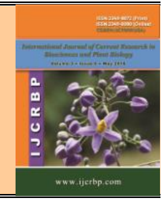
Int. J. Curr. Res. Biosci. Plant Biol. **2016, 3(5): 147-156**

EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 (Online) • Volume 3 • Number 5 (May-2016)

Journal homepage: www.ijcrbp.com



Original Research Article doi: http://dx.doi.org/10.20546/ijcrbp.2016.305.023

Characterization of Sugarcane (*Saccharum officinarum* L.) Cultivars of Republic of Benin

O. S. Ekpélikpézé[1], P. Agre[1], I. Dossou-Aminon[1], A. Adjatin[2], A. Dassou[1] and A. Dansi[1]*

[1]*Laboratory of Biotechnology, Genetic Resources and Plant and Animal Breeding (BIORAVE), Faculty of Sciences and Technology of Dassa, Polytechnic University of Abomey (UPA), BP14, Dassa, Benin*
[2]*Faculty of Sciences and Technology of Dassa, Polytechnic University of Abomey (UPA), BP14, Dassa, Benin*

Corresponding author.

Abstract

In Benin, sugarcane (*Saccharum officinarum* L.), is both a food security and cash crop neglected by scientific research and development programs. To assess its diversity at national level, 89 farmer-named cultivars were collected from different production zones, planted in completely randomized bloc design with three repetitions and characterized using 15 qualitative and 10 quantitative morphological parameters. Data collected were analyzed using descriptive statistics and multivariate analysis. Among the qualitative traits, five (color of the stipule, leaflet cover, pubescence of the leaves, external color and split of the stem) presented high variability. Among the stem colors recorded, black (49.44%), red (14.49%) and yellow (13.48%) were the most represented. Apart the leaves length, all of the quantitative traits considered exhibited high variability hence indicating the possibility of improvement of the crop using local germplasm to respond to farmers and consumers' preferences and needs. Correlation matrix revealed strong relationships between different quantitative traits. Both principal component analysis (PCA) and cluster analysis grouped the 89 cultivars into four morphological groups with different characteristics. Some putative duplicates were identified and for their certification the use of molecular markers such as SSRs or advanced techniques such as GBS were recommended.

Article Info

Accepted: 05April 2016
Available Online: 06 May 2016

Keywords

Agromorphological characterization
Cultivar groups
Saccharum officinarum L.
Sugarcane

Introduction

Member of Poaceae family, the gender *Saccharum* contains six species among which two wild and poor in sugar (*Saccharum spontaneum* and *Saccharum robustum*) and four cultivated (*Saccharum officinarum*, *Saccharum barberi*, *Saccharum sinense* and *Saccharum edule*) rich in sugar (Nair, 2009). Native to Southeast Asia, sugarcane (*Saccharum officinarum* L.) is a food crop that plays an essential economic role in many tropical and subtropical countries (Jangpromma et al., 2010; Singh et al., 2010). It is very rich in carbohydrates, minerals, fiber and vitamin B6 (Archimede et al., 2011). Sugarcane cultivation enriches soil in organic matter and allows better conservation of their structure (Bell et al., 2001). Although sugar and rum markets have always been the prerogative of this crop, other markets such as energy and biofuels are also opening (Small and Catling, 2006).

In Benin, *Saccharum officinarum* is grown in lowlands of different agro-ecological regions and is an important source of household income for rural producers (Ekpélikpézé et al., 2016a). Its production is mostly used by SuCoBe, a Chinese sugar industry installed at Savè, district of central Benin, for ethanol production

(Ekpélikpézé et al., 2016a). However, despite its economic importance, sugarcane still remains scientifically under-researched in Benin. Its production is facing many biotic and abiotic constraints causing huge losses to producers (Ekpélikpézé et al., 2016a). Recently, an ethnobotanical study was conducted in the production zones and helped to understand the on farm management of the existing diversity and identify production constraints and farmers' preference criteria (Ekpelikpezé et al., 2015). Physicochemical analysis was also carried out to support decision making with regard to the use of the cultivars (Ekpélikpézé et al., 2016b).

The development of an economically profitable production of any plant species like sugarcane undoubtedly requires the use of improved high yielding varieties. To facilitate breeding efforts, characterisation of available germplasm is a necessary first step since it especially benefits a plant breeder in choosing proper parental materials (Pandey et al., 2011). Also knowledge about interrelationships among descriptors (characteristics), from a plant breeder's perspective, aids in the selection of superior genotypes from the breeding population and is important in planning and evaluating breeding programmes (Sheela and Gopalan, 2006).

The objectives of this study were to assess the diversity among local sugarcane cultivars in Benin using agromorphological descriptors and to study interrelationships among descriptors used in order to identify outstanding accessions that could be involved in national breeding programs for the benefit of both producers and consumers.

Materials and methods

Plant material and cultivation

The plant material is composed of eighty-nine (89) sugarcane accessions collected in different production areas in Benin (Table 1) and maintained as a field collection at the experimental site of the Faculty of Science and Technology (FAST) of Dassa located at Djrègbé, a village of south-eastern Benin. Djrègbé is a humid zone characterized by four seasons (two rainy and two dry) with an average rainfall exceeding 1100 mm/year.

Soils are in majority hydromorphic, the average temperature is about 27°C and the relative humidity is relatively high (Akoègninou et al., 2006). For each accession, cuttings of 30 cm length were planted on straight row and on a Completely Randomized Block Design with three repetitions. Distance between ridges and between plants was kept at 1 m and 1.55 m respectively following Abdelmahmud et al. (2012).

Table 1: List of sugarcane (*Saccharum officinarum*) accessions studied and their origin.

N°.	Accession no.	Vernacular names	Collection sites	Districts	Departments
1	AT13	Gartin fonharoun	Bocossi	Péhunco	Atacora
2	AT14	Gartin wonka	Bocossi	Péhunco	Atacora
3	AT15	Gartin Dombourou	Bocossi	Péhunco	Atacora
4	AT16	Archibi	Kparatéki	Kérou	Atacora
5	AT17	Alékébogoun	Gounsaroun	Kérou	Atacora
6	Atl67	Azéléké	Kpé Aholouko	Calavi	Atlantique
7	Atl68	Azéléké	Assogbénoukpèvi	Kpomassè	Atlantique
8	Atl69	Azéléké	Assogbénoudaho	Kpomassè	Atlantique
9	Bo18	Alékédoudou	Titirou	Parakou	Borgou
10	Bo19	Alékéolomihessou	Titirou	Parakou	Borgou
11	Bo20	Alékéolomiwé	Titirou	Parakou	Borgou
12	Bo21	Alékéolomiwé	Titirou	Parakou	Borgou
13	Co25	Arékébaki	Agbo	Savè	Collines
14	Co26	Arékéfari	Agbo	Savè	Collines
15	Co27	Aréké Tourawa	Agbo	Savè	Collines
16	Co28	Léké founfoun	Alafia	Savè	Collines
17	Co29	Léké kpikpa	Alafia	Savè	Collines
18	Co30	Léké doudou	Alafia	Savè	Collines
19	Do01	Kantooma	Doguê	Bassila	Donga
20	Do02	Karakoukpéto	Timba	Djougou	Donga
21	Do03	Karakouhouloumou	Timba	Djougou	Donga
22	Do04	Karaisoori	Toko-Toko	Djougou	Donga
23	Do05	Karaipieri	Toko-Toko	Djougou	Donga

N°.	Accession no.	Vernacular names	Collection sites	Districts	Departments
24	Do06	Ipèokanga ignonyé	Affongosso	Djougou	Donga
25	Do07	Ipèokanga ipègni	Affongosso	Djougou	Donga
26	Do08	Ipèokanga ipègni	Affongosso	Djougou	Donga
27	Do09	Karai Itchirè	Copargo centre	Copargo	Donga
28	Do10	Karai Kparè	Copargo centre	Copargo	Donga
29	Do11	Gnankaniguê	Pabegou	Copargo	Donga
30	Do12	Gnankani Mori	Pabegou	Copargo	Donga
31	Do22	Gnakani Mori	Pabegou	Copargo	Borgou
32	Do23	Gnankaniguê	Pabegou	Copargo	Borgou
33	Do24	Karaikoukpéti	Déguina	Bassila	Borgou
34	Mo31	Souclétchi Mamoui	Sèwokondji	Mono	Mono
35	Mo32	Léké Mamoui	Djanglanmè	Grand popo	Mono
36	Mo33	Léké wéwé	Djrado	Porto-Novo	Mono
37	Mo34	Souclétin Hé	Sèwokondji	Grand popo	Mono
38	Mo35	Souclétin Hi	Sèwokondji	Grand popo	Mono
39	Mo36	Léké vêê	Djanglanmè	Grand popo	Mono
40	Mo37	wandanwandan	Donkondji	Athiémé	Mono
41	Mo38	Azélékéyibo	Donkondji	Athiémé	Mono
42	Mo39	Founfounyibo	Aguinhoué	Grand popo	Mono
43	Mo40	Souclétin Djin	Sèwokondji	Grand popo	Mono
44	Mo41	Founfoun Djin	Aguinhoué	Grand popo	Mono
45	Mo42	Founfoun Djin	Aguinhoué	Grand popo	Mono
46	Mo43	Konakri	Aguinhoué	Grand popo	Mono
47	Mo78	Founfoun You	Sazoué	Athiémé	Mono
48	Mo79	Azélékédaho	Agonvè	Lokossa	Mono
49	Mo80	Azéléké Huinihuini	Agonvè	Lokossa	Mono
50	Mo81	Lékéwéwé	Agonvè	Lokossa	Mono
51	Mo82	Léké vovo	Agonvè	Lokossa	Mono
52	Mo83	Dawéléké	Tanvè	Bopa	Mono
53	Mo84	Azéléké	Tanvè	Bopa	Mono
54	Mo85	Léké vovo	Tanvè	Bopa	Mono
55	Oue44	Azéléké	Dangbo	Ouémé	Ouémé
56	Oue45	Lékékoklodjonon	Dangbo	Ouémé	Ouémé
57	Oue46	Azéléké	Tovè	Dangbo	Ouémé
58	Oue47	Azéléké vêvê	Tovè	Dangbo	Ouémé
59	Oue48	Azéléké gokpitikpiti	Tovè	Dangbo	Ouémé
60	Oue49	Azéléké	Abato	Adjohoun	Ouémé
61	Oue50	Atinwlinwlin	Abato	Adjohoun	Ouémé
62	Oue51	Léké fèfè	Djèrègbé	Sèmè-Kpodji	Ouémé
63	Oue52	Gounléké	Afamè	Adjohoun	Ouémé
64	Oue59	Azéléké	Kpodji	Sèmè-Kpodji	Ouémé
65	Oue60	Azéléké	Kpodji	Sèmè-Kpodji	Ouémé
66	Oue61	Azéléké	Djèrègbé	Sémè-Kpodji	Ouémé
67	Oue62	Azéléké Assi	Agonsagbo	Sèmè-Kpodji	Ouémé
68	Oue63	Azéléké Assou	Agonsagbo	Sèmè-Kpodji	Ouémé
69	Oue64	Azéléké Wiwi	Djeffa	Sèmè-Kpodji	Ouémé
70	Oue65	Azéléké Vôvô	Djeffa	Sèmè-Kpodji	Ouémé
71	Oue66	Azéléké	Agongo	Sèmè-Kpodji	Ouémé
72	Oue76	Azéléké	Agbokou	Porto-Novo	Ouémé
73	Oue77	Lékéwéwé	Agbokou	Porto-Novo	Ouémé
74	Pla53	Iréké Oniandoudou	Monsafè	Kétou	Plateau
75	Pla54	Yéké foufou	OKéodon	Adjawèrè	Plateau
76	Pla55	Yéké fonton	Goézi	Adjawèrè	Plateau
77	Pla56	Yéké	Goézi	Adjawèrè	Plateau
78	Pla57	Ogniguin	Onigbolo	Pobè	Plateau
79	Pla58	Iréké doudou	Pobè	Pobè	Plateau

N°.	Accession no.	Vernacular names	Collection sites	Districts	Departments
80	Pla86	Aléké Kpikpa	Gbodogui	Pobè	Mono
81	Pla87	Alékédoudou	Igbo Idi	Pobè	Mono
82	Pla88	Léké Akparon	Igbo Idi	Pobè	Mono
83	Pla89	Aléké Kpikpa	Igbo Idi	Pobè	Mono
84	Zo70	Sèmèléké	Toué	Covè	Zou
85	Zo71	Sèmèlékéwiwi	Bamè	Zangnannado	Zou
86	Zo72	Sèmèléké vovo	Bamè	Zangnanado	Zou
87	Zo73	Gbaglo	Bamè	Zangnanado	Zou
88	Zo74	Léké vovo	Zouto	Djidja	Zou
89	Zo75	Léké wéwé	Zouto	Djidja	Zou

Data collection and analysis

Twenty six parameters (15 qualitative and 11 quantitative) selected among sugarcane descriptors (IPGRI, 1994) were used. List, measurement methods and levels of score of the parameters are summarised on Tables 2 and 3. Following Abdelmahmoud et al. (2012), all the data were collected at 180 days after planting except the number of suckers taken 60 days after planting.

Table 2: Qualitative traits used for morphological evaluation and their scoring levels.

Qualitative data	Type of variable	Code	Evaluation level
Data taken at 6 months after planting	Stem external color	SEC	Yellow (1), Green (2), Black (3), Red (4), Yellow reddish (5), Brown green (6), Violet (7)
	Internal color of the stem	ICS	White (1), Other (2)
	Limb color	LC	Green (1) Other (2)
	Stipule color	SC	Green(1), Yellow (2), Red (3), Brown (4), Other (5)
	Color of the leaflet	CL	Brown (1), Brown green (2), Green (3), Other (4)
	Pubescence of leaflet	PL	Present (1), absent (0)
	Shape of the buds	SB	Oval (1), other (2)
	Bud cover	BC	Present (1), absent (0)
	Prunescence	Pru	Present (1), absent (0)
	Leaflet cover	LC	Close (1), other (2)
	Alignment of internode	AIn	Heterogeneous (1), other (2)
Data taken at 12 months after planting	Flowering	Flo	Present (1), absent (0)
	Split of the stem	SpS	Present (1), Absent (0)
	Shape of inter-node	SIN	Cylindrical (1), Other (2)
	Node swelling	NS	Non swelling (1), Other (2)

Table 3: Quantitative data used for morphological evaluation and their measurement.

Data collecting period	Quantitative traits	Measurement techniques
Two months after planting	Sucker number	Count of the number of suckers
Six months after planting	Leaf width (cm)	Width of the broadest portion of the third fully opened leaf from tip measured
	Length of the leaf (cm)	Distance between the leaf tip and base measured on the third fully opened leaf from the tip.
	Length of stipule (cm)	Measured in cm
	Stem diameter (cm)	Recorded after cutting the stem and on three different plants
	Internode length (cm)	Distance between two consecutive nodes measured on the stem
	Bud size (cm)	Distance between the base of the bud and its tip
	Number of internodes	Count of the number of internodes on 1m
	Node diameter (cm)	An horizontal measure of stem cut at the node level
12 months after planting	Stem weight (kg)	Leaves removed and the sucker weighted
	Plant size (m)	Measured from ground to the top of the plant

Results and discussion

Variability of qualitative traits

The distribution of the accessions following the modalities of the qualitative variables is presented on Fig. 1. Low variability was observed for the leaf pubescence (LP) and the split of the stem (SpS) characters while high variability was recorded for the external color of the stem (ECS), the stipule color (SC) and the color of the leaf sheath (CLS). The majority (85.39%) of the collected accessions were pubescent and most (76.4%) of them do not exhibit inter-nodes cracking. On sugarcane markets, stems with inter-nodes cracking are disliked by the consumers. In the fields, cultivars whose stems generally exhibit inter-nodes cracking are not preferred by the producers as they get rot faster than uncracked stems (Ekpélikpézé et al., 2016a). Within the collection studied, accessions with black stem (49.44%), red wine stem (14.49%) and yellow stem (13.48%) are the most represented and account, altogether, for 67.041% of the accessions (Fig. 1). Concerning the color of the stipule, three types (brown, dark green, green) were observed in the proportions of 66.29%, 17.98% and 15.73% respectively. The color of the leaf was also variable. Brown color was the most recorded (53.93%) followed by than green (16.86%), yellow (15.73%) and red (13.48%) color. Within the parameters considered, no geographical distribution of the modalities is observed as the general tendency of predominance in the study area was also the same for each of the regions surveyed (Table 2).

Fig. 1: Variability of the stem external color of the sugarcane cultivars collected in Benin.

Out of the 15 qualitative traits considered, Principal Component Analysis helped to identify five (color of the stipule, leaflet cover, pubescence of the leaves, external color and split of the stem) that are highly discriminative and useful for sugarcane germplasm characterization. Using these five qualitative parameters and the UPGMA clustering method, the accessions were classified into three classes named C1, C2 and C3 (Fig. 2). C1 groups most of the accessions having black stem, C2 mostly gathers accessions of yellow stem while accessions with green stem dominate C3. The dendrogram constructed (Fig. 2) showed the existence of an important phenotypic diversity with the presence of some accessions with different phenotypic traits in the same cluster and also the presence of many probable duplicates. This calls for the use of molecular markers such as SSR or SNP to assess the genetic diversity, clarify synonymies and identify duplicates with the germplasm following Grivet and Arruda (2001), Silva et al. (2005), Edmé et al. (2005), Kawar et al. (2009), Pinto et al. (2011) and Gouy (2012). Qualitative traits have been used to assess genetic diversity in many other crops such as cassava (Agre et al., 2015), sorghum (Dossou-Aminon et al., 2015), millet (Sy et al., 2015) and spider plant (Kiebre et al., 2015).

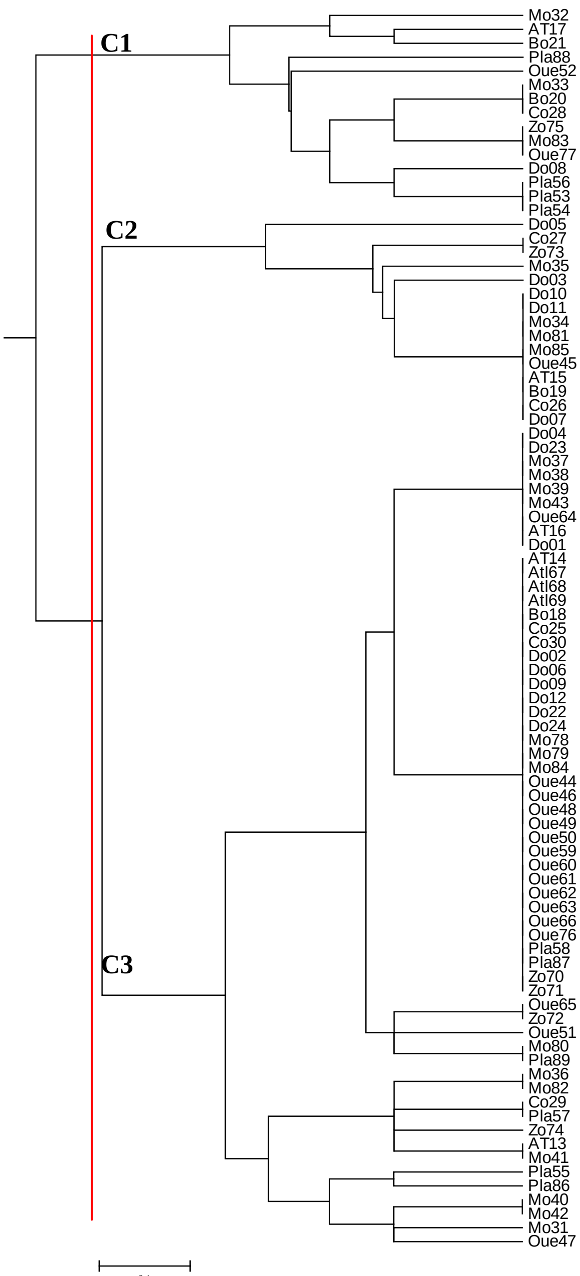


Fig. 2: Dendrogram of 89 sugarcane cultivars using UPGMA clustering method.

Variability of quantitative traits

Quantitative data of *Saccharum officinarum* analyzed through descriptive statistical (minimum, maximum, average mean, Standard deviation, coefficient of variation) were presented in Table 4. High variation were observed between the minimum and the maximum for some traits such as stem weight (SW), bud size (BS), internodes length (IL), stem diameter (SD), leaf width (LW) and the plant size (PS). The stem weight per meter varies from 1.63 kg to 6.80 kg with an average of 4.21 kg. The bud size it varies from 0.46 cm to 1.17 cm with 0.81 cm as average. The internodes length and stem diameter varied respectively from 6.13 cm to 18.86 cm and 1.82 cm to 6.06 cm. Concerning the size of the sugarcane at harvest time, the average mean was estimated to 5.4 m and the smallest value was 3.92 m while the highest was 6.61 m. The leaf width that inform on total biomass varies from 4.81cm to 9.09 cm with 7.28 cm on average. Across the literature, quantitative genetic studies on sugarcane related to the yield were principally based on biomass, plant size, stem weight, stem diameter and the number of sucker (Silva et al., 2005; Gouy, 2012).

In general, the majority of the quantitative traits used presented high coefficients of variations (CV). These CVs vary from 6.58% (leaf length) to 26.35% (stem weight). The high value (CV>20%) of these parameters were observed with stem weight per meter (26.35%) and the bud size (22.38%). These results show the importance of quantitative traits in assessing sugarcane diversity in Benin. These results are similar to those reported by Dossou-Aminon et al. (2015) on sorghum (*Sorghum bicolor*) and Agre et al. (2015) on cassava (*Manihot esculenta* Crantz).

Significant correlations ($p<0.05$) were observed between the quantitative variables. The highest positive correlation (r = 0.90) was obtained between the nodes' diameter (ND) and stem weight (SW) while the highest negative correlation (r = - 0.89) was between the nodes number and the internodes length. Moreover, the stem weight and stem diameter were highly correlated between themselves and with leaf width, leaf length and stipule length (Table 5). The correlation matrix showed that the plant height, bud height and the sucker number were not correlated with the others variables. These results indicated that the larger and heaviest the stem, the high its number of nodes and the small the distance between nodes. Muhammad and Farooq (2009) reported negative correlation between sucker number and the others yield variables. This difference could be explained by the counting time of the sucker which was done two months after sugarcane planting (Abdelmahmoud et al., 2012). The high coefficients of variation observed for most (75%) of the studied traits indicated the presence of a high heterogeneity within the population characterized that can be exploited for breeding purpose in Benin. According to Agre et al. (2015), correlation data constitute an essential tool in the choice of characters to be integrated in a breeding scheme. The results of our study constitute an important database for sugarcane selection and varietal improvement programs in Benin.

Table 4: Descriptive statistics of quantitative traits.

Parameters	Minimum	Maximum	Mean	Standard deviation	CV (%)
LW	4.81	9.09	7.276	1.339	18.40
LL	1.406	1.741	1.612	0.106	6.58
LOL	3.88	7.133	5.802	0.984	16.96
SD	2.05	5.89	4.032	0.788	19.54
IL	9.046	18.093	12.067	2.379	19.71
SW	1.135	6.305	4.186	1.103	26.35
TN	2	4	3.196	0.463	14.49
BS	0.473	1.533	0.706	0.158	22.38
IN	5.52	12.26	8.853	1.358	15.34
ID	2.7	5.58	4.296	0.798	18.58
PH	3.92	6.61	5.397	0.649	12.03

Table 5: Correlations between the quantitative traits of sugarcane cultivars in Benin.

Parameters	LW	LL	LOL	SD	IL	SW	SN	BS	DIN	ID	PS
LW	1.00										
LL	0.80*	1.00									
LOL	0.70*	0.84*	1.00								
SD	0.82*	0.74*	0.56*	1.00							
IL	-0.65*	-0.49	-0.53*	-0.54*	1.00						
SW	0.85*	0.80*	0.68*	0.88*	-0.47	1.00					
SN	0.09	0.00	0.08	0.04	-0.06	0.04	1.00				
BS	-0.02	0.17	0.29	0.08	-0.13	0.13	-0.06	1.00			
DIN	0.65*	0.54*	0.57*	0.60*	-0.89*	0.52*	0.06	0.13	1.00		
ID	0.87*	0.82*	0.70*	0.87*	-0.54*	0.90*	-0.02	0.15	0.58*	1.00	
PS	0.20	0.23	0.29	0.25	-0.09	0.34	0.23	0.28	0.13	0.30	1.00

*: Significant correlation (R> 0.50) at $p<0.05$.

The principal component analysis (PCA) grouped the variables into different components of which the first four explained 85.59% of the total variability (Table 6). The first two components are the most relevant and contributed alone for 66.26% of the total morphological variability. The first factor (PC1) contributes to 54.61%. Variables negatively correlated to PC1 were leaf width (LW), leaf length (LL), stipule length (SL), stem diameter (SD), stem weight (SW), Internodes number (IN) and nodes diameter (ND). Internodes length (IL) is positively correlated to PC1.

In this study, PC1 is important because most of the variables related to the sugarcane performance and to the crop development are well represented. The second component (PC2) contributed to 11.64% of the total variance. Plant height (H) is the only one parameter negatively correlated to it. PC3 and PC4, contributed 9.99% and 9.34% to the total variance respectively and are positively correlated to sucker number (SN) and to bud size (BS). Fig. 3 shows the projection of the accessions analyzed on the plan defined by the two factors PC1 and PC2. Four groups (Fig. 3) were observed. Group1 and group 3 are more represented on factor 1. Accessions of group 1 are positively correlated while accessions of the group 3 are negatively correlated on this first factor. Accession of the group 2 and group 4 are positively correlated to factor 2 (Fig. 3). The group 1 has the largest number of accessions (48 accessions) while group 2 and group C3 gather together 17 and 24 accessions respectively. Group 4 has the lowest number of accessions. Accessions from different agro-ecological zones were grouped in same cluster and have the same performances. Results of this study are similar to those obtained by Adebo et al. (2015) on *Corchorus olitorius* and Gbaguidi et al. (2015) on *Vigna unguiculata*.

Table 6: Eigen vectors and values for the four principal component axes.

Parameters	PC 1	PC 2	PC 3	PC 4
LW	-0.92	0.17	0.13	-0.12
LL	-0.89	-0.01	-0.11	-0.18
LOL	-0.82	-0.16	-0.10	0.05
SD	-0.88	0.08	0.03	-0.20
IL	0.72	-0.24	-0.08	-0.58
SW	-0.91	-0.05	-0.01	-0.30
TN	-0.07	-0.38	0.84	0.15
BS	-0.19	-0.62	-0.56	0.38
NN	-0.76	0.22	0.07	0.53
ND	-0.93	0.01	-0.07	-0.22
PH	-0.33	-0.76	0.14	-0.09
Eigen value	6.00	1.28	1.09	1.02
Value	54.61	11.64	9.99	9.34
Cumulative percentage %	54.61	66.26	76.25	85.59

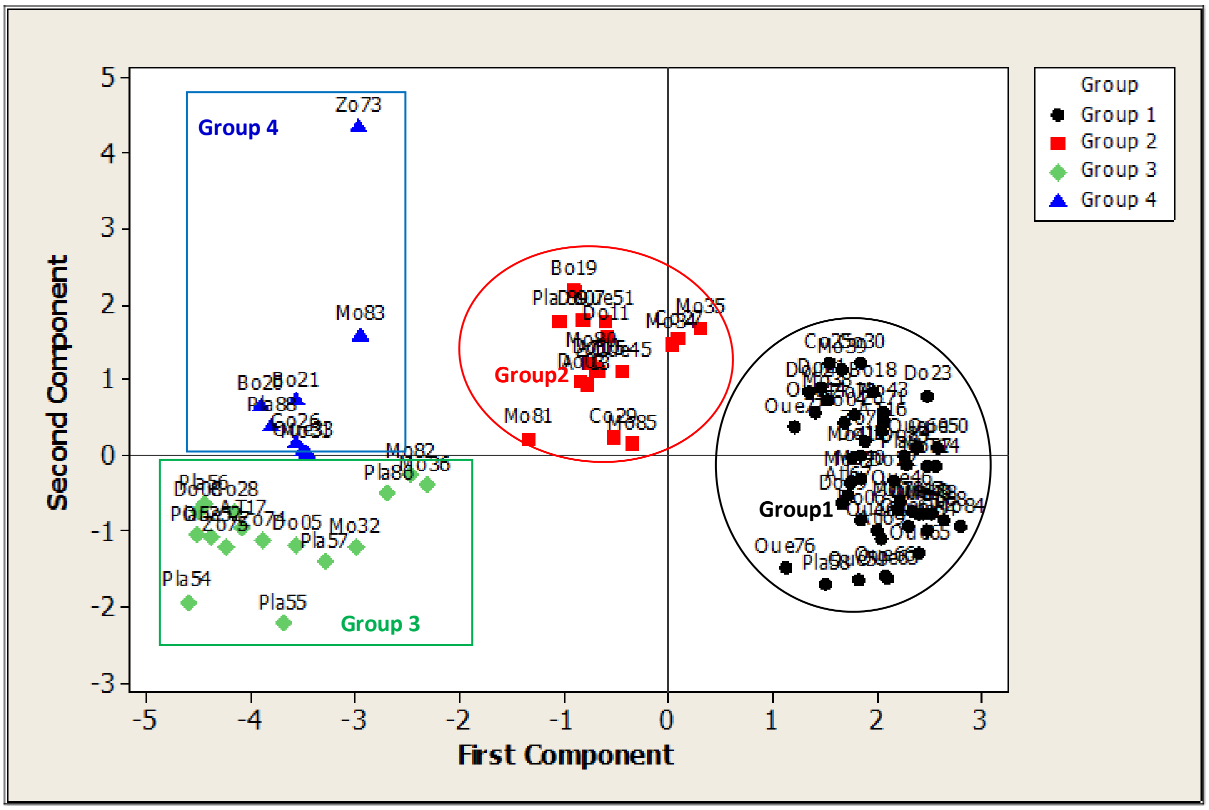


Fig. 3: Grouping of the accessions with principal component analysis using quantitative data.

The performances of each group are presented on Table 7. Accessions of group 1 are characterized by moderate leaf width, length leaf, length of stipule, large diameter of stem, high weight of stem and many internodes. Accessions of the group2 are characterized by the high height of the stem, the large sized buds and the small number of nodes (small). They are highly productive (Table 7). Accessions of group 3 are characterized by long internodes and few nodes. The variability observed in this studied through PCA analysis is an important step in the genetic diversity study as it helps to select accessions to be considered in breeding programs (Sheela and Gopalan, 2006; Lahbib et al., 2012). For instance, crossing between accessions of group 1 and group 2 and between G1 and G3, would lead to respectively sugarcanes with height and big stems and with few nodes. According to Ekpélikpézé et al. (2016a), sugarcane with big stems and few nodes are easy to eat and have more economic value. Moreover the high productivity is one of the important criteria reported by sugarcane farmers. Regarding the characteristics of the different varieties in each group, local accessions need to be improved through crosses to generate high-yielding hybrids that can be promoted as observed on potato sweet (Norman et al., 2014), sorghum (Dossou-Aminon et al., 2015) and cassava (Agre et al., 2015).

Table 7: Variability of quantitative data through the different classes.

Parameters		LL	LW	LS	SD	IL	SW	SN	BS	NI	DIN	PS
Class 1 (48 accessions)	Mean	**8.41***	**1.69***	**6.47***	**4.58***	10.72	**5.04***	3.21	0.70	**9.63***	**4.90***	5.48
	Ecart type	0.49	0.03	0.61	0.47	0.68	0.34	0.44	0.11	0.51	0.39	0.48
	CV %	5.82	1.54	9.42	10.32	6.37	6.84	13.65	15.19	5.31	7.99	8.76
Class 2 (17 accessions)	Mean	6.45	1.58	5.68	3.91	12.06	3.76	3.25	**0.85***	8.91	4.10	5.90
	Ecart type	0.23	0.09	0.63	0.28	2.55	0.62	0.44	0.13	1.42	0.29	0.52
	CV %	3.58	5.93	11.08	7.23	21.16	16.61	13.43	15.49	15.96	6.99	8.86
Class 3 (19 accessions)	Mean	5.52	1.45	4.46	3.02	14.80	2.79	3.12	0.63	7.22	3.18	4.91
	Ecart type	0.66	0.08	0.59	0.41	2.09	0.69	0.52	0.21	1.00	0.37	0.72
	CV %	12.01	5.66	13.21	13.43	14.10	24.73	16.52	33.40	13.82	11.67	14.61
Class 4	Mean	5.72	1.45	4.53	2.97	**16.04***	3.01	**3.46***	0.80	6.66	3.25	**6.04***
(5 accessions)	Ecart type	0.23	0.01	0.10	0.04	1.03	0.20	0.22	0.18	0.50	0.13	0.16
	CV %	9.14	2.5	5.34	3.35	14.43	15.34	14.59	48.07	16.95	9.01	6.21

* Important value of the mean per line.
NB: LL: Length of the leaf; LW: Leaf width; LS: Length of the stipule; SD: Stem diameter; SW: Stem weight; SN: Sucker number; BS: Bud size; NI: Number of internodes; ND: Node diameter; PS: Plant size

Conclusion

The agromorphological characterization of eighty-nine (89) accessions of *Saccharum officinarum* showed that the sugarcane collection analyzed with qualitative and quantitative variables presented high variation. This genetic variability among accessions is an asset to the selection program. With the Principal component analysis, the accessions were grouped into four classes with complementary characters indicating opportunities for improvement and breeding. It is important to use in addition molecular and biochemical markers for better characterization of the accessions.

Conflict of interest statement

Authors declare that they have no conflict of interest.

Acknowledgement

We wish to thank the Laboratory of Biotechnology, Genetic Resources and Animal and Plant Breeding (BIORAVE) of the Faculty of Sciences and Technology of Dassa-Zoumé for financial support. We express our gratitude to Benin sugarcane producers particularly those of Djèrègbé and Sèmè-Podji districts for providing support, supplying samples and useful information during the documentation.

References

Abdelmahmoud, O. A., Ahmed, O., 2012. Correlation pattern among morphological and biochemical traits in relation to tillering capacity in sugarcane (*Saccharum* spp.). Acad. J. Plant Sci. 5(4), 119-122.

Adebo, H. O., Ahoton, L. E., Quenum, F., Ezin, V., 2015. Agro-morphological characterization of *Corchorus olitorius* cultivars of Benin. Annu. Res. Rev. Biol. 7(4), 229-240.

Agre, A. P., Dansi, A., Rabbi, I. Y, Battachargee, R., Dansi, M., Melaku, G., Augusto, B., Sanni, A., Akoegninou, A., Akpagana, K., 2015. Agro morphological characterization of elite cassava (*Manihot esculenta* Crantz) cultivars collected in Benin. Int. J. Curr. Res. Biosci. Plant Biol. 2(2), 1-14.

Akoègninou,A., Van Der Burg, W. J., Van Der Maesen, L. J. G., 2006. Flore analytique du Bénin. Backuys Publishers, Cotonou & Wageningen. 1034p.

Archimède, H., Xande, X., Gourdine, J. L., Fanchone, A., Alexandre, G., Boval, M., Coppry, O., Arquet, R., Fleury, J., Regnier, C., Renaudeau, D., 2011. La canne à sucre et ses co-produits dans l'alimentation animale. Innov. Agronomiq. 16, 165-179.

Bell, M. J., Halpin. N. V., Orange, D. N., Haines, M., 2001. Effect of compaction and trash blanketing on rainfall infiltration in sugarcane soils. Proceedings of the Australian Society of SugarCane Technologists. 23rd Mackay, Queensland, 1-4 May 2001. pp.161-167.

Chavent, M., Kuentz, V., Saracco, J., 2007. Analyse en facteurs: présentation et comparaison des logiciels SAS, SPAD et SPSS. Rev. Modulad. 37, 1-30.

Dossou-Aminon, I., Loko, Y. L., Adjatin, A., Ewédjè, B. K., Dansi, A., Rakshit, S., Cissé, N., Vishnu Patil, J., Agbangla, C., Sanni, A., Akoègninou, A., Akpagana, K., 2015. Genetic divergence in Northern Benin sorghum (*Sorghum bicolor* L. Moench) landraces as revealed by agromorphological traits and selection of candidate genotypes. Scient. World J. Article ID 916476, 10 pages. http://dx.doi.org/10.1155/2015/916476

Edmé, S. J, Miller, J. D., Glaz, B., Tai, P. Y. P., Comstock, J. C., 2005. Genetic contribution to yield gains in the Florida sugarcane industry across 33 years. Crop Sci. 45, 92-97.

Ekpélikpézé O., Loko L.Y, Dansi, A., 2016a. Diversité et évaluation participative des variétés de la canne à sucre (*Saccharum officinarum*) cultivées au Bénin. Int. J. Innov. Scient. Res. 2(2), 25-36.

Ekpélikpézé, O. S., Dansi, A., Agbangla, C., Akoegninou, A., Sanni, A., 2016b. Biochemical characterization of sugarcane varieties cultivated in Benin. Int. J. Curr. Microbiol. Appl. Sci. 5(2), 368-379.

Gbaguidi, A. A., Assogba, P., Dansi, M., Yedomonhan, H., Dansi, A., 2015. Caractérisation agromorphologique des variétés de niébé cultivées au Bénin. Int. J. Biol. Chem. Sci. 9(2), 1050-1066.

Gouy, M., 2012. Historique de l'amélioration de la canne à sucre et état de l'art des recherches en génétique d'association pour le rendement. Congrès sucrier ARTAS/ AFCAS 2012, La Réunion. 15p.

Grivet, L., Arruda, P., 2001. Sugarcane genomics: depicting the complex genome of an important tropical crop. Curr. Opin. Plant Biol. 5, 122-127.

IPGRI (International Plant Genetic Resources Institute), 1994. Annual Report-1993. Rome.

Jangpromma, N., Kitthaisong, S., Lomthaisong, K., Daduang, S., Jaisil, P., Thammasirirak, S., 2010. A proteomics analysis of drought stress-responsive proteins as biomarker for drought-tolerant sugarcane cultivars. Am. J. Agric. Biol. Sci. 6, 89-102.

Kawar, P. G., Devarumath, R. M., Nerkar, Y., 2009. Use of RAPD markers for assessment of genetic diversity in sugarcane cultivars. Ind. J. Biotechnol. 8, 67-71.

Kiebre, Z., Bationokando, P., Kiswendsida, R., Mahamadou, S. N., Zong, J-D., 2015. Caractérisation agromorphologique du caya blanc (*Cleome gynandra* L.) de l'Ouest du Burkina Faso. Int. J. Innov. Appl. Stud. 11(1), 156-166.

Lahbib, K., Bnejdi, F., Gazzah, M., 2012. Genetic diversity evaluation of pepper (*Capsicum annuum* L.) in Tunisia based on morphologic characters. Afr. J. Agric. Res. 7(3), 3413-3417.

Muhammad, S., Farooq, A. K., 2009. Genetic diversity among sugarcane cultivars in Pakistan. Am.-Euras. J. Agric. Environ. Sci. 6(6), 730-736.

Nair, N. V., 2009. Sugarcane Agriculture and Sugar Industry-Current Scenario and Future Prospect. International Training Course on Breeding Sugarcane for Sugar-Industrial Complex, Sugarcane Breeding Institute, Coimabtore. pp.12-16.

Norman, P. E., Beah, A. A., Samba, J.A., Tucker, M. J., Benya, M. T., Fomba, S. N., 2014. Agrophenotypic characterization of sweet potato (*Ipomoea batatas* L.) genotypes using factor and cluster analyses. Agric. Sci. Res. J. 4(2), 30-38.

Pandey, A., Mishra, R. K., Mishra, S., Singh, Y. P., Pathak, S., 2011. Assessment of genetic diversity among sugarcane cultivars (*Saccharum officinarum* L.) using simple sequence repeats markers. J. Biol. Sci. 11(4), 105-111.

Pinto, L., Leite, D., Favero, T., Pastina, M., Garcia, A., Perecin, D., GonÃ§alves, B., Creste, S., Xavier, M., Bidaia, M., 2011. Identification of microsatellites markers associated with yield components and quality parameters in sugarcane. Int. Sugar J. 113, 140-144.

Sheela, M. S., Gopalan, A., 2006. Association studies for yield and its related traits of fodder cowpea in F4 generation. J. Appl. Sci. Res. 2(9), 584-586.

Silva, C. M., Gonçalves-Vidigal, M. C., Filho, P. S. V., Scapim, C. A., Daros, E., Silvério, L., 2005. Genetic diversity among sugarcane clones (*Saccharum* spp.) Acta Sci. Agron. Maringá, 27, 2315-2319.

Singh, A., Pant, D., Korres, N. E., Nizami, A. S., Prasad, S., Murphy, J. D., 2010. Key issues in life cycle assessment of ethanol production from lignocellulosic biomass: challenges and perspectives. Bioresour. Technol. 101(13), 5003-5012.

Small, E., Catling, P. M., 2006. Blossoming treasures of biodiversity: 21. Sugarcane: an old star with a new act. Biodiver. 7(3-4), 37-46.

Sy, O., Amadou, F., Cissé, N., Noba, K. D., Diouf, D., Ndoye, I., Sane, D., Kane, A., Kane, N. A., Hash, T., Haussman, B., Elwegan, E., 2015. Étude de la variabilité agromorphologique de la collection nationale de mils locaux du Sénégal. J. Appl. Biosci. 87, 8030-8046.

How to cite this article:

Ekpélikpézé, O. S., Agre, P., Dossou Aminon, I., Adjatin, A., Dassou, A., Dansi, A., 2016. Characterization of sugarcane (*Saccharum officinarum* L.) cultivars of Republic of Benin. Int. J. Curr. Res. Biosci. Plant Biol. 3(5), 147-156. doi: http://dx.doi.org/10.20546/ijcrbp.2016.305.023