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Study of Genetic Variability and Heritability in Sugarcane (*Saccharum* spp. Complex)

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A B S T R A C T

Thirty sugarcane genotypes were evaluated for cane yield, sugar yield and related morphological characters. Genotypes significantly differed for all the 16 characters indicating sufficient variability in the experimental material. The characters germination % at 45 days followed by tillers at 120 days and shoots at 240 days showed high GCV and PCV. High estimates of heritability along with high genetic advance (% of mean) were observed for tillers at 120 days (000/ha) followed by germination % at 45 days, shoots at 240 days (000/ha), NMC at harvest (000/ha), and internodes/stalk at 360 days. Therefore, selection will be effective for these characters.

Introduction

Sugarcane (*Saccharum* spp. hybrids) is an important agro industrial crop and knowledge of heritability of agronomic traits is important in breeding program worldwide. The genetic variability present in the sugarcane cultivars, cultivated by the producers, has hybrid origin, generally. The *Saccharum officinarum* has been contributing for genetic variability in sugarcane more than *S. spontaneum*, *S. sinense* and *S. barberi*. In the genetic breeding program of sugarcane the main goal is to obtain new cultivars with more productivity and best industrial characteristics. Nowadays the plant breeding has been based on a common genetic base obtained by the pioneer ones from the beginning of the century, through inter crosses and retro crosses of *S. officinarum*. Sugarcane varieties in commercial cultivation are complex polyploid. The heterozygous and polyploidy natures of this crop have resulted in generation of greater genetic variability. The information on the nature and the magnitude of variability present in the genetic material is of prime importance for a breeder to initiate any effective selection program. Also genetic advance are very essential to improve any trait of sugarcane because this would help in knowing whether or not the desired objective can be achieved from the material (Tyagi and Singh, 1998).

Hence, the objective of present study was carried out to describe the nature and extent

of genetic variability, heritability and genetic advance between yield and related traits for the studied genotypes.

Materials and Methods

The experimental material consisted of 30 genotypes of sugarcane obtained from the germplasm maintained at Main Sugarcane Research Station, Navsari Agricultural University, Navsari and grown during 2010-11 in Randomized Block Design (RBD) with three replications. The gross plot size for each genotype was consisted of five rows each of six meter length with row to row spacing of 90 cm and the net plot was consisted of middle 3 rows each of 5 meter length with row to row spacing of 90 cm (excluding 0.5 m ring line at both ends of the plot). The two budded setts of sugarcane were planted in rows keeping 12 buds per meter row length. The crop was raised under irrigated conditions following all the recommended package of practices and 50 % recommended dose of NPK fertilizer i.e. 125 kg N + 62.5 kg P_2O_5 + 62.5 kg K_2O per ha + Acetobacter @ 2.5 lit/ha. The observations were recorded on yield components and quality traits *viz*., germination % at 45 days, tillers at 120 days (000/ha), shoots at 240 days (000/ha), stalk height at 360 days (cm), stalk diameter at 360 days (cm), internodes/stalk at 360 days, stalk weight at 360 days (kg), number of millable canes/ha (NMC) at 360 days (000/ha), cane yield at harvest (t/ha), juice brix % at 360 days, sucrose % juice at 360 days, juice purity % at 360 days, CCS % at 360 days, Fibre % cane at 360 days, pol % cane at 360 days and sugar yield at 360 days (t/ha). The analysis of variance was carried out following the procedure of Panse and Sukhatme (1978). The genotypic and phenotypic variations, phenotypic and genotypic coefficient of variability, heritability in broad sense and genetic advance as per cent of mean were determined as per the standard procedure.

Results and Discussion

The analysis of variance indicating the genotypic differences were highly significant for all the characters indicating considerable amount of genetic variability among the genotypes tested in the present study (Table 1). This indicated an ample scope of exploitation of the characters under study. Similar results were reported by Kumar *et al.*, (2004), Patel *et al.,* (2006), Rahman *et al.*, (2008), Rahman and Bhuiyan (2009), Anbanandan and Saravanan (2010) and Tyagi *et al.,* (2011).

The wide range of genotypic and phenotypic variation was observed for tillers at 120 days (510.41 and 627.75) followed by stalk height at 360 days (395.06 and 725.15) and shoots at 240 days (382.97 and 532.63). The low estimates of σ^2g and σ^2p were exhibited by internodes per stalk at 360 days (3.16 and 4.82), juice purity % (1.74 and 3.62), CCS t/ha (1.62 and 2.94) and rest of the traits. Similar findings were reported by Hapase and Hapase (1990) and Verma *et al.,* (1999) and Khan *et al.,* (1991) found variability of higher magnitude for number of shoots per plot, NMC and cane yield. Also Rahman *et al.*, (2008), Kumar *et al.,* (2010), Anbanandan and Saravanan (2010) and Pawar *et al.*, (2011) found similar results for most of the cane yield and its contributing traits.

The characters, *viz*., NMC at harvest (80.05 and 112.76), cane yield (64.44 and 109.79) and germination % at 45 days (52.66 and 69.98) had moderate values of σ^2g and σ^2p variance. Such type of results was reported by Doule and Balasundaram (1997), Kadian *et al.,* (1997), Verma *et al.,* (1999) and Rahman and Bhuiyan (2009). A perusal of the estimates of environmental component of variance in relation to their genotypic counterpart revealed that the estimates of σ^2g were higher than σ^2e for most of the

characters. The higher magnitude of genotypic variance suggested little influence of environments in the expression of genetic variability.

The estimates of genotypic and phenotypic coefficient of variation were high for shoots at 240 days (13.68 and 16.14) followed by germination % at 45 days (12.90 and 14.87) and tillers at 120 days (12.66 and 14.05). The moderate values of genotypic and phenotypic coefficient of variation were recorded by the characters NMC at harvest (7.89 and 9.37), stalk height at 360 days (7.76 and 10.52), internodes/stalk at 360 days (7.63 and 9.44), cane yield (6.76 and 8.83), stalk weight at 360 days (6.49 and 8.54) and stalk diameter at 360 days (5.67 and 7.64).

The lowest values of genotypic and phenotypic coefficient of variation were reported for juice purity % (1.42 and 2.06) and other quality parameters. Hapase and Hapase (1990) obtained highest GCV and PCV for germination per cent, total and millable height of cane, moderate for number of internodes and low for brix per cent and purity per cent. Also similar results were found by Doule and Balasundaram (1997) and Hapase and Repale (2004).

Table.1 Analysis of variance showing mean square for sixteen characters in sugarcane

Source	d.f.	Germination % at 45 days	Tillers at 120 days (000/ha)	Shoots at 240 days (000/ha)	Stalk height (cm) at 360 days	Stalk diameter (cm) at 360 days	Internodes /stalk at 360 days
Replication	2	19.798	18.908	0.321	66.811	0.0002	0.784
Genotype	29	175.318**	1648.577**	1298.588**	1515.27**	0.0746**	11.149**
Error	58	17.312	117.338	149.652	330.086	0.0159	1.666
S.Em +		2.402	6.254	7.062	10.489	0.072	0.745
C.V. %		7.39	6.07	8.55	7.10	5.11	5.54

Source	d.f.	Stalk weight (kg) at 360 days	NMC at harvest (000/ha)	Cane yield (t/ha)	Juice brix % at 360 days	Sucrose % juice at 360 days
Replication	2	0.007	1.905	8.358	0.591	1.228
Genotype	29	0.019**	272.861**	238.684**	2.273**	1.834**
Error	58	0.003	32.71	45.349	0.478	0.512
S.Em +		0.035	3.302	3.888	0.399	0.413
C.V. %		5.38	5.04	5.67	3.19	3.57

Source	d.f.	Juice purity % at 360 days	CCS %	Fibre % cane	Pol % cane	CCS (t/ha)
Replication	2	4.895	0.848	0.065	0.621	0.422
Genotype	29	7.119**	0.996**	0.449**	0.995**	6.185**
Error	58	1.881	0.306	0.159	0.282	1.327
S.Em +		0.791	0.319	0.230	0.307	0.665
C.V. %		1.48	3.90	2.66	3.53	6.85

Table.2 General mean, phenotypic range, variance components, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (% of mean) of sugarcane genotypes

Characters/ Parameters	General Mean	Range (Phenotypic)	Genotypic variance	Phenotypic variance	Environmental variance	GCV (%)	PCV (%)	H^2 (b) (%)	G.A. as % of mean
Germination % at 45 days	56.27	44.52-72.87	52.66	69.98	17.31	12.90	14.87	75.30	23.05
Tillers at 120 days (000/ha)	178.35	139.60-227.25	510.41	627.75	117.33	12.66	14.05	81.30	23.53
Shoots at 240 days (000/ha)	143.03	112.05-211.89	382.97	532.63	149.65	13.68	16.14	71.90	23.90
Stalk height (cm) at 360 days	255.88	209.33-297.00	395.06	725.15	330.08	7.76	10.52	54.50	11.81
Stalk diameter (cm) at 360 days	2.47	2.11-2.75	0.02	0.035	0.016	5.67	7.64	55.20	8.68
Internodes /stalk at 360 days	23.29	19.65-26.49	3.16	4.82	1.66	7.63	9.44	65.50	12.73
Stalk weight (kg) at 360 days	1.10	0.96-1.30	0.0005	0.009	0.004	6.49	8.54	57.90	10.19
NMC at harvest (000/ha)	113.38	101.67-142.88	80.05	112.76	32.71	7.89	9.37	71.00	13.70
Cane yield (t/ha)	118.72	100.59-131.82	64.44	109.79	43.35	6.76	8.83	58.70	10.67
Juice brix % at 360 days	21.65	20.08-23.41	0.59	1.07	0.47	3.57	4.79	55.50	5.49
Sucrose % juice at 360 days	20.04	17.92-21.44	0.44	0.95	0.51	3.31	4.87	46.30	4.64
Juice purity % at 360 days	92.52	89.23-95.67	1.74	3.62	1.88	1.42	2.06	48.10	2.04
CCS %	14.15	12.45-15.08	0.23	0.53	0.30	3.38	5.17	42.90	4.57
Fibre % cane	14.98	14.03-15.58	0.09	0.25	0.15	2.07	3.38	37.80	2.63
Pol % cane	15.03	13.61-16.17	0.23	0.52	0.28	3.24	4.80	45.60	4.51
CCS (t/ha)	16.80	13.61-19.87	1.62	2.94	1.32	7.57	10.22	55.00	11.57

In present study, the highest heritability estimate (81.30%) was obtained for tillers at 120 days followed by germination % at 45 days (75.30 %), shoots at 240 days (71.90 %), NMC at harvest (71.00%) and internodes/stalk at 360 days (65.50%). Low heritability was observed for fibre % cane (37.80%) followed by CCS % at harvest (42.90%). Heritability for rest of the characters was recorded moderate to low. Genetic advance as per cent of mean was recorded as high as 23.90 for shoots at 240 days followed by tillers at 120 days (23.53), germination % at 45 days (23.05), NMC at harvest (13.70), internodes/stalk at 360 days (12.73), stalk height at 360 days (11.81) and CCS (t/ha) (11.57); whereas, for rest of the characters genetic advance was moderate to low (Table 2).

Shift in the gene frequency towards superior side under selection pressure is termed as genetic advance and is generally expressed as percentage of mean (genetic gain). Johnson *et al.,* (1955) found it more useful to estimate heritability values together with genetic advance in predicting the ultimate choice of the best genotypes by selection. However, high genetic gain along with high heritability showed most effective condition for selection.

High heritability coupled with high genetic advance was observed for the characters tillers at 120 days (000/ha) followed by germination % at 45 days, shoots at 240 days (000/ha), NMC at harvest (000/ha) and internodes/stalk at 360 days. This indicated that these characters are governed by additive gene action and selection for these characters will be useful in choice of best genotype. Hapse and Repale (2004) reported high heritability coupled with high genetic advance for number of tillers at 120 days, germination percentage, total height and millable height of cane. Kumar *et al.*, (2004) observed same trend for number of tillers at 240 days, cane height and number of internodes/stalk. Similar results were obtained by Rahman *et al.,* (2008), Rahman and Bhuiyan (2009), Kumar *et al.,* (2010) and Pawar *et al.,* (2011) for the traits like stalk height and other yield contributing characters.

From the above results and discussion it can be concluded that high heritability coupled with high genetic advance was observed for the characters tillers at 120 days (000/ha) followed by germination % at 45 days, shoots at 240 days (000/ha), NMC at harvest (000/ha) and internodes/stalk at 360 days. This indicated that these characters are governed by additive gene action and selection for these characters will be useful in choice of best genotype.

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