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Genetic variability, heritability and genetic advance of quantitative traits in sugarcane

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Abstract
It is essential to have basic information on the genetic nature of variation of various metric traits in plantation crops for the proper planning of breeding strategies. An experiment was conducted with *15* early maturing sugarcane clones to assess the Genetic variability, heritability and genetic advance.at RPCAU Pusa in spring 2017. The analysis of variance revealed highly significant differences among the clones for twenty two traits and significant for one traits *i.e.* plant height at harvest. Moderate GCV and PCV were observed for the characters *namely* single cane weight at harvest, sugar yield and cane yield at harvest. High heritability with high genetic advance as per cent of mean was found in sugar yield at harvest while high heritability with moderate genetic advance as percent of mean was observed in germination percent, plant height at 240 days, cane diameter at harvest, single cane weight, millable cane at harvest, and cane yield at harvest, indicating the role of dominant genetic effects in determination of these characters and its improvements in early maturing sugarcane clones.

Keywords: Sugarcane, variability, PCV, GCV, heritability, genetic advance

Introduction
The success of a sugarcane (*Saccharum spp.)* breeding program depends on the knowledge of the involved genetic aspects. These depend, partly, on the recognition of several characters considered important in the selection. Information on the genetic variability or heritability of traits being improved is extremely important and of vital importance for the prediction of the progress. Sugarcane is a perennial, tropical; monocotyledonous crop which is cultivated in tropical and sub- tropical region of the world primarily for its ability to store high concentration of sugar in the inter-node and propagate through stem cutting. The cultivated varieties of sugarcane are interspecific hybrids involving at least three species, *S. officinarum, S. barberi and S. spontaneum* which themselves represent complex polyploidy. The chromosome number among varieties varies from 2n = 80 to 120. It is for this reason the sugarcane varieties are botanically described as *Saccharum spp.* complex hybrid. The heterozygous and polyploid nature of this crop has resulted in generation of greater genetic variability. The knowledge of nature and extent of genetic variation available in the germplasm or breeding material helps the breeder for planning sound breeding programmes. Therefore, present investigation was formulated to assess Genetic variability, heritability and genetic advance of quantitative traits in Sugarcane.

Materials and Methods
The experimantal materials were early maturing 15sugarcane clones *namely* CoSe 11451, CoSe 12451**,** CoLk 12207**,** CoLk 12208**,** CoP 11436**,** CoP 11438**,** CoP 12436**,** CoP 12437**,** CoP 13436**,** CoP 13437**,** CoP 16436**,** CoP 16437**,** CoP 16438**,** BO 153**,** CoP 11437 which were planted at Research farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, in a Randomized Block Design with three replications during spring 2017. Observations were record by selecting five random plants per genotype per replication for productive characters *namely*, germination % at 45 DAP, number of shoots at 120 DAP, plant height at 150, 240 and 300 days, cane diameter at harvest, number of millable canes, brix, pol, purity %, 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
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 as described by Spencer and Meade (1955) [22].

Pol in Juice

Pol refers to the sucrose per cent in juice. It was done according to the method described by Spencer and Meade (1955) [22]. 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.

Purity

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

Extraction per cent

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 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.

The data were statistically analyzed. The analysis of variance (ANOVA) was worked out according to the procedure of Randomized Block Design for each character as per methodology advocated by Panse and Sukhatme (1967) [16]. The analysis of variance was used to derive variance components (Cochran and Cox, 1957).

Estimation of genotypic and phenotypic coefficient of variation

The formulae used to calculate PCV and GCV were given by Burton and De vane (1953) [5].

Heritability (Broad Sense)

Heritability in broad sense was estimated by the formula given by Johnson *et al.* (1955) [11]. The heritability was categorized as low, moderate and high as given by Robinson *et al.* (1949) [11].

Genetic Advance

The estimates of genetic advance were obtained by the formula given by Lush (1949), Johnson *et al.* (1955) [11] and Allard (1960). The range of genetic advance is 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.

Results and Discussion

Variability is measured by estimation of genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation (GCV and PCV), heritability, genetic advance and genetic advance as per cent of mean. These parameters help in selection for improvement of desired characters. Environment plays an important role in the expression of phenotype. The phenotypic variability which is observable includes both genotypic (heritable) and environmental variation (non-heritable).

The analysis of variance (Table-1) showed highly significant differences for all the fifteen early maturing clones for twenty two traits while it was significant for plant height at harvest.This indicated that there is presence of sufficient variability in the genotypes which provides ample scope for selecting superior and desire clone by the plant breeder for further improvement. Earlier workers Doule and Balasundaram (2003), Singh *et al*. (2010) [20] reported high variability for different traits in sugarcane. To decipher the amount of existing variability in the present clones, range, mean and standard error were calculated (Table: 2) However, range is the crude method of estimation of variability, which indicates observed phenotypic variability only. It also showed the advisable range of co-efficient of variation for all the traits. From the perusal of the (Table: 3), it is observed that phenotypic variances for all the characters under study are higher than genotypic variances similar result was reported by Verma and Singh (2002). 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, cane yield at harvest, number of millable canes, and number of shoots at 120 days. These findings were in accordance of Ravishankar *et al.* (2004) [19] 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 difference between PCV and GCV were recorded for most of the traits. Moderate GCV and PCV were observed for the characters *namely* single cane weight at harvest, sugar yield and cane yield at harvest. The PCV and GCV of remaining traits were comparatively of lower magnitude. The high heritability in broad sense was recorded for the characters *viz.*, germination percent, and plant height at 240 dayscane diameter, single cane weight, and millable cane at harvest, brix and pol at 10 month, extraction percent, fibre percent, CCS at 10 month, sugar yield and cane yield at harvest. Out of twenty three characters only sugar yield at harvest exhibited high genetic advance as per cent of meanwhile germination percent, plant height at 150 & 240 days, cane diameter at harvest, single cane weight, millable cane at harvest, and cane yield at harvest showed moderately genetic advance as per cent of mean.

In conclusion, High heritability coupled with high genetic advance as percent of means was observed for only in sugar yield at harvest suggesting the preponderance of additive genetic effect in the determination of these characters. It also indicated that selection for these characters will be effective for future improvement of clones. However, high heritability with moderate genetic advance as percent of mean was observed in germination percent, plant height at 240 days, cane diameter at harvest, single cane weight, millable cane at harvest, and cane yield at harvest indicating the role of dominant genetic effects in determination of these characters

and it require careful selection for the desired improvements in the characters.

Table 1: Analysis of variance for twenty three traits of early maturing sugarcane clones

S. No	Character	Mean sum of square		
		Replication (d.f. =2)	Treatment (d.f. =14)	Error (d.f. =28)
1	Germination % at 45 DAP	3.27	29.68 **	5.39
2	Shoots at 120 DAP (000/ha)	6.49	185.55 **	47.54
3	Plant height at 150 DAP (cm)	12.07	272.20 **	57.49
4	Plant height at 240 DAP (cm)	65.11	510.46 **	90.18
5	Plant height at harvest (cm)	161.40	345.71 *	159.93
6	Cane diameter at harvest (cm)	0.006	0.093 **	0.009
7	Single cane weight at harvest (Kg).	0.001	0.024 **	0.002
8	Millable canes at harvest (000/ha).	9.72	222.09 **	34.50
9	Brix at 8 months stage (%)	0.099	2.896 **	0.607
10	Pol in juice at 8 months stage (%)	0.35	2.56 **	0.49
11	Purity at 8 months stage (%)	3.79	2.73 **	2.52
12	Brix at 10 months stage (%)	0.03	2.54 **	0.39
13	Pol in juice at 10 months stage (%)	0.004	2.00 **	0.335
14	Purity at 10 months stage (%)	0.16	1.39 **	1.07
15	Extraction at 8 months stage (%)	1.30	19.64 **	0.61
16	Extraction at 10 months stage (%)	0.48	19.61 **	0.44
17	Fibre at 8 months stage (%)	0.02	0.34 **	0.05
18	Fibre at 10 months stage (%)	0.01	0.44 **	0.03
19	CCS at 8 months stage (%)	0.28	1.33 **	0.26
20	CCS at 10 months stage (%)	0.45	0.98 **	0.15
21	Pol In cane at harvest (%)	0.005	1.53 **	0.228
22	Sugar yield at harvest (t/ha)	0.34	6.34 **	0.62
23	Cane yield at harvest (t/ha)	35.78	291.78 **	40.23

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

Table2: Mean, range and coefficient of variance for twenty three traits of early maturing sugarcane clones

S. No	Character	Mean ± SEM	Range		C.V.
			Max.	Min.	
1	Germination % at 45 DAP	38.93 ±1.34	44.33	35.67	5.96
2	Shoots at 120 DAP (000/ha)	102.31 ±3.98	116.33	86.00	6.74
3	Plant height at 150 DAP (cm)	99.44 ± 4.38	117.13	86.50	7.62
4	Plant height at 240 DAP (cm)	179.93 ± 5.48	197.07	156.87	5.28
5	Plant height at harvest (cm)	274.78 ± 7.30	289.30	257.23	4.60
6	Cane diameter at harvest (cm)	2.55 ± 0.06	3.03	2.37	3.74
7	Single cane weight at harvest (Kg).	0.85 ± 0.02	1.07	0.75	5.00
8	Millable canes at harvest (000/ha).	98.60 ± 3.39	112.78	84.05	5.96
9	Brix at 8 months stage (%)	18.83 ± 0.45	20.33	17.47	4.14
10	Pol in juice at 8 months stage (%)	16.57 ± 0.40	18.08	15.35	4.21
11	Purity at 8 months stage (%)	88.00 ± 0.92	90.13	86.76	1.80
12	Brix at 10 months stage (%)	19.30 ± 0.36	21.07	17.60	3.22
13	Pol in juice at 10 months stage (%)	17.01 ± 0.33	18.40	15.76	3.40
14	Purity at 10 months stage (%)	88.15 ± 0.60	89.66	87.30	1.17
15	Extraction at 8 months stage (%)	53.69 ±0.45	58.60	50.42	1.45
16	Extraction at 10 months stage (%)	56.36 ± 0.38	60.93	52.97	1.18
17	Fibre at 8 months stage (%)	14.93 ± 0.12	15.43	14.33	1.45
18	Fibre at 10 months stage (%)	13.11 ± 0.09	13.80	12.50	1.24
19	CCS at 8 months stage (%)	11.44 ± 0.30	12.54	10.56	4.48
20	CCS at 10 months stage (%)	11.75 ± 0.22	12.65	10.97	3.26
21	Pol In cane at harvest (%)	13.93 ± 0.28	15.18	12.84	3.43
22	Sugar yield at harvest (t/ha)	9.86 ± 0.46	13.27	7.94	8.01
23	Cane yield at harvest (t/ha)	83.75 ± 3.66	104.88	69.91	7.57

Table 3: genetic parameters for twenty three traits of early maturing sugarcane clones

S. No	Characters	σ^2G	σ^2P	GCV	PCV	h^2 (bs)	GA M
1	Germination % at 45 DAP	8.10	13.48	7.31	9.43	60.05	11.67
2	Shoots at 120 DAP (000/ha)	46.00	93.54	6.63	9.45	49.18	9.58
3	Plant height at 150 DAP (cm)	71.57	129.06	8.51	11.42	55.46	13.05
4	Plant height at 240 DAP (cm)	140.09	230.27	6.58	8.43	60.84	10.57
5	Plant height at harvest (cm)	61.93	221.86	2.86	5.42	27.91	3.12
6	Cane diameter at harvest (cm)	0.03	0.04	6.56	7.55	75.51	11.74
7	Single cane weight at harvest (Kg).	0.007	0.009	10.15	11.31	80.44	18.75
8	Millable canes at harvest (000/ha).	62.53	97.03	8.02	9.99	64.44	13.26

9	Brix at 8 months stage (%)	0.76	1.37	4.64	6.22	55.68	7.13
10	Pol in juice at 8 months stage (%)	0.69	1.18	5.02	6.55	58.77	7.93
11	Purity at 8 months stage (%)	0.07	2.59	0.30	1.83	2.67	0.10
12	Brix at 10 months stage (%)	0.72	1.10	4.39	5.45	65.01	7.29
13	Pol in juice at 10 months stage (%)	0.56	0.89	4.38	5.55	62.38	7.13
14	Purity at 10 months stage (%)	0.11	1.18	0.38	1.23	9.32	0.24
15	Extraction at 8 months stage (%)	6.34	6.95	4.69	4.91	91.27	9.23
16	Extraction at 10 months stage (%)	6.39	6.83	4.48	4.64	93.53	8.94
17	Fibre at 8 months stage (%)	0.10	0.15	2.11	2.56	67.97	3.58
18	Fibre at 10 months stage (%)	0.14	0.16	2.83	3.09	83.84	5.34
19	CCS at 8 months stage (%)	0.36	0.62	5.21	6.87	57.54	8.14
20	CCS at 10 months stage (%)	0.28	0.42	4.48	5.54	65.43	7.47
21	Pol In cane at harvest (%)	0.43	0.66	4.73	5.84	65.58	7.89
22	Sugar yield at harvest (t/ha)	1.91	2.53	14.00	16.12	75.35	25.03
23	Cane yield at harvest (t/ha)	83.85	124.08	10.93	13.30	67.58	18.52

GAM – Genetic Advane as percent of mean

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