ESTIMATION OF GENETIC PARAMETERS IN EARLY MATURING SUGARCANE CLONES FOR YIELD AND QUALITY TRAITS

ABSTRACT:

To make pragmatic selection of best performing clones, it is compulsory to know traits having high values of heritability. Hence, this work was initiated with the aim of estimating genetic parameters of twelve sugarcane clones planted in randomized block design with three replications. The tested clones were significantly different for all most all the traits at 1% and 5% level of significance. Genotypic and phenotypic variance, GCV and PCV, heritability in broad sense (h^2) and genetic advance as percent of mean was calculated for all traits taken. Low genotypic variances were obtained as compared to the corresponding phenotypic variances for the traits taken. High GCV and heritability coupled with high genetic advance as percent mean were obtained for Shoots at 240 DAP (Days After Planting) (000/ha), Single cane weight at harvest (Kg), commercial cane sugar (CCS) at 8 months stage (%), CCS at 10 months stage (%), Sugar yield at harvest (t/ha) and Cane yield at harvest (t/ha). Hence, selections based on these characters are appropriate for varietal improvement.

Comment [U1]: Specify the clone type. Clones in general or sugar cane clones.

Key words: *selection, sugarcane clones, genotypic, phenotypic variance, GCV, PCV, heritability in broad sense (h^2) and genetic advance as percent of mean.*

Comment [U2]: It is recommended not to have keywords that are contained in title.

Comment [U3]: Don't put large phrases in keywords

Comment [U4]: The last paragraph is long. Subdivide it into smaller paragraphs, for better reading and understanding

INTRODUCTION:

Sugarcane is a perennial, tall monocotyledonous tropical crop that belongs to the grass family Poaceae and Andropogona tribe. It is a major agricultural cash crop next to cotton in India. It act as a major industrial cash crop also, having potential to be a key crop in bio factory evolution as it produces high yield of valuable products like sugar, biofibres, waxes, bioplastic and biofuel ~~(Balwant, 2020)~~ [1]. Globally sugarcane is cultivated in an area of 25.97 million hectares producing 1.84 billion tons with the productivity of 70.85 t ha^{-1} [2]. India is next only to Brazil with respect to cane area. In India, it is cultivated in an area of 5130.75 thousand hectares with the production of 383892 thousand tonnes with average productivity of 78.24 tonnes per hectare [3].

Variety improvement in the sugarcane is a key to solve the problems of the sugar industries with respect to diversifying the gene pool of improved varieties for increasing both the cane and sugar yield. Hence, breeding programmes are aiming at development of cultivars with an early maturity connected with high sugar content is one of the main objectives as demanded by sugar industries [4 and 5]. Early maturing varieties have advantageous to both the growers and sugar industries. They provide an efficient and reliable means of achieving increased sugar yields at the beginning of the season [6], save the raw material required for a given crop cycle and allow earlier commencement of the harvesting and the processing season, and ensure profitability [7 and 8].

Economic characters, mostly polygenically controlled and having complex type of inheritance and are often influenced by the environment [9]. [10] Stated that genetic variability and heritability are useful parameters that can help the breeding during different stages of crop improvement. The success of such program will depend upon largely on the extents of genetic variability available in the base population and heritability of the characters under improvement. Therefore, a clear understanding of genetic parameters is of paramount importance to develop a breeding strategy. Sugarcane is a highly heterozygous and complex polyploidy in its nature. So, this has resulted in generation of genetic variability and opportunity for improvement and selection. The most important function of heritability in genetic studies of yield traits and its prediction value that could be used as a guide to the breeding value, also estimation of heritability along with genetic advance expected by selection for yield and its contributing characters, seem to help designing an effective breeding programme and selecting superior clones for the on-going sugarcane industry (11). Keeping in view, this experiment was taken up to study the genetic variability among different traits in a set of 12 early maturing sugarcane clones to understand the interrelationship among the traits.

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MATERIALS AND METHODS:

The experiment was conducted at Regional sugarcane and Rice research station, Rudrur, Nizamabad district, Telangana state during 2019-20 cropping season under black cotton soil, following Randomized Block Design (RBD) with three replications. Twelve early maturing clones of sugarcane, including three checks were used in this experiment. The three-eyed setts of each genotype were planted in 6 m × 8 m size plot. Row to Row distance was 1.2 m. Setts were planted in the ridge and furrow method. Data were collected on seventeen different yield quality characters namely Germination % at 30 DAP, Shoots at 120 DAP (‘000/ha), Shoots at 240 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 8 months stage (%), Pol in juice at 8 months stage (%), Purity at 8 months stage (%), Brix at 10 months stage (%), Pol in juice at 10 months stage (%), Purity at 10 months stage (%), CCS at 8 months stage (%), CCS at 10 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 required schedule.

Brix % at 8 and 10 month stage:

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 ° by using temperature correction chart [12].

Comment [U7]: Specify the temperature. Degrees Celsius, Fahrenheit?

Pol % at 8 and 10 month stage:

Pol refers to the sucrose per cent in juice. It was done according to Spencer and Meade (1955) [12] method. It was estimated with the help of Polari scope. First 100 ml juice was taken in conical flask and 4gm 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 % is determined by formula

$[S-(B-S) \times 0.4] \times 0.73$

Where,

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

Purity % at 8 and 10 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 [13]. The analysis of variance was used to derive variance components [14].

Genotypic and phenotypic coefficients of variation were estimated [15]. Heritability in broad sense (h^2) was estimated [16], Genetic advance (GA) and Genetic advance as percent of mean (GAM) was estimated [17].

RESULTS AND DISCUSSIONS:

The analysis of variance for all seventeen 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 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 [18,19 and 20] (Table 2) However, range is the crude method of estimation of variability, which indicates observed phenotypic variability only. Among all the clones, yield was recorded from 87.05 t/ha to 148.47 t/ha. It also showed the advisable range of co-efficient of variation for all the traits.

Table 1: Analysis of variance for seventeen yield and quality traits of early maturing sugarcane clones

S.No	**Characters**	**Mean sum of square**		
		Replication (d.f. =2)	Treatment (d.f. =11)	Error (d.f. =22)

1	Germination % at 30 DAP	12.23	66.58*	21.23
2	Shoots at 120 DAP (000/ha)	342.64	672.17 **	201.83
3	Shoots at 240 DAP (000/ha)	535.88	1229.66 **	179.26
4	Plant height at harvest (cm)	427.90	589.22 **	173.30
5	Cane diameter at harvest (cm)	0.003	0.08 **	0.01
6	Single cane weight at harvest (Kg).	0.01	0.07 **	0.01
7	Millable canes at harvest (000/ha).	55.30	867.11 **	179.49
8	Brix at 8 months stage (%)	0.19	1.85**	0.18
9	Pol in juice at 8 months stage (%)	0.20	4.94 **	0.54
10	Purity at 8 months stage (%)	2.40	56.19 **	7.99
11	Brix at 10 months stage (%)	0.03	6.01 **	0.09
12	Pol in juice at 10 months stage (%)	0.03	7.74 **	0.39
13	Purity at 10 months stage (%)	1.78	27.67 **	5.33
14	CCS at 8 months stage (%)	0.12	3.53 **	0.40
15	CCS at 10 months stage (%)	0.09	5.29 **	0.12
16	Sugar yield at harvest (t/ha)	4.60	34.30 **	2.18
17	Cane yield at harvest (t/ha)	320.04	1500.65 **	186.89

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

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Table.2 Mean, range and coefficient of variance for seventeen yield and quality traits of early maturing sugarcane clones

S.No	Characters	Mean ± SEM	Range		C.V.
			Max.	**Min.**	
1	Germination % at 30 DAP	46.55 ± 2.66	54.15	38.59	9.90
2	Shoots at 120 DAP (000/ha)	150 ± 8.20	168	120	9.50
3	Shoots at 240 DAP (000/ha)	127±7.73	151	85	10.56
4	Plant height at harvest (cm)	276.54 ± 7.60	298.67	253.00	4.76
5	Cane diameter at harvest (cm)	2.84 ± 0.06	3.08	2.46	3.48
6	Single cane weight at harvest (Kg).	1.09 ± 0.04	1.32	0.82	6.28
7	Millable canes at harvest (000/ha).	107 ± 7.74	131	71	12.50
8	Brix at 8 months stage (%)	15.47 ± 0.24	16.60	14.13	2.71
9	Pol in juice at 8 months stage (%)	12.13 ± 0.42	14.32	11.07	6.03
10	Purity at 8 months stage (%)	78.18 ± 1.63	86.22	72.63	3.62
11	Brix at 10 months stage (%)	1.21 ± 0.17	20.37	16.13	1.65
12	Pol in juice at 10 months stage (%)	15.92 ± 0.36	18.75	13.70	3.91
13	Purity at 10 months stage (%)	86.83 ± 1.33	92.11	83.47	2.66
14	CCS at 8 months stage (%)	7.88 ± 0.37	9.78	6.37	8.06
15	CCS at 10 months stage (%)	10.87 ± 0.20	13.22	9.29	3.21
16	Sugar yield at harvest (t/ha)	12.75 ± 0.85	17.44	8.77	11.59
17	Cane yield at harvest (t/ha)	116.45 ± 7.89	148.47	87.05	11.74

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As stated, the PCV (phenotypic coefficient of variation) and GCV (genotypic coefficient of variation) values are ranked as low, medium, and high with 0 to 10%, 10 to 20%, and >20%, respectively

[21]. The estimated phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits indicating greater environmental influence on these traits for total variation. Low GCV values were exhibited by Purity at 10 months stage (%) (3.14), Plant height at harvest (cm) (4.25), Brix at 8 months stage (%) (4.82), Purity at 8 months stage (%) (5.12), Cane diameter at harvest (cm) (5.45), Brix at 10 months stage (%) (7.71), Germination % at 30 DAP (8.35), Shoots at 120 DAP (000/ha) (8.37), Pol in juice at 10 months stage (%) (9.83) and Pol in juice at 8 months stage (%) (9.99), medium GCV for shoots at 10 months stage (%) (12.08), CCS at 8 months stage (%) (12.97), single cane weight at harvest (kg) (13.14), millable canes at harvest (000/ha) (14.11), shoots at 240 DAP (000/ha) (14.76) and cane yield at harvest (t/ha) (17.97) and high GCV only for Sugar yield at harvest (t/ha) (25.66). Low PCV was exhibited by Purity at 10 months stage (%) (4.12), Brix at 8 months stage (%) (5.53), Purity at 8 months stage (%) (6.27), Plant height at harvest (cm) (6.38), Cane diameter at harvest (cm) (6.47), Brix at 10 months stage (%) (7.89).,

Whereas intermediate PCV values were obtained for Pol in juice at 10 months stage (%) (10.58), CCS at 10 months stage (%) (12.5), Shoots at 120 DAP (000/ha) (12.65), Germination % at 30 DAP (12.95), single cane weight at harvest (kg) (14.56), CCS at 8 months stage (%) (15.27), shoots at 240 DAP (000/ha) (18.15) and millable canes at harvest (000/ha) (18.85). High PCV values were recorded for Cane yield at harvest (t/ha) (21.47) and Sugar yield at harvest (t/ha) (28.16) [22]. Low PCV and GCV values recorded for purity [23 and 24]. High PCV and GCV values obtained in this investigation for sugar yield [23]. This showed that sugar yield at harvest is under the influence of genetic control hence it suggest that better improvement by selection based on this trait is reliable. The evaluation of heritable variation with the help of genetic coefficient of variation alone may be deceptive [23]. Therefore genotypic coefficient of variation is not a correct measure to know the heritable variation present and should be considered together with heritability [22].

Heritability values are categorized as low (0–30 %), moderate (30–60 %), and high (60 % and above). Low heritability values were not obtained in this study where as Moderate heritability values were recorded for Germination % at 30 DAP, Shoots at 120 DAP (000/ha), Plant height at harvest (cm), Millable canes at harvest (000/ha), Purity at 10 months stage (%), as indicated in (table 3). High heritability was exhibited by Shoots at 240 DAP (000/ha), Purity at 8 months stage (%), Cane yield at harvest (t/ha), Cane diameter at harvest (cm), CCS at 8 months stage (%), Pol in juice at 8 months stage (%), Brix at 8 months stage (%), Single cane weight at harvest (Kg), Sugar yield at harvest (t/ha), Pol in juice at 10 months stage (%),CCS at 10 months stage (%) and Brix at 10 months stage (%) [25,26and27]. So, selection breeding for improvement of these varieties based these traits may be reliable. But heritability alone provides no indication of the amount of genetic improvement that would result from selection of individual genotype. Thus, information of heritability should be coupled with genetic advance.

Genetic advance (GA) is referred as the improvement of characters in genotypic value for the new population compared with the base population. Genetic advance as per cent mean is categorized as low (0-10), moderate (10-20) and high (>20) [17]. The genetic advance expressed as per cent of mean was highest for Shoots at 240 DAP (000/ha) (24.73), Single cane weight at harvest (Kg) (24.43), Millable canes at harvest (‘000/ha) (21.77), CCS at 8 months stage (%) (22.69), CCS at 10 months stage (%) (24.05), Sugar yield at harvest (t/ha) (48.18) and Cane yield at harvest (t/ha) (31.00). The high heritability coupled with high genetic advance was obtained for Shoots at 240 DAP (‘000/ha), Single cane weight at harvest (Kg), CCS at 8 months stage (%), CCS at 10 months stage (%), Sugar yield at harvest (t/ha) and Cane yield at harvest (t/ha). Thus, these characters are under the control of additive genetic effects and it confirms that selection based on the phenotypic performance of this trait is best for variety improvement program [23 and 28].

Table.3 Genetic parameters for seventeen yield and quality traits of early maturing sugarcane clones

S. 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	8.35	12.95	41.60	5.17	11.09
2	Shoots at 120 DAP (000/ha)	8.37	12.65	43.72	17.05	11.04
3	Shoots at 240 DAP (000/ha)	14.76	18.15	66.14	31.35	24.73
4	Plant height at harvest (cm)	4.25	6.38	44.44	16.17	5.84
5	Cane diameter at harvest (cm)	5.45	6.47	71.07	0.26	9.47
6	Single cane weight at harvest (Kg).	13.14	14.56	81.42	0.26	24.43
7	Millable canes at harvest (000/ha).	14.11	18.85	56.06	23.34	21.77
8	Brix at 8 months stage (%)	4.82	5.53	76.00	1.33	8.66
9	Pol in juice at 8 months stage (%)	9.99	11.67	73.27	2.13	17.61
10	Purity at 8 months stage (%)	5.12	6.27	66.79	6.74	8.63
11	Brix at 10 months stage (%)	7.71	7.89	95.63	2.83	15.54
12	Pol in juice at 10 months stage (%)	9.83	10.58	86.36	2.99	18.83
13	Purity at 10 months stage (%)	3.14	4.12	58.31	4.29	4.94
14	CCS at 8 months stage (%)	12.97	15.27	72.16	1.79	22.69
15	CCS at 10 months stage (%)	12.08	12.5	93.40	2.61	24.05
16	Sugar yield at harvest (t/ha)	25.66	28.16	83.07	6.14	48.18
17	Cane yield at harvest (t/ha)	17.97	21.47	70.09	36.09	31.00

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CONCLUSION:

The study indicated that there is wide range of genetic variability among the tested clones for growth and yield characters. It is evident that the high heritability coupled with high genetic advance reported in characters Shoots at 240 DAP (000/ha), Single cane weight at harvest (Kg), CCS at 8 months stage (%), CCS at 10 months stage (%), Sugar yield at harvest (t/ha) and Cane yield at harvest (t/ha). Hence, selection of the best performing clones based on these characters may be utilized in future selection breeding programme.

REFERENCES:

1. Balwant Kumar. “Glimpses of Sugarcane Varietal Screening and Improvement at Pusa, Bihar". Acta Scientific Agriculture. 2020:4(3): 01-12

2. http://www.fao.org/faostat; 2017

3. https://www.indiaagristat.com; 2018-19

4. Domaingue R, Ramdoyal K, Rivet I and Mamet LD. Vers un choix judicieux de parents dans le programme d’amelioration de la canne à sucre à L’Ile Maurice. Proc. Third Congr. Ass. Reunionnaise Dev. Technol. Agric. Sucr. 1988. p. 326-331

5. Das, P.K., Rarida, A.K., Nayak, N., Mahapatra, S.S. and Jena, B.C., Path coefficient, Regression and Discrimination function in Sugarcane. Inidan Sugar. 1997:47(1):31-34.

6. Singh, P.R. and M.R. Gupta. "Sugarcane management strategy for early maturing varieties for higher productivity in U.P." Ind. Sugar 1999:48(12) 983-989.

7. Muchow, R.C., Rnbertson, M.J. and Wood, A.W. Growth of sugarcane under high input conditions in tropical Australia. If. Sucrose accumulation and commercial yield. Field Crops Res. submitted. 1996.

8. Singh, R.K. and Singh, G.P. . Effect of sampling time on efficacy of selection for quality traits in sugarcane.*Sugar Cane*. 1998:**3**: 13–17.

9. Mali, S. C. and Patel, A. I,. Correlation and Heritability Studies in Sugarcane. *AGRES – An International e-Journal.* 2013: 2(4): 466-471.

10. Anshuman, S., Bhatnagar, P. K., Khan, A. Q. and Shrotria, P. K. Variability and heritability for cane yield, its components and quality characters in sugarcane (*Saccharum* spp complex). *Ind Sug J*. 2002: 53(4): 717-719.

11. Burton, G. W. C. Quantitative inheritance in grasses. *Proceeding Sixth Int Grassl Conf Journ.* 1952:1: 277-283.

12. Spencer, G.L. and Meade, G.P. Cane Sugar Hand Book. *J. Wiley and Sons, N.Y.* 1955.
13. Panse, V. G. and Sukhatme, P. V. Statistical methods of agricultural workers 2nd edn. ICAR, Publication, New Delhi. 1967: pp. 381.
14. Cochran, WG and Cox, GM. Experimental Designs. 2nd Edn. Wiley, New York. [1957].
15. Burton GW and Devane EW. Estimating heritability in tall fescue (Festuca arundiraceae) from replicated clonal material. Agronomy Journal. 1953: 45: 478-481.

16. Falconer DS. An Introduction of Quantitative Genetics-3rd edition. Longman. New York.1989.

17. Johnson, H.W., Robinson, H.F. and Comstock, R. E. Estimates of genetic and environmental variability in soybeans. Agronomy Journal, (1955): 47 (7): 314-318.
18. Doule, R. B. and Balasundaram, N. Genetic variability in sugar yield and its components for selection of sugarcane. *Journal of Maharashtra Agricultural Universities*. (2002):27(3): 326-327.
19. Singh, M. K., Pandey, S. S., Kumar, R. and Singh, A. K. Estimation of genetic variability, heritability and genetic advance in mid-late maturing clones of sugarcane. *Environment and Ecology*. (2010): 28(4): 2301-2305.
20. Praveen Kumar, S.S. Pandey, Balwant Kumar, D.N. Kamat and Mahesh Kumar. Assessment of Genetic Parameters for Various Productive Traits in Early Maturing Sugarcane. *Int.J.Curr.Microbiol.App.Sci.* 2018: 7(05): 1387-1392.

21. Shivasubramanian S, Menon M. Heterosis and inbreeding depression in rice. Madras Agric. J.1973:60: 1139.
22. Swamy Gowda S.N, Saravanan K and Ravishankar C.R. Genetic Variability, Heritability and Genetic Advance in Selected Clones of Sugarcane. Plant Archives. 2016: 16(2): 700-704.
23. Negi A. S, Sigh S.P, Jeena A.S. and Talha M. Estimation of Variability Parameters in Early Generation General Collection Progenies of Sugarcane (Saccharum Species Complex). International Journal of Agriculture Innovations and Research.2017:1(6): 2319-1473.
24. Patil, P.P. and Patel, D.U. Study of Genetic Variability and Heritability in Sugarcane (Saccharum spp. Complex). Int.J.Curr. Microbiol. App.Sci. 2017: 6(9): 3112-3117.
25. Singh, R.K., Singh, D. N., Singh, S. K. and Singh, H. N. Genetic variability and correlation studies in foreign commercial hybrid of sugarcane. *Agril.Sci. Digest*. 1996:**4**(2): 103-107.
26. Ghosh, J. and Singh, J. R. P. Variability in early maturity clones of sugarcane. *Cooperative sugar*.1996. **27**(5): 341- 345.
27. Kamat, D. N. and Singh, J. R. P. Variability in sugarcane under rainfed condition. *Sugar Tech*., 2001: **3**(1&2): 165-167.
28. Dereje S. Estimation of genetic parameters of sugarcane *(Sacharrum officinarum* L.*)* varieties grown at Arjo-Dedessa sugar Projest, Western Ethiopia. Int. J. Adv. Res. Biol. Sci. 2018:5(8): 30-35