

Research Note

Evaluation of mid-late sugarcane clones for their yield and quality characters in advanced selection stage in plant and ratoon crops

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Abstract

Comparative performance of six mid late maturing sugarcane clones were tested along with two standards in Advanced Varietal Trial in three crop cycles viz., plant I, plant II and ratoon at Sugarcane Research Station, Tamil Nadu Agricultural University, Sirugamani. Cane yield, sugar yield and seven other attributing traits like number of millable canes, cane height, cane thickness, internode length, Brix %, Pol % and commercial cane sugar % (CCS %) were studied in every crop cycles. The data observed in all three crop cycles were analysed separately and finally the data were pooled to carry out a pooled analysis. Significant differences were noticed among the test clones and standards for cane yield, sugar yield and its contributing parameters in plant I, plant II, ratoon and pooled analysis. Among the six clones tested, two test clones viz., Si 2009-13 and Si 2009-33 recorded significantly higher cane yield in plant I, II, ratoon and pooled analysis. The clone Si 2009-13 recorded significantly higher sugar yield in plant II, ratoon and pooled analysis. Similarly, the test clone, Si 2009-33 recorded significantly higher sugar yield in plant I, II, ratoon and pooled analysis. These two clones also recorded significant performance in most of the characters studied in all crop cycles and pooled analysis. Hence, these two clones viz., Si 2009-13 and Si 2009-33 were selected and promoted to multi-location trial in various sugarcane research stations to judge the cane yield and sugar yield in diversified environment.

Key words

Plant crop, ratoon, mid late maturing, cane yield and sugar yield

Sugarcane (*Saccharum* spp. Hybrid) is an important industrial and cash crop in India. It is the second largest producer of sugar after Brazil and accounts for 16 percent of world production. Besides sugar production, sugarcane produces numerous valuable by products like alcohol used by pharmaceutical industry, ethanol used as a fuel, baggage used for paper, chip board manufacturing and also burning sugar mills furnaces and pressmud used as a rich source of organic matter and nutrients for crop production (Soomro *et al.*, 2006).

Sugarcane and its products accounted for six percent of the total value of agriculture output and occupied about 2.5 percent of India's gross cropped area in 2014-15. In 2014-15, the total sugarcane production was 359 million tonnes with a productivity of 70 t/ha and the total sugar production was 20 million tones (Sugar India, 2016). Although this crop occupies an important place in cropping pattern of India and brings large dividends to growers, but its productivity has become stagnant for a decade. In India, Tamil Nadu is one of the major contributors in sugarcane production. Its productivity was 111 t/ha in 2011-12, but it was reduced to 94 t/ha in 2014-15. This may be due to moisture stress during formative phase, water logged condition, frequent occurrence of pest and disease, extension of cane cultivation in rainfed area, lodging of crop due to cyclonic storms in coastal areas and non-adoption of recommended varieties and cultivation practices.

Variety plays a pivotal role in increasing cane and sugar yields, proper choice of varieties, season and viable agronomic technologies will determine the success of any crop production and will hold good for successful cultivation of crop (Sharath Kumar Reddy *et al.*, 2014). Hence, sugarcane breeders are releasing new sugarcane varieties in different maturity group at frequent interval to increase the cane and sugar yield. Genetically improved sugarcane varieties may bear ability to produce satisfactory results for cane yield and sugar percentage under given set of environmental condition (Getaneh *et al.*, 2015). Since, sugarcane crop comes under the grass family, it also produces ratoon crop. Ratoon crop occupies almost 50 percent of the total area under sugarcane cultivation and contributes 30% of the total cane production in the country (Sundara, 2008). Ratoons are important for overall profitability of sugarcane cultivation as they save about 30% in the operational cost, mainly that of seed and reduced expenses for soil management (Sundara *et al.*, 1992). Hence, acceptance of a variety by the farmers are now depends very much on its ratooning potential. So, sugarcane varieties, which show good performance in both plant and ratoon crops, should be promoted for commercial cultivation.

Therefore present study was initiated to evaluate the relative performance of selected elite mid late maturing clones in both plant and ratoon crop during advanced varietal selection programme.

Materials and methods

Six mid late maturing sugarcane clones *viz.*, Si 2009-13, Si 2009-33, Si 2009-42, Si 2009-88, Si 2009-90 and Si 2009-138 along with two standards *viz.*, Co 86032 and TNAU sugarcane Si 8 were evaluated under advanced varietal trial at Sugarcane Research Station, Tamil Nadu Agricultural University, Sirugamani during 2013-14 and 2014-15. Each clone was planted in five rows of five meter length. The experiments were laid out in Randomized Block Design with three replications. All the University recommended package of practices were adopted for raising a good and healthy crop. After harvesting the plant crop, uneven stubbles were cut manually with the help of hand chopper. Then intercultural operations were carried out to control weeds, loosen the soil to help fresh root development and thus facilitate sprouting. At the same time, the second plant crop was planted similar to first plant crop. In all three crops, the data on number of millable canes (NMC), cane height, cane thickness, internode length and cane yield were recorded at the time of harvest. Juice Brix%, Pol% and CCS% were determined at harvest following the standard procedure (Meade and Chen, 1977). The sugar yield was determined based on CCS% and cane yield. The data recorded in plant crops and ratoon crop were analysed statistically using Fisher's analysis of variance techniques and least significant difference test (LSD) was used to compare the treatment means. Then the pooled analysis of all data also carried out. All the statistical analysis was carried out using TNAU STAT programme.

Results and Discussion

The analysis of variance and mean separation of the plant I, plant II, ratoon and pooled data are presented in Table 1, 2, 3 and 4 respectively.

Number of millable canes (NMC): Number of millable canes is the combined interaction of germination and tillering. It directly influences the cane yield. Adequate number of potentially heavy millable canes ensures high yield. Singh *et al.* (1985) reported that number of millable canes is a major yield contributing factor followed by cane height and girth. Analysis of variance of plant I, plant II, ratoon and pooled analysis revealed that existence of highly significant differences were existed among the clones for NMC. The standard, TNAU sugarcane Si 8 was the best standard for this trait in plant I, plant II, ratoon and pooled analysis. The clones *viz.*, Si 2009-13, Si 2009-33 and Si 2009-90 recorded significantly higher NMC than best standard in plant I trial. Four clones *viz.*, Si 2009-13, Si 2009-42, Si 2009-90 and Si 2009-138 recorded significantly higher NMC than best standard in plant II trial. The clone, Si 2009-33 alone recorded significantly higher NMC than best standard in ratoon. In pooled analysis, all test

clones, except Si 2009-88 recorded significantly higher NMC than the best standard. The differences in number of millable canes among the clones might be due to their inherent tillering potential.

Cane height: Plant height of sugarcane is increased progressively with advance in age of the crop upto maturity. Analysis of variance indicated that there is a significant difference among the genotypes tested in plant I, plant II, ratoon trials and pooled analysis. Significantly higher stalk length was observed in Si 2009-13, Si 2009-33 and Si 2009-90 in plant I; Si 2009-13 and Si 2009-33 in plant II; all test clones in ratoon and all clones except Si 2009-88 in pooled analysis when compared to the best standard, TNAU sugarcane Si 8. The variable cane height of the mid-late clones may be due to their variable inherent growth and development potential.

Cane thickness: Higher cane diameter showed positive reflectance on cane yield. ANOVA recorded significant difference among the test clones and standards in all trials and pooled analysis. The test clone, Si 2009-33 recorded significantly higher cane thickness when compared to best standard, TNAU sugarcane Si 8 in plant I trial. None of the test clone recorded significantly higher cane thickness than the best standard, Co 86032 in plant II trial. Two test clones, Si 2009-33 and Si 2009-90 observed significantly higher cane thickness than best standard, TNAU sugarcane Si 8 in ratoon trial. In pooled analysis, all mid-late test clones except Si 2009-138 recorded significantly higher cane thickness when compared to the best standard, TNAU Sugarcane Si 8.

Internodal length: Analysis of variance reveals that highly significant differences were existed among the test clones for this trait. The standard variety, TNAU Sugarcane Si 8 was the best standard in the plant trials, ratoon trial and pooled analysis. In plant I trial, two clones, Si 2009-33 and Si 2009-42 recorded significantly higher internodal length than the best standard. In plant II and ratoon trials, three clones *viz.*, Si 2009-13, Si 2009-33 and Si 2009-88 recorded significantly higher internodal length than best standard. But in pooled analysis, all test clones recorded significantly higher internodal length than the best standard.

Cane yield: Economically higher cane yield is the ultimate goal of every grower which is the function of the well coordinated interplay of genetic constitution and the environment to which it is exposed. Different yield attributes like number of millable canes, cane height, cane girth and thus per cane weight have direct bearing in the final yield per unit area (Aslam *et al.*, 2013). ANOVA of all three trials and pooled analysis indicated that the

presence of highly significant difference among the test clones and standards. The standard variety, TNAU sugarcane Si8 was the best standard in plant I trial, but Co 86032 was the best standard in plant II, ratoon and pooled analysis. In Plant I and II trials, the clones, Si 2009-13 and Si 2009-33 recorded significantly higher cane yield than their respective best standard. In ratoon trial, three clones *viz.*, Si 2009-13, Si 2009-33 and Si 2009-138 recorded significantly higher cane yield than the best standard. In pooled analysis, all test clones except Si 2009-88 recorded significantly higher cane yield than best standard. According to Mali and Singh (1995), the variation in cane yields and yield components among the varieties may be attributed due to their difference in genetic makeup.

Brix%: Brix% (Total soluble solids) plays an important role in determining the sugar recovery % of the sugarcane. As per the analysis of variance, there was a highly significant difference among the study materials in all trials and pooled analysis. The standard Co 86032 was the best standard in plant I, plant II trials and pooled analysis. Similarly the standard, TNAU sugarcane Si 8 was the best standard in ratoon trial. The clones, Si 2009-42 and Si 2009-138 in plant I, Si 2009-33 in plant II and Si 2009-42 in ratoon trial were the significantly higher Brix% clones when compared to their respective best standard. In pooled analysis none of the test clones recorded significantly higher performance than the best standard.

Pol%: The analysis of variance revealed that there was a highly significant difference among the study materials in all trials and pooled analysis. The popular variety, Co86032 was the best standard in all trials and pooled analysis. In plant I trial, none of the test clone registered significantly higher Pol% than the best standard. The clone Si 2009-13 recorded significantly higher performance in plant II. The test clones, Si 2009-13 and Si. 2009-33 recorded significantly higher performance in ratoon trial and pooled analysis than Co 86032.

Commercial cane sugar % (CCS %): The CCS% was determined using Brix% and Pol%. It gives the commercial cane sugar available in the cane juice. The ANOVA indicated that there was a significantly higher difference among the clones for this trait. The popular variety of Tamil Nadu, Co 86032, was the best standard in plant trials, ratoon trial and pooled analysis. In plant I trial none of the clone recorded significantly higher performance than the best standard. In plant II trial, Si 2009-13 recorded significantly higher performance than the best standard. In ratoon trial, two clones, Si 2009-13 and Si 2009-33 recorded significantly higher performance than the best standard. But in pooled analysis two clones, Si

2009-13 and Si 2009-33 recorded significantly higher performance than the best standard.

Sugar yield: The underlined goal of all efforts made by a Breeder is the attainment of higher tonnage of crystal sugar which is actually produced in the field and collected in the factory (Aslam *et al.*, 2013). It is the combination of cane weight and corresponding commercial cane sugar. It is evident from the data given in all tables that all the clones under study noticed highly and significantly difference from one another for the production of sugar yield. The popular variety, Co 86032 was the best standard in plant II, ratoon and pooled analysis. But the standard, TNAU sugarcane Si 8 was the best standard in plant I trial. The clone *viz.*, Si 2009-33, Si 2009-42, Si 2009-88 and Si 2009-90 in plant I recorded significantly higher sugar yield than the best standard. The clones Si 2009-13 and Si 2009-33 in plant II recorded significantly higher sugar yield than the best standard. Three clones *viz.*, Si 2009-13, Si 2009-33 and Si 2009-138 recorded significantly superior performance in ratoon trial. In pooled analysis, three clones *viz.*, Si 2009-13, Si 2009-33 and Si 2009-42 recorded significantly higher performance than the best standard. According to Aslam *et al.*, 2013, the differential behavior of sugarcane varieties/strains to produce sugar yield may be attributed due to the variability in their genetic constitution to exploit the given environment.

Conclusion

From the above results it is apparent that all characters under study have highly significant difference among the genotypes. It indicates that an ample scope for selecting a better genotype. Out of six mid late sugarcane clones tested, two clones *viz.*, Si 2009-33 and Si 2009-13 were selected on the basis of relatively better performance for most of the character under study in plant I, plant II, ratoon trials and pooled analysis. But performance evaluation in one location is not at all sufficient to judge the clone. So, a successful evaluation of clones for stable performance under varying environmental conditions based on the information on genotype x environment interaction for cane yield and sugar yield is an essential part of any sugarcane varietal development programme. Hence, these two selected genotypes are promoted to multi-location trial for evaluate their performance in other sugarcane research stations.

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Table 1. Analysis of variance and mean performance of different mid late clones for cane yield, sugar yield and it's contributing traits in plant I trial during 2013-14

Source of variation	Df	No. of millable cane (X 1000/ha)	Cane height (cm)	Cane thickness (cm)	Internodal length (cm)	Cane yield (t/ha)	Brix%	Pol%	CCS%	Sugar yield (t/ha)
Mean sum of squares										
Replication	2	7.81	1116.29	0.02	2.70	24.78	0.16	0.32	0.22	0.88
Genotype	7	558.04**	2225.04**	0.14*	9.50**	191.70**	5.95**	1.47**	0.29**	4.34**
Error	14	28.31	369.58	0.05	1.34	37.57	0.25	0.09	0.05	0.74
Mean separation										
Genotypes										
Si 2009-13		160.9	296.7	3.3	17.4	136.6	21.2	18.3	12.9	16.1
Si 2009-33		164.1	301.7	3.5	19.7	139.0	21.5	18.5	12.9	18.0
Si 2009-42		149.7	276.0	2.9	20.4	124.8	22.0	18.6	12.9	17.6
Si 2009-88		133.8	266.3	3.1	17.2	129.1	21.0	18.2	12.9	16.6
Si 2009-90		161.8	295.7	3.0	17.0	131.5	19.5	17.5	12.5	16.5
Si 2009-138		143.5	276.3	3.0	16.6	126.7	22.3	18.6	12.8	16.2
Co 86032		127.8	218.3	2.8	14.9	113.7	21.0	18.2	12.8	14.6
TNAU Sugarcane Si 8		140.9	257.3	3.0	16.7	123.1	18.0	16.6	12.0	14.8
Mean		147.8	273.5	3.1	17.5	128.1	20.8	18.1	12.7	16.3
SEd		4.34	15.70	0.18	0.95	5.00	0.40	0.24	0.19	0.70
CD (0.05)		9.32	33.67	0.38	2.03	10.73	0.87	0.51	0.40	1.50
CV%		3.60	7.03	7.07	6.62	4.79	2.38	1.63	1.79	5.27

Table 2. Analysis of variance and mean performance of different mid late clones for cane yield, sugar yield and it's contributing traits in plant II trial during 2014-15

Source of variation	Df	No. of millable cane (X 1000/ha)	Cane height (cm)	Cane thickness (cm)	Internodal length (cm)	Cane yield (t/ha)	Brix%	Pol%	CCS%	Sugar yield (t/ha)
Mean sum of squares										
Replication	2	25.45	619.3	0.09	0.48	5.2	0.95	0.12	0.05	0.04
Genotype	7	261.23**	1383.97**	0.21**	10.10**	232.43**	1.26**	0.95**	0.62**	5.34**
Error	14	14.40	138.03	0.04	1.16	8.09	0.18	0.12	0.17	0.39
Mean separation										
Genotypes										
Si 2009-13		142.0	324.2	3.7	14.7	140.9	20.3	18.3	13.2	18.6
Si 2009-33		131.2	343.7	3.7	16.5	142.2	20.6	18.0	12.7	18.1
Si 2009-42		149.9	298.0	3.8	12.2	137.9	19.1	17.5	12.6	17.4
Si 2009-88		138.6	289.5	3.5	15.5	119.3	20.2	17.8	12.7	15.1
Si 2009-90		157.1	306.0	3.4	13.0	135.2	18.7	16.4	11.6	15.7
Si 2009-138		144.5	302.7	3.2	13.2	126.7	19.2	17.5	12.6	16.0
Co 86032		130.6	276.3	3.6	11.4	134.8	19.8	17.7	12.6	17.0
TNAU Sugarcane Si 8		134.1	289.0	3.0	11.9	121.2	19.6	17.6	12.5	15.2
Mean		141.0	303.7	3.5	13.6	132.3	19.7	17.6	12.6	16.6
SEd		3.10	9.59	0.16	0.88	2.32	0.34	0.28	0.28	0.51
CD (0.05)		6.65	20.58	0.34	1.89	4.98	0.74	0.60	0.60	1.09
CV%		2.69	3.87	5.30	7.95	2.15	2.14	1.96	2.71	3.75



Table 3. Analysis of variance and mean performance of different mid late clones for cane yield, sugar yield and it's contributing traits in ratoon trial during 2014-15

Source of variation	Df	No. of millable cane (X 1000/ha)	Cane height (cm)	Cane thickness (cm)	Internodal length (cm)	Cane yield (t/ha)	Brix%	Pol%	CCS%	Sugar yield (t/ha)
Mean sum of squares										
Replication	2	20.07	98.12	0.03	0.85	15.91	0.31	0.03	0.08	0.86
Genotype	7	70.07**	2272.28**	0.16**	7.75**	173.18**	0.40**	0.13**	0.20**	4.74**
Error	14	8.21	16.54	0.03	0.75	17.67	0.06	0.03	0.03	0.31
Mean separation										
Genotypes										
Si 2009-13		151.9	295.8	3.0	14.5	140.5	20.2	18.1	12.9	18.2
Si 2009-33		155.9	332.4	3.5	16.5	144.8	19.5	18.0	13.1	18.8
Si 2009-42		151.6	271.0	3.1	13.1	129.8	20.5	17.9	12.6	16.4
Si 2009-88		149.6	262.3	3.2	15.7	126.5	20.3	17.8	12.6	15.9
Si 2009-90		146.9	266.9	3.4	14.0	132.7	20.3	17.5	12.3	16.3
Si 2009-138		151.1	272.5	3.1	14.2	137.6	19.7	17.8	12.8	17.6
Co 86032		139.4	245.5	2.7	11.7	129.0	19.7	17.7	12.6	16.2
TNAU Sugarcane Si 8		148.0	253.6	3.0	12.4	122.1	19.9	17.5	12.4	15.6
Mean		149.3	275.0	3.1	14.0	132.9	20.0	17.8	12.7	16.8
SEd		2.34	3.32	0.15	0.71	3.43	0.19	0.13	0.13	0.45
CD (0.05)		5.02	7.12	0.31	1.51	7.36	0.41	0.28	0.28	0.97
CV%		1.92	1.48	5.74	6.16	3.16	1.18	0.91	1.25	3.30

Table 4. Pooled analysis of variance and mean performance of different mid late clones for cane yield, sugar yield and it's contributing traits in plant I, plant II and ratoon trial during 2013-14 & 2014-15

Source of variation	Df	No. of millable cane (X 1000/ha)	Cane height (cm)	Cane thickness (cm)	Internodal length (cm)	Cane yield (t/ha)	Brix%	Pol%	CCS%	Sugar yield (t/ha)
Mean sum of squares										
Replication	6	17.80	611.24	0.05	1.35	15.30	0.47	0.16	0.12	0.59
Genotype	7	500.8**	5241.6**	0.26**	20.06**	434.33**	2.54**	1.57**	0.76**	10.15**
Season	2	475.3**	6938.06**	1.17**	110.73**	164.7**	8.29**	1.39**	0.14	1.81*
Genotype X Season	14	194.3**	319.85	0.12**	3.65**	81.49**	2.54**	0.49**	0.17**	2.13**
Error	42	17.00	174.71	0.04	1.08	21.11	0.16	0.08	0.06	0.48
Mean separation										
Genotypes										
Si 2009-13		151.6	305.6	3.3	15.6	139.4	20.5	18.3	13.0	17.6
Si 2009-33		150.4	325.9	3.5	17.5	142.0	20.5	18.2	12.9	18.3
Si 2009-42		150.4	281.7	3.3	15.2	130.8	20.5	18.0	12.7	17.1
Si 2009-88		140.7	272.7	3.3	16.2	124.9	20.5	18.0	12.7	15.9
Si 2009-90		155.3	289.5	3.3	14.7	133.1	19.5	17.1	12.1	16.2
Si 2009-138		146.4	283.8	3.1	14.7	130.3	20.4	18.0	12.7	16.6
Co 86032		132.6	246.7	3.1	12.7	125.8	20.2	17.9	12.7	16.0
TNAU Sugarcane Si 8		141.0	266.6	3.0	13.6	122.1	19.2	17.2	12.3	15.1
Mean		146.0	284.1	3.2	15.0	131.1	20.2	17.8	12.7	16.6
SEd		1.94	6.23	0.09	0.49	2.17	0.19	0.13	0.12	0.33
CD		3.90	12.52	0.19	0.99	4.35	0.38	0.26	0.24	0.66
CV%		2.82	4.65	6.13	6.93	3.50	1.98	1.56	2.01	4.17