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Association of Yield and Quality Characters in Sugarcane

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ABSTRACT

Relationship between tonnes sucrose and tonnes per hectare of cane (TS/TC) and quality traits were investigated in 46 sugarcane cultivars grown in savanah zone on Nigeria. Significant differences were observed among the clones for yield and related traits only in the ratoon crop. Negative phenotypic correlations were observed between TS/TC and other quality traits except % fibre which correlated positively. Path coefficient analyses revealed that agronomic practices which tend to increase cane yield is likely to increase the fibre content at the expense of sucrose in the juice.

INTRODUCTION

One of the criteria which determines commercial acceptability of sugarcane (*Saccharum* spp.) is sugar yields per hectare. This is usually expressed in terms of tonnes of sucrose (TS) obtainable from tonnes of harvestable cane stalks (TC). Thus, the ratio (i.e. TS/TC) in a clone is an indication of its potentiality.

TC, which is essentially cane yield in t/ha, primarily depends on stalk diameter, stalk length and number of millable cane stalks/ha. Brix content and quality traits such as % polarimeter (% POL), % Fibre, brix spindle and purity determine TS. Brix value is a useful tool in handling large number of genotypes in early stages of selection and is measured by % POL. A study elucidating the nature of the relationship between characters contributing to TC in the exotic and adapted sugarcane clones in Nigeria has been reported (Olaoye and Fatunla, 1987). An understanding of the association between TS/TC and quality characters will serve a useful guide in selecting for characters which favour increased sugar yields. In this study, phenotypic correlations and path coefficient analyses were used to obtain pertinent information on the relationship between TS/TC and these quality traits.

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MATERIALS AND METHODS

Fourty-six adapted and exotic sugarcane cultivars were grown in a randomised complete block design (RCBD) with two replications at Nigerian Sugar Company, Bacita in the 1981/82 cropping season. The plot size was single-row 5m long and 1.5m between the rows. Agronomic practices such as weed control and fertilizer application were carried out according to plantation practices. Stalk diameter, stalk length and brix content measurements were based on mean of 10 random cane stalks in each plot. Number of stalks per stool (an estimate of millable cane stalks) was based on the mean of five competitive stools selected at random in each plot. Cane yield was determined on whole plot basis at harvest and later converted to tonnes/ha.

After the initial harvest, the plant crop was left to ratoon and the same data was recorded in the 1982/83 cropping season. A 10-stalk sample from each plot was processed in a Jeffco cutter grinder. Juice was extracted from a 500 g sample of fibrated material in a Carver laboratory press. Expressed juice was analysed for brix, % Pol and % Sucrose. Residual fibre was dried at 100°C to estimate % Fibre. Purity was determined as [(% sucrose/Brix) x 100]. Kg-brix was estimated using the formula proposed by Miller (1977).

Data collected were subjected to analyses of variance (AOV) to test for significant differences among the clones for traits measured or estimated. Phenotypic correlation coefficients and path coefficient analyses as described by Johnson et. al (1955) and Dewey and Lu (1959), respectively, were computed to elucidate the nature of association between the quality traits and TS/TC. As shown in Figure 1, the direct effect (P) of a variable on (i) on TS/TC (y), is represented by unidirectional arrows while the indirect effects are shown by alternate pathways from a variable (i) through another variable j. Thus a single indirect effect is equal to the product of correlation coefficient and path coefficient i.e. I=(rij) x (Pjy).

RESULTS AND DISCUSSION

The performance of the clones was similar in the plant crop with respect to all the traits considered except for stalks/stool (Table 1). However, differences among clones were statistically significant in the ratoon crop (P=0.05 or 0.01). A possible explanation for the observed differences in the ratoon crop may be due to disproportionate reduction in vigour of different genotypes in the ratoon crop. This may also be responsible for the observed differences in the clones yielding abilities.

Table 1. Mean squares from analyses of variance for yield and related traits of 46 sugarcane clones grown at Bacita (Nigeria).

Source	df	stalks/ stool	Stalk diameter	Stalk length 10^3	Brix	Cane yield 10^3	Kg-brix 10^5
Replication	1	40.45	0.10	0.06	0.10	73.13	0.03
		(8.52)+	(0.01)	(4.14)	(1.32)	(0.19)	(0.10)
Genotype	45	45.85*	0.68	1.67	4.49	537.62	0.92
		(20.81**)	(0.34**)	(4.18**)	(5.46*)	(374.72**)	(0.80**)
Error	45	26.58	0.45	0.68	6.23	465.93	0.80
		(6.72)	(0.14)	(1.58)	(3.27)	(140.98)	(0.34)

+ Figure in parenthesis is for the first ratoon crop.

*,** Significant F test at 0.05 and 0.01 levels of probability respectively.

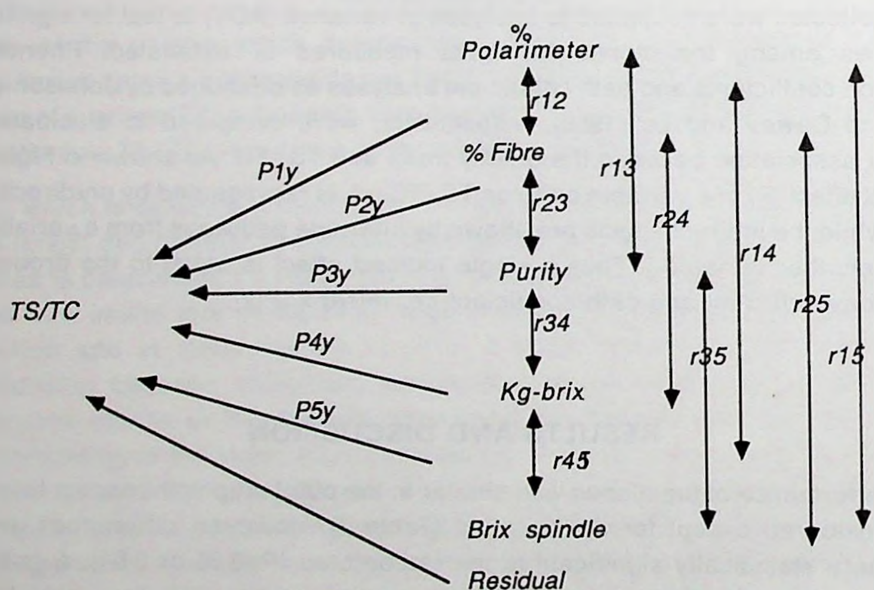

Figure 1. Path coefficient diagram of five variables on TS/TC Uni-directional arrows indicate the direct effects while the double arrows are correlation coefficients.

Three characters (i.e. % Pol, purity and brix spindle) appear to play an important role in determining the amount of sugar in the materials evaluated. These characters and brix had significant but negative association with TS/TC (Table 2). This is not unexpected in view of the fact that conditions which normally favour high cane yield (such as increased nitrogen fertilizer application, high precipitation and high temperatures) are not conducive to sucrose accumulation (Blume, 1983; Mongelsdorf, 1957; Singh and Singh, 1981). Association between TS/TC and % Fibre though positive, was not significant. Brix spindle was however observed to correlate positively and significantly with purity and % Pol (0.904 ** and 0.575**).

Table 2. Simple linear correlations of TS/TC and related quality traits in 46 sugarcane clones grown at Bacita (Nigeria).

	Brix	Brix Spindle	% Pol	Purity	% Fibre	Kg–brix
TS/TC	–0.48*	–0.787**	–0.930**	-0.881**	0.220	–0.100
Brix		0.210	0.156	0.108	0.131	0.149
Brix spindle			0.904**	0.575**	0.035	0.210
%Pol				0.845**	0.042	0.156
Purity					0.013	0.108
%fibre						0.131

*, ** Significant F test at 0.05 and 0.01 levels of probabilities respectively.

In order to understand the relationship between TS/TC and the quality traits, total correlation was partitioned into its components of direct and indirect effects by path coefficient analyses (Table 3). The term I represents total indirect effect of all variables considered in the path while C is the sum of both direct and indirect effects, r represents total observed correlation and E is the unexplained portion of the total correlation (i.e. residual). Brix was excluded from the analyses since it is part of Kg-brix. Percent Pol, which had the highest negative correlation with TS/TC (r = –0.930**), also had the largest negative direct effect (P = –0.599). With the exception of % Fibre which had a positive direct effect towards TS/TC (P=0.257), all other direct effects were negative though in some cases negligible. Thus, it appears

Table 3. Direct (on diagonal) and indirect effects (off- diagonal) of quality traits on TS/TC in 46 sugarcane clones grown at Bacita (Nigeria).

	% Pol	% Fibre	Purity	Kg-brix	Brix spindle	I	C	R	E
%Pol	-0.599	0.11	-0.303	0.003	0.042	-0.247	-0.846	-0.930	-0.084
%Fibre	-0.025	0.257	0.005	-0.004	-0.002	-0.036	0.221	0.220	-0.001
Purity	-0.506	0.003	-0.359	0.007	-0.027	-0.523	-0.882	-0.881	0.001
Kg-brix	0.050	0.029	0.065	-0.042	-0.027	-0.057	0.015	-0.100	-0.015
Brix spindle	-0.541	0.009	-0.206	-0.001	-0.047	-0.739	-0.786	-0.787	-0.001

that much of the observed increase in TC is likely due to fibre content. The large negative indirect effects (I=–0.523) made purity, which has a high negative correlation with TS/TC, less important than fibre content. High negative correlation between TS/TC is result of its interaction with % Pol and purity as indicated by their indirect effects in this study. Thus, % Pol may be a useful indicator of a variety's acceptability. It may also be a useful tool in later selection stages when juice quality becomes important in sugarcane as indicated by its direct effect towards TS/TC and its indirect effects through other characters.

Increased cane yield in terms of tonnes of harvestable canes per unit of cultivated land is the goal in commercial plantations. This undoubtedly can be achieved by growing cultivars which respond to increased N fertilizer input and other favourable environmental conditions. However, dilution effects and other impurities in the juice associated with excess N- application may lower the sucrose content and thus reduce sugar yield in terms of TS. Furthermore, much of the observed increase in yield may be due to increase in fibre content as indicated by result of this study. High firbe content lowers the milling qulaity of a cultivar and may make the cane unacceptable in the factory. Increase in fibre content has also been observed to be inversely proportional to the quantity of sucrose content in the stalk (Mangelsdorf, 1957).

Although nitrogen is essential for growth and yield, its level in the soil should be monitored before application of additional N. This will ensure an optimal utilization by the plants (Yadak, 1980), and subsequently, a leaf/stem ratio which is commensurate to acceptable sucrose level in the cane. This will also serve to reduce impurities to a reasonable level and thus facilitate crystallization in the factory. Therefore, sugarcane growers may have to focus attention on means of achieving high cane yield without necessarily increasing the fibre content. One possibility is to stop N-application about eight weeks before harvesting such that energy is diverted to synthesis and accumulation of sucrose in the stalk.

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