RESEARCH ARTICLE

SCREENING OF SUGARCANE GERMPLASM FOR TRAITS RELATED TO DIVERSIFIED USES

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Abstract: Sugarcane has diversified uses; apart from sugar and jaggery extraction, it is being used for cogeneration and ethanol production. Germplasm is the basic raw material with repository of beneficial traits. Constant evaluation and characterization of the existent, yet uncharacterized germplasm is useful and is the cornerstone for the development of new and better varieties. A systematic study was conducted to evaluate one hundred and thirty one germplasm accessions including four checks for quality and yield attributes. All the varieties varied greatly for different traits. Germplasm accessions possessing traits related to diversified uses were grouped and elucidated. The accessions; 2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36 and 2006T3 were found to possess characters that are considered for promotion of varieties for improving cane and CCS production and the accessions; 85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73, and 2005T89 were observed as reservoirs for production of promising sugarcane varieties suitable for cogeneration and paper making purpose. The genotypes, 2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52 and 2004T68 can be exploited in breeding programmes for production of ethanol efficient varieties.

Keywords: Sugarcane, Germplasm, Cogeneration, Paper making, Ethanol

INTRODUCTION

Sugarcane (*Saccharum spp.*) is an important food crop of the tropics and subtropics accounting for 62 per cent of world sugar production. It is a major source of byproducts which provide raw material for cogeneration, ethanol, pulp and paper production. Approximately 70% of the world's sugar supply in the form of sucrose comes from sugarcane. Sugarcane bagasse (fibrous residue) is the primary fuel source used in boilers, making most sugarcane mills energy self-sufficient. Some mills also generate electricity (referred to as co-generation) and sell the excess to public utilities. It is estimated that about 5000 MW of power can be generated from sugar mills in India as against 2200 MW with the use of energy canes with high fiber. The production of biofuel from sugarcane is seen as one of the best currently available options because it has a significantly higher energy conversion ratio than most other biofuel feed stocks, up to 1:8. National policy to scale up blending of ethanol from current 5% to 20% by 2017 requires about 4400 million liters ethanol as against the current production of 2170 million liters. Hence breeding programmes should integrate traits such as high fiber, high biomass and high total sugars in addition to cane yield and sucrose yield. Germplasm is the basic raw material where diversity of traits prevails and can be exploited for production of superior lines suitable for diversified uses. The present study focused on screening and grouping of sugarcane germplasm accessions for diversified uses and using them as parents in breeding programmes.

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MATERIAL AND METHOD

One hundred and thirty one germplasm accessions including four checks viz., 2003V46, Co6907, Co7219 and Co86032 were evaluated during 2012-13 at Agricultural Research Station, Perumallapalle, with plot size of 6m× 2R × 0.9m = 10.8 m^2 in augmented design II. Recommended package of practices were adopted to raise a healthy crop. Necessary prophylactic measures were taken to safeguard the crop from pests and diseases. The germplasm accessions were evaluated for quality and yield attributes viz., single cane weight, percentage of flowering, sucrose %, brix %, Commercial Cane Sugar %, fibre %, juice extraction %, cane yield and Commercial Cane Sugar yield. Single cane weight was derived by averaging the weight of 10 canes harvested randomly from each accession in the plot at the time of maturity. Brix per cent in juice was estimated by taking a sample of 100 ml of crushed juice for each entry after straining through a fine muslin cloth followed by measuring with brix hydrometer. Sucrose percentage was obtained by direct polarisation of the undiluted juice after clarification with 3 to 4 gm of dry lead subacetate with the help of polariscope. The polarisation reading was then converted into per cent of sucrose using Schmitz's tables (Hawaiian Sug. Tech. Association, 1931).

The Commercial cane sugar (%) was estimated from the following formula:

CCS% = 1.05 (S) – 0.3 (B), Where S = Sucrose % and B = Corrected Brix in juice

Fibre content was estimated from six randomly selected canes harvested at 360 DAP. They were

further sub-sampled to include top, middle and bottom portion from each cane. Cane was split vertically and the split cane was cut into small bits of 1cm length. All the bits of cane were pooled and 250g of fresh cut cane sample was taken for analysis. The sample was transferred to the bowl of the Rapipol extractor and 2 litres of water was added to the bowl. The motor was run for 5 minutes so that the cane bits were sheared into fibre. The contents of the bowl were then transferred to a muslin cloth filter and the fibrous material was washed in running water under the tap till the material was free from juice and dissolved solids. Then the fibre from the filter was transferred to a previously weighed cloth bag and the water was squeezed out. The contents of the bag were dried in an oven at 100^0C and then dry weight of the sample with bag was recorded. Fibre content was calculated as per the formula given by Thangavelu and Rao (1982).

Fibre content (%) = $\frac{A-B}{C} \times 100$

where,

A = Dry weight of bag + bagasse after drying (g)

B = Dry weight of bag alone (g)

C = Fresh weight of cane (g)

The juice extraction percentage (%) was obtained by extracting the cane juice by crushing in a three roller power operated crusher and is worked out as given below:

$$\text{Juice extraction per cent} = \frac{\text{Juice weight}}{\text{Cane weight}} \times 100$$

For cane yield (t ha^{-1}) the weight of canes in net plot after detrashing and detopping just below the spindle was recorded utilising the Avery platform balance and the value was converted to tons per hectare. Commercial Cane Sugar yield (t ha^{-1}) was estimated as per the formula,

$$\text{CCS (t ha}^{-1}\text{)} = \frac{\text{CCS \\%} \times \text{Cane yield (t ha}^{-1}\text{)}}{100}$$

RESULT AND DISCUSSION

All the germplasm accessions showed significant variation for the traits under study (Table 1). They were evaluated along with checks for the traits under study and an exercise was made for grouping the genotypes based on their per se performance related to diversified uses *viz*., high fibre percentage, low sucrose percentage, low CCS percentage, high juice extraction percentage, high single cane yield and cane yield per hectare.

Single cane weight showed significant variation among the genotypes (Table 1). The range varied from 0.4 to 1.8 kg. Among the genotypes, single cane weight with more than 1.5 kg was recorded in 24 genotypes. The genotypes *viz*., 2002V48, 2003T129, CoA7602, 92A326 and 92A10 recorded the highest single cane weight (1.8 kg) and the lowest single cane weight was observed in genotype SES594 (0.4kg) followed by BO91 and CoS767 with 0.7 kg (Table 2). Ravishankar *et al*. (2004) reported that a high positive association was present between number of tillers per plant and single cane weight and selection of clones based on these traits will be effective in improving the cane yield.

Out of 131 genotypes, 10 showed presence of flowering and 121 genotypes showed absence of flowering (Table 2). The genotypes which showed flowering were CoS8346 (20.93%), Co38436 (26.82%), 2006T33 (16.36%), 2006T23 (18.75%), 2006T19 (37.16%), 95V221 (7.01%), 95V72 (20%), 97R267 (23.52%), 97R424 (28.12%) and 93R217 (35.20%). The highest percentage of flowering was recorded in the genotype 2006T19 (37.16%) followed by 93R217 (35.20%). Singh (1980) reported that sucrose content in cane reduced especially when there was a high percentage of flowering. Miah and Sarkar (1981) observed that the fresh weight of non-flowered stalks was superior over the flowered ones. Hes (1951) reported that flowering reduced the purity of the juice. So in selection of genotypes for high sucrose % and high single cane weight, due importance should be given for non - flowering nature of selections.

Variation for sucrose among genotypes was significant (Table 1) and it ranged from 10.1 to 19.04 per cent (Table 2). The genotypes with <16.5 per cent of sucrose were observed to be 47 and >18% to be 15. Among the genotypes, the highest sucrose percent was recorded in 94V101 and 97R183 with 19.04 per cent followed by 95V74 (18.99%) and 93A145 (18.79%). The least percentage of sucrose was observed in the genotype SES594 (10.1%) followed by 95V303 (13.52%) (Table 2). Genotypes with low sucrose percent are preferred for cogeneration and pulp.

The range for brix per cent was from 14.32 to 20.48 per cent (Table 2) which was a significant variation among the genotypes (Table 1). Among the genotypes more than 20 per cent brix was recorded in 19 genotypes. The genotype 95V74 recorded the highest brix per cent (20.48%) followed by 88A189 (20.38%), 97R272, 86V96, 93A145, 2005T50 each with 20.36 per cent and the lowest brix per cent was observed in genotype SES594 (14.32%) followed by 95V303 (14.88%), 94V108, 94V104 and 95V72 each with 15.88%. Deep *et al*. (2004), Kadian and Mehla (2006) also classified the genotypes by utilising this characteristic. Kadian and Mehla (2006) reported positive and significant association among brix per cent, purity per cent and CCS per cent. Genotypes with high brix per cent are preferred for commercial cane cultivation as it has positive association with commercial cane sugar yield.

Commercial Cane Sugar (CCS) percentage showed significant variation among the genotypes (Table 1). Genotypes ranged from 6.15 to 13.57 percent for CCS percentage (Table 2). Genotypes with <11 percent of commercial cane sugar percentage were 34 and 38

with >12%. Among the genotypes, the highest CCS percent was recorded in 97R183 (13.57%) followed by 95V74 (13.42%) and 93A145 (13.26%). The least percentage of CCS was observed in SES594 (6.15%) followed by 95V303 (9.47%) and 97R395 (9.67%) (Table 2).

Significant variation among the genotypes was observed (Table 1) for fibre percentage which was ranging from 9.0 to 27.80 per cent. A total of 20 genotypes possessed high fibre percentage (>16%). Among the genotypes, the highest fibre percent was recorded in SES594 (27.80%) followed by 94A73 (18.48%) and 2005T89 (17.92%). The least percentage of fibre was observed in 2004A107 (9.0%) followed by CoC671 (10.32%) and 90A278 (10.40%) (Table 2). Kadian and Mehla (2006) used fibre percentage for grouping and classification of genotypes useful for cogeneration. Babu *et al.* (2009) observed a significant positive correlation between rind hardness and fibre content and advocated that it was beneficial for selection of erect and non-lodging canes suitable for mechanical harvesting and feedstock for co-generation. Radhamani *et al.* (2012) opined that high fibre sugarcane clones with optimum sugar and yield could be exploited for co-generation.

Cane yield showed significant variation among the genotypes (Table 1). Genotypes ranged between 62.5 and 173.76 t ha^{-1}. There were 110 genotypes which produced more than 100 t ha^{-1} cane yield. Among them, 93A53 (173.76 t ha^{-1}) followed by 2005T16 (166.4 t ha^{-1}), 2006T33 (165.12 t ha^{-1}) and 81V48 (157.5 t ha^{-1}) showed higher cane yields in comparison to the check varieties *viz*., 2003V46 (153.9 t ha^{-1}), Co6907 (101.64t ha^{-1}), Co7219 (118.83 t ha^{-1}) and Co86032 (128.44 t ha^{-1}) (Table 2). The lowest cane yield was recorded by CoS8346 (62.5 t ha^{-1}) followed by Co364 (75 t ha^{-1}), Co1148 (78 t ha^{-1}), 97R167 (82 t ha^{-1}), 87A298 (82.17t ha^{-1}) and 97R62 (82.42 t ha^{-1}). Rakkiyappan and Pandiyan (1992) opined that a variety meant for cogeneration purpose should contain high cane yield.

Significant variation among the genotypes was observed for juice extraction percentage among 115 genotypes (Table 1). The range for juice extraction percentage was from 31.5 to 72.9 per cent. Among the genotypes, 2004A103 (72.9%) followed by 2004T68 (70%), 95V221 (66.6%) and 97R424 (65.7%) recorded higher juice extraction percentage when compared to check varieties viz., 2003V46 (54.9%), Co6907 (53.3%), Co7219 (53.49%) and Co86032 (51.4%) (Table 2). The lowest juice extraction percentage was recorded by the genotype, SES594 (31.5%) followed by Co975 (37%), 94A73 (40.24%) and 2004A63 (40.7%). Rakkiyappan and Pandiyan (1992) and Radhamani *et al.* (2012) concluded that a variety meant for ethanol production should contain high juice extraction percent. Rao *et al.* (2007) reported that new multipurpose cane varieties with very high fibre content were found to produce more biomass per hectare and a wide range of brix values when compared to the traditional sugarcane varieties. High fibre multipurpose cane varieties with acceptable levels of fermentable sugars would extend the supply of bagasse and contribute to fuel ethanol production. Babu *et al.* (2009) conducted an experiment to ascertain whether the rind hardness of cane can be used as an index for fibre content in sugarcane and concluded that there was a significant positive correlation between rind hardness and fibre content which is beneficial for selection of erect non lodging canes suitable for mechanical harvesting and feedstock for co-generation. In order to support cogeneration and ethanol production there is need for developing varieties capable of high biomass with high fibre content and higher total sugars (Govindaraj, 2009).

Based on the review of literature an exercise was made to identify genotypes showing combination of all these traits useful for diversified uses such as commercial cane cultivation for cane and CCS yield, for cogeneration and for ethanol production (Table 3). Apart from cane and CCS yields, high sucrose percentage, absence of leaf sheath hairiness, easy or medium detrashing, small to medium sized bud, absence of splits, absence of pithiness and absence of flowering are the important characters which decide the acceptance of farmers for commercial cultivation of a variety. The genotypes 2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36 and 2006T3 were found to possess all these characters that are considered for promotion of varieties for improving cane and CCS production.

Similarly high fibre percentage, low sucrose percentage, low CCS percentage and high cane yield are the important characters for a genotype suitable for cogeneration, pulp and paper making. It was observed that the genotypes 85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73 and 2005T89 possess the aforesaid characters and can be considered as high biomass types useful for cogeneration, pulp and paper making.

A variety suitable for production of biofuel, ethanol should have high juice extraction percentage, high cane yield, high sucrose percentage, high CCS yield, absence or sparse leaf sheath hairiness, easy or medium detrashing, small to medium sized bud, absence of pithiness and absence of flowering. The genotypes, 2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52 and 2004T68 can be considered for production of ethanol as they have all the characters contributing to high ethanol production.

CONCLUSION

Identification and development of the canes for ethanol production, cogeneration, pulp and paper making augments economic prosperity of sugar

industries. Canes with traits useful for diversified uses are suitable for allied uses in sugar industry. Among 131 germplasm accessions maintained at Agricultural Research Station, Perumallapalle, 8 accessions showed a combination of traits suitable for commercial cane cultivation, 11 for cogeneration, pulp making purpose and 8 for ethanol production. These genotypes can be better exploited in breeding programmes for generation of new promising lines suitable for commercial cultivation, ethanol production, cogeneration and paper making purposes along with other traits desirable by the farmers and industry.

Table 1. Analysis of variance for traits related to cogeneration and pulp in sugarcane using Augmented design II

S. No.	Character	Mean Squares				Mean	C.D
		Block df = 2	Entries df = 114	Checks df = 3	Error df = 6		
1	Single cane weight (kg)	0.0175	0.069**	0.020	0.017	1.33	0.45(5)
2	Sucrose (%)	0.7252	2.059**	0.048	0.210	16.66	1.58(5)
3	Brix (%)	0.5963	1.960*	1.900	0.367	18.46	2.09(5)
4	CCS (%)	0.1517	1.172**	0.050	0.016	11.62	0.44(5)
5	Fibre (%)	0.2514	4.610**	1.530	0.313	14.04	1.93(5)
6	Juice extraction (%)	4.0674	37.710**	12.130	0.317	54.29	1.94(5)
7	Cane yield (t ha^{-1})	70.4680	507.190**	599.850	51.210	126.13	24.76(5)
8	CCS yield (t ha^{-1})	0.0777	9.736**	21.410	0.211	14.69	1.59(5)

*Significant at 5% level **Significant at 1% level

Table 2. Characterization of 131 sugarcane germplasm accessions for important characters

S.No.	Clone	Co7508	90A272	93A145	99V30	2000V59	83R23	93R44
1	**Single cane weight (Kg)**	1.72	1.2	1.5	0.9	1.4	1.2	1.2
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.8	15.75	18.79	14.68	16.04	16.35	17.09
4	**Brix %**	20.26	18.56	20.36	16.16	17.76	17.26	20.16
5	**CCS %**	12.28	10.67	13.26	10.28	11.21	11.67	11.57
6	**Fibre %**	12.44	12.56	12.32	13.92	14.2	14.48	15.32
7	**Juice extraction %**	55.94	50.44	60.3	56.56	49.79	51.89	58.89
8	**Cane yield (tha^{-1})**	149.98	125.52	150.6	101.25	131.25	127.3	101.23
9	**CCS yield (tha^{-1})**	18.42	13.39	19.97	10.41	14.71	14.86	11.71
S.No.	**Clone number**	**Co85004**	**Co94008**	**Co2001-13**	**Co2001-15**	**Co7219**	**CoT8201**	**83V15**
1	**Single cane weight (Kg)**	1.7	1.5	1.5	1.6	1.4	1.6	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17	16.95	16.73	15.82	17.61	17.88	16.97
4	**Brix %**	17.96	18.66	18.36	17.36	19.56	19.16	18.36
5	**CCS %**	12.13	11.87	11.73	11.1	12.29	12.68	11.98
6	**Fibre %**	14.36	14.36	13.32	13.68	14.6	13.56	13.68
7	**Juice extraction %**	55.5	49.2	54.9	43.72	53.49	53.96	52.1
8	**Cane yield (tha^{-1})**	147.56	150.15	142.05	144.8	118.83	147.2	129.36
9	**CCS yield (tha^{-1})**	17.9	17.82	16.66	16.07	14.6	18.66	15.5
S.No.	**Clone number**	**2002V48**	**85R186**	**97R401**	**97R272**	**97R129**	**97R383**	**Co86032**
1	**Single cane weight (Kg)**	1.8	1.2	1.6	1.4	1.2	1.6	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.97	14.68	15.8	18.27	16.99	14.66	17.82
4	**Brix %**	18.36	16.06	17.76	20.36	18.06	16.46	19.96
5	**CCS %**	11.98	10.32	10.96	12.73	12.09	10.18	12.39
6	**Fibre %**	14.36	17.72	14.84	13.84	13.64	17.64	14.72
7	**Juice extraction %**	58.6	50.5	54.85	62	51.25	52.1	51.4
8	**Cane yield (tha^{-1})**	138.24	119.81	111.87	118.16	100.32	128.48	128.44
9	**CCS yield (tha^{-1})**	16.56	12.36	12.26	15.04	12.13	13.08	15.91
S.No.	**Clone number**	**Co99004**	**2003T129**	**81V48**	**2002A192**	**97A44**	**92A355**	**92A38**
1	**Single cane weight (Kg)**	1.5	1.8	1.5	1.4	1.2	1.3	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.33	18.11	-	-	-	-	-
4	**Brix %**	20.06	20.16	-	-	-	-	-
5	**CCS %**	11.86	12.62	-	-	-	-	-
6	**Fibre %**	12.44	16.56	15.44	14.64	13.72	12.44	11.48

7	**Juice extraction %**	63.72	53.51	-	-	-	-	-
8	**Cane yield (tha^{-1})**	125	131.04	157.5	124.04	122.76	115.44	138.32
9	**CCS yield (tha^{-1})**	14.82	16.54	-	-	-	-	-
S.No.	**Clone number**	**90A278**	**92A54**	**CoS8346**	**BO91**	**BARAGUA**	**KHAKAI**	**81V99**
1	**Single cane weight (Kg)**	1.3	1.4	1	0.7	0.9	1	1.6
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	-	17	15.32	15.35	17.2	-	16.9
4	**Brix %**	-	18.38	18.12	17.12	18.52	-	19.32
5	**CCS %**	-	12	10.37	10.69	12.17	-	11.64
6	**Fibre %**	10.4	15.32	13.12	16.36	10.84	15.52	12.56
7	**Juice extraction %**	-	45.8	58.2	52	53.26	-	53.75
8	**Cane yield (tha^{-1})**	107.85	140.7	62.5	108	110	-	100
9	**CCS yield (tha^{-1})**	-	16.88	6.48	11.54	13.38	-	11.64
S.No.	**Clone number**	**97A85**	**SES594**	**Co6907**	**84A125**	**CoA7602**	**CoC671**	**Co7717**
1	**Single cane weight (Kg)**	1.5	0.4	1.1	1.2	1.8	1.4	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.36	10.1	17.46	16.74	16.72	17.36	15.53
4	**Brix %**	19.72	14.32	18.32	18.12	18.42	19.72	18.12
5	**CCS %**	11.98	6.15	12.49	11.82	11.72	11.98	10.58
6	**Fibre %**	15.04	27.8	13.96	13.6	12.44	10.32	12.36
7	**Juice extraction %**	53.7	31.5	53.3	58.8	58.12	47.9	56.07
8	**Cane yield (tha^{-1})**	93.75	83.3	101.64	114.36	153	110.12	92.4
9	**CCS yield (tha^{-1})**	11.23	5.12	12.69	13.52	17.93	13.19	9.78
S.No.	**Clone number**	**Co975**	**Co1148**	**Co997**	**Co419**	**Co62399**	**Co364**	**Co38436**
1	**Single cane weight (Kg)**	1.4	1.2	1.5	1.6	1.4	0.9	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	PRESENT
3	**Sucrose%**	15.34	17.21	18.13	15.16	14.46	17.87	17.42
4	**Brix %**	17.32	18.42	19.12	16.72	16.42	19.32	18.82
5	**CCS %**	10.62	12.21	12.94	10.62	10.69	12.62	12.31
6	**Fibre %**	12.84	13.76	15.72	12.08	11.28	15.76	13.6
7	**Juice extraction %**	37	63	58.33	57.1	55	54.6	55.5
8	**Cane yield (tha^{-1})**	87.5	78	97.5	138.4	136.08	75	104.16
9	**CCS yield (tha^{-1})**	9.29	9.52	12.61	14.7	14.54	9.46	12.82
S.No.	**Clone number**	**CoS767**	**2003V46**	**2004A75**	**2004A63**	**2004A55**	**2004A107**	**2004A103**
1	**Single cane weight (Kg)**	0.7	1.5	1.2	1.3	1.3	1.4	1.5
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.04	18.29	-	17.6	15.51	16.54	16.52
4	**Brix %**	17.82	20.12	-	20.12	18.52	17.92	17.92
5	**CCS %**	11.19	12.82	-	12.12	10.44	11.68	11.65
6	**Fibre %**	14.48	12.04	14.6	13.68	14.08	9	12.4
7	**Juice extraction %**	50	54.9	-	40.7	53.8	50	72.9
8	**Cane yield (tha^{-1})**	87.5	153.9	111.6	104.65	136.5	145.88	153.6
9	**CCS yield (tha^{-1})**	9.79	19.73	-	12.68	14.25	17.04	17.89
S.No.	**Clone number**	**2004A82**	**2006T34**	**2006T33**	**2006T10**	**2006T35**	**2006T13**	**2006T18**
1	**Single cane weight (Kg)**	1.4	1.2	1.6	1.2	1	1.5	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	15.32	15.83	16.65	18.33	17.89	15.98	14.46
4	**Brix %**	17.62	17.32	19.92	19.62	19.02	18.72	16.32
5	**CCS %**	10.51	11.12	11.2	13.01	12.73	10.86	10.01
6	**Fibre %**	14.2	14.68	10.52	12.84	12.92	12.32	14.32
7	**Juice extraction %**	53.84	54.68	61.4	62.5	53.4	53.3	55.5
8	**Cane yield (tha^{-1})**	151.2	153.6	165.12	146.4	112.03	159.45	151.2
9	**CCS yield (tha^{-1})**	15.89	17.08	18.49	19.05	14.26	17.32	15.14
S.No.	**Clone number**	**2006T36**	**2006T23**	**2006T19**	**2006T8**	**2006T3**	**95V221**	**89V74**
1	**Single cane weight (Kg)**	1.4	1.2	1.4	1.4	1.3	1.6	1.4
2	**Percentage of flowering**	ABSENT	PRESENT	PRESENT	ABSENT	ABSENT	PRESENT	ABSENT
3	**Sucrose%**	18.5	16.11	17.83	17.4	18.3	16.45	16.04
4	**Brix %**	20.4	17.22	19.92	19.12	19.8	18.88	18.18
5	**CCS %**	12.9	11.44	12.4	12.2	13	11.3	11.09
6	**Fibre %**	16.08	11	13.6	12.08	17.2	11.36	12.76
7	**Juice extraction %**	50.7	58.12	53	55.91	63	66.6	54.4
8	**Cane yield (tha^{-1})**	145.6	129.6	145.6	147.98	127.4	153.92	143.92
9	**CCS yield (tha^{-1})**	18.78	14.83	18.05	18.05	16.56	17.39	15.96
S.No.	**Clone number**	**97V178**	**92V225**	**95V48**	**97V118**	**94V101**	**93V297**	**92V104**
1	**Single cane weight (Kg)**	1.2	1.6	1	1.2	1.5	1.1	1
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.54	17.2	16.98	17.14	19.04	17.66	16.5
4	**Brix %**	18.08	18.58	18.28	20.28	20.28	19.38	18.18
5	**CCS %**	11.62	12.15	12.01	11.59	13.53	12.39	11.55
6	**Fibre %**	13.68	14.56	12.48	15.32	12.52	12.6	12.16
7	**Juice extraction %**	49.35	43.04	43.39	55	46.8	57.22	58.8

8	**Cane yield (tha^{-1})**	117.55	156.16	95.46	102.34	124.8	114.4	112.32
9	**CCS yield (tha^{-1})**	13.66	18.97	11.46	11.86	16.89	14.17	12.97
S.No.	**Clone number**	**94V104**	**95V423**	**95V74**	**97V163**	**95V428**	**92V206**	**95V72**
1	**Single cane weight (Kg)**	1.1	1	1.3	0.8	1.1	1.3	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	PRESENT
3	**Sucrose%**	14.69	15.79	18.99	-	16.72	16.29	14.69
4	**Brix %**	15.88	18.38	20.48	-	18.48	17.68	15.88
5	**CCS %**	10.38	10.77	13.42	-	11.69	11.48	10.38
6	**Fibre %**	11.36	12.4	16.12	16.64	15.52	13.48	14.84
7	**Juice extraction %**	53.5	54.54	56.6	-	47.91	51.2	54.54
8	**Cane yield (tha^{-1})**	114.4	94.6	124.41	82.24	109.82	121.68	107.51
9	**CCS yield (tha^{-1})**	11.87	10.19	16.7	-	12.84	13.97	11.16
S.No.	**Clone number**	**94V108**	**97R199**	**97R267**	**97R276**	**93R113**	**97R7**	**97R183**
1	**Single cane weight (Kg)**	1.4	1.5	1.4	1.6	1.3	1.2	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	14.69	16.25	15.99	15.84	14.84	-	19.04
4	**Brix %**	15.88	18.28	18.48	17.08	17.58	-	20.18
5	**CCS %**	10.38	11.27	10.95	11.2	10.03	-	13.57
6	**Fibre %**	13	13.84	13.08	15.68	17.84	16.52	14.88
7	**Juice extraction %**	58.46	47.91	65.07	56.15	52.5	-	58.46
8	**Cane yield (tha^{-1})**	143.64	145.05	148.51	123.84	128.31	118.44	143.52
9	**CCS yield (tha^{-1})**	14.91	16.35	16.26	13.87	12.87	-	19.47
S.No.	**Clone number**	**97R15**	**85A146**	**83V288**	**82V12**	**86V96**	**92R62**	**93R129**
1	**Single cane weight (Kg)**	1.4	1.6	1.4	0.8	1.6	1.5	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	14.67	16.97	16.07	16.67	18.51	-	14.89
4	**Brix %**	16.28	19.26	17.36	19.26	20.36	-	16.68
5	**CCS %**	10.24	11.72	11.35	11.41	12.98	-	10.35
6	**Fibre %**	15.4	13.24	17.16	14.84	14.24	14.68	15.28
7	**Juice extraction %**	50	53	55.55	50.76	57.5	-	57.5
8	**Cane yield (tha^{-1})**	149.1	144.8	125.33	85.12	145.15	-	126.45
9	**CCS yield (tha^{-1})**	15.27	16.97	14.22	9.71	18.84	-	13.09
S.No.	**Clone number**	**97R134**	**97R123**	**97R163**	**97R424**	**97R395**	**97R217**	**97R6**
1	**Single cane weight (Kg)**	1.4	0.9	0.8	0.8	1.01	1.1	1.6
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	PRESENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	-	15.34	15.63	16.29	14.57	-	14.63
4	**Brix %**	-	17.88	16.58	18.18	17.88	-	16.96
5	**CCS %**	-	10.45	11.13	11.33	9.67	-	10
6	**Fibre %**	12.6	16.16	13.68	17.52	14.28	15.12	12
7	**Juice extraction %**	-	50	50	65.7	55.55	-	51.54
8	**Cane yield (tha^{-1})**	105.84	92.16	99.84	106.5	95.14	87.78	104.96
9	**CCS yield (tha^{-1})**	-	9.63	11.11	12.07	9.2	-	10.5
S.No.	**Clone number**	**93R217**	**97R174**	**97R167**	**92A326**	**2000A213**	**2000A225**	**2005T16**
1	**Single cane weight (Kg)**	0.8	1.1	0.8	1.8	1.3	1.3	1.6
2	**Percentage of flowering**	PRESENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	15.6	16.53	-	15.99	-	16.55	18.08
4	**Brix %**	16.96	17.76	-	18.48	-	17.38	20.16
5	**CCS %**	11	11.7	11.19	10.95	-	11.84	12.59
6	**Fibre %**	15.32	14.8	17.16	12.04	17.72	14.92	13.4
7	**Juice extraction %**	50	60.8	-	58.8	-	46.66	54.16
8	**Cane yield (tha^{-1})**	118.14	125.84	82	149.76	109.46	111.54	166.4
9	**CCS yield (tha^{-1})**	13	14.72	9.18	16.4	-	13.21	20.95
S.No.	**Clone number**	**95V348**	**94V103**	**2002V2**	**95V303**	**92A10**	**88A189**	**94A73**
1	**Single cane weight (Kg)**	1.2	1.6	1.2	1.1	1.8	1.5	1.3
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	16.03	17.44	16.05	13.52	-	17.82	16.71
4	**Brix %**	17.88	19.48	17.66	14.88	-	20.38	18.68
5	**CCS %**	11.16	12.13	11.24	9.47	-	12.26	11.62
6	**Fibre %**	15.32	12.64	16	13.44	14.16	12.56	18.48
7	**Juice extraction %**	57.27	54.54	57.14	55.5	-	60.7	40.24
8	**Cane yield (tha^{-1})**	104.04	155.65	125.52	113.52	126.7	152.1	149.56
9	**CCS yield (tha^{-1})**	11.61	18.88	14.11	10.75	-	18.65	17.38
S.No.	**Clone number**	**92A374**	**93A53**	**92A126**	**87A298**	**92A130**	**2005T89**	**2005T52**
1	**Single cane weight (Kg)**	1.4	1.6	1.2	1.2	1.1	1.3	1.4
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
3	**Sucrose%**	17.89	14.72	14.92	16.98	17.17	15.12	16.92
4	**Brix %**	19.48	15.98	16.68	18.26	19.38	16.96	19.16
5	**CCS %**	12.59	10.37	10.38	12.02	11.89	10.5	11.69
6	**Fibre %**	13.84	12	15.44	10.84	14.88	17.92	13.64
7	**Juice extraction %**	47.7	58.97	51.11	60.7	53	50	60.9
8	**Cane yield (tha^{-1})**	120.67	173.76	137.28	118.75	127.57	140.4	148.4

9	**CCS yield (tha^{-1})**	15.19	18.02	14.25	14.27	15.17	14.74	17.35
S.No.	**Clone number**	**2004T67**	**2003T123**	**2005T50**	**2004T68**	**2003T121**		
1	**Single cane weight (Kg)**	1.4	1.6	1.4	1.1	1.5		
2	**Percentage of flowering**	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT		
3	**Sucrose%**	16.94	18.29	18.27	16.97	17.21		
4	**Brix %**	18.76	20.16	20.36	18.36	18.46		
5	**CCS %**	11.84	12.8	12.73	11.98	12.19		
6	**Fibre %**	14.36	17.64	13.24	13.92	14.64		
7	**Juice extraction %**	58.33	50	61.5	70	46.67		
8	**Cane yield (tha^{-1})**	145.6	150.72	134.4	128.04	156		
9	**CCS yield (tha^{-1})**	17.24	19.29	17.11	15.34	19.02		

Table 3. Grouping of genotypes for combination of economic traits

S. No.	Combination of characters	Genotypes	Diversified uses
1	High yield High sucrose % High CCS yield Absence of leaf sheath hairiness Easy / medium detrashing Small/ medium bud size Absence of splits Absence of pithiness Absence of flowering	2003T129, 2005T16, 2005T50, 86V96, 2003T123, 95V74, 2006T36, 2006T3.	Useful for commercial cane cultivation by farmers for cane and CCS yields.
2	High fibre % Low sucrose % Low CCS % High yield	85R186, 97R383, BO91, 93R113, 97R7, 83V288, 97R424, 2000A213, 2002V2, 94A73, 2005T89.	High biomass types useful for cogeneration and paper making.
3	High juice extraction percentage High cane yield High sucrose % High CCS yield Absence or sparse leaf sheath hairiness Easy/medium detrashing Small/medium bud size Absence of pithiness Absence of flowering	2006T3, 2005T50, 93A145, 97R272, Co1148, 87A298, 2005T52, 2004T68	Useful for ethanol production.

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