Madras Agric. J., 101 (10-12): 320-325, December 2014
https://doi.org/10.29321/MAJ.10.001207

Performance of Elite Early Maturing Sugarcane Clones for Yield and Quality Traits During Varietal Selection Process

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Performance of fourteen early maturing sugarcane clones developed through fuzz was assessed along with two local checks and one promising variety as standards at Sugarcane Research Station, Tamil Nadu Agricultural University, Sirugamani during 2012-13. Data were recorded for germination, economic shoot, cane thickness, cane height, number of internodes/ plant, internode length, cane yield, Brix (%), Pol (%), purity (%), CCS (%) and sugar yield. Analysis of variance revealed highly significant differences among test clones for cane yield, sugar yield and its attributing traits. On the basis of overall performance, three test clones, namely Si 07-101, Si 07-017 and Si 07-082 showed good performance in respect of cane yield with average mean values of 134.60, 132.30 and 131.10 t/ha respectively against the best standard CoSi(SC) 6 (127.30 t/ha). While, the test clone Si 07-102 produced the lowest cane yield of 91.20 t/ha. The highest average mean sugar yield was observed in Si 07-131 (18.54 t/ ha), Si 07-017 (18.14 t/ah), Si 07-082 (17.21 t/ha) and Si 07-101 (17.00 t/ha) against the best standard TNAU Sugarcane Si 7 (16.01 t/ha). However, the test clone Si 07-102 gave the lowest sugar yield of 9.46 t/ha against the standards. On the basis of over all performance it was concluded that the test clones Si 07-017, Si 07-082, Si 07-101 and Si 07-131 need to be forwarded to next selection stage for further progression and testing.

Key words: Sugarcane, Fuzz, Early maturing, Clone, Cane yield and Sugar yield

Sugarcane (*Saccharum* spp. hybrids) is one of the major cash crop grown extensively all over the world from tropical to sub-tropical regions. India is the second largest producer of sugarcane next to the Brazil in terms of area and production. In India, Tamil Nadu ranks third in area and production next to Uttar Pradesh and Maharastra and ranks first in productivity. In India, sugarcane is the main source of sugar and besides sugar production, it creates wider industrial base, providing several by-products like molasses, filter cakes, bagasse *etc.* for further utilization in other sectors and green fodder / concentrates for cattle. In this way employment is created on farm and industry (Junejo *et al.,* 2010). High yielding varieties have a decisive role in getting self sufficiency in local sugar consumption as well as to make surplus sugar to export. There may be several reasons of low cane yield with respect to varieties because sugarcane varieties deteriorate after a certain period of time due to evolution of new breeds of pathogens and change in environment from year to year. Therefore, a constant flow of fresh improved varieties is essential (Aslam *et al.,* 1998).

New sugarcane varieties are produced by sexual means and propagated vegetatively. Each year, a new population of original seedlings consisting of many thousands of new varieties is produced. These are screened clonally through several selection stages, their numbers are being reduced at each stage and the selected ones are tested in larger plots in which their performance can be evaluated more reliably (Skinner *et al.,* 1987). Careful selection of the clones in early stage may lead to the development of superior varieties (Panhwar *et al.,* 2003). Improved methods of selection resulting in higher yielding sugarcane cultivars would help in increased yield (Tahir *et al.,* 2014). Sugarcane clones are frequently evaluated in one or two row plots in early stages of selection. Selection in small plots should be based on sugar content, measuring cane yield in such trials may be inefficient, may necessarily delay progression of selected clones through to the next stages of selection (Jackson and Mc Rae, 2001). So, selection in early stages must concentrate on easily recognized characters with good repeatability such as good growth, tillering, leaf development, desirable stalk characteristics and resistance and tolerance to disease and pests (Skinner *et al.,* 1987).

Success of a variety depends upon its adaptability to agro-climatic conditions of the area. Selection of a proper variety to be sown in a particular agro-ecological zone is a primary requisite to explore its yield and sugar recovery potential (Arain *et al.,* 2011). Sugar recovery percentage is an important quality character of a sugarcane variety, which is closely correlated with economic value.

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Milligan *et al.* (1990) suggested that emphasis should be placed on selection for cane yield to increase sucrose content per unit area.

Sugarcane clones obtained from the same parents show heterogeneity in F_1 generation and the scientists exploit the variability in making selections (Keerio, 2000). Sugarcane is hard to flower under natural environment until some specific temperature, humidity and photo period requirements are fulfilled. Many sugarcane varieties flower and produce viable seeds upto 20_o North or South latitude, where photo thermal environment is favourable. In Tamil Nadu, photo thermal climate is favourable in Coimbatore, where many sugarcane varieties flower and produce viable fuzz. The varietal development programme at Sugarcane Research Station (SRS), Sirugamani utilizes the flowering of many sugarcane varieties along with production of viable fuzz. But the major constrain is non-synchronization of flowering among genotypes which in-turn reduces the possibility of making desired crosses. So, the sugarcane breeding programme in SRS, Sirugamani is carried out through locally collected fuzz from general cross, bi-parental, poly cross and fuzz/clones received from the other Sugarcane Research Stations come under Tamil Nadu Agricultural University (TNAU) and Sugarcane Breeding Institute (SBI), Coimbatore. New seedlings of sugarcane are produced from the fuzz and subsequent selection of the seedlings (clones) is done in different selection stages through setts. After careful examination of these clones for several traits, high cane and sugar yielding ones having resistance to insect pest and disease are selected.

In TNAU, the elite clones from Advanced Varietal Trial are tested in all three Sugarcane Research Stations and superior clones are pooled and tested in Sugar factory sites and farmers' fields throughout Tamil Nadu under Adaptive Research Trials (ART) and after achieving meaning full results, the State Variety Release Committee (SVRC) decides to release the elite clones for commercial cultivation.

Keeping in view, the importance of varietal aspects in Sugarcane, the present study was conducted to compare the yield and quality characteristics of fourteen early sugarcane clones evolved at SRS, Sirugamani along with promising variety in Tamil Nadu and locally evolved commercial varieties as checks.

Materials and Methods

The present study was conducted at Sugarcane Research Station, Tamil Nadu Agricultural University, Sirugamani. Seedlings were raised in nursery from the locally collected fuzz. These seedling clones were transferred to the main field and grown as single plants. The selected sugarcane clones from the single plant trial were promoted and tested year wise in subsequent selection stages. During January, 2010 fourteen early maturing sugarcane clones obtained from Preliminary Yield Trail and three checks were planted in Initial Varietal Trial in Randomized Block Design for further testing and selection. Five rows of each sugarcane clones were planted by overlapping method using two budded setts. The row length and row spacing were 5 m and 1.2 m respectively with three replications. Crop was fertilized as per the University recommendation. Entire dose of Phosphorous was applied at sowing as basal while Nitrogen and Potash were applied in three equal splits on 30, 60 and 90 days after planting. The plant production measures like weeding, hoeing, earthing up, irrigation and plant protection measures were taken according to crop condition and requirement.

The data for different parameters such as germination percentage, economic shoot count ('000/ha), cane thickness (cm), cane height (m), number of internode/plant, internode length (cm), cane yield (t/ha), Brix (%), Pol (%), Purity (%), commercial cane sugar (CCS) (%) and sugar yield (t/ha) were recorded during different growth stages of the crop. All data pertaining to cane yield except economic shoot count and cane yield were collected from the primary stalk. Five canes were randomly selected from each replication for juice analysis. The canes were crushed in the crusher and their juice was analyzed in the laboratory for the assessment of CCS (%). The data recorded were statistically analyzed as per Panse and Sukhatme (1978).

Results and Discussion

The analysis of variance of the present study for plant crop during 2012-13 cropping season revealed that there was a significant difference in the mean values for cane yield, sugar yield and its attributes (Table 1). This result revealed that there was a amble scope for selecting a better clone. The variation in cane yield and yield components among the varieties might be attributed due to their differences in genetic make up (Mali and Singh, 1995). Memon *et al.* (2005) also reported greater variability among the

Table 1. Mean square values and their significance from ANOVA for cane yield, quality and its components of different early Sugarcane clones

Source of variation	Mean square values												
	df	Germin-ation %	Economic shoots	Cane thickness	Cane height	No. of internodes / plant	Internode length	Cane yield	Brix %	Pol %	Purity %	CCS %	Sugar yield
Variety	16	286.47**	884.19**	0.68**	0.34**	30.46**	18.07**	580.89**	5.32**	4.92**	9.15**	2.47**	18.71**
Error	32	11.63	1.76	0.04	0.04	2.84	0.43	3.74	0.01	0.08	0.29	0.01	0.07
Total	50	99.15	284.60	0.24	0.13	11.63	6.09	188.30	1.71	1.63	3.11	0.79	6.03

sugarcane genotypes for cane yield and yield components.

The results regarding mean performance of different early sugarcane clones for yield and its attributing characters are presented in table 2. Germination is the most critical factor which determines the varietal potential to exploit the available resources and ultimately effects cane stand. It is evident from data in table 2 that the germination percentage ranged from 47.78 to 77.78. Among the test clones, the Si 07-012 recorded high germination percentage (77.78) and it is on bar with Si 07-001 (77.56), Si 07 -003 (74.56) and two standards (Co 86-032 and CoSi(SC) 6). While the clone Si 07-082 recorded very low germination percentage of 47.78. The remaining ten early clones were located between the highest and lowest values. The significant difference among the study material was also noticed by Imdad Ali Sohu *et al.* (2008).

The trait economic shoots directly influences the cane yield as it is the combined interaction of germination and tillering. From the table 2, it is understood that the economic shoot varied from 151.0 to 206.0 (x1000/ha). The test clone Si 07-101 produced significantly higher average economic shoot (206 x 1000/ha) and which is followed by Si 07-001 (201.1 x1000/ha). The test clone Si 07-082 produced minimum economic shoots of 151 (x1000/ ha). The differences in economic shoot count among the test clones might be due to their variable inherent tillering potential. This determination is in agreement with those referred by Hapase *et al.* (1995) and Panhwar *et al.* (2008).

Cane thickness is an important yield contributing character and more cane thickness would enhance the acceptability of varieties from commercial point of view (Ramdoyal, 1999). Sharma and Agarwal (1985) suggested that good germination and tillering with synchronized millable canes of average thickness are desired selection parameters to evaluate the agronomic performance of sugarcane varieties. Habib *et al.* (1991) also stated that number of millable stalks per plot and stalk diameter are most important components of cane yield. The cane thickness of the present study materials varied between 1.23 cm and 3.33 cm. The maximum average cane thickness was noticed by Si 07-101 (3.33 cm) and it is on par with two other test clones *viz.,* Si 07-017 (3.23 cm) and Si 07-081 (3.0 cm). These three clones are significantly higher in cane thickness values than the three standards. The minimum average cane thickness was noticed by Si 07-001 (1.23 cm). The remaining 10 clones and 3 standards are located between these maximum and minimum average cane thickness values. This finding is analogous with Junejo *et al.* (2010) who also found variable cane thickness among the twelve genotypes in their study.

Table 2. Mean performance of different early Sugarcane clones for cane yield and yield attributing traits during selection process

Genotypes	Germination %	Economic shoots ('000/ha)	Cane thickness (cm)	Cane height (m)	No. of internodes /plant	Indernode length (cm)	Cane yield (t/ha)
Si 07-001	77.56_{a}	201.1_{b}	1.23_{f}	1.83_{i}	19.00_{ghi}	13.07_{gh}	102.50_{j}
Si 07-003	74.56_{ab}	152.2_{l}	2.30_{e}	2.25_{fgh}	18.67_{hi}	16.00_{d}	105.10_{j}
Si 07-012	77.78_{a}	192.1_{d}	2.63_{cde}	2.37_{defg}	21.33_{defgh}	21.70_{a}	125.50_{de}
Si 07-015	56.00_{ef}	171.8_{h}	2.43_{de}	2.33_{defgh}	21.67_{cdefg}	15.87_{de}	123.30_{ef}
Si 07-017	59.89_{def}	196.5_{c}	3.23_{a}	3.18_{a}	26.33_{ab}	15.70_{de}	132.30_{ab}
Si 07-071	54.56_{fg}	164.5_{j}	2.80_{bc}	2.05_{ghi}	19.00_{ghi}	12.20_{h}	109.50_{i}
Si 07-072	60.33_{de}	159.5_{k}	2.83_{bc}	2.38_{def}	23.67_{bcd}	13.67_{g}	118.20_{gh}
Si 07-081	64.56_{cd}	176.8_{g}	3.00_{ab}	2.63_{bcd}	18.67_{hi}	14.87_{ef}	95.30_{k}
Si 07-082	47.78_{h}	151.0_{l}	3.20_{a}	2.85_{b}	22.67_{cdef}	15.37_{de}	131.10_{b}
Si 07-091	55.78_{efg}	186.7_{e}	2.77_{bcd}	2.52_{cdef}	17.67_{ij}	18.27_{c}	96.30_{k}
Si 07-092	50.11_{gh}	184.9_{ef}	2.53_{cde}	2.58_{bcde}	22.33_{cdef}	20.20_{b}	119.40_{g}
Si 07-101	61.00_{de}	206.0_{a}	3.33_{a}	2.72_{bc}	20.67_{efgh}	15.50_{de}	134.60_{a}
Si 07-102	70.22_{bc}	168.6_{i}	2.37_{e}	2.02_{hi}	15.33_{j}	16.07_{d}	91.20_{l}
Si 07-131	56.33_{ef}	191.8_{d}	2.80_{bc}	2.65_{bcd}	20.33_{fghi}	13.43_{g}	129.20_{bc}
Co 86-032	73.56_{ab}	183.9_{f}	2.63_{cde}	2.28_{efgh}	23.33_{cde}	15.83_{de}	115.30_{h}
CoSi(SC) 6	73.00_{ab}	193.3_{d}	2.73_{bcd}	2.77_{bc}	27.67_{a}	14.83_{ef}	127.30_{cd}
TNAU Sugarcane Si 7	71.56_{b}	197.8_{c}	2.53_{cde}	2.57_{bcdef}	24.33_{bc}	13.90_{fg}	120.80_{fg}
Mean	63.8	181.1	2.67	2.47	21.33	15.67	116.30
CV%	5.34	0.73	7.58	7.85	7.91	4.20	1.66
CD (5%)	5.67	2.21	0.34	0.32	2.81	1.09	3.22
CD (1%)	7.62	2.97	0.45	0.43	3.77	1.47	4.33

The clones indicated by same alphabet are on par in their performance

Height of a cane contributes materially towards final cane yield. According to Jackson and Mc Rae (2001) under good growing conditions, individual seedling clones may produce up to about 2.0 m of cane that can be planted to the next selection stage. The cane height of fourteen clones and three standards varied form 1.83 m to 3.18 m. The test clone Si 07-017 grew significantly taller (3.18 m) than all the three standards and remaining test clones, followed by six clones and 2 local standards which were on par in their height. The clone Si 07-001 was the shortest (1.83 m) among all the clones. The research work carried out by Panhwar *et al.* (2006) is in accordance with the present finding. The variable cane height of the clones might be attributed to their variable inherent growth and development potential. Amaya *et al.* (1996) stated that canes that grow tall and thin might be more prone to lodging; the tall clones with thick stalked canes that resist lodging might have great potential to be the high yielding varieties in future.

It can be inferred from the data presented in table 2 that the number of internodes per plant varied from 15.33 to 27.67. The local standard CoSi(SC) 6 recorded more number of internodes/plant (27.67) and it is on par with the test clone Si 07-017 (26.33). The lowest number of internodes/plant was recorded by Si 07 -102 (15.33). The remaining 12 clones recorded values between these two values. These results are in line with Khan *et al.* (2003) who pointed out that different varieties had different trend for number of internodes/cane.

Table 3. Mean performance of different early Sugarcane clones for sugar yield and quality attributing traits during selection process

Genotypes	Brix %	Pol %	Purity %	CCS %	Sugar yield (t/ha)
Si 07-001	19.47_{f}	17.33_{fg}	89.04_{def}	12.36_{i}	12.67_{g}
Si 07-003	18.65_{h}	16.14_{h}	86.54_{g}	11.35_{k}	11.92_{hi}
Si 07-012	20.33_{c}	18.13_{cd}	89.15_{cdef}	12.93_{e}	16.23_{c}
Si 07-015	20.13_{d}	18.12_{cd}	90.03_{c}	12.99_{e}	16.01_{c}
Si 07-017	22.50_{a}	19.48_{b}	86.60_{g}	13.71_{b}	18.14_{a}
Si 07-071	19.14_{g}	17.23_{g}	90.04_{c}	12.35_{i}	13.53_{f}
Si 07-072	19.84_{e}	17.33_{fg}	87.36_{g}	12.25_{i}	14.47_{e}
Si 07-081	19.86_{e}	17.34_{fg}	87.30_{g}	12.25_{i}	11.67_{i}
Si 07-082	19.33_{f}	18.02_{d}	93.21_{a}	13.12_{d}	17.21_{b}
Si 07-091	20.10_{d}	17.88_{de}	88.96_{ef}	12.75_{f}	12.28_{gh}
Si 07-092	19.15_{g}	17.46_{efg}	91.16_{b}	12.58_{h}	15.03_{d}
Si 07-101	20.03_{d}	17.75_{def}	88.62_{f}	12.63_{gh}	17.00_{b}
Si 07-102	16.95_{j}	14.72_{j}	86.85_{g}	10.37_{l}	9.46_{j}
Si 07-131	22.35_{a}	20.05_{a}	89.72_{cde}	14.35_{a}	18.54_{a}
Co 86-032	19.76_{e}	17.77_{def}	89.93_{cd}	12.73_{fg}	14.67_{de}
CoSi(SC) 6	18.14_{i}	16.21_{i}	89.38_{cdef}	11.58_{j}	14.74_{de}
TNAU Sugarcane Si 7	20.62_{b}	18.51_{c}	89.77_{cde}	13.25_{c}	16.01_{c}
Mean	19.78	17.62	89.04	12.56	14.68
CV%	0.48	1.62	0.60	0.57	1.78
CD (5%)	0.16	0.47	0.89	0.12	0.43
CD (1%)	0.21	0.63	1.20	0.16	0.58

The clones indicated by same alphabet are on par in their performance

The internode length of the clones and standard varieties ranged from 12.20 to 21.70 cm. The test clone Si 07-012 recorded lengthy inter-node of 21.70 cm which was followed by Si 07-092 (20.20 cm) and Si 07-091 (18.27 cm). These three clones recorded significantly lengthy internodes than the promising variety Co 86032 (15.83 cm). In contrast, the test clone Si 07-071 recorded the shortest internodes of 12.20 cm. The remaining 10 clones were intermediate than these two extreme values.

Cane yield is a major parameter to find out the economic potential of a variety. It is the combination of functions like environmental responses and genetic potential of a strain. Variable and significant data were recorded for cane yield. As far as the cane yield is concerned, the clones and standards ranged from 91.20 to 134.60 t/ha. The clone Si 07-101 yielded the highest tonnage (134.60 t/ha) and it was followed by Si 07-017 (132.30 t/ha). Both these clones were on par in their performance. It was followed by Si 07-082 in descending order and produced 131.10 t/ha. These three clones crossed all the three standards. The test clone Si 07 -102 recorded the lowest tonnage of 91.20 t/ha. The remaining 10 clones and 3 standards were in-between these clones. Similar reports were given by Soomro *et al.* (2006). Nazir *et al.* (1997) reported that higher cane yield is the function of high potential variety. Memon *et al.* (2005) and Panhwar *et al.* (2008) reported greater variability among the sugarcane genotypes for cane yield and yield components when tested in 4_{th} cycle under agro-climatic conditions of Thatta.

The search of varieties 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. The data regarding mean performance of sugar yield and its attributing characters of different early sugarcane clones are depicted in table 3. Brix (%) (Total soluble solids) plays an important role in determining the sugar recovery (%) of the sugarcane (Memon *et al.,* 2004). The Brix (%) of the present study material varied from 16.95 to 22.50. Two test clones *viz.,* Si 07-017 (22.50) and Si 07 -131 (22.35) recorded significantly higher Brix (%) than the best standard TNAU Sugarcane Si 7 (20.62). The test clone Si 07-102 recorded the lowest Brix (%) of 16.95. The remaining 11 clones and 2 standards were between these values. These results are in agreement with the findings of Keerio *et al.* (2003) who studied a number of sugarcane varieties and found different levels of Brix (%).

Pol (%) of cane is an important quality character of sugarcane. Its determination is useful in deciding the quality of sugarcane and it influences the sugar recovery and sugar production in factory (Thangavelu, 2007). The Pol (%) varied from 16.14 – 20.05. The test clone Si 07-131 recorded significantly high Pol (%) of 20.05 and followed by Si 07-017 (19.48). These two clones are superior to the best standard TNAU Sugarcane Si 7 (18.51). The test clone, Si 07-003 recorded the lowest Pol (%) of 16.14. Similar result was reported by Keerio *et al.* (2003).

Purity (%) ranged from 86.54 to 93.21. The test clone Si 07-082 recorded the highest purity of 93.21 and it was followed by Si 07-092 (91.16). These two clones were significantly superior to all the three standards. The test clone, Si 07-003 recorded the lowest purity (%) of 86.54. The remaining 11 clones were in-between these values. This finding is in analogous with Keerio *et al.* (2003) who found variable purity (%) for different cane varieties.

The CCS is the best judgement method of a strain's quality for breeders and millers. The CCS (%) of the present study varied from 10.37 to 14.35. The test clone Si 07-131 recorded significantly high CCS (%) of 14.35 and it was followed by Si 07-017 (13.71). And these two clones recorded significantly high CCS (%) than the best standard TNAU Sugarcane Si 7 (13.25). The clone Si 07-102 recorded significantly low CCS (%) of 10.37. The remaining 11 clones were between these values. This discussion showed a close relationship with those of Verma *et al*. (1998) and Panhwar *et al*. (2006).

Sugar yield is the combination of cane weight and corresponding commercial cane sugar. The sugar yield of the present study materials varied from 9.46 to 18.54 t/ha. Two clones *viz.,* Si 07-131 (18.54 t/ha) and Si 07-017 (18.14 t/ha) recorded significantly higher sugar yield. And it was followed by Si 07-082 (17.21 t/ha) and Si 07-101 (17.00 t/ha). All these 4 clones recorded significantly superior performance than the best standard and local variety TNAU Sugarcane Si 7 (16.01 t/ha). The clone Si 07-102 (9.46 t/ha) recorded very low sugar yield than all other test entries and standards. The results are almost same as demonstrated by Singh *et al.* (1992). The highest sugar yield in clones might be attributed to relatively more average cane yield and subsequent recoverable sugar percentage.

On the basis of over all performance, it was concluded that the test clones *viz.,* Si 07-017, Si 07-082, Si 07-101 and Si 07-131 exhibited better performance in terms of cane yield, sugar yield and its attributing traits. Hence, it was suggested that the selected early sugarcane clones should be further tested in advanced yield trial and the elite ones need to be tested under different agro-climatic conditions for identification of best cultivar for general cultivation.

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Received: June 20, 2013; Revised: June 5, 2014; Accepted: June 26, 2014