Genetic studies in advanced sugarcane mid-late clones through yield and quality traits

ABSTRACT

The experiment was conducted using a randomized block design with three replications and the trial consisted of nine mid-late sugarcane genotypes. Data on cane yield and quality traits were used to estimate the genetic variability parameters, heritability, and genetic advance (GA). Analysis of variance revealed highly significant and significant differences for all studied traits. Evaluated characters exhibited different levels of variability, heritability, and genetic advance among the studied genotypes. Low to high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded. The moderate GCV and PCV values were found particularly for Sugar Yield at harvest (18.09% and 21.64%) and Cane Yield at harvest (16.62% and 20.14%) respectively, whereas the lowest GCV and PCV (1.43% and 2.26% respectively) manifested for Purity at the 12 months stage. The highest broad sense heritability value manifested for Pol in juice at 12 months stage (%) (86.47%) followed by CCS at 12 months stage (%) (85.43%), while the lowest heritability (35.00%) revealed only for Germination % at 30 DAP. In the present study, high heritability and genetic advance as a percentage of the mean (>50) was recorded for Millable canes at harvest (000/ha) and single cane weight at harvest (Kg) indicating a predominance of additive gene action for these characters. Therefore the result of this study suggests the existence of variability for cane yield and quality traits in these sugarcane genotypes, which should be exploited in future breeding.

Keywords: *Sugarcane, Genetic variability, heritability, genetic advance, genotypic and phenotypic coefficient of variance*

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1. INTRODUCTION:

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Sugarcane (*Saccharum officinarum* L.) is polyploidy in nature with a high number of chromosomes. It is a cross-pollinated crop having vegetative propagation and perennial growth habit, which makes it a difficult crop from a breeding point of view [1]. The sugarcane varieties tend to run out or decline after some years of cultivation in a specific area. Hence to obtain high yield on a sustainable basis, it has been essential to substitute regularly grown varieties with new clones. Sugarcane varieties are clonally propagated and therefore are not expected to undergo genetic changes as they may occur in a seed-propagated crop. Several ratoons lead to a decline in the variety due to disease incidence and other environmental constraints with a need for seed replacement. Meanwhile Sugar industry is the second largest agro-based industry after textile contributing 2.0% of the total gross domestic product in India and is also very important to the production of ethanol and energy from its biomass. This advanced breeding material helps the breeder for planning sound breeding programmes. The present investigation was undertaken in this context to elucidate information on variability, heritability, and genetic advance in promising sugarcane clones. A good knowledge of genetic resources might also help in identifying desirable genotypes for future hybridization program [2].

Therefore, the genetic study was an attempt to assess the variability parameters including genotypic and phenotypic coefficients of variation and the genetic advance as well as heritability estimates for quantitative and qualitative characters for nine sugarcane clones in plant crop.

2. MATERIALS AND METHODS:

The experiment was conducted at Regional Sugarcane and Rice Research Station (RS&RRS), Rudrur, Nizamabad district,Telangana state during the 2021-22 cropping season in black cotton soil, following Randomized Block Design (RBD) with three replications. Nine mid-late maturing clones of sugarcane, including three checks were used in this experiment. The three-eyed setts of each genotype were planted in a 6 m × 9 m size plot. Row to Row distance was 1.5 m. Setts were planted in the ridge and furrow method. Data were collected on sixteen different yield and quality characters namely Germination % at 30 Days After Planting (DAP), Tillers at 120 DAP ('000/ha), Plant height at harvest (cm), Cane diameter at harvest (cm), Single cane weight at harvest (Kg),Millable canes at harvest (000/ha), Brix at 10 months stage (%), Pol in juice at 10 months stage (%), Purity at 10 months stage (%), Brix at 12 months stage (%), Pol in juice at 12 months stage (%), Purity at 12 months stage (%), CCS at 10 months stage (%), CCS at 12 months stage (%), Sugar yield at harvest (t/ha), Cane yield at harvest (t/ha). Intercultural operations like weeding, earthen-up, and irrigation were done as per the required schedule. The collected data were analyzed by statistical software, namely OPSTAT for Analysis of variance, Mean, range, Genotypic and phenotypic coefficient of variation (%), Heritability (Broad sense %), Genetic advance (GA), and Genetic advance as percent of the mean (%) analysis.

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Brix % at 10 and 12 months stage:

It is a measure of total soluble solids present in the juice. It was taken directly by using a Brix hygrometer. A total of 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 20ºC by using temperature correction chart [3].

Pol % at 10 and 12 months stage:

Pol **%**refers to the sucrose per cent in juice. It was done according to Spencer and Meade (1955) [3] method. 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.

CCS Percent& CCS yield (t/ha):

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

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

$$\text{CCS yield (t/ha)} = \frac{\text{CCS\% x Cane yield(t/ha)}}{100}$$

Purity % at 10 and 12 month stage:

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

The data were statistically analyzed. The analysis of variance (ANOVA) was worked out according to the procedure of Randomized Block Design for each character [4]. The analysis of variance was used to derive variance components [5].

Genotypic and phenotypic coefficients of variability were calculated (6). Heritability in broad sense (h2 b) was estimated (7) and genetic advance (GA) was calculated (8). GCV and PCV were categorized as low (0-10 percent), moderate (10-20 percent) and high (above 20 percent) according to Sivasubramanian and Menon (1973) (9), while heritability in broad sense was categorized as low (0-30 percent), moderate (31-60 percent) and high (above 60 percent) (10). Genetic advance as per cent of mean was categorized as low (0-10 percent), moderate (11-20 percent) and high (above 20 percent) (8). (1955).The phenotypic and genotypic correlation coefficients were obtained (8).

3. RESULTS AND DISCUSSION:

The analysis of variance for all sixteen characters showed statistically highly significant among the clones (Table 1) suggesting that the clones were genetically divergent. This indicates that there is ample scope for the selection of promising clones among nine clones for sugarcane improvement. High variability was recorded for different traits in sugarcane. To make sense of the amount of existing variability in the present clones, range, mean and standard error were calculated [11,12 and 13] (Table 2). However, range is the crude method of estimation of variability, which indicates observed phenotypic variability only. Among all the clones, the yield was recorded from 81.71 t/ha to 140.16 t/ha. It also showed the advisable range of co-efficient of variation for all the traits.

Table 1: Analysis of variance for sixteen traits of mid-late maturing sugarcane clones

S.No.	Characters	Mean sum of square		
		Replication (d.f. =2)	Treatment (d.f.=8)	Error (d.f.=16)
1	Germination % at 30 DAP	27.13	112.42**	43.02
2	Tillers at 120 DAP (000/ha)	58.06	548.43**	52.87
3	Plant height at harvest (cm)	227.68	1285.95**	130.31
4	Cane diameter at harvest (cm)	0.017	0.224**	0.015
5	Single cane weight at harvest (Kg).	0.004	0.159**	0.011
6	Millable canes at harvest (000/ha).	115.43	538.45**	38.71
7	Brix at 10 months stage (%)	0.78	6.74**	0.62
8	Pol in juice at 10 months stage (%)	0.50	12.88**	0.76
9	Purity at 10 months stage (%)	7.11	69.93**	7.42
10	Brix at 12 months stage (%)	0.19	1.55**	0.24
11	Pol in juice at 12 months stage (%)	0.16	1.76**	0.09
12	Purity at 12 months stage (%)	3.41	7.32**	2.46
13	CCS at 10 months stage (%)	0.28	8.51**	0.50
14	CCS at 12 months stage (%)	0.12	1.08**	0.06
15	Sugar yield at harvest (t/ha)	4.14	24.14**	3.03
16	Cane yield at harvest (t/ha)	167.03	1121.93**	151.76

* Significant at 5%, ** significant at 1% DAP – Days After Planting

Table.2 Mean, range and coefficient of variance for sixteen traits of mid-late maturing sugarcane clones

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S.No.	Characters	Mean ± SEm	Range		C.V.
			Max.	Min.	
1	Germination % at 30 DAP	44.61 ± 3.79	52.30	32.94	14.70
2	Tillers at 120 DAP (000/ha)	85 ± 4.20	104.00	67.00	8.59
3	Plant height at harvest (cm)	257.18 ± 6.59	290.73	222.13	4.44
4	Cane diameter at harvest (cm)	2.86 ± 0.07	3.35	2.43	4.34
5	Single cane weight at harvest (Kg).	1.47 ± 0.06	1.58	1.17	7.12
6	Millable canes at harvest (000/ha).	74 ± 3.59	93.00	58.00	8.38
7	Brix at 10 months stage (%)	18.14 ± 0.45	19.60	15.47	4.34
8	Pol in juice at 10 months stage (%)	15.34 ± 0.50	17.76	11.85	5.67
9	Purity at 10 months stage (%)	84.20 ± 1.57	90.65	76.61	3.24
10	Brix at 12 months stage (%)	21.84 ± 0.28	22.90	20.93	2.24
11	Pol in juice at 12 months stage (%)	19.48 ± 0.17	20.29	18.29	1.52
12	Purity at 12 months stage (%)	89.19 ± 0.91	90.73	85.48	1.76
13	CCS at 10 months stage (%)	10.38 ± 0.41	12.43	7.59	6.84
14	CCS at 12 months stage (%)	13.53 ± 0.14	14.14	12.44	1.79
15	Sugar yield at harvest (t/ha)	14.66 ± 1.00	19.83	11.48	11.87
16	Cane yield at harvest (t/ha)	108.21 ± 7.11	140.16	81.71	11.38

Table.3 Genetic parameters for sixteen traits of mid-late maturing sugarcane clones

Sl. No	Character (s)	Coefficient of Variation (%)		Heritability (Broad sense %)	Genetic advance (GA)	Genetic advance as percent of the mean (%)
		Genotypic	Phenotypic			
1	Germination % at 30 DAP	10.8	18.2	35.0	5.86	13.1
2	Tillers at 120 DAP (000/ha)	15.19	17.45	75.76	23.04	27.24
3	Plant height at harvest (cm)	7.63	8.83	74.72	34.95	13.59
4	Cane diameter at harvest (cm)	9.24	10.21	81.91	0.49	17.23
5	Single cane weight at harvest (Kg).	15.04	16.64	81.71	0.41	28.01
6	Millable canes at harvest (000/ha).	17.39	19.31	81.14	23.95	32.28
7	Brix at 10 months stage (%)	7.88	8.99	76.70	2.57	14.21
8	Pol in juice at 10 months stage (%)	13.11	14.28	84.24	3.80	24.79
9	Purity at 10 months stage (%)	5.42	6.31	73.74	8.07	9.59
10	Brix at 12 months stage (%)	3.03	3.77	64.56	1.09	5.01
11	Pol in juice at 12 months stage (%)	3.84	4.13	86.47	1.43	7.35
12	Purity at 12 months stage (%)	1.43	2.26	39.74	1.65	1.85

13	CCS at 10 months stage (%)	15.74	17.16	84.10	3.08	29.73
14	CCS at 12 months stage (%)	4.32	4.68	85.43	1.11	8.23
15	Sugar yield at harvest (t/ha)	18.09	21.64	69.91	4.56	31.16
16	Cane yield at harvest (t/ha)	16.62	20.14	68.06	30.56	28.24

The estimated genetic parameters (PCV, GCV, heritability, genetic advance) are furnished in Table 3. The results of genetic variability indicated that the moderate GCV and high PCV were observed for Sugar Yield at harvest (18.09% and 21.64%) and Cane Yield at harvest (16.62% and 20.14%), which were exhibited the existence of large genetic variability and demonstrated the effective selection for the given traits. The moderate values of GCV and PCV were recorded for millable canes at harvest (17.39% and 19.31%), followed by Germination at 30 DAP (%) (10.80% and 18.20%), Tillers at 120 DAP (000/ha) (15.19% and 17.45%), CCS at 10 month stage (%) (15.74% and 17.16%), Single Cane Weight at harvest (Kg) (15.04% and 16.64%), Pol in juice at 10 months stage (%) (13.11% and 14.28%) respectively.Similar results were reported by Tabassum *et al*.(14) and Pandey *et al*. [1] for Germination at 30 DAP (%).While Cane diameterat harvest (cm), low GCV (9.24 %) and moderate PCV (10.21%)were recorded. For Plant height at harvest (cm)(7.63% and 8.83%),Brix at 10 months stage (%) (7.88% and 8.99%),Purity at 10 month stage(%)(5.42% and 6.31%),Brix at 12 months stage (%) (3.03% and 3.77%),Pol in juice at 10 months stage (%) (3.84% and 4.13%),CCS at 12 month stage (%) (4.32% and 4.68%) and Purity at 12 month stage (1.43% and 2.26%) had the lowest GCV and PCV respectively, which exhibited a huge impact of the environment on the trait (Table 3).These results are in conformity withthe reports of Tabassum *et al*.(14) for Brix at 12 months stage (%),Purity at 12 month stage (%).

Heritability is a good indicator of transmission of characters from parents to its progeny. Heritability is classified as low (below 30%), medium (31%–60%) and high above 60%). The estimates of heritability help the plant breeder in selection of genotypes from diverse genetic population. Therefore, high heritability helps in effective selection for a particular character. Most of the traits in this study were manifested high heritability (64.56%–86.47%), while moderate heritability revealed only for Purity at 12 months stage (%) (39.74%) and Germination % at 30 DAP (35%). The highest broad sense heritability value manifested for Pol in juice at 12 months stage (%) (86.47%) followed by CCS at 12 months stage (%) (85.43%) (Table 3).Similar findings were reported by Gowda *et al.,*[15]as heritability is a good index of transmission of characters from parents to its progeny.

The genetic advance is a useful indicator of the effective and efficient selection progress that can be expected as result of exercising selection on the base population. In present study high genetic advances (>20%) were revealed for Plant height at harvest (cm), Cane yield at harvest (t/ha), Millable canes at harvest (000/ha) and Tillers at 120 DAP (000/ha), while others traits manifested low genetic advance (<10%) (Table 3).This finding is in line with investigation reported by [16] on sugarcane genotypes. In present study high heritability and genetic advance as percentage of mean (>50) was recorded for Millable canes at harvest (000/ha), Single cane weight at harvest (Kg) indicating predominance of additive gene action for these characters. This shows that selection is effective to improve these traits. On other hand high heritability with low Genetic advance as percentage of mean was revealed for Purity at 10 months stage (%), Brix at 12 months stage (%), Pol in juice at 12 months stage (%),Purity at 12 months stage (%) and CCS at 12 months stage (%). Similar result also reported by Kamat DN and Singh JRP [17].

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