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Unveiling the Genetic Diversity of Aerial Yam (*Dioscorea bulbifera* L.): Morphological Insights for Sustainable Crop Improvement

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Genetic diversity is a cornerstone of sustainable agriculture, enhancing the resilience and productivity of crops in changing environments. Aerial yam (*Dioscorea bulbifera* L.), a tuber crop primarily grown in tropical and subtropical regions, has the potential to contribute to food and nutritional security. Despite its importance, the genetic diversity of aerial yam remains largely unexplored, limiting its conservation and genetic improvement.

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Aim: The aim of this study was to assess the genetic diversity of 20 *D. bulbifera* landraces collected from six Nigerian states (Cross River, Akwa Ibom, Enugu, Abia, Benue, and Ebonyi) using morphological traits as markers.
Study Design: A randomized complete block design (RCBD) was used, with three replicates.
Place and Duration of Study: The experiment was conducted at the experimental field of University of Calabar, Calabar, Nigeria, from March 2023 to February 2024.
Methodology: Bulbils from 20 *D. bulbifera* landraces, were planted on March 19, 2023 on a single-row plot. Key morphological traits; vine length, leaf area, and bulbil production, were recorded and analyzed for ANOVA, principal component analysis (PCA), cluster analysis, and path coefficient analysis.
Results: Significant variations ($p < 0.05$) were observed for all traits, indicating genetic diversity among the landraces. PCA identified three principal components accounting for 57.25% of the total variability, with root length, leaf area, and bulbil count being the most influential traits. Cluster analysis grouped the landraces into two clusters with no strict adherence to geographic origin, suggesting possible gene flow. There is a positive relationship between vine length and leaf area ($r = 0.349$, $p < 0.05$), while leaf length had the strongest direct effect on bulbil production.
Conclusion: The findings highlight significant genetic variability within *D. bulbifera*, providing a basis for breeding and conservation. This study emphasizes the crop's potential for food security and sets the stage for integrating molecular techniques alongside morphological assessments.

Keywords: Aerial Yam (Dioscorea bulbifera); crop Improvement; genetic diversity; morphological traits; sustainable agriculture.

1. INTRODUCTION

Genetic diversity is fundamental to sustainable agriculture, ensuring crop species' resilience and long-term survival (Edem et al., 2023a; Edem et al. 2024a; Edem et al. 2024b). Aerial yam (*Dioscorea bulbifera* L.), a significant tuber crop cultivated in tropical and subtropical regions, is vital to food security and income generation for millions (Obidiegwu et al., 2020).

Aerial yam is unique among the Dioscorea species due to its specialized aerial bulbils, produced on petioles, and its vigorous growth habit, often reaching lengths of up to 20 m. It is a staple food crop in many tropical regions, offering essential nutrients such as carbohydrates, fiber, and vitamins A and C. (Beyene & Weldemichael, 2013; Kouam et al., 2018). Furthermore, aerial yam has been utilized in traditional medicine for treating various ailments, underscoring its cultural and economic value (Osuagwu et al., 2019).

In recent years, the increasing demand for affordable and nutritious food in Nigeria has shifted focus towards underutilized crops such as aerial yam (Nkwonta et al., 2024) as it holds promises for addressing food and nutritional security. However, the lack of systematic evaluation and characterization of *D. bulbifera* accessions hinders its potential for breeding and conservation, further exacerbating genetic erosion (Agrawal et al., 2023, Ekaette et 2024). Despite its nutritional and economic importance, the genetic diversity of aerial yam remains insufficiently explored, creating an urgent need for its evaluation and conservation (Edem & Osuagwu, 2023b).

Morphological traits analysis is a widely recognized method for assessing plant genetic variation, including aerial yam (Edem et al., 2024a, 2024b; Massawe & Temu, 2022). Traits such as leaf shape, stem color, tuber size, and bulbil production provide critical insights into genetic variation, enabling the identification of unique genotypes and the development of strategies for their conservation (Wu et al., 2014; Beyene, 2013; Osuagwu et al., 2019; Osuagwu & Edem, 2020; Ekaette et al., 2024). Morphological diversity studies also reveal significant intra- and inter-population variations, which are essential for understanding the genetic structure and adaptability of *D. bulbifera* across different agroecological zones (Ikiriza et al., 2023).

Research on *D. bulbifera* has highlighted the potential of morphological traits to serve as proxies for genetic diversity (Ekaette et al., 2024a; 2024b; Osuagwu et al., 2019; Beyene, 2013; Ikiriza et al., 2023). Such studies provide the baseline data required for efficient breeding programs to improve agronomic traits and ensure sustainable cultivation practices (Ewona & Udo, 2009).

This study aims to investigate the genetic diversity of 20 landraces of *D. bulbifera* using morphological traits as markers. By examining yield and yield-related characteristics through correlation and path coefficient analysis, this manuscript seeks to provide insights into trait inter-relationships that can guide selection and breeding strategies. The findings will contribute to the broader knowledge of aerial yam diversity, promoting its sustainable utilization and preservation as a critical resource for global and Nigeria’s food security.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The experiment was carried out during the 2023/2024 cropping season at the experimental farm of the Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Cross River State, Nigeria. The research site is located at 04°15’5"N latitude and 08°25’E longitude, about 791.7 km from Lagos. The area's elevation is 2164 m.a.s.l and receives an average annual rainfall of 2984.64 mm (Ewona & Udo, 2009).

2.2 Experimental Material

The planting materials comprised bulbils from twenty *Dioscorea bulbifera* landraces, collected from cultivated fields across Nigeria. These landraces represented entries from six states, including Cross River, Akwa Ibom, Enugu, Abia, Benue, and Ebonyi (Table 1).

2.3 Experimental Design and Planting

The landraces were established using a Randomized Complete Block Design (RCBD) with three replications. Planting was carried out on March 19, 2023, with each landrace assigned to a single-row plot. Row spacing was set at 1.5 m, and plants within rows were spaced 1 m apart to minimize competition and promote optimal growth. Each plant was supported with bamboo stakes to ensure proper vine training. Standard agronomic and weeding practices were regularly implemented to maintain favorable growing conditions.

Table 1. Landraces of *D. bulbifera* used in the study, their origin, and their ecological zones

S/N	Landraces	State of origin	Ecological zone
1	Anyikang	Bekwara, Cross River	Forest
2	Otuguan	Obudu, Cross River	Forest
3	Abia	Abia	Forest
4	Bakassi	Cross River	Forest
5	Akpabuyo	Cross River	Grassland
6	Ugboko	Benue	Grassland
7	Oiyi	Benue	Grassland
8	Ikot Nakanda	Cross River	Grassland
9	Izi	Ebonyi	Grassland
10	Ikot Offiong	Cross River	Grassland
11	Ikot Ene	Cross River	Forest
12	Creek Town	Cross River	Forest
13	Idundu	Cross River	Forest
14	Anangtigha	Cross River	Forrest
15	Nsuka	Enugu	Forest
16	Akamkpa	Cross River	Forest
17	Eket	Akwa Ibom	Forest
18	Ukpa	Nigeria	Forest
19	Beagang	Cross River	Forest
20	Itu	Akwa Ibom	Forest

2.4 Data Collection

Quantitative data were recorded for all 20 *D. bulbifera* landraces using appropriate measurement tools; measuring tapes and Vernier calipers. Measurements included morphological traits; Days to 50% seedling emergence, number of leaves, vine length, leaf length, root length, leaf area, and number of bulbils.

2.5 Data Analysis

The data were analyzed using analysis of variance (ANOVA) to assess significant differences among the landraces and where significant variations were observed, mean separation was conducted using the least significant difference (LSD) test. The traits were further evaluated through principal component analysis (PCA) to identify patterns of variation among the landraces. Cluster analysis was performed using Ward's method to group the landraces based on their quantitative traits. Correlation and path coefficient analyses were carried out to determine the relationships and direct or indirect effects of various traits. All statistical analyses were conducted using Predictive Analytics Software (PASW), version 20.

3. RESULTS

3.1 Variability in Yield and Yield-Related Traits of *Dioscorea bulbifera* Across Locations

Twenty accessions of aerial yam (*Dioscorea bulbifera*) were characterized using seven quantitative morphological traits. The analysis of variance revealed significant differences ($p < 0.05$) across all traits among the studied accessions (Table 2). Days to 50% seedling emergence ranged from 11 to 17 days, with accessions from Akpabuyo exhibiting the shortest emergence time (11.33 days) and those from Beagang, the longest (16.67 days). Leaf production varied significantly, with Akpabuyo having the highest number of leaves (54.00), followed by Ikot Ene (42.00) and Creek Town (40.67), while Oiyi recorded the lowest number of leaves (27.33).

For vine length, the longest plants were observed in accessions from Eket (296.33 cm), while the shortest was from Ukpa (235.3 cm). Leaf length also displayed significant variations, with Ikot Offiong (8.53 cm) having the longest leaves, followed closely by Nsukka (8.50 cm) and Anangtigha (8.43 cm). The shortest leaves were recorded from Obudu and Ugbogbo (6.93 cm each).

Leaf area was the widest in accessions from Eket (71.27 cm^2), followed by Bakassi (68.77 cm^2) and Obudu (61.67 cm^2). Beagang had the narrowest leaf area (52.93 cm^2). Root length was longest in Obudu (21.10 cm), followed by Beangang (20.07 cm) and Ikot Offiong (19.80 cm). The shortest roots were observed in Bakassi (14.30 cm), with similar values in Bekwara, Idundu, and Eket (15.00 cm each). The highest number of bulbils was recorded in the Akamkpa landrace (3.67), followed by Idundu (2.67) and Ikot Offiong (2.33). In contrast, Creek Town and Eket exhibited the fewest bulbils, with Abia, Ikot Ene, and Obudu producing 1.00 each, while Ukpa and Izi yielded 1.33 bulbils.

3.2 Principal Component Analysis (PCA)

Principal component analysis (PCA) for the morphological traits of the 20 *D. bulbifera* accessions presented in Table 3 revealed three principal components accounting for 57.25% of the total variation. PC1, PC2, and PC3 explained 21.93%, 18.15%, and 17.17% of the variation, respectively. Traits such as root length, number of bulbils, and leaf area showed high communalities (0.730, 0.701, and 0.663, respectively), indicating their significant contribution to the observed variation.

3.3 Cluster Analysis

Cluster analysis using Ward's method grouped the accessions into two major clusters (Fig. 1), with further subclusters within the first cluster. Cluster I included 18 accessions divided into four subgroups:

- Subgroup 1: Bekwara, Oiyi, Ogboko, and Ikot Ene,
- Subgroup 2: Akpabuyo, Creek Town, and Akamkpa,
- Subgroup 3: Bakassi, Izi, Abia, Ikot Nnakanda, Beangang, Nsukka, and Idundu, and
- Subgroup 4: Ukpa, Itu, Ikot Offiong, and Anangtigha.

Cluster II comprised only two accessions: Obudu and Eket. The dendrogram suggested that the grouping of accessions was not strictly based on their geographic origin, as intermixing among accessions from different locations was evident, suggesting gene flow.

Table 2. Means and standard errors ($\bar{x} \pm SE$) of nine quantitative traits studied in 20 landraces of *D. bulbifera*

Landraces	Number of leaves	Vine length (cm)	Leaf length (cm)	Root length (cm)	Leaf area (cm^2)	Number of bubil	Days to 50% seed emergence
Bekwara	32.00j±1.52	254.3f±15.05	7.33j±0.17	15.00 m±0.57	59.57d±0.80	1.67e±0.33	15.00c±0.57
Obudu	36.00e±3.05	283.7b±33.33	6.93±2.58	21.10a±0.60	61.67c±1.40	1.00i±0.57	13.00i±0.57
Abia	38.67d±4.37	243.3k±11.34	8.30d±0.55	16.83k±0.61	55.37i±1.71	1.00i±0.00	16.00b±0.57
Bakassi	34.67f±1.20	251.3i±12.97	7.53 h±0.06	14.30n±0.35	68.77b±1.08	1.67e±0.33	14.33e±1.33
Akpabuyo	54.00a±0.57	254.0 h±15.53	8.37c±0.24	17.37j±1.57	55.70f±1.70	1.67e±1.20	11.33k±0.33
Ugbokpo	28.33l±0.88	257.3e±23.87	7.13k±0.14	17.73 h±2.36	55.40i±0.58	1.67e±0.33	14.00f±1.00
Oiyi	27.33 m±0.66	262.0d±13.31	7.67 g±0.32	17.50i±1.50	54.33k±1.00	0.67j±0.33	13.00i±1.57
Ikot Nnakanda	32.33i±3.84	247.7j±10.47	7.40j±0.69	18.20 g±1.20	51.93n±1.50	1.67e±0.33	16.00b±0.57
Izi	36.00e±0.57	252.0i±9.64	7.17k±0.14	15.23 l±0.54	58.00e±4.00	1.33f±0.33	11.66j±0.33
Ikot Offiong	35.00e±2.51	242.0k±13.42	8.53a±1.38	19.80c±0.45	54.43j±0.60	2.33c±0.88	13.00i±1.52
Ikot Ene	50.00b±2.51	273.3c±16.79	8.30d±0.26	18.50f±1.46	57.87e±5.54	1.00i±0.00	13.33 h±0.33
Creek town	40.67c±9.38	251.0i±13.86	8.13e±0.39	19.57d±0.74	54.17k±0.98	0.67j±0.57	15.00c±0.57
Idundu	35.67±0.88	254.3 g±11.28	7.70 h±0.36	15.00 m±1.00	61.53c±2.66	2.67b±0.33	13.66 g±1.85
Anantiga	38.67d±2.90	236.0 m±4.50	8.43b±0.44	19.20f±1.86	56.53f±1.12	2.00d±1.52	14.66d±0.88
Nsuka	30.00±2.51	242.7k±6.64	8.50a±1.35	18.60e±2.06	61.33c±2.94	1.67e±1.20	14.66d±0.33
Akamkpa	34.67f±4.97	255.7f+0.26	8.13e±0.38	16.83k±1.85	54.83j±1.27	3.67a±1.20	16.00b±0.57
Eket	35.00e±5.85	296.7a±9.95	7.53 h±0.58	15.00 m±0.90	71.27a±3.42	0.67j±0.33	14.66d±0.33
Ukpa	31.33k±2.72	235.3 m±10.72	8.17e±0.31	18.53f±0.63	53.70 l±0.75	1.33f±0.33	16.00b±0.57
Beagang	42.00d±3.51	243.7k±5.78	7.77f±0.03	20.07b±1.33	52.93 m±0.97	2.00d±0.57	16.66a±0.88
Itu	28.67 l±1.20	240.0 l±7.02	8.37c±0.69	19.63d±0.62	61.23c±4.03	1.67e±0.66	14.33e±0.33

Table 3. Principal component analysis (PCA) of the morphological traits of aerial yams

	Communalities	**PC_1**	**PC_2**	**PC_3**
days 50% to emergence.	0.184	-0.412	0.033	0.111
Number of leaves	0.497	0.119	-0.059	0.693
Vine length	0.623	0.720	-0.127	0.298
Leaf length	0.610	-0.001	0.356	0.695
Root length	0.730	-0.360	-0.699	0.334
Leaf area	0.663	0.799	0.077	-0.135
Number of Bubils	0.701	-0.254	0.793	0.090
Eigenvalue	-	1.535	1.270	1.202
Proportion of variance (%)	-	21.931	18.149	17.167
Cumulative variance (%)	**-**	**21.931**	**40.080**	**57.247**

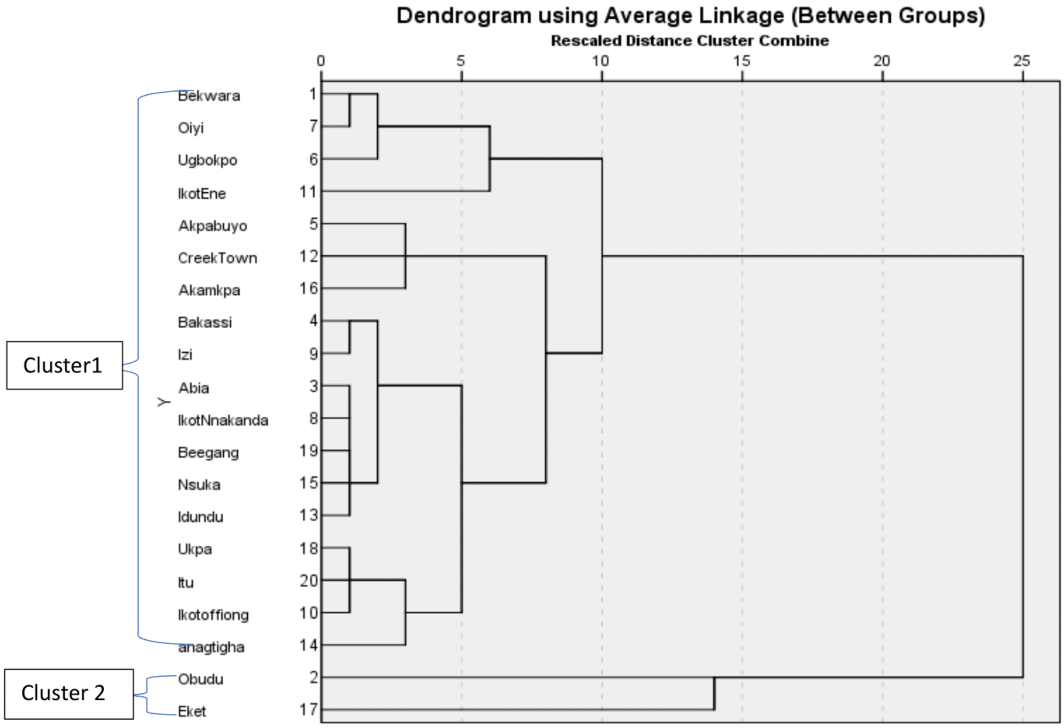

Fig. 1. Genetic relationships of 20 aerial yam landraces according to quantitative trait data

3.4 Correlation Analysis

Correlation analysis results presented in Table 4, revealed significant positive relationships between certain traits. Vine length showed a strong positive correlation with leaf area ($r = 0.349$; $p < 0.05$). Days to 50% emergence was negatively correlated with most traits except leaf length, root length, and the number of bulbils, where it correlates with the most important traits determining the yield. The number of leaves correlated positively with all evaluated parameters except days to emergence. Leaf area and vine length showed significant positive associations with leaf number and length.

3.5 Path Coefficient Analysis

Path coefficient analysis presented in Tables 5 and 6 identified leaf length as having the strongest positive direct effect (0.150) on the number of bulbils per plant, followed by the number of leaves (0.041) and days to 50% emergence (0.022). Conversely, root length (-0.256), vine length (-0.029), and leaf area (-0.118) exerted negative direct effects on bulbil production. Regression analysis in Table 7 indicated a significant relationship between the independent variables and bulbil production ($R^2 = 0.354$; $p < 0.05$).

Table 4. Correlation of growth parameters of *D. bulbifera* at 24 weeks

	50% DE	No. of leaves	Vine L.	Leaf L.	Root L.	LA	No. of Bulbils
50% days to emergence	1						
Number of leaves	-0.047	1					
Vine length	-0.096	0.103	1				
Leaf Length	0.055	0.121	0.108	1			
Root Length	0.068	0.088	-0.044	-0.003	1		
Leaf area	-0.140	0.009	0.349**	-0.042	-0.249	1	
Number of Bulbils	0.041	0.020	-0.153	0.147	-0.216	-0.112	1

***. Correlations are significant at the 0.01 level (2-tailed), DE-days to emergence, L- length, No.-number, LA-leaf area*

Table 5. Direct (underlined) and indirect effects of yield-related components on the number of bulbils per plant

	50% DE	No. of leaves	Vine L.	Leaf L.	Root L.	LA	No. of Bulbils
50% days to emergence	**0.022**						
Number of leaves	-0.047	**0.041**					
Vine length	-0.096	0.103	**-0.141***				
Leaf Length	0.055	0.121	0.108	**0.150****			
Root Length	0.068	0.088	-0.044	-0.003	**-0.256***		
Leaf area	-0.140	0.009	0.349**	-0.042	-0.249	**-0.118***	

Key: The bolded values are the beta regression values showing their direct effect on the number of bulbils, DE-days to emergence, L- length, No.-number, LA-leaf area

Table 6. Path coefficient analysis of yield and yield-related traits of the aerial yam

Model		Unstandardized coefficients		Standardized coefficients	T	Sig.	Collinearity statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5.241	2.927		1.791	0.079		
	50% days to emergence	0.014	0.084	0.022	0.165	0.870	0.971	1.030
	Number of leaves	0.006	0.019	0.041	0.313	0.756	0.966	1.035
	Vine length	-0.007	0.007	-0.141	-1.008	0.318	0.852	1.174
	Leaf Length	0.146	0.128	0.150	1.142	0.259	0.965	1.037
	Root Length	-0.118	0.062	-0.256	-1.908	0.062	0.926	1.080
	Leaf area	-0.024	-0.029	-0.118	-0.820	0.416	0.810	1.235

Dependent Variable: Number of Bubils
Predictors: (Constant), Leaf area, Number of leaves, Leaf Length, 50% days to emergence, Root Length, Vine length

Table 7. Analysis of variance of regression analysis for yield and yield-related traits in *D. bulbifera*

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	10.079	6	1.680	1.137	0.354^{b}
	Residual	78.321	53	1.478		
	Total	88.400	59			

a. Dependent Variable: Number of Bulbils
b. Predictors: (Constant), Leaf area, Number of leaves, Leaf Length, 50% days to emergence, Root Length, Vine length

4. DISCUSSION

The significant morphological variations observed across the 20 landraces of *Dioscorea bulbifera* highlight the presence of genetic diversity within the species. This variability, revealed through the analysis of variance (ANOVA), underscores the potential of morphological traits for varietal identification and genetic improvement efforts. Morphological traits like vine length, leaf area, and the number of bulbils are essential indicators for selection and conservation strategies (Osuagwu & Edem, 2021; Beyene & Weldemichael, 2013; Alcántara-Ayala et al., 2020). Similar observations have been reported in yams by Norman et al. (2011), who noted significant diversity in shoot-related traits among 52 yam genotypes from Sierra Leone. Likewise, Jayeola and Oyebola (2013) reported variations in vine length, leaf number, and bulbil production among *D. bulbifera* populations, emphasizing the importance of these traits in yield improvement.

The morphological diversity observed in this study may be attributed to genotype-environment interactions and the vegetative propagation of yams, which limits the creation of genetic recombination (Osuagwu et al., 2019). Despite these constraints, the high level of polymorphism suggests significant potential for selecting landraces with desirable traits. This is consistent with the findings of Beyene (2013), who noted substantial stem length variations among *D. bulbifera* accessions. In this study, accessions from Akpabuyo, Eket, and Akamkpa displayed superior performance in traits such as days to 50% emergence, vine length, and bulbil production, indicating their suitability for targeted breeding programs.

The PCA results provided insights into the variability and underlying structure of the accessions. The first three components accounted for 57.25% of the total variance; with root length, leaf area, and the number of bulbils contributing the most to the variation. These findings suggest that these traits are critical for distinguishing among accessions and should be prioritized in breeding programs. Similar studies by Massawe and Temu (2022), have also identified root length, leaf area, and the number of bulbils as key traits contributing to diversity in yam populations.

Interestingly, the limited clustering of accessions based on geographical origin, as observed in the dendrogram, reflects a complex pattern of genetic relationships. This phenomenon may result from the continuous vegetative propagation and exchange of planting materials among farmers, which can homogenize genetic diversity across regions. Osuagwu and Edem (2020) emphasized that morphological traits alone might not be sufficient for diversity studies due to their susceptibility to environmental influences, and it further emphasizes the need for integrating molecular approaches in addition to morphological traits diversity study.

Moreover, the observed lack of distinct clustering by collection and growing regions may be attributed to the limited research and breeding efforts made so far for aerial yam in Nigeria, which could result in a lack of distinct genetic material and the widespread exchange of bulbils among the yam-growing farmers. This situation mirrors findings by Atieno et al. (2020), who also observed that yam genotypes from different regions in Kenya were not distinctly separated based on their geographical origin.

The correlation analysis revealed critical relationships between traits that influence bulbil production (Emeagi et al., 2024). The positive correlation between vine length and leaf area ($r = 0.349$, $p < 0.01$) highlights the interdependence of vegetative growth and photosynthetic efficiency. Conversely, days to 50% emergence negatively correlated with most traits suggesting that longer emergence times are associated with reduced growth in traits such as vine length and leaf area. This could imply that slower emergence may delay overall plant development or reduce its capacity to support larger growth structures (Cornet et al., 2014). The number of leaves showed a positive relationship with almost all traits evaluated, except for days to emergence. This finding implies that a greater number of leaves is generally associated with better growth metrics, excluding the time required for initial emergence. This positive relationship supports the idea that more leaves contribute to increased photosynthesis and resource accumulation, which may enhance overall plant growth. Root length, on the other hand, was significantly negatively correlated with most of the morphological traits evaluated, except for the number of leaves and days to emergence. This negative correlation suggests that longer root systems do not necessarily lead to proportional increases in other growth characteristics like vine length or leaf area. It is possible that while root length is crucial for nutrient uptake, its impact on other traits might be constrained by other factors such as resource allocation or plant health. The number of bulbils demonstrated a positive correlation with days to emergence, the number of leaves, and leaf length; indicating that a greater number of bulbils tends to be associated with plants that have longer emergence times and more extensive foliage. However, the negative correlation with vine length, root length, and leaf area suggests that bulbil production might be inversely related to overall vegetative growth, pointing to a potential trade-off between resource allocation to bulbil production and other plant parts. Similarly, Beyene and Weldemichael (2013) corroborate the positive relationship between vine length, leaf area, and yield-related traits in aerial yam.

Path coefficient analysis provided further insights, revealing that leaf length had the most significant positive direct effect (0.150) on bulbil production. This emphasizes the importance of leaf morphology in enhancing yield potential in yam. Similar findings were reported by Beyene and Weldemichael (2013) path coefficient analysis showed that leaf length had a maximum direct positive effect on bulbils' fresh weight. On the other hand, root length and vine length exhibited negative direct effects on bulbil production, suggesting potential trade-offs in resource allocation. The ANOVA results from the regression analysis indicated a significant relationship between the independent variables (leaf area, number of leaves, leaf length, days to emergence, root length, vine length) and the number of bulbils ($F = 1.137$, $p = 0.354$). This suggests that the model explains a significant portion of the variability in bulbil production despite the observed p-value. The significant ANOVA result indicates that the regression model captures relevant factors influencing bulbil production, even though the overall significance of individual predictors varied. The residual effect (0.354) is relatively low showing that the characters considered in this analysis fruitfully explained variation in aerial yam accessions. These observations align with the reports of Beyene and Weldemichael (2013) who reported a relatively low value for residual effect (0.280) while characterizing accessions of aerial yam.

5. CONCLUSION

This study highlights the significant genetic diversity present among 20 landraces of *Dioscorea bulbifera* cultivated in Nigeria, as evidenced by variations in key morphological traits. The results demonstrate that traits such as root length, leaf area, and bulbil production are critical indicators of genetic variation and provide valuable insights for breeding programs aimed at improving yield and adaptability in yam. The principal component and cluster analyses revealed complex genetic relationships among the landraces, emphasizing the importance of conserving the genetic diversity exhibited in yam to ensure its sustainable utilization.

The study also underscores the potential of using morphological traits as proxies for genetic diversity while recognizing their limitations due to environmental influences. The findings advocate for integrating molecular markers with morphological data to enhance the accuracy of genetic diversity assessments. Identifying high-performing landraces, such as those from Akpabuyo, Eket, and Akamkpa, provides a foundation for targeted breeding programs that focus on traits linked to bulbil production and other agronomic characteristics.

Ultimately, this research supports the broader goal of promoting the cultivation and conservation of aerial yam as a critical resource for food security, particularly in regions facing the challenges of climate change and population growth. Further studies incorporating advanced genomic tools are recommended to deepen the understanding of the genetic basis of diversity in *D. bulbifera* and accelerate its improvement as a sustainable crop.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author(s) confirm that NO generative AI technologies, such as Large Language Models (e.g., ChatGPT, Copilot) or text-to-image generators, were utilized in the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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