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GENETIC VARIABILITY PARAMETERS FOR CANE YIELD AND ITS COMPONENT TRAITS IN EARLY MATURING SUGARCANE (*Saccharum officinarum)*

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Sugarcane is a monocotyledonous, perennial crop which is raised in tropical and sub- tropical region primarily for its high concentration of sugar in the inter-node and propagates through stem cutting. The cultivated sugarcane varieties are interspecific hybrids involving at least three species*, S. officinarum, S. barberi and S. spontaneum* which themselves represent complex polyploidy. Botanically sugarcane is described as *Saccharum spp.* complex hybrid because among varieties, chromosome number varies from 2n = 80 to 120. To meet the expected combined demand posed by anticipated population and consumption increase along with the other challenges, India will have to produce 51 million tonnes of white sugar by 2050 from the present 27.7 million tonnes, which will be possible only with a quantum jump in sugarcane productivity and sugar recovery (Chogatapur *et al.,* 2017). In this reference, there is huge demand for the development of sugarcane varieties with high tonnage and sucrose percent which is in turn one of the initial goals of the varietal development program. The polyploid and heterozygous nature of sugarcane has resulted in generation of greater genetic variability. The understanding of nature and extent of available genetic variation in the breeding materials or germplasms lead the breeder for executing sound breeding programmes. Hence understanding the various genetic parameters is a basic step for improvement of any crop. Genetic variability estimation with heritability and genetic advance pass an idea of the potential improvement of the character by selection. Keeping these in view, the present study was taken up to study of genetic variability parameters for yield and its components traits in early maturing Sugarcane.

The present investigation analyzed 15 early maturing sugarcane clones, listed in Table 1, obtained from Sugarcane Research Institute Pusa.

Plants were raised at Regional Research Station Madhopur, West Champaran district of Bihar, in a Randomized Block Design with three replications, plot size of 6m x 3m, row to row distance 75 cm, during February 2017.

Table 1. List of genotypes used under study

S. No.	Genotype
1	CoSe 11451
2	CoSe 12451
3	CoLk 12207
4	CoLk 12208
5	CoP 11436
6	CoP 11438
7	CoP 12436
8	CoP 12437
9	CoP 13436
10	CoP 13437
11	CoP 16436
12	CoP 16437
13	CoP 16438
14	BO 153
15	CoP 11437

Observations were record by selecting five random plants per genotype per replication for productive characters, namely, germination percent at 45 days after planting (DAP), number of shoots at 120 DAP, plant height at 150, 240 and 300 DAP, cane diameter at harvest, number of millable canes, brix, pol, purity percent, extraction, fibre, CCS at 8 &10 month stages, Pol in cane at harvest, single cane weight, sugar yield and cane yield at harvest.

Brix percent 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 as mentioned by Spencer and Meade (1955).

Pol in juice refers to the sucrose per cent in juice.

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It is estimated according to the method described by Spencer and Meade (1955). 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 was 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 was called dial reading. Sucrose per cent in juice was taken by referring the brix and dial reading to Schmitz's table.

$$\text{Purity percent of juice} = \frac{\text{Sucrose per cent in juice}}{\text{Corrected brix}} \times 100$$

For Juice extraction percent five canes from each plot were taken at 8 & 10 month stage and weighed. Juice was extracted with the help of power juice extractor and weighed juice extraction percentage was calculated with the help of following formula:

$$\text{Juice extraction \%} = \frac{\text{Weight of juice}}{\text{Weight of cane}} \times 100$$

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.

The data were statistically analyzed. The analysis of variance (ANOVA) was worked out according to the procedure of Randomized Block Design for each genotype as per methodology advocated by Panse and Sukhatme (1967). The analysis of variance was used to derive variance components (Cochran and Cox, 1957). The formulae used to calculate PCV and GCV were given by Burton and De vane (1953). Broad sense heritability was estimated by the formula given by Johnson *et al.* (1955). The heritability was categorized as high, moderate and low as given by Robinson *et al.* (1949).

The estimates of genetic advance were obtained by the formula given by Lush (1949), Johnson *et al.* (1955) and Allard (1960). The range of genetic advance was classified as suggested by Johonson *et al*. (1955). Observed data for all the traits of 15 early maturing sugarcane clones were assessed for statistical analysis.

Table 2. Analysis of variance for various traits of early maturing sugarcane clones

Sl. No.	Character	Mean sum of square		
		Replication (d.f. =2)	Treatment (d.f. =14)	Error (d.f. =28)
1	Germination % at 45 DAP	3.48	15.23**	4.54
2	Shoots at 120 DAP (000/ha)	48.95	283.04**	29.19
3	Plant height at 150 DAP (cm)	6.80	262.29**	46.13
4	Plant height at 240 DAP (cm)	26.65	457.42**	94.57
5	Plant height at harvest (cm)	30.09	1150.61**	145.37
6	Cane diameter at harvest (cm)	0.0009	0.237**	0.007
7	Single cane weight at harvest (Kg).	0.0003	0.014**	0.001
8	Millable canes at harvest (000/ha).	65.14	223.75**	23.63
9	Brix at 8 months stage (%)	0.97	2.48**	0.46
10	Pol in juice at 8 months stage (%)	1.26	2.31**	0.50
11	Purity at 8 months stage (%)	5.40	2.96	3.55
12	Brix at 10 months stage (%)	0.29	0.60**	0.20
13	Pol in juice at 10 months stage (%)	0.45	0.83**	0.29
14	Purity at 10 months stage (%)	1.25	2.45	1.36
15	Extraction at 8 months stage (%)	0.36	14.68**	0.34
16	Extraction at 10 months stage (%)	0.34	10.94**	0.27
17	Fibre at 8 months stage (%)	0.015	0.77**	0.06
18	Fibre at 10 months stage (%)	0.19	0.37**	0.06
19	CCS at 8 months stage (%)	0.76	1.21**	0.30
20	CCS at 10 months stage (%)	0.28	0.50*	0.19
21	Pol In cane at harvest (%)	0.2799	0.55**	0.19
22	Sugar yield at harvest (t/ha)	0.3662	3.68**	0.63
23	Cane yield at harvest (t/ha)	67.9	210.28**	29.43

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

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Table 3. Mean, Range and CV of various traits of early maturing sugarcane

Sl. No.	Character	Mean	Range		C.V.
			Max.	Min.	
1	Germination % at 45 DAP	35.51±1.23	39.00	33.33	6.00
2	Number of shoots at 120 DAP (000/ha)	101.04±3.12	110.67	82.67	5.35
3	Plant height at 150 DAP (cm)	99.86±3.92	115.53	84.80	6.80
4	Plant height at 240 DAP (cm)	179.44±5.61	196.33	161.80	5.42
5	Plant height at harvest (cm)	256.47±6.96	286.13	218.78	4.70
6	Cane diameter at harvest (cm)	2.28±0.05	2.78	1.90	3.72
7	Single cane weight at harvest (Kg).	0.86±0.02	1.01	0.78	3.65
8	NMC at harvest (000/ha).	95.71±2.81	105.93	79.03	5.08
9	Brix at 8 months (%)	16.68±0.39	18.47	14.87	4.07
10	Pol in juice at 8 months (%)	14.38±0.41	16.02	12.52	4.92
11	Purity at 8 months (%)	86.12±1.09	87.40	84.12	2.19
12	Brix at 10 months (%)	18.64±0.26	19.17	17.73	2.41
13	Pol in juice at 10 months (%)	16.31±0.31	17.00	15.30	3.31
14	Purity at 10 months (%)	87.50±0.67	89.00	86.17	1.33
15	Extraction at 8 months (%)	53.98±0.34	57.17	51.58	1.08
16	Extraction at 10 months (%)	55.94±0.30	59.00	53.53	0.93
17	Fibre at 8 months (%)	14.51±0.15	15.23	13.33	1.75
18	Fibre at 10 months (%)	12.92±0.14	13.50	12.37	1.92
19	CCS at 8 months (%)	9.82±0.32	10.98	8.45	5.57
20	CCS at 10 months (%)	11.23±0.25	11.80	10.46	3.85
21	Pol In Cane At harvest (%)	13.39±0.25	14.03	12.57	3.28
22	Sugar Yield At harvest (t/ha)	9.27±0.46	11.99	7.83	8.57
23	Cane Yield At harvest (t/ha)	82.51±3.13	101.40	71.18	6.58

Table 4. Genetic parameters for twenty three traits of early maturing sugarcane

Sl. No.	Character	σ^2G	σ^2P	GCV	PCV	h^2 (bs)	GAM
1	Germination % at 45 DAP	3.565	8.10	5.32	8.02	44.00	7.27
2	Number of shoots at 120 DAP (000/ha)	84.616	113.81	9.10	10.56	74.35	16.17
3	Plant height at 150 DAP (cm)	72.053	118.18	8.50	10.89	60.97	13.67
4	Plant height at 240 DAP (cm)	120.950	215.52	6.13	8.18	56.12	9.46
5	Plant height at harvest (cm)	335.080	480.45	7.14	8.55	69.74	12.28
6	Cane diameter at harvest (cm)	0.077	0.08	12.16	12.71	91.43	23.95
7	Single cane weight at harvest (Kg).	0.004	0.01	7.75	8.56	81.86	14.44
8	NMC at harvest (000/ha).	66.705	90.34	8.53	9.93	73.84	15.11
9	Brix at 8 months (%)	0.673	1.13	4.92	6.38	59.35	7.80
10	Pol in juice at 8 months (%)	0.603	1.10	5.40	7.31	54.65	8.23
11	Purity at 8 months (%)	-0.195	3.35	0.51	2.13	-5.81	-0.25
12	Brix at 10 months (%)	0.134	0.34	1.96	3.11	39.81	2.55
13	Pol in juice at 10 months (%)	0.178	0.47	2.59	4.20	37.86	3.28
14	Purity at 10 months (%)	0.365	1.72	0.69	1.50	21.20	0.65
15	Extraction at 8 months (%)	4.781	5.12	4.05	4.19	93.36	8.06
16	Extraction at 10 months (%)	3.555	3.83	3.37	3.50	92.88	6.69
17	Fibre at 8 months (%)	0.235	0.30	3.34	3.77	78.41	6.10
18	Fibre at 10 months (%)	0.103	0.16	2.49	3.14	62.57	4.05
19	CCS at 8 months (%)	0.305	0.60	5.62	7.91	50.46	8.23
20	CCS at 10 months (%)	0.106	0.29	2.90	4.82	36.16	3.59
21	Pol In cane at harvest (%)	0.121	0.31	2.60	4.18	38.51	3.32
22	Sugar yield at harvest (t/ha)	1.016	1.65	10.87	13.84	61.67	17.58
23	Cane yield at harvest (t/ha)	60.283	89.71	9.41	11.48	67.20	15.89

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Estimates of phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean are required to measure amount of variability. These parameters aid in selection for improvement of desired characters. Phenotypic expression is observable and influenced by environment. Phenotypic variability includes both genotypic (heritable) and environmental variation (non-heritable). Analysis of variance (Table 2) revealed highly significant differences for all the fifteen early maturing clones for twenty one traits while it was non-significant for purity percent.

This marked that there is presence of sufficient variability in the genotypes which provides enough scope for selecting superior and desired clone by the plant breeder for further improvement. Doule and Balasundaram (2003) and Singh *et al*. (2010) reported high variability for various characters in sugarcane. To decipher the amount of existing variability in the present clones, range, mean and standard error were calculated (Table 3).

It showed the advisable range of co-efficient of variation for all the traits. From the perusal of the data (Table 4), it is observed that phenotypic variances for all the characters under study are higher than genotypic variances.

This may be due to the non-genetic factor which played an important role in the manifestation of these characters. Comparatively the maximum phenotypic and genotypic variances were exhibited by the traits *viz.* plant height, number of shoots at 120 days, number of millable canes at harvest and cane yield at harvest. These findings were in accordance with some other studies (Pooja *et al.,* 2020, Ravishankar *et al.,* 2004) for cane yield/ plot and number of millable cane/ plot. The numerical value of phenotypic coefficient of variation is higher than their genotypic counterpart indicating that apparent variation is not only due to genotypes but also due to influence of environment. The narrow differences between PCV and GCV were recorded for most of the traits. Moderate GCV and PCV were observed for the characters, namely cane diameter at harvest and sugar yield at harvest was in accordance with finding of (Ahmed and Obeid, 2012) for the girth of cane. The PCV and GCV of remaining traits were comparatively of lower magnitude. Heritability is a good index of the transmission of characters from parents to offspring and it estimates relative amount of heritable part of variability. High broad sense heritability was recorded for the characters *viz.,* number of shoots at 120 DAP, plant height at 150 days and at harvest, cane diameter, single cane weight, number of millable cane at harvest, extraction percent, fibre percent, sugar yield and cane yield at harvest. Out of twenty three characters, only cane diameter at harvest exhibited high genetic advance as per cent of mean similar was reported by (Gowda *et al., 2016)* and (Pooja *et al.* 2020) while number of shoots, plant height at 150 & harvest, single cane weight at harvest, number of millable cane, sugar yield and cane yield at harvest showed moderately genetic advance as per cent of mean.

Experiment results revealed small difference between PCV and GCV for most traits indicating high prospects for genetic enhancement through selection. High heritability associated with high genetic advance as percent of means was found for cane diameter at harvest indicating the preponderance of additive genetic effect in the determining of this character. It also showed that selection of character will be effective for future improvement of clones. However, high heritability with moderate genetic advance as percent of mean was observed in number of shoots at 120 days, plant height at 150 days and plant height at harvest, single cane weight, millable cane at harvest, sugar yield and cane yield at harvest revealed dominant genetic effects in determination of these traits and need careful selection for the desired improvements in traits.

Authors' contribution

Conceptualisation of research work and designing of experiments (SSP, BK); Execution of field/lab experiments and data collection (DNK, PK); Analysis of data and interpretation (MK, PK); Preparation of manuscript (PK).

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