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The Influence of Characters Association on Behavior of Sugarcane Genotypes (*Saccharum* Spp) for Cane Yield and Juice Quality

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Abstract: The investigation was carried out at the Sugarcane Research Centre, Sudan (14, 48 N°), during the season of 2003/2004 and 2004/2005. Eight sugarcane genotypes were evaluated in a randomized complete block design with four replications to study association of characters influenced the final behavior of eight sugarcane clones regarding cane yield characters namely; yield of cane (ton/ha), number of millable cane, stalk height, stalk diameter, single stalk weight and juice quality traits in terms of juice brix (%) juice pol %, juice purity % and cane fiber (%). The results indicated that genotypes R 579, SP 718210 and Co 6806 had shown superiority for yield of cane per ha where as genotype Co 527 followed by Co 997 were the best for juice pol percent. Characters association results showed a positive correlation between cane yield in one hand and number of millable stalks, stalk height, internodal number per stalk, single stalks weight on the other hand indicated improvement of one of these character may resulted in positive respone of the other character. Negative association of cane yield with stalk diameter, juice pol and purity % was noticed in this study.

Key words: Sugarcane (*Saccharum* spp) · Genotype · Juice quality · Characters_association

INTRODUCTION

Sugarcane (*Saccharum* spp)* is an essential constituent of the human diet as sweetener. Sugar is produced worldwide in over 120 countries. The total world sugar during the 2008-2009 is estimated to be 161 million tonnes. Nearly 80% of sugar produced is from sugarcane while the remaining 20% is contributed by beet [1]. Sugarcane is a vegetative propagated crop grown commercially as clones. Yield is a quantitatively inherited character involving various traits. Therefore, selection of genotypes with high cane and sugar yield based on a single trait might often be misleading, Stevenson [2] pointed that there may not be specific genes controlling the complex characters, but the sum total of their components might be influencing the important economic characters namely; cane and sugar yield.

Statistical correlation coefficient is a measure that denotes the degree and magnitude of interrelationship between any two casually related variables [3]. The association between two or more characters is due to peliotropic gene action or linkage [4]. In plant breeding correlation coefficient analysis measures the mutual relationship between two plant characters and it determines characters association for genetic improvement of yield and other economic traits. Since the association pattern among yield components help to select superior genotype from divergent population based on more than one interrelated characters, the present study was conducted to give clues and information on the association of various yield traits that dictated the final performance of genotype under field condition pertaining to yield of cane sugar.

MATERIALS AND METHODS

The study was carried out during 2003-2004 and 2004-2005 to test eight sugarcane genetic stocks during the plant cane season and the first ratoon crop, at the Sugarcane Research Centre - Gunied (14,48-15.00° N) and (33,13 - 32,22°E) where the soil is of Suliem series with clay percent at 42-61, calcareous and mildly to strongly alkaline in reaction. A randomized complete block design with four replicates was used to accommodate the materials. The experimental plot was sized to contained four rows each of 10 meters long with 155 cm as inter-row spacing. The standard cultural practices such as irrigation, fertilizations and pesticide application were carried out as per recommendations. All agronomic practices were kept normal for the eight genotypes. Irrigation was applied at

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an interval of 10 days during summer and 15 days during winter season. Nitrogen fertilizer in the form of urea at 465 Kg/ha and inform of P2O5 at a rate of116Kg/ha were both applied as whole doses at planting. Hand weeding was applied whenever necessary to ensure normal and healthy crop at harvest. The plant cane was harvested manually at 14 months of age whereas the ratoon crop was reaped at eleven months. At harvest of the plant cane and ratoon, yield of cane for each plot was weighed using digital weighing balance mounted in 70 HP-tractor machine. Long measuring scale and varnier caliper were used to measure the stalk height and stalk diameter of millable stalk at harvest respectively.

Estimation of Cane Yield Attributes: From each plot ten guarded plants were selected at random from the two inner rows in each plot per replication (Forty stalks per genotype) to record observations on cane characters namely; stalk height (SHT), stalk diameter (STD), single stalk weight (SSW) and number of internode per stalk (INN) as well as quality traits namely; juice brix percent (BRX %), juice pol percent (POL %), cane fiber percent (FIB %) and juice purity percent (PUR %).

Estimation of Mean Performance for Cane Characters:

Stalk height (cm) = Total height of selected stalks /10

Stalk diameter (mm) = Total diameter readings values for selected stalks /10

Number of Internodes = Total number of internodes in stalks/10

Estimation of mean performance for quality traits: The quality characters, sugar was estimated following the method suggested by Schneider [5] and followed at the Sugarcane Research Centre laboratory as follows.

Juice Pol%: After cane crushing the cane juice was collected and clarified with lead sub acetate and 200 ml cleared juice was polarized in polarimeter machine installed at Sugarcane Research Center Laboratory. After adjusting the refracted light, the juice pol percent was obtained and recorded.

Juice Brix (%): This denoted as the total soluble solid in the juice and was measured by using brix hydrometer floated in ajar containing juice sample. The temperature correction at periodic interval during the course of juice analysis was made.

Juice Purity (%): was calculated from the sucrose and brix of cane as per the following formula

$$\text{Juice purity \%} = \frac{\text{Sucrose percent x 100}}{\text{Corrected brix percent}} \times 100$$

$$\text{Cane fiber \%} = \frac{\text{Oven dried weighed sample (250g)}}{\text{Respective fresh weight}} \text{ x 100}$$

Associations of characters was studied, using simple correlation between each two characters, y and x, using the formula adopted by Phundan Singh and Naryanan [3] as follows

$$r_{xy} = \frac{\text{Cov } (x.y)}{\sqrt{\text{v Var x}} \text{ X } \sqrt{\text{v Var y}}}$$ Where,

Var x, Var y: variance of x variable, variance of y variable respectively

r_{xy}: correlation coefficient between any two different characters

Cov (x.y) : Covariance between any two characters

Test of significant of correlation coefficient (r) was carried out by referring to (t) table given by Snedecor and Cochran [6] using (n-2) degree of freedom.

Statistical Analysis: Analysis of variance, estimation of standard error and critical difference were carried out as per Panse and Sukhatme [7]. Test of significance for difference between characters means was worked out by referring to the F- table given by Snedecor and Cochran [6].

RESULTS

Mean Performance for Different Characters: Results of analysis of variance for cane yield and quality characters indicated significant difference among genotypes with regard to the characters studied. As shown in Table 1 genotype Co 527 had produced higher number of tillers at 120 days of age followed by FR 87421 and Co 6806 the lowest tillers was produced by R570. Three genotypes namely; R 579, SP 718210 and Co 6806 had shown superiority for cane yield per ha whereas, genotypes namely; R 570 and Co 6806 had produced higher mean for stalk height of millable cane at harvest, whereas genotype FR 718210 had recorded the lowest value for this character (Table 2).

Number of millable cane at harvest was found to range from 57.9 x 10^3 to 96.8 x $10^{3=}$/ha. The highest millable cane at harvest was produced by Co 527 and Co 6806, where as the lowest value was showed by R570.

Table 1: Means performance (ranked) and analysis of variance for different characters across eight genotypes

Character	Ranking of genotypes performanc 1st	2nd	3rd	4th	5th	6th	7th	8th	SE±	C.V (%)	L.S.D (0.05)
Tiller counts(x10^3)/ha at 120 days	Co527 (77.09) (806.67)	FR87421 (67.643) (749.67)	Co6806 (60.200) (676.67)	Kn9376 (56.210) (668.670	Co997 (55.090) (659)	SP718210 (52.920) (637.67)	R579 (51.636 (629.33)	R570 (46.666) (571.67)	71.94	10.55	154.36
Stalk height (cm)	R579 (173.01)	Co6806 (172.25)	SP718210 (157.55)	Kn9376 (152.92)	Co997 (147.29)	Co527 (142.04)	R570 (141.17)	FR87421 (108.5)	97.7	13.93	170.96
Stalk diameter (cm)	R579 (2.69)	R570 (2.66)	Kn9376 (2.62)	SP718210 (2.58)	FR87421 (2.54)	Co997 (2.51)	Co527 (2.3)	Co6806 (2.19)	14.46	12.41	31.41
Single stalk weight(cm)	R579 (0.94)	R570 (0.83)	SP718210 (0.82)	Kn9376 (0.78)	Co997 (0.73)	Co6806 (0.66)	Co527 (0.6)	FR87421 (0.58)	0.941	5.71	2.02
Internode number	Co997 (24.67)	Co527 (24.13)	R579 (23.17)	R570 (22.93)	Kn9376 (22.63)	Co6806 (22.29)	FR87421 (22.17)	SP718210 (21.79)	0.145	7.52	0.33
Juice brix (%)	Co527 (19.54)	Co997 (19.44)	FR87421 (18.8)	R579 (18.78)	Kn9376 (18.57)	SP718210 (18.34)	R570 (18.18)	Co6806 (17.46)	0.07	11.84	0.154
Juice purity (%)	Co527 (89.29)	R570 (88.49)	FR87421 (88.39)	Kn9376 (88.23)	SP718210 (87.68)	R579 *(87.29)*	Co997 (86.66)	Co6806 (85.84)	1.00	5.36	2.15
Cane fiber (%)	SP718210 (17.73)	FR87421 (17.7)	R579 (17.67)	Co997 (17.57)	R570 (17.48)	Kn9376 (17.47)	Co6806 (17.07)	Co527 (17.03)	0.91	5.99	1.95
Number of Millablecane/ha	Co527 96849.58	Co6806 90700.37	SP718210 82620.27	Co997 78676.85	R579 76885.9	FR87421 63108.08	Kn9376 62753.22	R570 57906.83	2.08	2.9	4.56
Cane yield (ton/ha)	R579 102.887	SP718210 102.054	Co6806 97.8894	Co997 94.129	Co527 92.8914	Kn9376 84.4662	R570 81.8006	FR87421 70.686	0.68	4.74	1.45

Table 2: Characters associations among eight exotic sugarcane genotypes

Characters	TLC	STH	INN	STD	SSW	BRX	POL	PUR	FIB	NMC	CYD
TLC	1.000	-0.415	-0.476	-0.647	-0.842**	0.203	0.428	0.378	-0.537	0.054	-0.230
STH	-0.415	1.000	0.488	-0.119	0.591	-0.005	-0.385	-0.593	-0.223	0.710*	0.857**
INN	-0.476	0.488	1.000	0.052	0.496	0.380	-0.006	-0.224	-0.066	0.360	0.638
STD	-0.647	-0.119	0.052	1.000	0.713*	-0.114	0.144	0.279	0.835**	-0.558	-0.172
SSW	-0.842**	0.591	0.496	0.713*	1.000	-0.080	-0.180	-0.172	0.495	0.010	0.466
BRX	0.203	-0.005	0.380	-0.114	-0.080	1.000	0.747*	0.067	-0.273	0.225	0.193
POL	0.428	-0.385	-0.006	0.144	-0.180	0.747*	1.000	0.468	0.107	-0.069	-0.042
PUR	0.378	-0.593	-0.224	0.279	-0.172	0.067	0.468	1.000	0.010	-0.668	-0.520
FIB	-0.537	-0.223	-0.066	0.835**	0.495	-0.273	0.107	0.010	1.000	-0.379	-0.118
NMC	0.054	0.710	0.360	-0.558	0.010	0.225	-0.069	-0.668	-0.379	1.000	0.828**
CYD	-0.230	0.857	0.638	-0.172	0.466	0.193	-0.042	-0.520	-0.118	0.828	1.000

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

Where,

TLC: Tiller counts at 120 days; STH - Stalk Height (cm); STD: Stalk Diameter (cm); SSW: Single Stalk Weight (kg); CYD: cane yield (Ton/hac); Juice Cane Brix (%); POL: Juice pol%; PUR: Juice purity%: FIB: Cane fiber%: NMC - Number of millable cane at harvest.

Regarding the stalk diameter character, genotypes R579 and R70 were found to register highest values followed by the genotype Kn 9376.

Three genotypes namely; R570, R579 and SP 718210 recorded highest single stalk weight at harvest followed by Kn 9367, where for the internodal number per stalk, Indian varieties namely; Co 527 and Co 997 recorded highest values for this trait, the lowest number of internodes per stalk at harvest was produced by SP 718210.

Quality characters, juice brix percent was found highest in variety Co 527 and Co997 followed by FR 718210 and R570, where juice purity percent two genotypes namely; Co 527 and R 570 recorded highest mean among the genotypes studied.

Pol percent juice ranged from 17.47 to 19.54. The highest value was noticed in genotype Co 527 at 19.44 followed by Co 997. Cane fiber percent in cane was highest in genotypes SP 718210 and FR 718210 with 17.73 and 17.70 percent respectively. The minimum

value was recorded by Co 527 among the genotypes studied.

Characters Association: Association of tillers number with cane characters namely stalk height, stalk diameter and single stalk weight was found negative between all genotypes, where with quality traits the association was found positive with exception to the cane fiber percent the association was negative.

Stalk height was associated negatively with all quality characters in this study, where its association with cane yield, number of millablecane, single stalk weight and internode number per stalk was noticed positive.

Internodal number had associated positively with single stalk weight and stalk diameter whereas the association with quality was negative. The association of the this character with cane yield and number of millable cane was positive Three quality characters namely juice brix; pol and purity percent had associated negatively with single stalk weight where its association with cane yield and millable cane was found positive Percent juice brix had negatively associated with percent juice pol and purity where the association with cane fiber percent was negative. Positive association of this character was noticed with cane yield and number of millable cane at harvest Percent juice pol, purity and cane fiber showed negative association with cane yield and number of millable cane. The latter character had showed strong positive association with cane yield.

DISCUSSION

Analysis of variance results indicated significant different between different genotypes with regard to different cane yield and quality traits indicated sufficient genetic variations among the genotypes studied. Srivastava *et al.* [8] reported that sugarcane clones vary in their ability to produce profitable crop at harvest.

The coefficient of variations was found to range from 2.09 to 13.93 indicated the accuracy of the experimentation procedure.

Among the genotypes R 579, SP 718210 and Co 6806 were the best clones in terms of yield of cane per ha. The former clones reported higher value of stalk height, stalk diameter and single stalk weight, these three characters may contributed for higher cane yield in this genotype. According to Singh and Singh [7], among the cane yield components affecting the final yield of sugarcane are the number o f millable cane, single stalk weight and stalk diameter, the stalk height and number of internodes per stalk. These characters were found to associate positively with cane yield with exception of stalk diameter; indicated improvement in any of the three charactecter may result in positive response of the cane yield. Hogarth [10] also found that a positive correlation of (0.81) between stalk height and cane yield whereas Hooda *et al*. [11] reported that a significant positive correlation between stalk diameter and clump yield.

Two genotypes namely SP 718210 Co 6806 were found to have higher number of millable cane and stalk height at harvest, the two clones were found to rank as 2nd and 3rd respectively in terms of cane yield per ha. Skinner [12], reported that stalk diameter, number of millable cane and stalk height are by far the main cane yield components. These two traits were positively correlated with cane yield and might dictated for higher cane yield in these two clones; high and positive correlation coefficients of 0.83 between number of millable cane and cane yield was reported by James [13]. Whereas George [14] found that stalk number and stalk diameter (as an indirect measures of stalk yield) were highly correlated to clump yield in three different crosses of sugarcane.

The correlation between characters and cane genotypes (Table 2) seems to play a crucial role in influencing the clump yield. Number of millable cane and stalk height are positively correlated in the material studied where as the stalk diameter had showed negative association with millable cane between the genotypes. This indicated possibility of simultaneous improvement under selection for number of millable cane and stalk height. But in contrast, although these two characters are the main yield components, simultaneous improvement of all these three characters at a time is seems rather difficult because of the predominant negative relationship between number of millable cane and stalk diameter. Hence, a judicious combination of expression of these two characters is needed for yield improvement; the limit for such difficulty is being set by stalk diameter.

Among the genotypes three clones namely Co 527, Co 997 and FR 718210 were found to produce better juice quality in terms of precent juice prix and juice pole, the association of these two traits was found strong and positive through out the materials. This might indicated simultaneous improvement of these two characters under selection. None of the above three genotypes appeared among the top genotypes for cane yield, according to this study, negative correlation between juice brix and juice pol percent was noticed. The study indicated difficulty in improvement of the cane character in one hand and juice quality characters at a time for their negative association.

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