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Research Article

Genetic Variability, Heritability and Character Association of Twelve Sugar Cane Varieties in Finchaa Sugar Estate West Wolega Zone Oromia Region of Ethiopia

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Abstract

Field experiment was conducted to estimate variability, heritability, and character associations for twelve sugarcane genotypes for sprouting percentage, number of tiller and millable cane, internode length and cane height, cane yield, sugar percent cane, and sugar yield using completely randomized block design on luvisol types at Finchaa Sugar Estate of Ethiopia. The result indicated medium GCV and PCV for millable cane (15.32 and 17.30), cane yield (13.22 and 17.59) and low GCV and Medium PCV for sugar yield (8.73 and 15.05) while; low GCV for number of inter node (2.64), cane diameter (6.28) and sucrose % (8.19). 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 the expressed phenotype of the traits. However, the high GCV and PCV indicated that selection could be effective based on these characters and their phenotypic expression would be good indication of the genotypic potential. Moreover, high heritability were recorded for characters such as cane yield (64.85) and millable cane (78.46); moderate heritability for interned length (56.28), plant height (46.50), stalk diameter (58.96) and sugar yield (33.65), while low heritability were recorded for number of internodes (13.26). This confirms for traits that expressed high to medium heritability, simple selection would be effective method of sugar cane variety selection since these traits are highly heritable from parents to progenies. On the other hand, analysis of character association showed that cane yield was positively and highly ($P<0.01$) significantly correlated with single cane height ($r = 0.50^{**}$) and millable cane number ($r = 0.57^{**}$) while positively and significantly correlated with inter node length, and cane diameter ($r = 0.31^{*}$) and number of internode ($r = 0.27^{*}$). Further, length of internode had positive significant correlation with plant height and sucrose %. However, on contrary, millable cane number was negatively and highly significantly correlated with sucrose % ($r = -0.43^{**}$) and single cane weight ($r = -0.26^{*}$). Negative correlation indicated their inverse relationship with each other. Therefore, more emphasis should be given on number of millable cane, cane height and those traits positively correlated with them, while compromising for traits negatively correlated with them during phenotypic selection for developing high yielding genotypes of sugarcane.

Keywords: Luvisol, Heritability, Association and Finchaa

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* (Matsuoka *et al.,* 1999). In the genetic breeding program of sugarcane the main goal is to obtain new cultivars with more productivity and best industrial characteristics (Bicudo, 1987). 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* (Matsuoka *et al*., 1999). 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. 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).

Yield in sugarcane is dependent on a number of factors. Agronomist and breeders have adopted yield component studies through correlation and path coefficient analysis, as a crop improvement strategy. The concept of correlation is used to explore and reveal the relationship between yield and its components. It has also proved valuable in determining the association of quantitative attributes with yield for selecting characters that influence the yield. Several studies, Mohammadi *et al.*, (2003), have been carried out to assess the relationship between different crop characters. Yield is a complex quantitative character so as knowledge of interrelationships between yield and its contributing components will improve the efficiency of breeding programs through the use of appropriate selection indices (Mohammadi *et al.*, 2003).

Hence, the objective of present study was carried out to describe the nature and extent of genetic variability, heritability, correlation between yield and related traits for the studied genotypes.

Materials and Methods

Study areas

The experiment was conducted at Finchaa sugarcane plantation of Ethiopia; located at 9º 30' to 10º 00' N, and 37º 30' E; elevated 1600 m.a.s.l, and receives long years average min/max temperature ranges of 15to 31 Cº.

Treatments and experimental design

Twelve sugarcane varieties introduced from Cuba and designated by C86-12, C90-501, C86-165, C132-81, C120-78, C1051-73, B78-505, B80-250, SP70-1284, NCO334, B52-298 and C86-56 were evaluated at Finchaa sugarcane plantation. The trial was laid out in completely randomized block design with three replications in luvisol. Each experimental plot composed of 6 rows of 5m length. The spacing was 1.45m for furrows, 1.5m between adjacent plots, 2m between replications, and 3 meters from the border crop. Equal number of two budded sett of each variety was planted.

Data collected and analysis

Data were collected from the four central rows of each plot for sprouting percentage, number of tiller and millable cane, internode length and cane height, cane yield, sugar percent cane, and sugar yield. All the data were subjected to statistical analysis using Mini Tab 11.12 computer software.

For the sake of convenience especially to estimate heritability and genetic advance, data were analyzed as per RCBD (Cochran and Cox, 1957). Mean comparisons among treatment means were conducted by the least significant difference (LSD) test at 5% levels of significance. The analysis of variance was used to derive variance components (Cochran and Cox, 1957).

RCBD ANOVA was computed using the following model:

$$Yij = \mu + rj + gi + \varepsilon ij$$

Where, Yij = the response of trait Y in the ith genotype and the jth replication
μ = the grand mean of trait Y
rj = the effect of the jth replication
gi = the effect of the ith genotype
εij = experimental error effect

Estimation of phenotypic and genotypic variances
The phenotypic and genotypic variances of each trait were estimated from the RCBD 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 the methods suggested by Burton and Devane (1953).

Genotypic variance ($\sigma^2 g$) =

$$\frac{Msg - Mse}{r}$$

Environmental variance ($\sigma^2 e$) = Mse
Where;

Msg and Mse are the mean sum of squares for the genotypes and error in the analysis of variance, respectively, and r is the number of replications.
The phenotypic variance was estimated as the sum of the genotypic and environmental variances.

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

Estimation of genotypic and phenotypic coefficient of variability

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

Table 1. ANOVA

Source of variation	Df	Mean square	Expected mean square
Replication	r-1	Ms_r	$\sigma^2 e + g\sigma^2 r$
Genotypes	g-1	Ms_g	$\sigma^2 e + r\sigma^2 g$
Error	(r-1)(g-1)	Ms_e	$\sigma^2 e$

Where, r = number of replications; Msr = mean square due to replications; g = number of genotypes; 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

Coefficient of correlation

Estimation of genotypic and phenotypic correlation coefficients were done based on the Procedure of Dabholkar (1992):

Genotypic correlation coefficient (rg) = COVg (xy)/σg (x) * σg (y)

Phenotypic correlation coefficient (rph) = COVph (xy) /σph (x) * σph (y)

where: COVg (xy) and COVph (xy) are the genotypic and phenotypic covariances of two variables (X and Y), respectively; σg (x) and σg (y) are the genotypic standard deviations for variables, X and Y, respectively; and, σph (x) and σph (y) are the phenotypic standard deviations of variables, X and Y, respectively.

The calculated phenotypic correlation value was tested for its significance using t-test:

t = rph/SE (rph)

where: rph = Phenotypic correlation; and,
SE (rph) = Standard error of phenotypic correlation was obtained using the following formula (Sharma, 1998),

SE (rph) = $\sqrt{(1-r^2 ph)/(n-2)}$

Where: n is the number of genotypes tested, rph is phenotypic correlation coefficient.

The coefficients of correlations at genotypic levels were tested for their significance by the formula described by Robertson (1959) as indicated below:
t = rgxy/Sergxy

The calculated "t" value was compared with the tabulated "t" value at (n-2) degree of freedom at 5% level of significance; where, n is number of genotypes.

Results and Discussion

Variances

The analysis of variances for characters confirmed the existence of highly significant variability among studied genotypes for INL, PH, SD, mc, chm and scs at p 0.01 level and significant variability were also resulted for shm at p 0.05 significance level (Table 2). 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). Rewati R Chaudhary (2001) reported similar results for characteristics such as Millable Cane number, Single stock weight, Cane height and Sucrose %. These result point to that there are wider variations among the studied genotypes possibly characters lead to design better sugar cane improvement breeding programs.

Genotypic and phenotypic coefficients of variation

After separating components of variance, genotypic and phenotypic variance were computed and results indicated that medium GCV and PCV were recorded for Millable cane (15.32 and 17.30), Cane Yield (13.22 and 17.59) and low GCV and Medium PCV were recorded for Sugar Yield (8.73 and 15.05) while; number of inter node (2.64), cane diameter (6.28) and sucrose % (8.19) resulted in low GCV (Table 3). Results of current study are not similar to Feyissa et al (2014), Balasundarum and Bhagyalakshmi, (1978); Nair et al., (1980) high genotypic coefficient of variation for millable cane were reported; this report is against to Singh and Sangwan (1980) reported before High genotypic and phenotypic coefficients of variation for a cane weight and millable cane number. 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. 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. High GCV and PCV indicated 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

Phenotypic and Genotypic coefficient of variation alone is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. There fore heritability of traits should also in composed in setting better plan breeding strategy. As indicated in <u>table three</u> High heritability were recorded for characters such as cane yield (64.85) and millable cane (78.46); moderate heritability for interned length (56.28), plant height (46.50), stalk diameter (58.96) and sugar yield (33.65), while low heritability were recorded for number of internodes (13.26) (table 3). Heritability values are categorized as low (0- 30%), moderate (30-60%) and high (60% and above) as stated by Robinson et al., (1949).

Similar to present study high heritability estimates results were reported in Rewati R Chaudhary (2001) for millable cane number (88%) and cane weight (84%), Nair et al., (1980) and Singh et al., (1994) reported similar results for mentioned characters. This indicates that simple selection for these traits would be effective method of sugar cane variety selection since these traits are highly heritable from parents to progenies. 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).

Correlation

The pair wise simple correlation coefficient (r) among various characters is presented in Table 4. Cane yield was positively and highly ($P<0.01$) significantly correlated with single cane height ($r = 0.50^{**}$) and millable cane number ($r = 0.57^{**}$) while positively and significantly correlated with inter node length. There was also positive significant correlation of cane yield with cane diameter ($r = 0.31^{*}$) and number of internode ($r = 0.27^{*}$). A positive value of r shows that the changes of two variables are in the same direction, ie high values of one variable are associated with high values of other and vice versa.

A positive and highly significant correlation between cane yield and its components cane height, stalk length and millable cane number was reported by Brown et al (1969), Balasundarum and Bhagyalakshmi (1978) and Punia et al (1983). Hooda et al (1979) also observed cane diameter having significant positive correlation with cane yield. Length of internode had positive significant correlation with cane yield, plant height and sucrose %. Millable cane number was negatively and highly significantly correlated with sucrose % ($r = -0.43^{**}$) and single cane weight ($r = -0.26^{*}$) (table 4). Balasundarum and Bhagyalakshmi (1978) also reported similar results. Negative correlation indicated their inverse relationship with each other.

Table 2. ANOVA of eight for twelve studied genotypes

Source	**Df**	**NI**	**INL**	**PH**	**SD**	**mc**	**chm**	**scs**	**shm**
Replication	2	1.69	1.13	465.7	8.817	27.8	1.99	0.02	0.05
Genotypes	11	2.87	3.59**	1163.2**	10.791**	1256.9**	14.34**	3.52**	0.12*
Error	22	1.97	0.74	322.4	2.032	105.4	2.93	0.54	0.05

** Significant at 1% level, * Significant at 5% level

Where: Df=degree of freedom, NI= number of Internodes, INL= Internodes' length (cm), PH=Plant height(cm), SD=Stalk diameter(cm), mc= millable cane (000/ha), chm= cane yield /ha/month, scs= Sucrose % and shm= Sugar yield/ha/month

Table 3. Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), Broad sense heritability (h_b^2) for twelve studied genotypes

Parameters	NI	INL	PH	SD	mc	chm	scs	shm
σ2g	0.30	0.95	280.27	2.92	383.83	3.80	0.99	0.02
σ2ph	2.27	1.69	602.67	4.95	489.23	6.73	1.53	0.07
σph	1.51	1.30	24.55	2.23	22.12	2.59	1.24	0.27
σg	0.55	0.98	16.74	1.71	19.59	1.95	1.00	0.16
GCV	2.64	8.23	6.83	6.28	15.32	13.22	8.19	8.73
PCV	7.25	10.97	10.01	8.18	17.30	17.59	10.17	15.05
h_b^2	13.26	56.28	46.50	58.96	78.46	56.49	64.85	33.65
G. mean	20.78	11.85	245.24	27.22	127.85	14.75	12.16	1.78

Where: Where: σ2g = genotypic variance, σ2ph= phenotypic variance, σph= phenotypic standard deviation, σg= genotypic standard deviation, GCV=genotypic coefficient of variation, PCV= coefficient of variation, and h_b^2= broad sense heritability

Table 4. Phenotypic Correlation between characters of studied genotypes
Correlations (Pearson)

	NI	**INL**	**PH**	**SD**	**cm**	**chm**	**scs**
INL	-0.48**						
PH	0.20	0.76**					
SD	0.16	-0.23	-0.12				
tm	-0.01	0.16	0.15	-0.55**			
chm	0.21	0.32*	0.50**	0.06	0.57**		
scs	-0.13	0.03	-0.04	-0.03	-0.43**	-0.50**	
shm	0.17	0.35*	0.52**	0.04**	0.33*	0.74*	0.18**

Where: Df=degree of freedom, NI= number of Internodes, INL= Internodes' length(cm), PH=Plant height(cm), SD=Stalk diameter(cm), cm= millebel cane (000/ha), chm= cane yield /ha/month, scs= Sucrose % and shm= Sugar yield/ha/month

Conclusion

The result for sprouting percentage, number of tiller and millable cane, internode length and cane height, cane yield, sugar percent cane, and sugar yield gave medium GCV and PCV for millable cane, cane yield and low GCV and Medium PCV for sugar yield while; low GCV for number of inter node, cane diameter and sucrose %. 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 the expressed phenotype of the traits. However, the high GCV and PCV indicated that selection could be effective based on these characters and their phenotypic expression would be good indication of the genotypic potential.

Moreover, high heritability were recorded for characters such as cane yield and millable cane; moderate heritability for internode length, plant height, stalk diameter and sugar yield, while low for number of internodes. This confirms for traits that expressed high to medium heritability, simple selection would be effective method of sugar cane variety selection since these traits are highly heritable. On the other hand, character association showed cane yield was positively and highly significantly correlated with single cane height and millable cane number while positively and significantly correlated with inter node length, and cane diameter and number of internode. Further, length of internode had positive significant correlation with plant height and sucrose %. However, on contrary, millable cane number was negatively and highly significantly correlated with sucrose % and single cane weight. Negative correlation indicated their inverse relationship with each other.

Therefore, more emphasis should be given on number of millable cane, cane height and those traits positively correlated with them, while compromising for traits negatively correlated with them during phenotypic selection for developing high yielding genotypes of sugarcane.

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