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Complementary Application of NPK 15.15.15 Fertilizer with Different Source of Ash Materials on the Soil Properties, Nutritional Composition and Yield Performance of *Ipomoea batatas*

Princewill Ogugua Onyiba[1,2], Adedoyin Ayobami Asa[1,2] and Nchedo Thecla Mbah[1,2]

1. National Root Crop Research Institute, Umudike 440109, Abia State, Nigeria

2. Federal Ministry of Agriculture and Food Security, 900211, Nigeria

Abstract: The research trial was to evaluate the complimentary effects of NPK 15.15.15 with different source of ash materials on the soil chemical properties, proximate content, growth and yield of sweet potato. The field trial was arranged using randomized complete block design (RCBD) with five (5) different treatments: NPK at 400 kg/ha, NPK at 200 kg/ha + dried mango leave ash, NPK at 200 kg/ha + rice husk dust, NPK at 200 kg/ha + wood ash, and control (no fertilization) replicated three times. The composites of soil sample of the field were collected between 0-20 cm depth, analyzed for pre-cropping soil properties, and after treatments during harvest to determine the changes in soil chemical properties due to soil amendments. The results indicated significant difference ($p < 0.05$) among the treatments on all the parameters measured. The results showed that mineral content, dry matter, crude ash, starch, sugar, fats, crude protein and dietary fiber content were significantly improved in amended soil with ash materials when compared with sole NPK fertilization. The best performance on the growth and yield of sweet potato was significantly recorded from the plot amended with the integration of NPK plus rice husk dust of 18 t/ha while the control was the least. There were significant increases of soil organic carbon when treated with inorganic fertilizers and other ash material sources. The highest value of total nitrogen (0.17 g/kg) and lowest organic carbon (1.16 g/kg) was significantly recorded in the sole application of inorganic fertilizer whereas the highest increase in pH (5.7) and organic carbon (1.85 g/kg) were significantly recorded in the integration of NPK plus rice husk ash. It showed that sweet potato can perform optimally when there is integration of synthetic fertilizer amended with ash materials.

Key words: Synthetic fertilizer, ash material sources, sweet potato, proximate content and soil chemical properties.

1. Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam) is an important staple food crop in several tropical countries, where it is among the priority food security crops. It is one of the world's highest yielding crops with the total food production per unit area exceeding that of rice, and having greater food value. It is a major source of carbohydrate and beta-carotene for millions of people, especially in developing countries [1]. The plant is grown for its edible tuberous roots that contain about 70% water, 2% protein,0.2% fats, 1% fiber, 27% carbohydrate, 3%-5% sugar, calcium, iron and high concentration of vitamins especially vitamin A and C [2]. Fresh sweet potatoes provide about 50% more calories than fresh potatoes. The leaves are used as leaf vegetables as well as good fodder value and much more industrial value. They are a great source of minerals such as manganese, folate, copper, and iron. The coloured variety is a great source of carotenes (precursor of vitamin A), vitamin C, B_2, B_6, E and biotin. Sweet potatoes are also a fantastic source of dietary fibre. The crop can best be grown in well-drained sandy loam soils.

Corresponding author: Princewill Ogugua Onyiba, Ph.D., research fields: soil microbial ecology and soil health.

Productivity of sweet potato is constrained by poor soil fertility. The decline in sweet potato production is attributable to the increasing decline in the soil fertility and dearth of soil management practises. In highly nutrient depleted soils of sub-Saharan Africa (SSA), balanced nutrition of N, P, and K is required to enhance the crop yield. Lehmann [3] reported that integrating organic manure with inorganic fertilizer under the recommended quantity enhanced root productivity and quality than when the treatments were applied singly. The application of NPK fertilizer to the soil actually boasts the growth and yield performance of the crop though its persistent affects soil health status [4]. Different sources of organics such as ash materials contain high content of silicon, carbon, potassium and nutrients, and they have great potential for soil amendments [3]. Researchers have proved that incorporation of ash materials such as rice husks dust, wood ash, etc. can significantly improve soil properties, bulk density, pH, organic carbon content, cation exchange capacity, and increasing nutrients such as nitrogen, phosphorous, potassium, and removing heavy metals from the system, ultimately increasing crop yields [5, 6]. Wood ash contains varying amounts of nutrients such as magnesium, phosphorous, and calcium which can improve soil pH of acidic soils [7-9]. Ash materials increase pH, mineral nutrients and microbial life even though most of the nitrogen, sulphur and carbon are lost as gases. The objective of research study is to evaluate the complimentary effects of NPK 15:15:15 with different source of ash materials on the soil chemical status, proximate content, and yield performance of sweet potato.

2. Materials and Methods

The research was carried out in 2019 cropping season at the Research Farm of National Root Crop Research Institute, Igbariam substation and Federal College of Agriculture, Ishiagu Ebonyi State. The pre-cropping and post cropping soil analysis was determined using standard procedure. The treatments comprised of two levels of NPK 15:15:15 (200 kg/ha and 400 kg/ha) in combination with dried mango leaves ash, rice husk duct, wood ash and control (no application). The field trial was arranged using randomized complete block design (RCBD) with nine different treatments: NPK at 400 kg/ha (T_1), NPK at 200 kg/ha (T_2); NPK at 400 kg/ha + dried mango leave ash (T_3), NPK at 400 kg/ha + rice husk dust (T_4), NPK at 400 kg/ha + wood ash (T_5); NPK at 200 kg/ha + dried mango leave ash (T_6), NPK at 200kg/ha + rice husk dust (T_7), NPK at 200 kg/ha + wood ash (T_8) and Control T_9 (no manure application) replicated three times. The planting materials were an improved variety of sweet potato, TIS 87/00087 (Pink fleshed colour), bred by the NRCRI, Umudike. All the necessary agronomic practices were carried out as required in the trial, and data collected from six randomly selected tagged plants at 4, 6, 8, and 12 Week after planting (WAP). The following parameters were considered: number and weight of tubers; soil pH [10], organic carbon content [11, 12], total nitrogen (Kjedahl method), available phosphorous using Bray II method [13], cation exchange capacity as well as proximate contents of the crop. The data collected were analysed using analysis of variance (ANOVA) and significant treatment means were compared using Duncans test at $p < 0.05$ to determine the significant differences between the treatment [14].

3. Results and Discussions

3.1 Effects of NPK and Ash Materials on the Soil Physicochemical Properties

The results of soil physicochemical properties as seen in Table 1 indicated that the soil was sandy loam, clay, silt 13% and fine sand 61%. The pH value was 5.4 while the organic carbon and total nitrogen were 0.52 g/kg and 0.070 g/kg respectively. The exchangeable sodium and potassium were 0.04 and 0.09 cmol/kg respectively whereas calcium and magnesium values were 1.80 and 1.40 cmol/kg respectively. Table 2 showed the results of NPK amended with ash materials on soil chemical properties which indicated that there was significant ($p < 0.05$) improvement on soil chemical properties especially soil pH, etc. among the treatments. As indicated in Tables 1 and 2, the results showed the influence of NPK complemented with ash materials gave rise to an increase in soil pH than sole application of NPK. The combination of synthetic fertilizer with rice husk duct treated plots recorded a pH of 5.70 within the trial. This followed by the plot amended with NPK and mango leaves with pH of 5.60, while the least value of pH 5.20 was from the application of NPK sole treated plots. This may be attributed to liming ability of ash materials. According to Lombin et al. [15], ash materials can induce a pH increase by as much as 0.60 to 1.00 units in humus soils. The soil organic carbon showed a significant effect due to the treatments. The plots treated with NPK and rice husk duct recorded 1.85g/kg which improves organic carbon pool in the soil over other treatments. The least value of organic carbon was 0.83 g/kg recorded on the control plots. Total nitrogen was significant among the treatments as the plots treated with sole NPK produced the highest value of 0.17 g/kg, followed by NPK and rice husk duct with a value of 0.14 g/kg while least value of 0.07 g/kg was from the control. The increase in the values of soil chemical properties in the plots complemented with NPK and rice husk duct may be due to the chemical components of rice husk duct. Eyitalo [6] revealed that the application of rice husk duct significantly improves the chemical properties of soils.

3.2 Effect of NPK and Ash Materials on the Yield Performance of Sweet Potato Crop

The results in Table 3 showed the influence of NPK complemented with ash materials on the number of storage roots of sweet potato at harvest. There was significant $p < 0.05$ difference among the treatments. The table indicated that storage roots increased at 62.00 when amended with NPK and rice husk duct followed by the plots treated with NPK and mango leave ash with the value of 35.00 while control recorded the lowest value of 20.33. Again, the treatment effect on the weight of the storage roots indicated that there was significant difference existing among the treatments applied. NPK and rice husk duct application recorded the highest value of 18.9 t/ha followed by NPK and wood ash materials with value of 11.2 t/ha while control recorded the least mean value of 6.20 t/ha. The higher values recorded in the number and weight of storage roots were an indication that NPK complemented with rice husk duct may be due to the available mineral nutrients such as nitrogen and phosphorus in the combination. According to Chand et al. [16], the combination of synthetic and organic fertilizer promotes crop growth and yield. The mixture of the two fertilizers acts as growth promoters for crop, thereby leading to abundance in storage roots of sweet potato. A soil amended with organic fertilizers shows vigorous vegetative growth and higher yield when compared to synthetic fertilizer alone. The combination of organic and inorganic fertilizers results in higher yields of sweet potato than sole application of each nutrient source [17].

3.3 Effect of NPK and Ash Materials on the Nutritional Component of Sweet Potato Crop

Table 4 showed that the synthetic fertilizers combined with ash materials have significant effect on the proximate content of sweet potato. The results revealed that moisture content increased from 70.50 to 73.50 when NPK was combined with rice husk duct. The same trend happened with NPK and wood ash which gave 73.20. According to Endrias et al. [18], the moisture content of orange-fleshed sweet potato showed variation, which may be related to the diversity in variety, agro-climatic conditions and agriculture practices employed. The low moisture content is very important for orange-fleshed sweet potato flour to maintain long shelf life. Dry matter content improves significantly as the inorganic fertilizer was combined with organic fertiliser. The results indicated that the dry matter content increased from 30.50 to 34.50 as NPK was combined with rice husk duct.

Protein, crude ash, crude fibre, fats, starch and energy content of sweet potato increased significantly when NPK fertilizer was combined with organic fertilizer. The results showed that protein content of sweet potato was in the range of 1.91% to 5.83% [19]. Crude fiber as one of the non-digestible carbohydrates plays a role in cholesterol level reduction. It also encourages the growth of natural microbial flora in gut. The total dietary fiber of 3.6% was reported in sweet potato, but the lower concentrations like 0.35% were reported in different varieties of sweet potato [18]. These variations may be related to the varietal and agro-climatic differences of the crop. Ash values in sweet potato were from 1.17%-4.33%, which may be as a result of varietal and agro-geological differences [19]. The fat concentration of sweet potato is less than 1%. This trend is usually the property of roots and tubers. The fat concentrations directly influence the energy density of the food, but people with limited energy to avoid certain disease can consume orange flesh sweet potato (OFSP) (Mohammad et al., 2016). The high starch content (65.41%) was reported in sweet potato on fresh weight basis. Starch is one of the very important energy sources for the consumers. So, sweet potato can be consumed as the staple crop because of high concentration of carbohydrates [20].

Energy content serves as a very important property of the staple crops, which is reported to be in the range of 344.52-375.05 kcal/100g. Due to this property, sweet potato is one of the choices for staple foods [18].

Table 1 Initial soil physical and chemical properties of the studied soil.

Soil properties	Values
Texture class	Sandy loam soil
Clay (%)	8.0
Silt (%)	13.0
Fine sand (%)	61.0
Coarse sand (%)	18.0
pH	5.4
Organic carbon (g/kg)	0.52
T. nitrogen	0.07
Avail. phosphorous	5.60
Exchangeable bases (cmol/kg)	
Sodium	0.04
Potassium	0.09
Calcium	1.80
Magnesium	1.40
Cation exchange capacity (cmol/kg)	15.20
Base saturation (%)	21.91

Table 2 Effect of NPK and ash materials on some selected soil properties.

Treatments	Soil pH	Organic carbon (g/kg)	Total nitrogen (g/kg)
T_1	5.20	1.17	0.17
T_3	5.50	1.65	0.11
T_4	5.70	1.85	0,14
T_8	5.0	1.45	0.10
T_9	5.40	0.83	0.07
$LSD_{(0.05)}$	0.15	1.06	0.03

Table 3 Effect of NPK and ash materials on the storage root yield performance of sweet potato.

Treatments	No. of roots	Weight of storage roots (kg)
T_1	35.00	8.60
T_2	33.00	8.10
T_3	34.00	8.15
T_4	40.00	9.01
T_5	42.00	9.20
T_6	35.00	9.40
T_7	62.00	18.90
T_8	35.00	11.20
T_9	20.33	6.20
$LSD_{(0.05)}$	11.08	6.20

Table 4 Effect of NPK and ash materials on the nutritional content of sweet potato.

Treatments	Moisture (%)	Dry matter content (%)	Crude fibre (%)	Ash contents (%)	Crude protein (%)	Fats (%)	Carbohydrate /starch (%)	Energ. (kcal/100g)
T_1	70.50	30.80	1.25	1.80	2.10	0.91	68.80	350.00
T_2	68.90	29.50	1.10	1.91	1.91	0.80	68.00	344.05
T_3	72.50	31.00	1.50	1.82	2.45	0.83	69.50	355.50
T_4	73.50	33.00	1.80	1.85	2.50	0.95	70.00	365.00
T_5	73.20	34.50	1.90	1.85	2.45	0.95	70.50	362.50
T_6	70.00	34.00	1.15	1.90	1.95	0.85	69.00	345.50
T_7	70.50	36.50	1.15	1.89	2.00	0.85	70.00	349.10
T_8	72.00	34.00	1.18	1.95	2.10	0.82	70.50	348.05
T_9	69.00	28.50	1.00	175	1.90	0.89	68.00	345.00

4. Conclusion

Soil chemicals have been confirmed to be important for soil health and quality. This research trial revealed the effectiveness of different organic manure sources on soil chemical properties, proximate content, growth and yield of crop production especially sweet potato. The integration of NPK synthetic fertilizer with rice husk duct can improve the nutritional composition as well as the growth and yield of sweet potato for increased food production and sustainability. Farmers should adopt the integration of NPK synthetic fertilizer with organic manure for sustainable crop production, since they increase and enhance the soil chemical properties such as soil pH, organic carbon and nutrients for good soil health and subsequent nutrient uptake by crops.

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