International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 67 No. 2 Jul. 2023, pp. 202-212

http://www.ijisr.issr-journals.org/

Selection and agronomic variability of twenty-nine accessions for the yield of bambara groundnut [*Vigna subterranea* (L.) Verdcourt] cultivated in the Far West of Niger

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ABSTRACT: Bambara groundnut is a food legume grown mainly by women. In Niger, this plant is mainly cultivated without improved techniques, while improving the production of this crop can contribute to ensuring food security. The objective of this work is to characterize twenty-nine accessions of Bambara groundnut cultivated in the Far West region of Niger to evaluate their agro-morphological diversity and selected the best accessions for yield. The study was carried out according to a randomized complete block design with four replications. Sixteen (16) characters, including four (4) phenological, four (4) morphological, and eight (8) related to yield, were evaluated to characterize the accessions. Descriptive statistical analysis showed coefficients of variation fluctuating between 2.80% and 40.46%. Significantly high values (CV>20%) were observed for 8 of the 16 metric traits analyzed. The strongest correlations reflecting a high variability of the characters within the studied collection are obtained between the number of petioles and the number of leaves (r=0.99), the weight of seeds and the yield (r=0.99), pod weight and seed weight (r=0.97), pod weight and yield (r=0.97).The results revealed a great morphological diversity of the vegetative and yield characters allowing to group the accessions in three (3) groups of which the first one is composed of accessions performing in the characters related to the yield, the second one is composed of accessions performing in yield and seeds, and the third one gathers the accessions having similar phenological characters. Accessions Do 024 (782.60 kg/ha), Do 001 (732.51 kg/ha), Do 013 (688.33 kg/ha), and Do 016 (685.84 kg/ha), Do 019 (646, 02 kg/ha), Do 011 (623.16 kg/ha), Do 007 (623.00kg/ha), Do 036 (621.60 kg/ha) and Do 003 (605.42 kg/ha) produced the highest yields in kg/ha.

KEYWORDS: *Vigna subterranea* L., Diversity, Accessions, Yield, Dosso, Niger.

1 INTRODUCTION

In 1992, Wilson [1] estimated that 7000 plant species are harvested for food worldwide. Major crops have significant global land cover, well-developed marketing systems, and market research, and receive maximum research attention, while underutilized crops lack such support systems [2]. These underutilized crops rely only on fragmentary knowledge and often on qualitative local evidence from growers rather than multi-location research covering the entire supply chain. Bambara groundnut or Bambara pea, one of the underutilized crops, is generally highly valued in countries where it is traditionally grown, especially in sub-Saharan Africa [3]. It is a plant that produces average yields ranging from 350 to 800 kg/ha in regions where the soil is poor and the rainfall low [4]. According to Azam-Ali *et al*., [5] Yields can, reach 3000 to 3500 kg/ha under controlled

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conditions with the use of fertilizers. Recent work has shown in this variety the existence of significant variability at the morphological, agronomic, and molecular level [6; 7; 8; 9; 10]. According to Baudoin [11], this genetic diversity has been accumulated under the effect of natural and human selection and is therefore very poorly exploited in the management of available resources. Several accessions collected in different regions of Niger have contrasting characters [12]. Unfortunately, very little information is currently available on the genetic and agro-physiological diversity of this species which, however, should be taken into account in the design of genetic and agronomic selection programs in the country and the West African sub-region [7]. The creation of varieties involves the use of plant material with wide genetic variability. This study aims to assess the agronomic variability of accessions collected in the southern region of Niger through the analysis of their phenological, morphological, and agronomic characteristics.

2 MATERIAL AND METHODS

2.1 MATERIAL

The plant material is composed of seeds from 29 Bambara groundnut accessions from the Dosso region (Table 1), which were obtained from the Department of Biology of the Faculty of Science and Technology (FAST) of the Abdou Moumouni University of Niamey as part of the collection carried out throughout the country of Niger from 2012 to 2013 [12].

Table 1. List of accessions and municipalities covered by the study in the Dosso region of Niger

N°	Accessions	Communes	N°	Accessions	Communes
1	Do 001	Yellou	16	Do 019	Dosso
2	Do 002	Dosso	17	Do 022	Yellou
3	Do 003	Tibiri	18	Do 023	Dosso
4	Do 004	Yellou	19	Do 024	Yellou
5	Do 006	Gaya	20	Do 025	Kara-Kara
6	Do 007	Kara-Kara	21	Do 029	Zabori
7	Do 008	Yellou	22	Do 030	Kassari
8	Do 009	Yellou	23	Do 031	Yellou
9	Do 011	Fakara	24	Do 035	Yellou
10	Do 013	Tibiri	25	Do 036	Yellou
11	Do 014	Dosso	26	Do 037	Yellou
12	Do 015	Dosso	27	Do 038	Zabori
13	Do 016	Boboye	28	Do 040	Tibiri
14	Do 017	Dosso	29	Do 041	Kassari
15	Do 017	Dosso			

2.2 METHODS

The experiment was conducted during the 2021 rainy season at the research station of the of the Radio-Isotopes Institute (IRI), which is located on the right side of the Niger River, precisely on the campus of Abdou Moumouni University (UAM) at (13°29 north latitude and 2°10 east longitude). The terrain is deep, little evolved, ferruginous tropical soil on poorly leached dune sand. The superficial horizon (0 and 50cm) is characterized by a strong dominance of sand (96%) with only 0.16% organic matter and a very low cation exchange capacity (1.3mèq/100g of soil). The assimilable phosphorus content of the surface horizon is 3ppm (Bray Method1); the fixing power i being low (r/R 0.4). The pH is slightly acidic with a low water retention capacity (8 to 11.2cm3/100cm3). During this study, the rainfall in the area was a total of 512.5 mm thirty-eight (38) rainy days.

The experimental design consisted of 4 blocks of 13.75m^2 (5.5mx2.5m) spaced 1m apart. In a block there are 3 plots of 3.75 m^2 (2.5mx1.5m) containing at least 9 lines of accessions. The seeds are sown in pure culture on fallow land in July 2021. They are buried in the ground 2 cm deep with a spacing of 0.25m in plots spaced 0.5m apart. Two seeds per accession are sown 7 times on the same line (only one will be left after germination and out of the ground). Each accession is thus represented by 28 plants.

2.3 DATA COLLECTION

Data collection was carried out following the indications given in the list of the Bambara groundnut descriptors [13]. Nineteen (19) agro-morphological parameters from this list were selected. These are three (3) qualitative parameters, four (4) phenological parameters, four (4) morphological parameters and eight (8) yield and yield-related parameters (Table 2).

Table 2. Quantitative variables used for the evaluation of local races of Bambara groundnut (Vigna subterranea (L.) Verdc.)

Traits	Codes	Descriptions	Units
Qualitative traits			
1.Seed coat color		Recorded in two months after harvest	
2.Eye shape		Recorded in two months after harvest	
3.eye color		Recorded in two months after harvest	
Phenological traits			
4. Days to emergence	**DE**	The number of days from planting to the arrival of 1st typical leaf on the soil surface.	DAS
5. Days to flowering	**DF**	This parameter corresponds to the number of days elapsed between sowing and the appearance of the first flower.	DAS
6. Days to 50% flowering	**50F**	Taken from seed germination to the arrival of 50% flowering (s)	DAS
7. Days to maturity	**DM**	Days number from sowing to initial time of harvest	DAS
Quantitative traits			
8. Plant height	**PH**	Measured from ground level (at the base of the plant) to the tip of the highest point, terminal leaflet included. Recorded 10 weeks after planting; average height of five plants.	Cm
9. Number of stems	**NS**	Recorded after harvest; average number of three stems of five healthy plants.	
10. Number of petioles per plant	**NP**	Data counted 2 weeks later of 1st flowering, randomly from five healthy plants.	
11. Number of leaves	**NL**	Data counted 2 weeks later of 1st flowering, the average number of 5 plants.	
Yield and components traits			
12. Number of pods per plant	**NPP**	The number of individual pods of the 5 central plants after drying was used for the parametric measurements.	-
13. Biomass dry weight weight per plant	**BDW**	Weight of dried plant, recorded after maintaining the harvested plant dried in sun.	g
14. Hundred seed weight	**HSW**	Observed within two months after harvest (with 12% moisture content).	g
15. Dry pod weight	**DPW**	Data measured after drying of pods (12% moisture).	g
16. Shell weight	**SW**	Data measured within two months of harvest.	g
17. Number of seeds per plant	**NSP**	Data counted after dehusking all pods, randomly average values from 5 plants.	
18. Seed weight	**SWe**	Data measured after drying of seeds (12% moisture).	g
19. Yield	**YLD**	Data weighted of dried pods (at 12% moisture content) per plot, lastly converted the plot yield to a kilogram per hectare (kg/ha).	

2.4 STATISTICAL ANALYSIS

R 4.0.4 software was used to test for significant differences through the analysis of variance (ANOVA) procedure at the LSD level ($P \leq 0.05$) and to compare the mean values of the studied traits. Correlations between quantitative variables were determined using Pearson's correlation coefficient formula. The same R software was also used to perform principal

component analysis (PCA) and ascending hierarchical classification (CHA); which made it possible to assess the degree of resemblance and dissimilarity between the characters analyzed.

3 RESULTS

3.1 QUALITATIVE TRAITS

The shape and color of the eye and the coloring of the coat are very diversified as indicated by the morphological observations in table 2. We observed cream-colored integuments (with dotted lines: brown, red, black; mottling: brown, red, black), black, red (with black dots); black or brown butterfly-shaped eyes and eyes without shapes or colors (Table 3).

Fig. 1. different types of seeds

Table 3. Qualitative characteristics of the 29 Bambara groundnut accessions studied

Accessions	Seed coat color	Eye shape	Eye color
Do 001	Cream, dotted brown	Butterfly	Black
Do 002	Red dotted cream	Butterfly	Brown
Do 003	Cream	Butterfly	Black
Do 004	Cream	Absence	Absence
Do 006	Red marbling cream	Butterfly	Black
Do 007	Cream	Absence	Absence
Do 008	Cream, dotted red	Butterfly	Black
Do 009	Cream	Butterfly	Brown
Do 011	Black	Absence	Absence
Do 013	Red dotted black	Absence	Absence
Do 014	Black	Absence	Absence
Do 015	Cream, brown marbling	Butterfly	Brown
Do 016	Dotted cream red, marbling black	Butterfly	Black
Do 017	Red dotted cream	Butterfly	Brown
Do 018	Cream	Butterfly	Brown
Do 019	Cream, dotted red	Butterfly	Black
Do 022	Cream	Butterfly	Black
Do 023	Red marbling cream	Butterfly	Black
Do 024	Cream, dotted red	Butterfly	Brown
Do 025	Cream, dotted brown	Butterfly	Brown
Do 029	Cream, dotted red	Butterfly	Brown
Do 030	Red marbling cream	Butterfly	Black
Do 031	Black marbling cream	Butterfly	Brown
Do 035	Red	Absence	Absence
Do 036	Red marbling cream	Butterfly	Black
Do 037	Cream	Absence	Absence
Do 038	Cream	Butterfly	Brown
Do 040	Red marbling cream	Butterfly	Black
Do 041	Dotted cream brown	Butterfly	Brown

3.2 QUANTITATIVE TRAITS

The descriptive statistical analyses (Table 4) indicate significant differences between the minima and maxima. The results showed that the date of emergence varies between 6 and 8 days after sowing (DAS). The time taken for the emergence of the seedlings was 7 DAS (Day After Sowing), versus 32 DAS for the start of flowering, and 34 DAS for 50% flowering. The coefficients of variation range from 2.80% (maturity date) to 40.46% (weight of dry biomass). Significantly high values (CV>20%) for 8 (number of pods per plant, weight of dry biomass, number of seeds, the weight of seeds, the weight of hulls, the weight of pods, yield in kg/ha and the weight of 100 seeds) of the 16 metric characters analyzed were highlighted.

Table 4. Descriptive statistics of the morphological traits measured on the Bambara groundnut accessions

	Median	Min	Mean	Max	SD	Var	CV (%)
NP	39,80	25,75	39,62	52,53	6,12	37,44	15,45
NL	118,95	77,25	119,59	157,59	18,01	324,35	15,10
PH (cm)	20,15	11,25	20,28	24,75	2,80	7,87	13,80
NSP	26,04	10,70	24,35	38,85	6,28	39,48	25,79
NS	9,05	6,78	9,14	12,55	1,53	2,33	16,74
BDW (g)	8,34	3,78	9,17	19,65	3,71	13,73	40,46
TNP	20,72	10,42	20,54	31,55	5,78	33,44	28,14
DSW (g)	8,83	4,01	8,57	12,57	1,94	3,78	22,64
SeW (g)	2,44	1,47	2,67	5,24	0,81	0,65	30,34
DPW (g)	11,31	6,30	11,23	17,02	2,53	6,39	22,53
YLD (kg/ha)	529,8	249,8	532,4	782,6	120,90	14617,96	22,71
HSWe (g)	159,02	90,31	173,24	322,79	47,44	2251,01	27,38
DTM (d)	84,50	80,75	84,81	89,50	2,37	5,64	2,80
DE (d)	7,00	6,25	7,15	7,75	0,33	0,11	4,61
DF (d)	32,35	30,00	32,36	35,00	1,29	1,67	3,98
D50%F (d)	33,25	31,00	33,53	37,50	1,75	3,06	5,22

Legend: Max: maximum; Min: minimum; CV: coefficient of variation, Var: Variance, SD: standard deviation, DTE: days to emergence, DF: days to flowering, D50%F: days to 50% flowering, DTM: days to maturity, PH: plant height, NS: number of stems per plant, NP: number of petioles per plant, NL: number of leaves per plant, BDW: biomass dry weight per plant, TNP: total no. of pods per plant, DPW: dry pods weight, NSP: number of seeds per plant, DSW: dry seed weight per plant, HSWe: hundred seed weight, YLD: yield, SeW: shell weight, d: day.

3.3 AGRO-MORPHOLOGICAL DIVERSITY OF BAMBARA GROUNDNUT ACCESSIONS

The characters so studied were grouped into principal components (PC). The first three (3) components: CP1, CP2 and CP3, explain nearly 68.58% of the total variability observed in each component 37.18%, 18.20% and 13.20%, respectively (Table 5).

Table 5. Eigenvalues and contribution of variables (parameters) to PCA axes

Axes	Eigen values	Proportions (%)	Cumulative percentages (%)
1	5,95	37,18	37,18
2	2,91	18,20	55,38
3	2,11	13,20	**68,58**

Table 6 indicates the lists of characters responsible for these variabilities. The main component 1 (CP1) is represented by the number of petioles per plant, the number of leaves per plant, the number of stems per plant, the weight of dry biomass, the number of pods, the number of seeds, the weight number of pods, seed weight and yield (kg/ha). Principal component 2 (CP2) is represented by the flowering date and 100-seed weight and CP3 by the maturity date, flowering date, and 50% flowering date. The principal component 1 (CP1) can intervene in a choice for a selection based on parameters related to the yield.

Table 6. Correlations between the starting variables (parameters) and each of the first two principal components

	Dim1	Dim2	Dim3
	0.738	0.463	-0.173
NP	**0.750**	0.435	-0.198
NL	0.242	0.471	0.371
PH (cm)	**0.794**	-0.099	-0.269
TNP	**0.826**	0.341	-0.149
NS	**0.545**	0.348	-0.173
BDW (g)	**0.759**	-0.019	-0.303
NSP	**0.704**	**-0.693**	0.062
DSW (g)	**0.761**	-0.155	0.404
SeW (g)	**0.791**	**-0.578**	0.164
DPW (g)	**0.711**	**-0.686**	0.046
YLD (kg/ha)	-0.219	**-0.610**	0.461
HSWe (g)	-0.121	0.091	**0.606**
DTM (d)	-0.206	0.041	-0.026
DE (d)	0.323	**0.543**	**0.691**
DF (d)	0.428	0.233	**0.658**

Legend: Max: maximum; Min: minimum; CV: coefficient of variation, Var: Variance, SD: standard deviation, DTE: days to emergence, DF: days to flowering, D50%F: days to 50% flowering, DTM: days to maturity, PH: plant height, NS: number of stems per plant, NP: number of petioles per plant, NL: number of leaves per plant, BDW: biomass dry weight per plant, TNP: total no. of pods per plant, DPW: dry pods weight, NSP: number of seeds per plant, DSW: dry seed weight per plant, HSWe: hundred seed weight, YLD: yield, SeW: shell weight, d: day.

3.4 CLUSTER ANALYSIS

The hierarchical ascending classification (HAC) by the method Unweighted Pair-Group Method with Arithmetic mean (UPGMA) made it possible to group the accessions into three groups according to the degree of similarity of the characters. Group 1 (G1) is made up of 44.82% accessions (Do 006, Do 007, Do 009, Do 029, Do 038, Do 019, Do 036, Do 003, Do 011, Do 013, Do 016, Do 001, Do 024), group 2 (G2) by 13.79% accessions (Do 025, Do 035, Do 023, Do 040) and group 3 (G3) by 41.38% accessions (Do 004, Do 031, Do 017, Do 037, Do 002, Do 015, Do 014, Do 022, Do 008, Do 018, Do 030, Do 041). The characteristics of the groups are shown in Table 6. Group 1 consists of accessions with the highest average number of pods per plant (26.58) and the highest average yield (635.67 kg/ha). Group 2 contains less efficient accessions in terms of yield-related parameters, on the other hand, they have the highest seedlings.

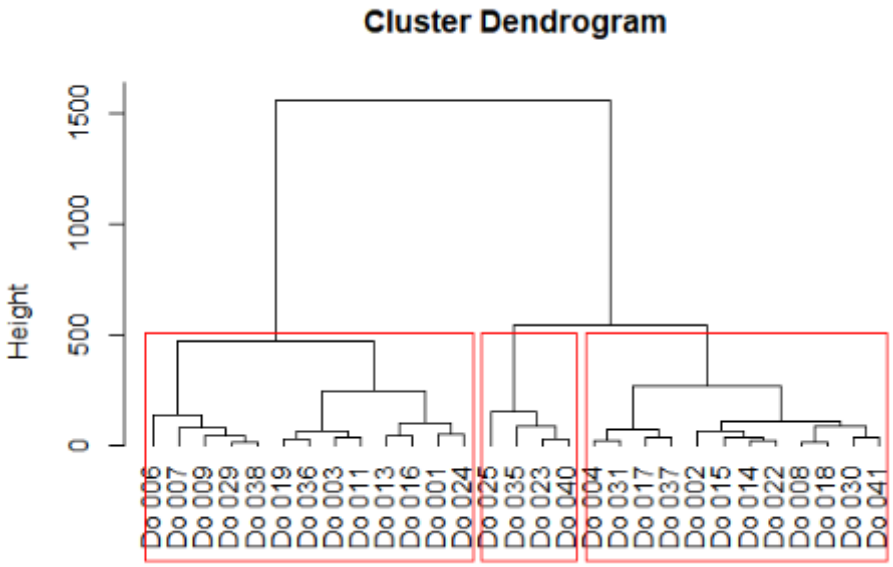

Fig. 2. Dendrogram from the CAH of Bambara groundnut accessions

Accessions Do 024 (782.60 kg/ha), Do 001 (732.51 kg/ha), Do 013 (688.33 kg/ha) and Do 016 (685.84 kg/ha), Do 019 (646.02 kg/ha), Do 011 (623.16 kg/ha), Do 007 (623.00 kg/ha), Do 036 (621.60 kg/ha), Do 003 (605.42 kg/ha), Do 009 (597.80 kg/ha), Do 032 (572.29 kg/ha)), Do 019 (557.67 kg/ha), Do 004 (550.04 kg/ha), Do 019 (549.42 kg/ha) produced a yield in kg/ha higher than the average total yield (532.44 kg/ha).

Table 7. List of accession groups

	G1 (44,82%)	G2 (13,79%)	G3 (41,38%)
NP	39,91	35,98	40,53
NL	121,37	107,94	121,54
PH (cm)	19,75	21,21	20,54
NSP	26,58	19,01	23,73
NS	9,32	8,31	9,23
BDW (g)	9,11	7,54	9,79
TNP	21,46	17,06	20,70
DSW (g)	10,24	5,43	7,80
SeW (g)	3,14	1,91	2,42
DPW (g)	13,36	7,32	10,22
YLD (kg/ha)	8263,73	1352,09	5825,09
HSWe (g)	202,22	135,83	154,31
DTM (d)	84,44	85,31	85,04
DE (d)	7,17	7,13	7,15
DF (d)	32,27	32,25	32,50
D50%F (d)	33,85	33,31	33,27

Legend: Max: maximum; Min: minimum; CV: coefficient of variation, Var: Variance, SD: standard deviation, DTE: days to emergence, DF: days to flowering, D50%F: days to 50% flowering, DTM: days to maturity, PH: plant height, NS: number of stems per plant, NP: number of petioles per plant, NL: number of leaves per plant, BDW: biomass dry weight per plant, TNP: total no. of pods per plant, DPW: dry pods weight, NSP number of seeds per plant, DSW: dry seed weight per plant, HSWe: hundred seed weight, YLD: yield, SeW: shell weight, d: day.

3.5 CORRELATION BETWEEN PARAMETERS

To establish a possible correlation between the 16 quantitative parameters measured, a Pearson correlation matrix was produced (table 8). Strong positive correlations are observed between: the number of pods per plant with the number of leaves per plant (r=0.56), the number of stems per plant (r=0.64), the weight of pods per plant (r=0.61), the weight of seeds (r=0.60), the number of petioles per plant (r=0.54), the number of seeds (r=0.68) and with the yield in kg /ha (0.61); the number of petioles per plant with the number of leaves per plant (r=0.99), the number of stems per plant (r=0.77), the weight of dry biomass (r=0.53) and the weight seeds (r=0.64); the weight of dry biomass with the number of leaves per plant (r=0.53) and the number of stems per plant (r=0.59); the weight of pods per plant with the number of seeds per plant (r=0.56), the weight of shells (r=0.79), the weight of seeds per plant (r=0.97) and the yield in kg/ha (r=0.97); the weight of seeds with the number of seeds per plant (r=0.55), the weight of shells (r=0.62) and the yield in kg/ha (r=0.99); the yield in kg/ha with the number of seeds (r=0.56) and the weight of shells (r=0.62); the date of 50% flowering with the flowering date (r=0.76). A negative correlation was obtained between the weight of 100 seeds and the number of seeds (r=-0.60).

Table 8. Interrelation between the studied Bambara groundnut characters (Pearson Correlation Matrix)

	DF	DTM	PH	NL	TNP	NSP	NP	NS	DSW	BDW	SeW	DPW	DSW	YLD	DTE	D50 %F
DF	1															
DTM	0.31	1														
PH	0.44	0.35	1													
NL	0.36	-0.21	0.18	1												
TNP	-0.02	-0.17	0.25	**0.56**	1											
NSP	0.003	-0.07	0.15	0.47	**0.68**	1										
NP	0.39	-0.17	0.18	**0.99**	**0.54**	0.46	1									
NS	0.33	-0.06	0.27	**0.77**	**0.64**	**0.64**	**0.77**	1								
DSW	-0.06	0.08	-0.24	-0.33	-0.21	**-0.60**	-0.34	-0.44	1							
BDW	0.28	-0.32	0.18	**0.53**	0.36	0.26	**0.53**	**0.59**	-0.24	1						
SeW	0.44	0.03	0.24	0.41	0.42	0.39	0.41	0.48	0.12	0.41	1					
DPW	0.06	-0.06	-0.01	0.30	**0.61**	**0.56**	0.28	0.43	0.24	0.23	**0.79**	1				
DSW	-0.09	-0.08	-0.12	0.21	**0.60**	**0.55**	0.18	0.35	0.28	0.12	**0.62**	**0.97**	1			
YLD	-0.10	-0.09	-0.11	0.22	**0.61**	**0.56**	0.19	0.35	0.26	0.13	**0.62**	**0.97**	**0.99**	1		
DTE	0.06	-0.16	-0.07	-0.11	-0.22	-0.37	-0.09	-0.01	0.19	0.15	-0.11	-0.13	-0.13	-0.13	1	
D50%F	**0.76**	0.13	0.27	0.26	0.10	0.16	0.28	0.30	0.007	0.15	0.48	0.28	0.18	0.17	-0.22	1

Legend: Max: maximum; Min: minimum; CV: coefficient of variation, Var: Variance, SD: standard deviation, DTE: days to emergence, DF: days to flowering, D50%F: days to 50% flowering, DTM: days to maturity, PH: plant height, NS: number of stems per plant, NP: number of petioles per plant, NL: number of leaves per plant, BDW: biomass dry weight per plant, TNP: total no. of pods per plant, DPW: dry pods weight, NSP: number of seeds per plant, DSW: dry seed weight per plant, HSWe: hundred seed weight, YLD: yield, SeW: shell weight, d: day

4 DISCUSSION

The study highlighted the variability that exists within 29 accessions of Vigna subterranea grown in the Dosso region of Niger. The accessions are characterized by a diversity of color of the integuments and eyes. Gbaguidi *et al.,* [14] also concluded that there was significant color diversity between Bambara groundnut seeds in similar work. Wassouo *et al*., [8], believe that this difference in coloration is linked to biological factors. In addition, Brink *et al*., [15] reported that seed coloring is one of the traits that enters into the indication of the choice of varieties by farmers. The seed coats are all smooth, and a complete absence of roughness has been observed, reported by Mahmudul *et al*., [16].

The descriptive analysis of the studied traits showed that the emergence time varies between 6 and 8 DAS, which is in accordance with the results of Djé *et al*., [17] and Ibrahim *et al*., [10] who have obtained the same emergence interval. Mahmudul *et al*., [9] obtained an interval between 5 and 13 DAS. Karikari [18] observed higher values (14 to 24 DAS). For Wassouo *et al*., [8], these variations are explained by the genotype of each plant material, environmental conditions, and seed storage conditions.

The significant gaps observed between minima and maxima confirm the results of Harouna *et al*., [7] who found significant gaps between minima and maxima, working on 14 Bambara groundnut morphotypes in Niger. The coefficients of variation vary from 2,80% (maturity date) to 40,46% (dry biomass weight). Sévérin and Yao *et al*., [19] obtained coefficients of variation between 0% and 63.30%, Harouna *et al*., [7] between 10.3% and 72%, Moussa [20] between 4, 16% and 72.51%, Mahmudul *et al*., [16] between 13.17% and 41.21%. This indicates the presence of strong heterogeneity within local voandzou accessions as clearly demonstrated by Harouna *et al*., [7], Wassouo *et al*., [8], Mahmudul *et al*., [9] and Ibrahim *et al*., [10]. Eight yield-related parameters (number of pods per plant, the weight of dry biomass, number of seeds, the weight of seeds, the weight of shells, weight of pods, yield in kg/ha, and hundred seed weight) showed coefficients of variation high (CV>20%). Ibrahim *et al*., [10] obtained high coefficients of variation with yield-related parameters. In 1998, Swanevelder [21] reported that yield in *Vigna subteranea* is very unstable.

According to Mohammed [22] and Mahmudul *et al*., [9] in plant breeding, a correlation matrix is an important approach for judging the degree of association between two or more variables. Adebisi *et al*., [23] even think that for a genotype selection program, taking into account the correlation matrix can be a large measurement scale. In this present work, the analysis of the matrix revealed the presence of strong correlations. The strongest correlations are obtained between the number of petioles per plant and the number of leaves per plant (r=0,99), the weight of seeds and the yield in kg/ha (r=0,99), the weight of pods per plant and seed weight per plant (r=0,97), pod weight per plant and yield in kg/ha (r=0,97), pod weight per plant and husk weight (r=0,79), the number of petioles per plant and the number of stems per plant (r=0,77). These results are close to those obtained by Harouna *et al*., [7], who had a strong correlation between the weight of seeds per plant and the weight of pods (r=0,96). Wassouo *et al*., [8] also obtained a strong correlation between seed weight and the number of pods (r=0,94). This reveals the interrelationship between performance and certain components; this is all the more so since the weight of seeds would logically be correlated with the weight of pods [8]. In 2008, Ouedrago *et al*., [24] reported that traits such as the number of pods per plant, number of seeds per plant, and hundred seed weight are positively correlated with yield in Bambara groundnut.

The principal component analysis confirmed this significant morphological variability. The high representativeness of the first three PCA axes (68.58%) shows the existence of a strong genotypic and phenotypic organization of the material studied. The ascending hierarchical classification highlighted three groups of diversity. According to Sévérin and Yao *et al*. [19] these morphological and phenological dissimilarities observed between the different groups of phenotypic diversity suggest that the accessions are maintained under very different evolutionary processes in their respective agroecosystem. Indeed, the mode of management of seeds by farmers such as selective sorting, recycling of seeds by cultivation and agricultural practices leads to a selection leading to the maintenance, even the creation of a significant phenotypic diversity [25]. This constant evolution influenced by soil, climatic, and anthropogenic factors in the different agroecosystems gives the accessions their own characteristics [5].

5 CONCLUSION

The study of the agronomic diversity made it possible to observe a significant variability between the accessions of Bambara groundnut cultivated in the western zone of Niger. This observed variability, for agronomic, morphological and phenological characteristics, could contribute to the genetic improvement of this species for better productivity and adaptation to local climatic conditions. The 29 accessions are organized into three (3) distinct morphological groups. Group 1 is made up of accessions that perform well in parameters related to yield, group 2 of accessions that have the longest heights, and group three which is represented by phenological parameters. In short, this exponentiation can be of an important contribution to a better valorization of the genetic resources of the Bambara groundnut in the programs of selection.

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