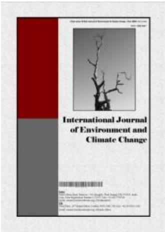

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Assessment of Quality Parameters in Different Clones of Sugarcane (*Saccharum officinarum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The analysis of the quality indices in sugarcane plays a vital role in the process of refining sugarcane breeding, cultivation, and production management. The present investigation was conducted at Agricultural Research Station, Basanthpur-Mamidigi, Medak Dist., Telangana during 2016-2017 to study the quality parameters of twelve sugarcane clones. The field experiment was conducted with 12 varieties in randomized block design replicated thrice. The observations made from the study stated that varieties varied significantly for the quality parameters. Among the varieties, Co 8014, has recorded the highest sucrose and Commercial Cane Sugar (CCS) percent followed by Co 86032, Co C 671 and Co 95020. The variety, 97 R 129 has recorded the lowest sucrose and CCS, followed by 97 R 401, 85 R186, Co 99006 and 83 R 23. The Brix values were high for Co 86032 and low for 97 R 401. Similarly, Co 99006 and Co C 92061 showed high and low values, respectively for purity percentage. Further, it could be attributed that the clones Co

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86032 and Co 95020 recorded the highest sugar and cane yields. Conversely, the clones 83 R 23 and 85 R 186 recorded the lowest sugar and cane yields. Higher cane yield, sucrose and CCS percent in varieties had resulted in significantly higher sugar yields.

Keywords: Sugarcane; sucrose content; CCS; Brix value; purity percent; etc.

1. INTRODUCTION

Sugarcane the most important industrial cash crop of India, involves low risk and farmers are assured of returns up to some extent even under certain adverse conditions. The second largest agro-based industry is depending on the raw materials provided by the sugarcane crop. It being a C_4 plant is a distinct and more efficient converter of solar energy, thus having the potential to produce huge amounts of biomass. It is grown in an area of 50.32 l ha with a cane production of 356.56 Mt and productivity of 70.86 t ha^{-1} in India during 2014-15. It occupied an area of 49,000 ha with a cane production of 3.67 Mt and productivity of 75 t ha^{-1} in the state of Telangana in 2014-15. India ranks second in terms of area and per hectare productivity.

The various research studies are generally oriented towards developing sugarcane varieties or clones that can yield high even under varied environmental conditions. In this course of study, the yield parameters of the crop were given the utmost importance. The current study aimed at a physiological screening of twelve sugarcane clones for their root characteristics. Plants demonstrate a considerable degree of variability in the less visible underground elements: root systems. Root system architecture varies between species, and also within species, subject to genotype and environment. Roots are important to plants for a wide variety of processes. Roots serve as the major interface between the plant and various biotic and abiotic factors in the soil environment: by both sensing and responding to environmental cues, roots enable plants to overcome the challenges posed by their sessile status. Understanding the development and architecture of roots holds potential for the exploitation and manipulation of root characteristics to both increase plant yield and optimize agricultural land use (Smith et al., 2012). The purpose of the physiological screening were to identify clones with suitable root parameters which could be used for the further breeding objectives.

However, the study aimed at cane yield as the main parameter in relation to root parameters, as it is preferred by farmers, but the sugar yield is of prime importance to the cane-dependent industries. Lately, there is a growing interest to measure sugarcane quality in the field. The information on the quality parameters measured will be an important input for the adoption of processing techniques in industries. The ability to measure quality values in different clones of sugarcane would also bring benefits for clonal evaluation [1]. The measurement of sugarcane quality, known as Commercial Cane Sugar (CCS) is an important parameter for the optimization of sugar value at harvest. The CCS values would also allow the optimization of inputs for production and harvest schedules [2]. The quality characters in sugarcane are influenced by variations in cane variety, changes in the agro climatic conditions, and fluctuations in the processing procedures [3]. Considering the significance of sugar yield to the processing industries, the quality parameters such as brix percentage, purity percentage, sucrose content, CCS, cane and sugar yield were assessed for the twelve clones under study.

2. MATERIALS AND METHODS

The present study was conducted on specially constructed raised rectangular root structures each of size 1 m x 1 m x 1.2 m (L x B x Ht). A total of three blocks of katcha root structures, each block containing 12 structures were constructed especially with bricks and cement. Each structure was filled with soil up to 1.2 m levels (Fig. 1 layout). Soil physical and chemical properties [4] of the simulated root structure were quantified and presented in Table 1.

2.1 Treatments

The 12 varieties/clones used for screening quality characters were V_1- Co 94008,V_2 - Co 99006, V_3 - Co 99004,V_4 - Co 86032, V_5 - Co C 92061, V_6 - 85 R 186, V_7 - 83 R 23, V_8 - Co 95020, V_9 - Co 8014, V_{10} - Co C 671, V_{11} - 97 R 129 and V_{12} - 97 R 401. Planting, fertilization, irrigation and harvesting were done as per the recommended practices. Accordingly, single node seedlings @12 no.s were planted in each root structure. The following parameters were measured using standardized methods as explained below.

Table 1. Soil physical and chemical properties of the simulated root structure

Soil physical parameters		Values	Units
1	Soil texture	Sandy clay loam	-
2	Soil colour	Red	-
3	Bulk density	1.59	Mg m^{-3}
4	Particle density	2.82	Mg m^{-3}
5	Water holding capacity	38.7	%
6	Porosity	42.6	%
Soil chemical parameters		**Values**	**Units**
1	Soil Ph	7.09	-
2	Electrical conductivity	0.24	dSm^{-1}
3	Organic carbon	0.34	%
4	Available N	132.51	kg ha^{-1}
5	Available P_2O_5	16.58	kg ha^{-1}
6	Available K_2O	189.75	kg ha^{-1}

2.2 Brix Percent Juice

The Brix value of the juice samples was recorded using a handheld refractometer. After making necessary temperature corrections brix values were noted.

2.3 Purity Percent

The purity co-efficient of juice was calculated from Brix (total solids) percent and sucrose percent using the following formula.

$$purity\ co-efficient = \frac{sucrose\ percent}{Brix\ percent} \times 100$$

2.4 Sucrose Content (%)

Sucrose or pol is defined as the value determined by direct or single polarization of the normal weight solution in a saccharimeter. Out of three kinds of sugars (sucrose, glucose and fructose), sucrose is the only recoverable crystal form of sugar in a sugar factory. The term pol derived from polarization, therefore denotes for all practical purposes only sucrose.

Take about 100 ml of cane juice into a 250 ml conical flask and add 2-3 g of lead sub-acetate to the juice and shake the contents well. Filter the contents of the conical flask through a filter paper (Whatman) and collect the clear filtrate in a clean, dry 100 ml beaker. Reject the first few drops of filtrate and collect only the remaining clear filtrate (about 75 ml). The polarization value of the clarified juice is estimated in a manually operated ISS scale. Switch on the polarimeter and allow the sodium vapor lamp to attain full intensity (bright yellow color). Check the instrument for zero error with distilled water and make necessary corrections as per requirement. The instrument is checked with 1 N sucrose solution (26 g pure AR grade Sucrose in 100 ml distilled water) for polarization value of 100 ISS scale.

The observation tube of the polarimeter (20 cm length) is filled with the filtrate after rinsing the tube thoroughly. Take care that no air bubble should be present in the observation tube. The observation tube is kept in the polarimeter and viewed through the eyepiece until a half-shadow appears. Adjust the screw of the analyzer until the field becomes uniformly bright yellow without any half shadow. Note the polarization value through the eyepiece of the graduated scale (ISS 0-1000). If the hairline is in between two whole numbers, adjust the vernier scale knob so that the hairline coincides with the whole number on the right-hand side of the scale.

Add the decimal point from the vernier scale to the whole number on the main scale to get the polarization value. The sucrose percentage is obtained by referring the Schmitz's table. While referring to Schmitz's table, only the observed brix value has been considered. On the horizontal side brix readings and on the vertical side polarization values are given in Schmitz's table. By referring to the table against a horizontal and vertical column for brix and polarization values respectively, the sucrose percent juice is obtained [5].

2.5 Commercial Cane Sugar

Commercial cane sugar percent represents the amount of white crystal sugar that could be obtained from the given cane sample. The CCS (%) is derived by using the formula given below:

$$CCS\% = (S - (B - S)0.4)0.73 \; OR = (1.022S) - (0.292B)$$

Where,

S = Sucrose percent of the juice
B = Brix percent of the juice.
CCS % obtained in the cane was later converted and expressed as tonnes per hectare.

2.6 Cane Yield

All the canes in the plot were cut close to the ground level at harvest. The tops and fresh leaves were removed and cane yield per raised bed was recorded. The cane yield was expressed in tonnes per hectare (t ha^{-1}).

2.7 Sugar Yield

Sugar yield was calculated using the following formula and expressed in tonnes per hectare (t ha^{-1}).

$$Sugar\ yield\ (t\ ha-1) = \frac{CCS\% \times Cane\ yield\ (\text{t ha} - 1)}{100}$$

2.8 Statistical Analysis

Fisher's method of analysis of variance was applied for the analysis of the data and the results were interpreted as suggested by Panse and Sukhatme [6]. The level of significance used in the F and t-test was P = 0.05. The critical difference (CD) values were calculated at 5 percent probability level, wherever the F test was significant.

3. RESULTS AND DISCUSSION

All the quality parameters measured showed significant variation (Table 2) among the varieties. The variation observed for every parameter were discussed in detail below.

3.1 Brix Percent

Brix percentage is a measure of the sucrose, or sugar content. Many factors, such as temperature, altitude, soil fertility, climate, and yield management plays a vital role in deciding the amount of sucrose in base sugarcane juice. A higher Brix percentage in the base sugarcane juice leads to a higher sugar yield. The brix percent among the different varieties showed significant variation and ranged from 18.55 to 21.67 percent. Varieties, Co 86032 (21.67%) and Co C 671 (20.97%) had resulted in significantly higher brix percent in cane juice. The lowest and on par brix percentage was noticed with the varieties, 97 R 401 (18.55%), 97 R 129 (18.71%), 83 R 23 (18.95%), 85 R 186 (18.74%), Co 99004 (19.37%) and Co 99006 (18.97%). Similar results were recorded by Hemaprabha et al., [7], Sanghera et al., [8] and Kadam et al., [9]. Different vareties of sugarcane can differ greatly in their sucrose levels ranging from 15% Brix to 23% Brix. The cane with a Brix percentage closer to 23% is considered to produce the highest quality of cane sugar.

Table 2. Quality parameters of different sugarcane varieties raised in root structures at maturity stage

S. No.	Variety	Brix	Sucrose %	Purity %	CCS (%)	Cane yield	Sugar yield(kg ha^{-1})
1	Co 94008	19.87	18.24	91.79	12.84	121.66	15.621
2	Co 99006	18.97	17.85	94.13	12.71	116.21	14.766
3	Co 99004	19.37	18.15	93.73	12.9	109.2	14.087
4	Co 86032	21.67	19.8	91.4	13.91	142.66	18.453
5	Co C 92061	19.91	18.18	91.31	12.77	119.98	15.317
6	85 R 186	18.74	17.5	93.42	12.42	96.15	11.939
7	83 R 23	18.95	17.73	93.57	12.58	101.26	12.742
8	Co 95020	20.17	18.9	93.75	13.43	140.32	18.308
9	Co 8014	21.51	19.82	92.16	13.98	121.61	17.001
10	Co C 671	20.97	19.59	93.44	13.9	130.52	18.138
11	97 R 129	18.71	17.18	91.84	12.09	120.46	14.568
12	97 R 401	18.55	17.25	92.99	12.21	126.2	15.413
	Mean	**19.78**	**18.35**	**92.79**	**12.98**	**120.52**	**15.53**
	CD (P=0.05)	**0.82**	**0.92**	**2.09**	**0.74**	**18.6**	**1.42**
	CV (%)	**2.44**	**2.97**	**1.33**	**3.35**	**9.11**	**5.4**

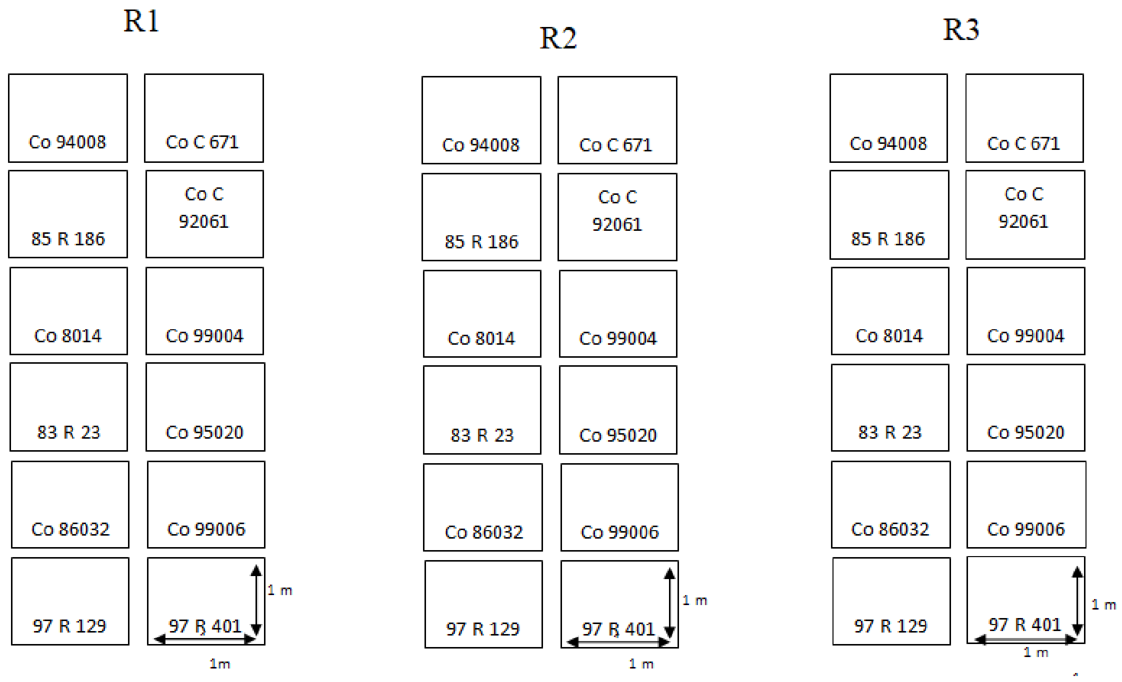

Fig. 1. Layout of Root structure

3.2 Purity Percent

It refers to the percentage of sucrose present in the total solids content in the juice. A higher purity indicates the presence of higher sucrose content out of the total solids present in juice. The purity percentage along with sucrose percent helps in determining the maturity of cane. A cane crop is considered fit for harvesting if it has attained a minimum of 16% sucrose and 85% purity. The purity percent of different varieties under study, ranged from 91.31% to 94.13%. The lowest purity percent was noted with the varieties, Co 92061 (91.31%), Co 86032 (91.40%), Co 94008 (91.79%) and 97 R 129 (91.84%). All other varieties remained superior to the above varieties with significantly higher purity percent. The results were in similarity to the findings of Thangavelu and Chiranjivi [10].

3.3 Sucrose Content

The sucrose percentage of different varieties ranged from 17.18 to 19.82 percent. The varieties, Co 8014 (19.82%), Co 86032 (19.80%), Co C 671 (19.59%) and Co 95020 (18.90%) being at par had maintained significantly highest sucrose percent at maturity. High sucrose contents of promising genotypes were also reported by Hemaprabha et al., [7], Kulkarni et al., [11], Mukunda Rao et al., [12] and Rakkiyappan et al., [13]. The lowest sucrose content was noticed with the varieties, 97 R 129 (17.18%), 97 R 401 (17.25%), 85 R 186 (17.50%), 83 R 23 (17.73%) and Co 99006 (17.85%). It can be deduced that the high purity and Brix percentage observed in cane varieties (Co 86032 and Co C 671) have resulted in high sucrose content.

3.4 Commercial Cane Sugar Percent (CCS)

Commercially recoverable sugar content in sugarcane (CCS, expressed as a percentage) is a key selection criterion in sugarcane breeding programs. CCS is the source of payment in the sugarcane industry. It is not a direct measure of sucrose content but estimates the total sugar (%) with Brix, %Pol, and %Fiber in sugarcane. Similar to sucrose content, the commercial cane sugar percent at maturity also has shown significant differences among the varieties. The CSS percent has followed a similar trend as that of sucrose content. The varieties, Co 8014 (13.98%), Co 86032 (13.91%), Co C 671 (13.90%) and Co 95020 (13.43%) which recorded the highest sucrose content consequently recorded the highest commercial cane sugar percent and were found best over the other varieties. The lowest CCS per cent was observed with the varieties, 97 R 129 (12.09%), 97 R 401(12.21%) and Co 99006 (12.71%), Co C 92061 (12.77%), 85 R 186 (12.42%) and 83 R 23 (12.58%). The results are in accordance with Sanghera et al., [14] and Naidu et al., [15].

3.5 Sugar Yield

The data on sugar yield was computed based on cane yield and CCS percent. The data on sugar yield revealed highly significant differences among the varieties. Higher cane yield, sucrose and CCS percent in varieties, Co 86032 (18.45 t ha^{-1}), Co 95020 (18.31 t ha^{-1}) and Co C 671 (18.14 t ha^{-1}) resulted in significantly higher sugar yields. The same were the results obtained by Kadam et al., [9] and Naidu et al., [15] stating that the two quality parameters sucrose content and CCS have resulted in determining high sugar yield. Conversely, the sugar yield was lowest with the varieties, 85 R 186 (11.94 t ha^{-1}) and 83 R 23 (12.74 t ha^{-1}).

3.6 Cane Yield

Cane yield is the ultimate manifestation of morphological, physiological, biochemical processes and growth parameters. The data on cane yield recorded after harvest indicated a significant difference among the varieties. The cane yield of different varieties ranged from 96.15 to 142.66 t ha^{-1}. The varieties, Co 86032 (142.66 t ha^{-1}), Co 95020 (140.32 t ha^{-1}), Co C 671 (130.52 t ha^{-1}) and 97 R 401 (126.20 t ha^{-1}) being at par had recorded significantly highest cane yields over the remaining varieties [4]. The positive influence of yield attributes in increasing the cane yield of promising sugarcane cultivars was reported by Kadam et al., [9]. On the other hand, the lowest cane yields were observed with the varieties, 85 R 186 (96.15 t ha^{-1}), 83 R 23 (101.26 t ha^{-1}) and Co 99004 (109.20 t ha^{-1}). It can be stated that higher cane yield, sucrose and CCS percent in varieties had resulted in significantly higher sugar yields.

4. CONCLUSION

The above study concludes that the estimation of quality parameters in sugarcane varieties is of importance to determine the value of cane in processing industries. The calculation of Brix and purity percentage in sugarcane aids in deciding the maturity of cane for harvest. Further, the study also stated that the varieties Co 8014, Co 86032, Co 95020 and Co C 671 have performed best among the twelve varieties, for the Brix %, purity %, sucrose content, CCS and sugar yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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