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Genetic Variability and Heritability Studies Among Early Generation Sugarcane Clones

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Abstract

The aim of the present investigation was to estimate the selection parameters by using 144 C3 generation sugarcane clones along with 5 check varieties. The observations were recorded on thirteen cane yield and juice quality characters. Analysis of variance revealed presence of significant differences among all the clones for all the thirteen characters studied. These results indicated the presence of substantial variability among clones. Moderate to high magnitude of GCV, PCV along with high h^2b and GAM were recorded for germination per cent, number of tillers, number of millable canes, single cane weight, cane yield and CCS yield, indicated wider range of variability in the material and importance of additive gene action in the inheritance of these characters in sugarcane. These characters would lead to a significant improvement in yield in limited selection cycles.

Key words : *Saccharum, genetic variation, heritability, genetic advance.*

Sugarcane is a cross pollinated, monocotyledonous crop of tropical and sub-tropical regions of the world, store sucrose in its stem and grown as an important cash crop. It belongs to the family Poaceae, tribe Andropogoneae, sub tribe Saccaharinineae and genus *Saccharum* (1). Varieties of sugarcane are complex polyploids, have a C4 photosynthesis mechanism with chromosome number varies from 2n = 100 to 120 or more (2). India is the second largest producer of sugarcane in the world after Brazil. Sugarcane belongs to genus *Saccharumof* family Poaceae. *Saccharumspecies* complex is widely cultivated in India after nobalization because of highsucrose content and adaptability to adverse environmental conditions (3, 24). Being a higher biomass producer with well-established farming, harvesting and processing techniques, sugarcane is a leading crop for the production of bioenergy and feedstock for bio-refineries (4). Yield is a complex polygenic characterwhichdependsupon a number of yieldcontributing characters and shows genotype × environment interaction. Direct selection for yield may produce misleading results. Therefore, knowledge ofdifferent genetic variability parameters is essential, much valuable and play important role for selection (5). Genetic variabilityis the tendency of individuals in a population to vary from one another. For a breeder information on the nature and the magnitude of present variability is of prime importance to initiate a breeding programme. Heritability denotes the proportion of phenotypic variance that is due to genotype. The concept of heritability plays a vital role in formulating breeding plans for crop improvement and is useful in predicting the transmission of characters from the parents to their offspring. Genetic advance is also important as it indicates the magnitude of the expected genetic gain from one cycle of selection (6). Therefore, this experiment was conducted for the estimation of genetic variability, heritability and genetic advance by using various cane yield and juice quality parameters.

Materials and Methods

The present experiment was conducted in Augmented Block Design with 144 C3 generation clones of sugarcane with 5 check varieties at Sugarcane Breeding Block, N. E.Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar. Each entry was allotted to a single row plot of 5.0 m long with 0.90 m plot to plot spacing. The observations were recorded on thirteen cane yield and juice quality characters*viz.,* germination percent, number of tillers, number of millable canes, single cane weight, cane height, cane diameter, brix per cent, polarity per cent, sucrose per cent, purity per cent, CCS per cent, cane yield and CCS yield.Statistical analysis includes analysis of variances for augmented block design-II (7). Both genotypic and phenotypic coefficients of variation (GCV and PCV) were calculated for each trait according to the method given by (8).Heritability in broad sense was calculated by using formula given by (9). Genetic advance (GA) for each character was calculated by formulae given by (10).

Results and Discussion

Analysis of variance (Table-1) revealed that significant differences were present among all the clones for all the thirteen characters under study. Highly significant differences were recorded for twelve characters namely cane yield (339.386), number of tillers (266.897), number

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Table-1 : Analysis of variance of augmented block design for thirteen traits in C_3 generation sugarcane clones.

Source of Variation	DF	Germ	NT	NMC	SCW	Ht	Dia
Block	5	46.769*	480.845***	342.409***	0.077**	0.443***	0.087
Entries	148	66.534***	266.897***	185.608***	0.043**	0.113**	0.101*
Checks	4	249.398***	213.991**	143.374**	0.166***	0.462***	0.179**
Varieties	143	51.825**	283.273***	199.184***	0.043**	0.115**	0.098**
Checks vs. Varieties	1	1438.488***	-1863.151	-1586.915	-0.364	-1.509	0.201*
Error	20	15.676	30.881	21.103	0.014	0.048	0.042

Source of Variation	DF	Brix %	Polarity %	Sucrose %	Purity %	CCS %	CY	CCSY
Block	5	6.026***	132.792***	7.163***	239.964***	7.470***	1171.144***	52.900***
Entries	148	1.019***	40.980***	2.182***	29.900**	1.817***	339.386**	13.769**
Checks	4	2.383***	96.300***	4.965***	20.622	3.447***	1199.574***	71.634***
Varieties	143	1.125***	40.799***	2.192***	37.341***	1.910***	357.160**	13.932**
Checks vs. Varieties	1	-19.552	-154.492	-10.380	-997.100	-17.967	-5643.002	-241.108
Error	20	0.158	9.400	0.516	8.549	0.468	106.279	5.148

Note:*=significance at 5%, **=significance at 1%, ***=significance at 0.01%,
(Germ- Germination %, NT-No of tillers (000 /ha), NMC. – Number of Millable Canes (000/ha), SCW- Single cane weight (Kg), Ht – Cane Height (m), Dia – Cane Diameter (cm), CCS- Commercial cane sugar, CY- Cane yield (t/ha), CCSY - C.C.S. yield(t/ha)

of millable canes (185.608), germination per cent (66.534), polarity per cent (40.980), purity per cent (29.900), CCS yield (13.769), sucrose per cent (2.182), CCS per cent (1.817), brix per cent (1.019), cane height (0.113) and single cane weight (0.043), whilecane diameter (0.101) recorded significant difference among the clones.For five standard used, the variances (mean square) were found to be highly significant for twelve characters namely cane yield (1199.574), germination per cent (249.398), number of tillers (213.991), number of millable canes (143.374), polarity per cent (96.300), CCS yield (71.634), sucrose per cent (4.965), CCS per cent (3.447), brix per cent (2.383), cane height (0.462), cane diameter (0.179) and single cane weight (0.166), however for purity per cent (20.622), non-significant difference was observed. Significant differences among clones for most of the characters studied revealed presence of substantial variability indicating that these characters are of very high utility in selection for improvement of these traits through breeding. Earlier workers (6, 11) reported high variability for these characters in sugarcane.

Mean and range : The first step invariability assessment is theestimation ofmean range of present variation. Most of the characters such as germination per cent (39.41, 23.33-56.67), number of tillers (82.71, 51.11-140.00), NMC (64.32, 37.78-106.67), cane height (2.01, 1.20-2.70), cane diameter (2.25, 1.63-3.35), brix per cent (20.81, 17.00-23.50), polarity per cent (80.37, 55.00-92.00), sucrose per cent (19.29, 13.59-21.90), purity per cent (92.74, 66.70-99.56), cane yield (72.66, 34.67-145.78) and CCS yield (14.01, 6.73-25.60) recorded higher mean and wider mean range, respectively, indicatedhigher level of variation present in the population. Higher cane yield could be obtained with more no of millable cane, cane height and single cane weight. In present study a wide mean range was recorded for most of the character, which provide a chance to select best individuals for the concerned character. Higher mean and range for variouscane yield and juice quality characters were also observed by (6, 12).

Genetic variability parameters estimation : Results of variability parameters revealed that phenotypic coefficients of variation were higher than genotypic coefficients of variation for all the characters and the closeness between PCV and GCV values and the lower values of ECV for all characters indicated little influence of the environment. GCV and PCV values werecategorized as low (0-10%), moderate (10- 20%) and high (above 20%) by (13). Higher GCV and PCV values were recorded for no of millable canes (20.00 and 20.41), cane yield (20.11 and 24.61) and CCS yield (20.00 and 25.41). Moderate GCV and PCV were observed for germination percent (14.18 and 17.42) no of tillers (17.69 and 18.92), single cane weight (13.67 and 17.26) and cane height (11.87 and 16.10). Moderate PCV and low GCV were recorded for cane diameter. Low GCV and PCV were observed for brix percent, polarity percent, sucrose percent, purity per cent and CCS per cent. These results indicate the presence of limited genetic variability for these characters. Presence of variability is essential to practice effective selection in desired direction and higher magnitude of GCV and PCV is a good indication of genetic potential of the population.The extent of variability as measured by GCV and PCV, gives information regarding the relative amount of variation in different characters. High GCV and PCV indicated that selection might be

Table-2 : Various selection parameters for different traits in C_3 generation sugarcane clones.

S. No.	Characters	Mean	Range	GCV	ECV	PCV	h^2b	GA	GA % of mean
1.	Germination %	39.41	23.33-56.67	14.18	10.12	17.42	0.66	9.30	23.77
2.	No of tillers (000 /ha)	82.71	51.11-140.00	17.69	6.71	18.92	0.87	28.23	34.08
3.	NMC (000/ha)	64.32	37.78-106.67	19.12	7.14	20.41	0.88	23.76	36.91
4.	Single cane weight (kg)	1.14	0.76-1.80	13.67	10.54	17.26	0.63	0.25	22.31
5.	Cane height (m)	2.01	1.20-2.70	11.87	10.88	16.10	0.54	0.36	18.04
6.	Cane diameter (cm)	2.25	1.63-3.35	9.76	9.10	13.34	0.54	0.33	14.71
7.	Brix %	20.81	17.00-23.50	4.36	1.91	4.76	0.84	1.71	8.23
8.	Polarity %	80.37	55.00-92.00	6.45	3.82	7.49	0.74	9.16	11.42
9.	Sucrose %	19.29	13.59-21.90	6.20	3.73	7.24	0.73	2.11	10.95
10.	Purity %	92.74	66.70-99.56	5.34	3.16	6.21	0.74	8.78	9.48
11.	CCS %	13.64	8.38-15.81	8.14	5.03	9.57	0.72	1.94	14.27
12.	Cane yield	72.66	34.67-145.78	20.11	14.19	24.61	0.67	24.60	33.85
13.	CCS yield	14.01	6.73-25.60	19.55	16.23	25.41	0.59	4.33	31.00

Note : NMC= Number of millable canes, GCV-Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation, GA-Genetic advance

effective on these characters and their phenotypic expression is a good indication of their genotypic potential. These results indicated that these characters exhibited considerable amount of variability among genotypes and improvement in these characters would lead to a significant improvement in yield in limited selection cycles. These results were found similar to the earlier findings of (14). Low GCV and PCV values for brix percent, polarity percent, sucrose percent and purity per cent were also recorded by(4),(6) and also by (15) continuously for three years in their experiment.

Heritability in Broad Sense : It is not possible to determine the amount of heritable variation with the help of genetic coefficient of variation alone (16). Therefore, it should be considered together with heritability estimates to obtain the best picture of the extent of heritable variation. (17) categorized heritability as low (0- 30%), moderate (30-60%) and high (60 and above). High broad sense heritability estimates were recorded for most of the characters*viz.,* number of millable canes (88%), number of tillers (87%), brix per cent (84%), polarity per cent (74%), purity per cent (74%), sucrose percent (73%), CCS percent (72%), cane yield (67%), germination per cent (66%) and single cane weight (63%). Moderate heritability values were observed for CCS yield (59%), cane height (54%)and cane diameter (54%).The heritability estimates provides measures of heritable variation, which plays a vital role in selection for concerned characters. Higher heritability estimates for number of millable canes, number of tillers, single cane weight, sucrose per cent, brix per cent, CCS percent and cane yield was also reported by (14, 18). Higher heritability for brix percent and polarity percent were also recorded by (19).

Genetic advance as percent of mean (GAM) : GAM was categorized by (10) as low (0-10%), moderate (10-20%) and high (20 and above). Higher values of GAM were recorded for number of millable canes (36.91%), number of tillers (34.08%), cane yield (33.85%), CCS yield (31.00%), germination per cent (23.77%) and single cane weight (22.31%). Moderate GAM was observed for cane height, cane diameter, CCS percent, polarity percent and sucrose percent. The heritability estimates are more useful when expressed in terms of genetic advance. High heritability with high GAM were reported for germination per cent, number of tillers, number of millable canes, single cane weight, cane yield and CCS yield. It indicated that most likely the additive gene effects govern these characters and selection for these characters will be effective for improvement in successive generations. As heritability in broad sense is high it also indicated that the environmental effects least influence these characters.

Moderate to high magnitude of GCV, PCV along with high h^2b and GAM were recorded for germination per cent, number of tillers, number of millable canes, single cane weight, cane yield and CCS yield, indicates wider range of variability in the material and importance of additive gene action in the inheritance of these characters in sugarcane. These characters could be improved through simple selection. High GCV, PCV, heritability and genetic advance were also obtained by (20) working with exotic sugarcane genotypes. Similar results were also reported by (21)and (22) for cane yield, CCS yield and germination percent. Preponderance of additive gene action for number of millable canes was also reported earlier by (23).

A critical perusal of PCV and GCV indicated that, PCV estimates were higher than GCV for all the characters and the closeness between GCV and PCV values for almost all the characters indicated that the environment less influences these characters. Moderate

to high magnitude of GCV, PCV along with high h^2b and GAM were recorded for germination per cent, number of tillers, number of millable canes, single cane weight, cane yield and CCS yield, indicated wider range of variability in the material and importance of additive gene action in the inheritance of these characters in sugarcane. Therefore these characters could be improved through simple selection. These results indicated that these characters exhibited considerable amount of variability among genotypes and improvement in these characters would lead to a significant improvement in yield in limited selection cycles.

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