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Characterization of phenotypic diversity of edible tiger nut (*Cyperus esculentus* L.) accessions collected from Côte d'Ivoire

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Cyperus esculentus is a highly valued food plant in Côte d'Ivoire, yet its production remains insufficient. To address this issue, the development of a genetic improvement program is essential. Achieving this goal requires a comprehensive understanding of the phenotypic diversity among accessions. In this context, 43 accessions were collected from 8 locations across the country. A randomized experimental design with three replications was implemented at Jean Lorougnon Guedé University. On the experimental plots, two qualitative and eighteen quantitative traits were recorded and subjected to statistical analyses: one-way ANOVA and multivariate analyses (PCA, HCA, and DFA). Of the 18 quantitative parameters assessed, 10 contributed significantly as principal components. Principal Component Analysis (PCA) revealed three main axes explaining the total variation (1 : 60.69 %, 2 : 19.41 %, 3 : 15.06 %). Hierarchical Cluster Analysis (HCA) identified two distinct groups : 1 (12 accessions) and 2 (32 accessions). Discriminant Factor Analysis (DFA) showed NTP, ToM and ES were the most discriminant variable between these groups. Regarding qualitative traits, color analysis revealed a single phenotype (yellow), while shape analysis identified three phenotypes: elongated, oval, and round, across the accessions.

Keywords: accessions, *Cyperus esculentus*, Ivory Coast, phenotypic diversity, food security

INTRODUCTION

Edible tiger nut, scientifically known as *Cyperus esculentus* L., was first described by Linnaeus in 1753. This herbaceous species belongs to the Cyperaceae family, which includes over 700 documented species (Govaerts R. et al. 2018). Tiger nut is valued for its nutrient-rich tubers, which are high in macronutrients (Arafat et al. 2009) and micronutrients (Omeje *et al.* 2022), as well as for its traditional medicinal properties that are particularly beneficial for vulnerable populations such as children, pregnant women, and the elderly. The tubers contain starch, sugars, dietary fiber, and vitamins C and E, among other compounds. As such, tiger nut represents a promising crop to support food security. Since its discovery and domestication, numerous studies have investigated its diverse characteristics across the globe, and economic assessments have highlighted its potential contribution to achieving sustainable development goals.

In Côte d'Ivoire, tiger nut commonly known as "tchongon" (Kouame and Kanga, 2023) is among the cultivated crops, although it is predominantly grown in the northern regions of the country. The dried tubers are sold on both rural and urban markets at prices ranging from 700 to 1500 FCFA per kilogram. Despite being consumed locally, tiger nut production remains limited. It is cultivated on a small scale, with relatively low yield per hectare. In efforts to promote the crop's value, several studies have investigated the physico-chemical and therapeutic properties of tubers found in Côte d'Ivoire (Ban-Koffi et al.

2005; Kouame et al. 2022). Nevertheless, tiger nut production is still excluded from national agricultural statistics. This low level of production is attributable to several factors, notably the origin of the accessions available to farmers and the absence of certified tiger nut seeds in Côte d'Ivoire. Moreover, the accessions accessible to producers are often of questionable quality, with no available information on their productive traits. To optimize yields, some research has focused on improving cultivation practices through fertilization, as has been done in Burkina Faso. However, one of the main barriers to the crop's development lies in the lack of comprehensive characterization of the phenotypic diversity of locally cultivated accessions. This gap hinders both yield improvement efforts and the development of enhanced varieties. Therefore, a genetic diversity study using morphological markers is essential for achieving optimal results. Understanding the morphological characteristics (e.g., plant height, number of leaves) and agronomic traits (e.g., yield, number of tubers per plant, tuber weight) of the 43 accessions collected from markets across Côte d'Ivoire is crucial to identify those with the greatest potential for agronomic improvement. In response to this observation, The objective of the present study is to establish a crop improvement program for edible tiger nut (*Cyperus esculentus*) production in Côte d'Ivoire by assessing its phenotypic diversity.

MATERIALS AND METHODS

Collection of biological material and presentation of sampling sites

For the establishment of the experiment, the plant material consisted of edible tiger nut (*Cyperus esculentus* L.) tubers collected from eight different locations, either directly from farmers or from local markets. In total, 43 accessions were collected. Accessions from the northern regions of Côte d'Ivoire (Boundiali, Samatiguila, Ferkessédougou, and Tingrela) were obtained directly from producers, whereas those from the western, central, and southern regions (Daloa, Man, Yamoussoukro, and Abidjan) were collected through market sampling (Fig.1 and Table 1).

Table 1 : Characteristics of the collection sites of *Cyperus esculentus* in Côte d'Ivoire

LOCALITIES	COORDINATES	VEGETATION	CLIMATE	SOIL	RAINFALL (mm/an)
Abidjan	5° 20' North 4° 1'West	Dense humid forests,Savannas	Humid subequatorial	Ferralitic soils, Alluvial soils	1553-2198
Boundiali	9°31' North, 6°29' West	Wooded or grassy savannas, Sparse forests	Sudano-Guinean	Ferralitic soils, lithosols	1300 - 1500
Daloa	6°53 North 6°27 West	Dense humid forests, Wooded savannas	Tropical humid	Ferralitic soils, hydromorphic or sandy soils	1300 - 1800
Ferkessedougou	9°59' North -5°19' Ouest	Grassy savannas	Tropical savanna	Ferralitic soils	1000 - 1200
Man	7.3° North 8.5° West	Dense forests	Tropical humid	Ferralitic soils, Clayey	1500 - 1770
Samatiguila	9.818° North –7.561° West	Tree-studded, wooded, grassy savannas	Tropical savanna	Ferralitic soils, Tropical ferruginous	1200 - 1500
Tingrela	10°30′ North 6°23′ West	Wooded savannas	Soudanese, Sudano-Guinean	Ferralitic soils, ferruginous	1000 - 1200
Yamoussoukro	06° 49-06° 47 North. 05°16-05°15 West	Savannas, Pre-forests	Tropical humid, Baoulean	Ferralitic soils	900 - 1400

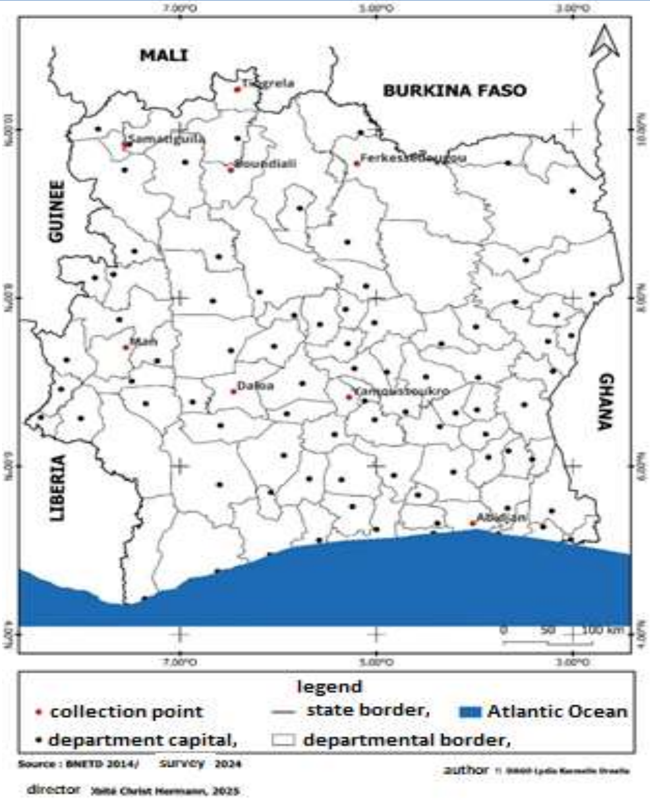

Figure 1 : Geographical location of the eight collection zones in Côte d'Ivoire.

Experimental site

The study was conducted at Jean Lorougnon Guédé University (6°54′25.9″ N, 6°26′11.3″ W), located in the city of Daloa (6°53′ N, 6°27′ W). The soils in this area are predominantly ferralitic, as reported by Kouame *et al*. (2021), although considerable heterogeneity exists, with the presence of clay–sandy and sandy soils in certain areas, including the experimental site. Historically, the natural vegetation of Daloa consisted of dense semi-deciduous humid forests. However, according to N'Guessan *et al*. (2014), this vegetation has gradually evolved into degraded semi-deciduous forests and mesophilic savannas. The climate is classified as humid tropical, characterized by a dry season from October to March and a more pronounced rainy season from June to September. Annual rainfall ranges between 1,300 mm and 1,800 mm, providing favorable agroecological conditions for the cultivation of edible tiger nut in the Daloa region.

Experimental setup crop management

The tubers obtained after collection were grown in an open field as part of a provenance trial. This preliminary phase enabled the production of new seed tubers that underwent uniform post-harvest treatments, including identical drying and storage periods for the main experiment. Long before the implementation of the experimental setup, the area designated for installation was carefully prepared. This preliminary work involved clearing existing vegetation and removing tree roots buried in the soil that could hinder the installation of the setup. Covering an area of 180 m², the plot of the main experiment was arranged according to a "split-plot" design with three (3) randomized blocks, each containing three replications. The experimental treatment consisted of planting tubers according to their geographical origin. The different accessions were arranged in columns, each representing a specific region. The columns were spaced 80 cm apart, and the plants within each column were spaced 60 cm apart. The three (3) blocks were separated by a distance of 1.5 meters. The elementary plots, with a surface area of 600 cm², each contained 30 plants, all grown in oil palm nursery bags. These bags were filled with fertile, organic-rich soil (black soil), ideal for successful cultivation. Once this stage was completed, the seeds were sorted and counted to retain only those in perfect condition. They were then soaked in water for two days. Sowing was done manually, placing three tubers per bag, arranged at the edges. Two weeks after germination, thinning was carried out, retaining only the most vigorous plant. Regular weeding and appropriate watering were performed, especially during dry periods. Three months after germination, the harvest took place, and the tubers were air-dried until fully dehydrated.

Data collection

A total of 2580 plants were included in the evaluation of phenotypic diversity, based on the measurement of 20 plants per accession and per replication. Data collection began as soon as the first seedlings showed vigor. This initial phase allowed for the determination at the emergence speed and average emergence time. During the growth phase, 60 days after sowing, morphological or phenotypic parameters were measured. These included plant height (PH), number of tillers per plant (Til), collar diameter (ColD), leaf length (LL), leaf width (LW), number of leaves (NL), root biomass (RB), and foliar biomass (FB). Production parameters were also evaluated after harvesting and drying the tubers. These included: number of tubers per plant (NTP), tuber length and width (LT and WT), total number of tubers (ToNbT), tuber mass per plant (M), total tuber mass per accession (ToM), the weight of 100 tubers (W100), and yield in kilograms per hectare (Yi).

Data processing and analysis

Before the analysis, all data were entered into Microsoft Excel 2016. In order to evaluate the 43 accessions based on the measured parameters and identify the best-performing ones, a preliminary descriptive analysis was conducted to determine the means, minimum and maximum values, standard deviations, and coefficients of variation for each parameter. A multivariate analysis (MANOVA) was then performed to assess the effect of the accessions on the measured traits. To precisely locate this effect, an analysis of variance (ANOVA) was carried out at a 5% significance level. In cases of significant differences, the Newman-Keuls test for the smallest significant difference (LSD) was applied. Additional analyses, such as Principal Component Analysis (PCA), Hierarchical Cluster Analysis (HCA), and Discriminant Factor Analysis (DFA), were conducted to structure the diversity among the accessions. These analyses respectively allowed for the formation of homogeneous groups, the hierarchical clustering of these groups, and the identification of the most discriminating variables among them. All statistical analyses were performed using R software version 4.3.0 and STATISTICA 7.1.

RESULTS

Evaluation of phenotypic diversity

Description of quantitative variables for the evaluation of accessions

The results of the morphological characterization of edible tiger nut (*Cyperus esculentus*) accessions are presented in Table 2. The coefficients of variation (CV) indicate a high degree of variability among accessions for fourteen (14) evaluated traits (CV > 15%). These include collar diameter (ColD), number of tillers per plant (Til), foliar biomass (FB), root biomass (RB), total number of tubers (ToNbT), total tuber mass per accession (ToM), number of leaves (NL), tuber length (LT), tuber width (lT), number of tubers per plant (NTP), weight of 100 tubers (W100), tuber mass per plant (M), yield (Yi), and average emergence time (AET). These high CVs reflect significant variability among accessions for these traits. Additionally, large disparities were observed in the minimum and maximum values for certain parameters. For example, yield (Yi) ranged from 3880.292 kg/ha to 13096.88 kg/ha; the total number of tubers (ToNbT) ranged from 312 to 1328; and the weight of 100 tubers (W100) ranged from 30.892 g to 106.72 g. In contrast, low coefficients of variation (CV < 15%) were observed for the remaining traits.

The high coefficients of variation observed for the majority of the quantitative traits suggest substantial phenotypic variability among the accessions. This diversity may result from genetic differences among the accessions.

Table 2 : Minimum, maximum, mean, standard deviation, and coefficient of variation of the 18 quantitative variables studied

	indices				
Variables	**Min**	**Max**	**Mean**	**sd**	**CV (%)**
PH	82.050	110.95	99.928	5.422	5.426
ColD	12.550	27.50	17.950	2.999	16.705
Til	5.500	12.90	8.490	1.950	22.974
LL	61.463	97.77	73.775	6.509	8.822
LW	0.635	0.95	0.818	0.069	8.485
NL	26.700	72.25	49.196	9.759	19.836
FB	6.091	13.18	9.708	1.786	18.395
RB	1.794	5.90	3.492	0.949	27.186
LT	9.350	26.40	16.062	4.021	25.037
WT	6.500	14.09	10.134	1.680	16.583
NTP	15.600	46.80	31.415	6.630	21.103
ToNbT	312.000	1328.00	657.709	178.930	27.205
ToM	12.259	39.29	24.573	6.228	25.345
M	245.181	1045.85	512.123	150.693	29.425
W100	30.892	106.72	61.005	18.033	29.560
Yi	3880.292	13096.88	7959.752	2108.814	26.493
ES	3.571	4.29	4.219	0.147	3.475
AET	3.000	4.59	3.566	0.391	10.962

Min: minimum; Max: maximum; sd: standard deviation; CV: coefficient of variation; FB : foliar biomass (g) ; RB : root biomass (g) ; PH : plant height (cm); LL : leaf length (cm) ; LW : leaf width (cm) ; ColD : collar diameter (mm) ; NL : number of leaves ; Til : number of tillers per plant, ToN bT : total number of tubers; LT : tuber length (mm) ; IT : tuber Width (mm) ; NTP : number of tubers per plant ; ToNbT : total number of tubers. M : tuber mass per plant (g) ; ToM : total tuber mass per accession (g) ; W100 : the weight of 100 tubers (g) ; Yi : yield in kilograms per hectare (kg/ha) ; ES : emergence speed (tuber/day) ; AET : average emergence time (day).

Qualitative description (Color and shape) of edible tiger nut tubers Color

Following the harvest of the tubers after the experiment, the results focused on color indicated that the tubers were homogeneous in color (Fig 2), exhibiting a single yellow hue despite varying shapes. No notable variation in shade was observed among the different collected accessions. However, previous studies, such as Kouame *et al*. (2022), reported both yellow and black tubers in the Bondoukou region in northeastern Côte d'Ivoire. Other research, such as Haoua *et al*. (2018) in Niger, documented tubers with a variety of colors including light brown, dark brown, reddish, and black. Diverse colorations were also observed by Adjahossou *et al*. (2021) in Benin and Ji *et al*. (2023), including light yellow, brown-yellow, and black. The strong presence of yellow tubers in Côte d'Ivoire may be related to cultural factors, local dietary preferences, and higher yields (Britwum and Demont, 2021; Zuza *et al.* 2024). Specific historical and dietary factors could also contribute to this dominance (Sangare *et al.* 2023).

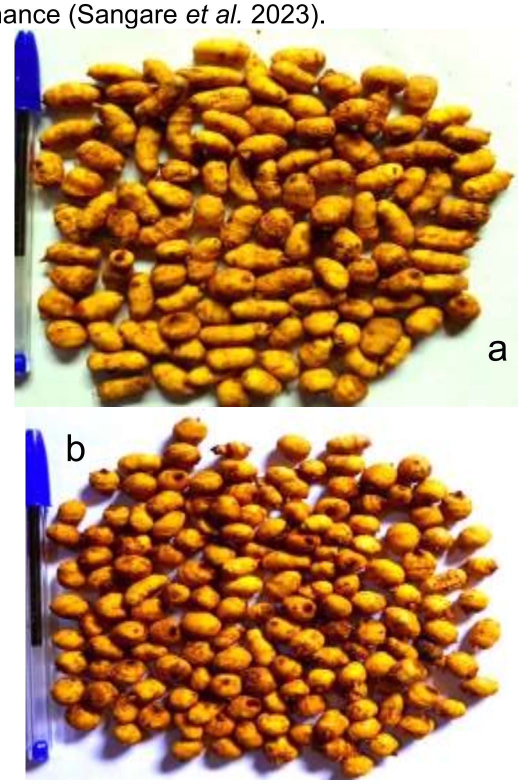

Figure 2 :Tuber color of two varieties of *Cyperus esculentus*

a: Elongated shape; b: Round shape

Tuber Shapes

Among all the collected accessions, various shapes were observed (Fig 3). The results revealed three different shapes: round, oval, and elongated. The elongated shape was dominant, representing 72% of the tubers across the accessions, while the oval shape was present in only 5% of the accessions. Similar shapes were documented by Ban-Koffi *et al*. (2005) in their study on the physicochemical characterization and therapeutic potential of tiger nut (*Cyperus esculentus* L. (Cyperaceae)). Moreover, similar trends were observed by other authors in several countries, including De Ryck *et al*. (2023), and Yang *et al*. (2022) in China. However, in Niger, wild ecotypes predominantly display oval and round shapes, as reported by Codina-Torrella *et al*. (2015).

These morphological differences can be explained, on one hand, by genetic factors, notably the presence and function of genes. For example, Pandey *et al*. (2022) demonstrated the crucial role of genes in the morphology of potatoes. Indeed, genes influence cell growth and division as well as the morphogenesis of plant organs, thus playing a central role in the formation of different fruit shapes. On the other hand, the growing environment is also a determining factor. Temperature, humidity, and soil quality can influence tuber shape, as highlighted by Bacelar et al. 2024, Fanwoua et al. 2013, and Wang et al. 2020.

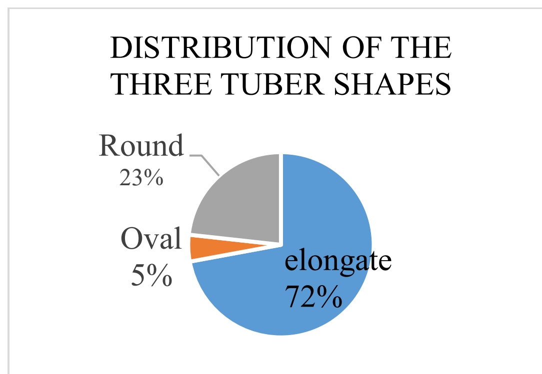

Figure 3 : The number of the three different tuber shapes in *Cyperus esculentus* accessions : elongated, oval, and round

Correlation Between the Different Agromorphological Parameters Evaluated by Locality

The correlation analysis (Fig. 4) presented alongside reveals that the number of leaves (NL) is positively correlated with the number of tillers per plant (Til, r = 0.70). Tuber mass per plant (M) also shows a strong association with the total number of tubers (ToNbT, r = 0.80), the weight of 100 tubers (W100, r = 0.60), and the number of tubers per plant (NTP, r = 0.65). Mass is determined by these variables. Similarly, NTP exhibits a significant correlation with total mass (ToM, r = 0.65). Yield (Yi), a component of production, is strongly and positively correlated with total tuber mass per accession (ToM, r = 0.91), tuber mass per plant (M, r = 0.57), and the number of tubers per plant (NTP, r = 0.56).

Moreover, a notable negative correlation is observed between emergence speed and average emergence time (ES – AET, r = –0.61). Additionally, a correlation exists between plant height and leaf length (r = 0.58), confirming the interconnection between morphological traits.

Correlation analyses between morphological and agronomic variables indicate no significant link between them. Thus, tiger nut productivity does not seem to depend on its vegetative stage. This finding aligns with the conclusions of Enyi (1977), who, in his study on growth analysis and tuber yield of sweet potato cultivars (*Ipomoea batatas*), observed that some fast-growing cultivars did not necessarily produce higher tuber yields. This suggests that rapid growth is not always a reliable indicator of final tuber productivity.

The lack of correlation may be attributed to environmental factors, as explained by Liebig's law of the minimum (1840), as well as the species' genetic characteristics. However, correlations do exist within growth parameters and within production parameters. In this regard, yield is positively correlated with the number of tubers per plant and tuber mass. This correlation results from the fact that these parameters are components used to calculate yield. They were also used to estimate potato yield in the study by Mohammed Amar *et al*. (2022) on monitoring production of an irrigated crop under an agro-photovoltaic system.

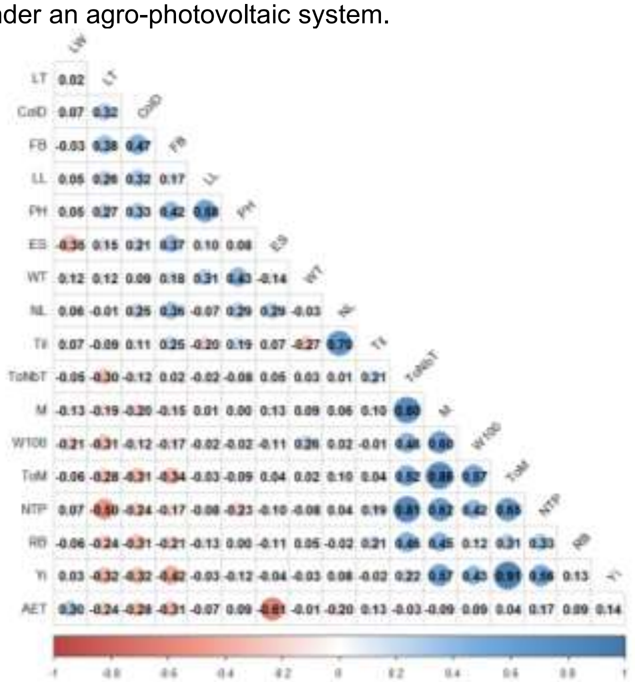

Figure 4 : Correlation matrix among 18 measured variables in *Cyperus esculentus* individuals

Structuring the diversity of tigernut

Out of all the evaluated variables, ten were found to be significant and were retained for the analysis of diversity structure.The Principal Component Analysis (PCA) (Table 3) highlights a good overall representation of the variables, with 95.15 % of the total variance explained by the first three axes. Axis 1 (60.69 %) represents a productivity gradient, strongly associated with yield and agronomic performance variables (M, ToM, NtP, ToNbT, W100, Yi). This axis can therefore be interpreted as a productivity gradient: individuals with high scores on this axis exhibit the best productive performance. Axis 2 (19.41 %) reflects seedling vigor (ES, AET) and vegetative growth (NL, Til). It is positively correlated with ES, NL, and Til, but negatively with AET. This axis thus contrasts vegetative development characteristics with water stress constraints. Finally, Axis 3 (15.06 %) is strongly correlated with Til and AET, and moderately with NL (Fig 5).

Based on these axes, a Hierarchical Cluster Analysis (HCA) (Fig. 6) was performed, leading to the identification of two distinct groups of accessions : Group I included 12 individuals (27.91 % of the total), mainly originating from Abidjan, Daloa, Man, and Yamoussoukro. In line with the Principal Component Analysis, these accessions exhibit good productivity. Group II was composed of 34 individuals (79.06 %), originating from Ferkessédougou, Samatiguila, and Boundiali. Although they have low productivity and low AET, they show good plant vigor and strong vegetative growth.

Discriminant Factorial Analysis (DFA) revealed the standardized coefficients associated with the first discriminant function (LD1) (Fig. 7 and Table 4 ; 5). These coefficients reflect the unequal contribution of the variables to the differentiation among accession groups. Among the set of traits assessed, three variables exhibited particularly strong contributions to group discrimination : Emergence speed (ES) showed a high positive coefficient (5.317), indicating that it is the most influential variable on LD1. Accessions exhibiting high emergence vigor are thus projected towards the positive end of this axis. Conversely, total tuber mass per accession (ToM) displayed a strongly negative coefficient (−4.500), suggesting that accessions characterized by longer or later maturation are positioned on the negative side of LD1. Number of tubers per plant (NTP) also contributed significantly to the discriminant function (1.701), highlighting the role of this productivity-related trait in shaping the discriminant axis. These traits related to emergence and productivity therefore play a key role in distinguishing between the different accession groups.

The classification accuracy derived from the DFA is summarized in Table 6. The results show that 40 out of the 43 individuals predicted to belong to Group I were correctly classified, corresponding to 100% classification accuracy. Similarly, Group II comprised 3 individuals out of 3, also reflecting 100% correct classification.

In summary, the structuring of diversity using PCA, HCA, and DFA revealed two clearly differentiated groups of accessions. These groups were primarily separated based on their productivity traits, which proved to be the most reliable discriminant factors. Accessions from Group 1 exhibited significantly higher productivity, suggesting that these traits are key indicators of diversity within tiger nut (*Cyperus esculentus*) populations and constitute a determining factor for distinguishing agronomic performance across geographical regions.

Table 3 : Eigenvalue matrix and total variance of the projection of significant variables of *Cyperus esculentus* in the plane

Principal compoment	Axis 1	Axis 2	Axis 3
Eigenvalue	4.069	1.940	1.5973
total Variance (%)	60.689	19.406	15.059
Cumulative Total Variance (%)	60.68	80.095	95.154
Til	0.172	0.561	**0.775****
NL	0.119	**0.772****	0.477
NTP	**0.832****	0.076	0.149
ToNbT	**0.779****	0.087	0.013
M	**0.902****	0.097	0.189
ToM	**0.903****	0.030	0.119
W100	**0.685****	0.145	0.056
Yi	**0.681****	0.139	0.050
ES	0.000	**0.747****	0.497
AET	0.081	**-0.738****	**0.665****

NL : number of leaves ; Til : number of tillers per plant, ES : emergence speed (tuber/day) ; AET : average emergence time (day); NTP : number of tubers per plant ; ToNbT : total number of tubers. M : tuber mass per plant (g) ; ToM : total tuber mass per accession (g) ; W100 : the weight of 100 tubers (g) ; Yi : yield in kilograms per hectare (kg/ha)

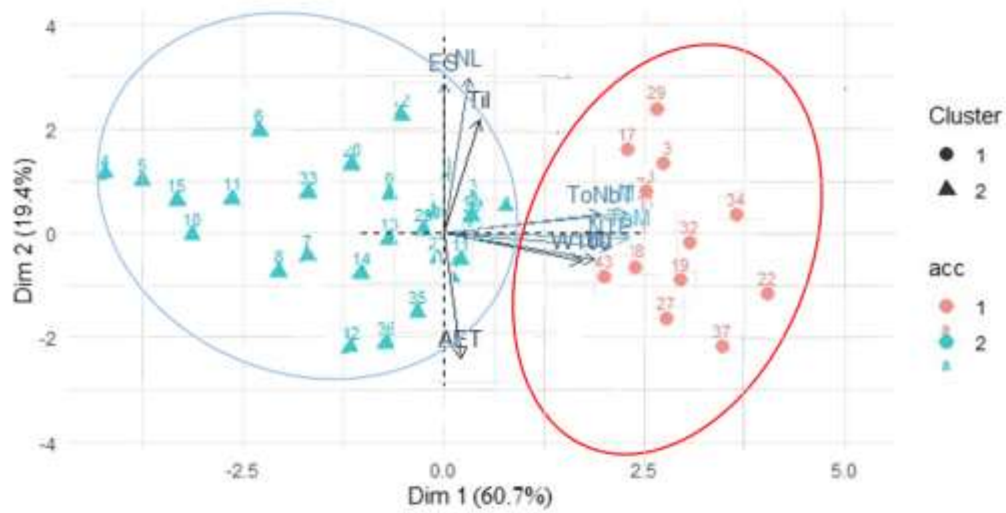

Figure 5 : Projections of significant variables explaining the diversity of *Cyperus esculentus*

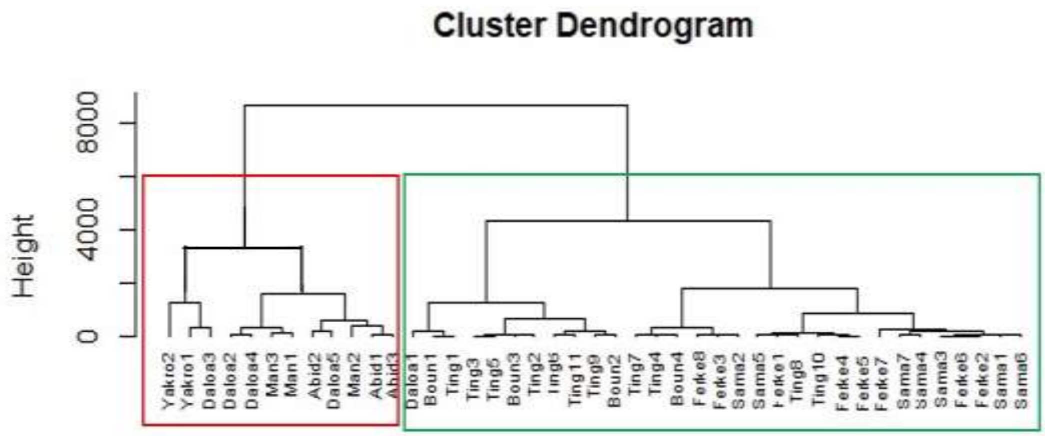

Figure 6 : Dendrogram of the hierarchical classification of the 43 *Cyperus esculentus* individuals

Table 4 : Discriminant variables of different groups resulting from Hierarchical Ascending Classification

	Groups			
Variables	**G I = 12**	**G I = 31**	**F**	**p**
TIL	8.730 ± 1.599[a]	8.407 ± 1.381[a]	0.412	0.524
NL	48.595 ± 10.609 [a]	49.402 ± 6.539 [a]	0.089	0.767
NTP	27.189 ± 5.131 [b]	32.867 ± 4.622 [a]	11.692	**0.001**
ToNbT	615.227 ± 190.344 [a]	672.313 ± 145.578 [a]	1.0730	0.306
M	19.122 ± 3.503 [b]	26.447 ± 4.105 [a]	27.923	**0.000**
ToM	434.263 ± 154.582 [b]	538.888 ± 110.188 [a]	5.9704	**0.019**
W100	57. 405 ± 15.132[a]	100.768 ± 51.079[a]	13.344	**0.002**
Yi (Kg/ha)	5711.823 ± 425.676 [b]	8732.478 ± 1334.98 [a]	53.670	**0.000**
ES	3.24 ± 0.088 [b]	4.212 ± 0.115 [a]	9.55	**0.043**
AET	3.523 ± 0.504 [a]	3.58 ± 0.315 [a]	0.193	0.663

Til : Number of tillers per plant ; ES : Emergence speed (tuber/day) ; AET : average emergence time (day) ; NTP : number of tubers per plant ; ToNbT : total number of tubers ; M : tuber mass per plant (M) ; ToM : total tuber mass per accession ; Yi : yield in kilograms per hectare

Table 5 : Discriminant factor analysis based on the significant parameters of the groups

Variables	**Wilks_Lambda**	**F_value**	**p_value**	**1-Tolerance (R^2)**	**Tolerance**
Til	0.700	0.01	0.921	0.000	0.900
NL	0.634	1.42	0.240	0.066	0.734
NTP	0.078	13.49	**0.009**	0.922	0.078
ToNbT	0.805	0.21	0.649	0.095	0.605
ToM	0.006	10.23	**0.036**	0.759	0.006
M	0.582	0.07	0.788	0.098	0.692
W100	0.632	1.36	0.251	0.168	0.832
Yi	0.723	0.98	0.327	0.277	0.723
ES	0.401	27.49	**0.000**	0.799	0.401
AET	0.676	1.61	0.402	0.394	0.560

Til : Number of tillers per plant ; ES : Emergence speed (tuber/day) ; AET : average emergence time (day) ; NTP : number of tubers per plant ; ToNbT : total number of tubers ; M : tuber mass per plant (M) ; ToM : total tuber mass per accession ; Yi : yield in kilograms per hectare ; W100 : the weight of 100 tubers (g)

Variables	LD1
Til	0.114
NL	-0.084
NTP	**1.701**
ToNbT	-0.083
ToM	**-4.500**
M	0.162
W100	0.044
Yi	0.004
ES	**5.317**
AET	-0.291

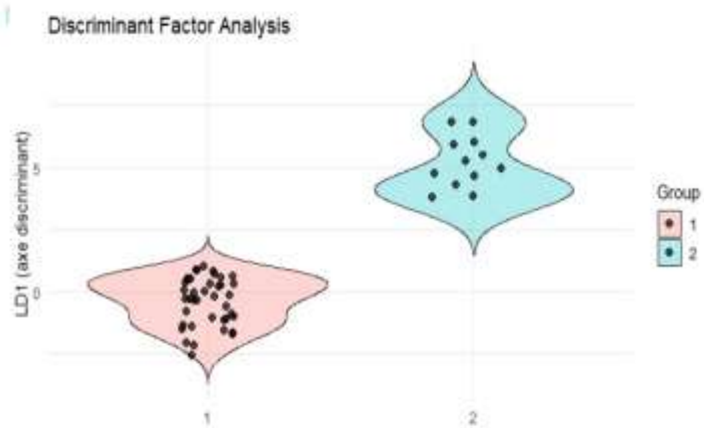

Figure 7 : Standardized coefficients associated with the first discriminant function (LD1)

Table 6 : Distribution of the 43 *Cyperus esculentus* accessions across groups I and II

		Groups		
Groups	**Pourcentage de classification (%)**	**Group I**	**Group II**	**Total**
Group I	100	12	0	12
Group II	100	0	31	31
Total	100	33	10	43

CONCLUSIONS

This study represents a key step toward the development of a breeding program for *Cyperus esculentus* production. Based on the analysis of 18 quantitative and 2 qualitative traits, significant phenotypic diversity was observed among the accessions collected across Côte d'Ivoire. The analysis of diversity structure revealed two distinct groups. Group I, composed of accessions from Daloa, Man, Yamoussoukro, and Abidjan, exhibited high productivity. In contrast, accessions from Boundiali, Ferkessedougou, Tingrela, and Samatiguila were characterized by vigorous vegetative growth and rapid seedling emergence. These groups were primarily discriminated by three traits: emergence speed (ES), number of tubers per plant (NTP), and total tuber mass per accession (ToM). Although phenotypic diversity has been demonstrated, agro-morphological traits are often influenced by environmental factors. Therefore, it is necessary to validate these findings through molecular studies that explore the genetic mechanisms underlying the observed diversity, using appropriate molecular markers.

Nevertheless, the genetic groups identified in this study may serve as a foundation for future hybridization and genetic improvement efforts.

Supplementary materials

Not applicable.

Author contributions

Conceptualization: D.L.K.O. and G.B.B.; methodology: D.L.K.O. and G.B.B.N.; software: N.K.E.; validation: G.B.B.N. and A.D.S.; formal analysis: D.L.K.O., N.K.E. and A.B.I.; investigation: D.L.K.O., E.K.J.B. and G.S.F.; resources: A.D.S.; data curation: D.L.K.O.; writing—original draft preparation: D.L.K.O.; writing—review and editing: G.B.B.N., A.D.S and D.D.; visualization: A.B.I.; supervision: G.B.B.N. and A.D.S.; project administration: G.B.B.N.; funding acquisition: D.L.K.O., G.B.B.N. and A.D.S

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All of the data is included in the article/Supplementary Material.

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Conflict of interest
The authors declared that present study was performed in absence of any conflict of interest.

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