Character Association among Yield and Quality Traits in Early Maturing Sugarcane Clones

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Authors' contributions

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ABSTRACT

Eleven early maturing sugarcane clones were planted in Randomized Block Design for this study. The objective of this study was to investigate the relationships among the yield and quality parameters with cane yield and sugar yield in sugarcane, in order to provide information to help breeders in adopting traits for developing high yield and quality varieties. The analysis of variance revealed significant differences among genotypes for eleven yield and quality characters. Highest cane yield (176.66 t/ha) was recorded in clone 2015R10 and highest Commercial Cane Sugar (CCS) % (14.16) were observed in Co C 671. Correlation coefficient results indicated that cane yield was positively correlated with germination (0.166), number of millable canes (0.210), cane length (0.650), cane girth (0.610), single cane weight (0.880), CCS yield (0.518) whereas Brix% (-0.838), Sucrose% (-0.821), Purity % (-0.720) and CCS % (-0.812) showed negative correlation with cane yield. Sugar yield per hectare is positively correlated with purity% (0.187), cane length (0.413), cane

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girth (0.503), single cane weight (0.515) and cane yield (0.518). Results indicate that the genotypes should be selected on the basis of cane length, cane girth and single cane weight for getting higher sugarcane yield.

1. INTRODUCTION

Sugarcane (*Saccharum sp.*) is an important cash crop in India and is cultivated on about 4.9 million hectares with a total cane production of 352.12 million tons. The country's average cane yield hovers around 71.09 tons per hectare. However, there is a gap when comparing sugarcane yield in India (352.12 million tons) with that of other countries like Brazil (621 million tons). In Telangana, sugarcane is cultivated on 35,000 ha with a total production of 2.41 million tons. The average cane yield in Telangana is 69 tons per hectare, which is less than the national average [1]. Sugarcane is considered to be mature and ready for harvest when the cane juice has over 16% sucrose and 85% purity. Varieties that attain this level at 10 and 12 months age if planted in January/February are classified as early and mid-late maturing types, respectively.

There are several reasons for lower cane yield per unit area in India: lack of high cane yielding cultivars with high sugar content, drought stress, pest disease incidence, ratoon crop management problems. Moreover, the quality of the crop is severely deteriorated by the unfavourable winter, negatively affecting sugar recovery. Finally, the yield of ratoon crops with traditional low-yielding cultivars is not proportionate to their plant-cane crops. Therefore, early maturing sugarcane varieties need to be developed specifically for India, with both high-yield of cane and high-quality in terms of sucrose recovery. To accomplish this, it is necessary to acquire knowledge about the relationships that exist among the different cane yield contributing traits. The correlation studies are used to measure the intensity and direction of character association. Since selection is usually concerned with improving a group of characters simultaneously, an understanding of inter se correlations is of prime interest of the breeder. Hence, in the present investigation an attempt is made to understand the type of association existing between sugarcane yield and its component characters. This paper focuses mainly on the character association of different cane yield and quality traits in sugarcane.

2. MATERIALS AND METHODS

The present study comprised eleven early maturing sugarcane genotypes (ready to harvest in 10 months after planting) evaluated at Regional Sugarcane and Rice Research Station, Rudrur, Nizamabad, Telangana during 2018. A total of 11 early maturing genotypes were planted in Randomized block design with 3 replications. The plot size was of 1.2 m x 6 m long in six rows. The planting was done at 12 buds per meter row length. All the recommended cultural practices were followed to obtain a good crop. The data were recorded as per standard statistical procedures for yield and quality attributes viz. Germination, Shoots count at 240 days after planting, Number of millable Canes, Brix, Sucrose, Purity, Commercial Cane Sugar%, Cane length, Cane girth, Single Cane weight, Cane Yield and Commercial Cane Sugar yield.

Germination per cent was calculated at 30 days after planting. The number of millable canes was counted within each plot at the time of harvesting. For the determination of the cane length (cm), a measurement tape was used to measure a sample of ten canes at harvest. A vernier caliper was used to measure the cane girth (cm) of the same ten canes, which the reading region was defined as one third of the cane length (from the basis to the top) at harvest. Then, the ten canes were weighed, and the mean weight (single cane weight) was obtained at harvest. The cane productivity was calculated from the weight of all millable canes per plot and the area occupied by each plot (t/ha).

2.1 Brix %

It is a measure of total soluble solids present in the juice. It was taken directly by using a Brix hygrometer. 250 ml juice was taken in measuring cylinder and hygrometer was dipped into the juice then reading was recorded from the juice level. These readings were corrected to the temperature at 20°C by using temperature correction chart.

2.2 Pol %

Pol refers to the sucrose per cent in juice. It was done according to Spencer and Meade method [2]. It was estimated with the help of Polari scope. First 100 ml juice was taken in conical flask and 4 gm Honey dry lead sub acetate was added and mixed well by shaking the flask. After few minutes this solution was filtered twice through a dry Whatsman no. 1 filter paper and the abstract was collected into a clean and dry beaker. The abstract poured into the Polari meter tube. These tubes were placed in the Polari scope. Thereafter Pol values were recorded by polarising the clear juice in Polari scope this value called dial reading. Sucrose Per cent in juice was obtained by referring the brix and dial reading to Schmitz's table.

2.3 CCS Percent

CCS % is determined by formula [S - (B - S) × 0.4] × 0.73

Where, S = Sucrose percent in juice (pol %), B = Brix percent in juice.

$$\text{Purity\% of Juice} = \frac{Sucrose\ percent\ in\ Juice}{Corrected\ Brix} \times 100$$

POL estimated using a polarimeter. Correlation coefficient analysis was calculated as per formulae suggested by [3,4,5].

3. RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among genotypes for all the plant characters (Table 1). Results regarding the mean performance of the genotypes for cane yield and its components showed significant (p≤0.01) differences amongst the clones (Table 2). Clone 2015R10 produced significantly highest cane yield (176.66 t/ha) followed by 2015R33 (173.66 t/ha), 2015R19 (165.07 t/ha) and 2015R26 (158.23 t/ha). The lowest cane yield was observed in clone 2015R28 (89.70 t/ha) (Table 2). With regard to cane girth (cm), 2015R33 (3.48) was at the top followed by 2015R47 (3.02), while minimum girth was observed in 2015R27 (2.53). Single Cane Weight (kg) was highest in 2015R33 (1.64) and minimum single cane weight was observed in 2015R27 (0.73). Significant differences were observed for number of millable canes. The maximum number of millable canes was observed in 2015R39 (127.84 thousands/ha), whereas minimum in Co C 671 (89.69 thousands/ha).

Mean values of different clones for Brix%, Sucrose%, CCS %, purity % and sugar yield t/ha were significantly different at p≤0.01 (Table 2). Significantly highest Brix%, Sucrose%, CCS %, purity % were observed in Co C 671 (19.80, 19.51, 98.61 & 14.16 respectively). Maximum CCS yield (t/ha) was obtained by 2015R33 (19.44 t/ha) followed by 2015R26 (17.88 t/ha). Sugarcane Clone 2015R27 produced the lowest sugar yield (12.51 t/ha). [6] Also found differences among varieties for cane and sugar yield.

The correlation coefficient results (Table 3) indicated that the cane yield was positively correlated with germination(r=0.16), number of millable canes (r=0.20), cane length (r=0.65*), cane girth (r=0.61*), single cane weight (r=0.88**). The Brix%, Sucrose%, Purity % and CCS % were negatively correlated with cane yield. The increase in cane yield was due to combined effect of stalks per stool, length of stalk and weight per stool concluded by [7].

A Positive and highly significant correlation between cane yield and its components viz., single stalk weight, stalk length and millable cane number was reported by [8,9]. The correlation of number of millable canes with cane length was positive, whereas single cane weight showed negative correlation with tiller numbers (Table 3). Cane yield is in positive correlation with Number of Millable Canes at harvest reported by [10]. In case of sugar yield positive correlation was observed with cane yield, cane weight, number of millable canes, cane length, cane girth, Brix%, sucrose %, CCS % and purity % and non significant correlation was observed with cane girth.

Sugar yield per hectare is mainly dependent on cane yield, Brix%, Sucrose%, purity % and CCS %. [11] Reported positive and significant association of sugar yield with Sucrose %. The negative correlation of Brix%, Sucrose%, purity% and CCS % with cane yield and positive correlation with sugar yield is one of the major constraints in the improvement of sugarcane (Table 2). Our results are in agreement with those mentioned by [12 and 13], who found that the cane yield, considered as the most important character of sugarcane, was positively and significantly correlated with number of millable canes, stalk diameter and stalk weight. Moreover, they noted negative associations of cane yield with juice pol, and purity %.

Table 1. Analysis of variance results for cane yield and quality traits in sugarcane

Source of Variations	df	Germination %	No of shoots@ 240 DAP	Number of millable canes	Brix %	Sucrose %	Purity %	CCS %	Length (cm)	Girth (cm)	SCW (Kg)	Cane yield (T/ha)	CCS yield (T/ha)
Replication	2	31.72	369.69	201.41	0.00	0.00	0.01	0.00	0.24	0.00	0.00	269.12	3.08
Treatments	10	67.95***	418.05	383.56***	8.48***	19.40***	123.79***	13.50***	1572.90***	0.21***	0.24***	2747.70***	15.43***
Error	20	10.46	134.13	70.47	0.01	0.01	0.01	0.01	15.22	0.00	0.00	104.63	1.62

CCS-Commercial Cane Sugar, SCW-Single Cane Weight

Table 2. Cane and sugar yield performances of sugarcane genotypes

S. No.	Genotypes	Germination (%)	No of shoots @ 240 DAP ('000/ha)	No of millable canes ('000/ha)	Brix (%)	Sucrose (%)	Purity (%)	CCS%	Length (cm)	Girth (cm)	SCW (Kg)	Cane yield (T/HA)	CCS yield (T/HA)
1	2015R10	44.07	137.50	123.33	14.51	11.33	78.13	7.33	245.73	2.94	1.43	176.66	12.95
2	2015R19	43.11	135.26	108.21	15.99	12.98	81.10	8.58	255.13	2.94	1.53	165.07	14.16
3	2015R26	48.52	137.89	110.31	17.58	16.07	91.78	11.31	255.07	2.98	1.44	158.23	17.88
4	2015R27	44.59	153.39	122.72	19.77	19.28	97.51	13.93	189.07	2.53	0.73	89.70	12.51
5	2015R32	37.93	132.41	105.92	19.50	18.82	96.53	13.54	234.47	2.91	1.23	129.99	17.60
6	2015R33	38.00	132.02	105.62	17.01	15.83	93.22	11.19	233.07	3.48	1.64	173.66	19.44
7	2015R39	43.55	147.30	127.84	18.13	16.98	93.31	12.04	220.40	2.89	0.89	118.12	14.22
8	2015R47	46.37	135.57	108.46	18.50	16.96	91.66	11.93	212.80	3.02	1.14	123.42	14.72
9	2015R48	47.85	155.32	124.26	18.28	17.21	94.20	12.27	262.80	2.55	1.05	130.86	16.06
10	83 R 23 ©	47.18	133.26	106.61	19.38	17.87	92.21	12.60	251.67	2.62	1.18	125.52	15.81
11	Co C 671 ©	33.56	112.11	89.69	19.80	19.51	98.61	14.16	213.53	2.81	1.02	91.61	12.98
	Mean	43.16	137.46	112.09	18.04	16.62	91.66	11.72	233.98	2.88	1.21	134.80	15.30
	C.V.	7.50	8.43	7.49	0.63	0.47	0.10	0.78	1.67	1.47	3.30	7.59	8.33
	C.D. 5%	5.51	19.73	14.30	0.19	0.13	0.16	0.16	6.65	0.07	0.07	17.42	2.17
	C.D. 1%	7.52	26.91	19.50	0.26	0.18	0.22	0.21	9.06	0.10	0.09	23.76	2.96
	S.E.	1.87	6.69	4.85	0.07	0.05	0.05	0.05	2.25	0.02	0.02	5.91	0.74

CCS-Commercial Cane Sugar, SCW-Single Cane Weight

Table 3. Genotypic and phenotypic correlation coefficient for cane yield and quality traits in sugarcane

Characters	Variation	Germination %	No of Shoots @ 240 DAP	No of Millable Canes ('000/ha)	Brix%	Sucrose %	Purity %	CCS%	Length (cm)	Girth (cm)	SCW (Kg)	CCS Yield (t/ha)
Germination%	Genotypic	**1.000**	0.774**	0.653*	-0.197	-0.269	-0.314	-0.283	0.390	-0.398	-0.082	-0.035
	Phenotypic	1	0.613*	0.549	-0.152	-0.219	-0.253	-0.228	0.312	-0.324	-0.067	0.048
No of Shoots @ 240 DAP	Genotypic	0.774**	**1.000**	0.987**	-0.100	-0.088	-0.053	-0.086	0.043	-0.481	-0.424	-0.213
	Phenotypic	0.613*	1	0.840**	-0.06	-0.058	-0.037	-0.053	0.044	-0.298	-0.272	0.121
No of millable canes	Genotypic	0.653*	0.987**	**1.0000**	-0.338	-0.323	-0.290	-0.318	0.057	-0.325	-0.321	-0.387
	Phenotypic	0.548	0.840**	1	-0.274	-0.256	-0.226	-0.25	0.025	-0.261	-0.267	0.026
Brix%	Genotypic	-0.196	-0.100	-0.338	**1.0000**	0.987**	0.915**	0.979**	-0.492	-0.466	-0.697*	0.005
	Phenotypic	-0.152	-0.060	-0.274	1	0.985**	0.913**	0.979**	-0.473	-0.451	-0.680*	0.004
Sucrose%	Genotypic	-0.268	-0.088	-0.323	0.987**	**1.0000**	0.967**	0.100	-0.520	-0.391	-0.683*	0.062
	Phenotypic	-0.219	-0.058	-0.256	0.985**	1	0.967**	0.999	-0.509	-0.383	-0.673*	0.052
Purity%	Genotypic	-0.313	-0.052	-0.290	0.915**	0.967**	**1.0000**	0.975**	-0.495	-0.230	-0.591	0.216
	Phenotypic	-0.253	-0.037	-0.226	0.913**	0.967**	1	0.975**	-0.486	-0.226	-0.584	0.187
CCS%	Genotypic	-0.283	-0.086	-0.318	0.979**	0.999	0.975**	**1.0000**	-0.524	-0.376	-0.678*	0.073
	Phenotypic	-0.228	-0.053	-0.25	0.979**	0.999	0.975**	1	-0.51	-0.365	-0.666*	0.067
Length	Genotypic	0.390	0.043	0.057	-0.492	-0.520	-0.495	-0.524	**1.0000**	0.048	0.617*	0.465
	Phenotypic	0.312	0.043	0.024	-0.473	-0.509	-0.486	-0.51	1	0.071	0.625*	0.413
Girth	Genotypic	-0.398	-0.481	-0.325	-0.466	-0.391	-0.230	-0.376	0.0482	**1.0000**	0.730*	0.566
	Phenotypic	-0.324	-0.298	-0.261	-0.451	-0.383	-0.226	-0.365	0.0715	1	0.735*	0.503
SCW	Genotypic	-0.082	-0.423	-0.321	-0.697*	-0.683*	-0.591	-0.678*	0.617*	0.730*	**1.0000**	0.589
	Phenotypic	-0.067	-0.272	-0.267	-0.680*	-0.673*	-0.584	-0.666*	0.625*	0.735*	1	0.515
CCS Yield (t/ha)	Genotypic	-0.035	-0.212	-0.387	0.005	0.062	0.216	0.073	0.465	0.566	0.589	**1.0000**
	Phenotypic	0.048	0.121	0.026	0.004	0.052	0.187	0.067	0.413	0.503	0.515	1
Cane yield (t/ha)	Genotypic	0.166	-0.089	0.034	-0.885**	-0.867**	-0.762**	-0.860**	0.691*	0.644*	0.935**	0.436
	Phenotypic	0.166	0.084	0.210	-0.838**	-0.821**	-0.720*	-0.812**	0.650*	0.610*	0.880**	0.518

CCS-Commercial Cane Sugar, SCW-Single Cane Weight

Single cane weight had negative correlation with Brix% (r = -0.68), Sucrose % (r=-0.673), CCS% (r=-0.668) but had positive correlations with yield (r= 0.88) and cane girth (r = 0.735). Its correlation with the number of shoots at 240 days after planting was weak and negative (r = -0.272) which was in agreement with the results of Tyagi *et al* (2012). Cane yield, was positively and significantly correlated with single cane weight as reported by [14].

Sucrose% had the positive correlation with Brix (r= 0.985**) and purity (r= 0.967**) and negative correlation with single cane weight (r= -0.67) and cane yield (r= - 0.82). Similarly, the correlation of Brix was highly significant with purity (r= 0.913**) and CCS% (r= 0.979**). Our data showed negative significant correlation between cane yield and any of the sucrose-related traits. Tyagi *et al* (2012) also found a strong negative correlation between Brix, sucrose percent, purity percent in juice and cane yield/plot. This could be attributed to the difference in length of growth and time of sampling for sucrose traits. Bora *et al* (2014) found that sugar recovery had a high and significant correlation with field brix and sucrose. Hence these two characters must be given importance for improvement of sugar recovery. Cane yield is associated with its various components genotypically and phenotypically in various magnitudes [15]. Further, their study has indicated the magnitude of the correlations among cane yield traits. In general, genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients indicating a fairly strong inherent relationship among the traits. The lower estimates of phenotypic correlation indicated that the relationships were affected by environment at phenotypic level. Such environmental influence in reducing the correlation coefficients in rice was also reported by [16]. This study revealed that higher cane length, cane girth endowed with better single cane weight are the important characters which should be considered while selection to be made for higher sugar yield in sugarcane genotypes.

4. CONCLUSION

A perusal of the results of correlation analysis revealed that cane yield was positively correlated with germination (r=0.16), number of millable canes(r=0.20), cane length (r=0.65*), cane girth (r=0.61*), single cane weight (r=0.88**). Sugar yield was positively correlated with Brix% (0.004), Sucrose% (0.052), Purity% (0.187),

CCS% (0.067), Girth (0.503), Cane yield (0.518). Thus, these traits were identified to be the major cane, sugar yield factors and major emphasis may be given towards selection of these traits for improvement of cane and sugar yield in Sugarcane. Hence, emphasis should be given to these traits while formulating selection criteria for improvement in cane and sugar yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ministry of Agriculture; 2019.
2. Spencer GL, Meade GP. Cane sugar hand book. J. Wiley and Sons, N.Y; 1955.
3. Al-Jibouri HA, Miller PA, Robinson HF. Genetic and Environmental variances and covariances in upland cotton cross of interspecific origin. Agron J. 1958;50:633-637.
4. Miller PA, William CV, Robinson HF, Comstock RE. Estimates of genotypic and environmental variance and covariance in upload cotton and their implication in selection. Agron. J. 1958;50:126-131.
5. Dewey DR, KH Lu. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 1959;51:515-518.
6. Getaneh A, Tadesse F, Ayele N, Bikila M. Agronomic Performance of Ten Sugarcane Varieties under Wonji-Shoa Agro-Climatic Conditions. Scholarly Journal of Agricultural Science. 2015;5(1):16-21.
7. Chaudhry BA. Fertilizer and dolomitic lime requirments of some sugarcane soil in Negros occidental, Philippines. Ph. D. Dissertation, Univ. of Philippines, Los Banos, Philippines; 1982.
8. Bora GC, Goswami PK, Bordolol. Studies on variability and character association in sugarcane (Saccharum spp). Under rain fed condition of North Eastern India. Direct. Res. J. 2014;2(5):55-59.
9. Gowda SNS, Saravanan K. Correlation and Path Analysis for Yield and Quality Attributes in Sugarcane. International Journal of Science Technology & Engineering. 2016;3(2):133-137.
10. Kheni NV, Mali SC, Pandya MM, Viradiya YA. Variability, Correlation and Path analysis Studies in sugarcane (Saccharum spp.). Green Farming. 2015;6(3):460-463.

11. Alemu S, Hussein M, Feyissa T. Correlation of Traits on Sugarcane (Saccharum Spp) Genotypes at Metahara Sugar Estate, International Journal of Advanced Research in Biological Sciences. 2018;5(3):1-5

12. Tyagi VK, Sharma S, Bhardwaj SB. Pattern of association among cane yield, sugar yield and their components in sugarcane (*Saccharum officinarum* L.). J. Agric. Res. 2012;50(1):29-38

13. Kumar S, Kumar D. Correlation and path coefficient analysis in sugarcane germplasm under subtropics. African J. of Agric. Res. 2014;9(1):148-153.

14. Tadesse F, Dilnesaw Z. Genetic variability, heritability and character association of twelve sugar cane varieties in Finchaa Sugar Estate West Wolega Zone Oromia Region of Ethiopia. Int. J. Adv. Res. Biol. Sci. 2014;1(7):131–137.

15. Jamoza JE, Owuoche J, Kiplagat O, Opile W. Broad-sense heritability estimation and correlation among sugarcane (*Saccharum* spp. hybrids) yield and some agronomic traits in western Kenya. International J. of Agric. Policy and Res. 2014;2(1):16-25.

16. Chaudhary PK, Singh RP. Genetic variability, correlation and path analysis of yield components of rice. Madras Agric. J. 1994;81(9):468-470.