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Evaluation of Yield Responses of five Water Yam (*Dioscorea alata*) Genotypes to Varying Rates of NPK (15:15:15) Fertilizer in an Ultisol.

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Abstract: Yield responses of five genotypes of *Dioscorea alata* (TDa 00/00060, TDa 02/00812, TDa 02/00019, TDa 02/00019, TDa 00/00060 and Uyo local), NPK fertilizer rates (300 and 400kg) and three yield components (seed tuber yield, ware tuber yield and total tuber yield (t/ha) were evaluated. Particle size analysis showed that sand fractions was 91.40% and 84.80% at 0-15 and 15-30cm depths, respectively, followed by clay, 6.40 and 10.20%, and silt 2.20 and 5.00% respectively. The soil phosphorus content was high (212.31 and 255.91 at 0-15 and 15-30cm depths, respectively) whereas the organic matter content, total nitrogen, and exchangeable bases were below critical values at both 0-15 and 15-30 cm soil depths. Results also revealed that the yield of *D. alata* genotypes differed significantly (P<0.05) with fertilizer application. Highest seed tuber yield (17.27 t/ha was obtained with TDa 00/00060 at 400kg/ha application rates. While the least (0.97 t/ha) was obtained with local variety at 0kg/ha application rate. Similarly, ware tuber yield was highest (6.23 t/ha) in TDa 00/00060 at 400kg/ha rate but least (1.10 t/ha) in TDa 02/000812 receiving 0kg/ha fertilizer. The total tuber yield was highest 923.50 t/ha) in TDa 00/00060 receiving 400kg/ha fertilizer and least (6.24 t/ha) in local variety receiving 0kg/ha. The finding of this experiment recommends 400kg/ha fertilizer application for optimum production of *Dioscorea alata* in the area.

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1.0 Introduction

Yams, *Dioscorea alata* "water yam" is tuberous root vegetable which belongs to the genus Dioscorea. It is also known as Ube in Phillipines where it is consumed as delicious and delightful sweet water yam. *Dioscorea alata* is not grown in the same quantities as some other African yams. It is the largest worldwide of any cultivated yam, being grown in Asia, the Pacific Island, African and West Indies (Mignouna and Dansi, 2003).

The tubers are large, coarse and less spherical. Some are oblong, elliptic to flat and fan shape or hand shaped with thick short fingers. When cut the tubers are soft and drops of white appear on the surface hence the name. The leaves are usually larger and broader than those of white yam and the tubers are more fibrous and less firm, and do not keep so well as white yam and yellow yam.

Water yam grows best at temperature of 25°C and their cultivation is essentially restricted to the tropics. A well distributed rainfall between 1200 mm and 1300 mm is favourable for its cultivation. Water yam requires a well-drained sandy loam soil, too clayey soil results in tuber rot and harvesting is difficult. *Dioscorea alata* is mainly cultivated for its large white edible flesh root with high carbohydrate content. More than 85% of carbohydrate reserves in *Dioscorea alata* comprises of starch, generally utilized for its edible and medical values.

Dioscorea flour is widely used for cullinery purposes throughout the world. Water yam has numerous edible and medical uses, due to high carbohydrate content in the form of starch. The fleshy root of this herbaceous vine is quite nutritious. The root is considered to be an ideal source for energy. *Dioscorea alata* can be cooked and consumed with stew or vegetables or fried, roasted and produced into paste. It is used by the yorubas to make delicacies like "Ikokore" (water yam porridge) and "Ojojo" (fried grated water yam balls). In ibibios and Efiks, it can also be used to prepare "ekpang nkukwo" and "anyan ekpang".

The aromatic flavor of *Dioscorea alata* can be used in tarts, cookies, cakes, ice creams, milk and pastries. *Dioscorea alata* flour is widely used in preparing dehydrated food products. Medically, it has been used as laxative in various healing practices. It is widely known for curing burned hemmorides, fever, gonorrhea, tumors and many more. It is also used to solve a number of digestive problems and blood pressure issues.

D. alata serves as an essential ingredient in minimizing dehydration and also prevent vomiting and sickness symptoms during early pregnancy. It contains a lot of minerals like calcium, potassium, iron, phosphorus and copper. It also contains vitamin C and E which have anti-oxidant properties. These nutritional attributes make it a good base for food preparation for infants and pregnant women and could be incorporated in weaning food for infants.

Therefore, the purpose of this research was to assess the yield responses of five *Dioscorea alata* genotypes to varying rates of NPK (15:15:15) fertilizer in an ultisol.

2.0 Materials and Methods

2.1 Experimental site and cropping history

The study was conducted at University of Uyo Teaching and Research Farm, Use-Offot, during the early planting season of 2018 (between the months of May and December). Uyo is situated between latitude $4^0$30´N and $5^0$27´ N and longitude $7^0$50´E and $80^0$20´E and altitude 38.1m above sea level. The area which lies within the humid tropical rainforest zone of southeastern Nigeria has average annual rainfall of about 2500 mm, mean monthly sunshine of about 3.14 hours and a mean annual temperature range of 26^0C-28^0C. Uyo has an annual mean relative humidity of 79% and evaporation rate of 2.6 cm^2 and the rainfall pattern of Uyo is bimodal. Rain usually starts in March and ends in November, with a short period of relative moisture stress in August traditionally referred to as "August break" (AKSMRD, 2004). The dominant weeds on the experimental plot were *Aspilia africana, Calapogonium mucunoides, Cynodon dactylon, Panicum maximum, Cyperus sp; Euphorbia sp; Eleusine indica, Ageratum conyzoides, and Chromolena odorata.*

2.2 Land Preparation.

The experimental site was manually cleared with machete and raked, marked out and mounds constructed at 1m x 1m spacing in May, 2018.

2.3 Soil collection and analysis

After clearing and before marking out the field, composite soil samples were collected at two depths (0-15cm and 15-30cm). The samples were collected using soil auger. The soil samples were carefully labeled and taken to the laboratory where they were air dried and bulked then the bulked samples were crushed and sieved through a 2.0 mm-mesh, labeled and stored in dry polyethylene bags for physico-chemical analysis. pH of the soil was determined in water (1:2, soil: water ratio) using pH meter with glass electrode. Total nitrogen in the soil was determined by the micro-kjeldahl digestion and distillation method as described by Bremner (1996), while organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (1935). Similarly, the available P was determined by the Bray-1 method of Bray and Kurtz, (1945), exchangeable cations were extracted with neutral NH_4OAC while Calcium and magnesium were determined in the extract by EDTA titration (Jackson, 1962) and potassium and sodium by the use of flame photometer. Exchangeable acidity determined as described by Juo (1975). Effective cation exchange capacity (ECEC) was obtained by the summation of the exchangeable base (TEB) and exchangeable acidity (EA) i.e. ECEC = TEB + EA (IITA, 2004). Electrical conductivity was determined by conductivity bridge and cell method as described by Ogunwale (2006), while percentage Base Saturation (B.S) was computed as follows:

$$\% \text{ B.Sat.} = \text{TEB/ECEC} \times 100$$

2.4 Experimental design and treatments

The experiment was laid out in a randomized complete block design and replicated three times. five *D. alata* genotypes: TDa 00/00074, TDa 02/000812, TDa 02/00019, TDa 00/00060 and local best cultivar (*Afia ebighe*) constituted the main treatments, while three fertilizer rates (control - 0, 300 and 400 kg/ha) were the sub-treatments.

2.5 Agronomic Practices

Planting was done on 11th May, 2018 at a spacing of 1m x 1m and at a planting depth of 10 cm. An average weight of 200g of tuber was used. Weeding was done manually at 1, 3, 5, months after planting (MAP) using a native hoe. Staking was done when the yam shoots were about 50cm long. Single erect staking materials of about 2m long were provided for each stand at two months after planting (2 MAP). A compound fertilizer NPK (15:15:15) was applied at 2 months after planting (MAP) using ring method.

2.6 Harvesting

Harvesting was done at 7 months after planting (7MAP). All the tubers were arranged on plot bases according to treatments.

2.7 Data collection and Analysis

Yield parameters including seed tuber yield, ware tuber yield and total tuber yield Data collected were analysed using analysis of variance (ANOVA) and the means separated with LSD at 5% probability level.

3.0 Result

3.1 Physico-chemical parameters of Soil before Planting

Table 1 shows soil physico-chemical properties of the experimental site before planting. Particle size analysis showed that the sand fractions was 91.40% and 84.80% at 0-15 and 15-30cm depths respectively, followed by clay, 6.40 and 10.20%, and silt 2.20 and 5.00%, respectively. The organic matter content, total nitrogen, and exchangeable bases were below critical values at both 0-15 and 15-30 cm soil depths; while available phosphorus was high. pH value indicated that the soils were acidic with values of 4.42 and 4.60 at 0-15 and 15-30cm depths respectively. From all indications, the overall fertility status of the soil was low.

Table 1: Soil physico-chemical characteristics of the experimental site before planting

Properties	Soil depth (cm)	
	0.15	15-30
pH	4.42	4.60
EC (Cmol/kg)	0.07	0.06
Org. matter (%)	1.66	1.41
Total N (%)	0.08	0.04
Avail. P (mg/kg)	212.31	255.91
Exchangeable bases (cmol - 1)		
Ca	2.98	2.86
Mg	1.88	1.77
K	0.12	0.13
Na	0.07	0.05
Exchangeable acidity	1.04	1.06
ECEC	7.48	7.31
Base saturation (%)	67.47	66.38
Particle size analysis (%)		
Sand	91.40	84.80
Clay	6.40	10.20
Silt	2.20	5.00

3.2 Yield of water yam as influenced by genotypes and fertilizer rates

Seed tuber yield (t/ha) as influenced by water yam genotypes differed significantly (Table 2). The highest seed tuber yield was obtained in TDa 00/00060, (17.27 t/ha), followed by TDa 02/00019, (16.95 t/ha), TDa 02/000812, (15.99 t/ha) and TDa 00/00074, (15.21t/ha). The least seed tuber yield was recorded in Afia ebighe, (2.77 t/ha). The TDa 00/00060 recorded significant ($P<0.05$) higher yield over other genotypes by 2-54%.

The seed yam yields as influenced by fertilizer rates showed significant differences (Table 2). However, the application of 400kg/ha of fertilizer produced the highest seed yield followed by 300 kg/ha while the control rate produced the least. Ware tuber yield as influenced by water yam species differed significantly ($P<0.05$) (Table 2).

The highest ware yam was recorded in TDa 00/00074, (5.20 t/ha) followed by TDa 02/00019, (3.90 t/ha), and local variety, Afia ebeghe, (3.47 t/ha). The least ware tuber yield was recorded in TDa 02/0001812, (1.10 t/ha). The TDa 00/00060, produced 18-82% more ware tubers than other genotypes. The ware tuber yields as influenced by fertilizer rates was significantly ($P<0.05$) different (Table 2). Application of 400kg/ha of fertilizer produced the highest ware tuber yield followed by 300 kg/ha while the control rate produced the least irrespective of the genotypes.

The total fresh tuber yields as influenced by water yam genotypes was significantly different ($P<0.05$) (Table 2). The highest tuber yield was obtained from the TDa 00/00060 (23.85 t/ha), followed by TDa 02/00019 (20.85t/ha) and TDa 00/00074 (20.42 t/ha). The least tuber yield was obtained from *Afia ebighe* (6.24 t/ha). The TDa 00/00060 genotype out yielded other genotypes by 11-74%. Total tuber yields as influenced by fertilizer rates showed significant differences ($P<0.05$) (Table 2). The application of 400kg/ha of fertilizer rate produced the highest total tuber yield followed by

300 kg/ha, while the control rate produced the least irrespective of the genotypes. The interaction effect between water yam genotype and fertilizer rates was not significantly different.

Table 2: Yield of water yam as influenced by genotypes and fertilizer rates

Water Genotype	Fertilizer rate (kg/ha)	Seed tuber yield (t/ha)	Ware tuber yield (t/ha)	Total tuber yield (t/ha)
TDa 00/00074	0	12.15	3.50	17.15
	300	16.40	3.50	19.90
	400	17.09	12.11	29.20
	Mean	15.21	5.20	20.42
TDa 02/000812	0	11.49	0.00	11.49
	300	17.89	0.00	18.60
	400	18.60	3.31	20.20
	Mean	15.99	1.10	17.10
TDa 02/00019	0	12.88	2.30	10.08
	300	15.58	4.50	15.18
	400	22.40	4.90	27.30
	Mean	16.95	3.90	20.85
TDa 00/00060	0	12.72	5.38	18.10
	300	16.90	6.00	22.90
	400	22.18	7.33	29.51
	Mean	17.27	6.23	23.50
Local (Afia Ebighe)	0	0.97	2.33	3.30
	300	3.63	3.40	7.10
	400	3.70	4.70	8.33
	Mean	2.77	3.47	6.24
LSD ($P \leq 0.05$)				
Genotypes (G)		3.22	5.10	1.41
Fertilizer rate (F)		0.38	23.0	8.20
G x F interaction		ns	ns	ns

ns = not significant

4.0 Discussion

The result of soil analysis showed that fertility status of the experimental site was low. The soil was deficient in major nutrient elements and fell below the critical levels except for phosphorus. Therefore, soil amendment was required to make it productive. The yam genotypes showed significant difference in their yield responses to fertilizer rates. This finding agreed with Aighewi *et. al.* (2001) that different species and varieties of water yam differ in their response to varying nutrient limits.

The difference in yield components among the water yam genotypes could be attributed to inherent characteristics. This corroborates the results of earlier researchers (Onwueme and Charles, 1994; Nweke, *et. al.* 1994; Ekpe, 1998; IITA, 2004; Hahn and Keyser, 1985; Asiedu, *et. al.* (2006). Nweke *et. al,* (1994), noted that tuber yields of the genotypes were significantly higher than local cultivars even with or without fertilizer. This confirms the current result.

The result showed significant differences in yield as influenced by fertilizer rates and agrees with findings of FAO (2003) that different varieties of a particular crop differ in their nutrient requirements and response to fertilizer. This study is in agreement with the findings of Asadu, *et. al.* (1996) who noted that location, fertilizer and cultivars significantly affect tuber yield. The response of studied parameters of *D. alata* as observed in this research clearly authenticates the notion that fertilizer treatment significantly increased the tuber yield in this crop and this increase was dose dependent. The importance of fertilizer in optimizing crop production is verified in that tuber yield was reduced in stands where fertilizer was not applied and vice versa. This corroborates the findings of Law-Ogbomo and Remison, (2009). The low tuber yield in stands not receiving fertilizer amendment may be attributed to insufficient nutrient uptake by plants from control soils which must have been deficient in the basic primary nutrients (N, P and K) needed by plants for optimum growth and development. Nitrogen and phosphorus are key nutrients which are supplied to the soil directly through fertilizer application which are vital in the synthesis of chlorophyll and enhancement of foliage growth and organ development in plants. On the other hand, potassium being a base cation, serves as osmotically active ion in soil solution regulating its pH and thus increasing the nutrient accessibility to plants especially under acidic nutrient limiting conditions (Okon, *et al.* 2013 and Law-Ogbomo and Osaigbovo, 2014). This study confirmed that the inorganic nutrient supplement significantly improved the yield performance in all studied genotypes.

5.0 Conclusion

This study showed that the soil of the study area was low in essential nutrient elements. The results showed that TDa 00/00060 (23.50), Tda 02/00019 (20.85), and Tda 00/00074 (20.42) produced highest tuber yields while the local cultivar, *Afia ebighe* (6.20) produced least tuber yield and that the application of 400kg/ha fertilizer rate is optimum for *D. alata* production. Based on these observations, water yam Farmers in Uyo should cultivate Tda 00/00060 and Tda 00/00074 for high fresh tuber yields. Fertilizer rate of 400kg/ha will induce optimum tuber yield in this crop.

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