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EVALUATION OF SUGARCANE CLONES FOR HIGH YIELD AND GOOD RATOONING ABILITY FOR EAST COAST ZONE OF INDIA

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Abstract

The present investigation was undertaken with the objective of evaluation and identification of sugarcane clones for high yield, quality and its contributing traits in plant and ratoon crops. The study consists of three evaluation trials *viz*., Advanced Varietal Trial- plant-I (AVT-I), Advanced Varietal Trial-Plant-II (AVT-II) and AVT- Ratoon. All the three experiments consists of five test clones *viz*., CoA 12321, CoA 12322, CoA 12323, CoOr 12456 and CoV 12356 and three standards (Co 6907, CoC 01061, CoA 92081). Observations were recorded for number of tillers (x1000/ha), number of millable cane (x1000/ha), stalk length (cm), stalk diameter (cm), single cane weight (kg), cane yield (t/ha), brix (%), purity (%), sucrose (%), CCS (%) and CCS yield (t/ha). The results revealed that, among the test clones CoA 12322 and CoA 12321 registered the higher cane yield and CCS yield. The clone CoV 12356 recorded better performance for quality traits *viz*., sucrose per cent, purity per cent and CCS per cent. Hence these three clones may be promoted for further evaluation trial and could be released as new sugarcane variety suitable for east coast zone of India.

Introduction

Sugarcane (*Saccharum* spp. hybrids) is one of the major commercial and industrial crop grown extensively all over in the world from tropical to sub-tropical regions. Evaluation and identification of varieties for different yield and quality parameters is of paramount importance in sugarcane cultivation to comprehend higher recoveries for sugar mills and cane yield for farmers. Selection of variety plays a important role in both increasing and decreasing the area under sugarcane cultivation and productivity (Mian 2006). India is the second highest producer of sugarcane in the world after Brazil in terms of area (58.83 lakh ha) and production (362.07 m.tonnes). In India, Tamil Nadu ranks fourth in area and production next to Uttar Pradesh, Maharastra and Bihar and ranks first in productivity (99.5 t/ha). (Govt. of India, Sugarcane Statistics 2023).

Sugarcane is a clonally propagated crop which is initially grown as plant crop and subsequently as many ratoon crops. The cost incurred in seed material and planting operations can be saved by raising a ratoon crop (Shanthi *et al.* 2014). Hence, ratooning is a common practice in sugarcane cultivation throughout the world (Ram and Sahi 2012). In India, approximately 40% of the total area of sugarcane is occupied by ratoon crop (Danawale *et al.* 2012). Any new sugarcane variety should have both high yield and superior juice quality to ensure profitability for both farmers and sugar mills. Varieties with good ratoon performance gave additional income to the farmers without replanting. Keeping in this view, the ratoon study was undertaken in this study.

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The early maturing sugarcane varieties are chosen in the beginning of crushing season for higher sugar recoveries. Besides, the influence of season is less pronounced on early maturing varieties and in late planted conditions, growing of early maturing clones facilitate recovery of higher CCS yield (Ganapathy *et al*. 2024). Hence it is imperative to identify new sugarcane varieties to replace the deteriorating commercial varieties through which the overall productivity could be stabilized. Therefore, to meet the immediate need of sugarcane farmers and sugar factory, there is a need of more number of high yield varieties with high sugar and good ratooning ability to meet the challenges for increase the productivity and improving sugar recovery (Mirajkar *et al.* 2019). Hence, the present study was undertaken with the objective of evaluation and identification of superior sugarcane clones for high yield, quality and its contributing traits in plant I, Plant II and ratoon crops.

Materials and Methods

The present investigation were conducted during 2018-19 and 2019-20 at Sugarcane Research Station, Tamil Nadu Agricultural University, Cuddalore, Tamil Nadu, India (latitude; 11º 46' North; longitude: 79º.46' East; altitude: 4.60 m MSL). The present study consists of three research trials *viz*., Advanced Varietal Trial- plant- I (AVT-Plant-I), Advanced Varietal Trial- Plant-II (AVT-Plant-II) and Advanced Varietal Trial – Ratoon (AVT- R). Advanced Varietal Trial- Plant-I was conducted during 2018-19 and AVT-plant-II and AVT- Ratoon crops were conducted in 2019-20. All the three experiments consist of five early maturing clones *viz*., CoA 12321, CoA 12322, CoA 12323, CoOr 12346 and CoV 12356 obtained from east coast zones of India and three check varieties (Co 6907, CoC 01061 and CoA 92081). After harvesting of Advanced Varietal Trial-Plant-I, the ratoon crop was maintained for ratoon study.

All the test clones (Experimental materials) planted in Randomized Block Design with three replications during 2018-19 and 2019-20**.** The plot size for each entry was six rows of five meter length spaced at 90 cm with a seed rate of twelve buds per meter. Recommended cultural (agronomic) practices *viz*., weeding, earthing up (at 120 days after planting), de-trashing (during 6^{th} months) and propping (during 6^{th} months) were followed and need based plant protection measures were followed uniformly in all the three trials. The data on yield, quality and its contributing characters were recorded during the entire cropping period in all the three experiments. Among these parameters, data on number of tillers (x1000/ha) were recorded at 120^{th} days after planting, while all other characters were recorded at harvest. The number of millable canes (NMC) (x1000/ha) were recorded at harvest. For quality analysis, the cane samples were taken from each clone and juice was extracted by power crusher and analysed for brix (%) and sucrose (%) as per the method suggested by Meade and Chen (1977). Sucrose per cent was calculated as per Schmitz's tables. The Commercial Cane Sugar (CCS) % was calculated as per the following formula.

CCS% = (Sucrose % - 0.4 (Brix % - Sucrose %)) x 0.75.

Then, the CCS yield was calculated based on CCS per cent and cane yield. All the collected data were statistically analysed by Panse and Sukhatme (1978).

Results and Discussion

The analysis of variance in the present investigation revealed that there was a significant difference in the mean values for yield, quality and its component traits. The genetic differences between the genotypes may account for the variance in cane yield and its contributing traits. High variability among sugarcane genotypes for cane yield and juice quality contributing traits was already reported by Ganapathy *et al.* (2024a). The yield and quality contributing characters pertaining to AVT- I, AVT-II and AVT ratoon crops were presented in Tables 1, 2 and 3.

Table 1. Performance of sugarcane clones for yield and quality traits in Advanced Varietal Trial - Plant – I (AVT- Plant-I).

Sl.No	Clone/ Genotype	No.of tillers(x1000/ha)	Number of millable cane (x1000/ha)	Stalk length (cm)	Stalk diameter (cm)	Single cane wt. (kg)	Cane yield (t/ha)	Brix (%)	Purity (%) (10 m)	Sucrose (%)	CCS (%)	CCS Yield. (t/ha)
1	CoA 12321	131.05	115.60	285.10	2.83	1.27	132.45	20.75	89.37	17.50	12.60	16.69
2	CoA 12322	130.41	118.30	292.35	2.90	1.32	133.60	20.72	89.26	17.55	12.64	16.90
3	CoA 12323	126.35	115.75	280.41	2.75	1.30	130.70	20.95	90.15	17.76	12.81	16.74
4	CoOr 12346	134.60	112.35	284.72	2.85	1.26	126.15	20.85	90.12	17.75	12.72	15.28
5	CoV 12356	125.10	114.50	271.33	2.74	1.42	123.80	21.15	90.50	17.85	12.73	15.76
Standard												
6.	Co 6907	120.42	110.75	267.15	2.62	1.15	100.15	19.65	88.12	17.10	12.40	12.42
7.	CoC 01061	138.55	125.20	270.80	2.41	1.25	110.30	20.81	90.10	17.75	12.71	14.02
8.	CoA 92081	121.80	110.35	265.72	2.75	1.32	120.85	20.62	88.90	17.23	12.62	15.25
	S.Ed.	5.17	5.42	6.43	0.10	0.08	5.10	0.15	0.61	0.17	0.09	0.55
	CD (0.05%)	12.05	13.64	12.81	0.21	0.19	10.76	0.45	1.24	0.35	0.24	1.35
	CV (%)	5.85	6.53	3.88	3.71	8.25	5.28	1.14	0.82	1.24	0.87	5.42

Table 2.Performance of Sugarcane Clones for Yield and Quality traits in Advanced Varietal Trial- Plant- II (AVT Plant- II).

Sl. No.	Clone / Genotype	No. of tillers (x1000/ha)	Number of millable cane (x1000/ha)	Stalk length (cm)	Stalk diameter (cm)	Single cane wt. (kg)	Cane yield (t/ha)	Brix (%)	Purity (%)	Sucrose (%)	CCS (%)	CCS Yield. (t/ha).
1	CoA 12321	134.65	116.85	280.00	2.87	1.23	135.92	20.68	89.12	17.38	12.55	17.06
2	CoA 12322	132.44	117.93	294.33	2.78	1.31	137.25	20.64	88.95	17.71	12.72	17.45
3	CoA 12323	127.95	110.68	277.33	2.75	1.19	124.81	20.85	90.45	17.87	12.85	16.04
4	CoOr 12346	129.37	115.42	271.33	2.62	1.25	117.85	20.73	89.89	17.75	12.68	14.94
5	CoV 12356	124.75	107.45	265.33	2.71	1.37	122.74	21.02	90.42	17.76	12.80	15.71
Standard												
6	Co 6907	125.35	109.60	264.00	2.61	1.10	99.81	19.88	87.81	16.87	12.45	12.43
7	CoC 01061	135.17	118.42	273.33	2.37	1.06	111.47	20.82	90.35	17.73	12.74	14.20
8	CoA 92081	117.60	105.16	263.33	2.63	1.26	114.56	20.60	88.82	17.65	12.67	14.62
	S.Ed.	5.16	5.70	6.51	0.08	0.07	5.04	0.17	0.80	0.15	0.10	0.62
	CD (0.05%)	10.97	12.08	13.82	0.17	0.16	10.68	0.36	2.12	0.31	0.21	1.31
	CV (%)	4.92	6.19	2.92	3.75	7.39	5.12	1.02	1.20	1.02	0.98	4.97

Table 3. Performance of sugarcane clones for yield and quality traits in Advanced Varietal Trial- Ratoon (AVT- R).

Sl. No.	Clone / Genotype	No. of tillers (x1000/ha)	Number of millable cane (x1000/ha)	Stalk length (cm)	Stalk diameter (cm)	Single cane wt. (kg)	Cane yield (t/ha)	Brix (%) (10 m)	Purity (%) (10m)	Sucrose (% at harvest)	CCS (% at harvest)	CCS Yield. (t/ha).
1	CoA 12321	128.15	110.45	277.20	2.84	1.27	125.75	20.52	89.45	17.51	12.65	15.90
2	CoA 12322	124.34	112.70	283.50	2.82	1.21	127.55	20.70	89.71	17.73	12.67	16.16
3	CoA 12323	121.85	105.40	272.00	2.75	1.25	118.57	20.85	90.46	17.86	12.83	15.21
4	CoOr 12346	127.62	112.30	272.67	2.74	1.19	110.92	20.56	89.95	17.72	12.69	14.08
5	CoV 12356	125.42	102.60	265.33	2.71	1.32	115.24	21.03	90.18	17.74	12.72	14.66
	Standard											
6	Co 6907	112.33	102.05	270.00	2.65	1.11	95.76	19.80	88.22	16.92	12.60	12.07
7	CoC 01061	133.85	107.39	271.67	2.35	1.05	100.52	20.83	90.40	17.73	12.71	12.77
8	CoA 92081	115.52	97.96	261.67	2.70	1.29	105.59	20.42	89.12	17.14	12.63	13.34
	S.Ed.	5.26	5.45	6.15	0.08	0.07	4.88	0.16	0.65	0.11	0.10	0.67
	CD (0.05%)	11.07	11.58	13.04	0.18	0.14	10.34	0.34	1.39	0.24	0.22	1.41
	CV (%)	5.08	6.45	2.78	3.84	6.78	5.37	0.96	0.89	0.80	1.02	5.84

The tables revealed that, maximum number of tillers were expressed by check variety CoC 01061 (138.55/ha) and minimum numbers by the standard Co 6907 (120.42/ha). Among test clones, the clone CoOr 12346 recorded the highest number of tillers (134.60/ha) followed by clone CoA 12321 (131.05/ha) and CoA 12322 (130.41/ha). In Advanced varietal trial- Plant-II, the tillers counts ranged from 117.35 to 135.17 (x1000/ha). Among the test clones, the clone CoA 12321 recorded highest tillers counts (134.65) followed by the clone CoA 12322 (132.44) (Table 2). In AVT - Ratoon, the maximum tillers were observed in the standard CoC 01061 (133.85/ ha) and minimum number of tillers were observed in Co 6907 (112.33) (Table 3). Among the test clones, none of the clones were recorded superior performance over the best standard CoC 01061 in all the three evaluation trials. The results on tillers number are in agreement with that of Ganapathy and Ravichandran (2022) who indicated that, tillering potential of a sugarcane clone ultimately reflect directly on cane yield.

The number of millable cane (NMC) directly influences the cane yield and the combined interaction of germination per cent and number of tillers. In AVT- Plant-I trial, the number of millable cane, ranged from 110.75 to 125.20 (x1000/ha). None of the test clones have expressed superior performer over the best check CoC 01061, which was 125.20 (x1000/ha). The results on the AVT-Plant-II, indicated that, maximum number of millable cane was expressed in the check variety CoC 01061 (118.42/ha) and minimum in CoA 92081 (105.16/ha) (Table 2). In ratoon crop, the NMC ranged from 97.96 to 112.70 (x1000/ha). The highest NMC was expressed by the clones CoA 12321 (112.70/ha) (Table 3). The present results corroborates with Saranraj *et al*. (2023).

For this trait, the maximum stalk length was observed in CoA 12322 (292.35 cm) and minimum in CoA 92081 (265.72 cm). All the five clones recorded better stalk length over the best standard CoC 01061 (270.80 cm). For AVT- II plant, cane length varied from 294.33 (CoA 12322) to 263.33 cm (CoA 92081). Three clones recorded higher stalk length over the best standard CoC 01061, which was 273.33 cm (Table 2). In ratoon crop, maximum cane length (283.50 cm) was expressed by the clone CoA 12322 and minimum by CoA 92081 (261.67 cm). Four clones *viz.*, CoA 12322, CoA 12321, CoOr 12346 and CoA 12323 were recorded higher stalk length over the standard variety (Table 3). In sugarcane, stalk length contributes considerably towards final cane yield. In yield evaluation trials, under good growing conditions, individual clone seedlings may produce above 250 cm of stalk length could be advanced to the next generation (Ganapathy and Jayakumar 2023).

As regards to AVT- Plant- I, the stalk diameter in test clones, varied from 2.41 cm (CoC 01061) to 2.90 cm (CoA 12322). The highest stalk diameter was exhibited in the clone CoA 12322 (2.90 cm) and followed by CoOr 12346 (2.85 cm). Among the clones, all the clones were recorded superior performance over the best standard CoA 92081 (2.75 cm) and one clone shows in equivalence with checks (Table 1). In AVT-Plant-II, the maximum cane diameter was in CoA 12321 (2.87 cm) and minimum value expressed by the clone CoC 01061 (2.37 cm). In AVT-ratoon crop, the stalk diameter varied from 2.35 cm to 2.84 cm (CoA 12321). All the five test clones were recorded the higher stalk diameter than the standard variety (Table 3). Cane thickness is an important yield contributing character and more cane thickness would enhance the acceptability of varieties for farmer's point of view. This finding is analogous with Hamida *et al.* (2022) who reported variable cane thickness among the sugarcane genotypes.

In Advanced Varietal Trial plant-I, for single cane weight, the highest single cane weight was recorded in CoV 12356 (1.42 kg) and minimum in Co 6907 (1.15 kg). Only one clone recorded numerically higher single cane weight than the best check variety CoA 92081 (1.32 kg). With regard to AVT- II, single cane weight ranged from 1.06 kg to 1.37 kg (CoV 12356). Only two clones were recorded higher than the best standard variety CoA 92081. In AVT ratoon crop, single cane weight was higher in the clone CoV 12356 (1.32 kg) and lower in CoC 01061 (1.05 kg).

Only one clone (CoV 12356) was recorded higher single cane weight over the best check variety CoA 92081 (1.29 kg) (Table 3).

The results on cane yield in AVT plant-I, revealed that, the test clones and standards were ranged from 100.15 t/ha (Co 6907) to 133.60 t/ha (CoA 12322). The clone CoA 12322 yielded the highest tonnage and it was followed by CoA 12321 (132.45 t/ha) and CoA 12323 (130.70 t/ha). Among the clones evaluated, all the test clones were recorded higher cane yield over the best check variety CoA 92081, which was recorded by 120.85 t/ha. In AVT- Plant-II, it varied from 99.81 to 137.25 t/ha. The best performing clones are CoA 12322 (137.25 t/ha), CoA 12321 (135.92 t/ha) and CoA 12323 (124.81 t/ha). With regard to AVT, Ratoon, the cane yield was maximum in the clone CoA 12322 (127.55 t/ha) and minimum in the standard Co 6907 (95.76 t/ha). All the test clones were recorded higher cane yield over the standards. Cane yield is a major trait to identify the economic potential of a genotype. Ganapathy and Jayakumar (2023) reported that, it is mainly the combination of environmental responses and genetic potential of a genotype. The results on cane yield in the present study were found consistent to Arain *et al*. (2011). Pooja *et al*. (2022) also reported higher variability among the sugarcane genotypes for cane yield and yield contributing traits, when tested in clonal evaluation trials.

Brix per cent at 10^{th} month was revealed that, maximum brix value was expressed by CoV 12356 (21.15%) and minimum brix per cent was in the clone Co 6907 (19.65%). Among the clones evaluated, only three clones expressed higher brix per cent over the best check variety CoC 01061, which was 20.81%. In the AVT plant-II, the brix per cent was ranged from 19.88 (Co 6907) to 21.02 (CoV 12356%) and two test clones recorded higher brix value over the standard variety CoC 01061 (20.82%). In ratoon crop, same trend of results were revealed and it ranged from 19.80 to 21.03%. Only two clones CoV 12356 (21.03%) and CoA 12323 (20.85%) were expressed higher brix values over the check variety. Brix per cent plays vital role in determining the sugar recovery per cent of sugarcane. Ali *et al.* (2019) revealed in their experiments on brix per cent of sugarcane.

In AVT plant-I, the purity per cent was ranged from 88.12% to 90.50 % (CoV 12356). Three clones *viz*. CoV 12356, CoA 12323 (90.15%) and CoOr 12346 (90.12) were recorded numerically higher purity percent than the best check variety CoC 01061 which was in 90.10%. In AVT Plant-II, it was ranged from 87.81 to 90.45% (CoA 12323). Two test clones (CoA 12323 and CoV 12356) were recorded higher purity per cent over the standard. For AVT ratoon crop, the purity percentage varied from 88.22 to 90.46 % (CoA 12323). Only one clone CoA 12323 (90.46%) recorded higher purity percent over the best check CoC 01061. Ganapathy and Jayakumar (2023) reported in their experiment, in different levels of brix percent and purity per cent in different sugarcane clones.

The Sucrose per cent of test clones varied from 17.10 to 17.85% (CoV 12356). For this trail, only two clones *viz*., CoV 12356 and CoA 12323 recorded numerically higher sucrose per cent over the best check variety CoC 01061, which recorded 17.75%. In AVT plant-II trial, sucrose per cent was ranged from 16.87 to 17.87% (CoA 12323). Three test clones *viz*., CoA 12323, CoV 12356 and CoOr 12346 expressed higher sucrose per cent over the best standard variety CoC 01061 (17.73%). In ratoon crop, the sucrose percentage was maximum in the clone CoA 12323 (17.86%) and minimum in the clone Co 6907 (16.92%). Two clones (CoA 12323, CoV 12356) recorded superior sucrose percent over the best check variety CoC 01061. Sucrose content in cane juice is an important quality trait in sugarcane. Its determination is useful in deciding the quality of sugarcane clones and it influences the sugar recovery and sugar production. Nawaz *et al.* (2017) also reported on sucrose content in sugarcane juice.

The Commercial Cane Sugar (CCS) percentage varied from 12.40% (Co 6907) to 12.81 % (CoA 12323) in AVT plant-I. Among the test clones, three clones *viz.* CoA 12323, CoV 12356 and CoOr 12346 recorded higher percentage of CCS over the standard variety CoC 01061 (12.71%). In AVT Plant-II, CCS per cent was ranged from 12.45 to 12.85% (CoA 12323). In this trait, two clones namely CoA 12323 and CoV 12356 were expressed higher CCS per cent over the best standard variety CoC 01061 (12.74%). In ratoon crop, CCS per cent was ranged from 12.60 to 12.83% and two clones (CoA 12323 and CoV 12356) were exhibited higher CCS per cent over the best check variety CoC 01061 (12.71%). CCS per cent is the best method in sugarcane for assessing the clone's quality for breeders and affects the sugar recovery and sugar production in factory (Thangavelu 2007). The present results corroborate with Ganapathy *et al*. (2022), who also reported on CCS % of sugarcane.

The Table 1 reveals that, the highest CCS yield was exhibited by the clone CoA 12322 (16.90 t/ha) and lower yield was reported by Co 6907 (12.42 t/ha). For CCS yield, all the test clones were recorded higher CCS yield over the best check variety CoA 92081 (15.25 t/ha). In the AVT- plant-II, the maximum CCS yield was reported by the clone CoA 12322 (17.45 t/ha) and lowest yield was observed in Co 6907 (12.43 t/ha). In AVT ratoon, CCS yield was ranged from 12.07 to 16.16 t/ha (CoA 12322). The test clones *viz.*, CoA 12322 (16.16 t/ha), CoA 12321 (15.90 t/ha) and CoA 12323 (15.21 t/ha) are the top performing clones for CCS yield in ratoon crop. All the test clones were exhibited higher CCS yield over the best standard CoA 92081. CCS yield is the combination of cane yield and corresponding commercial cane sugar per cent. The higher CCS yield in particular sugarcane clones may be attributed to relatively more average cane yield and subsequent commercial cane sugar. The results were in agreement with that of Elayaraja and Shanthi (2021). Ganapathy *et al.* (2024b) also stated that sugarcane clones were promoted for next yield trials based on the CCS yield in their experiments.

Identification of promising sugarcane clones for variety release is mainly based on the higher cane yield coupled with superior juice quality traits with good rationing ability. On the basis of overall performance of sugarcane clones evaluated in advanced varietal trial- Plant-I, AVT plant-II and AVT - Ratoon, it was concluded that, among the test clones evaluated along with standards. Three test clones *viz*., CoA 12322, CoA 12321 and CoA 12323 were expressed better performance in terms of cane yield, CCS yield and its contributing traits. Hence it was concluded that, these three sugarcane clones could be promoted for next breeding trials for yield confirmation and promising best one could be released as new sugarcane variety suitable for south India.

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