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DIVERGENCE ANALYSIS AND ASSOCIATION OF SOME ECONOMICAL CHARACTERS OF SUGARCANE (*SACCHARUM OFFICINARUM* L.)

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A B S T R A C T

The experiment was carried out in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad to examine the genetic variability and contribution of some morphological characters for cane yield and sucrose %age. Eleven varieties of sugarcane (*Saccharum officinarum* L.) were evaluated for correlation, metroglyph analysis and divergence analysis. Data on various economic important traits like plant height, cane height, number of tillers /plant, number of leaves/plant, leaf area, cane diameter, cane weight, dry matter contents, juice contents, sucrose value and brix value was recorded. The results pertaining to analysis of variance elucidated highly significant differences among the accessions for all the traits except number of leaves/plant and considerable range of variability. Correlations among various traits were computed and found that association of brix value with cane diameter, leaf area**,** dry matter contents and sucrose value was positive and significant at genotypic level and positive but highly significant at phenotypic level. Correlation of brix value with number of leaves, cane weight and beggas weight was positive but significant at genotypic and non- significant at phenotypic level. Metroglyph analysis showed that eight clusters had been made with different index scores. Divergence analysis showed that genetic dissimilarity was highest between No.46 and SPF-232 and was lowest among SPSG-26 and COJ-84. Brix value had the highest contribution to genetic divergence followed by cane height and cane weight due to genetic dissimilarity among the genotypes for these traits. The cane diameter and sucrose value had no contribution to the total genetic divergence due to genetic similarity among the genotypes.

Keywords: Metroglyph, Brix value, Genetic divergence.

INTRODUCTION:

Sugarcane is an important food crop of the tropics and subtropics that is cultivated in about 74 countries, encompassing approximately half the globe (FAO, 1998). It is an important cash crop of Pakistan, mainly grown for sugar and sugar-related production i.e. like sugar, chipboard and paper. Its share in value added of agriculture and GDP are 3.4 and 0.7%, respectively. In Pakistan, sugarcane is grown on 1.099 million ha with average cane yield of 47.32 t ha^{-1} having sugar recovery of 8.74% as compared to world average of 63.7 tones per hectare with sugar recovery as of 10.6%. Pakistan occupies an important position in cane producing countries of the world and ranks at the fifth position in cane acreage and 15th position in sugar production that indicated low sucrose recovery (Anonymous, 2010).

Sugarcane is the raw material for the sugar industry. Cane juice is used in the manufacture of gur, shaker, sugar and cane tops are used as fodder. The by- product of the sugar industry is beggas, molasses, filter-cake and wax etc. Sugarcane ratoons have an additional advantage of better juice quality and sugar recovery in comparison to plant crop of same variety under similar conditions. In Punjab about 50 percent of sugarcane acreage comes under ratoon crop. The percentage of sucrose varies from 8-16% depending of the variety of cane, its maturity, condition of soil, climate and agricultural practices followed by the growers.

Considerable difficulties have been encountered in the improvement of sugarcane through hybridization due to narrow base of variation available. Thus progress in breeding of sugarcane, a highly polyploidy with chromosome number in somatic cells, (2n) ranging

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from 80-124 in cultivated and 48-150 in wild types (Garcia *et al*., 2006). In sugarcane frequently aneuploid is impeded by its narrow gene pool, complex genome, poor fertility, caused by genetic recombination as well as long breeding selection cycle.

The study of correlations provide the informations that how strongly traits are genetically associated with one another. Thus through the estimates of genotypic and phenotypic correlations among yield components and as a result it paved the basis for selection of superior genotypes from the diverse breeding populations. Therefore, the present study was undertaken to find sugarcane genetic variability, character association and contribution of yield and quality contributing characters on yield and quality and thereby to establish appropriate plant attributes for selection to improve the yield and quality status of sugarcane varieties in Pakistan.

Metroglyph analysis (Anderson's Metroglyph) is a simple technique and is used for preliminary grouping of accessions. With the help of this technique, one can easily predict genotypes which have high index scores and fell into different clusters can be crossed to have maximum variability of good combinations of characters.

Divergence analysis is a powerful tool in quantifying the degree of divergence at genotypic level. It quantifies the degree of divergence based on phenotypic observations in different crops. These studies have shown that accessions from the same geographical region may differ genetically as well as phenotypically and also in adaptability. In the present study, Divergence analysis was used to determine the genetic diversity among eleven sugarcane clones existing in Pakistan.

MATERIALS AND METHODS:

The present study was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the crop season of September 2010-11. Eleven accessions of sugarcane viz. COJ-84, COJ-64, Katha, SPF-232, CPF-235, SPSG-26, CP 43-33, CP-72-2086, BF-162, No.64, and No.46 were sown in a randomized complete block design with three replications. Plant to plant and row to row distances were maintained 30 cm and 75 cm respectively. All the recommended agronomic practices were followed for growing the crop. At maturity, ten guarded cane were selected randomly for quantitative parameters study. The data were recorded for twelve characters. plant height (cm), cane height (cm), number of tillers /plant, number of leaves/plant, leaf area (cm^2), cane diameter (cm), cane weight (g), juice contents (g),beggas weight (g), dry matter contents (g), brix value (%) and sucrose value (%).

Ten-guarded stools were selected and from each guarded stool, one tiller was selected randomly and height was measured from ground level to top of the cane with the help of meter rod in cm. Cane height was measured from bottom to the tip of cane after removing top of cane, by using of meter rod in centimeter. Ten-guarded stools from each replication were selected randomly and all the tillers from selected guarded stool and number of leaves were counted. The length of the leaf is measured in cm with the help of meter rod. Then width of the leaf was measured with meter rod at three points i.e. near the tip, middle and base of the leaf. The value of the leaf length was multiplied with mean of the leaf width and these values were multiplied by correction factor 0.77 to have area value. After removing top and leaves, weight of ten canes was measured by electric balance. The thickness of cane was measured in centimeter at three different places i.e., from top, middle and base of the cane with the help of Vernier Calliper. Ten selected plants from each experimental unit were crushed in an electric powered cane crusher for juice extraction. After juice extraction, the beggas obtained from 10 tillers of ten randomly selected guarded stools per replication was weighed collectively. The beggas weighed above was subjected to dryness in direct sunlight for a period of 45 days. From extracted juice, brix value (%) was recorded by "Hand Refractometer" standardized at 20 C^0. Sucrose content was determined by "polari meter" and further sugar analysis was done.

Statistical Analysis:

Genotypic and phenotypic correlation coefficients among the characters under study were estimated according to the statistical techniques outlined by Kown and Torrie (1964). Genotypic and phenotypic correlations among various attributes were computed according to Steel *et al.*1997.

Divergence analysis was also performed according to using pivotal elements to conduct the analysis of dispersion according to Wilk's criterion (Singh and Chaudhary, 1985).

Genetic divergence was estimated by Mahalanobis D^2 statistic. The genotypes were grouped on the basis of minimum generalized distance using Toucher's method

described by Rao (1952). Mahalanobis D^2 statistic is defined as:

$D^2 = b_1d_1 + b_2 d_2 + \text{----} + b_p d_p$

Here, the b_1 values are to be estimated such that the ratio of variance between the populations to the variance within the population is maximized. In terms of variances and covariance, the D^2 value is obtained as follows:

$D^2 = W_{ij} (X_i^1 - X_i^2) (X_j^1 - X_j^2)$

Where, W_{ij} is the inverse of estimated variances covariance matrix. After calculating the D^2 values test of significance was performed. The D^2 value obtained from pair of population was taken as calculated value of chi-square and was tested against tabulated value for all characters at 5% and 1% level of significance. Contribution of each individual character towards divergence was calculated by ranking each character on the basis $d_i = Y_i - Y_i$ values. Rank one was given to highest mean difference and rank P was given to lowest mean difference. These genotypes were grouped into various clusters. Metroglyph analysis was performed. Andersons (1957) is a simple technique and is used for preliminary grouping of accessions Clusters will be made by using Toucher's method (Rao, 1952).

RESULTS AND DISCUSSION:

The results pertaining to analysis of variance elucidated highly significant differences among the accessions for all the traits except number of leaves/plant and considerable range of variability. Association of brix value with cane diameter, leaf area**,** dry matter contents and sucrose value was positive and significant at genotypic level and positive but highly significant at phenotypic level**.** Correlation of brix value with number of leaves/plant, cane weight and beggas weight was positive and significant at genotypic and positive but non-significant at phenotypic level. Number of tillers /plant was associated positively and significantly with brix value at both genotypic and phenotypic level. Nosheen and Ashraf (2003) found that brix value showed positive and significant genotypic correlation with sucrose contents.

Table-1: Correlation of cane weight with number of leaves/plant, juice contents**,** beggas weight and dry matter contents was positive and significant at genotypic level and positive but highly significant at phenotypic level. Correlation of cane weight with cane height, leaf area, brix value, sucrose value and cane height were positive but significant at genotypic and non-significant at phenotypic level. Plant height and cane weight were positively and significantly associated with each other at both genotypic and phenotypic levels. Tyagi and Singh (2000) also showed that cane weight had a significant and positive association with cane diameter, cane height and number of leaves/plant.

The association of juice contents with plant height, cane weight, beggas weight and dry matter contents was positive and significant at genotypic level and positive but highly significant at phenotypic level. Association of juice contents with number of tillers, number of leaves/plant, brix value and sucrose value were positive and significant at genotypic and phenotypic level (Table-1). Cane height and juice contents were positively and significantly associated with each other at both genotypic and phenotypic levels. Singh *et al.* (2000) reported that juice contents are positively correlated with cane weight and cane height.

Correlation of sucrose value with number of tillers/plant, leaf area and brix value was positive and significant at genotypic level and positive but highly significant at phenotypic level. It was also found that correlation of sucrose value with cane weight, juice contents and beggas weight was positive and significant at genotypic and positive but non- significant at phenotypic level. Association of sucrose value with cane diameter was positive and non-significant at genotypic and positive but highly significant at phenotypic level. Plant height and cane height were negatively and non-significantly associated with value sucrose (Table-1). Das et al. (1996) showed opposite results that sucrose value in juice was significantly correlated with cane height.

Table-2: Eight clusters were obtained by Anderson's Metroglyph analysis. Cluster I had genotypes COJ-84, SPSG-26 and CP 43-33 with maximum index score 84. Cluster number II had genotypes COJ-64 and CP-72-2086 with index score 54.

Table 2: Cluster Number, index scores and sugarcane genotypes included in each cluster following Metroglyph technique.

Cluster No.	Genotype	Cluster Index
I	2,4,8	84
II	3,9	54
III	6	24
IV	5	23
V	1	18
VI	10	18
VII	11	16
VIII	7	14

Table 1: Genotypic and Phenotypic correlation Coefficient among Characters studied of Sugarcane genotypes

	Plant Height	Cane Height	No. of Tillers/ plant	No. of Leaves/ plant	Leaf Area	Cane Diameter	Cane Weight	Juice Contents	Beggas Weight	Dry Matter	Brix Value	Sucrose Value
Plant height	1.00 1.00	0.9279* 0.8251**	-0.3401 -0.2547	0.2186* 0.1610	-0.2366 -0.2229	0.4866* 0.4089*	0.4350* 0.4141*	0.5405* 0.5034**	0.3834* 0.3604*	0.4294* 0.4028*	-0.2575 0.2350	-0.3207 -0.2880
Cane Height		1.00 1.00	-0.2561 -0.2345	0.3419* 0.2226	0.1308* 0.1261	0.5266* 0.5029**	0.3191* 0.3122	0.3977* 0.3926*	0.1127* 0.1060	0.1327* 0.1279	-0.1066 -0.1041	-0.1349 -0.1290
No. of tillers/plant			1.00 1.00	-0.4856 -0.3670*	-0.2944 -0.2667	0.1345 0.1263	0.2619* 0.2472	0.2245* 0.1999	0.2328* 0.2122	0.3480* 0.3241	0.4742* 0.4373*	0.7149* 0.6475**
No. of Leaves/plant				1.00 1.00	0.8724* 0.6915**	0.3062 0.1846	0.7454* 0.5685**	0.3059* 0.2106	0.6191* 0.4755**	0.3867* 0.2908	0.3643* 0.2939	0.2884 0.2211
Leaf Area					1.00 1.00	0.3247* 0.3087	0.2154* 0.2131	-0.0552 -0.0537	0.0524* 0.0516	-0.0092 -0.0061	0.5760* 0.5727**	0.4573* 0.4467**
Cane Diameter						1.00 1.00	0.3667* 0.3368	-0.0339 -0.0176	0.4445* 0.4026*	0.5351* 0.4989**	0.5089* 0.4681**	0.5463 0.4742**
Cane Weight							1.00 1.00	0.7404* 0.7355**	0.8924* 0.8879**	0.8343* 0.8322**	0.3387* 0.3382	0.3304* 0.3250
Juice Contents								1.00 1.00	0.4513* 0.4475**	0.5672* 0.5648**	0.1366* 0.1342	0.0420* 0.0408
Beggas Weight									1.00 1.00	0.9031* 0.8992**	0.2462* 0.2449	0.2491* 0.2453
Dry Matter Contents										1.00 1.00	0.4538* 0.4518**	0.3587* 0.3514*
Brix Value											1.00 1.00	0.9110* 0.8951**
Sucrose Value												1.00 1.00

Table:3 D^2 values in matrix.

Parents genotypes	No.46	SPSG-26	COJ-64	COJ-84	CPF-235	SPF-232	Katha	CP 43.33	CP72.2086	BF-162	No.64
No.46	0	91.39781	97.04916	84.05939	90.58946	135.2062	15.84334	87.55795	61.08629	34.59515	41.27371
SPSG-26		0	13.37479	1.616407	11.74681	52.59915	64.53286	5.897924	11.51647	21.34111	27.81639
COJ-64			0	16.19953	42.04256	80.10522	82.94622	19.88456	18.10543	36.95778	52.95808
COJ-84				0	7.12653	44.90502	53.22111	4.486858	9.912558	17.05519	19.8802
CPF-235					0	38.91466	47.64429	16.73048	26.74456	20.44281	13.24414
SPF-232						0	90.48032	49.03513	58.64054	52.50277	47.15119
KATHA							0	59.79861	45.71606	18.07737	12.42292
CP 43-33								0	4.17924	19.63659	27.25895
CP-72- 2086									0	12.55506	24.19801
BF-162										0	5.283332
No.64											0

Cluster III had genotype SPF-232 with index score 24. Cluster IV and V had single genotype each i.e. CPF-235 and No.46 with index score 23 and 18 respectively. Cluster VI, VII and VIII had also single genotype each i.e., BF-162, No.64 and Katha with index score 18, 16 and 14 respectively. Mujahid *et al* (2001) showed that twelve accessions of sugarcane formed eight distinct clusters. The genotypes SPF-234, TCP-81-10 and BF-129 were included in cluster I. SPF-232 and RB-82-5336 included in cluster II. Cluster III also included one genotypes. Kashif and Khan (2007) reported that Metroglyph scatter diagram shows four groups from 14 genotypes of sugarcane. The accessions CP-77-400, Triton, SPSG-26, and CP-72-2086 were indicated in cluster I while COL-54, COJ-64, CPF-235, and SPF-234 indicated cluster II. COJ-84, SPF-232, CP-43-33 and BF-129 were indicated cluster III and cluster IV had two accessions.

In total 55 values of D^2 were calculated to know the genetic distance between the eleven genotypes. The genetic dissimilarity was highest between No.46 and SPF-232 and was lowest among SPSG-26 and COJ-84 (Table-3). These results might be concluded that high D^2 value was due to genetic dissimilarity among genotypes and low D^2 value was due to genetic similarity among genotypes. NO. 46 was diverse clone among all genotypes. SPSG-26 was genetically similar to COJ-84 and CP 43-33 was also genetically similar to CP-72-2086. The contribution of each character to the genetic divergence showed that brix value had the highest contribution to genetic divergence (29.09%) followed by cane height and cane weight (16.36%), it was due to genetic dissimilarity among the genotypes for these traits (Table-4).

Table: 4 Contribution of each character to divergence

Character	Plant height	Cane height	No.of tillers	leaves area	Cane diameter	Cane weight	Juice contents	Dry matter	Brix value	Sucrose value	Total
First ranking	1	9	4	2	0	9	8	6	16	0	55
% contribution	1.82	16.36	7.27	3.64	0.0	16.36	14.55	10.91	29.09	0.0	100.0

Cane diameter and sucrose value had no contribution (0.00%) to the total genetic divergence; this might be due to genetic similarity among the genotypes for these traits. Silva *et al.* (2005) reported that brix value and juice contents contributed the highest in genetic divergence among 129 genotypes and concluded that brix value and juice contents were more favorable for genetic diversity study in sugarcane. Nair *et al*. (1998) found that cane weight was significantly added to genetic diversity among sugarcane genotypes. Sajjad and Khan (2009) reported that cane weight contributed 0.38 to divergence and appeared three times in first ranking. Nair *et al*. (1998) found that cane height contributed the highest to genetic divergence and cane weight was significantly added to genetic diversity among sugarcane genotypes. Based on the relative magnitude of D^2 values computed for all possible pairs of studied genotypes, the twelve genotypes were grouped into five clusters based on statistical differences (Table-5). Cluster I had No.46, Katha and BF-162. Cluster II was largest cluster and had four genotypes (SPSG-26, COJ-84, CP 43-33 and CP-72-2086). Cluster III had two genotypes CPF-235 and No.64. Cluster IV and Cluster V had single genotype each, SPF-232 and COJ-64 respectively.

Table 5: Grouping of sugarcane genotypes into various clusters

Cluster No	Genotypes
I	NO. 46, KATHA, BF-162
II	SPSG-26, COJ-84, CP 43-33, CP-72-2086
III	CPF-235, NO.64
IV	SPF-232
V	COJ-64

CONCLUSION:

All the investigation in this study proved quite successful because a handful increase in brix value is possible as they provide information regarding a suitable combination of characters with their maximum influence on the enhancement of brix value. The clone will be selected with such combinations of characters which to give maximum improvement in their brix value. NO. 46 was diverse clone among all genotypes. SPSG-26 was genetically similar to COJ-84 and CP 43-33 was also genetically similar to CP-72-2086. The contribution of each character to the genetic divergence showed that brix value had the highest contribution to genetic divergence (29.09%) followed by cane height and cane weight (16.36%), it was due to genetic dissimilarity among all the traits of genotypes.

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