Effects of NPK (15:15:15) Fertilizer on Growth and Yield of Guinea white yam (*Dioscorea rotundata* Poir) Genotypes in Uyo South-South Nigeria.

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Abstract: A study was conducted to assess the effects of 400kg/ha of NPK fertilizer (15:15:15) on some growth and yield parameters of *Dioscorea rotundata* (white yam). The experiment was laid out using a randomized complete block design and replicated three times. Four genotype of *D. rotundata* (TDr 98/01164, TDr 96/01168, TDr 96/00060 and local variety were used for the experiment and the parameters measured were number of leaves per plant, vine length, leaf area and total yield (t/ha). The results showed that fertilizer treatment had a significant ($P<0.05$) effects on the growth and yield on the parameters studied and that the genotypes responded differently to the treatments. TDr 98/01164 recorded highest number of leaves (11.02, 80.56, 110.02 and 177.19 at 1, 2, 3 and 4 MAS, respectively) while the least was recorded for the local genotype (10.69, 53.62, 130.41 and 175.40 at 1, 2, 3 and 4 MAS. Similarly, TDr 98/01164 recorded highest vine length of 105.26, 168.24, 186.98 and 198.02cm at 1, 2, 3 and 4 MAS respectively, while TDr 96/01168 recorded 68.92, 92.40, 182.24 and 187.94 at 1, 2, 3 and 4 MAS, respectively. Also, the largest leaf area was recorded for TDr 98/01164 (44.11, 50.90 and 66.33 at 1, 2, 3 and 4 MAS respectively whereas the local genotype recorded the least leaf area (30.05, 31.51, 34.99 and 37.21 at 1, 2, 3 and 4 MAS respectively. TDr 96/011799, TDr 96/01168, TDr 98/01164 and local genotype recorded tuber yields of 15.45, 15.21, 13.98 and 7.60t/ha, respectively at 4 MAS. Generally, fertilizer application significantly stimulated growth and improved yield of the genotypes. TDr 96/011799 and TDr 96/01168 could be recommended to local and commercial farmers.

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1. Introduction
1.0 Introduction

Yams are herbal or woody, climbing plant with tuberous starch rich storage organs which belong to the family Discoreaceae. They are perennial plants with a strongly marked annual growth. Yams have a fibrous root system confined mostly to the top 30cm of soil Udoh *et al*., 2005). In species where the stem is very spiny, some spines may also be present on the roots. In many species, a few thin roots can also be found on the body of the tuber. The yam is neither stem nor a root tuber (Onwueme and Charles, 1994). Detailed morphogenic studies indicated that it develops from the hypocotyl region. Unlike tropical roots tubers such as cassava and sweet potato, yam does not develop by the enlargement of primary roots and it lacks the analogue of a root cap at its tip. Unlike the tropical stem tubers such as potato, it does not possess a terminal bud at its growing point and is devoid or scale leaves, and auxiliary buds (“eyes”) are absent from the general tuber surface.

Yam is a very important tuber crop in Nigeria. It is a staple food, which contributes substantially to national food security. In the major producing area, yam is consumed at least once a day, during the yam season, from October to March of succeeding year (Ugwu, 1990). It is a major source of income to small scale yam farmer in West Africa (Dansi, *et. al.* 2001). Yam is commonly consumed as boiled yam and as pounded yam. The boiled yam or pounded yam is consumed with oil, stew or vegetables. Yam may be roasted, fried or baked. It can also be processed into flour, paste and eaten with either soup or vegetables. There is very limited or little international trade in yams. Processed forms in which yam can be stored are also found in Africa. The most common is yam flour. This is made by drying thin slices of peeled tubers and milling the dried pieces to produce flour which can be stored for months. Other processed forms of yam include chips, which are used as snacks, and yam flakes. The flakes when stirred with boiling water is reconstituted into a product identical to pounded yam. *D. rotundata* is the most viscous of all yams. Ajayi, *et. al.* (2006) has shown the effects of NPK fertilizers on yield of *D. rotundata* of IDr-99-6 in South western Nigeria. Their results confirmed short term and residual effects which were significantly different. However, this crop yield is declining over time in the South-south region of Nigeria due to poor soil management. This reason necessitates the current research.

2. Material 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 (AKSMRD, 2004). It has an 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. 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).

2.2 Land Preparation.

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

2.3 Experimental design and treatment

The experiment was laid out in a randomized complete block design and replicated three times. Four *D. rotundata* genotypes: TDr 98/01164, TDr96/01168, TDr 96/00060 and local best variety (*eteme*) constituted the main treatment effect.

2.4 Crop Management Practices

Planting was done on 11^{th} May, 2018 at a spacing of 1m x 1m and at a planting depth of 10 cm. An average weight of 200g sett 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 2 m long were provided for each stand at two months after planting (2 MAP). A compound fertilizer NPK (15:15:15) was applied (400kg/ha) at 2 months after planting (MAP) using ring method. Harvesting was done at 7 months after planting (7 MAP). All the tubers were arranged on plot bases according to treatments.

2.5 Data Collection and Analysis

2.5.1 Growth and Yield Evaluation

The following growth parameters were measured:

(i) Number of functional leaves per plant: Number of leaves per plant was determined by counting the number of functional leaves of each five tagged yam genotype per plot at 1, 2, 3 and 4 months after sprouting (MAS).

(ii) Leaf area (cm^2): This was obtained by measuring the length and width of the leaves of five tagged plants and value multiplied by correction factor (Anon, 1975).

(iii) Vine length (cm): The vine length was determined by measuring the length of each three tagged yam plants with a measuring tape at 1, 2, 3 and 4 MAS.

(iv) Tuber yield (t/ha) was determined by weighing seed and ware yam together according to treatment basis and later converted to t/ha.

2.5.2 Data Analysis

Data collected were analyzed using analysis of variance (ANOVA) and the means separated with LSD at P<0.05.

3. Results

3.1 Number of Leaves

Number of leaves per plant in the white yam genotypes differed significantly at 1, 2 and 3 MAS (Table 1). Number of leaves per plant gradually increased from 1-4 MAS. TDr 96/00060 genotype produced the highest number of leaves per plant (12.53 and 155.12 at 1 and 3 MAS), while TDr 98/01164, produced the highest number of leaves per plant at 2 and 4 MAS (80.56 and 177.19) respectively. The least number of leaves was recorded in the local variety (Eteme), with 10.69 and 53.62 leaves at 1 and 2 MAS and 95.61 and 162.82 by TDr 96/01168, at 3 and 4 MAS, respectively. The TDr 96/00060 produced 3-35 and 15-55% more leaves than other genotypes at 1 and 2 MAS while TDr 98/01164 produced 20-39 and 9-51 % more leaves than other genotypes at 2 and 4 MAS, respectively.

Table 1: Establishment percentage and number of leaves per plant of Guinea White Yam as influenced by genotypes and fertilizer rates

Genotypes	Fertilizers rates (kg/ha)	Establishment (%)	Number of leaves per plant Months after sprouting			
			1	2	3	4
TDr 98/01164	400	69.42	11.02	80.56	110.02	177.19
TDr 96/01168	400	75.17	10.77	69.53	94.61	162.82
TDr 96/00 060	400	62.11	12.53	57.47	155.12	179.23
(local (Eteme)	400	57.05	10.69	53.62	130.41	175.40
LSD (P≤ 0.05)						
Genotypes (G)		NS	0.18	4.38	3.17	NS
Fertilizer rates (F)		NS	NS	NS	8.11	6.05
G x F interaction		NS	NS	NS	NS	NS

NS =not significant

3.2 Vine Length

Significant differences (P<0.05) were observed in vine length among the guinea white yam genotypes at 1 and 2 MAS (Table 2). The genotype TDr 98/01164 produced the longest vines at 1, 2, 3 and 4 MAS, (105.26, 168.24, 184.62 and 198.02cm) followed by TDr 96/01799, (94.00 and 136.43cm at 1 and 2 MAS, local variety, 184.11cm at 3 MAS), while TDr 96/01799 was 194.62cm. The shortest vines (68.92, 92.40 and 182.24cm) were recorded in TDr 96/01168 genotype at 1, 2 and 3 MAS. At 4 MAS, the shortest vines were recorded in the local variety, (176.27 cm). The TDr 98/01164 genotype produced 11-35, 25-45, 5-26 and 7-31% longer vines than other genotypes at 4 MAS.

Table 2: Vine length (cm) as influenced by white yam genotypes and fertilizer rates

Genotypes	Fertilizer rates (kg/ha)	Vine length (cm) Months after sprouting			
		1	2	3	4
TDr 98/01164	400	105.26	168.24	186.98	198.02
TDr 96/01799	400	94.00	136.43	182.24	194.62
TDr 96/01168	400	68.92	92.40	182.24	187.94
Local (Eteme)	400	79.65	106.55	184.11	176.27
LSD (P≤ 0.05)					
Genotype (G)		7.21	3.81	NS	NS
Fertilizer rate (F)		NS	NS	7.40	5.61
G x F interaction		NS	NS	NS	NS

NS = not significant

3.3 Leaf Area

White yam leaf area among the genotypes differed significantly (P<0.05) at 4 MAS (Table 3). TDr 98/01164, produced the widest leaf area at 1, 2, 3 and 4 MAS, (44.1, 50.90, 57.18 and 66.33 cm^2, respectively). The TDr 98/01164, produced 8-31, 2-15, 17-25 and 39-50% wider leaf area than other genotypes at 1, 2, 3 and 4 MAS, though it was significantly different only at 4 MAS.

Table 3: White yam leaf area as influenced by genotypes and fertilizer rates

Genotypes	Fertilizer rates (kg/ha)	Leaf area (cm^2) Months after sprouting			
		1	2	3	4
TDr 98/01164	400	44.11	50.90	57.18	66.33
TDr 96/01799	400	32.63	44.34	56.53	61.01
TDr 96/01168	400	35.35	38.81	50.69	56.43
Local (Eteme)	400	30.05	31.51	34.99	37.21
LSD (P≤ 0.05)					
Genotypes (G)		NS	NS	NS	3.40
Fertilizer rate (f)		NS	NS	1.15	3.03
G x F interaction		NS	NS	NS	NS

NS = not significant

3.4 Number of tubers per plant as influenced by white yam genotypes

Number of tubers per plant among the white yam genotypes differed significantly (Table 4), TDr 96/01799 genotype produced highest number of tubers per plant (5.39), followed by the local variety, *Eteme*, (3.78), and TDr 98/01164, (3.59). The least number of tubers per plant was recorded in TDa 96/01168 being 3.10. Number of seed tubers per plant differed significantly (P<0.05). TDr 96/01799 produced the highest number of seed tubers, (4.64), followed by local variety, (2.89), and TDr 98/01164, (2.48). Least number of seed tubers per plant was recorded in TDr 96/01168, (1.89). The TDr 96/01799, produced 3-5% more number of seed tubers than other genotypes. Number of ware tubers as influenced by white yam genotypes showed no significant difference (Table 4). The highest number of ware yam was recorded in TDr 96/01168, (1.22), followed by TDr 98/01164, (1.11). The least number of ware tubers was obtained in TDr 96/01799, (0.75). The 96/01168 produced 9-39 % more ware tubers than other white yam genotypes.

Table 4: Number of tubers as influenced by white yam genotypes

Genotypes	Fertilizer rate (kg/ha)	Number of tubers per plant	Number of seed tubers per plant	Number of ware tubers per plant
TDr 98/01164	400	3.59	2.48	1.11
TDr 96/01799	400	5.39	4.64	0.75
TDr 96/01168	400	3.10	1.89	1.22
Eteme	400	3.78	2.89	0.89
LSD (P≤ 0.05)				
Genotypes (G)		0.25	0.33	NS
Fertilizer rate (F)		1.12	NS	NS
G x F interaction		NS	NS	NS

NS = not significant

4.0 Discussion

Fertilizer application is one of the age long practices which are common among local farmers. It is employed as a means of increasing the economic yield of common crops and is believed to optimize crop production especially under nutrient limiting conditions (Law-Ogbomo and Remison, 2009). From this study, it is confirmed that application of NPK (15:15:15) fertilizer induced significant differences (P<0.05) in growth parameters as well as tuber yield components (number of tubers) of the plants as observed amongst the yam genotypes. The number of leaves, vine length, leaf area and number of tubers confirmed earlier reports that fertilizer application increase growth and yield of crops in that these parameters generally increased significantly in stands receiving NPK (15:15:15) fertilizer treatment. The increase in number of leaves and leaf area indicates a corresponding increase in the photosynthetic system and translocation leading to optimization of high dry matter content and increased tuber yield (Law-Ogbomo and Remison, 2009).

Also, as was observed the response of genotypes to fertilizer treatment varied significantly. These observations tally with the reports of IITA, 2004 and Asiedu, *et. al.* 2006). This gap may be due to their inherent varietal characteristics and individual adaptability to soil conditions and nutrient supply. This observation agrees with other findings (Ekpe, 1998 and Law-Ogbomo and Osaigbovo, 2014) and that there are marked variations among the major types and varieties of yam with regards to their different growth and morphological characteristics. Hahn and Keyser (1985) further suggested that the variations could be due to gene contributions from wild and semi-domesticated species of yams which provides opportunities for selection systems and mode of utilization. In line with the current research, IITA (2004) opined that growth and tuber yield is strongly influenced by variety. Generally, the trend of this work agrees with the reports of Nweke *et al* (1994) that tuber yield of yam hybrids and varieties are often significantly higher than local cultivars even with or without fertilizer.

5.0 Conclusion and Recommendations

Conclusively, two yam varieties TDr 96/011799 and TDr 96/01168 were observe to produced highest tuber yields while *Eteme* (Local variety) produced the least tuber yield using NPK (15:15:15) fertilizer rate at 400kg/ha to enhanced growth and tuber yields in *D. rotundata*. Upon these, the following were recommended:

(i) Farmers in Uyo should cultivate TDr 96/011799 and TDr 96/01168 for higher fresh tuber yield.

(ii) Application of 400kg/ha of NPK (15:15:15) fertilizer could enhance tuber yield in this crop.

(iii) However, more work is needed to be carryout to ascertain the maximum rate of fertilizer application.

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