks after planting			
	2	4	6	8
	cm			
0	9.22 ^d	15.99 ^d	22.91 ^d	25.44 ^d
2	11.45 ^c	26.77 ^c	45.73 ^c	59.28 ^c
4	16.40 ^b	33.48 ^b	64.13 ^b	65.77 ^b
6	20.33 ^a	44.38 ^a	70.23 ^a	78.13 ^a
LSD($p < 0.05$)	3.17	3.83	4.34	4.67

3.3 Number of Leaves per Plant as Influenced by Wood Ash Rates

The number of leaves per plant, influenced by the application of wood ash, demonstrated significant differences at 4, 6, and 8 weeks after planting (WAP) as shown in Table 5. The treatment with 6 tons per hectare (t/ha) of wood ash resulted in a notably higher leaf count, with averages of 25.91, 30.44, and 40.49 leaves per plant at 4, 6, and 8 WAP, respectively. Additionally, the treatment using 4 t/ha of wood ash yielded 43.65 leaves per plant at 8 WAP. The least leaf counts were recorded in the control treatment, with mean values of 8.76, 11.88, and 16.67 leaves per plant.

Table 5. Number of leaves per plant as Influenced by Wood Ash Rates

Treatments	Weeks after planting			
	2	4	6	8
0	3.37 ^a	8.76 ^c	11.88 ^c	16.67 ^d
2	5.63 ^a	18.66 ^b	24.81 ^b	30.12 ^c
4	5.76 ^a	23.32 ^a	28.71 ^a	36.12 ^b
6	5.79 ^a	25.91 ^a	30.44 ^a	40.43 ^a
LSD($p < 0.05$)	NS	3.11	3.67	4.49

3.4 Yield and Yield Components of Fluted Pumpkin

The results concerning foliar yield, number of pods per plant, and pod yield are detailed in Table 6. The application of wood ash to fluted pumpkin significantly enhanced foliar yield. Specifically, the treatment with 6t/ha of wood ash yielded 19.71 t/ha, while the 4t/ha treatment resulted in 18.63 t/ha. The lowest foliar yield at 8.81 t/ha was recorded in the control treatment.

The number of pods per plant was also significantly influenced by the rates of wood ash ($p<0.05$) (Table 6). The treatment with 6t/ha of wood ash achieved the highest number of pods per plant, averaging 3.60, followed closely by the 4t/ha treatment with an average of 3.43 pods. The control treatment, however, had the lowest pod count, with only 1.12 pods per plant.

In terms of pod yield, the application of wood ash resulted in significant differences ($p<0.05$) as shown in Table 6. The treatment receiving 6t/ha of wood ash produced a pod yield of 26.81 t/ha, while the 4t/ha treatment yielded 25.01 t/ha. The control treatment recorded the least pod yield at 7.44 t/ha.

Table 6. Yield and yield components of fluted pumpkin

Treatments	Foliar Yield	Number of Pods per Plant	Pod Yield (t/ha)
0	8.81 ^c	1.12 ^b	7.44 ^c
2	13.80 ^b	2.33 ^a	17.39 ^b
4	18.63 ^a	3.43 ^a	25.01 ^a
6	19.71 ^a	3.60 ^a	26.81 ^a
LSD($p<0.05$)	3.61	1.41	3.36

4. Discussion

Soil chemical properties, such as organic matter, total nitrogen, and exchangeable cations, were found to be low, except for high levels of available phosphorus before planting. The observed deficiency in soil nutrients at the experimental site before planting can be attributed to continuous cultivation without the optimal incorporation of organic materials to enhance soil organic matter.

Post-planting soil analysis revealed an increase in nutrient levels following the application of wood ash. Before planting, the soil at the experimental site exhibited a medium acidity level, with a pH of 5.50. According to [Brady and Weil \(1999\)](#), soils within a pH range of 5.2 to 5.6 are classified as having medium acidity. After applying wood ash, higher pH values—ranging from 6.2 with 2 tons per hectare to 8.63 with 6 tons per hectare—were recorded at harvest. This increase is likely due to the liming effects of the wood ash biomass added. [Ikeh et al. \(2023\)](#) reported that using wood ash as a soil amendment effectively reduced soil acidity to levels conducive for the production of egusi melon (*Colocynthis citrullus*) in an ultisol of southeastern Nigeria. As a calcium-containing mineral, wood ash raises the soil pH. In a similar context, [Akata et al. \(2016\)](#) noted that the use of oil palm empty fruit bunch ash as an amendment resulted in increased soil pH values compared to non-ash-treated soils in cassava farms within the rainforest ecology of southeastern Nigeria.

The performance observed in the control treatment indicated that the soil possessed a low fertility status. [Ikeh et al. \(2025b\)](#) have reported that wood ash serves as an effective soil amendment for enhancing plant growth and yield, particularly for crops like egusi-melon and cucumber, which both belong to the same plant family as fluted pumpkin. The positive effects of wood ash on pumpkin growth are attributed to its capacity to improve soil pH, supply essential macronutrients, and enhance soil structure. However, its effectiveness is influenced by various factors, including application rate, soil type, and the existing fertility of the soil.

According to [Pitman \(2006\)](#), wood ash also affects the decomposition of soil organic matter and microbial activity. The introduction of ash encourages microbial processes such as nitrification and mineralization, which enhance the availability of nitrogen and other nutrients vital for plant growth.

This study has demonstrated that the application of wood ash leads to increased growth, yield, and biomass accumulation in pumpkin.

Furthermore, growth and yield parameters such as the number of leaves per plant, vine length, number of pods per plant, and pod yield were enhanced in plots treated with wood ash. This improvement can be attributed to the wood ash supplying essential soil nutrients, thus promoting the growth, development, and yield of the crop compared to the control treatment.

5. Conclusion

The findings of this study indicate that the use of wood ash significantly enhanced the growth and yield attributes of fluted pumpkin. To optimize the effects of wood ash application on the growth and yield of fluted pumpkin in the acidic soils of the rainforest zone in southeastern Nigeria, it is recommended that wood ash be applied at a rate of 4 t/ha. This recommendation is based on the observation that the yield from the 6 t/ha treatment did not show a significant difference when compared to the yield from the 4 t/ha treatment. Furthermore, soil analysis conducted at harvest revealed that the application of wood ash can contribute to sustainable soil management in the ultisol of southeastern Nigeria.

6. References

- Akata, O. R., Essien, O. A., Ben, F. E., & Ikeh, A. O. (2025). Performance of fluted pumpkin (*Telfairia occidentalis* Hook F.) under different nitrogen fertilizer grades in a high humid ecology of Southern Nigeria. *AKSU Journal of Agriculture and Food Sciences*, 9 (2), 82-93.
- Akata, O. R., Uko, A. E., Nwagwu, F. A., Ndaeyo, N. U., Ikeh, A. O., & Essang, D. M. (2016). Weed dynamics, growth, and yield of cassava (*Manihot esculenta* Crantz) as influenced by organic fertilizer sources and rates in an Ultisol. *Journal of Basic and Applied Research International*, 18 (2), 68-76. <https://ikprress.org/index.php/JOBARI/article/view/3996>
- Akpan, E. A., Essien, O. A., Akata, O. R., & Opeolu, E. M. (2024). Effect of oil palm bunch ash and harvesting intervals on okra (*Abelmoschus esculentus* L.) cultivars in Obio Akpa, Akwa Ibom State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 20 (1), 21-30.
- Ayodele, O. J., & Shittu, O. S. (2014). Fertilizer, lime and manure amendments for Ultisols formed on coastal plain sands of Southern Nigeria. *Agriculture, Forestry and Fisheries*, 3 (6), 481-488. <https://doi.org/10.11648/j.aff.20140306.17>
- Baloch, S. B., Ali, S., Bernas, J., Moudry, J., Konvalina, P., Mushtaq, Z., Murindangabo, Y. T., Onyebuchi, E. F., Baloch, F. B., Ahmad, M., Saeed, Q., & Mustafa, A. (2024). Wood ash application for crop production, amelioration of soil acidity and contaminated environments. *Chemosphere*, 357, 141865. <https://doi.org/10.1016/j.chemosphere.2024.141865>
- Bates, R. A. (1954). *Electrometric determination*. John Wiley and Sons, Inc.
- Black, C. A. (1965). *Methods of soil analysis: Agronomy No. Part 2*. American Society of Agronomy.
- Brady, N. C., & Weil, R. R. (2002). *The nature and properties of soils* (13th ed.). Pearson Education.
- Bray, R. H., & Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science Journal*, 59 (1), 39–45.
- Buol, S. W., Southard, R. J., Graham, R. C., & McDaniel, P. A. (2011). *Soil genesis and classification*. Holmberg, S. L., & Claesson, T. (2001). Mineralogy of granulated wood ash from a heating plant in Kalmar, Sweden. *Environmental Geology*, 40, 820–828.
- Ibia, T. O. (2005). Forms and content of iron and aluminum in the inland flood plain of South-Eastern Nigeria. *Agronomie Africaine Journal*, 17 (3), 211–218.
- Ibia, T. O., & Udo, E. J. (2009). *Guide to fertilizer use for crops in Akwa Ibom State, Nigeria*. Uyo: Sibon Books Limited Publisher.

- Idem, N. U. A., Ikeh, A. O., Asikpo, N. S., & Udoh, E. I. (2012). Effect of organic and inorganic fertilizer on growth and yield of fluted pumpkin (*Telfaria occidentalis*. Hook. F) in Uyo, Akwa Ibom State, Nigeria. *Nigeria Journal of Agriculture and Social Research*, 12 (2), 74-84. <https://www.ajol.info/index.php/jasr/article/view/112531>
- Ikeh, A. O., Apeh, C. C., Orji, J. O., Azmi, Y., Latuponu, H., & Rahmat, A. (2025a). Sustainable groundnut (*Arachis hypogaea*) cultivation using various soil amendment sources in an Ultisol of Southeastern Nigeria. In Book of Abstracts: International Colloquium on Youth, Environment and Sustainability. Bandung, Indonesia, November 19, 2025.
- Ikeh, A. O., Etokeren, U. E., Essien, I. E., Udo, E. A., Ukut, A. N., & Nwanne, A. J. (2017). Effects of crop residue ash application on soil, cowpea yield and economic return to management in Uyo, Niger Delta Region of Nigeria. *Journal of Forestry, Environment and Sustainable Development*, 3 (1), 154-165.
- Ikeh, A. O., Sampson, H. U., Ukabiala, M. E., Anonaba, N. K., Okamigbo, J. N., & Akuwueze, C. G. (2025b). Effect of soil ameliorations on cucumber (*Cucumis sativus* L.) yield and soil physico-chemical properties in an Ultisol of Southeastern Nigeria. *Open Soil Science and Environment*, 5 (1), 1-9. <https://doi.org/10.33292/ost.vol5no1.2025.146>
- Ikeh, A. O., Udounang, P. I., Essien, I. E., Etokeren, U. E., & Ndaeyo, N. U. (2016). Response of maize to different crop residue ash sources in acid coastal plain soil of Southeastern Nigeria. *Journal of Forestry, Environment and Sustainable Development*, 2 (1), 80-87.
- Ikeh, A.O., J. O. Orji, J. O., Sampson, H. U., & Akata, O. R. (2023). Effect of Oil Palm Bunch Refuse Ash in Sustainable Production of Egusi-Melon (*Colocynthis citrullus*) in an Ultisol. *Asian Journal of Agricultural and Horticultural Research*, 10 (3), pp. 138-148. DOI: 10.9734/AJAHR/2023/v10i324
- Juo, A. S. R., & Wilding, L. P. (1996). Soils of the lowland forest of West and Central Africa. In Essays on the ecology of the Guinea Congo rainforest (Proceedings Royal Society of Edinburgh, Vol. 1043, Section B: Biological Science, pp. 15–22). Edinburgh, Scotland, U.K.
- Olubode, A. A., Soretire, A., & Adeyemi, N. O. (2017). Influence of organic manure and wood ash on the abundance of soil microorganisms, organic carbon, and grain yield of soybean (*Glycine max* L. Merrill) in acid soil. *Journal of Agricultural Science and Environment*, 8 (1 & 2), 87-96.
- Onweremadu, E. U. (2007). Characterization of a degraded Ultisol amended with cassava peel, cattle dung, and poultry droppings in Southeastern Nigeria. *Journal of Plant Sciences*, 2, 564-569. <https://doi.org/10.3923/jps.2007.564.569>
- Pitman, R. M. (2006). Wood ash uses in forestry: A review of the environmental impacts. *Journal of Forestry*, 79 (5), 563-588.
- Sampson, H. U., Ikeh, A. O., Orji, J. O., Uko, U. I., Okparaiheoma, D. A., Akuwueze, C. G., Anonaba, N. K., & Okamigbo, J. N. (2025). Effects of soil amelioration on productivity of okra (*Abelmoschus esculentus* (L) Moench) in an Ultisol of Southeastern Nigeria. *Open Soil Science and Environment*, 3 (1). <https://doi.org/10.70110/osse.v3i1.33>