RESEARCH ARTICLE

STUDIES ON VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS FOR CANE YIELD, ITS COMPONENTSAND QUALITY CHARACTERS IN SUGARCANE MIDLATE CLONES

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Abstract: Twenty-two sugarcane midlate clones were evaluated for agro-morphological and quality characters in randomized block design (RBD) at CCS, Haryana Agricultural University Regional Research Station,Karnal during 2019-20. Analysis of variance showed that mean squares due to genotypes were highly significant for all the characters studied, indicated the presence of sufficient genetic variability and appropriateness of the material selected for the present study. Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters representing more environmental impact on these characters for total variation. High heritability (broad sense) coupled with high genetic advance was observed for stalk length. High heritability (broad sense) coupled with moderate genetic advance as percent of mean was observed for cane yield, stalk length, stalk diameter and CCS (t/ha), therefore, it indicates that simple selection will be effective for genetic improvement of these characters.Genotypic and phenotypic correlation coefficients for cane yield exhibited significant and positive relationship with number of tillers at 120 DAP, number of shoots at 240 DAP, NMC at harvest, single cane weight and CCS (t/ha). These traits play a greater role as an important contributing character for higher cane yield and quality. Lack of association of quality characters namely sucrose percent, brix percent and purity with grain yield at genotypic and phenotypic level in present study suggests that we can improve quality content without affecting cane yield. The path coefficient analysis indicatedthe maximum positive direct effect on cane yield was shown by CCS (t/ha) followed by number of shoots at 240 DAP, single cane weight, number of millable cane and germination at 45 DAP, extraction percent and stalk length.Therefore, in order to increase cane yield, effective selection can be accomplished for the characters having high direct effects.

Keywords: Sugarcane, Heritability, Genetic advance, Correlation coefficient,Path coefficient analysis

INTRODUCTION

Sugarcane (*Saccharum* spp. complex) isone of the most important agro industrial crop of the world.Sugar per unit area is determined by the cane yield per unit area and sucrose percent in juice. As the demand for white sugar is increasing continuously, the cane productivity and sugar recovery has to be increased accordingly.In India, it occupies an area of 4.57 million ha with production of 355.7 million tonnes with average yield of 77.89 t/ha. In Haryana, sugarcane was cultivated on 0.10 million ha with production of 7.63 million tonnes with an average yield of 80.98 t/ha during 2019-20.

The *Saccharumofficinarum* is the main source for genetic variability in sugarcane as compared to *S. spontaneum*, *S. sinense*, *S. barberi* (Lima *et al*., 2002). Development of new mordern varieties is mainly governed by the extent of genetic variability in the base material. Estimation of GCV and PCV along with the heritability as well as genetic advance is used to improve any trait of sugarcane. In sugarcane, the cane and sugar yields are considered to be the complex characters. The information on the phenotypic and genotypic interrelationship of cane yield and commercial cane sugar (CCS) yield with their component characters would be of great help to the sugarcane breeder. The association between two characters can directly be observed as phenotypic correlation while genotypic correlation expresses the extent to which two traits are genetically associated. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding programme. Correlation coefficients measure the absolute value of the correlation between variables in a given body of data. Correlation does not say anything about the cause and effect relationship. A path coefficient measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects. Path coefficient analysis specifies the cause and measures the relative importance of the characters, while correlation measures only mutual association without considering causation (Dewey and Lu, 1959).The present study was undertaken to derive information on genetic variability, estimation of extent of association between pairs of characters in genotypic and phenotypic levels and thereby compare the direct and indirect effects of the characters.

MATERIALS AND METHODS

The experiment was conducted at research farm of CCS Haryana Agricultural University, Regional Research Station, Karnal to study the genetic variability, correlation and path analysis among twenty two midlate clones of sugarcane during season of 2019-20. The experiment was conducted in

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a randomized block design with three replications with spacing of 90 cm between rows. The plot size was 4r × 6.0 m × 0.90 m. Observations were recorded on five random but representative plants of each genotype for quantitative traits viz., single cane weight (kg), stalk length (cm), stalk diameter (cm), CCS (t/ha), CCS percent at 12month, sucrose percent at 12 month, juicebrix percent at 12 month and juice purity percent 12 month. The observations on plot basis were recorded for cane yield (t/ha), number of millable canes (000/ha) at 360 days after planting (DAP), number of shoots (000/ha) at 240 DAP, number of tillers (000/ha) at 120 DAP, germinationpercent at 45 DAP. Recommended package of practices was followed to raise a good crop. Analysis of variance was performed as per methodology given by Panse and Sukhatme (1967). Genotypic and phenotype coefficients of variation (GCV and PCV) were calculated by formula given by Burton and de Vane (1953), heritability in broad sense (h^2) by Hanson *et al.*(1956)and genetic advance as given by Johnson *et al*. (1955). Correlation and path coefficients were worked out as per method suggested by Al-Jibouri *et al*. (1958) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

In present study, the analysis of variance revealed significant differences for all the characters thereby indicating presence of substantial genetic variation among the genotypes. The estimates of variability parameters for yield and its component traits in 22 sugarcane genotypes are presented in Table 1. The high range was observed for characters viz., stalk length, number of millable canes at harvest, number of tillers at 120 days after planting (DAP), cane yield at harvest and germination percent at 45 days after planting (DAP).

The phenotypic coefficient of variation value was highest for CCS (t/ha) (12.90) followed by cane yield (11.61), number of shoots at 120 DAP (11.58) and germination percent at 45 DAP (10.15).Genotypic coefficient of variation value was highest for CCS (t/ha) (9.16) followed by cane yield (9.15), stalk length (7.66) and number of tillers at 120 DAP (7.48). Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits signifying greater environmental influence on these traits for total variation which is in agreement with finding ofSharma *et al* (2022). Moderate estimates of phenotypic coefficient of variation were recorded for CCS (t/ha), cane yield at harvest, number of tillers at 120 DAP and germination percentage at 45DAP and while lowgenotypic coefficient of variation was observed for all the characters under study. The lowest phenotypic coefficient of variation was observed for juice purity percent. (Neetu*et al*. 2018).

The high heritability estimate was recorded for sucrose percent at 12 m followed by stalk diameter, juice brix percent 12m, stalk length, CCS percent, cane yield. CCS (t/ha), single cane weight, number of shoots at 120 DAP, number of shoots at 240 DAP, number of millablecaneat harvest, germination percent at 45 DAP and extraction percent showed moderate heritabilityimplying simple selection for these characters will be effective. Low heritability estimateswere recorded for juice purity percent.The results are in confirmations with Singh *et al.* (2010) for high heritability values for stalk diameter and moderate for cane yield and number of millable canes at harvest. Neetu *et al.*(2018) observed high estimates of heritability for cane yield, cane quality characters like CCS yield, CCS % and Juice sucrose % while moderate heritability was observed for juice purity.

In case of genetic advance, high value was recorded for stalk length and moderate for number of tiller at 120DAPand cane yield.Moderate genetic advance as percent of mean was recorded for cane yield, CCS (t/ha), stalk length and stalk diameter.High genetic advance as percent of mean recorded for stalk length by Sanghera *et al*. (2015). Kumar and Kumar (2014) observed moderate genetic advance for cane yield.

The result of present study obviously specified high heritability coupled with moderate genetic advance as percent of means for cane yield, stalk length and stalk diameter at harvest suggesting the role of additive genetic effects in determination of these characters and it require simple selection for the desired improvements in these characters.Singh *et al.* (2010) also recorded high heritability coupled with moderate genetic advance for plant height (cm) at harvest and cane diameter (cm). Similar results were also reported by Patel andMali (2013) that high heritability coupled with moderate genetic advance for cane yield.Hardeep*et al.* (2021) observed high heritability coupled with high genetic advance as percentage of mean for number of tillers at 120DAP, single cane weight, cane length, CCS (t/ha) and cane yield. Therefore, these characters may be exploited in future breeding programme for developing high yielding varieties of sugarcane.

In sugarcane, understanding the nature of relationship of characters may not be of direct help in selection of breeding material in segregating population. However, it is very much beneficial in selection of parent genotypes either for cane yield or quality parameters based on the information accessible on the nature of relationship of characters. It also emphases on the degree of importance to be given, while selecting a genotype as a parent in hybridization. In the present study, genotypic and phenotypic correlation coefficient between cane yield and other productive traits are presented in Table 3. Cane yield showed significant and positive relationship with NMC at harvest, number of tillers at 120 DAP, number of shoots at 240 DAP, germination at 45DAP, single cane weight and CCS (t/ha) at both genotypic and phenotypic level. These traits play a greater role as an important contributing character for higher cane yield. Cane yield exhibited non-significant correlation with stalk length, stalk diameter, CCS percent, sucrose percent, brix percent, juice purity percent and extraction percent at phenotypic level. However, cane yield showed negative and significant correlation with CCS percent and juice purity percent at genotypic level. Above mention results were also observed by Reddy and Khan (1984) with NMC stalk weight (Pal *et al*., 1999). Khan *et al.*(2012) indicated that cane yield was positively correlated with weight per stool, sugar yield and tiller numbers whereas Pol % and CCS % showed negative correlation with cane yield. Lack of association of quality characters namely sucrose percent, brix percent and purity with cane yield at genotypic and phenotypic level in present study suggests that quality can be improved without affecting cane yield. Kang, *et al*. (1983) also found a weak correlation between cane yield and sucrose percent.

CCS (t/ha) exhibited significant and positive association with cane yield, NMC at harvest, number of shoots at 240 DAP, CCS percent, sucrose percent and brix percent. Sucrose percent showed significant and positive association with CCS per cent, brix per cent and purity percent at both genotypic and phenotypic level.

Path coefficient analysis can be a valuable tool for use in a crop species selection programme based on component breeding. The path coefficient analysis explains whether the association of cane yield with its component characters is due to the direct effects of component characters on cane yield or is a result of their indirect effects via some other characters.

Using the path coefficient analysis approach in present study, the estimated magnitude of phenotypic correlation coefficients was partitioned to determine the direct and indirect effects. The maximum positive direct effect on cane yield was shown by CCS (t/ha) (1.027) followed by number of shoots at 240 DAP (0.046),single cane weight (0.035), number of millable cane 0.013) and germination percent (0.010), extraction percent (0.003) and stalk length (0.001). Thesimilar results were also reportedby Kumar and Kumar (2014) and Sanghera*etal*. (2015) for number of shoots at 240 DAP, number of millable cane, stalk weight had positive direct effect on yield.Number of tillers at 120 DAP, stalk diameter, CCS percent, sucrose percent, brix percent and juice purity percent exhibited negative direct effect on cane yield. The highest positive indirect effect on cane yield byCCS (t/ha) was observed via number of shoots at 240 DAP, single cane weight, NMC at harvest and germination percent.Highest positive direct effect of CCS (t/ha) on cane yield was also recorded.

Table 1. Estimates of variability parameters for agro-morphological and quality characters in midlate sugarcane clones

S. No.	Characters	Mean ± S.E(m)	Range	Genotypic Coefficient of Variations	Phenotypic Coefficient of Variations	Heritability (Percent)	Genetic Advance	Genetic Advance value % means
1	Cane yield (t/ha)	82.12 ±3.76	63.30-95.10	9.15	11.61	62.06	12.19	14.84
2	Number of millable canes (000/ha) at 360 DAP	96.53±4.93	75.73-109.50	6.39	9.93	41.45	8.18	8.48
3	Number of shoots (000/ha)at 240 DAP	110.71±5.05	88.90-128.97	6.33	9.60	43.50	9.52	8.60
4	Number of tillers (000/ha)at 120	143.79±6.97	114.83-164.50	7.48	11.58	41.69	14.31	9.95
5	Germination (%) at 45 DAP	45.19±3.17	38.87-50.83	5.89	10.15	33.71	3.18	7.05
6	Single cane weight (kg)	0.89±0.02	0.73-0.97	4.54	6.41	50.12	0.06	6.62
7	Stalk length (cm)	240.20±6.86	199.67-280 28	7.66	9.40	66.37	30.86	12.85
8	Stalk diameter (cm)	2.28±0.05	1.90-2.67	6.33	7.47	71.87	0.25	11.05
9	CCS (t/ha)	10.00±0.55	8.27-12.60	9.16	12.90	50.38	1.34	13.39
10	CCS (%) at 12m	12.18±0.25	10.60-12.27	5.15	6.34	65.93	1.05	8.61
11	Sucrose (%) 12m	17.57±0.30	15.43-19.03	4.93	5.81	72.09	1.52	8.62
12	Brix (%) 12m	19.77±0.32	17.70-21.37	4.81	5.75	70.06	1.64	8.30
13	Purity (%) 12m	88.87±1.21	85.53-94.40	1.58	2.98	28.31	1.54	1.74
14	Extraction (%) 12m	60.23±1.36	56.97-65.73	2.82	5.11	30.49	1.93	3.21

m=month

Table 2. Genotypic (r_g) and phenotypic (r_p) correlation coefficients of cane yield with various growth and quality components in midlate sugarcane clones

Characters		**Cane Yield (t/ha)**	**Number of millable canes (000/ha) at 360 DAP**	**Number of shoots (000/ha)at 240 DAP**	**Number of tillers (000/ha) at 120 DAP**	**Germination % at 45 DAP**	**Single cane weight (kg)**	**Stalk length (cm)**	**Stalk diameter (cm)**	**CCS (t/ha)**	**CCS (%) at 12m**	**Sucrose (%) 12m**	**Brix (%) 12m**	**Purity (%) 12m**
Numbe of millable canes (000/ha) at 360 DAP	r_g r_p	0.826** 0.788**												
Number of shoots (000/ha)at 240 DAP	r_g r_p	0.760** 0.720**	0.973** 0.937**											
Number of tillers (000/ha) at 120 DAP	r_g r_p	0.480** 0.369**	0.837** 0.627**	0.874** 0.722**										
Germination % at 45 DAP	r_g r_p	0.678** 0.259*	0.772** 0.148	0.628** 0.156	0.464** 0.156									
Single cane weight (kg)	r_g r_p	0.704** 0.507**	0.215 0.011	0.260* -0.022	0.001 -0.195	0.016 0.047								
Stalk length (cm)	r_g r_p	0.241 0.147	0.140 0.045	0.112 0.017	0.402** 0.106	0.068 0.119	0.409** 0.294*							
Stalk diameter (cm)	r_g r_p	0.130 0.064	-0.163 -0.125	-0.102 -0.058	-0.276* -0.078	-0.181 -0.112	0.688** 0.363**	0.031 -0.095						
CCS (t/ha)	r_g r_p	0.850** 0.871**	0.676** 0.690**	0.520** 0.628**	0.124 0.254*	0.535** 0.184	0.671** 0.402**	0.186 0.062	-0.027 0.006					
CCS (%) at 12m	r_g r_p	-0.298* -0.090	-0.292* -0.056	-0.437** -0.050	-0.642** -0.165	-0.260* -0.098	-0.076 -0.123	-0.106 -0.140	-0.278* -0.126	0.250* 0.408**				
Sucrose (%) 12m	r_g r_p	-0.211 -0.055	-0.212 -0.034	-0.344** -0.044	-0.552** -0.151	-0.226 -0.091	0.003 -0.077	-0.045 -0.098	-0.225 -0.111	0.332** 0.429**	0.990**0 .977**			
Brix (%) 12m	r_g r_p	0.002 0.037	-0.017 0.023	-0.109 -0.022	-0.312* -0.090	-0.137 -0.057	0.183 0.046	0.092 0.015	-0.088 -0.053	0.497** 0.396**	0.899**0 .742**	0.951** 0.868**		
Purity (%) 12m	r_g r_p	-0.666** -0.180	-0.615** -0.111	-0.742** -0.044	-0.777** -0.125	-0.306* -0.072	-0.545** -0.233	-0.442** -0.226	-0.402** -0.097	-0.462** 0.073	0.382** 0.479**	0.251* 0.280*	-0.061 -0.232	
Extraction % 12	r_g r_p	-0.061 -0.109	-0.262* 0.026	-0.287* 0.007	-0.013 0.130	0.303* -0.100	-0.003 -0.295*	-0.286* -0.154	0.264* 0.211	-0.085 -0.123	-0.068 -0.063	-0.117 -0.085	-0.219 -0.121	0.356** 0.085

*, **Significant at P=0.05 and P=0.01 levels, respectively

Table 3. Direct (diagonal and bold) and indirect effects of different characters on cane yield in midlate sugarcane clones

Character	Number of millable canes (000/ha) at 360 DAP	Number of shoots (000/ha)at 240 DAP	Number of tillers (000/ha) at 120 DAP	Germination % at 45 DAP	Single cane weight (kg)	Stalk length (cm)	Stalk diameter (cm)	CCS (t/ha)	CCS (%) at 12m	Sucrose (%) at 12m	Brix (%) at 12m	Purity (%) at 12m	Extrac-tion (%) at 12m	Phenoty-pic correlation with cane yield
Number of millable canes (000/ha) at 360 DAP	**0.0129**	0.0437	-0.0090	0.0015	0.0004	0.0000	0.0018	0.7084	0.0169	0.0060	-0.0002	0.0060	0.0001	0.788**
Number of shoots (000/ha)at 240 DAP	0.0121	**0.0466**	-0.0104	0.0016	-0.0008	0.0000	0.0008	0.6448	0.0150	0.0077	0.0002	0.0024	0.0000	0.720**
Number of tillers (000/ha) at 120 DAP	0.0081	0.0336	**-0.0144**	0.0016	-0.0067	0.0001	0.0011	0.2613	0.0496	0.0265	0.0008	0.0068	0.0004	0.369**
Germination % at 45 DAP	0.0019	0.0073	-0.0022	**0.0103**	0.0016	0.0001	0.0016	0.1894	0.0294	0.0160	0.0005	0.0039	-0.0003	0.259*
Single cane weight (kg)	0.0001	-0.0010	0.0028	0.0005	**0.0345**	0.0002	-0.0051	0.4131	0.0371	0.0135	-0.0004	0.0127	-0.0009	0.507**
Stalk length (cm)	0.0006	0.0008	-0.0015	0.0012	0.0101	**0.0007**	0.0013	0.0632	0.0421	0.0172	-0.0001	0.0123	-0.0005	0.147
Stalk diameter (cm)	-0.0016	-0.0027	0.0011	-0.0012	0.0125	-0.0001	**-0.0140**	0.0059	0.0380	0.0196	0.0005	0.0053	0.0006	0.064
CCS (t/ha)	0.0089	0.0293	-0.0037	0.0019	0.0139	0.0000	-0.0001	**1.0271**	-0.1229	-0.0755	-0.0034	-0.0040	-0.0004	0.871**
CCS (%) at 12m	-0.0007	-0.0023	0.0024	-0.0010	-0.0043	-0.0001	0.0018	0.4195	**-0.3008**	-0.1719	-0.0063	-0.0260	-0.0002	-0.090
Sucrose (%) at 12m	-0.0004	-0.0020	0.0022	-0.0009	-0.0027	-0.0001	0.0016	0.4405	-0.2938	**-0.1760**	-0.0073	-0.0152	-0.0003	-0.055
Brix (%) at 12m	0.0003	-0.0010	0.0013	-0.0006	0.0016	0.0000	0.0007	0.4070	-0.2232	-0.1528	**-0.0084**	0.0126	-0.0004	0.037
Purity (%) at 12m	-0.0014	-0.0020	0.0018	-0.0007	-0.0081	-0.0002	0.0014	0.0753	-0.1441	-0.0493	0.0020	**-0.0544**	0.0003	-0.180
Extraction (%) at 12m	0.0003	0.0003	-0.0019	-0.0010	-0.0102	-0.0001	-0.0030	-0.1266	0.0189	0.0150	0.0010	-0.0046	**0.0030**	-0.109

Residual are 0.00166, *, **Significant at P=0.05 and P=0.01 level, respectively

Therefore, in order to increase cane yield, effective selection can be accomplished for the characters having high direct effects and for the traits through which indirect effects are mainly applied on cane yield. Varietal selection in succeeding generations should be based on CCS (t/ha), number of shoots at 240 DAP, single cane weight and number of millable cane and stalk lengthfor evolving high yielding sugarcane varieties.

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