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Research Article

EVALUATION AND IDENTIFICATION OF PROMISING SUGARCANE CLONES FOR YIELD, QUALITY, AND RESISTANCE TO RED ROT SUITABLE FOR INDIA'S EAST COAST ZONE

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Abstract: The field experiment was conducted to assess the performance of mid-late sugarcane clones for red rot resistance, cane yield, CCS yield, and their contributing traits. Observation on germination per cent, number of tillers (x1000/ha), number of shoots (x1000/ha), number of millable cane (x1000/ha), stalk length (cm), stalk diameter (cm), single cane weight (kg), cane yield (t/ha), brix per cent, sucrose (%), purity (%), extraction (%), fibre (%), CCS (%), and CCS yield (t/ha). From the results, it could be concluded that the mid-late maturing clone, CoC 15339, was found to be the best among the test clones for sucrose per cent and CCS yield with resistance to red rot disease. Another clone, CoC 15340, was the next-best entry, with higher cane yield, CCS yield, and sucrose percent compared to the better standards. As a result, clones CoC 15339 and CoC 15340 were identified as the best entries and could be forwarded for further yield evaluation trials before being released as a new sugarcane variety for India's East Coast Zone.

Keywords: *Sugarcane, Mid-late clones, Cane yield, sucrose (%), CCS yield, Red rot disease, Resistance clone*

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Introduction

Sugarcane (*Saccharum* spp. hybrid) is a major commercial crop grown for sugar production in both tropical and subtropical regions of the world. Sugarcane is the main source of sugar in India, and in addition to sugar production, it creates a larger industrial base by producing by-products such as molasses, filter cakes, bagasse, and so on for further use in other sectors, as well as green fodder and concentrates for cattle. This creates jobs in agriculture and industry. India is the second-largest producer of sugarcane next to Brazil in terms of area (48.67 lakh ha) and production (376.91 million metric tonnes). In India, Tamil Nadu ranks fourth in area and production next to Uttar Pradesh, Maharashtra, and Bihar and ranks first in productivity. In Tamil Nadu, sugarcane was grown in an area of 1.31 lakh hectares, producing 14.12 million tonnes of sugarcane with a productivity of 107.62 t/ha[1].

High-yielding varieties play an important role in achieving self-sufficiency in local sugar consumption as well as producing surplus sugar for export. The lower yield from the sugarcane is attributed to varietal degeneration after a certain amount of time, the development of new races of pathogens, and changes in the environment. Hence, replacement of the existing varieties with new ones is needed for sustainable yield in sugarcane[2].

Variety development for different maturity groups is critical in sugarcane cultivation to achieve higher recoveries in sugar mills. Sugarcane production relies heavily on the proper selection of varieties, season, and appropriate agronomic technologies, as well as balanced nutrients application [3]. Non-adoption of any of the components leads to a reduction in sugarcane production, which affects not only cane growers and sugar mills, but also the national economy as a whole [4]. Sugarcane red rot disease, caused by *Collectotrichum falcatum* Went, is prevalent in all sugarcane growing areas. Most high yielding and high sugared varieties, such as CoC 671, CoC 90063, CoC 8001, CoC 85061, and CoC 92061, are susceptible to the disease [5]. Mid-late varieties are planted in February-March, and harvest occurs in February and March the following year, giving farmers a higher yield due to the north-east monsoon and more water shoots [6].

Because mid-late varieties have a high sucrose content and cane should be supplied throughout the crushing season after the early season canes are harvested, developing varieties for the mid-late group is critical. Hence, the present investigation was conducted to evaluate the mid-late maturing sugarcane clones for high sucrose content, high cane yield, CCS yields, and their contributing traits along with red rot resistance in the Zonal Varietal Trials of the AICRP on sugarcane.

Materials and Methods

The field experiment was conducted at the Sugarcane Research Station, Cuddalore, India (latitude: 11°46'N; longitude: 79°46'E; altitude: 4.60 m MSL) during 2017–18. Five mid late maturing CoC 15339, CoC 15340, CoOr 15346, PI 15376 and PI 15377 along with three check varieties Co 06030, Co 86249 and CoV 92102 were evaluated in a random block design with three replications. With a seed rate of 12 buds per metre, the plot included six rows of five metres each, spaced 90 cm apart. There was uniform adherence to advised agronomic procedures and need-based plant protection measures.

Data on germination percentage was recorded on the 30thday after planting, tiller counts on the 120thday following planting, and shoot counts (x1000/ha) on the 170thday following planting. All other parameters were recorded at harvest. Each test clone's cane sample was collected for quality analysis, and juice was extracted using a power crusher and tested for Brix percent and sucrose percent using a method recommended by Meade and Chen (1977) [7]. Sucrose per cent was calculated as per Schmitz's tables. CCS per cent was determined as per the following formula.

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

The CCS yield was estimated based on CCS per cent and cane yield. All the collected data were statistically analysed by statistical procedures described by Panse and Sukhatme (1978) [8].

Table-1 Mean performance of mid-late sugarcane clones for yield and quality traits in Zonal Varietal Trial

SN	Clone	Germination (%)	No. of tillers ('000/ha)	No. of shoots ('000/ha)	NMC ('000/ha) (12 m)	Stalk length (cm)	Stalk Diameter (cm)	Single Cane Wt. (kg)	Cane yield (t/ha)
1	CoC 15 339	56.613	127.27	115.31	101.25	296.67	2.85	1.34	140.21
2	CoC 15 340	60.273	119.74	106.18	98.36	291.33	2.78	1.41	137.26
3	CoOr 15 346	48.883	121.54	110.87	108.66	274.67	2.75	1.35	125.50
4	PI 15 376	52.217	127.84	126.54	104.23	283.67	2.71	1.29	126.26
5	PI 15 377	60.330	123.25	108.50	95.88	274.33	2.83	1.31	130.13
Standard									
1.	Co 06 030	47.480	124.13	103.18	106.31	267.33	2.71	1.24	125.34
2.	Co 86249	50.867	141.04	122.27	113.38	275.67	2.45	1.02	100.42
3.	CoV 92102	50.027	114.16	110.82	92.87	261.67	2.63	1.27	105.91
	S.Ed.	2.23	6.64	6.79	5.71	8.32	0.08	0.08	5.20
	CD (0.05)	4.74	14.07	14.40	12.11	17.64	0.19	0.16	11.03
	CV (%)	5.13	6.51	7.36	6.81	3.66	3.97	7.15	5.14

Table-2 Mean performance of mid-late sugarcane clones for yield and quality traits in Zonal Varietal Trial

SN	Clone	Brix (%)(12 m)	Sucrose (%) (12 m)	CCS (%)(12 m)	Purity (%)(12 m)	Extraction.(%)(12 m)	Pol. (%) (cane)(12 m)	Fibre (%)(12 m)	CCS (t/ha)
1	CoC 15 339	21.60	18.05	13.03	91.26	50.66	14.13	13.17	18.27
2	CoC 15 340	21.14	17.65	12.77	89.87	50.19	13.54	13.85	17.52
3	CoOr 15 346	20.73	17.71	12.81	90.42	50.23	13.82	13.29	16.07
4	PI 15 376	21.07	17.84	12.76	90.06	50.41	13.84	13.24	16.11
5	PI 15 377	21.24	17.67	12.68	90.66	50.34	13.74	13.41	16.50
	Standard								
1	Co 06 030	21.07	17.75	12.72	90.11	50.18	13.58	13.15	15.95
2	Co 86249	19.82	16.83	12.53	88.15	49.07	12.91	13.47	12.58
3	CoV 92102	21.06	17.77	12.76	90.64	50.26	13.82	12.84	13.52
	S.Ed.	0.18	0.15	0.10	0.75	0.24	0.23	0.22	0.68
	CD (0.05)	0.37	0.32	0.21	1.58	0.50	0.48	0.48	1.43
	CV (%)	1.02	1.05	0.94	1.01	0.58	2.02	2.06	5.24

Screening of sugarcane clones for red rot disease resistance

Plug method

The test clones were planted in two rows, with two canes from each 20clump inoculated using the plug method. *Colletotricum falcatum* pathotypes CF 06 (CoC 671) inoculums were prepared in sterile distilled water with the spore load of 106cfu/ml and inoculated in the middle of the third exposed inter-node from the bottom in each cane with an IISR inoculator and sealed with China clay. After two months of incubation, the inoculated canes were split open longitudinally along the point of inoculation and graded on a 0-9 scale. The test clones were planted in two rows and two canes of each 20 clumps were inoculated by plug method. The inoculums of *Colletotricum falcatumpatho* types CF 06 (CoC 671) was prepared with sterile distilled water with spore load of 106cfu /ml and inoculated in the middle of the third exposed inter-node from bottom with a IISR inoculators in each cane and sealed with China clay. The top condition was scored as green 0; yellow / Dry 1. Lesion widths above inoculated internodes were scored 1, 2, and 3. White spots are assigned a 1 for restricted type and a 2 for progressive type. The number of nodes crossed above the inoculated inter-node was scored as 1 if one node crossed, 2 if two nodes crossed, and 3 if three nodes crossed. The disease reaction was classified using the average score. The clones were classified as Resistant (0 to 2.0), Moderately Resistant (2.1 to 4.0), Susceptible (4.1 to 6.0), Susceptible (6.1 to 8.0), and Highly Susceptible (above 8.0) [9].

Nodal method

The nodal cotton swab approach was used to inoculate two canes in each of 20 clumps. The cane's leaf sheath was as nearly removed as feasible, and the lowermost node was inoculated by wrapping cotton swabs dipped in freshly made inoculum suspension around the cane and covering the nodal region. The cotton swab was held in place by parafilm being wrapped around it. Two months after inoculation the cotton was removed and the nodal region was scraped with a knife. The reaction was recorded as susceptible (S) if the lesion spread into the stalk and as resistant (R) if no lesions developed (R) [10].

Results and Discussion

The current study's analysis of variance revealed that all characters in the study were significantly different among the treatment mean squares. The results revealed that there was ample opportunity for selecting a better genotype. The variation in cane yield and yield components among genotypes may be attributed to genetic differences. The data on cane and yield contributing traits are furnished in [Table-1] and quality characters were presented in [Table-2].

Evaluation of sugarcane clones on the growth and yield parameters

A maximum of 60.73 germination percent was recorded for clone CoC 15340, and a minimum of 47.48 germination percent was recorded for clone Co 06030. Among the five test clones evaluated, only four clones showed a higher germination percentage over the better standard Co 86249 (50.87%). The germination percent directly influences the number of tillers and shoots [11].

In this trial, the highest number of tillers (x1000/ha) was recorded by Co 86249 (126.54) and the lowest number by Co 06030 (103.18). No test clone recorded a higher number of millable cane than the better standard Co 86249 (126.54/ha). The number of tillers per cane directly influences cane yield as it is a function of the interaction between the number of shoots in a unit area. Tillering potential of a clone ultimately effects cane yield positively. Similar reports were already reported by [11]. The clone PI 15376 (126.54 x1000/ ha) had the highest number of shoots population, while Co 06030 had the lowest (103.18 x1000/ ha). Only one of the five test clones, PI 15376, outperformed the standard Co 86249 (122.27 x1000/ ha/ha). The number of shoots has a direct influence on cane yield because it is the result of the interaction of tillers and millable cane population.

Evaluation of yield and yield contributing characters

In this trial, Co 86249 (103.38) recorded the highest number of millable cane populations (x1000/ ha), and PI 15377 the lowest (95.88). None of the five test clones that were analysed produced more millable cane than the Co 86249 standard. Number of millable cane directly influences the cane yield as it is the combined interaction of tillers and shoot numbers [3].

Cane yield and CCS yield are directly connected with stalk (cane) length. In good growing conditions, individual seedling clones can generate up to 2.0 m of cane, which can be planted to the following selection stage, according to[12]. In the present study, the clone CoC 15339 recorded higher cane length (296.67 cm) and minimum by check CoV 92102(261.67 cm). Among the five clones, three clones recorded superior performance over the better standard Co 86249 (275.67 cm). The similar research work carried out by [13].

The stalk diameter (thickness) ranged from 2.45 cm (Co 86249) to 2.85 cm (CoC 15339). Four of the five clones exceeded the better standard Co 06030, which measured 2.71 cm. Canes that grow tall and thin may be more prone to lodging; tall clones with thick stalked canes that resist lodging may have a significant potential to be the high yielding variety in the future. Stalk diameter is an important yield contributing character, and larger stalk diameter would improve farmer acceptability of varieties [11]. The weight of a single cane is the product of its length and girth and contributes directly to cane yield [11].

It ranged from 1.02 kg (Co 86249) to 1.41 kg (CoC 15339). Among the test clones, four performed better than the standard CoV 92102, which recorded 1.27 kg [11].

Cane Yield (t/ha)

Cane yield is a major trait to find out the economic potential of a genotype. It is the combination of functions like environmental response and genetic potential of a genotype. High cane yielding varieties showed best environmental response and hence revealed good performance of cane yield as compared to the other varieties[13].In the present experiment, the maximum cane yield was recorded in CoC 15339(140.21 t/ha) and minimum in Co 86249 (100.42 t/ha). All the clones were recorded numerically superior value over the standard variety Co 06030 (125.34 t/ha). The similar work was already reported by Ganapathy and Jayachandran (2016) [14].

Evaluation of sugarcane clones on the CCS yield and Quality attributes

Brix per cent at maturity stage (Total Soluble Solids) plays an important role in determine the sugar recovery per cent of the genotype. In the present study, the brix per cent was range from 21.60 (CoC 15339) to 19.82 (Co 86249). The test entries *viz*., CoC 15339 (21.60%), CoC 15340 (21.14 %) and PI 15377 (21.24%) recorded superior performance over the best standard Co 06030 (21.07 %). These results are in agreement with the findings of Ganapathy and Jayachandran (2016) [14] and studied a number of mid-late maturing sugarcane clones and found different levels of Brix per cent.

The sucrose per cent is useful in deciding the quality of sugarcane genotype and it influences the sugar recovery and sugar production. In the present study, sucrose per cent during harvest varied from 18.05 (CoC 15339) to 16.83(Co 86249). Among the test clones, two test clones namely CoC 15339 and PI 15376 were recorded superior performance over the better standard CoV 92102, which recorded 17.77 per cent. The results are almost similar as demonstrated by Hapase, *et al.,* (2013) [15].

Purity per cent of the cane juice at harvest is important quality trait, it was deciding the quality of genotype and it influences the sugar recovery and sugar production in sugar mills. In the present study, purity per cent varied from 91.26 (CoC 15339) to 88.15 (Co 86249). Only two test clones CoC 15339 and PI 15376 were expressed superior performance over the better check variety CoV 92102 (90.64 %).Extraction per cent of cane juice at harvest is important quality character, it was deciding the quality of genotype and it influences the sugar recovery and sugar production in sugar mills. In the present study, extraction per cent varied from 0.60 (CoC 15339) to 49.07 (Co 86249). Three test clones were recorded superior value over the best check variety CoV 92102 (50.26 %).

The pole per cent in cane is important trait for deciding the quality of sugarcane genotype and it influences the sugar recovery and sugar production. In the present study, pole per cent at harvest varied from 14.13 (CoC 15339) to 12.91 (Co 86249). Two test clones namely CoC 15339 and PI 15376 (13.84 %) were expressed superior performance over the better standard CoV 92102, which recorded 13.82 per cent. Fibre per cent at maturity, in the study, varied from 13.85 (CoC 15340) to 12.84 (CoV 92102). The test clone CoC 15340 (13.85 %) recorded superior performance over the better standard Co 86249 (13.47 %).

CCS per cent at harvest

Commercial cane sugar (CCS) per cent is the best tool for breeders and millers for identification of high quality genotypes [13]. The CCS per cent of the present investigation varied from 13.03 (CoC 15339) to 12.53 (Co 86249). The three test entries *viz*., CoC 15339 (13.03%), CoOr 15346 (12.81%) and CoC 15340 (12.77%) were recorded numerically superior performance over best standard CoV 92102, which recorded 12.76 %. This discussion shows a close succinctness with [13].

CCS Yield (t/ha)

In the present experiment, commercial cane sugar (CCS) yield was ranged from 18.27t/ha (CoC 15339) to 12.58t/ha (Co 86249). Among the five clones evaluated, all the five test clones recorded numerically superior performance over the best standard variety Co 06030 (15.95 t/ha). This discussion shows a close conciseness with those of [11,13 &14].The higher CCS yield of clones may be attributed to relatively more average cane yield and commercial cane sugar percent [16].

Reaction of sugarcane clone to red rot disease

The results of red rot reaction for different mid-late maturing clones are given in [Table-3]. The clones *viz*., CoC 15339, CoC 15340 and CoOr15346 were found to be moderately resistant, PI 15376 was moderately susceptible and PI 15377 was highly susceptible by plug method of inoculation. All the test clones were found resistant except PI 15377 by nodal method of inoculation. The similar results were already reported by Ravichandran, *et al*., (2021) [17].

Table-3 *Screening of sugarcane clones for resistance to red rot disease by plug method of Inoculation and nodal cotton swab method.*

SN	Entry	Red rot disease (Plug Method)		Nodal Method
		Score	Disease Reaction	
1	CoC 15 339	2.8	MR	R
2	CoC 15 340	4.0	MR	R
3	CoOr 15 346	3.8	MR	R
4	PI 15 376	5.8	MS	R
5	PI 15 377	8.3	HS	S
	Check			
6	CoC 671 (S)	9.0	HS	S
7	Co 86249 (R)	2.0	R	R

Conclusion

Identification of promising sugarcane clones that, besides having desirable characteristics, exhibit high sugar content is an important aspect in sugarcane breeding. Sugar recovery stands the factor of prime importance both from millers and breeding point of view. On the basis of overall performance of different clones evaluated, the test clones *viz*., CoC 15339 and CoC 15340 were exhibited better performance in terms of cane yield, CCS yield and its contributing traits. Hence it was suggested that the promising selected clones could be promoted for further breeding trials for confirmation and promising clone could be released as a new sugarcane variety for east coast zone of India.

Application of research

Study of mid-late maturing sugarcane clones for high sucrose content, high cane yield, CCS yields, and their contributing traits along with red rot resistance in the Zonal Varietal Trials of the AICRP on sugarcane

Research Category: Sugarcane Research

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Study area / Sample Collection: Sugarcane Research Station, Cuddalore, India

Cultivar / Variety / Breed name: Sugarcane (*Saccharum* spp. hybrid)

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