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Field evaluation of selected hybrid *Dioscorea rotundata* Poir (white yam) for tuber yield in two selected locations in South-eastern Nigeria

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Abstract

Diascorea rotundata Poir (yam) is a primary staple food for many Nigerians, and the country produces the highest percentage of the crop in the world. Its efficiency is influenced by both genotypic traits and environmental factors. The experiment was laid out in randomized complete block design (RCBD) with nine treatments of yam genotypes and three replications to evaluate tuber yield of the nine genotypes across two locations in one growing season. Propagation was done by cutting each tuber into several pieces of approximately 150g each.
The study was carried out at the National Root Crops Research Institute (NRCRI) research farm Umudike, Abia State and Faculty of agriculture research farm Abakaliki, Ebonyi State University (EBSU). The analysis of the genotypes showed some variations within and across the locations; genotypes grown in Abakaliki were superior in the length of vines (cm), while those grown in Umudike were superior in germination percentage and vine girth. At harvest those in Abakaliki recorded total mean yield of 8 tubers and 3.17kg tuber weight, while those in Umudike recorded mean yield of 12 tubers and mean weight of 5.20kg. Across the locations TDr1401785 recorded the highest yield performance with mean yield of 19 tubers while TDr1000021 recorded the least with mean yield of 4 tubers. TDr1400359 recorded the maximum tuber size with mean weight of 6.8kg while TDr8902665 recorded the least with mean weight of 1.17kg. Applying diverse environmental and physicochemical conditions to study yam genotypes is essential for improving production techniques and optimizing breeding methods for better performance.

Keywords: Yam, Treatments, Genotypes, Southeast Nigeria, Yield, Abakaliki, Umudike.

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INTRODUCTION

Yam *(Dioscorea sp.)* is a primary staple food for many Nigerians, and the country produces the highest percentage of the crop (65-70%) in the world (FAOSTAT, 2022). It is an important tuber crop of the tropics, some Eastern Asian Countries and South America (Idumah, 2014). Its performance is majorly dependent on the immediate environmental factors. However, its demand far exceeds supply due to low productivity, which is constrained by several biotic and abiotic factors, farmers are forced to recycle poor quality seed yams at the risk of poor performance. Nematodes, viruses, tuber rotting fungus, and bacterial diseases are all important contributors to seed yam quality and yield losses (Adeniji *et al*., 2012). Breeding serves as a powerful approach for promoting sustainable yam cultivation and securing food supplies. However, advancements in improving yam traits are largely dependent on detailed genetic insights and a thorough understanding of trait dynamics across diverse environments. Studies on yam quantitative traits as described by (Akinyosoye *et al.,* 2017; Norman *et al.,* 2021; Adjei *et al*., 2022) have repeatedly underscored the critical role of genotype-by-environment interaction (GEI). It describes the varying performance of genotypes across different growth environments. Analyzing these patterns in breeding trial data is essential, as it aids in identifying genotypes that exhibit superior and stable performance across multiple environments. Investigations across varied settings have shown that both hereditary and environmental factors influence phenotypic differences. The share of overall variability attributed to environmental conditions, genetic makeup, and their interplay differs based on the particular characteristic under examination (Egesi *et al.,* 2009). Nevertheless, investigating GEI is intricate due to the extensive datasets generated by testing numerous genotypes across diverse conditions. Analyzing and interpreting such data becomes challenging, especially when multiple traits are assessed in breeding trials. This intricacy highlights the importance of developing a multi-trait stability index capable of simultaneously capturing and assessing the stability of various traits. Such a method is vital for selecting genotypes based on multiple characteristics. Numerous studies (Norman *et al.,* 2021; Asfaw *et al*., 2021) have illuminated this significant interaction, emphasizing its influence on the performance of yam genotypes across varying environmental settings. With the global population projected to reach 9.6 billion by 2050, enhancing the productivity of vital food crops like yam, while maintaining environmental sustainability, is vital for ensuring food security (Danquah *et al*., 2022). Hence this study aims to contribute to food security by advancing breeding strategies that enhance yam production through the propagation of several genotype to optimize performance across diverse environmental conditions and locations to meet the growing global demand while maintaining environmental sustainability by selecting genotypes with superior and stable performance based on tuber output.

MATERIALS AND METHODS

Study area

The experiment was carried out at two locations, the National Root Crops Research Institute (NRCRI) farm Umudike

(Latitude 5˚29˙ North and Longitude 7˚32˙ East) in Abia State, on sandy loamy soil with pH of 4.1 and Faculty of Agriculture research farm Abakaliki, (Latitude 6˚19˙ North and Longitude 7˚42˙ East) in Ebonyi State University (EBSU), on sandy loamy soil and pH of 6.1.

Collection of planting material

The treatments consisting of nine (9) local genotypes of *Dioscorea rotundata* were selected and supplied by the yam programme National Root Crops Research Institute (NRCRI), Umudike for the study. Genotypes are; TDr0900135, TDr1000021, TDr1100128, TDr1400158, TDr1400359, TDr1400359, TDr1400766, TDr1401785, TDr8902665.

Experimental design and planting

The trial was laid out in Randomized Complete Block Design (RCBD) with nine (9) genotypes as treatments, and three replications to assess the performance of the (9) nine genotypes in the field during one growing season. The field was prepared by ploughing the soil in ridges and mounds of nine (9) with each ridge containing ten (10) mini setts and replicated three (3) times to give a total of 27 ridges and 270 seeds with a spacing of 1m x 1m. Propagation was done by cutting each tuber into several pieces or planting sets of approximately 150g each.

Germination of the seed yam and other measured parameters

Germination count started 4 weeks after planting (WAP). Counting was done weekly for two months. The total number of seeds of each genotype that germinated between the time of planting and the time of taking the reading were expressed as a percentage of the number of seeds of each genotype that was planted and recorded as the germination percentage. The length of vine and the vine girth were measured in the 4th and 5th months using the measuring tape (cm) and the digital Vernier caliper (mm).

Tuber yield at harvest

The yam tubers at maturity were harvested in groups according to their genotypes. Tuber yield per genotype were expressed in kg/ha. From the yield values, the average tuber weights (kg) of each genotype were calculated.

Statistical analysis

All data generated were subjected to statistical analysis of variance (ANOVA) using the R, Statistics (version 4.2.1) package. Means separation was carried out by employing Fisher's Least Significant Difference (F/LSD) test to determine the level of statistical difference of the genotypes. T-test analysis was employed using SPSS (version 22) to assess the relationships of the variables across the locations. The probability level accepted for significant relationship was set at $p \leq 0.05$.

RESULTS

The results of the data collected from the germination study conducted in the two locations are presented in Tables 1 and 2. In Umudike, genotypes varied significantly from week 1, with TDr1400766 recording the highest sprouting percentage of 73.3% while TDr1400537 recorded the least germination percentage of 23.3% with $P \leq 0.014$. From week 2 sprouting percentage increased in all the genotypes. In Abakaliki variations were also observed among the nine genotypes tested. Significant differences were observed from week 1 to 8. In week 1 TDr1400359 and TDr1400766 recorded the highest and the same sprouting percentage of 83.3% while TDr1000021, TDr1100128, and TDr8902665 recorded the least with 23.3% each. There were no significant differences in TDr1000021 from week 2 to 8 which is also the genotype with the least sprouting percentage. The establishment counts also known as survival percentage of the nine genotypes were carried out at the fourth month after planting and Figure 1 showed the comparison of mean establishment counts across the two locations. Analysis of variance conducted revealed that there were slight significant differences within the genotypes and high significant differences across the two locations. The result suggests that differences in the soil factors present in the two locations could be responsible in the variations observed in the rate of germination of the nine yam genotypes grown in Umuahia and Abakaliki.

Table 1: Mean germination percentage of Umudike genotypes

Genotypes	Germ ct_wk1	Germ ct_wk2	Germ ct_wk3	Germ ct_wk4	Germ ct_wk5	Germ ct_wk6	Germ ct_wk7	Germ ct_wk8
TDr0900135	63.3	76.7	86.7	86.7	93.3	96.7	96.7	96.7
TDr1000021	56.7	63.3	80.0	90.0	90.0	100	100	100
TDr1100128	50.0	60.0	76.7	76.7	93.3	96.7	96.7	96.7
TDr1400158	60.0	63.3	73.3	76.7	80.0	83.3	83.3	83.3
TDr1400359	50.0	53.3	70.0	70.0	83.3	90.0	90.0	90.0
TDr1400537	23.3	26.7	40.0	40.0	46.7	73.3	80.0	83.3
TDr1400766	73.3	80.0	90.0	90.0	93.3	100	100	100
TDr1401785	36.7	36.7	70.0	76.7	76.7	76.7	80.0	80.0
Genotype Interactions	0.014	0.020	0.060	0.088	0.025	0.047	0.038	0.030

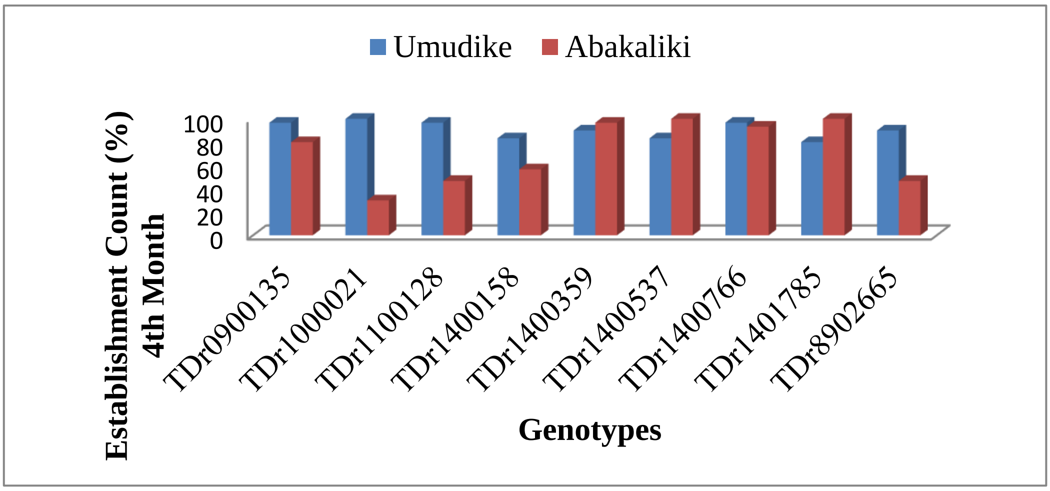
Key: germ – germination, ct – count, wk – week; (P ≤ 0.05**).**

Table 2: Mean percentage germination of Abakaliki genotypes

Genotypes	Germ ct_wk1	Germ ct_wk2	Germ ct_wk3	Germ ct_wk4	Germ ct_wk5	Germ ct_wk6	Germ ct_wk7	Germ ct_wk8
TDr0900135	60.0	76.7	80.0	80.0	80.0	80.0	80.0	80.0
TDr1000021	23.3	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TDr1100128	23.3	36.7	43.3	46.7	46.7	46.7	46.7	46.7
TDr1400158	43.3	56.7	56.7	56.7	56.7	56.7	56.7	56.7
TDr1400359	83.3	90.0	96.7	96.7	96.7	96.7	96.7	96.7
TDr1400537	50.0	76.7	96.7	96.7	100	100	95.7	100
TDr1400766	83.3	90.0	93.3	93.3	93.3	93.3	93.3	93.3
TDr1401785	43.3	66.7	96.7	96.7	96.7	96.7	100	100
TDr8902665	23.3	30.0	36.7	40.0	40.0	46.7	46.7	46.7
	0.035	0.011	0.009	0.004	<0.001	0.003	0.003	0.002

(P ≤ 0.05)

Vine girth measurements were carried out at fourth and fifth months after planting. The results revealed that all the genotypes grown in Umudike had wider vine girth more than those grown in Abakaliki for both 4th and 5thmonth of harvest. The genotype TDr1100128 recorded the highest mean diameter of vine girth at both periods in Umudike while in Abakaliki location, the highest mean diameter was given by TDr1400158. Statistical analysis conducted revealed that there were no significant differences in the mean diameters of vine of genotypes within location in the 4th and 5th month, but there were high significant differences observed in the genotypes across locations with $P<0.001$ indicating that locations have high significant influence in the vine girth of the genotypes. Also, the results of the data collected on the vine length of the nine genotypes grown in the two locations at 4th and 5th month after planting revealed that length of vine of the genotypes at the 4th and 5th month within and across location were highly significant. In Abakaliki location, the genotype TDr1400158 attained the highest vine length of 211.4cm while the least vine length was given by TDr1400766 with vine length of 137.4cm.

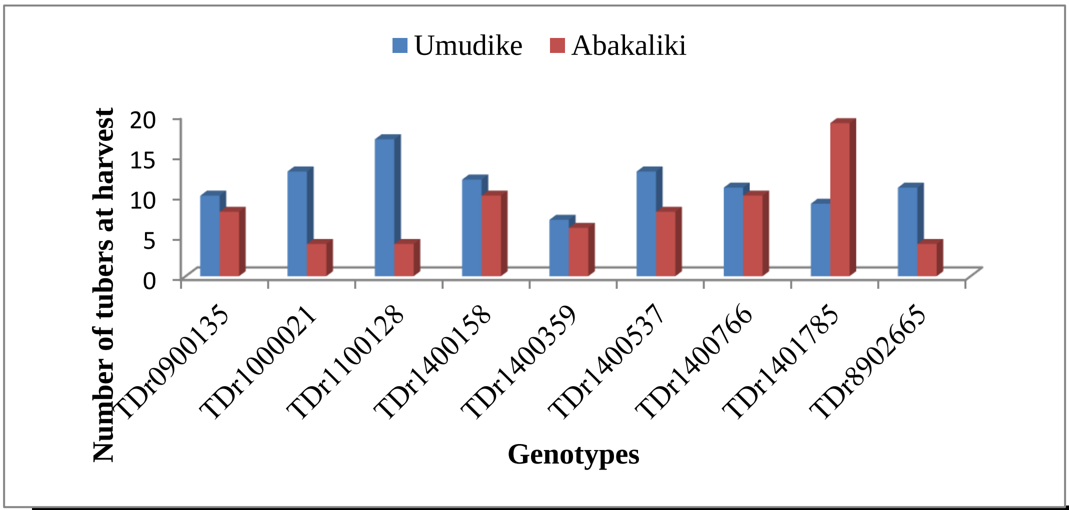


Source of variation	d.f.	s.s.	m.s.	v.r.	probabilities
rep stratum	2	25.593	12.796	3.48	
Genotypes	8	73.148	9.144	2.49	0.031
Location	1	46.296	46.296	12.59	0.001
Residual	34	125.074	3.679		
Total	45				

($P \leq 0.05$**).** Key: d.f - degree of freedom, s.s – sum of square, m.s – mean square, v.r – virtual reality.

Figure 1: Comparison of mean establishment counts at 4thmonth of the genotypes across the two locations

At harvest, Figure 2 revealed that Abakaliki recorded the highest mean yield of 19 tubers with TDr1401785, while TDr8902665 and TDr1000021 recorded the least with 4 tubers each. Similarly, in Umudike location, TDr1100128 genotype produced the highest mean yield of 17 tubers and the least mean yield of 7 tubers was attained by TDr1400359. Statistical analysis conducted revealed that the total number of tubers yield by the nine tested genotypes were not influenced by the genotypes within locations while across the locations high significant differences were observed indicating that locations have significant influence on the total number of tubers at harvest, while in the size of tubers data showed that Umudike recorded the best mean tuber weight of 6.87kg with TDr1400359 genotype, followed by TDr1100128 (6.27kg),TDr1400537 (6.17kg),TDr1400766 (6.03kg), TDr1400158 (5.53kg), TDr1000021 (4.67kg),TDr8902665 (3.93kg), TDr0900135 (3.80kg) and the least is TDr1401785 with 3.50kg. Similarly, in Abakaliki, the best tuber weight was produced by TDr0900135 and TDr1401785 with 5.43kg each, TDr1400158 and TDr1400766 recorded 3.50kg, TDr1100128 (2.90kg), TDr1400537 (2.83kg), TDr1400359 (2.47kg), TDr1000021 (1.27kg) and the least tuber weight of 1.17kg was given by TDr8902665. The statistical analysis conducted revealed that there were no significant differences in the mean weight of tubers of the nine grown genotypes within locations while there were high significant differences observed in the genotypes across the two locations with $P<0.001$ indicating that locations have high significant effect on the sizes of the tubers at harvest. Summary of the results of the statistical analysis conducted are presented in Table 3. The data revealed the mean comparison of the various parameters (variables) of the nine genotypes measured across the locations**.**



Source of variation	d.f.	s.s.	m.s.	v.r.	probabilities
rep stratum	2	26.33	13.17	0.74	
Genotypes	8	242.67	30.33	1.71	0.131
Locations	1	136.96	136.96	7.73	0.009
Residual	34	602.33	17.72		
Total	45				

($P \leq 0.05$)

Figure 2: Mean comparison of number of tubers of the genotypes across the two locations at harvest

Table 3: Mean comparison of the various parameters (variables) measured across the two locations

Germination Count in Weeks	Umudike	Abakaliki	T-test value
Germination counts at week 1 (%)	51.9	48.1	0.544
Germination counts at week 2 (%)	58.1	61.5	0.573
Germination counts at week 3 (%)	73.0	70.0	0.651
Germination counts at week 4 (%)	75.6	70.7	0.45
Germination counts at week 5 (%)	81.1	71.1	0.082
Germination counts at week 6 (%)	88.9	71.9	0.004
Germination counts at week 7 (%)	90.7	71.7	0.001
Germination counts at week 8 (%)	91.5	72.2	0.030
Established plant count after 4th months (%)	90.7	72.2	0.001
Girth of vines (mm) 4th months	4.20	2.74	<0.001
Girth of vines (mm) 5th months	4.31	2.93	<0.001
Length of vines (cm) 4th month	144.50	168.70	<0.001
Length of vines (cm) 5th month	148.60	168.00	0.002
Total Number of tubers at harvest	12.0	8.0	0.009
Total Tuber weight (kg) at Harvest	5.20	3.17	<0.001

($P \leq 0.05$)

Table 4: Soil chemical properties

Location	Depth	Ph	P	N	Ca	K	Mg	Na	EA	ECEC	BS
Umudike	0-20	4.05±0.07	43.33±0.40	0.15±0.01	11.80±0.28	0.92±0.005	8.20±0.28	0.06±0.01	3.92±0.00	24.07±0.014	83.72±0.00
Abakaliki	0-20	6.20±0.14	43.41±0.06	0.17±0.00	13.90±1.14	0.113±0.001	10.10±0.14	0.08±0.003	1.84±0.00	26.03±0.00	92.94±0.00
	Total	5.13±1.24	43.37±0.24	0.16±0.01	12.85±1.23	0.102±0.013	9.15±1.11	0.07±0.01	2.88±1.20	25.05±1.13	88.33±5.32
	P≤ 0.05	0.003	0.808	0.095	0.011	0.027	0.014	0.079	0.000	0.000	0.000

Table 5: Soil physical properties

Locations	Depth	Sand	Silt	Clay	OC	OM
Umudike	0-20	78.4±0.00	8.30±0.71	13.30±0.01	0.6250±0.007	1.08±0.71
Abakaliki	0-20	54.40±0.00	33.00±1.41	12.60±0.01	0.3150±0.007	0.54±1.41
	Total	66.40±13.86	20.65±14.29	12.95±0.18	0.4700±0.179	0.81±1.00
	P≤ 0.05	0.000	0.002	0.595	0.001	0.000

The results of the data collected from the soil samples of the two locations are presented in Tables 4 and 5. The analysis on the soil chemical properties revealed that pH, Calcium (Ca), Potassium (K), Magnesium (Mg), Exchangeable acidity (EA), Effective Cation Exchange Capacity (ECEC) and Base Saturation (BS) were highly significant across the locations while Nitrogen (N), Phosphorus (P) and Sodium (Na) showed no significant influence among the tested nine genotypes at ($P \leq 0.05$). For the physical properties, there were also no significant differences observed in the soil Clay contents, but high significant differences were observed in Sand, Silt, Organic carbon (OC) and Organic matters (OM)contents of the soil, thus suggesting the variations observed in the yield performance among the genotypes across the locations.

DISCUSSION

This study provides information on the field performance of nine (9) yam genotypes *(Dioscorea rotundata)* in Umudike and Abakaliki South-East Nigeria.

The vegetative growth features like germination percentage were recorded highest in TDr1400766 with 90.8% in Umudike and 94.2% in TDr1400359 in Abakaliki, while across locations Umudike recorded mean germination of 90.7% and Abakaliki 72.2% indicating that Umudike had a better sprouting percentage. This could be due to the different variations in the genetic make-up of the genotypes and also the differences in the soil physiochemical conditions as shown in Tables 4 and 5. Comparable results were also reported by Mitchell *et al*. 2016; Chukwu *el al*. 2023.

Statistical analysis conducted on vine girth revealed high significant differences across the locations at fourth and fifth months after planting. In length of vine, there were no significant differences observed in Abakaliki from fourth month to fifth month, while significant differences were recorded in Umudike from fourth month to fifth month at ($P \leq 0.05$), across locations there were also significant differences recorded in the length of vine at fourth and at fifth month. The substantial differences observed among genotypes for the evaluated characters underscore the genetic diversity present within the examined population (Adjei *et al.,* 2022; Alice *et al*., 2024).

At harvest, it was observed that the tested nine genotypes exhibited certain variations with TDr1401785 recording the highest mean yield in Abakaliki with 19 tubers and mean weight of 5.43kg. Similarly in Umudike TDr1100128 recorded highest mean yield of 17 tubers and mean weight of 6.27kg. Comparison of the yield performance of the nine genotypes across locations showed that there were high significant differences with Umudike recording a mean yield of 12 tubers with mean weight of 5.20kg and Abakaliki producing a mean yield of 8 tubers with mean weight of 3.17kg, while TDr1400359 recorded the maximum tuber size with mean weight of 6.8kg in Umudike. The best performance of the nine genotypes as recorded in Umudike could be attributed to favourable physiochemical properties of the soil in Umudike with high organic matter when compared with that obtained in Abakaliki as shown in Tables 4 and 5. This interaction reveals that genotype performance is shap ed by both genetic composition and environmental factors. A significant tuber yield achievement pinpointing superiority in some genotypes could be it adaptability with the environment (Nduwumuremyi *et al.,* 2017), as performance may vary across different settings (Emmanuel *et al.,* 2022).

Each genotype displayed distinct agronomic features, presenting valuable opportunities for focused selection and breeding initiatives aimed at improving specific genotype of interest. In conclusion, the study has demonstrated significant location-based variations in the agronomic performance of nine yam genotypes grown in Umuahia and Abakaliki. The differences in soil chemical and physical properties between the two locations notably influenced key growth parameters such as establishment counts, vine girth, vine length, tuber yield, and tuber size. Genotype TDr1100128 consistently showed superior performance in Umudike, while TDr1400158 excelled in Abakaliki, underscoring the critical role of site-specific soil characteristics in yam cultivation. The findings highlight the necessity for targeted agronomic practices and genotype selection tailored to specific environmental conditions to optimize yield outcomes. This research provides valuable insights for yam breeding programs and sustainable agricultural practices aimed at improving yam production in diverse ecological zones.

Author contribution

OAO - conceptualization, manuscript drafting, methodology, investigation, project administration, conceptualization and funding. NFA- conceptualization, writing, editing, methodology, validation and supervision. IBJ- investigation, analysis of data, visualization and resources. OVA- review of the draft manuscript, editing and funding. OFO- investigation, project administration and analysis of data. OPT- Investigation, project administration and review of the draft manuscript.

Conflict of interest

The authors have no conflict of interest to declare.

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