

ETHNOBOTANICAL AND AGROMORPHOLOGICAL ASSESSMENT OF PEARL MILLET [*Pennisetum glaucum* (L.) R. Br.] ACCESSION FROM SOUTH OF CHAD

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ABSTRACT

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important staple cereals in the semiarid tropics, adapted to very harsh rain-fed conditions. The present study was conducted in South of Chad in two Province where twelve pearl millet accessions were collected and assessed in Bébédjia (9°55'N and 15°8'E) during the rainy season of 2017 to evaluate the genetic diversity. Farmers traditionally used the spike shape, accession's origin and animal name to classify name of pearl millet accession. Qualitative evaluation showed that pearl millet landraces had dominance of cylindrical-shape and threshing with the touch spike, hexagonal shape and grey colored seed with the endosperm mostly corneous. All traits assessed except total tiller per plant revealed high significant difference ($p < 0.001$) between twelve landraces. Heritability was high for all traits with high genetic advance of percentage of mean was observed for all traits except total tillers, plant height, days to flowering and thousand grain weight suggesting that these traits are governed by additive gene action and possibility of improving these traits through selection. Positive correlation of grain weight with number of days to flowering indicates that indirect selection of simply inherited agronomic traits can assist in effective selection for grain yield.

Keywords: Pearl millet, diversity, taxonomy, germplasm, genetic advance, Chad.

1. INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is thought to have originated from the Sahel region in Africa (Hannaway and Larson, 2004). The earliest evidence of domesticated pearl millet has been found in the Lower Tilmesi Valley in northeastern Mali, where the cereal was cultivated already 4500 years ago (Manning *et al.*, 2011). It is particularly adapted to nutrient poor soil and low rainfall conditions, yet it is capable of rapid and vigorous growth under favorable conditions (Maiti and Bidinger, 1981). Pearl millet's deep root system grows relatively fast (Hannaway and Larson, 2004), and can scavenge residual nutrients. It is a good choice for low-input sustainable agricultural systems. Pearl millet is cross-pollinated, with flowers opening on the inflorescent spike from the top down.

Pearl millet has been used as a food crop for thousands of years in a variety of food products and continues to be used as a staple grain by approximately 90 million people in Africa and India (Gulia *et al.*, 2007). In the Sahel, today, more than 38 million people depend on the pearl millet

which provides them more than 1000 calories per day (Chittaranjan, 2006; Vadez *et al.*, 2012). It is also rich in vitamin B-complex, potassium, phosphorus, magnesium, iron, zinc, copper and manganese (Nambiar *et al.* 2011). In Chad, pearl millet is one of the most important staple cereals for the millions inhabiting. It grown in 1.23 million hectares with a production of 774,498 tones grains per year and occupies about 37% of total area planted under cereals, and accounts for about 27% of total cereals production in Chad (DSA, 2018). Despite its importance in the daily food supply of populations of Chad, very little studies were carried out to assess the genetic diversity of pearl millet cultivated by Chadian farmers.

The average productivity of pearl millet in Chad for the ten last years has been 525.44 kg.ha⁻¹ for a maximum productivity of 636.51 kg.ha⁻¹ (DSA, 2018). In other countries like India, average productivity of pearl millet was 930 kg.ha⁻¹ (AICPMIP, 2017). Some studies in India showed that a hybrid variety of pearl millet produced 1270 kg.ha⁻¹ (Gupta *et al.*, 2015). The low production of pearl millet in Chad leads to the need of developing varieties with stable production irrespective of growing place and time under stress conditions.

Genetic variation among landraces for existent germplasm is of vital importance to breeding programs that aim to produce improved landrace-based cultivars for marginal growing environments (Yadav *et al.*, 2001). Genetic variability studies provide basic information regarding the genetic properties of the population based on which breeding methods are formulated for further improvement of the crop. The progress of selection is more important in any crop improvement and this progress is depends on the existence of genetic variability for yield and yield contributing characters and their heritability (Allard, 2000).

Unfortunately, there is no national collection of pearl millet landraces from Chad and moreover, very little information is available on the diversity of cultivated pearl millet accessions in the country. The objectives of this research were to study the nomenclature of collected cultivars from two regions of Chad and to assess the phenotypic and agronomical diversity of these collected cultivars.

2. MATERIAL AND METHODS

2.1 Collecting accessions and ethnobotanic survey

The prospecting mission was undertaken in South of Chad and two Province, Logone Oriental and Moyen-Chari were involved (table 1). The region of Logone Oriental is subdivided into 6 departments and that of Moyen-Chari into 3 departments and prospecting was covered all these departments. One village was randomly selected per department and accessions were collected and ethnobotanic investigation was realized. For each accession collected only one spike was sampled beside one farmer and some data about accession such us local name, origin, method of seed conservation, using and management of diversity were collected. Through group interviews, detailed information on morphological, agronomic and culinary descriptions (according to farmer perception) was documented. Thus, information on the vegetative cycle, the origin of the first seeds, the uses made of each variety and the factors that determine the maintenance or disappearance of each of the local varieties are collected.

Table 1 : Site survey, ethnic group and their localization

Region	Department	Village	Ethnic group
Logone Oriental	Monts de Lam	Kamkoutou	<i>Laka</i>
	Nya Pendé	Timbéri	<i>Kaba</i>
	Nya	Mbanguirati 2	<i>Ngambaye</i>
	Pendé	Maïbombaye	<i>Mongoh</i>
	Kouh Est	Békodo	<i>Gor</i>
	Kouh Ouest	Bodo	<i>Gor</i>
Moyen-Chari	<i>Bahr Koh</i>	<i>Djoli</i>	<i>Sarah Madjingai</i>
	<i>Grande Sido</i>	<i>Kobdogué</i>	<i>Ngama</i>
	<i>Lac Iro</i>	<i>Guilagondéré</i>	<i>Sarah Kaba</i>

2.1 Agronomical and phenotypic assessment of accessions sampled

Twelve accessions from the current collecting mission were used to assess the genetic diversity (table 2). All the accessions assessed were landraces due to the fact that they belonged to farmers which were inherited from their ancestors.

Field experiments were conducted at Bébédjia, Agricultural Research Station, Chadian Institute of Agricultural Research for Development (ITRAD), Chad (9°55'N and 15°8'E) during the rainy season of 2017 with 1175.2 mm of rainfall. Experiment was planted on 17 July and three weeks after sowing, plots were fertilized with 5/10/15N, P, and K at a rate of 200 kg.h⁻¹ as a broadcast application. The experimental design was a randomized block design (RCBD) with three blocks. Seed from each accession were planted in a spacing of 0.8 m between plants and rows.

The observations were recorded for 20 agro-morphological traits. Among these traits, 10 were qualitative traits, like early growth vigor, tillering attitude, sheath pubescence, nodal pubescence, endosperm texture, spike shape, seed covering, seed color, spike threshing and seed shape recorded following guidelines of IBPGR and ICRISAT (IBPGR and ICRISAT 1993). Ten quantitative traits included total tillers per plant; productive tillers per plant, plants height, spike length, spike girth, exertion length, number of days to flowering, thousand grain weights, weight of main spike and grain weight of main spike were recorded. Five plants of each accession in each replication were randomly selected for the quantitative traits recording.

Analysis of variance (ANOVA) was used to analyze the data of all quantitative traits assessed. Differences among cultivars were determined using the Tukey test. The Pearson correlation coefficients were calculated to determine relationships among the observed traits, using adjusted means. The principal component analysis (PCA) of the standardized data was performed. The phenotypic and genotypic variances were computed according to Falconer (1981). Heritability as

broad sense (H^2) was calculated according to Allard (1960). Genotypic and phenotypic coefficients of variation were estimated as proposed by Burton *et al.* (1952). Genetic advance as % of mean was estimated as suggested by Johnson *et al.* (1955). The data analysis among traits was done by using GenStat 12th Edition.

3. RESULTS AND DISCUSSION

3.1 Collecting and survey missions

The prospecting mission allowed collecting twelve accessions of pearl millet in five villages. In fact nine villages were prospected but in only five villages were found the pearl millet accessions. In Logone Oriental, six villages were prospected, but six accessions were collected in only three villages that represented two accessions per village. In Moyen Chari three villages were prospected and six accessions presenting 2 accessions per village.

Table 2 : origin of accessions collected used for agro-morphological assessment

N°	Local name	Villages	Province	
1	<i>Ngaoteïn</i>	Timbéri	Logone Oriental	
2	<i>Konteïn</i>			
3	<i>Teïnkoro</i>	Mbanguirati 2		
4	<i>Teïnkohbé</i>			
5	<i>Teïn Kobbé</i>	Maïmbonbaye		
6	<i>Teïn precoce</i>			
7	<i>Batinda</i>	Guilagonderé		
8	<i>Klabissi</i>			
9	<i>Djekoualé</i>			
10	<i>Teïn Tend</i>	Djoli		Moyen Chari
11	<i>Teïn Nbarley</i>			
12	<i>Teïn Woke</i>			

3.2 Local taxonomy and characteristics of varieties collected

Farmers traditionally classify name of pearl millet accession they used in relation to spike shape, accession's origin and animal names (table 3). In the Logone Oriental region, «*Teïn Kohbé*» or «*Teïn Kobbé*» accessions, which mean ancestry pearl millet were most found. In village of Guilagonderé, from Moyen Chari region, the animals' names were used in taxonomy to identify

accessions. Than «*Klabissi*» means Tail of dog is used to name the accession regarding to the tip of spike which is crooked. It is reported, by farmers the presence of several other accessions of pearl millet including accessions possessed bristles which unfortunately could not be collected. The bristles are located at the glumes level that protect the spike against the tingling of birds. This is a characteristic used in areas where birds devastate crops.

Table 3: Farmer's nomenclature of collected pearl millet accessions

Village	Local name	Code	Meaning	Characteristics
Timbéri	<i>Ngaotein</i>	V1	Pearl millet male	Small spike
	<i>Kontein</i>	V2	Pearl millet female	Big spike
Mbanguirati 2	<i>Teinkoro</i>	V3	Pearl millet from Koro	
	<i>Tein Koh bé</i>	V4	Ancestry pearl millet	
Maïmbonbaye	<i>Tein Kobbé</i>	V5	Ancestry pearl millet	
	<i>Tein précoce</i>	V6	Early production pearl millet	
Guilagonderé	<i>Batinda</i>	V7	White monkey	Short spike
	<i>Klabissi</i>	V8	Tail of dog	Medium spike, tip crooked
	<i>Djekoualé</i>	V9	Pearl millet with long head	Long spike
Djoli	<i>Tein Tend</i>	V10		Sensitive to Striga
	<i>TeinNbarley</i>	V11		Like by birds and tolerant to Striga
	<i>TeinWoke</i>	V12		Small spike, appreciate by farmers, productive

3.3 Agronomical and phenotypic performance

Distribution of qualitative traits indicates that all of assessed accessions had pubescence in node but did not have it in leaf (table 4). In emergency stage, 33% of accession had low seedling vigor; same amount of accession had high seedling vigor; however, 34% of accession had intermediate seedling vigor. There was predominance of accessions with cylindrical shape (85%), while candle and conical shape represented 8% each. These accessions mostly had grey colored seed (58%) followed by ivory color (25%). Most of the accessions (58%) had tillers with

a spread attitude. Accessions with hexagonal seed shape (50%), exposed seed covering (67%) and seeds with mostly corneous endosperm texture (67%) were predominant in the collection.

Table 4: Frequency distribution (%) of six qualitative traits for 12 pearl millet genotypes assessed

Characters	Modality	Percentage (%)
Early vigor	Low	33
	Intermediate	34
	High	33
Tillering attitude	Erect	8
	Intermediate	33
	Spreading	58
Leaf pubescence	absent	100
Node pubescence	Present	100
Endosperm texture	Mostly corneous	67
	Partly corneous	0
	Mostly starchy	33
Spike shape	Cylindrical	84
	Candle	8
	Conical	8
Seed covering	Exposed	67
	Intermediate	33
Seed color	Grey	58
	Grey brown	8
	Ivory	25
	Yellow	8
Spike threshing	Threshing with the Touch	58

	Threshing difficult	42
Seed shape	Globular	33
	Hexagonal	50
	Obovate	17

Analysis of variance compared different accessions based on calculated value of ‘F’ and showed that accessions were significantly different ($p < 0.001$ and $p < 0.005$) for all traits except total tillers (Table 5). Most of the variability observed was mainly explained by the “accession” factor through traits, which revealed highly significant differences ($R^2 \geq 47.2\%$). High F-values were observed for traits spike length, plant height and days to flowering. The coefficient of variation (CV) gives an idea of relative variability present in the accessions. The computed CV for five of the ten traits was fairly small ranging from 4.6 to 13.1%. However, productive tillers had the highest CV of 43.3%, followed by spike weight (CV = 32.6) and grain weight per spike (CV = 30.8).

Agronomic evaluation of germplasm accessions revealed wide range of variation for all the characters (table 5) and performances of each accession were recorded in table 6. The total tillers per plant produced by accessions ranged from 11.5 to 16.8 with an average of 14.8, so the productive tillers per plant ranged from 4.4 to 15.9 with an average of 9.1 tillers per accessions. The mean plant height varied from 259.9 to 357 cm with an average of 304.9 cm. The genotypes that exhibited tall plants were V6, V3 and V11, while V8, V12 and V10 displayed short plant height (table 6). The exertion length varied between 5 and 13.2 cm with an average of 9.5 cm. The characteristics of spike showed that, spike length varied from 14.3 to 41.8 cm and spike girth ranged from 6.4 to 9.5 cm. The spike weight ranged from 14.5 to 51.8 g with an average of 33.4 g and each of spike produced grain which weight ranged from 8.2 to 25.6 g with an average of 18.3 g. The genotypes that had higher spike weights were V5, V6 and V3, and then the genotypes with smaller spike weights were V10, V12 and V8. Number of day to flowering ranged from 77 to 87.8 days and thousand-seed weight ranged between 8.6 and 25.6 g. The genotypes V1, V2 and V3 had the highest 1000-grain weight, whereas V7, V8 and V12 had low 1 000-seed weights.

Table 5: Analysis of variance and contributing for 10 quantitative traits for pearl millet genotypes

Characters	Min.	Max.	Means	CV	R ²	Pr > F
Total tillers per plant	11.5	16.8	14.8±1.7	11.8	26.9	0.3186
Productive tillers per plant	4.4	15.9	9.1±3.9***	43.3	60.6	0.0001
Plant height (cm)	259.9	357	304.9±34***	11.2	82	< 0.0001
Spike length (cm)	14.3	41.8	28.3±7***	24.8	86.8	< 0.0001

Spike girth (cm)	6.4	9.5	7.7±1***	13.1	73.6	< 0.0001
Exertion length (cm)	5.0	13.2	9.4±2.7**	28.7	47.2	0.00726
Days to flowering (days)	77.0	87.8	82.4±3.8***	4.6	76.8	< 0.0001
Thousand seed weight (g)	8.6	11.0	9.4±0.67**	7.1	52.3	0.0018
Main spike weight (g)	14.5	51.8	33.4±10.9***	32.6	68.6	< 0.0001
Seed weight per main spike (g)	8.2	25.6	18.3±5.6***	30.8	61.1	< 0.0001

, significant effects at $P \leq 0.05$; ** significant effects at $P \leq 0.01$; * significant effects at $P \leq 0.001$; CV: coefficient of variation; Min.: Minimum observed value; Max.: Maximum observed value*

Table 6: Means and sources of variance of ten quantitative traits of 12 sorghum genotypes

Genotypes	TTL	PTL	PHT	SPL	SPG	EXL	NDF	TSW (g)	WMS (g)	WSS (g)
V1	16.1	7.2	321.2	29.5	7.3	9.7	85.7	10	35.2	21
V2	14.4	6.8	313.7	29.4	9	6.7	85.7	9.9	33	18.5
V3	12.4	5.9	356.5	34.4	7	5.5	85.2	11	45.6	25.5
V4	15.5	7.2	319.9	27.3	7.2	12.5	84	9.7	33.8	19.4
V5	11.5	4.4	283.9	26.1	8.4	12.7	86	9.2	51.8	25.1
V6	14.6	5.8	357	41.8	6.6	5	87.7	9.7	45.8	25
V7	16.8	10.7	276.1	24.6	8.8	8.9	77	8.7	28.6	16.7
V8	14.3	14.3	259.9	28	6.4	13.2	79.7	8.7	28.2	13.5
V9	13	8.1	305.5	29.6	7.5	9	77.7	9.2	33.6	19.2
V10	16.5	15.2	270.9	14.3	9.5	11	79.7	9.2	14.5	8.2
V11	16.2	7.5	331.2	34.3	6.8	9	81.7	9.3	33.1	17.6
V12	16.3	15.9	263	20.1	8.2	9.5	77.7	8.6	17.5	9.98

TTL: total tillers, PTL: productive tillers, PHT: plants height, SPL: spike length, SPG: spike girth, EXL: exertion length, NDF: number of days to flowering, TSW: thousand grain weight, WMS: weight of main spike and WSS: grain weight of main spike

3.4 Genetic variability, Heritability and Genetic advance

The estimates of variability, heritability and genetic advances for 10 quantitative characters are presented in Table 7. Estimates of phenotypic variance (PV) and genotypic variance (GV) ranged

from 0.36 – 934.3 and 0.26 – 868.8 respectively. For all the characters assessed, phenotypic variances were higher than the corresponding genotypic variances.

The estimate of phenotypic coefficient of variance (PCV) ranged from 4.16 to 38.74 and genotypic coefficient of variance (GCV) ranged from 3.96 to 35.2. High (>20%) GCV and PCV were observed for productive tillers (35.2 – 38.74), spike length (21.6 – 22.2), exertion length (20.5 – 25.71), main spike weight (27.1 – 29.19) and grain weight of main spike (25.37 – 27.59). Moderate GCV and PCV were observed for spike length (11.06 – 11.76). Low genotypic GCV and PCV were recorded for total tillers (6.6 – 10.56), plant height (9.67 – 10.02), days to flowering (3.96 – 4.16) and thousand grain weight (5.4 – 6.36). Phenotypic coefficient of variance was found higher than genotypic coefficient of variance for all studied traits. However, the difference between PCV and GCV was very low for majority of the traits assessed, more closer values found for number of day to flowering followed by plant height and panicle length (differences of 0.2; 0.35 and 0.55, respectively) and quiet a high level of differences was observed for exertion length (5.24).

Heritability and genetic advance as percentage of mean are the two important parameters of which, H^2 is used to estimate the expected genetic advance through selection. In this investigation, assessed characters except for one (total tillers), registered high heritability ($H^2 \geq 63.4\%$) indicating that these traits could be governed by additive genes. In this study, the highest heritability was recorded for spike length (95.1%), followed by plant height (93%), day to flowering (90.7%) and spike girth (88.5%). The highest genetic advances as a percent of mean were recorded for productive tillers (65.85%), followed by main spike weight (51.67%), grain weight for main spike (48.07%), spike length (43.5%)

High H^2 along with high genetic advance as a percent of means is an important factor for predicting the resultant effect for selecting the best individuals. Productive tillers per plant, main spike weight, grain weight for main spike, spike length, exertion length and spike girth had high heritability accompanied with high genetic advance, while plant height, days to flowering and thousand grain weights had high heritability coupled with low genetic advance as a percent of mean. Only total tillers per plant had low heritability with low genetic advance as a percent of mean.

Table 7: Estimates of variability and genetic parameters of pearl millet genotypes

Characters	Vg	Vp	H ²	GCV (%)	PCV (%)	GA	GAM (%)
Total tillers	0.97	2.45	39.6	6.6	10.56	1.28	8.62
Productive tillers	10.3	12.45	82.5	35.2	38.74	6.00	65.85
Plant height	868.8	934.3	93	9.67	10.02	58.55	19.20
Spike length	37.5	39.4	95.1	21.6	22.2	12.30	43.50
Spike girth	0.7	0.82	88.5	11.06	11.76	1.66	21.44

Exertion length	3.7	5.85	63.4	20.5	25.71	3.16	33.56
Days to flowering (days)	10.7	11.75	90.7	3.96	4.16	6.40	7.78
Thousand grain weight (g)	0.26	0.36	72	5.4	6.36	0.89	9.44
Main spike weight (g)	81.6	95	85.9	27.1	29.19	17.25	51.67
Grain weight for main spike (g)	21.6	25.57	84.6	25.37	27.59	8.81	48.07

Vg: genotypic variance; Vp: phenotypic variance; GCV: genotypic coefficient of variation; PCV: phenotypic coefficient of variation; H²: Heritability in broad sense; GA: genetic advance; GAM: genetic advance as percent of mean

3.5 Correlation between characters

The association among the agronomical traits was estimated by correlation analysis (Table 8). Grain weight of main spike expressed a positive correlation with plant height ($r=0.743$, $p=0.01$), spike length ($r=0.771$, $p=0.01$), number of day to flowering ($r=0.737$, $p=0.01$), thousand grain weight ($r=0.65$, $p=0.01$) and weight of main spike ($r=0.973$, $p=0.01$), while it expressed a negative correlation with total tillers per plant ($r=-0.641$, $p=0.01$), productive tillers per plant ($r=-0.937$, $p=0.01$), spike girth ($r=-0.415$, $p=0.01$) and exertion length ($r=-0.395$, $p=0.01$).

Number of day to flowering was negatively correlated with total tillers ($r=-0.39$, $p=0.01$) and productive tillers ($r=-0.75$, $p=0.01$), while it was positively correlated with plant height ($r=0.693$, $p=0.01$) and spike length ($r=0.586$, $p=0.01$).

Productive tillers per plant had positive correlation with total tillers per plant ($r=0.542$, $p=0.01$) and exertion length ($r=0.354$, $p=0.01$). However, productive tillers per plant exhibited negative correlation with plant height ($r=-0.761$, $p=0.01$), spike length ($r=-0.708$, $p=0.01$), number of days to flowering ($r=-0.750$, $p=0.01$), thousand seed weight ($r=-0.636$, $p=0.01$), weight of main spike ($r=-0.901$, $p=0.01$) and grain weight per main spike ($r=-0.937$, $p=0.01$).

Table 8: Pearson correlation coefficient among 10 assessed characters of pearl millet

Variables	TTL	PTL	PHT	SPL	SPG	EXL	NDF	TSW	WMS
PTL	0.542**								
PHT	-0.232*	-0.761**							
SPL	-0.343**	-0.708**	0.825**						
SPG	0.188	0.281*	-0.495**	-0.730**					
EXL	0.054	0.354**	-0.690**	-0.589**	0.084				
NDF	-0.390**	-0.750**	0.693**	0.586**	-0.259*	-0.317**			
TSW	-0.361**	-0.636**	0.813**	0.507**	-0.257*	-0.536**	0.721**		
WMS	-0.731**	-0.901**	0.633**	0.731**	-0.412**	-0.272*	0.731**	0.545**	
WSS	-0.641**	-0.937**	0.743**	0.771**	-0.415**	-0.395**	0.737**	0.650**	0.973**

**Significant at 0.01 probability level; *Significant at 0.05 probability level; TTL: total tillers, PTL: productive tillers, PHT: plants height, SPL: spike length, SPG: spike girth, EXL: exertion length, NDF: number of days to flowering, TSW: thousand seed weight, WMS: weight of main spike and WSS: grain weight per main spike

3.6 Principal component analysis

The quantitative data were subjected to principal component analysis (PCA), which revealed that the first three principal components with Eigen value ≥ 1 provided a reasonable summary of data and explained 84.88% variance in pearl millet germplasm. The characters in the PCs were identified on the basis of eigenvectors. The first principal component (PC1) was the most important and accounted for 49.14% of variation. Plant height, spike length, weight of main spike and grain weight of main spike contributed to the first component in positive direction while productive tillers and spike girth contributed to the first component in the negative direction. Second principal component accounted for 24.51% of variation was loaded on number of days to flowering. The third principal component accounted for 11.23% of the total variation. Total tillers and plant height contributed more the third component in negative direction while exertion length contributed more to the third component in negative direction.

Table 9: Eigenvalue and proportions of variability as assessed by agronomic traits contributed to three PCs of germplasm

	PC1	PC2	PC3
Eigen values	6.388	3.186	1.460
Contribution rate (%)	49.14	24.51	11.23
Cumulative contribution rate (%)	49.14	73.65	84.88
Total tillers	-0.230	-0.161	-0.521
Productive tillers	-0.366	0.044	-0.053
Plant height	0.351	0.005	-0.328
Spike length	0.351	0.113	-0.093
Spike girth	-0.236	-0.183	-0.106
Exertion length	-0.196	-0.105	0.634
Days to flowering (days)	0.318	-0.261	0.047
Thousand grain weight (g)	0.300	-0.044	-0.184
Main spike weight (g)	0.368	-0.013	0.233
Grain weight for main spike (g)	0.376	0.010	0.113

4. DISCUSSION

The primary objective of the current study was to collect landraces and assess their phenotypic and agronomical diversity, especially with regard to the specific traits linked to the yield improvement. This study allowed collecting 12 landraces of pearl millet from two Provinces of South of Chad. Six were from Logone Oriental and six from Moyen Chari. The study showed the low diversity of pearl millet through little number of landraces collected per villages in these two Provinces. More than landrace collected were mentioned by farmers during the ethnobotanic survey; unfortunately, many of them were lost or abandoned by farmers. Folk nomenclature was used by farmers to indicate each landrace. Some traits relative to the spike shape, accession's origin and animal names were used to the vernacular name of the pearl millet landrace. According to Dansi (2009) farmers traditionally classify, name and group the plant species they used in relation to introduction, agronomic, agro-ecological, use, technological-related traits and morphological attributes.

Qualitative evaluation allowed finding the wide range of variation between assessed landraces. The pearl millet landraces had dominance of cylindrical-shape and threshing with the touch spike, hexagonal shape and grey colored seed with the endosperm mostly corneous. Other

studies on ICRISAT pearl millet genebank have also reported same result (Upadhyaya *et al.*, 2007).

The pearl millet of this current collection had characterized by early number of days to flowering (77 to 88 days) medium and high plant height (259.9 to 357 cm), good tillers capacity (up to 11 per plant). Number of productive tillers were highly variable (CV: 43.3%) even from 4.4 to 15.9 tillers. Compared to sorghum, pearl millet will produce more tillers and has a woodier stem (Kajuna, 2001). For Kumari *et al.* (2016), in India pearl millet, number of productive tillers got CV of 38% and ranged from 2 to 16 tillers. Analysis of variance revealed significant differences among the genotypes ($p < 0.001$) for all traits except for total tillers per plant indicating presence of significant variability in the genotypes which can be exploited through selection. According to Govindaraj *et al.* (2010) there were the highly significant differences exist among the traits except number of productive tillers and days to maturity.

The study showed that, phenotypic coefficients of variation (PCV) estimates were higher than genotypic coefficients of variation (GCV) for all the characters studied among the twelve pearl millet genotypes, indicating the substantial influence of environment in the expression of these characters. Similar findings were reported in pearl millet earlier by Fadlalla (2002), Bezaweleaw *et al.* (2006) and Ghazy *et al.* (2012). Estimation of GCV alone does not assess the amount of heritable variation. GCV computed in conjunction with heritability estimates would provide a better indication for selection on the phenotypic performance (Burton, 1952).

In the present investigation, there was a high Heritability for all the traits studied whereas GAM ranged from moderate to high. High heritability with high GAM indicates preponderance of additive genes which respond to selection. Similar findings of high heritability and high GAM for agronomic traits were reported by Kumar *et al.* (2017) and Anuradha *et al.* (2018). High heritability with moderate GAM was observed for plant height indicating the presence of both additive and non-additive genes. However, relatively high estimate of heritability with low genetic advance which were exhibited for days to flowering, thousand grain weight and total tillers, indicated the presence of non-additive gene action. Thus, simple selection for this character will not be effective. According to Musa and Atif (2013) in such situation recombination breeding may give better response for improvement of millet.

Correlation coefficient is a measure of the degree of association between the two traits worked out at the same time (Meena *et al.*, 2014). It could help to do indirect selection for complex traits like yield via other biometrical traits which are closely and positively associated. The study allowed to find highly and significantly correlated in positive direction between grain weight per main spike and number of days to flowering. This result corroborated with study of Kaushik *et al.* (2018).

Contrariwise Bidinger *et al.* (1987), found a strong negative correlation between flowering time and grain yield when pearl millet receives terminal drought stress. Singh and Chhabra, 2018, found negative correlation between grain yield per panicle and day to 50% flowering. Because of the high interannual rainfall variability common in West Africa (Haussmann *et al.*, 2012), the relationship between grain yield and flowering time can be expected to vary not only across sites, but also across years at individual sites (Pucher *et al.*, 2015). This indicates that selection for a specific, uniform flowering time may not be the best strategy.

Grain weight per main spike was highly and significantly correlated in positive direction with plant height, spike girth and weight of main spike. Singh and Chhabra, 2018, found positive correlation between yield per panicle and plant height. On the other side, total and productive tillers were negatively correlated to grain weight per main spike. In fact a high production of tillers per plant, contributed to the reduction of the yield for each spike of this plant.

Trait-specific evaluation of pearl millet genetic resources is important for enhancing utilization by plant breeders and refining genetic resource management strategy (Kumari *et al.* 2016). This study allowed identifying accessions with specific traits like early maturity, spike length, grain weight. Some accessions with high performance traits were also identified for example, earliness flowering (V7) yield of main spike (V3), short plant height (V8) and high productive tiller (V12).

5. CONCLUSION

Prospection of pearl millet in Logone Oriental and Moyen Chari, two Provinces in South of Chad allowed collecting twelve landraces. Assessment of agronomical and morphologic diversity showed that the pearl millet of this collection had early number of day to flowering (77 to 88 days), medium and high plant height (259.9 to 357 cm), good tillers capacity (up to 11 per plant) and good productive tillers (4.4 to 15.9). GCV and PCV ranged from low to high for traits studied indicating presence of low to high variability in the current population. High heritability and genetic advance were observed for traits like productive tillers, spike length, spike girth, exertion length, main spike weight and grain weight for main spike suggesting predominance of additive gene action and lower influence of environmental factors in the expression of these traits with possibility for improvement through selection. This study allowed identifying accessions with specific traits like early maturity, spike length, grain weight. Some accessions with high performance traits were also identified for example, earliness flowering (V7) yield of main spike (V3), short plant height (V8) and high productive tiller (V12).

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