Genetic Variability and Heritability in Sugarcane

Rewati R Chaudhary

Sugarcane Research Programme, Nepal Agricultural Research Council, Jitpur, Bara

Abstract

Thirty-two genotypes were evaluated in a replicated trial at Sugarcane Research Program, Jitpur, Bara, Nepal in 2000-2001 to estimate phenotypic and genotypic coefficients of variation, heritability and genetic advance for seven stalk characters in sugarcane (*Saccharum officinarum* L). Analysis of variance revealed highly significant differences between genotypes for all the characters studied. Genotypic variance was higher than environmental one for cane yield, millable cane number, single cane weight, stalk diameter and stalk length. A single cane weight, germination at 45 days after planting and millable cane number had high genotypic and phenotypic coefficients of variation. High heritability estimates were recorded for millable cane number, stalk diameter and single cane weight. Maximum genetic gain as percent of mean was observed for single cane weight and millable cane number.

Key words: Genetic advance, genetic variability, heritability, sugarcane

Introduction

Sugarcane varieties in commercial cultivation are complex polyploid. The heterozygous and polyploid nature 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. Genotypic and phenotypic coefficients of variation along with heritability as well as 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). The present study was, therefore carried out to know the nature and extent of genetic variability, heritability and genetic advance in some important traits of sugarcane.

Materials and Methods

The experimental material for the present study consisted of 32 genotypes of sugarcane including four standard checks viz. BO 99, BO 102, BO 91 and CoS 767 representing early, mid and late maturing groups (Annex 1). Sugarcane was planted in ring method with three replications at the farm of Sugarcane Research Program, Jitpur, Bara, Nepal during Feb 2000. The crop received 150 kg N, 60 kg P_2O_5 and 40 kg K_20 ha^{-1}. All agronomical practices were adopted during the entire crop season. Data were recorded on germination percentage at 45 days after planting (DAP), millable cane number, stalk diameter, stalk length, single cane weight, sucrose content and cane yield (Annex 1).

Analysis of variance was used for calculating genotypic, phenotypic and environmental characters. The broad sense heritability was estimated according to the method suggested by Johnson et al. (1955) and the expected genetic advance was calculated by the method given by Robinson et al. (1949).

Results and Discussion

The analysis of variance for all the characters showed that genotypes included in the test differed significantly ($p \leq 0.01$) with respect to all characters studied (Table 1). This indicates that there was significant amount of phenotypic variability and all the genotypes differed each other with regard to the characters that opened a way to proceed for further improvement through simple selection (Punia, 1982).

Table 1. Analysis of variance for seven stalk characters in 32 sugarcane genotypes grown at the farm of Sugarcane Research Program, Jitpur, Nepal during 2000/2001

Source	df	Cane yield	Millable cane number	Single cane weight	Stalk diameter	Stalk length	Germination at 45 DAP†	Sucrose
Replications	2	19.84	16.86	0.0017	0.0108	436.02	7.868	0.811
Genotypes	31	219.04**	2817.45**	0.094**	0.025**	1918.8**	160.96**	20.087**
Error	62	33.58	117.3	0.005	0.0092	215.95	75.39	8.334

** Significant at 1% level; † DAP, Days after planting.

Mean values for cane yield varied between 30.8 t ha^{-1} in clone Co 94024 and 86.67 t ha^{-1} in clone CoSe 95422 (Annex 1). Millable cane varied from 73000 in clone BO 99 to 158000 in clone CoSe 95422. Single cane weight varied from 0.35 kg in clone Co 94024 to 0.64 kg in clone CoB 94162. The clone Co92031 was the tallest (221 cm), while the clone Co 94023 was the shortest (133 cm) in stalk length. Likewise sucrose content varied from 17.56% in the clone CoP 92181 and 21.4% in the clone CoB 94162 (Annex 1).

Genotypic and phenotypic coefficients of variation

After partitioning phenotypic variance, it was found that genotypic variance was higher than the environmental one for five characters studied (Table 2). The magnitude of variance was the highest in millable cane (σ^2_g = 900.05, σ^2_e = 117.3) followed by stalk length (σ^2_g = 567.61, σ^2_e = 215.95). These results indicate that a negligible role was played by the environmental factors in the inheritance of these characters in sugarcane. The high genotypic variance for millable cane was reported also by other researchers (Balasundarum and Bhagyalakshmi, 1978; Nair et al., 1980).

Table 2. Components of variances, coefficients of variation, heritability, genetic advance for seven stalk characters in sugarcane genotypes grown at Jitpur, Nepal in 2000/2001

Component†	Cane yield	Millable cane	Single cane weight	Stalk diameter	Germ 45 DAP‡	Stalk length	Sucrose
PCV, %	19.4	29.18	41.52	14.64	32.56	15.48	18.33
GCV, %	15.63	27.44	38.01	13.54	21.86	13.17	10.37
σ^2_p	95.4	1017.35	0.0346	0.062	137.24	783.56	12.25
σ^2_g	61.82	900.05	0.029	0.053	61.85	567.61	3.92
σ^2_e	33.58	117.3	0.005	0.009	85.39	215.95	8.334
H, %	65	88	84	85	45	72	32
GAdv, %	25.98	52.9	70.0	25.58	30.19	38.15	12.08

† PCV, Phenotypic coefficient of variation; GCV, Genotypic coefficient of variation; σ^2_p, Phenotypic variance; σ^2_g, Genotypic variance; σ^2_e, Environment variance; H, Heritability percentage; GAdv, Genetic advance.
‡ Germ 45 DAP, Germination at 45 days after planting.

The estimates for phenotypic coefficient of variation (PCV) were higher than for genotypic coefficient of variation (GCV) in all the traits, indicating greater influence of environment on genetic variation. The highest phenotypic and genotypic coefficient of variation were observed for single cane weight (PCV = 41.52%, GCV = 38.01%) followed by germination at 45 DAP (PCV = 32.56%, GCV = 21.86%) and millable cane number (PCV = 29.18% and GCV = 27.44%). High genotypic and phenotypic coefficients of variation for a single cane weight and millable cane number were reported earlier by Singh and Sangwan (1980).

Heritability

Genotypic coefficient of variation is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. In the present experiment, high heritability estimates were recorded for millable cane number (88%), stalk diameter (85%) and a single cane weight (84%). This suggests that simple selection for these traits would be effective. It is

reported that a high heritability estimate for single cane weight (Nair et al., 1980; Singh et al., 1994). Moderate values for heritability estimates were found in stalk length (72%) and cane yield (65%), whereas, low heritability estimates were observed in germination at 45 days after planting (45%) and sucrose percent (32%). Similar results were obtained by Sahi et al. (1977) for juice quality characters. Selections might be considerably difficult or virtually impractical for a character with low heritability (less than 0.4) due to the masking effect of environment on genotypic effects (Singh, 1993).

Genetic advance

Heritability estimates along with expected genetic gain is more useful than the heritability value alone in predicting the resultant effect for selecting the best genotypes (Johnson et al., 1955). Maximum genetic gain (as percent of mean) was observed for a single cane weight (70%) followed by millable cane number (52.9%) indicating that there exists a scope to improve cane yield to a considerable extent by adopting suitable breeding procedures. High genetic advance (as percent of mean) for single cane weight was also reported by Sahi et al. (1977), Tyagi and Singh (1998). Stalk diameter had high heritability with moderate genetic advance. Pandey (1989) had earlier reported the low genetic advance with moderate to high amount of heritability for stalk diameter suggesting a little scope in the improvement of this character.

The results suggest that selection should be practiced on the basis of single cane weight and millable cane number for higher cane yield. Improvement in these traits would lead to a significant improvement in yield in limited selection cycles.

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Annex 1. Sugarcane yield and its attributes as affected by different genotypes

SN	Genotype	Cane yield, t ha^{-1}	Single cane weight, kg	Stalk length, cm	Stalk diameter, cm	Germination at 45 DAP†, %	Millable cane number, '000 ha^{-1}	Sucrose, %
1	Co 92030	50.72	0.41	174	1.95	34.6	129	19.50
2	Co 92031	36.50	0.40	221	1.81	23.5	85	19.14
3	Co 94022	42.35	0.39	163	1.72	40.8	117	19.40
4	Co 94023	34.45	0.37	133	1.63	41.4	89	18.72
5	Co 94024	30.83	0.35	189	1.87	25.6	97	18.93
6	CoP 92181	50.21	0.43	186	1.78	35.4	117	17.46
7	BO 130	63.56	0.58	197	1.85	46.7	113	19.83
8	CoB 94161	40.78	0.46	185	1.75	34.8	116	19.50
9	CoB 94162	55.49	0.64	192	1.86	35.7	83	21.41
10	CoSe 95421	51.26	0.36	198	1.48	49.2	137	18.98
11	CoSe 95422	86.67	0.51	204	1.83	46.4	158	18.50
12	CoSe 91232	53.30	0.53	169	1.74	34.4	89	19.50
13	CoSe 96234	59.65	0.54	167	1.67	36.8	109	18.75
14	BO 131	63.20	0.53	175	1.69	31.1	111	19.40
15	BO 132	55.15	0.48	194	1.62	32.4	103	18.01
16	CoSe 95435	62.30	0.55	179	1.71	31.3	101	17.90
17	CoP 92184	53.82	0.52	178	1.73	33.2	105	19.20
18	CoP 92186	40.05	0.44	166	1.64	42.3	93	19.15
19	CoSe 92429	42.36	0.46	157	1.84	48.1	94	19.46
20	CoSe 92423	75.53	0.61	209	2.02	36.3	108	18.98
21	CoSe 92430	68.34	0.59	195	1.85	31.2	95	18.51
22	CoSe 92437	44.80	0.42	167	1.77	41.9	90	18.70
23	CoSe 92440	48.68	0.54	178	1.78	38.4	95	19.04
24	CoSe 92032	39.40	0.53	164	1.89	43.4	84	18.64
25	CoP 95181	51.12	0.55	215	1.79	29.7	93	17.85
26	CoP 95182	50.14	0.51	214	1.76	27.5	104	17.90
27	CoSe 93234	52.50	0.53	205	1.75	33.6	106	19.13
28	BO 99	53.45	0.36	165	1.64	35.3	73	17.84
29	BO 102	55.15	0.41	176	1.63	40.5	127	17.60
30	CoS 687	38.39	0.38	168	1.70	31.1	99	18.67
31	BO 91	55.68	0.46	204	1.88	43.2	113	19.71
32	CoS 767	36.67	0.47	213	1.70	32.5	78	17.78