Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 1384-1388
Received: 22-09-2019
Accepted: 24-10-2019

N Sabitha
Scientist (Plant Breeding) RARS, Tirupati, Andhra Pradesh, India

M Hemanth Kumar
Principal Scientist (Plant Breeding), ARS, Perumallapalli, Andhra Pradesh, India

KR Tagore
Associate Director of Research, RARS, Nandyala, Andhra Pradesh, India

Corresponding Author:
N Sabitha
Scientist (Plant Breeding) RARS, Tirupati, Andhra Pradesh, India

Performance of pre release early maturing sugarcane clones for cane yield & yield components in the coordinated varietal trials of southern zone

N Sabitha, M Hemanth Kumar and KR Tagore

Abstract
Five pre release sugarcane clones viz., Co11001, Co11004, CoM11081, CoM11082 and CoM11084 in the early group were tested against the three standards Co85004, Co94008 and CoC 671 in two plant crops and one ratoon from 2016-17 to 2017-18. Based on their performance in the plant and ratoon crops, the clone CoM 11082 was found to be on par with the standards for cane and sugar yields. The clone CoM 11082 also recorded higher mean values for length of millable cane and single cane weight compared to other test clones. The clone CoM 11081 was found to be superior for juice quality over the other test clones but was on par with the standards The high yielding clone CoM 11082 may be recommended for commercial cultivation in Rayalaseema region after on testing in farmers' fields. Number of millable canes, single cane weight, percent CCS and sucrose may be given due importance while for making selections for higher cane and sugar yields as the associations among themselves were positive and significant and also with CCS yield and cane yield.

Keywords: Sugarcane clones, plant crop, ratoon, cane yield and CCS yield

Introduction
Sugarcane is one of the important commercial crops of Rayalaseema region after cotton. In Chittoor district it occupied earlier second position with an area of 35,000 ha in the state while Visakhapatnam continues to occupy the first position. However, in the recent past there is a drastic reduction in cane area. Cane productivity is stagnant due to several known reasons. One of the major reason is the non-availability of improved clones in early group in the place of the currently commercially grown clones viz., 86V96, 2003V46 and 87A298. Hence, there is an urgent need for identification of high yielding sugarcane clones rich in sucrose coupled with tolerance to moisture stress, red rot, and smut. The present study was carried out with five pre-release sugarcane clones along with three standards to identify the suitable clones for the Rayalaseema region.

Materials and methods
Five test clones viz., Co11004, Co 11081, Co 11082, Co 11084 and Co 11001 were tested against three standards Co 85004, Co 94008, Co C 671 in a RBD with three replications in two plant and ratoon crops during 2016-17 to 2017-18. Each clone was grown in six rows of 5.0 M length adopting 90cm spacing between rows. A fertilizer dose of 224 kg N, 100kg P205 and 120 kg was applied as per the recommendations for the region. All the good agronomic practices were followed in raising a healthy crop. Data on shoot population at 120 DAP, NMC at harvest, cane yield, length of cane, cane girth, single cane weight were recorded. Juice quality parameters viz., percent Brix, Sucrose, Purity and CCS at 8thand 10th months in plant crops at 9th month in ratoon crops as per the standards procedure (Meade and Chen 1977) [2]. Mean data was analysed following standard statistical procedures as suggested by (Panse and Sukhatme 1978) [3].

Results and Discussion
Shoot population at 120 DAP (000'/ha)
It varied from 81.8 (CoM 11082) to 165.6 (CO 85004) in I plant; from 82.2 (CoM 11082) to 125.9 (Co 85002) in II plant and from 56.9 (CoM 11081) to 151.8 (Co 85004) in ratoon crop with a mean value of 102.8; 100.6 and 165.7, respectively. The standard Co 85004 recorded maximum shoot population at 120 DAP in plant and ratoon crops followed by CoC 671 and Co 94008.

Among the pre release clones, Co11001 in two plant crops and Co M 11084 in ratoon crop have recorded higher shoot population at 120 DAP (Table1).

Juice Quality parameters at 8th month

Percent brix, Sucrose, Purity and CCS recorded at 8th and 10th months in two plant crops and at 9th month in ratoon crops were presented in Table 1.

Brix percent at 8th month ranged from 14.5 (Co 94008) to 17.4 (CoM 11081) in I plant and from 15.1(CoM 11084) to 18.5 (CoC 671) in II plant crop with an average value of 16.4 and 16.6 percent. Among the test clones CoM 11081 recorded percent brix on par with the best standard Co 94008 in I and II Plant crops.

Percent sucrose in I and II crops at 8th month ranged from 13.8 (Co 94008) to 16.4 (Co 85004) and from 12.9 (CoM 11084) to 16.8 (CoC611 in II plant crop with a mean value of 15.5 and 14.9, respectively. Among the standards Co 81002 and among the test clones CoM 11081 registered higher percent juice sucrose at 8th month in both the plant crops.

Percent purity varied from 92.5 (CoM 11084) and CoM 11081 to 98.6 (CoC 67) in I plant and in II plant from 85.6 (CoM 11084) to 92.2 (Co94008) with a mean value of 95.1 and 89.2, respectively. Co 94008 and Co 671 among standards and Co11001 and CoM 11082 among the test clones registered higher purity percent values at 8th month.

CCS percent varied in I plant ranged from 9.9 (Co 94008) to 11.9 (Co 11001) and from 9.6 (Co11004) to 11.8 (CoC671)in II plant with a general mean value of 11.1 and 10.3 percent, respectively. None of the test clones were found superior for the character to compared to standards.

Juice Quality parameters at 10th month in plant crops and at harvest in ratoon

Brix percent at 10th month in I plant crop varied from 17.7 (Co 11004 and CoM 11081) to 19.8 (CoC671); in II Plant crop from 18.7 (Co 94008) to 21.4 (CoC671) and in ratoon crop it varied from 13.8 (Co 94008) 16.4 (Co 85004). The mean values for I, II and ratoon crops were 18.1, 20.0 and 15.5 respectively. Percent Juice sucrose at 10th month ranged from 16.3 (Co 94008 and CoM 11084) in plant crop; from 17.3 (Co 94008) to 20.1 (CoC671) in II plant crop and from 13.2 (C011004) to CoM 11081 in ratoon crop at harvest with a mean of 17.4, 18.4 and 14.7, respectively. Among the standards CoC671 and Co 85004 and among test clones Co11001 and CoM 11081 have recorded higher juice sucrose in two plant and ratoon crops.

Purity percent values at 10th month varied from 91.4 (Co 94008) to 98.2 (CoM 11082 and Co 85004) in I plant; from 90.0 (CoM 11084) to 94.2 (CoM 11081) in II plant and from 87.1 (Co 11004) to 96.9 (Co 94008) at 9th month in ratoon crop. The mean Purity percent values in I and II plant and ratoon were 95.9, 91.9 and 92.7, respectively. The test clone CoM 11081 and all the standards have registered higher percent purity values. Percent CCS at 10th month in I plant ranged from 10.6 (Co 94008) to 12.4 (Co11004 and CoC671); from 12.2 (Co 94008) to 14.3 (Co 671) in II plant crop and from 9.1 (Co 11004) to 11.4 (CoM 11081) with a mean value of 11.9, 13.0 and 10.4, respectively. The test clone CoM 11081 and standards CoC 671 and Co85004 registered high CCS percent values compared to other clones.

Table 1: Mean data for yield components and juice quality parameters in plant and ratoon crops

S. No	Clone No	Stalk Population at 240 DAP			No. of Millable Canes at Harvest			Length of the cane (cm)			Girth of the cane (cm)		
		I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon
1	Co11004	109.7	87.6	90.8	80.4	66.8	79.4	322.3	219.0	225.0	2.5	3.0	2.7
2	CoM 11082	81.8	82.2	101.8	76.1	66.4	75.7	304.3	234.3	222.3	2.7	2.9	2.7
3	CoM11084	119.3	99.1	133.3	75.5	71.5	96.5	296.3	207.1	190.0	2.5	2.7	2.3
4	Co11001	123.5	106	85.3	98.4	69.7	81.3	284.3	195.0	158.0	2.6	3.0	2.8
5	CoM11081	109.8	93.3	56.9	79.9	56.1	57.5	283.7	192.3	176.7	2.5	2.9	2.7
6	Co85004(C)	165.6	125.9	151.8	107.9	80.2	112.3	300.7	197.0	196.3	2.4	2.7	2.7
7	CoC671(C)	158.3	106.6	93.3	83.9	75.0	65.8	336.7	206.0	183.0	2.7	2.5	2.6
8	Co94008(C)	124.9	105.4	132.9	102.3	86.9	95.6	306.7	215.7	191.0	2.7	2.8	2.7
	Mean	102.9	100.6	105.7	88.1	71.6	83.0	304.4	208.3	192.8	2.6	2.8	2.7
	CD at 5%	8.3	15.4	21.3	6.9	13.8	13.9	15.7	18.0	28.7	0.1	0.2	0.2
	CV (%)	5.8	10.9	11.4	4.7	10.9	9.4	2.9	4.9	8.4	2.4	4.8	4.2

S. No	Clone No	Single cane weight (Kg)			Brix % at 8th Month			Sucrose % at 8th Month			Purity % at 8th month			CCS % at 8th month		
		I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon
1	Co11004	1.4	1.4	1.1	16.7	16.1	15.7	14	93.8	92.1	11.1	9.6	16.7	16.1	15.7	14
2	CoM 11082	1.8	1.4	1.3	16.8	16.2	15.8	14.8	94.0	90.7	11.2	10.4	16.8	16.2	15.8	14.8
3	CoM11084	1.3	1.1	0.9	16.6	15.1	15.3	12.9	92.1	85.6	11.8	8.8	16.6	15.1	15.3	12.9
4	Co11001	1.2	1.1	0.9	16.6	16.1	16.3	14.1	98.4	87.4	11.9	9.7	16.6	16.1	16.3	14.1
5	CoM11081	1.3	1.1	0.8	17.4	17.2	16.0	15.6	92.1	90.5	11.3	10.9	17.4	17.2	16.0	15.6
6	Co85004(C)	1.1	0.9	1.0	16.9	17.5	16.4	15.4	96.6	88.2	11.8	10.7	16.9	17.5	16.4	15.4
7	CoC671(C)	1.4	1.1	1.0	15.3	18.5	15.1	16.8	98.6	91.1	10.9	11.8	15.3	18.5	15.1	16.8
8	Co94008(C)	1.4	1.2	1.1	14.5	16.4	13.8	15.2	95.3	92.2	9.9	10.7	14.5	16.4	13.8	15.2
	Mean	1.4	1.2	1.0	16.4	16.6	15.5	14.9	95.1	89.2	11.1	10.3	16.4	16.6	15.5	14.9
	CD at 5%	0.1	0.2	0.2	0.6	1.4	0.4	1.7	4	4.7	0.4	1.5	0.6	1.4	0.4	1.7
	CV (%)	4.1	8.1	10.7	2.2	4.8	1.5	6.7	2.4	2.6	2.1	8.2	2.2	4.8	1.5	6.7

S. No	Clone No	Brix % at 10th month			Sucrose% at 10th month			Purity at 10th month			CCS % at 10th month		
		I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon
1	Co11004	17.7	20.0	15.7	17.2	18.4	13.2	97.4	92.1	87.1	12.4	13.0	9.1
2	CoM 11082	18.1	20.2	15.8	17.8	18.2	14.9	98.2	90.2	93.9	12.1	12.7	10.6
3	CoM11084	17.7	19.9	15.3	16.3	17.9	13.7	91.7	90	88.8	11.3	12.5	9.5
4	Co11001	17.9	19.4	16.3	17.4	17.7	14.5	98	91.2	92.1	12.3	12.4	10.2
5	CoM11081	18.0	20.2	16.0	17.3	19.0	15.9	96.1	94.2	94.1	12.1	13.5	11.4
6	Co85004(C)	17.9	20.5	16.4	17.6	18.7	15.2	98.2	91.5	94.5	12.2	13.2	10.8
7	CoC671(C)	19.8	21.4	15.1	19.2	20.1	15.5	96.9	93.9	93.5	12.4	14.3	11
8	Co94008(C)	17.8	18.7	13.8	16.3	17.3	15.0	91.4	92.4	96.9	10.6	12.2	10.8
	Mean	18.1	20.0	15.5	17.4	18.4	14.7	95.9	91.9	92.7	11.9	13.0	10.4
	CD at 5%	1.1	1.1	0.4	1.0	1.3	1.3	2.9	1.2	0.63	0.4	1.2	1.2
	CV (%)	3.3	3.1	1.5	3.4	4.0	4.8	1.7	3.1	2.4	1.9	5.0	6.2

S. No	Clone No	Cane Yield (kg ha^{-1})			CCS Yield (kg ha^{-1})		
		I Plant Crop	II Plant Crop	Ratoon	I Plant Crop	II Plant Crop	Ratoon
1	Co11004	111.4	90.3	86.0	13.9	11.7	7.9
2	CoM 11082	135.3	89.3	91.7	16.3	11.3	9.7
3	CoM11084	101.6	73.5	87.7	11.5	9.2	8.5
4	Co11001	124.9	72.9	65.5	15.3	9.1	6.1
5	CoM11081	104.4	58.2	45.0	12.0	7.9	5.1
6	Co85004(C)	120.8	72.0	108.1	15.4	9.5	11.7
7	CoC671(C)	119.6	80.2	60.7	16.8	11.5	6.7
8	Co94008(C)	145.3	94.4	99.1	16.5	11.6	10.7
	Mean	116.9	78.8	80.5	14.1	10.2	8.3
	CD at 5%	14.6	19.8	21.1	1.7	2.1	2.4
	CV (%)	6.6	14.2	14.9	6.7	7	6.5

Yield Components

Length of millable cane (cm)

It varied from 283.7 (CoM 11081) to 336.7 (CoC671) in I plant; from 192.3 (CoM 11081) to 234.3 (CoM11082) in II plant crop and from 158.0 (Co 11001) to 225.0 (Co 11004) in ratoon with a mean value of 304.4, 208.3 and 192.8 cm, respectively. Among the test clones Co1104 and CoM 11082 have recorded higher values for this character compared to standards and other test clones in plant and ratoon crops.

Cane girth (cm)

Among the clones it varied from 2.4 (Co85004) to 2.7 (CoM11082, CoC671 and Co94008) in I plant crop; from 2.5 (CoC671) to 3.0 (Co11004 and Co11001) in II plant and from 2.3 (CoM11084) to 2.8cm (Co11001) in ratoon crop. The general mean in first, second and ratoon crop include 2.6, 2.8 and 2.7, respectively.

Single cane weight (kgs)

In the I plant crop, single cane weight ranged from 1.1 (Co85004) to 1.8 (CoM11082); from 0.9 (Co85004) to 1.4 (Co11004) and (CoM 11082) in II plant and from 0.8 (CoM11081) to 1.3 (CoM 11082) in ratoon with a general mean of 1.4, 1.2 and 1.0 kg, respectively. The test clone CoM 11082 recorded higher single cane weight in plant and ratoon crops compared to other test clones and standards.

NMC at harvest ('000/ ha')

Number of millable canes at harvest ranged from 75.5 (CoM 11084) to 107.9 (Co85004) in I plant; from 56. (CoM 11081) to 86.9 (Co94008) in II plant crop and from 57.5 (CoM11081) to 112.3 thousands/ha (Co85004) with a mean of 88.1, 71.6 and 83.0, respectively. The standards Co85004 and Co94008 registered more number of millable canes at harvest compared to other clones studied.

Cane yield (t/ha)

Cane yield in I plant crop ranged from 101.6 (CoM11084) to 145.3 (Co 94008); from 58.2 (CoM11081) to 94.4 (Co94008) in II plant and from 45.0 (CoM11081) to 108.1 (Co 85004) in ratoon with a mean value of 116.9, 78.8 and 80.5 t/ha, respectively. Among the test clones CoM11082 among the standards Co94008 registered higher cane yields in I, II and ratoon crops compared to other clones studied in this trial. Similar results were also observed by Sabitha *et al*. (2015).

CCS Yield (t/ha)

The character ranged from 11.5 (CoM11084) to 16.8 (CoC671) in I plant crop; from 7.9 (CoM11081) to 11.7 (Co11004) in II plant crop and from 5.1 (CoM11081) to 11.7 (Co 85004) in ratoon crop with a mean CCS yield of 14.1, 10.2 and 8.3 t/ha, respectively. Among the test clones CoM11082 and among Standards Co85004 and Co94008 were found superior for CCS yield compared to other genotypes.

Simple correlation coefficients worked out for yield components and juice quality parameters with cane yield are presented in Table 2.

Table 2: Association among yield components and with cane yield in early maturing clones of sugarcane

Plant Character	Shoot population at (000'/ha)	Stalk population (000'/ha)	NMCat harvest (000'/ha)	Cane length (cm)	Cane girth (cm)	Single cane weight (kg)	Brix (%) at 10th month	Sucrose (%) at 10th month	Purity (%) at 10th month	CCS (%) at 10th month	Cane yield (t/ha)	CCS yield (t/ha)
Shoot population (000'/ha)	1.000	0.622**	0.606**	0.307	-0.096	0.204	0.327	0.349	0.165	0.306	-0.063	0.072
Stalk population (000'/ha)		1.000	0.820**	-0.286	-0.042	-0.199	-0.372	-0.362	-0.127	-0.357	0.374	0.019
NMC at harvest (000'/ha)			1.000	-0.150	-0.056	-0.136	-0.146	-0.094	0.039	-0.91	0.501**	0.386
Cane length(cm)				1.000	0.073	0.342	0.613**	0.526**	0.066	0.469	0.139	0.336
Cane girth(cm)					1.000	0.422*	0.146	0.121	0.009	0.119	0.338	0.265
Single cane weight (kg)						1.000	0.553**	0.449*	0.014	0.392	0.472*	0.279
Brix (%) at 10th month							1.000	0.855**	0.106	0.777**	0.150	0.496*
Sucrose (%) at 10th month								1.000	0.606**	0.988**	0.095	0.476*
Purity (%) at 10th month									1.000	0.704**	-0.203	0.153
CCS (%) at 10th month										1.000	-0.008	0.464*
Cane yield(t/ha)											1.000	0.881**
CCS yield (t/ha)												1.000

* significant at 5% level
** significant at1% level

Association among the yield components and juice quality parameters with cane yield

Shoot population at 120 DAP showed positive and significant associations with stalk population at 240DAP, (0.622**) and number of millable canes at harvest (0.606**).The association of shoot population at 120 DAP with cane length (0.307), single cane weight (0.204), cane yield (0.313), brix (0.327), sucrose (0.349), Purity (0.167) and CCS per cent (0.306) and CCS yield (0.072) was positive but non-significant. The character had negative and non-significant association with cane length (-0.286) and cane girth (-0.096).

Stalk population at 240 DAP had significant and positive association with NMC at harvest (0.820**). However, the association of stalk population with cane length (-0.286), cane girth (-0.042), single cane weight (-0.199), brix (-0.372), sucrose (-0.362), purity (-0.127), CCS (-0.157) was negative but non-significant while the association of stalk population with cane yield (0.374) and CCS yield (0.019) was positive and non-significant.

Number of millable canes showed positive and significant association with cane yield (0.501**) but with CCS yield it was non-significant (0.386). NMC at harvest had either negative or positive but non-significant associations with cane length (-0.150), cane girth (-0.056), single cane weight (-0.136), brix (-0.146), sucrose (-0.091), purity (0.039) and CCS (-0.091). Cane length had significant and positive association with brix (0.613**), sucrose (0.520**), and CCS (0.469*) and non-significant association with cane girth (0.073), single cane weight (0.342), purity (0.066), cane yield (0.139) and CCS yield (0.336).

Association of cane girth with single cane weight (0.422*) was significantly positive while the associations of cane girth with per cent Brix (0.146), sucrose (0.121), purity (0.009), CCS (0.119), cane yield (0.338) and CCS yield (0.265) were non-significant but positive. Single cane weight had positive and significant association with percent brix (0.553**), sucrose (0.449**) and cane yield (0.472*) while its association with percent purity (0.014), CCS (0.392) and CCS yield (0.276) was positive but non significant.

Percent brix showed positive and significant association with sucrose (0.855 **), CCS percent (0.777**) and CCS yield (0.496*) while the association of percent brix with percent purity (0.106) and cane yield (0.150) was non significant. Percent sucrose had positive and significant association with percent purity (0.606**), CCS percent (0.988**), CCS yield (0.476*) while the same character showed positive but non significant association with cane yield (0.095).

The association of per cent purity with CCS percent was positive and significant (0.988**). However, the associations of percent purity with cane yield (-0.203) and CCS yield (0.153) were non significant. Associations of CCS percent with CCS yield (0.464*) and cane yield with CCS yield (0.881**) were positive and significant. CCS percent showed non significant association with cane yield (-0.008). Thus, economically important traits viz percent sucrose with CCS percent and CCS yield; CCS percent with CCS yield and cane yield with CCS yield were positive and significant. Milligan *et al*. (1990) [8], Mohammad Tahir *et al*. (2014) [6], and Anbanandan and Eswaran (2018) [4] also reported similar results of significant and positive associations of cane yield with single cane weight, number of millable canes, sucrose per cent, per cent CCS and sugar yield in sugarcane.

Conclusions

The clone CoM 11082 was found to be on par with the standards for cane and sugar yields. The clone CoM 11082 also recorded higher mean values for length of millable cane and single cane weight compared to other test clones. The clone CoM 11081 was found to be superior for juice quality over the other test clones but was on par with the standards The high yielding clone CoM11082 may be recommended for commercial cultivation in Rayalaseema CCS and sucrose may be given due importance while making selections for higher cane and sugar yields as the associations among themselves were positive and significant and also with CCS yield and cane yield.

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