

Assessment of Variability in Sugarcane Genotypes Based on Morphological Traits

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Abstract: This study was undertaken at the experimental fields of SCRI, Mardan, Khyber Pakhtunkhwa-Pakistan during the spring cropping season of 2010-11. Sixteen sugarcane genotypes i.e., MS91CP272, MS94CP15, MS91CP238, MS92CP979, MS99HO391, S97CP288, MS99HO317, RS97N45, MS99HO388, MS99HO675, MS99HO93, S96SP1215, Hoth127, CP89831, Mardan 93 and CP77400 were used in this study. These genotypes represented diverse collection from sugarcane breeding stations including USA, South Africa and Brazil. The aim of the study was to characterize these genotypes on the basis of morphological traits including cane height, cane color, hardness, thickness, leaf color, attitude, leaf shape, ligule size, dewlap color, pith, bud shape, lodging, streaks, wax, tillering, pubescence, growth, maturity, tops and trash. The cluster analysis divided 16 sugarcane genotypes into four different clusters at Euclidean distance of 4.99. Pair wise Euclidean distance ranged from 2.30 to 7.43. The highest Euclidean distance was recorded between genotypes Hoth127 and MS91CP238, while the lowest was recorded between genotypes S96SP1215 and MS99HO93. The cluster-I comprised 25% of the sugarcane genotypes. Common traits in cluster-I genotypes were; medium cane height and leaf shape and no streaks and pubescence. The cluster-II had only one (6.25%) sugarcane genotype and having attributes which were intermediate among other clusters like tall stature, light red cane color, droopy attitude, broad leaf shape, white dewlap color, no pith and streaks, rounded bud shape, self-trash, medium (legule size, lodging and pubescence) and moderate tillering and tops. Genotypes in cluster-III (43.75%) also had attributes intermediate among other clusters. Most of the genotypes of cluster-III possessed medium cane height, green cane color, medium hardness, dark green leaf color, medium leaf size, small legule size, light green dewlap color, no pith and streaks, medium wax, moderate tillering, sparse pubescence, bent type of growth and moderate trashing. Genotype in cluster-IV (25%) commonly possessed small legule size and light red dewlap color. Other traits like medium cane height, white cane color, hard type hardness, thick girth, light green leaf color, pith, late maturity and light tops were displayed by most of the genotypes in this cluster. It was concluded that morphological traits evaluated in this study could be used for varietal identification and selection of desirable genotypes in sugarcane.

Key words: Cluster analysis • Sugarcane genotypes • Morphological traits • Euclidean distance

INTRODUCTION

Sugarcane is botanically called as *Saccharum officinarum* L. with chromosome number $2n = 80$ or $10x = 100-130$. It belongs to the family Poaceae and is a complex aneu-polyploidy hybrid of six different *Saccharum* spp i.e., *S. officinarum*, *S. barberi* ($2n = 81$ to 124), *S. sinensi*

($2n = 111$ to 120), *S. spontaneum* ($2n = 40$ to 128), *S. robustum* ($2n = 60$ to 80) and *S. edule* [1]. It usually propagates a sexually through its vegetative parts, called as setts. The ability to store sucrose in stem cell vacuoles, along with high biomass potential makes sugarcane one of the world's most productive agricultural crop. Sugarcane is grown in tropical and sub-tropical regions

(latitude 35° N and 35° S) of the world in a range of climates from hot dry environments near sea level to cool, moist about 609 meters elevation [2]. It is thought that sugarcane is originated from Asia as East Indonesia/ New Guinea is a particularly rich source of *Saccharum* gemplasm [3].

The important sugarcane growing countries in world are Australia, Cuba, Mexico, India, Brazil, Pakistan, China, Thailand and Philippines. Sugarcane contributes about 70% of the total sugar produced in the world while the remaining 30% is obtained from sugar beet [4]. Different countries produce numerous valuable by-products from sugarcane like alcohol used by pharmaceutical industry, ethanol used as a fuel, bagasse used for manufacturing paper and chipboard and press mud used as a rich source of organic matter and nutrients for crop production.

Sugarcane is an important cash crop of the Pakistan and Pakistan holds a prominent position in the world among the cane producing countries. In cane acreage, it ranks fifth while 15th in cane production. Asia is ranked 1st in the production of sugarcane in the world, followed by Europe. The average Pakistan's sugar yield is about 4 t ha⁻¹, while other sugarcane cultivating countries, having yields of 6 to 13 t ha⁻¹. During 2012-13, the area covered by sugarcane crop in Pakistan was 1124 thousand hectares with cane production of 62472 thousand tons, while the average cane yield was 55.580 t ha⁻¹[5]. During 2011-12, in Khyber Pakhtunkhwa (KPK), the cultivated area under sugarcane crop was 105.90 thousand hectares with cane production of 4684.29 thousand tons while the average cane yield was 44.23 t ha⁻¹ [6].

Morphological traits as markers have considerable utility in plant breeding in germplasm management. They are simple, easy and do not require complicated equipments for their scoring. Scientific classification of plant species depends on morphological traits. In sugarcane breeding, morphological characterization of genotypes, wild species and landraces is essential for breeders to develop sugarcane varieties with superior attributes. The characterization of sugarcane germplasm is based on morphological attributes and growth parameters such as cane weight, amount of trash, weight of tops, leaf sheath and shape, attitude, internode, node and bud, drought index, dewlap, auricle and legule. Morphological characterization is a pre-requisite for the protection of newly developed sugarcane varieties and to maintain the purity and uniformity of the existing varieties. Morphological characterization helps the breeders and researchers for identification of varieties, construction of

phylogenetic tree (relationship) and development of criteria for selection of desirable traits of economic importance. At various international sugarcane research institutes morphological parameters are used for characterization. These include leaf hairs, leaf shape, tillers, cane color, cane attitude, maturity, stature and auricle color and size etc. The objectives of the present studies were to morphologically characterize sugarcane genotypes in the field and to select promising sugarcane genotypes for breeding programs and development of sugarcane varieties with superior attributes.

MATERIALS AND METHODS

This study on morphological characterization comprising qualitative attributes of 16 sugarcane genotypes (Table 1) was conducted at Sugar Crops Research Institute, Mardan (Khyber Pakhtunkhwa, Pakistan) during the spring cropping seasons of 2010-11. Double sets with three buds were used as sowing materials. Plant to plant distance was kept as 90cm. Recommended dose of fertilizer was applied as N (150 Kg ha⁻¹), P (100 Kg ha⁻¹) and K (100 Kg ha⁻¹) from Sulphate of Potash (SOP), Di Ammonium Phosphate (DAP) and Urea as 225.00 kg DAP ha⁻¹ at planting time and 250.00 kg SOP with 125 kg urea ha⁻¹ in May/June. Urea was additionally applied as 125.00 kg ha⁻¹ at the time of earthing up. Data were recorded on 20 morphological qualitative traits. Description of each qualitative trait is given in Table 2. The data were recorded from the central row only in each plot at time of crop maturity. Morphological traits were scored according to the description given by Skinner [7] and Artschwager [8] with modifications for this study regarding growth and habit of sugarcane crop in this area. For classification of cane height, tillering and thickness, the following scale was used.

Cane height			
Less than	120 cm	=	Dwarf
	121-170 cm	=	Medium tall
	171- 220 and above	=	Tall
Tillering			
Less than	140	=	Poor
	141-200	=	Moderate
	201-260 and above	=	Good
Thickness			
Less than	20 mm	=	Thin
	21-22	=	Medium
	23-24 and above	=	Thick

Table 1: List of 16 sugarcane genotypes and their source used for morphological characterization at SCRI, Mardan, during 2010-11.

S.No	Genotypes	Source
1	MS91CP272	USDA-ARS stations at Canal Point, USA
2	MS94CP15	USDA-ARS stations at Canal Point, USA
3	MS91CP238	USDA-ARS stations at Canal Point, USA
4	MS92CP979	USDA-ARS stations at Canal Point, USA
5	MS99HO391	USDA-ARS stations, Houma, Louisiana, USA
6	S97CP288	USDA-ARS stations at Canal Point, USA
7	MS99HO317	USDA-ARS stations, Houma, Louisiana, USA
8	RS97N45	South African Research Institute, Natal (South Africa)
9	MS99HO388	USDA-ARS stations, Houma, Louisiana, USA
10	MS99HO675	USDA-ARS stations, Houma, Louisiana, USA
11	MS99HO93	USDA-ARS stations, Houma, Louisiana, USA
12	S96SP1215	São Paulo (Brazil)
13	Hoth127	USDA-ARS stations, Houma, Louisiana, USA and Sugarcane Research Institute, Thatta
14	CP89831	USDA-ARS stations at Canal Point, USA
15	CP77400 (Check-I)	USDA-ARS stations at Canal Point, USA
16	Mardan93 (Check-II)	USDA-ARS stations at Canal Point, USA

MS: Mardan Selection, Hoth: Houma-Thatta, SP: São Paulo, HO: Houma, N: Natal

USDA-ARS: United States Department of Agriculture-Agriculture Research Service

Table 2: List of morphological qualitative attributes of 16 sugarcane genotypes.

Traits	Classes
1. Cane Height:	i) Tall ii) Medium iii) Dwarf
2. Cane Color:	i) White ii) Yellow iii) Light green iv) Green v) Light red vi) Red vii) Purple
3. Hardness:	i) Soft ii) Medium iii) Hard
4. Thickness:	i) Thick ii) Medium iii) Thin
5. Leaf Color:	i) Light green ii) Green iii) Dark green
6. Attitude:	i) Erect ii) Semi-erect iii) Horizontal iv) Drooping
7. Leaf Shape:	i) Broad ii) Medium iii) Narrow
8. Ligule Size:	i) Small ii) Medium iii) Large
9. Dewlap Color:	i) White ii) Yellow iii) Light Green iv) Green v) Light Red vi) Pubescence
10. Pith:	i) Absent ii) Moderate iii) Pithy
11. Bud Shape:	i) Rounded ii) Ovate iii) Pointed
12. Lodging:	i) Low (Tolerant) ii) Medium iii) High
13. Streaks:	i) Nil ii) Few iii) Moderate iv) Many
14. Wax:	i) Weak ii) Medium iii) Strong
15. Tillering:	i) Poor ii) Moderate iii) Good
16. Pubescence:	i) Sparse ii) Medium iii) Profuse
17. Growth:	i) Upright ii) Inter med iii) Bent
18. Maturity:	i) Early ii) Medium iii) Late
19. Tops:	i) Light ii) Moderate iii) Heavy
20. Trash:	i) Self ii) Moderate iii) Clinging

Statistical Analysis: Cluster analysis was used to determine the genetic diversity among the genotypes. The phenogram was constructed by complete linkage cluster analysis using the SAHN (Sequential, Agglomerative, Hierarchical and Nested) option of statistical software NTSYS-pc 2.2 version [9]. The morphological attributes were standardized by using STAND module prior to cluster analysis. The matrix of average taxonomic distance for individuals and morphological traits was then calculated using SIMINIT function and Euclidean distance coefficient.

RESULTS

The analyzed data for morphological attributes along with frequency of each parameter is shown in Table 3. Considerable variations were manifested for tillering, hardness, thickness, bud shape, legule size, cane height, cane color, pith, dewlap color, attitude, growth, tops and maturity. On the basis of these traits sugarcane breeders easily characterize different genotypes and can therefore, maintain and ensure the purity of breeding material.

Table 3: Frequency distribution of qualitative traits of 16 sugarcane genotypes

Traits	Frequency	Frequency %	Traits	Frequency	Frequency %
Cane Height			Pith		
Tall	3	18.75	Absent	8	50.00
Medium	13	81.25	Moderate	4	25.00
Dwarf	0	0.00	Pithy	4	25.00
Cane Color			Bud Shape		
White	3	18.75	Rounded	3	18.75
Yellow	3	18.75	Ovate	4	25.00
Light green	0	0.00	Pointed	9	56.25
Green	8	50.00	Lodging		
Light red	0	0.00	Low	7	43.75
Red	0	0.00	Medium	9	56.25
Purple	2	12.50	High	0	0.00
Hardness			Streaks		
Soft	1	6.25	Nil	13	81.25
Medium	8	50.00	Few	3	18.75
Hard	7	43.75	Moderate	0	0.00
Thickness			Many	0	0.00
Thick	5	31.25	Wax		
Medium	8	50.00	Medium	9	56.25
Thin	3	18.75	Strong	7	43.75
Leaf Color			Tillering		
Light green	6	37.50	Poor	3	18.75
Green	4	25.00	Moderate	9	56.25
Dark green	6	37.50	Good	4	25.00
Attitude			Pubescence		
Erect	3	18.75	Sparse	11	68.75
Semi- erect	7	43.75	Medium	5	31.25
Horizontal	4	25.00	Growth		
Droopy	2	12.50	Upright	4	25.00
Leaf Shape			Inter mediate	5	31.25
Broad	3	18.75	Bent	7	43.75
Medium	11	68.75	Maturity		
Narrow	2	12.50	Early	6	37.50
Ligule Size			Medium	5	31.25
Small	9	56.25	Late	5	31.25
Medium	6	37.50	Tops		
Large	1	6.25	Light	5	31.25
Dewlap Color			Moderate	8	50.00
White	4	25.00	Heavy	3	18.75
Yellow	1	6.25	Trash		
Light Green	1	6.25	Self	8	50.00
Green	1	6.25	Moderate	8	50.00
Light red	9	56.25	Clinging	0	0.00
Pubescence	0	0.00			

Table 4: Euclidean's distances among 16 Sugarcane genotypes calculated from morphological qualitative data of 2010-11

Genotypes	MS91 CP272	MS94 CP15	MS91 CP238	MS92 CP979	MS99 HO391	S97 CP288	MS99 HO317	RS97 N45	MS99 HO388	MS99 HO675	MS99 HO93	S96 SP1215	Hoth 127	CP89 831	CP77 400
MS94CP15	5.83	0.00													
MS91CP238	5.06	5.05	0.00												
MS92CP979	4.43	5.26	3.95	0.00											
MS99HO391	5.73	5.87	5.29	6.22	0.00										
S97CP288	6.82	6.07	7.01	5.93	5.99	0.00									
MS99HO317	4.97	5.80	2.87	3.91	4.55	6.62	0.00								
RS97N45	5.87	4.31	4.31	4.90	4.98	5.43	5.22	0.00							
MS99HO388	5.78	5.43	6.63	5.22	7.00	3.96	6.93	5.49	0.00						
MS99HO675	6.10	2.62	5.08	5.32	6.30	5.45	5.86	4.39	4.82	0.00					
MS99HO93	6.03	3.72	5.15	5.64	5.26	4.48	5.49	3.98	5.45	3.58	0.00				
S96SP1215	6.25	3.12	5.21	5.90	4.81	5.07	5.27	3.89	6.16	3.38	2.30	0.00			
Hoth127	6.34	5.99	7.43	6.56	6.30	2.95	7.26	5.68	3.11	5.58	5.44	5.69	0.00		
CP89831	6.04	3.56	5.40	5.23	5.31	4.16	5.55	3.82	4.69	3.29	2.80	2.76	4.57	0.00	
CP77400	6.46	4.58	6.49	5.98	6.70	4.32	6.75	5.77	3.93	4.24	5.13	5.07	4.34	4.14	0.00
Mardan93	6.63	3.97	5.44	5.40	5.68	4.53	5.72	3.78	4.70	4.09	3.12	3.68	5.13	3.00	4.22

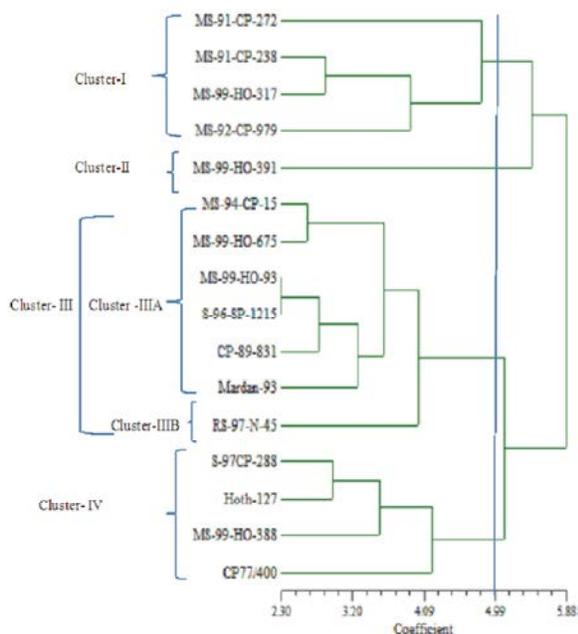


Fig. 1: Dendrogram of genetic relationship among sugarcane genotypes based on morphological qualitative traits.

Cluster Analysis: Among the multivariate statistical techniques, numerical taxonomy is primarily concerned with phenotypic relationships. It was developed in the late 1950s and commonly used in species classification based on morphological attributes [10]. Detail morphological attributes in the present study (categorized sugarcane genotypes using numerical taxonomy) and

these helped to build a profile for each genotype. Cluster analysis using Unweighted Pair Group Method with Arithmetic means showed a general agreement with the four group classification system in the present study. The four traditional groups in the dendrogram revealed that the investigated morphological characters were useful in classifying sugarcane genotypes used in this study.

The results of cluster analysis are presented as phylogenetic tree in Fig.1. Pair wise Euclidean distance ranged from 2.30 to 7.43. The highest Euclidean distance (7.43) was recorded between genotypes Hoth127 and MS91CP238, while the lowest (2.30) between genotypes S96SP1215 and MS99HO93 (Table 4). The cluster analysis classified 16 sugarcane genotypes into four different clusters at Euclidean distance of 4.99. The cluster-I possessed four genotypes MS91CP272, MS91CP238, MS99HO317 and MS92CP979. The genotype MS99HO391 was separately branched into cluster-II. The cluster-III showed intra cluster variations and was further divided into sub-cluster IIIA and sub-cluster IIIB. The sub-cluster IIIA consisted of six genotypes MS94CP15, MS99HO675, MS99HO93, MS-97-SP-1215, CP89831 and MS99HO93 while the sub-cluster IIIB comprised the solitary genotype RS97N45. The cluster-IV was composed of four genotypes S97CP288, Hoth127, MS99HO388 and CP77400.

Characteristics of Genotypes in Each Cluster

Cluster-I: The cluster-I possessed four (25%)sugarcane genotypes. Common traits in this cluster were medium cane height and leaf shape and was devoid of streaks and

pubescence. The rest of attributes were intermediate among other clusters. Most of the genotypes in this cluster possessed medium thickness, light green leaf color, horizontal attitude, medium legule size, white dewlap color, pointed bud shape, tolerance against lodging, good tillering ability, early maturity, moderate tops and self-trashing. Distinctive characteristics of each genotype are given as follows.

MS91CP272: This genotype was characterized by medium cane height, yellow cane color, medium hardness and medium girth, light green leaf color, semi-erect attitude, medium sized of leaf shape, medium size legule, white dewlap color, moderate pith, rounded bud shape, low lodging, no streaks, medium wax, good tillering ability, sparse type pubescence, intermediate growth, medium maturity, moderate tops and self-trash.

MS91CP238: This genotype had medium cane height, green cane color, hard type hardness, thick girth, green leaf color, erect attitude, medium leaf and legule size, white dewlap color, no pith, pointed bud shape, low lodging, no streaks, strong wax, good tillering ability, sparse type pubescence, upright growth, early maturity, moderate tops and trash.

MS99HO317: This genotype had medium cane height, green cane color, hard type hardness, medium girth, light green leaf color, semi-erect attitude, medium leaf shape, large legule size, white dewlap color, no pith, pointed bud shape, moderate lodging, no streaks, strong wax, moderate tillering ability, sparse pubescence, intermediate growth, early maturity, heavy tops and self-trash.

MS92CP979: The genotype MS92CP979 had medium cane height, yellow cane color, medium hardness and thickness, light green leaf color, semi-erect attitude, medium leaf shape and legule size, yellow dewlap color, moderate pith, pointed bud shape, low lodging, no streaks, medium wax, good tillering ability, sparse pubescence, upright growth, early maturity, moderate tops and self-trash.

Cluster-II: This cluster embodied maximum diversity and was separately branched. This cluster was having of only one (6.25%) sugarcane genotype which manifested those attributes which were intermediate among other clusters including, tallness, light red cane color, droopy attitude, broad leaf shape, white dewlap color, no pith and streaks, rounded bud shape, self-trashing, medium (legule size,

lodging and pubescence), moderate tillering and tops. Distinctive characteristics of this genotype are given as follows.

MS99HO391: This genotype had tall cane height, green cane color, hard type of hardness, medium girth, dark green leaf color, horizontal attitude, broad leaf shape, medium legule size, white dewlap color, no pith, rounded bud shape, moderate lodging, no streaks, strong wax, moderate tillering ability, medium pubescence, profuse growth, early maturity, moderate tops and self-trash.

Cluster-III: The cluster-III comprised seven (43.75%) sugarcane genotypes. Most of the genotypes in this cluster possessed medium cane height, green cane color, medium hardness, dark green leaf color, medium leaf size, small legule size, light dewlap color, no pith and streaks, medium wax, moderate tillering, sparse pubescence, bent type of growth and moderate trashing. Distinctive characteristics of each genotype are given as follows.

MS94CP15: This genotype had tall cane height, green cane color, soft type hardness, thin girth, dark green leaf color, erect attitude, medium leaf shape and legule size, green dewlap color, no pith, ovate bud shape, low lodging, no streaks, medium wax, moderate tillering ability, sparse pubescence, upright growth, medium maturity, moderate tops and self-trash.

MS99HO675: This genotype had medium cane height, green cane color, medium hardness, thin girth, green leaf color, erect attitude, medium leaf shape, small legule size, light red dewlap color, no pith, ovate bud shape, low lodging, no streaks, medium wax, moderate tillering ability, medium pubescence, upright growth, medium maturity, heavy tops and moderate trash.

MS99HO93: This genotype had medium cane height, purple cane color, medium hardness, thick girth, green leaf color, horizontal attitude, medium leaf shape, small legule size, light red dewlap color, moderate pith, pointed bud shape, medium lodging, no streaks, medium wax, moderate tillering ability, medium pubescence, bent growth, late maturity, light tops and moderate trash.

MS97SP1215: Genotype had medium cane height, purple cane color, medium hardness, thin girth, dark green leaf color, horizontal attitude, broad leaf shape, medium legule size, light red dewlap color, no pith,

pointed bud shape, medium lodging, no streaks, medium wax, poor tillering ability, sparse pubescence, bent growth, late maturity, heavy tops and moderate trash.

CP89831: This genotype had tall cane height, green cane color, medium hardness and girth, green leaf color, horizontal attitude, medium leaf shape, small legule size, light red dewlap color, no pith, pointed bud shape, medium lodging, no streaks, strong wax, moderate tillering, sparse pubescence, bent growth, medium maturity, moderate tops and trash.

Mardan93: This genotype had medium cane height, green cane color, medium hardness and girth, dark green leaf color, erect attitude, medium leaf shape, small legule size, light red dewlap color, moderate pith, pointed bud shape, medium lodging, few streaks, medium wax, moderate tillering, sparse pubescence, bent growth, early maturity, light tops and self trash.

RS97N45: This genotype had medium cane height, green cane color, hard, medium girth, dark green leaf color, erect attitude, broad leaf shape, small legule size, light green dewlap color, pithy, pointed bud shape, medium lodging, no streaks, strong wax, moderate tillers, sparse pubescence, intermediate growth, early maturity, moderate tops and trash.

Cluster-IV: The cluster-IV comprised four (25%) genotypes. Small legule size and light red dewlap color were the common among all the genotypes of this cluster. Other traits like medium cane height, white cane color, hard type hardness, thick girth, light green leaf color, pith, late maturity and light tops were exhibited by most of the genotypes of this cluster. Distinctive characteristics of each genotype are given as follows.

S97CP288: This genotype had medium cane height, yellow cane color, hard, thick girth, light green leaf color, droopy attitude, medium leaf size, small legule size, light red dewlap color, pithy, pointed bud shape, medium lodging, no streaks, medium wax, poor tillering ability, medium pubescence, bent growth, late maturity, light tops and moderate trash.

Hoth127: This genotype had medium cane height, white cane color, hard and thick girth, light green leaf color, horizontal attitude, medium leaf shape, small legule size, light red dewlap color, pithy, rounded bud shape, medium lodging, few streaks, strong wax, poor tillering, sparse

pubescence, bent growth, late maturity, light tops and moderate trash.

MS99HO388: This genotype had medium cane height, white cane color, hard and thick girth, light green leaf color, semi-erect attitude, narrow leaf shape, small legule size, light red dewlap color, pithy, ovate bud shape, low lodging, few streaks, strong wax, good tillering, medium pubescence, intermediate growth, medium maturity, light tops and self-trash.

CP77400: This genotype had medium cane height, white cane color, soft, medium thickness, dark green leaf color, semi erect attitude, narrow leaf shape, small legule size, light red dewlap color, no pith, ovate bud shape, no lodging, no streaks, medium wax, moderate tillering, sparse pubescence, intermediate growth, late maturity, moderate tops and self-trash.

DISCUSSION

For sugarcane breeders description of various cane varieties through morphological markers is of fundamental importance to ensure purity of sugarcane varieties in the field. In the present study the genotypes showed differences and were therefore, classified into four different clusters on the basis of morphological qualitative traits. Pair wise Euclidean distance ranged from 2.30 to 7.43. The highest Euclidean distance was recorded between genotypes Hoth127 and MS91CP238 which indicated that these genotypes were diverse from each other. The lowest Euclidean distance was recorded between genotypes S96SP1215 and MS99HO93 which showed that these two genotypes had a very narrow genetic background.

In the present study, 62.50% of the genotypes had erected and semi erect attitude while 18.75% of the genotypes had small rounded bud shape. Erect cane attitude, lesser leaves with straight lamina, small round buds and blade joint are essential quality traits that makes the cane variety suitable for mechanical farming and post-harvest handling [11]. In country like Pakistan where most of the growers use manual harvesting, prefer the variety having erect attitude coupled with no pubescence or sparse pubescence. Most of the genotypes (68.75%) had sparse pubescence, which is used as a control measure by resistant host plant (hypersensitive reaction) [12]. The progressive growers even search for more traits like erect attitude, yellow or white color, green leaves, no pubescence, no streaks and lodging. The traits influenced highly by environmental factors are usually of

quantitative nature e.g., size, number and color. These traits have a less contribution in sugarcane varietal identification as compared to stable traits e.g., shape, structure and arrangement of aerial organs [13]. In our study, 25% of genotypes had green leaves. Abubakar *et al.* [12] reported that green leaves of cane variety harvest maximum sunlight during photosynthesis process. Maximum genotypes (56.25%) had wax on cane surface. Piscitelli [14] reported that among the morphological qualitative traits, wax and shapes of the aerial organ are very important because these are not influenced by environmental fluctuations. Hence these can be used in selection process in any cane breeding program.

CONCLUSIONS

Morphological markers have been widely used as genetic markers in sugarcane breeding and germplasm management. These attributes provide peculiar plant distinctions and thus facilitate germplasm categorization. The four group classification system in present studies displayed phenotypic relationships among the sugarcane genotypes. The genotypes MS91CP272, MS91CP238, MS99HO317 and MS92CP979 could be selected on the basis of cane height, tillering ability, early maturity, bud shape, wax, lodging, pubescence, leaf color, cane color, pith, attitude and streaks.

The genotypes clustered for valuable traits could be exploited for crop improvement programs either through selection or hybridization. The genotypes in various clusters exhibited variations for morphological traits. These genotypes can be a part of the future breeding programs to develop improved varieties of sugarcane.

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