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# Effect of Integrating Arbuscular Mychorrizal and N.P.K Fertilizer on Soil Properties, Nutritional Composition and Performance in Sweet Potato Production

**Onyiba, P.O., Onuba, M.N., Mbah, T.N., Okoh, T. and Opara, T.C.**

National Root Crop Research Institute, Umudike, Abia State
Corresponding Author's email: princewillogugua@yahoo.com

**Abstract**
Agricultural practices based on application of bio-fertilizers and inorganic fertilizers would produce vigorous growth and more sustainable yield performance. The experimental trial was conducted in 2018 to evaluate the effects of Glomale mycorrhizal fungal inoculants with NPK fertilizer on the soil properties, nutritional composition, and yield performance of two orange fleshed sweetpotato (OFSP) varieties; Tis 0087/87 and Tis 8164. The inocula at the rate of 250kg/ha were tested separately with NPK fertilizers at 200kg/ha. The results obtained showed that N.P.K significantly enhanced and improved the soil chemical properties than AM (Arbuscular Mychorrizal). There were significant increases of microbial agents as AM were introduced than NPK, which reduced the number of bacteria and fungi. The nutritional value of the two varieties of OFSP were significantly improved when mycohrrizal fungi and NPK were applied, showing that Tis 8164 has more nutritional value than Tis 0087/87. Application of NPK fertilizer at 200kg/ha increased nutritional value more than AM. Inoculating plants with AM-fungi and NPK significantly increased yield and improved root organic composition. In general, the results indicated that application of organic and inorganic fertilizers enhanced sustainable sweet potato production and productivity.

***Keywords: Arbuscular Mycorrhizal, NPK, Soil properties, Nutritional composition, Sweet potato***

## Introduction
Sweet potato (*Ipomoea batatas (L). Lam*) is an important staple food and nutrition security root crop for many people (Gakonyo, 1993; Mutuura *et al*., 1992), rich in beta carotene, natural precursor of vitamin A, and as such important in alleviating vitamin A deficiency nutritional disorders (FAOSTAT, 2011). The productivity of this crop is being hampered by many factors among which include declining soil fertility, which was mitigated through shifting cultivation in the past to allow a particular soil fallow for a long time and resuscitate its fertility. In addition, for sustainable production of the root crop by farmers in Nigeria, soil fertility improvement package which inculcates the use of inorganic fertilizer (NPK), and bio-fertilizers have to be developed. Though the continuous application of inorganic fertilizers, especially phosphorus and nitrogen, improved crop yields, but has its limitation. It can directly or indirectly affect soil biological properties which can affect the quality and productivity of such soils. Soil microorganisms are important components of many agricultural ecosystems because of their role in organic matter decomposition, nutrient transformations and cycling (Cakmakci *et al*., 2006). The use of arbuscular mycorrhiza (AM) fungi as bio-fertilizers to improve the soil proved important for sweet potato production. George *et al*. (1992) asserted that most agricultural crops are more productive when they are well colonized by AM Fungi inoculation of plant roots. AM fungi are particularly important in improving uptake of phosphorous, and micro-nutrients including; calcium, sulphur, zinc and copper (Blat *et al.,* 1990), enhance phyto-accumulation of heavy metals (Khan *et al*., 2000; Al-agely *et al*., 2005). To overcome these deficiencies in sweet potato production, the use of Arbuscular mycorrhizae and N.P.K compound fertilizer was tested on the crop. Therefore, the objective of this study was to evaluate the effect of the arbuscular mycorrhizae fungi and N.P.K fertilizer on the soil biological health, yield performance and nutritional quality in sweet potato production.

## Materials and Methods
The research trial was executed at the experimental field of National Root Crop Research institute, Igbariam Sub-station, Anambra State in 2018 cropping season. The field was ploughed, harrowed and ridged. Sample of the soil (0 – 30cm depth) was randomly collected and analysed for physic-chemical parameters (Page *et al*., 1982), and for soil biological parameters to ascertain the

total number of microbial agents such as bacteria and fungi using standard procedure. The experiment was laid in a randomized complete block design (RCBD) with three replications. Each replicates includes 12 treatments with Control plots which represent all possible combinations. The sweet potato cultivars Tis 87/0087 and Tis 8164 obtained from NRCRI were used. Chemical fertilizer in the form of N.P.K 20-10-10 were bought and applied at 200kg/ha a week after planting (WAP) as shown in Table 1. The symbiotic species of arbuscular mycorrhizal fungi (AMF), *Glomus mosseae*, was inoculated at 250kg/ha to the rhizospheric root zone of the plant, a week after planting (Dawa *et al*., 2007) with the exception of the control plots that were not treated with either fertilizer or AM. Data collected at harvesting stage,16 weeks after planting were fresh weight of tuber root (average of five uniform roots (kg), marketable root yield (ton fed.$^{-1}$) and unmarketable root yield (ton fed.$^{-1}$) were recorded. Then, nutritional compositions of tuber roots such as β-carotene (mg100g$^{-1}$ fresh weight), crude fiber, total sugars, protein, fats, starch, carbohydrate (Witham *et al*., *1971*), and mineral compositions were determined (AOAC, 1995). All the data were subjected to statistical analysis of variance (ANOVA), using LSD at 0.05 probability level (Steel and Torrie, 1980).

## Results and Discussion

### *Physico-chemical properties of soil analysis*

The results of the selected soil parameters used for this experiment were presented in Tables 2 and 3. The results showed that the soil was sandy loam in texture. It also indicated that the soils are moderately acidic with a pH of 6.45. The exchangeable bases are low except for Na (2.57 mol/kg) and Ca (1.60 mol/kg) which are relatively high when compared to the other bases. The exchangeable acids were very low at 1.56mg/kg. The soil total nitrogen was low at 0.13% and organic carbon moderate at 2.56%. Soil available phosphorus was moderate at 69.80mg/kg. The organic carbon, total nitrogen including available phosphorous of the soil cultivated with Tis 87/0087 showed significant reduction with the application of AMF compared to NPK. This trend was the same as regards the treatment of Tis 8164. Exchangeable bases such as Ca, Mg, Na, K and Exch. acids significantly recorded low values when AMF was applied than NPK. Though, the pre-planting soil treatments in Table 2 showed reduced values in terms of soil chemical properties than when organic and inorganic soil amendments were applied to the two varieties of sweet potato. Lower values of available P was observed in AMF treated soil relative to the N.P.K treatment and significantly higher than the value in control soil as well as soil treated with higher rate of NPK fertilizer. This indicated the ability of AM to encourage absorption/uptake of P in the soil as earlier reported by Smith and Read (1997) which stated that AMF are very effective in helping the plants to absorb P from the soil and invariably prevents P runoff that leads to eutrophication (undesired biological growth and productivity), increased phosphorous uptake by mycorrhiza plants can help to reduce the quantity of this nutrient to be added to the soil, and decrease the accumulated phosphorous soil and water. Table 4 indicated that there was significant increase in microbial organisms in the soil when treated with AMF compared to NPK. AMF amendment increased the fungi characteristics of the soil, whereas, NPK reduced the microbial characteristics of the soil in both varieties of sweet potato.

Tables 5 and 6 showed the results of the effects of AMF and NPK soil amendments on the nutritional composition of sweet potato varieties. There were significant higher values of proximate [protein content of Tis 87/0087 as 3.67 (AMF) and 4.78 (NPK); that of 8164 as 4.05 (AMF) and 5.51(NPK)] and mineral content (32.50 and 40.25 Ca, 40.08 and 45.20 K, 138.45 and 157.01 P) of sweet potato varieties when AMF and NPK were applied to the soil. The soil treated with NPK showed significant increase in both proximate (starch 73.15 and 76.21) and mineral content (Mg 34.15 and 35.10) than AMF (starch 68.02 and 69.68; Mg 30.05 and 31.10). According to Mohammad *et al*. (2016), the protein content of orange-fleshed sweet potato was in the range of 1.91%–5.83%, when inorganic nutrient was used to cultivate the crops. The results showed that inorganic nutrient application have more protein content when compared to AMF amendments (Lyimo *et al*., 2010). The fat concentration of orange-fleshed sweet potato is less than 1% (Mohammad *et al*., 2016; Rodrigues *et al.,* 2016). The AMF soil amendment showed less fat concentration than NPK application, indicating that inorganic fertilizer supplied more nutrients for the growth of crops than AMF. The high starch content (60.62%) for AMF, and 64.41% NPK were within the range of starch content reported in orange-fleshed sweet potato on fresh weight basis (Rodrigues *et al*., 2016). According to Endrias *et al.* (2016), the total dietary fiber of 3.6% (maximum) was reported in orange-fleshed sweet potato, but the lower concentration (0.35%) in different varieties of orange-fleshed sweet potato. These variations may be related to the varietal and agro-climatic differences of the crop. β-Carotene are natural pigments responsible for fruits, vegetables, and flowers coloration, distinct aromatic scents, and flavors (Fraser *et al.,* 2004), and are natural precursors for vitamin A. Beta carotene of Tis 87/0087/Tis 8164 was high (150.25 and 158.05; 155.10 and 160.00) when different soil amendments, AMF and NPK fertilizer were applied respectively. According to Tomlins *et al.* (2012), the highest range (20–364 (μg/g db)) of the beta carotene in orange flesh sweet potato were observed from different varieties grown in Uganda or America. The presence of high concentration of beta carotene (150.25 and 155.10) in the orange flesh sweet potato (Tis 87/0087 or Tis 8164) yielded high amount of the pro-vitamin A. These variations were attributable due to varietal, soil amendments and agro-climatic factors of the crops.

The results of mineral compositions of Tis 87/0087 and 8164 for Ca (32.50 and 32.54, 40.25 and 40.75); Mg (30.05 and 31.10, 34.15 and 35.10); K (40.08 and 40.12, 45.20 and 45.55); Fe (10.65 and 12.10, 14.10 and 14.45); P (138.50 and 138.45, 156.15 and 157.01); Zn (0.35 and 0.38, 0.60 and0.72); Na (35.90 and 36.10, 46.06 and 47.08) showed that there were significant variations existing between AMF and NPK fertilizer applications respectively for the two sweet potato varieties. Endrias *et al*. (2016) and Ukom *et al.* (2009) observed that the calcium content of 24.40–45.54mg/100g was reported in orange fleshed sweet potato, as well as magnesium concentration of 3–37mg/100 g which was attributed to the varietal and agro-climatic conditions (Endrias *et al.,* 2016; Laurie *et al*., 2012). The recommended daily allowance of 700mg phosphorus is for healthy adults, and phosphorous of 15–51mg/100g was reported (Endrias *et al*., 2016; Lyimo *et al*., 2010). The roots and tubers are good source of potassium, and orange fleshed sweet potato is moderately providing the recommended daily allowance of potassium for consumers (Constán Aguilar *et al.,* 2014).

The Zn results (0.35 and 0.38, 0.60 and 0.72), indicated that NPK application on Sweet potato varieties were high when compared with AMF soil amendments. The results of Fe (10.65 and 12.10, 14.10 and 14.45) indicated that NPK application was also high when compared to AMF. Orange-fleshed sweet potato was reported to be 0.63–15.26mg/100g of iron. Therefore, orange fleshed sweet potato is a good source for provision of the recommended daily allowance (RDA) of iron (Endrias *et al.,* 2016). Orange fleshed sweet potato provides very small quantities of the Zn, but the bio-availability is more comparative to the cereals and grains because of no or less anti-nutritional factors (phytate) (Wanasundera *et al.,* 1994). The results of Na (35.90 and 36.10, 46.06 and 47.08) showed NPK was higher than AMF, whereas orange fleshed sweet potato was reported to have 23–59 mg/100mg of Na (Endrias *et al*., 2016; Lyimo *et al*., 2010). Recommended daily allowance of sodium is 1,500mg; less concentration of the sodium in food source may not have any health problem, because the addition of sodium in form of table salt is a common practice in human food preparation.

The results in Table 7 showed that the two varieties of sweet potato responded differently to the AMF inoculation and NPK fertilizer applications as regards to the fresh root yield. There were significant differences on the varieties of sweet potato response to AMF and NPK application. The Tis 87/0087 recorded the highest yield of 7.94t/ha when treated with AMF than NPK with the yield of 6.30t/ha. The trend was the same in Tis 8164 varieties. This showed that there were significant increases in yield performance of sweet potato when AMF were inoculated to the soil than the application of NPK.

**Conclusion**

The application of arbuscular mycohrrizal fungi and inorganic fertilizer improved greatly the soil health status as well as nutritional content and sustainable yield productivity. NPK has more significant effect on the sweet potato productivity when compared to AM, but AM has proved to be more sustainable in enhanced root organic composition and supporting soil biological characteristics. Hence, it is acceptable to use organic means and/or inorganic means for enhanced sweet potato productivity.

**Table 1: Treatment factors applied in the field trial**

| Sweet potato Varieties | Fertilizer Rate | Arbuscular Mycorrhizal Rate |
|---|---|---|
| $V_1$= Tis 87/0087 | 200kg/ha | 250kg/ha |
| $V_2$= Tis 8164 | | |

**Table 2: The result of pre-planting soil analysis of sweet potato**

| Soil Parameters | Pre-planting |
|---|---|
| Texture | Sandy Loam |
| pH(water) | 6.45 |
| Organic Carbon(%) | 2.56 |
| Total Nitrogen(%) | 0.13 |
| Available Phosphorus(mg/kg) | 69.80 |
| Exch. Bases(mol/kg) | |
| Ca | 1.60 |
| Mg | 0.15 |
| Na | 2.57 |
| K | 0.34 |
| Exch.Acids(mg/kg) | 1.56 |

**Table 3: Effects of AMF and NPK on the Soil Chemical Properties**

| Treatment/Chemical properties | | pH | Organic C | Total. N | Avail. P | Ca | Mg | Na | K | Exch. Acids |
|---|---|---|---|---|---|---|---|---|---|---|
| Tis 87/0087 | AMF | 6.15 | 2.51 | 0.25 | 71.18 | 2.57 | 0.28 | 2.55 | 0.39 | 1.52 |
| | N.P.K | 6.67 | 2.82 | 0.28 | 72.97 | 2.53 | 0.33 | 2.65 | 0.32 | 1.67 |
| Tis 8164 | AMF | 6.13 | 2.63 | 0.17 | 70.00 | 2.45 | 0.18 | 2.72 | 0.37 | 2.01 |
| | N.P.K | 6.65 | 2.81 | 0.20 | 75.94 | 2.55 | 0.31 | 2.81 | 0.35 | 2.09 |

**Table 4: AMF and NPK effect on Microbial populations**

| Treatment/Soil Microbial Agent | | Bacteria($x10^6$)Cfu | Fungi($x10^6$)Cfu |
|---|---|---|---|
| Tis 87/0087 | AMF | 8.50 | 9.52 |
| | N.P.K | 6.24 | 7.40 |
| Tis 8164 | AMF | 8.35 | 9.23 |
| | N.P.K | 6.05 | 7.00 |

**Table 5: AMF and NPK effect on proximate content of sweet potato**

| Treatment/Nutrient Composition (%) | | B-carotene (µg) | Cruder fiber | Sugars | Proteins | Fats | Starch | Carbohydrate |
|---|---|---|---|---|---|---|---|---|
| Tis 87/0087 | AMF | 150.25 | 3.10 | 68.02 | 3.67 | 0.39 | 60.62 | 90.15 |
| | NPK | 158.05 | 3.65 | 73.15 | 4.78 | 0.42 | 64.41 | 96.16 |
| Tis 8164 | AMF | 155.10 | 2.95 | 69.68 | 4.05 | 0.39 | 62. 45 | 90.29 |
| | NPK | 160.00 | 3.35 | 76.21 | 5.15 | 0.53 | 67.53 | 96.85 |

**Table 6: AMF and NPK effect on mineral composition**

| Treatment/Mineral Composition(mg/100g) | | Ca | Mg | K | P | Fe | Zn | Na |
|---|---|---|---|---|---|---|---|---|
| Tis 87/0087 | AMF | 32.50 | 30.05 | 40.08 | 138.00 | 10.65 | 0.35 | 35.90 |
| | N.P.K | 40.25 | 34.15 | 45.20 | 156.15 | 14.10 | 0.60 | 46.06 |
| Tis 8164 | AMF | 32.54 | 31.10 | 40.12 | 138.45 | 12.10 | 0.38 | 36.10 |
| | N.P.K | 40.75 | 35.10 | 45.55 | 157.01 | 14.45 | 0.72 | 47.05 |

**Table 7: AMF and NPK effect on yield performance of sweet potato**

| Treatment | | WTR(kg) | MRY(t/ha) | URY(t/ha) | T. Yield(t/ha) |
|---|---|---|---|---|---|
| Tis87/0087 | AMF | 0.54 | 5.93 | 2.01 | 7.94 |
| | NPK | 0.41 | 4.13 | 2.17 | 6.30 |
| Tis8164 | AMF | 0.55 | 10.17 | 1.62 | 11.79 |
| | NPK | 0.49 | 4.98 | 1.43 | 6.41 |

***** WTR - Weight of tuber roots; MRT - Marketable root yield; URT - Unmarketable root yield; TY -Total yield***

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