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# EVALUATION OF ORGANIC AND INORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF SWEET POTATO (*Ipomea Batatas*) VARIETIES IN A SANDY-LOAM SOIL

**BY**

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***Abstract***
*Poor Soil fertility has severed quality yields in tuber crops like sweet potato in Bichi and its environs. Field trial was conducted at the Teaching and Research Farm of Agricultural Education Department to evaluate the effect of organic and inorganic fertilizers on the growth and yield sweet potato varieties during the 2022 rainy season. The treatments comprised three sweet potato varieties (Dan-china, PIAPIA and 87/OP/195) and four levels of organic and inorganic fertilizer along with the control (0 level, 200kg/ha NPK 15:15:15, 60tons/ha cow-dung and a mixture of 30tons/ha cow-dung and 100kg/ha NPK). The treatments were arranged in a randomized Complete Block Design with three replications. Data was collected on the length of primary vine, number of secondary vines, number of leaves and tuber yield per plant. Descriptive statistics was used to analyse the data. Result of the study showed that 87/OP/195 recorded the longest length of primary vine with lower leaf number compared to the control but with the highest tuber yield (2.6kg/plant) when 30kg/ha of NPK 15:15:15 and 30tons/ha of cow-dung under sandy Loam textural class. Similarly, PIAPIA and Dan-China treated with the mixture of NPK 15:15:15 and Cow-dung also produced the second and third higher yields (2.5kg and 1.6kg/plant respectively) even though under an acidic soil condition. The research recommended 87/OP/195 and PIAPIA with even lower rates of organic fertilizer without necessarily adding NPK or Urea but with improved management practices.*

**Keywords:** Sweet potato, Organic fertilizer, Inorganic fertilizer, Variety



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## Introduction

Sweet potato (*Ipomoea batatas)* regarded as Atsaka in Tiv, Dankele in Hausa, dun odunkun in Yoruba and uto nduku in Ibo is a carbohydrate rich cultivated perennial herbaceous root crop with a potential to supply protein, lipid, calcium, vitamins and carotene. The above attributes make the crop a valuable source of food, animal feed, and industrial raw material as reflected in Neela & Fanta, (2019). The crop by global food production is ranked seventh and equally regarded as the third most important root crop after Yam and Cassava (Fan, et al., 2012; Hossain, 2020). Sweet potato yield has been reported to be on a rapid decline. In China, the usual average yield of 27,600kg /ha has drastically reduced to 15,000kg/ha in mature soils (Li et al, 2022). Similarly, Nigeria regarded as the second largest Sweet Potato producer by global standard also recorded a dramatic yield reduction from 14.39 million metric tons to 3.46 million metric tons per annum (FAO, 2016; Semira and Bikila, 2018).

While China has a record-breaking production rate of 131 million metric tons with an average productivity of 17.67t $ha^{-1}$ (CIP, 2011 cited in Abdel-Razzak *et al.*, 2013) annually, Nigeria's average yield dropped to 3.46 million metric tons annually. This is still far low compared to China's 106 million metric tons per annum.

The low yield generally has been attributed to high gravel content, poor nutrient content, acidic soils and very low organic carbon content (Fan, et al., 2012; Xu, et al., 2021), which has also affected soil microbiological activities. Additionally, deficiencies in Nitrogen, Phosphorus, Magnesium, Boron and Iron as well as Aluminum toxicity, acidic and saline soil conditions have been reported to greatly constrain increased sweet potato yield (Ames, Smit, Braun, O'Sullivan & Skoglun, 1996 cited in Esan and Omilani, 2018; Daniel and Gobeze, 2016).

Mwanja, Goler, and Gugu, (2017) reported that large quantities of Sweet Potato are produced by small scale farmers however, the yields realized are low due to the use of poor fertilizer combination and low yielding varieties. Fertilizer inputs are known to have significant benefits in terms of improved crop yield and soil fertility status (Palm *et al.* 1997; Ayoola and Agboola, 2002). According to Moji et al., (2019**),** Nitrogen (N), Phosphorus (P) and Potassium (K) are the major determinants of yield in crop productivity. However, the Sudan and Northern Guinea Savanna soils of Nigeria are inherently low in soil fertility especially when continuously cropped without restoring the nutrients exported in harvested produce. Unfortunately, over 100 million tons of chemical fertilizers are required annually to fix this nutrient imbalance but there are un-affordable by peasant farmers because of cost.

Organic fertilizers according to Hartemink, (2003) in combination with inorganic N, P and K were reported to have significant tuber yield in sweet potato production. Giller et al. (1998) equally observed and reported a positive interaction between organic and inorganic inputs when applied simultaneously. Organic sources of fertilizers are much more readily available than the chemical fertilizer. This research therefore seeks assess the best fertilizer combination with reduced over-dependence on chemical fertilizer.

The broad objective of this research is aimed at determining the effect of organic and inorganic fertilizers on sweet potato varieties in the study location. Specifically, the research is designed to;

1. Determine the effect of organic and inorganic fertilizer on sweet potato production in the study area
2. Evaluate the yield of sweet potato varieties

## Materials and Methods

### Site Description

The experiment was conducted at the Teaching and Research farm of the Department of Agricultural Science Education, School of Secondary Education (Vocational), Federal College of Education (Technical) Bichi extension, Kano State, Nigeria in the Sudan Savannah Agro-ecological zone. The Research farm lies between latitude 12°13'15" N of the equator and between longitude 8°13'0" E of the Greenwich meridian with a land mass of 1332m$^2$. The rainfall ranges between 250mm to 650mm per annum in the north with the driest and wettest season lasting from December to February and July to September respectively.

### Field Layout

The experimental area of 1332m$^2$ (Fig., 1) was marked out from the field. Each plot size consisted of six ridges each made to be 3 m long. The total plot size was 36m x 11m with each replication having a plot size of 8m x 3m. The intra and inter row spacing was 30 cm and 100 cm, respectively. Rows of each variety were separated by a 1m boundary and replications were separated by 2m boundaries. The chicken manure was applied and worked into the ridges two weeks (to allow further decomposition) before planting of vines was done. Vine cuttings of each variety of 30cm length from apical sections and other actively growing sections were planted in each block. Two-thirds of each sweet potato vine (with 3 to 6 nodes) were planted on top of the ridges (about 15 to 20 cm deep) with cuttings facing the right-side up leaving one-third above the soil. The NPK (15-15-15) rates were applied two weeks after planting (WAP). One hoe weeding was done at both locations at 3 to 4 WAP to control weeds.

### Treatment and Experimental Design

The varieties comprises two hybrids and one local namely; Dan-china, PIA PIA, and 87/OP/195 which were obtained from the National Root Crops Research Institute, Umudike through International Institute for Tropical Agriculture, Minjibir research farm, Kano State. The treatments were as shown in the table below;

Table 1: Treatment combination

| S/NO | VARIETAL COMBINATION | TREATMENT NUMBER |
|---|---|---|
| 1 | Dan-china + O | 1 (Variety + Zero application) |
| 2 | PIA PIA + O | 2 (Variety + Zero application) |
| 3 | 87/OP/195 + O | 3 (Variety + Zero application) |
| 4 | Dan-china + NPK | 4 (Variety + NPK application @ 200kg / ha) |
| 5 | PIA PIA + NPK | 5 (Variety + NPK application @ 200kg / ha) |
| 6 | 87/OP/195. + NPK | 6 (Variety + NPK application @ 200kg / ha) |
| 7 | Dan-china + OM | 7 (Variety + Organic Manure @ 6tons / ha) |
| 8 | PIA PIA +OM | 8 (Variety + Organic Manure @ 6tons / ha) |
| 9 | 87/OP/195 + OM | 9 (Variety + Organic Manure @ 6tons / ha) |
| 10 | Dan-china + NPK + OM | 10 (Variety + NPK @ 100kg / ha +OM @ 3tons / ha) |
| 11 | PIA PIA + NPK + OM | 10 (Variety + NPK @ 100kg / ha +OM @ 3tons / ha) |
| 12 | 87/OP/195+ NPK + OM | 10 (Variety + NPK @ 100kg / ha +OM @ 3tons / ha) |

Source: FCE(T) Bichi, Agricultural Education Teaching and Research Farm - Moji K.T. 2023

The treatments as shown in Table 1 were laid out in a Randomized Complete Block Design (RCBD) with 12 treatments and 3 replications. Cow dung manure (6 tons/ha) and NPK (15:15:15) fertilizer **(**200kg/ha**)** were applied 2 weeks after planting; weeding was also done with hoe at specified intervals.

**Laboratory Soil Analysis**

Soil sampling was done randomly at a depth of 0 -30cm for physico-chemical analysis of the inherent nutrient status. A spade was used to collect initial 9 soil samples and 3 samples on each replication across the treatments. The 9 samples were bulked to form a composite sample and the 36 soil samples were also bulked according to the treatments and a sub sample was taken for laboratory analysis. The soil samples were air-dried under shade, soil lumps were crushed using pestle and mortar and organic residues were removed. The soil samples were then sieved using a 2mm mesh sieve, sub-samples collected and routinely analyzed according to standard laboratory procedures (Anderson and Ingram 1993).

**Data collection and Analysis**

Data was collected on the growth and tuber yield component at harvest. The Data collected was: Length of the primary vein, Number of leaves, Number of secondary Vein and weight of tuber per plant. Data collection was statistically analyzed using descriptive statistics.

**Results**

The results of the Soil characteristics of the trial site as well as the effect of Cow-dung and NPK on the growth and yield of sweet potato varieties in FCE(T) Bichi is as presented below.

Table 2 shows some Physical and Chemical properties of the soils at the departmental farm of Agricultural Science Education, School of Secondary Education (Vocational).

| PARAMETER | INITIAL SOIL SAMPLE | FINAL SOIL SAMPLE | SS-PIAPIA-NPK | SS-PIAPIA-ORG | SS-PIAPIA-MIXED | SS-87/0P/195-ORG | SS-87/0P/195-NPK | SS-87/0P/195-MIXED |
|---|---|---|---|---|---|---|---|---|
| Sand (%) | 85.12 | 83.12 | 89.12 | 91.12 | 89.12 | 87.12 | 91.12 | 91.12 |
| Silt (%) | 10.56 | 12.56 | 8.56 | 6.56 | 8.56 | 10.56 | 8.56 | 8.56 |
| Clay (%) | 4.32 | 4.32 | 2.32 | 2.32 | 2.32 | 2.32 | 0.32 | 0.32 |
| **Textural Class** | LOAMY SAND | LOAMY SAND | SAND | SAND | SAND | SAND | SAND | SAND |
| pH (H2O) 1:2:5 | 6.95 | 6.09 | 6.95 | 6.38 | 6.18 | 6.86 | 5.43 | 5.8 |
| **pH (0.01N CaCl2)** | 6.12 | 5.67 | 6.23 | 5.86 | 5.65 | 6.19 | 4.78 | 5.29 |
| **EC (µS/cm)** | 79.4 | 160.6 | 21.3 | 21.7 | 3340 | 51.8 | 22.2 | 22.2 |
| **%O.C** | 0.78 | 0.74 | 0.60 | 0.42 | 0.64 | 0.50 | 0.56 | 0.62 |
| **%O.M** | 1.34 | 1.27 | 1.03 | 0.72 | 1.10 | 0.86 | 0.96 | 1.07 |
| EA (cmolkg-1) | 0.17 | 0.33 | 0.17 | 0.33 | 0.33 | 0.33 | 0.50 | 0.33 |
| Total N (%) | 0.11 | 0.18 | 0.11 | 0.14 | 0.07 | 0.11 | 0.14 | 0.11 |
| **AVP (mg/kg)** | 8.44 | 17.68 | 10.40 | 15.02 | 8.67 | 12.60 | 8.90 | 13.52 |
| **Ca (Cmol/kg)** | 2.64 | 1.67 | 1.32 | 1.43 | 1.33 | 1.58 | 1.28 | 1.22 |
| **Mg (Cmol/kg)** | 0.76 | 0.71 | 0.63 | 0.62 | 0.65 | 0.62 | 0.63 | 0.61 |
| **Na (Cmol/kg)** | 0.30 | 0.30 | 0.30 | 0.26 | 0.32 | 0.30 | 0.31 | 0.31 |
| **Exch. K (Cmol/kg)** | 0.15 | 0.12 | 0.06 | 0.12 | 0.07 | 0.08 | 0.05 | 0.06 |
| **CEC (Cmol/kg)** | 4.02 | 3.14 | 2.48 | 2.76 | 2.71 | 2.91 | 2.77 | 2.54 |

**Key:** O C-Organic Carbon, EC- Electrical Conductivity, OM-Organic Matter, EA-Exchangeable Acidity, N- Nitrogen,
P- Phosphorus, K- Potassium

Table 3: Effect of organic and inorganic fertilizers on the growth and yield of sweet potato

| Treatments | Length of primary vein (cm) | Number of leaves | Number of secondary veins | AVFW (g) | AVDW (g) | Tuber Yield (Kg) |
|---|---|---|---|---|---|---|
| Dan-china Control | 131.4 | 25 | 6 | 582.8 | 8.1 | 1.1 |
| PIAPIA Control | 107.1 | 20 | 5 | 306.5 | 7.2 | 0.2 |
| 87/OP/195 Control | 124.5 | 30 | 7 | 447.5 | 11.2 | 0.9 |
| Dan-china - Cow dung | 104.1 | 21 | 5 | 664.3 | 8 | 1.1 |
| PIAPIA - Cow dung | 100.4 | 23 | 5 | 590.1 | 7.5 | 0.3 |
| 87/OP/195 - Cow dung | 122.5 | 35 | 6 | 204.7 | 11.4 | 1.0 |
| Dan-china - NPK | 141.6 | 17 | 7 | 934.8 | 11.6 | 0.4 |
| PIAPIA - NPK | 114.2 | 23 | 6 | 483.2 | 7.6 | 0.3 |
| 87/OP/195 - NPK | 135.4 | 40 | 6 | 771.1 | 10.9 | 1.4 |
| Dan-china - NPK + Cow dung | 135.7 | 21 | 7 | 851.6 | 12.2 | 1.5 |
| PIAPIA - NPK + Cow dung | 110.6 | 20 | 6 | 530.7 | 6.8 | 2.5 |
| 87/OP/195 - NPK + Cow dung | 145.5 | 33 | 6 | 573.9 | 9.5 | 2.6 |

Source: FCE(T) Bichi, Agricultural Education Teaching and Research Farm - Moji et al., 2023.

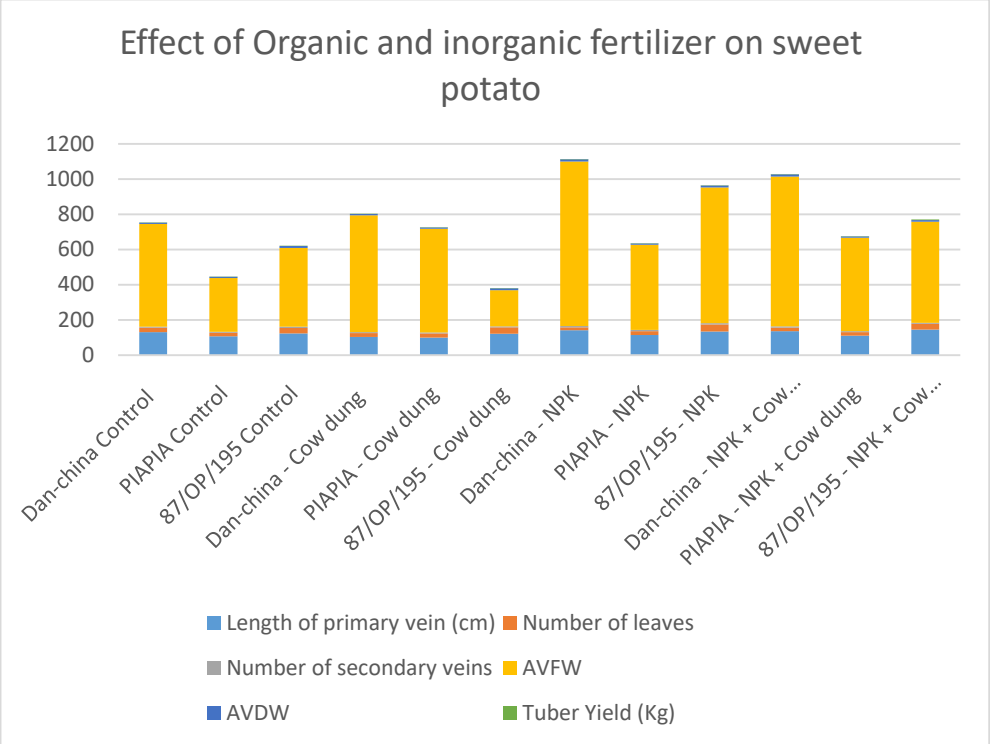


Fig 2: Effect of Organic and Inorganic fertilizer on sweet potato growth and yield

## Discussion

### Soil characteristics of the trial site

Table 2 shows the physical and chemical properties of the soils at the Teaching and Research farm of FCE(T) Bichi located at the departmental farm of Agricultural Science Education,

school of secondary education (Vocational). The initial soil sample had higher percentage of sand (85.12%) with very low percentage of silt (10.56%) and clay (4.32%) just like the final soil sample which had the same percentage of clay (4.32%) in it, low silt (12.56%) and high sand (83.12%). The textural classes are therefore Loamy Sand respectively.

The result of the soil reaction in Table 2 for the initial soil sample (control) was slightly acid (pH 6.1) while that of the final soil sample was neutral (pH 6.95). Similarly, the soil reaction when PIAPIA was supplemented with only NPK (15:15:15:) and 87/0P/195 with only organic manure were neutral ( pH 6.95 and pH 6.86 respectively). When PIAPIA was treated with only organic manure (cow-dung) as well as half dose of cow-dung and NPK, the soil reaction was slightly acid (pH 6.38 and pH 6.18 respectively). However, when 87/0P/195 was applied with only NPK and also half dose of cow-dung and NPK, the soil reaction was strongly acid and moderately acid (pH 5.43 and pH 5.8 respectively). The acidic pH could be attributed to the low Organic Carbon as well as total N, available P and exchangeable K in the soils. This result corroborates the work of Salako (2003) who reported that low pH reduces the availability of primary and secondary nutrient elements and increases the solubility of Al, Mn and Fe which are toxic to plants in excess.

The Electrical conductivity of the soils with various treatments was non-saline (0 - 2) except that of the soil where PIAPIA was applied with half dose of cow-dung and NPK fertilizers which was surprisingly very saline (3.3dS/cm). The Organic Carbon content of the treatments ranged from very low (<5) to low (<10) based on the fertility classes for Northern Nigerian Savanna soils by Esu, (1991). The organic carbon content of the final soil sample was higher than that of the initial soil sample. Similarly, the organic carbon content of the treatments with NPK supplement turned to be higher than the treatments without NPK supplement. The low levels of organic carbon could be attributed to continuous and intensive cropping without any addition / incorporation of organic matter in the form of manures and crop residues. Total N levels across the treatments are very low based on the fertility classes for Northern Nigerian Savanna soils by Esu, (1991). The low levels of N across the treatments could be attributed to the low soil organic matter levels and lower pH of the soils in the experimental sites. The levels of available P were ranged from low (8.44mg/kg) to high (17.68mg/kg). The treatments showed an increase in P levels with the application of organic manure compared to NPK. The results clearly demonstrate low P fertilizer need in subsequent cropping season. The levels of exchangeable potassium in the soils from the trial site was generally low (<0.15Cmol/kg). The lowest values (0.05 and 0.06Cmol/kg) were observed in 87/0P/195 when supplied with NPK 15:15:15 but low pH.

**Effect of Organic and Inorganic fertilizer on vine number**

The result of analysis in Table 3, figure 2 showed that the length of primary vines ranged from 100.4cm to 145.5cm with 87/OP/195 treated with half dose of NPK 15:15:15 and cow-dung manure. Dan-china treated with NPK complete dosage recorded the second longest vein with 141.6cm followed by Dan-china treated with half dose of NPK and cow-dung (135.7cm) compared to their controls.

**Effect of Organic and Inorganic fertilizer on leaf number**

On the other hand, 87/OP/195 treated with complete dose of NPK recorded the highest number of leaves (40) followed by 87/OP/195 treated with cow-dung compared to the control treatments. On the contrary, the highest number of secondary vines were recorded in Dan-china treated with only NPK and also half dose of NPK and Cow-dung.

**Effect of Organic and Inorganic fertilizer on Vine Fresh Weight**

On Average Vine Fresh Weight (AVFW), the result of analysis showed that Dan-china treated with only NPK recorded the highest vine weight (0.94kg/plant) still followed by Dan-china treated half dose of NPK and Cow-dung (0.85kg/plant) compared to the control with 0.58kg/plant weight.

**Effect of Organic and Inorganic fertilizer on Tuber Yield**

The result of analysis from fig 3 showed that 87/OP/195 treated with half dose of NPK and cow-dung recorded the highest tuber yield of 2.6kg per plant and an estimated yield of 865.8kg/ha compared to 297.6kg/ha in the control followed by PIAPIA with a yield of 2.5kg/plant with an estimated yield of 821.0kg/ha compared to 73.6kg/ha in the control.

**Summary**

This study sought to assess the effect of organic and inorganic fertilizer on sweet potato growth and yield in the Teaching and Research farm of School of Secondary Education (Vocational), Federal College of Education (Technical) Bichi, Kano State. Based on this, a comprehensive field trial was designed and carried out.

The result of the soil characteristics showed that the soils were Sandy Clay Loam and Sandy respectively in texture with low clay content. The soil pH was slightly acid (pH 6.1) and neutral (6.95), organic carbon levels were also very low (<5gkg-1) and low (<10gkg$^{-1}$) respectively, low (0.7gkg$^{-1}$) levels of total nitrogen as well as low available phosphorus were also recorded. However, the acidic pH (6.1) of the trial site (control) as well as the strongly acidic (5.43) and moderately acidic (5.8) pH of the soils planted with 87/OP/195 and supplemented with only NPK (15:15:15) and a mixture of NPK and Cow-dung could be responsible for the low Organic Carbon as well as total N, available P and exchangeable K in the soils. This result corroborates the work of Salako (2003) who reported that low pH reduces the availability of primary and secondary nutrient elements and increases the solubility of Al, Mn and Fe which are toxic to plants in excess. This clearly shows that the continuous application of chemical fertilizers without organic amendments will further deteriorate fertility status, reduce microbial activities in the soil and grossly affect research activities.

The effect of organic and inorganic fertilizer on sweet potato varies showed that 87/OP/195 treated with a mixture of organic and NPK compared to other varieties treated with only NPK as well as the control was more promising in length (145.5cm) of primary vine and tuber yield (2.6kg/plant). Similarly, PIAPIA treated with a mixture of Cow-dung and NPK was the second with the yield of 2.5kg/plant while Dan-China produced the lowest yields of 1.5kg/plant when applied with 100kg/ha and 30tons/ha of NPK (15:15:15) and Cow-dung manure.

**Conclusion**

Potato plant growth and tuber yield is largely dependent on the type of fertilizer supplied, environmental conditions and genetic make-up. Sandy loam proved to be the most suitable soil for the production of 87/OP/195 followed by PIAPIA varieties. The performance of this improved sweet potato variety (87/OP/195) even on acidic soil pH shows the variety's ability to withstand such unfavourable soil conditions. With appropriate sustainable soil management techniques involving the use of organic manures with the right quantity, unimaginable yields will be recorded from 87/OP/195 and PIAPIA. The taste of 87/OP/195 variety is better than other varieties just like in yields, however, farmers complain of its perishable nature compared to other varieties.

## Recommendation

Information obtained from this research may be limited to the sweet potato varieties used in this study and the specific environmental condition in the study location in which the parameters were measured. Nevertheless, experimental results clearly demonstrated that 87/OP/195 and PIAPIA could be the best alternative varieties under little or zero chemical fertilizer supplementation in Bichi and the Sudan Savannah at large with the potential yield of over 900kg/ha.

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**References**

Anderson, J. M. and Ingram, J. S. I. (1993). *Tropical Soil Biology and Fertility*: A Hand Book of Methods (2nd ed.). C.A.B. International Wallingford, U.K. pp. 221.

Abdel-Razzak H.S., Moussa A.G., Abd El-Fattah M.A. and El-Morabet G.A., (2013). Response of Sweet Potato to Integrated Effect of Chemical and Natural Phosphorus Fertilizer and Their Levels in Combination with Mycorrhizal Inoculation. *Journal of Biological Sciences, 13: 112-122.*

Ames T., Smit NE J.M., Braun A. R, O'Sullivan J. N., Skoglund L.G. (1996). Sweet potato: Major pests, diseases, and nutritional disorders. International Potato Center (CIP), Lima, Peru.

Ayoola OT, Makinde EA (2002). Performance of green maize and soil nutrient changes with fortified cow dung. Afr. J. Plant Sci. 2(3):019- 022.

Daniel Markos and Gobeze Loha (2016). Sweet Potato Agronomy Research in Ethiopia: Summary of Past Findings and Future Research Directions. *Agriculture and Food Sciences Research, 3(1): 1-11*.

Esan V. I. and Omilani, (2018). Assessment of four sweet potato varieties for adaptability and productivity in Iwo, Osun State. *Asian Journal of Agricultural and Horticultural Research 1(1): 1-8*.

Fan, W.; Zhang, M.; Zhang, H.; Zhang, P. (2012**).** Improved tolerance to various abiotic stresses in transgenic sweet potato (*Ipomoea batatas*) expressing spinach betaine aldehyde dehydrogenase. *PLoS ONE, 7*, e37344. [CrossRef] [PubMed]

Food and Agricultural Organization (2016). FAO Statistics, Food and Agricultural Organization, Rome, Italy.

Giller, K. E., Rob, G., Luke, M.M., Lucia, M., Bharati K.P., &Stephen R.W. (1998). Practical Approaches to Soil Organic Matter Management for smallholder maize production in Southern Africa. Researchgate.net/publication/297275075.

Mwanja Y.P., Goler, E.E. and Gugu F.M., (2017). Assessment of Root and Vine Yields of Sweet Potato Landraces as influenced by plant-population Density in Jos- Plateau State, Nigeria. *International Journal of Agricultural Researh, 12 (2): 88-92. ISSN 1816-4897*.

Neela, S.; Fanta, S.W.(2019**).** Review on nutritional composition of orange-flfleshed sweet potato and its role in management of vitamin A defificiency. *Food Sci. Nutr. , 7*, 1920–1945. [CrossRef] [PubMed]

Palm CA, Myers RJK, Nandwa SM (1997). Combined use of organic and inorganic nutrient sources for fertility maintenance and replenishment. In: Replenishing soil fertility in Africa (Eds.) R.J. Buresh, P.A. Sanchez and F. Calhoun. SSSA Special Republication 51:193-217. SSSA and ASA, Madison, WI**.**

Semira Nasir1 and Bikila Akassa (2018). Review on effect of population density and tuber size on yield components and yield of potato (*Solanumtuberosum* L.). *African Journal of Plant Science. Vol. 12(12), pp. 319-323*: 70316E859432; ISSN 1996-0824.

Xu, X.; Zhang, Y.; Wang, J.; Zhang, H.; Tang, Z.; Zhang, A.; Li, H.; Liu, Q. (2021**)**. Soil nutrient status and soil fertility evaluation of farmland in three main sweet potato regions in China. *Soil Fert. Sci. China, 5*, 27–33.