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Principal Component Analysis (PCA) of Some Morphological and Quality Traits in Sugarcane (Saccharum officinarum L.)

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Abstract
The aim of present study was to enhance the efficiency of selection by developing new artificial variables which will serve as selection criterion. Brix value and sucrose percentage were positively and highly significantly correlated. Both of these showed positive significant association with cane diameter, dry matter content and commercial cane sugar (CCS). Strong positive correlation was found between CCS and juice contents. The PCA revealed that first 4 PCs explained more than 85% of the total variation. The PC1 added 35.4% share to the total variation while the share of PC2 was 27.2%. The contribution of PC3 and PC4 was 14.3% and 8.7% respectively. The remaining nine PCs explained only about 15% of the total variation. By probing screen plot it was evident that first 9 PCs have considerable variability while in remaining 4 PCs differences were negligible. Biplot exposed that in the PC1 and PC2 together internodal length and commercial cane sugar (CCS) showed minimum differences while other traits showed more differences. The information thus acquired from the research could be utilized to frame the suitable selection scheme to develop clones of the best commercial merits, suitable for cultivation in different environments.

INTRODUCTION

Sugarcane is a tropical grass native to Asia where it has been grown in gardens for over 4000 years ago. It is the product of interbreeding four species of the genus Saccharum (Saccharum officinarum, Saccharum barberi, Saccharum sinense and Saccharum spontaneum) as a result a giant, robust and sugary cane plant is obtained. Chromosome numbers are different for all sugarcane species ranging from about 48 to more than 148. Methods for manufacturing sugar from sugarcane were developed in India about 400 B.C. Over 62 percent of the world's sugar is obtained from sugarcane (jiskani, 2004). Sugarcane crop has a vital place in economy of the Pakistan and is supreme important to run the huge sugar industry. It is the source of byproducts and raw material for clip board, paper and ethanol. The share of sugarcane in value added in agriculture sector and GDP is 3.2% and 0.7%, respectively. In Pakistan, it occupies a significant position in the agricultural economy and covers an area of about 1.124 Million hectares with an average yield of 1390 Mounds/Hec(Pakistan Economic Survey, 2012-13). In Pakistan, sugarcane is the raw material for the sugar industry. It is the source of income for the growers and occupation for many farm labors all-round the year. At present 60% of the sugarcane is used in sugar mills for sugar production, 25 % is used for gur and shakar making and remaining 10-15% is reserved for seed, chewing and fooder (Hussainet al., 2008).

Correlation study is an important tool in the hands of plant breeder to determine the relationship between yield and other traits. It gives knowledge about various factors contributing to the yield. Sometimes improvement in one character is through other character due to association among them. Therefore it is necessary to determine the character association by correlation studies (Salahuddinet al., 2010).

Principal component analysis (PCA) is a valuable method, which works by determining inter-relationship among variables. By using PCA we not only compare different treatments, but the meaningfulness of comparing treatments is also increased (Sneedon, 1970). PCA is well-defined such as "a technique of data reduction to elucidate the association among two or more traits and to split the whole variation of the original traits into a restricted number of un-associated new variables". PCA can be implemented on two kinds of data conditions; a variance-covariance condition and a correlation condition. With traits of different scales, a correlation matrix systematizing the original data set is favored. The core benefit of using PCA over cluster analysis is that each statistics can be allocated to one cluster only (Khodadadiet al., 2011).

The overall scope of this study is to enhance the efficiency of selection. The information thus obtained from the experiment could be utilized to formulate the appropriate selection strategy to develop clones of the best commercial merits, suitable for cultivation in different environments. The results from present research will provide information and this information will be tremendously helpful in planning future plant breeding programs for the evaluation of high yielding and better quality sugarcane varieties in Pakistan.

MATERIALS AND METHODS

Present study was conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. 15 genotypes (CP-72, SPF-234, HSF-240, CPF-246, HSF-247, SPF-232, CPF-248,

COJ-84, SGH-2924, CPF-235, CP72-2086, CP77-400, COJ-64, CP43-33, 11-72) were sown in Randomized Complete Block Design with three replications. Plant to plant distance and row to row distance was maintained 30 and 75 cm, respectively. All recommended agronomic practices were applied. Ten guarded plants from each replication were selected for recording data on the following morphological and quality traits:

1. Plant height (cm)
2. Cane height (cm)
3. Cane diameter (mm)
4. Number of leaves
5. Leaf area (cm2)
6. Cane internodal length (cm)
7. Number of tillers per stool
8. Juice contents (ml)
9. Brix value (%)
10. Sucrose content (%)
11. Fresh cane weight (g)
12. Dry matter content (g)
13. Commercial cane sugar (%)

Statistical Analysis

The collected data of all measured traits was analyzed by standard analysis of variance technique.The treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5 % probability level. Genotypic and phenotypic correlation coefficients among the characters under study were estimated according to the statistical techniques. Finally the data was analyzed by using the Principal component analysis and from a number of observed variables a smaller number of new/artificial variables (principal components) were developed.

RESULTS AND DISCUSSION

The results pertaining to analysis of variance elucidated highly significant differences among genotypes for all the traits. Strong positive association was found between plant height and cane height and both of these were positively and significantly correlated with juice contents, fresh cane weight, dry matter content and commercial cane sugar. While these were negatively correlated with brix value and sucrose content but this association was not so significant. Brix value and sucrose percentage were positively and highly significantly correlated. Both of these showed positive significant association with cane diameter, dry matter content and commercial cane sugar (CCS). Strong positive correlation was found between CCS and juice contents.

The PCA revealed that first 4 PCs explained more than 85% of the total variation. The PC1 contributed 35.4% share to the total variation while the share of PC2 was 27.2%. The contribution of PC3 and PC4 was 14.3% and 8.7% respectively. The remaining nine PCs explained only about 15% of the total variation. In the first principal components plant height, cane height, number of leaves, juice content and fresh cane weight were the most important traits contributing to variation. In the second principal component cane diameter, brix value, sucrose content and dry matter contents were the most important traits.

By examining scree plot it was evident that first 9 PCs have considerable variability while in remaining 4 PCs differences were negligible. The variability reduced gradually and it ended at 0.00195% at 13th PC with eigen value 0.000253. Scatter plot showed that genotypes CPF-246, HSF-247, COJ-84, SGH-2924, CPF-235, CPF-234 and CP-72 are not much diverse from each other as they were congested to same area. While genotypes CP77-400, CP72-2086, CPF-248, SPF-232, 11-72, HSF-240, CP43-33 and COJ-64 were present at distance from other genotypes with respect to PC1 and PC2 so more diverse. Biplot revealed that in the PC1 and PC2 together internodal length and commercial cane sugar (CCS) showed minimum differences while other traits showed more differences.

The information thus obtained from the experiment could be utilized to formulate the appropriate selection strategy and crossing scheme to develop clones of the best commercial merits, suitable for cultivation in different environments.

Chaudhary and Joshi (2005) carried out a study to determine the role of six morphological traits on cane yield. Data was recorded and statistically analyzed from 65 sugarcane clones. Cane yield showed positive significant correlation with weight of the cane, length of the stalk, number of millable canes, cane diameter and number of internodes. Internodal length showed positive non-significant correlation with cane yield. Path coefficient analysis showed that the highest direct effects on cane yield were due to single cane weight followed by number of millable canes. There was significant and positive correlation of cane yield with cane thickness and stalk length and this was due to indirect effects of single cane weight.

Singh et al. (2005) studied correlation and path analysis among different traits with ratoon yield. Results indicated the high positive significant correlation of brix value, sucrose percentage and commercial cane sugar

percentage with Pol percentage in cane. Ratoon yield was positively correlated with number of millable canes (NMC), single cane weight and cane height. Path analysis study uncovered that NMC and single cane weight displayed substantial positive direct contribution for ratoon yield. This cane weight was added by cane height to cane yield. Even though all the traits which presented substantial positive association were vital but on the basis of path analysis NMC and single cane weight had paid more for ratoon yield.

Tyagi and Lal (2007) concluded that plant height, plant volume, number of millable cane/stool, stalk diameter and weight of millable cane were the characters of great significance for sugarcane yield. Path coefficient analysis revealed that weight of millable canes was the most important trait having the highest direct effects on sugarcane yield. Other traits having direct effect on cane yield were stalk height, number of millable stalks and stalk thickness. Correlation and path coefficient studies suggested that for high sugarcane yield such clones or varieties should be included in the breeding programme which had high plant height and plant volume.

Yahayaet al.(2009) studied correlation and path coefficients in sugarcane genotypes to find the interrelationship and significance of some traits as yield components. Number of millable stalks, cane length, cane thickness and number of internodes per stalk showed high positive association with sugarcane yield and with each other. The path coefficient analysis showed that cane length had the maximum direct influence on sugarcane yield followed by number of millable stalks.

Al-Sayed et al.(2012) used different statistical techniques to study the role of some morphological characters on sugar yield in saccharumofficinarrum. Sugar yield showed positive significant correlation with number of internodes per stalk, number of millable canes/m2, total soluble solid and sucrose percentage. It was revealed by the path analysis that number of millable canes/m2 was the major and most important character influencing the sugar yield. The other factors influencing yield directly or indirectly were sucrose percentage and stalk weight. Full model regression and stepwise multiple linear regression also showed that number of millable canes/m2, sucrose percentage and stalk weight were responsible for most of the variability in sugar yield.

Khan et al. (2012)compared the cane yield, Pol percentage and commercial cane sugar percentage of 12 sugarcane clones. Clone NIA82-1026P5 showed the highest cane yield (144t/ha), while CP84-1198 showed the highest Pol% (20.82) and CCS% (16.45). Correlation studies indicated the positive correlation of cane yield with diameter of cane, weight/stool, sugar yield, number of tillers per stool and purity percentage. Pol and CCS percentages were negatively correlated with cane yield.

Kang et al. (2013) conducted an experiment to study the genetic variability and association of some morphological traits with sugarcane yield and sucrose percentage. At genotypic level brix value was positively and significantly correlated with cane thickness, leaf area, dry matter contents and sucrose percentage. But at phenotypic level this association was positive and highly significant. Metroglyph analysis revealed that 8 clusters had been made which had different index scores.

Smiullah et al. (2013) evaluated 10 accessions of sugarcane by using principal component analysis. PCA revealed that number of millable canes, number of stools/plant and internodal distance had positive impact on genetic diversity while all other characters had negative contribution. It was concluded that most of the diversity in sugarcane genotypes was due to two principal components which were named vigor and quality.

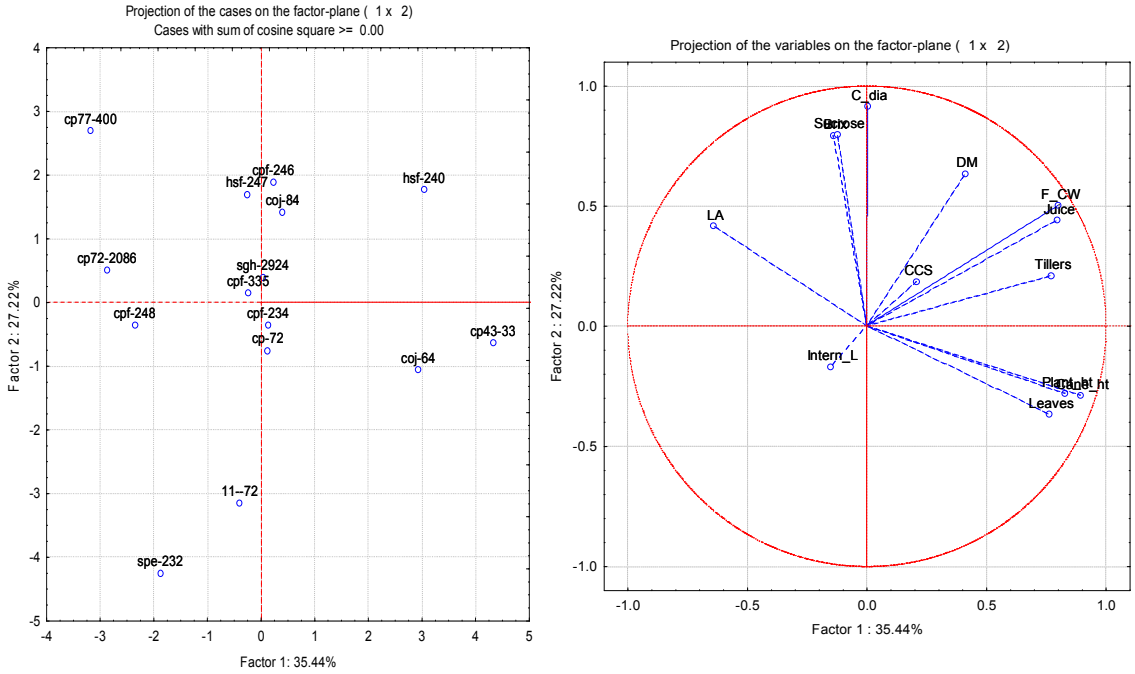
Eigen values and % total variance for principal components.

Principal components	Eigen value	% Total - variance	Cumulative – Eigen value	Cumulative - %
PC1	4.606727	35.43636	4.60673	35.4364
PC2	3.538051	27.21577	8.14478	62.6521
PC3	1.861906	14.32236	10.00668	76.9745
PC4	1.137565	8.75050	11.14425	85.7250
PC5	0.686806	5.28312	11.83106	91.0081
PC6	0.460853	3.54502	12.29191	94.5531
PC7	0.353042	2.71570	12.64495	97.2688
PC8	0.213934	1.64565	12.85888	98.9145
PC9	0.089812	0.69086	12.94870	99.6054
PC10	0.040307	0.31006	12.98900	99.9154
PC11	0.006067	0.04667	12.99507	99.9621
PC12	0.004676	0.03597	12.99975	99.9981
PC13	0.000253	0.00195	13.00000	100.0000

Tahir et al. (2013) conducted an experiment comprising 25 genotypes to asses genetic divergence of sugarcane germplasm. Principal Component Analysis (PCA) showed that there were two principal components accounting for 88% of the total variation in the tested breeding material. The new components were named "Vigor", and "Quality". Principal Component Regression (PCR) indicated that these two accounted for 93.64% and 7.36% of variation in the yield, thus signifying the role of the "Vigor" component. It was concluded that two components (vigor and quality) accounted for maximum variation in yield.

Jamozaet al. (2014) studied heritability and correlation among some morphological traits and yield in sugarcane. High broad sense heritability (H2) was identified for cane thickness, number of millable cane, single cane weight and number of internodes, suggesting that these characters may perhaps be selected easily. Maximum expected genetic gains were recognized in cane weight and number of millable canes. It was concluded that selection for single cane weight and number of millable canes would be most effective for yield improvement in sugarcane.

Kumar and Kumar (2014) studied character association among sugarcane genotypes. The cane yield showed positive significant correlation with germination percentage, number of millable canes, number of stools/plant, cane thickness and number of green leaves. Cane yield showed positive but non-significant correlation with the top weight. There was negative correlation between cane yield and brix value.



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