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Research Article

GENETIC VARIABILITY OF TRAITS FOR SUGARCANE (*SACCHARUM* SPP) GENOTYPES AT METAHARA SUGAR ESTATE

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Abstract

This study was done with the objective of evaluating eleven newly introduced sugarcane genotypes from CIRAD in France along with three standard checks to investigate the genetic and phenotypic variability among traits under heavy, medium and light soil types of Metahra Sugar Estate. The trail was laid out in randomized complete block design with three replications. Data were collected for cane sprouting, tillering, height, girth, number of millable cane, cane yield, sugar percent cane and sugar yield. The results showed that the differences between PCV and GCV were small under the three soil types for most of the traits which indicated a high contribution of genotypic factor to the phenotypic performance and a low influence of the environment on these traits, suggesting higher gains from selection.

Keywords: Sugarcane, Genotypes, Soil Types, PCV, GCV

Introduction

Assessment of genetic and phenotypic variability is a basic step in any crop improvement program. The amount of variation present in any population is measured and expressed in terms of variance which has both genetic and environmental components. Phenotypic variation is therefore the result of genotypic variation and environmental deviation (Falconer and Mackay, 1996). Yield being a complex character influenced by a number of yield contributing characters controlled by poly genes and also influenced by environment (Aravind *et. al.*, 2006). Its value therefore differs under different environmental conditions. An important objective is to assess the relative importance of genotype versus environment variation. Phenotypic variability is defined as the observable variation present in a character in a population while genotypic variability is the heritable component of phenotypic variation resulting from the genotypic differences among individuals within a population (Acquaah, 2007). Genotypic variability is of prior importance for crop improvement program (Singh, 2007).

Therefore this study was initiated to study the nature and extent of genetic variability among some important traits of the introduced sugarcane genotypes.

Materials and Methods

The experiment was conducted at Metahara sugar estate. Metahara sugar estate is located in the Upper Awash Plain (UAP) in the Oromia Regional State. It is located at about 206 km East of Addis Abeba, 8° N latitude and 39° 52' E longitude with an elevation of 950 m asl. Metahara receives about 554 mm annual average rainfall with mean maximum and mean minimum temperature of 32.8°C and 17.5°C, respectively.
Eleven newly introduced sugarcane genotypes from CIRAD designated as CP 96 1252, CP 00 2180, CP 04 1935, CPCL 02-926, VMC 96-61, VMC 96-89, VMC 96-120, FG 06-622, FG 04-356, MPT 96-273 and MPT 97-203 were evaluated along with standard checks NCO 334, B 52- 298 and Mex 54/245 on three major soils (light, medium and heavy soil) of the sugar estate. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Field managements were as per the plantation practices. Data were collected for cane sprouting, tillering, height, girth, number of millable cane, cane yield, sugar percent cane and sugar yield. The data analyses were as per the following.

Table 1 Analysis of variance at individual location

Source of variation	Degree of freedom	Mean square	Expected mean square
Replication	r-1	Msr	$\sigma^2 e + g\sigma^2 r$
Genotypes	g-1	Msg	$\sigma^2 e + r\sigma^2 g$
Error	(r-1)(g-1)	Mse	$\sigma^2 e$

Where r=number of replications, g=number of genotypes Msr= mean square due to replications, Msg= mean square due to genotypes; Mse =mean square of error; $\sigma^2 g$, $\sigma^2 r$ and $\sigma^2 e$ are variances due to genotype, replication and error

The phenotypic and genotypic variances of each trait were estimated from the CRBD analysis of variance. The expected mean squares under the assumption of random effects model was computed from linear combinations of the mean squares and the phenotypic and genotypic coefficient of variations were computed as per Burton and Devane (1953).

Genotypic variance ($\sigma^2 g$) = (Msg – Mse)/r; Where Environmental variance ($\sigma^2 e$) = Mse and Msg and Mse are the mean sum of squares for the genotypes and error in the analysis of variance, respectively r is the number of replications.

The phenotypic variance was estimated as the sum of the genotypic and environmental variances.

Phenotypic variance ($\sigma^2 ph$) = $\sigma^2 g + \sigma^2 e$

The genotypic and phenotypic coefficients of variability were calculated according to the formulae of Singh and Chaundary (1977).

Genotypic Coefficient of Variation (GCV) = (σg/grand mean) * 100

Phenotypic Coefficient of Variation (PCV) = (σph / grand mean) * 100

Results and Discussion

The analysis of variances for characters confirmed the existence of highly significant variability among studied genotypes for sprouting, number of tillers, number of millable stalk, plant height, recoverable sucrose and sugar yield ($p \leq 0.05$). This indicates that there was significant amount of phenotypic variability and all the genotypes differed from each other with regard to the characters that opened a way to proceed for further improvement through simple selection (Punia, 1982) and possibly characters lead to design better sugar cane improvement breeding programs. Rewati RChaudhary (2001) and Feyissa T. and Zinaw D. (2014) also reported similar results for traits such as millable cane number, cane height, cane yield and sucrose %.

Variability under Heavy Soil

Under heavy soil the genotypic variance were higher than the corresponding environmental variance for sprouting, number of tillers, number of millable stalks and recoverable sucrose percentage signifying the existence of sufficient genetic variability among the studied genotypes for these traits. The genotypic variance were however lower than environmental variance for cane height, stalk girth, cane yield and sugar yield indicating a low genetic diversity for these traits and a greater influence of the environment on the phenotypic performance of these traits.

The relatively smaller difference between PCV and GCV for the traits sprouting, tillering, number of millable stalks and stalk girth indicates a high contribution of genotypic factor to the phenotypic performance and a low influence of the environment on these traits, suggesting higher gains from selection of these characters while the relatively large difference between PVC and GVC for the trait height, cane yield, recoverable sucrose and sugar yield suggests a high influence of the environment on their expression (Table 2).

Table 2 Variability and heritability for the 14 sugarcane genotypes grown under heavy soil

Variability	Mean	σ^2g	σ^2E	σ^2p	PCV	GVC	H^2b	GA	GAM
Sprouting	69.32	183.55	30.29	213.84	21.09	19.55	0.86	25.85	37.29
Tillering	239.43	1547.38	650.38	2197.76	19.58	16.43	0.70	67.99	28.40
M. stalk	109.48	306.34	104.00	410.34	18.51	15.98	0.75	31.16	28.46
Plant height	280.69	369.21	1198.81	1568.02	14.11	6.84	0.24	19.21	6.84
Stalk girth	26.52	2.10	5.17	7.27	10.17	5.46	0.29	1.60	6.04
Cane yield	215.74	569.25	986.36	1555.61	18.28	11.06	0.37	29.73	13.78
R.S. % cane	9.06	2.37	2.80	5.18	25.11	16.98	0.46	2.15	23.70
Sugar yield	19.61	10.86	27.05	37.91	31.41	16.81	0.29	3.63	18.53

Phenotypic (σ2p), genotypic (σ2g), and environmental variance (σ2E); phenotypic (PCV) and genotypic (GCV) coefficients of variations, broad sense heritability (H2), genetic advance (GA), genetic advance as percentage of means (GAM) and number of millable stalk (M. stalk).

As stated by Shivasubramanian and Menon (1973) the PCV and GCV values are ranked as low, medium and high with 0 to 10%, 10 to 20% and > 20% respectively. Medium GCV were recorded for sprouting, number of tillers, number of millable stalks, cane yield, recoverable sucrose and sugar yield and low GCV were recorded for plant height and stalk girth. High PCV were also recorded for sprouting percentage and recoverable sucrose and moderate PCV were recorded for number of tillers, number of millable stalks, plant height, stalk girth, cane yield and sugar yield (Table 2). High PCV and GCV indicates that selection may be effective based on these characters and their phenotypic expression would be good indication of the genotypic potential (Singh *et al.*, 1994).

Heritability values are categorized as low (0-30%), moderate (30-60%) and high (60% and above) as stated by Robinson *et al.*, (1949). Accordingly the high heritability estimates for the trait sprouting, number of tillers and number of millable stalks indicates a greater contribution of the genotype to the trait expression. Estimated heritability of cane yield and recoverable sucrose were medium while, it is low for plant height, stalk girth and sugar yield (Table 2). Thus simple selection for the traits with high heritability breeding program as they are highly heritable from parents to progenies, and therefore, selection can be done to improve those traits (for higher gains from selection). However, selections might be considerably difficult for a character with low heritability (less than 0.4) due to the masking effect of environment on genotype effects (Singh, 1993).

According to Johnson *et al.* (1955), genetic advance as percent of mean (GAM) was categorized as high (>20%), moderate (10-20%) and low (0-10). In this study, under heavy soil, high GAM was obtained from the traits sprouting, number of tillers, number of millable stalks and recoverable sucrose percentage. GAM was moderate for cane yield and sugar yield; while plant height and stalk girth had low GAM (Table 2).

Variability under Medium Soil

Under medium soil types, genotypic variance was greater than the corresponding environmental variance for the traits sprouting, tillering, number

would be effective method of sugarcane variety

of millable stalks, plant height, stalk girth, cane yield, recoverable sucrose percent and sugar yield (Table 3) indicating the existence of genetic variability for these traits.

The relatively smaller difference between PCV and GCV for the traits plant height and stalk girth indicates a high contribution of genotypic factor to the phenotypic performance and a low influence of the environment on these traits, suggesting higher gains from selection while the relatively large difference between PVC and GVC for the trait sprouting, number of tillers, number of millable stalks, cane yield, recoverable sucrose and sugar yield suggests a high influence of the environment on their expression (Table 3).

High GCV were recorded for the characters number of tillers, number of millable stalks, cane yield and sugar yield; medium GCV for sprouting, plant height and recoverable sucrose; while stalk girth had low GCV. The value of PCV were high for germination percentage, number of tillers, number of millable stalks, plant height and cane yield; medium for recoverable sucrose; and, low for stalk girth.

Table 3 Variability and heritability for 14 sugarcane genotypes grown under medium soil

Variability	Mean	σ2g	σ2E	σ2p	PCV	GVC	H^2 b	GA	GAM
Sprouting	64.88	101.58	80.96	182.54	20.82	15.54	0.56	15.49	23.87
Tillering	174.12	2426.69	1097.99	3524.68	34.1	28.29	0.69	84.2	48.36
M. stalk	68.56	489.65	124.01	613.66	36.13	32.28	0.8	40.71	59.39
Plant height	159.81	950.87	134.26	1085.13	20.61	19.3	0.88	59.46	37.21
Stalk girth	27.707	4.75	1.475	6.23	9.01	7.86	0.76	3.92	14.16
Cane yield	86.7391	744.75	105.99	850.74	33.63	31.46	0.88	52.6	60.64
Sucrose %	10.632	1.62	0.7395	2.36	14.45	11.97	0.69	2.17	20.43
Sugar yield	9.2	8.98	2.079	11.06	36.15	32.58	0.81	5.56	60.47

Phenotypic (σ2p), genotypic (σ2g), and environmental variance (σ2E); phenotypic (PCV) and genotypic (GCV) coefficients of variations, broad sense heritability (H2), genetic advance (GA) and genetic advance as percentage of means (GAM)

The high heritability estimates for the trait number of tillers, number of millable stalks, plant height, stalk girth, cane yield, recoverable sucrose and sugar yield indicate a greater contribution of the genotype to the trait expression and therefore selection can be done to improve those traits (higher gains from selection). On contrary, sprouting had moderate heritability estimates.

High genetic advance as percentage mean was obtained from the traits sprouting, number of tillers and millable stalks, plant height, cane yield, recoverable sucrose and sugar yield. GAM was moderate for stalk girth (Table 3).

Variability under Light Soil

Under light soil types, genotypic variance was greater than the corresponding environmental variance for the traits sprouting, number of tillers, number of millable stalks, stalk girth, cane yield, recoverable sucrose and sugar yield (Table 4) revealing the existence of genetic variability for these traits. However, higher contributions of the environment to the phenotypic performance and low genetic variability were observed for plant height and purity percentage more evidenced by the higher environmental variance than genotypic variance for these traits (Table 4).

The relatively smaller difference between PCV and GCV for the traits sprouting and stalk girth indicates a high contribution of genotypic factor to the phenotypic performance and a low influence of the environment on these traits, suggesting higher gains from selection while the relatively large difference between PVC and GVC for the trait number of tillers, number of millable stalk, plant height, cane yield, recoverable sucrose and sugar yield suggests a high influence of the environment on their expression. High GCV were recorded for the trait sprouting, number of tillers, number of millable cane, cane yield and sugar yield; medium GCV were obtained for the traits plant height, stalk girth and recoverable sucrose. However, high PCV were recorded for the characters sprouting, number of tillers and millable stalks, plant height, cane yield and sugar yield (Table 4).

Table 4 Variability and heritability for 14 sugarcane genotypes grown under light soil

Variability	Mean	$\sigma 2g$	$\sigma 2E$	$\sigma 2p$	PCV	GVC	H^2 b	GA	GAM
Sprouting	57.48	276.26	42.78	319.04	31.07	28.91	0.87	31.86	55.42
Tillering	51.81	207.32	53.98	261.30	31.19	27.79	0.79	26.41	50.98
M. stalk	46.61	193.72	59.23	252.95	34.11	29.86	0.77	25.08	53.82
Plant height	120.71	238.32	455.66	693.98	21.82	12.79	0.34	18.63	15.44
Stalk girth	26.80	7.84	3.66	11.50	12.65	10.45	0.68	4.76	17.76
Cane yield	48.60	154.05	34.92	188.97	28.29	25.54	0.82	23.08	47.50
Sucrose %	10.54	1.32	1.16	2.48	14.94	10.90	0.53	1.73	16.39
Sugar yield	5.10	1.58	0.56	2.14	28.70	24.66	0.74	2.23	43.66

Phenotypic ($\sigma 2p$), genotypic ($\sigma 2g$), and environmental variance ($\sigma 2E$); phenotypic (PCV) and genotypic (GCV) coefficients of variations, broad sense heritability (H2), genetic advance (GA) and genetic advance as percentage of means (GAM)

The high heritability estimates for the trait sprouting, number of tillers, millable stalks, stalk girth, cane yield and sugar yield indicate a greater contribution of the genotype to the trait expression and therefore selection can be done to improve those traits (higher gains from selection). On the other hand, the trait plant height had medium heritability. High GAM was obtained from the traits sprouting, number of tillers, millable stalks, cane yield and sugar yield. GAM was moderate for plant height, stalk girth and recoverable sucrose (Table 4).

Higher genotypic variance has also been reported by Feyissa *et al.,* (2014) for sprouting, tillering, number of millable stalks, and stalk girth at heavy and light soils. The higher genotypic variance further confirms the existence of genetic variability for the traits indicating the possibility of high gains from selection. Higher environmental variance has also been reported by Feyissa *et al.,* (2014) and Chaudhary (2001) for plant height and sucrose percentage. Johnson *et al.* (1955) elucidated further that heritability along with genetic advances is usually more useful than heritability alone in predicting the resultant effect of selecting the best individuals.

Conclusion

Under the three soil type's estimates of genotypic variance were higher than the corresponding environmental variance for sprouting, number of tillers, millable stalks and recoverable sucrose percentage signifying the existence of sufficient genetic variability among the studied genotypes for these traits. The genotypic variance were however lower than the corresponding environmental variance for cane height under heavy and light soil indicating a low genetic diversity for these traits and a greater influence of the environment on the phenotypic performance of these traits. The relatively smaller difference between PCV and GCV for the traits plant height and stalk girth were recorded under three soil types indicated that a high contribution of genotypic factor to the phenotypic performance and a low influence of the environment on these traits, suggesting higher gains from selection of these characters while the relatively large difference between PVC and GVC for the characters sprouting, number of tillers, millable stalks, cane yield, sugar yield and recoverable sucrose percent suggests a high influence of the environment on their expression. The differences between PCV and GCV were small under all soil types for most of the traits. The relatively smaller difference between PCV and GCV for most traits indicates a high contribution of genotypic variance to the phenotypic variance, suggesting higher gains from selection. The high values of heritability and GAM for traits such as number of tillers and millable stalks under three soil types; sprouting under heavy and light soils and sugar and cane yield under medium and light soils may suggests the predominance of additive gene action indicating that these traits could be transmitted to the progeny and phenotypic selection based on these traits would be effective for the improvement of sugarcane genotypes performance.

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