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Genetic diversity of genotypes of tiger nuts (*Cyperus esculentus* L.) using morphological descriptors in Burkina Faso

Nogueba Abraham Kombeleme*[1], Koussao Some[2], Djakaridia Tiama[2], Wendmanegda Hermann Tonde[1], Saïdou Yamwemba[1], Pauline Bationo/Kando[1]

[1]*Plant Genetics and Improvement Team, Biosciences Laboratory, Department of Plant Biology and Plant Physiology, UFR/SVT, University Joseph KI-ZERBO, Ouagadougou, Burkina Faso*

[2]*Institute for the Environment and Agricultural Research (INERA), CREAF of Kamboinse Plant Production Department, Ouagadougou, Burkina Faso*

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Abstract

Genetic diversity is an essential component of selection and conservation. Morphological descriptors are the primary tools for germplasm management. The aim of this study was to determine the morphological variability of a collection of genotypes of Tiger Nuts (*Cyperus esculentus* L.) in Burkina Faso. A total of 44 genotypes were evaluated using an apha lattice block design with three replications. Each replication consisted of two blocks with 22 genotypes per block. Data were collected on 5 qualitative and 11 quantitative variables. The data collected were subjected to descriptive, variance, bivariate and multivariate analyses. The results of the study revealed morphological variability between genotypes. Ten morphological descriptors (tuber shape, tuber colour, inflorescence, leaf width, number and weight of tubers per plant, tuber yield, weight of 100 tubers, length and diameter tubers) discriminate the genotypes studied. The genotypes were divided into five distinct groups, irrespective of geographical origin. This structuring has enabled to distinguish groups I and II, constitute of genotypes of average agronomic performance. Group III has grouped genotypes with broad leaves. Group IV is composed of genotypes producing a large number of tubers per plant and of small size. Group V contains genotypes with large tubers and higher yields. The results of this study could be used to improve Tiger Nuts varieties in Burkina Faso.

* **Corresponding Author:** Nogueba Abraham Kombeleme ✉ abrahamkombelem@gmail.com

Introduction

Tiger Nuts (*Cyperus esculentus* L.) is an herbaceous plant cultivated for its tubers. Native to the Mediterranean and East Asia (Sakatai *et al.*, 2020), Tiger Nuts are produced in Europe, particularly in Spain, but also in West Africa (Sissoko *et al.*, 2011; Bado *et al.*, 2015; Yang *et al.*, 2022). In Niger, it is produced in the Maradi and Dosso regions (Bori *et al.*, 2019). In Mali, Tiger nuts are produced in the Sikasso and Kadiolo regions (Sissoko *et al.,* 2011). Burkina Faso is an ecological niche for Tiger Nuts, with the wild variety present in several parts of the country (Yamwemba, 2020). Tiger Nuts is mainly produced in the Hauts Bassins, Sud-Ouest and Cascades regions (Yamwemba *et al.*, 2020; Zeba, 2017). Previous studies by Yang *et al.* (2022) have shown that nutsedge tubers can accumulate a large quantity of nutrients including starch, oil, sugars, proteins, high levels of dietary fibre, minerals and vitamins. As a result, the tubers are eaten raw or processed into milk called "horchata" (Ndiaye, 2021). This plant is used in the treatment of colon cancer, obesity, diabetic and gastrointestinal disorders (Asare *et al.*, 2020). Research has also shown that Tiger Nut milk is very nutritious for infants and nursing mothers (Ndiaye, 2021). Tiger Nuts effectively combats poverty and malnutrition, especially among women, who account for 95% of the production and processing chain (Yamwemba *et al.*, 2020). Nutsgrass can therefore help to improve the food and nutritional security of populations. However, most previous studies on Tiger Nuts have focused on the biochemical composition of the tubers. Few studies have been carried out on the genetic diversity of this species. Tiger Nuts can therefore help to improve the food and nutritional security of populations. However, most previous studies on Tiger Nuts have focused on the biochemical composition of the tubers. However, most previous studies on Tiger Nuts have focused on the biochemical composition of the tubers. Few studies have been carried out on the genetic diversity of this species. But, in recent years in Niger, Mali and Cameroon, some authors have carried out morphological and genetic characterisation work on Tiger Nuts (Bori *et al.*, 2019, Sakatai *et al.,* 2020, Sissoko *et al.,* 2011). In Burkina Faso, this plant is classified as a neglected crop (Bado *et al.*, 2015). As such, few research projects has been conducted for the development of Tiger Nuts in Burkina Faso research centres, at the exception of a pioneering study realise by Yamwemba *et al.* (2022). This study has enabled to identify the areas where Tiger Nuts are grown and to characterise the genotypes cultivated at national level. However, a study of genetic diversity associating several collections from several Nutsedge producing countries in the sub-region has not yet been carried out. In fact, in-depth knowledge of this genetic diversity will enable to lay the basics for genetic improvement, management and conservation of yellow nutsedge.

It is therefore necessary to know the genetic diversity of Tiger Nuts in West African countries, particularly the largest producers, such as Mali, Togo, Niger and Burkina Faso (Bado *et al.*, 2015). Morphological markers are the first tools for assessing genetic diversity (Gmakouba *et al.*, 2018). Morphological descriptors reveal the diversity as perceived and selected by local farmers, who are the main stakeholders in the management of varietal diversity (Ouedraogo *et al.*, 2010). These markers were therefore used in this study to (i) assess the level of genetic diversity and (ii) establish the organisation of this diversity in a collection of nutsedge from Burkina Faso, Togo and Mali.

Materials and methods

Plant materials

The plant material used constituted of 44 genotypes of Yellow nutsedge. These genotypes come from three West African countries. 6 genotypes came from Togo, 7 from Mali and 31 from Burkina Faso. The genotypes from Burkina Faso come from several of the most productive provinces, namely Bougouriba (13 genotypes), Poni (2 genotypes), Kenedougou (12 genotypes) and Comoé (4 genotypes).

Experimental site

An experimental trial was conducted at the research station of the Center of Research Environmental

Agricultural and Formation of Kamboinse (CREAF/K), a station of Burkina Faso's Institute of Environmental of Research Agricultural (INERA). The station is located around 12 km north of Ouagadougou, the capital of Burkina Faso. The geographical coordinates of the station are 12°28' north latitude and 1°32' west longitude, at an altitude of 296 m. According to Guinko (1985), the station belongs to the North Sudanese type of climate, as it lies between isohyets 600 and 900 mm. The soils at Kamboinse are classified as leached ferruginous soils, underlain by deeper sandy material, and hydromorphic soils with low humus content. The station recorded 775.6 mm of water during the experimental trial and temperatures ranging from 26.1 to 33.6°C, with an average temperature of 30.02°C.

Experimental design

The experimental design used was an alpha lattice block at three replications. Each replication constituted of two blocks. The distance between the replication was 2m and that between the blocks was 1m. Each block constituted of 22 lines (ridges) and measure 4m of long. The inter-bundle distance was 0.4m and the inter-row distance was 0.5m, 11 bundles per line. The trial measured a length of 31m and a width of 11.5m, giving a surface area of 356.5m².

Cultivation practices

Soil preparation began with flat ploughing using a motorised tractor. A ridge was then realised after application an organic fertiliser at a dose of 6.25T/ha. Sowing was carried out on 26 July 2021 at a reason of one tuber per poquet. Manual weeding was carried out 14 days after sowing (DAS), followed by sarclobinage on the 45th and 60th DAS respectively. Mineral fertilisation with NPK fertiliser (14-23-14) at a dose of 150 kg/ha was applied on 15th DAS. Harvesting was carried out by 108 DAS.

Data collection

Data was collected from plant emergence to harvest. A total of 16 morphological descriptors were collected, including five qualitative and 11 quantitative variables. The morphological descriptors used are taken from studies by Tachie-Menson (2016), Bori *et al.* (2019) and Sakatai *et al.* (2020) on *Cyperus rotundus* L. and *Cyperus esculentus* L.

Qualitative variables

The qualitative variables were determined by visual observations or by deduction after measurement. Visual observations were made on all the plants in the row of each genotype. These are the colour of the leaf blade (COL), colour of Inflorescence (COI), colour of tubers (COT), tuber shape (TUS) and the Inflorescence (IFL), which indicate the presence or absence of flowering. Tuber colour (COT) was determined using the method proposed by Bori *et al.* (2019). Tuber shape (TUS) was determined using the tuber length/diameter ratio proposed by Morell Mascarell (1983), 30 dry tubers from each randomly selected genotype were soaked in water for 72h. The length and diameter of these tubers were measured with a calliper to the nearest 0.001 mm. A length/diameter ratio of less than 1.3 corresponds to a round shape, between 1.3 and 1.8 corresponds to an oval shape, and greater than 1.8 corresponds to a long shape.

Quantitative variables

The quantitative variables were determined by counting, measuring and calculating. These were the number of leafy shoots (NLS), height of plant (HTP), length of leaf (LLE) and width of leaf (WLE) obtained by measuring four plants in the middle of the line at maturity. The number of leafy shoots (NLS) was counted at the 45th DAS. Variables such as plant height (HTP), length of leaf (LLE) and width of leaf (WLE) were measured using a graduated ruler (in cm) at the 60th DAS. Length of tuber (LTU) and diameter of tuber (DTU) variables were measured on random samples of 30 mature tubers from each genotype at harvest (108 JAS). Description of the different measurements taken are given in Table 1.

Statistical analysis

The Excel 2016 spreadsheet was used to calculate the frequencies of the different qualitative variables

observed. Quantitative data were analysed using RStudio Version 4.3.1 software. Descriptive and variance analyses (ANOVA) were carried out to determine the variability of the plant material studied. The Pearson correlation matrix was used to determine the relationship between two quantitative variables. The morphological diversity of the genotypes was structured using Principal Component Analysis (PCA) and Ascending Classification Hierarchical (ACH) with the discriminating quantitative variables. The Student-Newman-Keuls test at the 5% probability threshold was used to determine the performance of the groups of genotypes derived from the ACH.

Table 1. Description of quantitative variables measured

Variables	Description
HTP	The height of the plant at maturity (HTP) was measured between the surface of the soil and the highest point of the plant in natural orientation
LLE	The length of the leaves (LLE) was taken from the base to the apex
WLE	Width of Leaf (WLE) was measured between the two edges of the leaf, perpendicular to the midrib in the widest part of the leaf
NLS	The number of leafy shoots (NLS) was counted on the plants in the middle of the semi row
LTU	Length of Tuber (LTU) was measured using a caliper between the proximal and distal ends of the tuber.
DTU	Diameter of Tuber (DTU), measured using a calliper on the central part of the tubers
NTP	Number of tubers per plant (NTP), obtained by dividing the number of tubers harvested (NTR) by the number of plants harvested. (NPR), NTP = NTR / NPR
WTU	Weight of 100 tubers (WTU), measured by weighing 100 well dried tubers after harvesting
WTP	The weight of tubers per plant (WTP) was obtained by dividing the weight of harvested tubers (WTR) by the number of plants harvested (NPR) (WTP = WTR / NPR)
YTU	The Yield of tubers (YTU) in Tonnes/ha was obtained by applying the following. YTU=(WTP/1ha)×number of plants/ha

Results

Description of the collection based on qualitative variables

Frequency analysis showed that, with the exception of the colour of the leaf blade (COL) and colour of inflorescence (COI), which were uniform (light green and golden-red respectively) for all genotypes (100%), the other three variables, tuber shape (TUS), inflorescence (IFL) and colour of tuber (COT), discriminated between genotypes (Table 2). For tuber shape (Fig. 1), all the genotypes in the collection produced mainly round tubers (52%), oval tubers (39%) and a small proportion of long tubers (9%). Genotypes from Mali produced oval tubers (100%). Genotypes from Togo produced round tubers (66.66%), oval tubers (16.16%) and long tubers (16.16%). The three tuber shapes were noted on genotypes from Burkina Faso, with a predominance of the round shape (54.83%), followed by the oval shape (38.70%), then the long shape (6.45%).

Table 2. Variation in the qualitative variables studied

Phenotypic variables	Terms and conditions	Frequency (%)
The Inflorescence (IFL)	Absence of flowering	64.12
	Presence of flowering	35.87
Tuber Shape (TUS)	Round	52
	Oval	39
	Long	9
Colour of Tubers (COT)	Yellow	62.87
	Yellowish	18.93
	Light brown	11.36
	Dark brown	2.27
	Brun	4.54
Colour of the Leaf Blade (COL)	Light green	100
Colour of Inflorescence (COI)	Golden red	100

Fig. 1. Different tuber shapes identified, (a=round), (b=oval), (c=long

Fig. 2. Different colours of tubers identified, (A=light brown), (B=dark brown), (C=brown), (D=yellowish), (E=yellow)

The majority of the genotypes studied did not flower (64.12%), while 35.87% did flower. A comparison of the flowering of genotypes by country shows that 48.38% of genotypes in Burkina Faso flowered, compared with 57.14% in Mali and 66.66% in Togo. In terms of tuber colour (Fig. 2), the genotypes studied produced mainly yellow tubers (62.87%), followed by yellowish tubers (18.93%), light brown tubers (11.36%), brown tubers (4.54%) and dark brown tubers (2.27%). For genotypes from Togo and Mali, four and five tuber colours were identified, namely yellow tubers (55.73% and 66.98% respectively), light brown tubers (11.72% and 21.34% respectively), yellowish tubers (25.57% and 7.33% respectively), dark brown tubers (6.47% and 0.58% respectively), and brown tubers (0% and 3.20% respectively). For genotypes from Burkina Faso, five colours were recorded: yellow tubers (61.72%), yellowish tubers (20.92%), dark brown tubers (6.17%), light brown tubers (11.29%) and brown tubers (5.01%).

Description of the collection based on quantitative variables

The results of the descriptive and variance analyses showed differences ranging from significant ($p < 0.05$)

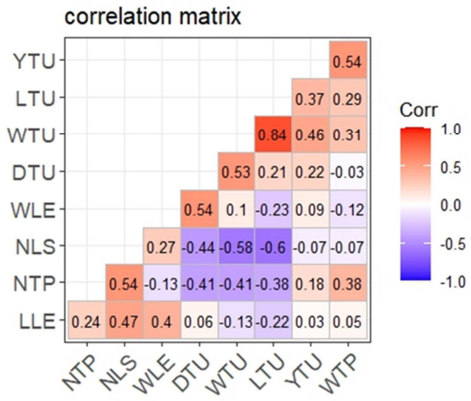
to highly significant ($p < 0.001$) between the genotypes for all the variables measured, with the exception of the variables (Table 3) length of leaf (LLE), height of plant (HTP) and number of leafy shoots (NLS). The number of leafy shoots (NLS) varied from 8 to 24.46. The number of tubers per plant (NTP) ranged from 27.77 to 132.5 tubers for all the genotypes studied. Length of tuber (LTU) ranged from 8.47 to 20.91 mm and diameter of tuber (DTU) from 8.72 to 13.7 mm. width of leaves (WLE) varied from 1.05 to 1.42 cm and length leaf (LLE) from 52.83 to 63.25 cm. Height of Plant (HTP) varied from 65.95 to 78.75 cm. The weight of 100 tubers (WTU) varied from 21.66 to 65g for all genotypes. The weight of tubers per plant (WTP) varied from 16.39 to 60.75g and the tuber yield from 0.37 to 2.44Tonnes per hectare. The coefficients of variation varied from 6.69% for length of leaf (LLE) to 37.55% for weight of tuber per plant (WTP). The variables weight of tubers per plant (WTP), number of tubers per plant (NTP) and yield of tubers per hectare (YTU) showed coefficients of variation greater than 30% (Table 3).

Table 3. Descriptive and variance analysis of quantitative variables

Variables	Min	Max	Avg	CV (%)	F- value	P-value
LLE	52.83	63.25	58.1	6.69	1.275	0.168NS
NLS	8	24.46	18.28	22.57	1.521	0.065NS
HTP	65.95	78.75	72.27	6.92	1.26	0.06NS
LTU	8.47	20.91	14.74	11.82	8.469	<0.0001***
DTU	8.72	13.7	11.65	8.15	3.604	<0.0001***
WTU	21.66	65	47.41	14.81	6.988	<0.0001***
WLE	1.05	1.42	1.23	7.18	2.569	<0.0001***
NTP	27.77	132.5	55.64	34.82	1.029	<0.0001***
WTP	16.39	60.75	29.21	32.72	5.17	<0.0001***
YTU	0.37	2.44	1.15	37.55	3.27	<0.0001***

Min : minimum ; Max : maximum ; Moy : moyenne ; CV% : coefficient de variation ; HTP (cm) : height of plant ; NLS : Number of leafy shoots, NTP : number of tubers per plant ; LLE (cm) : length of leaves ; WLE (cm) : width of leaves ; WTU (mm) : length of tubers ; DTU (mm) : diameter of tubers ; PTP (g) : weight of tubers per plant ; WTU (g) : weight of 100 tubers ; YTU(T/ha) : yield of tubers per hectare. *** very highly significant at the 5% level, ** highly significant at the 5% level, *: significant at the 5% level, % (percentage), NS (not significant).

Table 4. Results of variable correlation analysis



HTP (cm): height of plant, NLS: number of leafy shoots, NTP: number of tubers per plant, LLE (cm): length of leaf, WLE (cm): width of leaf, WTU (mm): length of tuber, DTU (mm): diameter of tuber, WTP (g): weight of tubers per plant, WTU (g): weight of 100 tubers, YTU (Tonnes/ha): yield of tuber per hectar

Relationships between the quantitative variables studied

The Pearson correlation matrix presented in Table 4 shows negative and positive correlations between the different quantitative variables. Length of leaf (LLE) is very strongly and positively correlated (r=0.82) with height of plant (HTP). The weight of tuber per plant (WTP) is moderately and positively correlated (r=0.54) with yield of tubers per hectare (YTU). Width of leaf (WLE) is moderately and positively correlated (r=0.54) with diameter of tuber (DTU). The weight of 100 tubers (WTU) are very strongly and positively correlated (r=0.84) with length of tuber (LTU), but moderately correlated (r=0.53) with diameter of tuber (DTU). On the other hand, the number of leafy shoots (NLS) was strongly and negatively correlated (r=-0.60, r= -0.58) with length of tuber (LTU) and weight of 100 tuber (WTU)

respectively, moderately and positively correlated (r=0.54) with the number of tubers per plant (NTP).

Association of quantitative variables

The first three axes with eigenvalues greater than 1 (2.70, 1.86 and 1.34 respectively) explain 84.25% of the total variability (Table 5). Axis 1 (Table 5, Fig. 3), which accounts for 38.50% of the variability, positively associates the variables diameter of tuber (DTU), weight of 100 tubers (WTU), length of tuber (LTU) and yield of tuber per hectare (YTU). Axis 2 (Table 5, Fig. 3), which accounts for 26.61% of total variability, positively associates the variables number of tubers per plant (NTP) and weight of tuber per plant (WTP). Axis 3 (Table 5, Fig. 3), which accounts for 19.13% of total variability, is positively associated with the width of leaf variable (WLE).

Table 5. Contribution of variables to the PCA dimension

Variables	Dim1	Dim2	Dim3
WLE	1.24	14.59	42.04
DTU	14.79	14.33	11.20
WTU	33.45	0.00	1.45
LTU	24.81	1.55	16.62
NTP	6.99	25.60	13.45
PTP	5.36	30.64	4.84
YTU	13.35	13.28	10.40
Eigen value	2.70	1.86	1.34
Percentage of variation (%)	38.50	26.61	19.13
Cumulative variation (%)	38.50	65.12	84.25

WLE (cm): width of leaves; LTU (mm): length of tubers; DTU (mm): diameter of tubers; WTU (g): weight of 100 tubers, NTP: number of tubers per plant, WTP (g): weight of tubers per plant, YTU (Tonnes/ha): yield per hectare, % (percentage), dim: size.

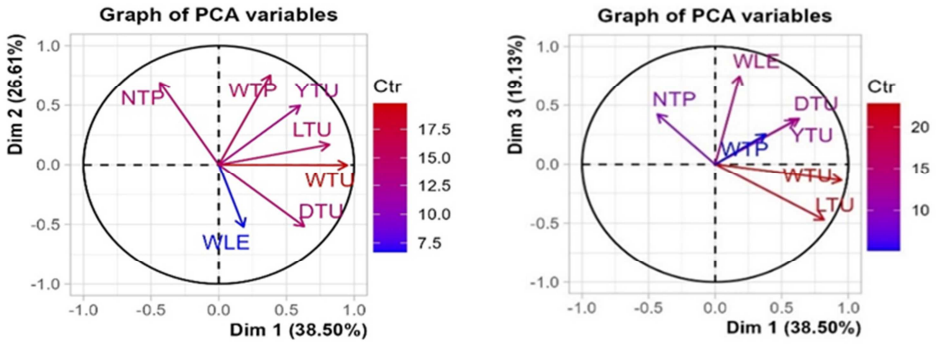


Fig. 3. Correlation circles for quantitative variables

Table 6. Characterisation of AHC groups

Variables	GI	GII	GIII	GIV	GV	F	P -value
WLE	1.18a	1.23a	1.26a	1.07b	1.21a	3.64	0.013*
NTP	29.19e	46.02d	61.78c	104.03a	86.13b	94.77	<0.0001***
YTU	1.02b	1.130b	1.07b	0.61b	2.21a	8.638	<0.0001***
LTU	17.105a	15.37a	13.60a	9.02b	17.79a	6.17	<0.0001***
DTU	11.88a	11.89a	11.62a	8.88b	11.79a	5.459	0.0013 **
WTU	58.75a	49.87ab	42.54a	22.67c	59.67a	11.56	<0.0001***

***: very highly significant at the 5% level ; **: highly significant at the 5% level ; *: significant at the 5% level ; NTP : number of tubers per plant, WTP (g) : weight of tubers per plant, YTU (Tonne/ha) : yield of tubers per hectare, LLE (cm) : width of leaves, LTU (mm) : length of tubers, DTU (mm) : diameter of tubers, WTU (g) : weight of 100 tubers, G : group, g : gram.

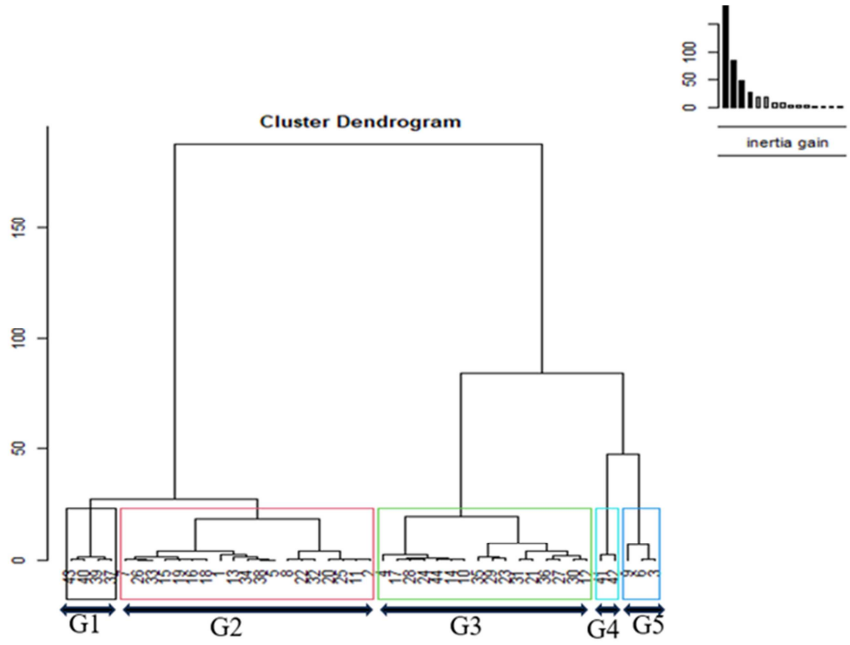


Fig. 4. Dendrogram resulting from the hierarchical ascending classification of the 44 genotypes based on the Euclidean distance using Ward's aggregation method

Structuring the diversity of the collection

The dendrogram resulting from the Ascending Classification Hierarchical (ACH) showed a grouping of genotypes into five classes independently of their provenance (Fig. 4). The average performance of the ACH groups is shown in Table 6. Group I is made up of 4 genotypes, 2 of which came from Mali and 2 from Togo. Group II is composed 19 genotypes from Burkina Faso. These two groups (I, II) included genotypes of average performance whose tubers were of average size respectively length of tuber = 17.10mm, diameter of tuber = 11.88mm and length of tuber = 15.37mm, diameter of tuber = 11.89mm. Group III is included 16 genotypes, including 9 from Burkina Faso, 4 from Mali and 3 from Togo. This group included genotypes with wider leaves (leaf width = 1.26 cm). Group IV consisted of 2 genotypes from Togo. This group is characterised by a large number of tubers per plant (NTP=104 tubers per plant), small calibre tubers (LTU=9.02mm, DTU= 8.88mm), tapered leaves (WLE=1cm) and a low weight of 100 tubers (WTU=22.67g). Group V included 3 genotypes from Burkina Faso. It was more characterised by genotypes with large tubers (length of tuber =17.79mm, diameter of tuber=11.79mm), a high 100 tuber weight (WTU= 59.67g) and a high tuber yield (YTU=2.21T/ha).

Discussion

Morphological characterisation of the collection of stump genotypes from Burkina Faso, Mali and Togo revealed variability in the genotypes studied. In fact, on the one hand, the qualitative variables observed, proved this variability. On the other hand, the descriptive and variance analyses of the quantitative variables showed differences ranging from significant ($p<0.05$) to highly significant ($p<0.001$). This variability could be explained by the farmers seed management and conservation methods. Farmers exchange seeds for the production of their crops. Previous studies by some authors have shown the exchange of plant material between producers, possible sources of seed mixing in the field and or on the market (Some *et al.,* 2014; Kiebre *et al.*, 2016; Asare *et al.,* 2020) as a source of variability in genotypes of different crops.

The variability of the genotypes concerned qualitative variables such as tuber shape, tuber colour and inflorescence. Thus the round, oval and long shapes of the tubers observed would be of genetic origin rather than to the effect of the environment. Similar results concerning the three tuber shapes were found by Pascual *et al.* (2000).

In addition, an morphological characterisation carried out in China in 2022 revealed these same tuber shapes on a sample of 42 genotypes from Mali, Ghana, Cameroon, China, Spain and Russia (Yang *et al.,* 2022). As for tuber colour, the yellow, yellowish, dark brown, light brown and brown tubers observed show variability between genotypes for this trait. Previous work by Ban-Koffi *et al.* (2009) revealed yellowish and blackish tubers. Bori *et al.* (2019) found light brown, dark brown, red and black tubers in their morphological characterisation study. In the study carried out by Yang *et al.* (2022) in China, out of 42 genotypes, only one genotype showed red tubers and the rest yellow tubers. As for Asare *et al.* (2020), two tuber colours, brown and black, were observed. The different tuber colours varied from one country to another. These results could be explained by the effect of the environment, as the structure of the soil could affect the colour of the tuber skin. Most of the genotypes (64.12%) evaluated did not produce flowers. According to Lorougnon (1969), out of 2259 plants of the West African variety of nutsedge that he tested, 96.54% of the plants did not flower. In the study by Yang *et al.* (2022) in China, 98% of the genotypes did not flower. This poor flowering of nutsedge favours vegetative propagation rather than sexual reproduction.

The positive and significant correlations between the number of leafy shoots and the variables number of tubers per plant and weight of tubers per plant showed that tuber productivity depends on the number of leafy shoots. In fact, genotypes that produce more large-diameter (robust) leafy shoots produce more large-calibre tubers, and therefore higher yields. Tubers are formed at the apex of the rhizomes of each leafy shoot by the accumulation of nutrient reserves. The work of Dodet (2006) showed a strong exponential relationship between the number of tubers formed and the number of leafy shoots. Also, according to Yang *et al.* (2022), high-yielding Tiger Nuts genotypes tend to have a higher number of tillers. For Quero-García *et al.* (2006), the number of leafy shoots is a variable with high heritability. It could therefore be used as a selection criterion for yield in varietal improvement programmes.

Ascending classification Hierarchical enabled us to classify the 44 genotypes into five distinct groups, irrespective of their origin. This could be explained by the trade in Tiger Nuts between these three countries (Burkina Faso, Togo and Mali). This hypothesis has already been pointed out by Garba (2007). In addition, genotypes from Burkina Faso were distributed among the five groups independently of their area of origin. This distribution of genotypes could explain the exchange of seeds between growers in the different collection zones in Burkina Faso (Kenedougou, Comoe, Bougouriba, Poni). The groups are made up of genotypes differentiated by leaf width, tuber length, tuber diameter, weight of 100 tubers, number of tubers per plant and tuber yield. These variables made it possible to distinguish the Tiger Nutsedge group (GI and GII) with medium-sized tubers (oval shape) and average tuber yield. The Nutsedge group (GIII), which was distinguished by the width of its leaves and round tubers, could be used in breeding programmes for Nutsedge varieties with high leaf yield. The Tiger Nutsedge group (GIV) has small, round tubers and tapering leaves. This group could be exploited in the form of croquettes for human consumption. The Tiger Nuts (GV) group, with better tuber yields and larger tubers, could be exploited for Tiger Nuts breeding programmes. This structuring of morphological diversity could make it possible to choose multiple genitors in Tiger Nuts breeding programmes.

Conclusion

Morphological characterisation using agrmorphological markers revealed diversity with in the strain genotypes étudie. This genetic variability observed between genotypes would be an asset for selection work. The 10 morphological descriptors (tuber shape, tuber colour, presence or absence of flowering, leaf width, weight of 100 tubers, tuber length, tuber diameter, number of tubers per plant, tuber weight per plant and tuber yield) will be useful for future studies of Yellow Nutsedge.

The positive correlations between leafy shoots and the number of tubers per plant will be very important in Tiger Nuts breeding programmes. The structuring of genetic diversity and the average performance of the groups observed could make it possible to select several sources of breeding stock for Tiger Nuts improvement. The Tiger Nuts (GV) group, with its large tubers and good yield, could be used as a source of broodstock in a programme to improve Tiger Nuts yield. The broad-leaf Tiger Nuts (GIII) group could be exploited to improve haulm yield. On the other hand, the Tiger Nuts group (GIV), with its small, round tubers, could be used as Tiger Nuts for human consumption.

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