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Morphological Characterization and Identification of Morphological Markers for Selected Sugarcane (*Saccharum* spp.) Cultivars

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A B S T R A C T

The variety identification serves the important goals such as mitigating legal claims and confirming intellectual property rights and maintenance of genetic purity. Plant morphological characters are universally adopted descriptors for DUS testing and varietal characterization of crop genotypes. In this study 10 sugarcane cultivars (TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15) were characterized using 27 morphological descriptors. Among the 27 descriptors, width of root band opposite to bud alone was monomorphic, 14 were dimorphic and 12 were found to be polymorphic. Distinct morphological profiles were obtained for four out of ten cultivars. The dendrogram based on UPGMA analysis using DUS characters, grouped ten sugarcane cultivars into two major groups at 43 per cent similarity level. The similarity matrix coefficient ranged from 43 per cent to 63 per cent with an average of 53 per cent.

Introduction

Sugarcane (*Saccharum* spp.) is one of the most important industrial crops in the world. The leading sugarcane producing countries of the world are Brazil, India, China, and Thailand. Cane sugar constitutes around 80 per cent of the total sugar produced in the world and the rest being contributed by beet sugar and other sources such as hydrolyzed starch product. Sugarcane cultivars differ in their agronomic traits like; stalk height, girth and sugar contents due to their genetic makeup and management practices. Different sugarcane cultivars generally resemble each other in their appearance, but each has different morphological characters. Among the characters that are generally influenced by environmental factors are usually quantitative character like size, number and colour, etc. These characters are not as valuable in identifying a variety as are stable characters, like the shape of vegetative organs and arrangement of various floret parts (Grassl, 1956). Many attempts have been made to define the morphological characteristics for identification of different sugarcane cultivars (Barber, 1915; Cowgill, 1917). These characteristics are the size, number and colour of stalks, bud, node and nodal characteristics, ivory markings, splits, bud groove, leaf characteristics, adult root system and

underground branching. A botanical description is a necessity for sugarcane workers to enable them to identify the cultivars in the field. The knowledge of morphology will help in identification and characterization of clones, cultivars, cultivars and related species. The main objective of the present study was to characterize the selected sugarcane cultivars to provide the information about morphological markers that help in the identification of different sugarcane cultivars in the field.

Materials and Methods

Material for varietal identification

In the present study, setts belonging to three sugarcane cultivars from Sugarcane Research Station, Sirugamani (TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8) and seven cultivars from Sugarcane Breeding Institute, Coimbatore (Co 86032, Co 99004, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15) were used for conducting research work.

Study of plant morphological traits and observations recorded

The sets of ten sugarcane cultivars (Table 1) were sown in the field of Agricultural College and Research Institute, Madurai during July 2012. All the recommended agronomic and plant protection measures were adopted for raising a healthy crop. The DUS guidelines of the Protection of Plant Varieties and Farmers' Rights Authority (PPV and FRA), India was used to characterize sugarcane cultivars.

Results and Discussion

In the present study, ten cultivars of sugarcane *viz*., TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15, where characterized using 27 morphological DUS descriptors as prescribed by DUS guidelines of PPV and FR Authority, New Delhi, India. The morphological trait observations were taken at three different stages of crop growth, which were 240 (End of grand growth stage), 300 (Maturity stage) and 360 (Harvest stage) days after planting. Among the 27 descriptors, width of roots band opposite to bud alone was monomorphic, 14 were dimorphic and 12 were found to be polymorphic (Table 2). The dendrogram based on UPGMA cluster analysis using DUS characters, grouped ten sugarcane cultivars into two major Groups at 43 per cent similarity level (Fig. 1). The similarity matrix coefficient ranged from 43 per cent to 63 per cent with an average of 53 per cent. In Group 1, genotype Co 86032 alone formed a separate cluster in the phonogram. In Group 2, there were 2 major subgroups. Sub group 1 contained cultivars TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8 and Co 94012 were genetically close to each other. Sub group 2 included 6 cultivars *i.e.*, TNAU Sugarcane Si. 6, Co 94008, Co 99006, Co 2001-15, Co 99004 and Co 2001-13 showing more genetic similarities.

A botanical description is a necessity for sugarcane workers to enable them to identify the cultivars in the field. The knowledge of morphology will help in identification and characterization of clones, cultivars, cultivars and related species. In the present study, distinct morphological profiles were obtained for four out of ten cultivars that help in the identification of different sugarcane cultivars in the field, *i.e*., erect plant growth habit in Co 99004 (Fig. 2), Smooth Internode rind surface and long lanceolate inner auricle in TNAU Sugarcane Si. 8 (Fig. 3), Tight clasping of leaf sheaths on internodes in Co 2001-13 (Fig. 4) and Light internode waxiness and weak (not swollen) growth ring in Co 86032 (Fig. 5).

Fig.1 Dendrogram depicting the classification of ten sugarcane cultivars constructed through UPGMA method and based on morphological markers

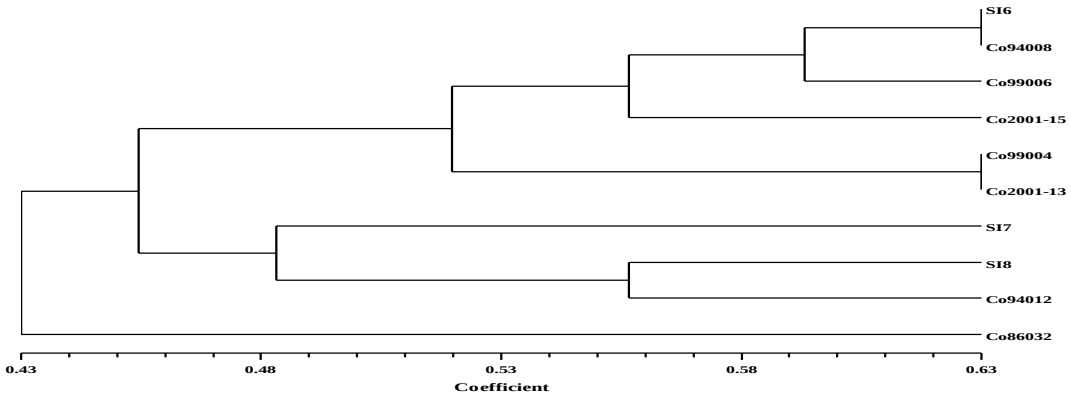


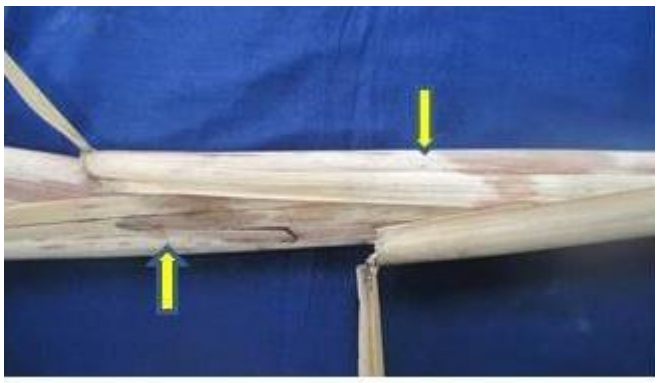
Fig.2 Distinct morphological profile of Co 99004 (erect plant growth habit)

Co 99004

Fig.3 Distinct morphological profile of TNAU Sugarcane Si. 8 (long lanceolate inner auricle and smooth Internode rind surface)

TNAU Sugarcane Si. 8

Fig.4 Distinct morphological profile of Co 2001-13 (tight clasping of leaf sheaths on internodes)



Co 2001-13

Fig.5 Distinct morphological profile of Co 86032 (light internode waxiness and weak (not swollen) growth ring)

Co 86032

Table.1 Sugarcane cultivars subjected to varietal characterization

S. No.	Variety	Parentage	Origin/ Release Center	Duration (Month)
1	TNAU Sugarcane Si. 6	Co 8213 x CoA 7602	Sirugamani	12
2	TNAU Sugarcane Si. 7	Co 99034 x Co.G. 93076	Sirugamani	12
3	TNAU Sugarcane Si. 8	CoC 90063 x Co 8213	Sirugamani	12
4	Co 86032	Co 62198 x CoC 671	SBI	12
5	Co 99004	Co 62175 x Co 86250	SBI	12
6	Co 99006	84 WL 22 x Co 775	SBI	12
7	Co 94008	Co 7201x Co 775	SBI	12
8	Co 94012	Somaclone of CoC 671	SBI	12
9	Co 2001-13	Co 7806 GC	SBI	12
10	Co 2001-15	C0 85002 x Co 775	SBI	12

Table.2 Morphological characterization of sugarcane cultivars based on DUS guidelines

S. No	Characteristics	States	Cultivars	Score
1	**Plant: Growth habit	Erect	Co 99004	1
		Semi-erect	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si 8, Co 86032, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15.	2
2	***Leaf sheath:Hairiness	Absent	TNAU Sugarcane Si. 7, Co 99004 and Co 99006.	1
		Sparse	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 86032, Co 94008 and Co 2001-13.	3
		Dense	Co 94012 and Co 2001-15	5
3	***Leaf sheath: Shape of ligule	Strap-shaped	Co 99004	1
		Deltoid	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7 and Co 94012.	2
		Crescent-shaped	TNAU Sugarcane Si. 8, Co 86032, Co 99006, Co 94008, Co 2001-13 and Co 2001-15.	3
		Arch (bow) shaped	----	4
4	***Leaf sheath: Shape of inner Auricle	Incipient	TNAU Sugarcane Si. 7 and Co 94008	1
		Deltoid	Co 86032, Co 99004, Co 99006 and Co 2001-13.	2
		Dentoid	TNAU Sugarcane Si. 6	3
		Unciform	----	4
		Calcariform	Co 2001-15	5
		Lanceolate	TNAU Sugarcane Si. 8 and Co 94012.	6
		Falcate	----	7
5	***Leaf sheath: Colour of dewlap	Green (PMS 367, 373,374)	Co 2001-13, Co 99004 and Co 86032.	1
		Greenish-Yellow (PMS 381, 387)	Co 2001-15 and TNAU Sugarcane Si. 8	2
		Yellow	----	3
		Yellowish green (PMS 100, 393)	TNAU Sugarcane Si. 6 and TNAU Sugarcane Si. 7	4
		Brown	----	5
		Purple (PMS 224,225,	Co 94008, Co 94012 and Co 99006.	6

		231)		
6	***Leaf blade: Curvature	Erect	TNAU Sugarcane Si. 7 and Co 86032.	1
		Curved tip	Co 99004, Co 2001-13 and Co 2001-15.	2
		Arched	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 99006, Co 94008 and Co 94012.	3
7	**Leaf blade: Width	Narrow (<3.0 cm)	----	3
		Medium (3.0-5.0 cm)	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8 and Co 2001-15.	5
		Broad (>5.0 cm)	TNAU Sugarcane Si. 6, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012 and Co 2001-13.	7
8	***Plant: Adherence of leaf sheath	Weak (self de-trashing)	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012 and Co 2001-15.	3
		Medium (semi clasping)	TNAU Sugarcane Si. 7	5
		Strong (tight clasping)	Co 2001-13	7
9	***Internode: Colour (Not exposed to sun)	Green	----	1
		Green yellow (PMS 380, 381, 382)	Co 2001-15, TNAU Sugarcane Si. 8 and Co 99006.	2
		Green white	----	3
		Yellow (PMS 1205, 382)	TNAU Sugarcane Si. 7 and Co 99004	4
		Yellow green (PMS 122, 379, 394, 395)	Co 94012, TNAU Sugarcane Si. 6, Co 2001-13, Co 86032 and Co 94008.	5
		Yellow white	----	6
		Orange white	----	7
		Greyed green	----	8
		Greyed yellow	----	9
10	***Internode: Colour	Green yellow	TNAU Sugarcane Si. 8	1

	(Exposed to sun)	group (PMS 3822x)		
		Yellow green group (PMS 388, 3965)	TNAU Sugarcane Si. 6 and Co 99004	2
		Yellow group (PMS 396)	Co 99006	3
		Greyed group	----	4
		Brown group (PMS 702, 703)	Co 86032 and Co 2001-15	5
		Purple group (PMS 205, 210, 212, 215)	Co 94012, TNAU Sugarcane Si. 7, Co 2001-13 and Co 94008.	6
11	**Internode: Diameter	Thin (<2.2 cm)	----	3
		Medium (2.2-3.0 cm)	TNAU Sugarcane Si. 6, Co 99004, Co 2001-13 and Co 2001-15.	5
		Thick (>3.0 cm)	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032, Co 99006, Co 94008 and Co 94012.	7
12	**Internode: Shape	Cylindrical	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 99004, Co 99006, Co 2001-13 and Co 2001-15.	1
		Tumescent	---	2
		Bobbin shaped	----	3
		Conoidal	Co 86032, Co 94008 and Co 94012.	4
		Obconoidal	----	5
		Curved	----	6
13	**Internode: Zig zag alignment	Absent	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032 and Co 94012.	1
		Present	TNAU Sugarcane Si. 6, Co 99004, Co 99006, Co 94008, Co 2001-13 and Co 2001-15.	9
14	**Internode: Growth crack (Split)	Absent	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 99004, Co 99006, Co 94008, Co 94012 and Co 2001-13.	1

		Present	TNAU Sugarcane Si. 6, Co 86032 and Co 2001-15.	9
15	***Internode: Rind surface appearance	Smooth	TNAU Sugarcane Si. 8	1
		Corky patches only	TNAU Sugarcane Si. 6, Co 99004, Co 99006, Co 94012, Co 2001-13 and Co 2001-15.	2
		Ivory marks only	TNAU Sugarcane Si. 7	3
		Corky patches and ivory marks present	Co 86032 and Co 94008	4
16	***Internode: waxiness	Light	Co 86032	3
		Medium	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 99006, Co 94012 and Co 2001-15.	5
		Heavy	Co 99004, Co 94008 and Co 2001-13.	7
17	***Node: shape of bud	Ovate	TNAU Sugarcane Si. 6, Co 86032, Co 99004, Co 99006, Co 94008 and Co 2001-15.	1
		Obovate	----	2
		Oval	Co 94012	3
		Round	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8 and Co 2001-13.	4
		Pentagonal	----	5
		Rhomboid	----	6
		Rectangular	----	7
		Triangular pointed	----	8
		Beaked	----	9
18	**Node: Size of bud (Measured from base of bud to the tip)	Small (6 mm or less)	----	3
		Medium (6-9 mm)	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012 and Co 2001-15.	5
		Large (9 mm or more)	TNAU Sugarcane Si. 8 and Co 2001-13	7
19	**Node: Bud groove	Absent	TNAU Sugarcane Si. 7, Co 86032, Co 99004, Co 94012, Co 2001-13 and Co 2001-15.	1
		Shallow	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 99006 and Co 94008.	3
		Deep	----	5

20	**Node: Bud cushion (Space between bud base and leaf scar)	Absent	TNAU Sugarcane Si. 7, Co 94008, Co 94012 and Co 2001-13.	1
		Present	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 99006 and Co 2001-15.	9
21	***Node: Bud tip in relation to growth ring	Below growth ring	TNAU Sugarcane Si. 7	1
		Touching the ring	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 94008, Co 94012, Co 2001-13 and Co 2001-15.	3
		Above growth ring	Co 99006	5
22	**Node: Prominence of growth ring	Weak (Not swollen)	Co 86032	1
		Strong (Swollen)	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 99004, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15.	9
23	*Node: Width of root band (Opposite to bud)	Narrow	----	3
		Medium	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 99006, Co 94008, Co 94012, Co 2001-13 and Co 2001-15.	5
		Broad	----	7
24	**Internode: Cross section	Round	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 99004, Co 94008, Co 94012, Co 2001-13 and Co 2001-15.	1
		Oval	Co 86032 and Co 99006	2
25	**Internode: Pithiness	Absent	TNAU Sugarcane Si. 7, Co 86032, Co 99006, Co 2001-13 and Co 2001-15.	1
		Present	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 8, Co 99004, Co 94008 and Co 94012.	9
26	**Plant: Number of millable canes (NMC) per stool	Low (<3.0)	-----	3
		Medium (3.0-5.0)	TNAU Sugarcane Si. 6, TNAU Sugarcane Si. 7, Co 99004, Co 99006, Co 94008, Co 2001-13 and Co 2001-15.	5
		High (5.1-7.0)	TNAU Sugarcane Si. 8, Co 86032 and Co 94012.	7
		Very high (>7.0)	----	9
27	**Plant: Cane	Short	----	3

	height	(<1.75 m)		
		Medium (1.75-2.5 m)	TNAU Sugarcane Si. 6, Co 99006, Co 94008 and Co 2001-15.	5
		Tall (2.6-3.25 m)	TNAU Sugarcane Si. 7, TNAU Sugarcane Si. 8, Co 86032, Co 99004, Co 94012 and Co 2001-13.	7
		Very tall (>3.25 m)	----	9

* Monomorphic, ** Dimorphic, ***Polymorphic

Cuenya and Mariotti (1984) considered canes that deviate from erectness by more than 60 degrees as not acceptable. Elahi and Ashraf (2001) characterized six sugarcane varieties using three types (ascending transitional, dentoid and deltoid) of inner auricle. Auricle presence was used for classification of rice varieties by Singh *et al.,* (2004) and Madhavilatha and Suneetha (2005). Sankaranarayanan *et al.,* (1986) recognized sheath as loose, medium and tight sheath.

Swollen type of growth ring was also recorded by Akhtar *et al.,* (2006) in GT-1, GT-7, GT-11 and F-134, and Elahiand Ashraf (2001) in CP84-1198, CP85-1491, CP88-1165, CP89-846, TCP86-3368 and CP77-400. Artschwager and Brandes (1958) described growth ring as a narrow zone separating the roots band from the internode above and it runs horizontally but often curves slightly upward above the bud. Chandran (2011) observed the rind wax was very prominent in eight clones among fifteen observed by him.

Almeida and Crocorno (1994a) also stated that the width of the medium leaf blade, dewlap shape, ligule and sheath auricles are the outstanding characters of value for identification of different sugarcane cultivars. Pisdtelli (1994) reported that the most important exomorphological characteristics of sugarcane varieties are shape, colour and wax of aerial organs. Almeida and Crocorno (1994b) reported that the most outstanding, organographic characters of the sugarcane stalk were the bud shape.

It can be inferred from the present study morphological characters called, descriptors for sugarcane were presented for identification of 10 cultivars and distinct morphological markers were identified for sugarcane cultivars. This could be useful for identification of cultivars in the field.

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