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Path coefficient analysis of some sugar quality parameters of chewing sugarcane as affected by fertility rates and weed control treatments at Badeggi, Nigeria

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ABSTRACT: Field trials were conducted at the upland sugarcane experimental field of National Cereals Research Institute Badeggi, Nigeria in 2004 - 2005, 2005 - 2006 and 2006 - 2007 wet and dry seasons to determine the direct, indirect and individual percentage contribution of sugar quality parameters of chewing sugarcane to sucrose yield. The results obtained show the interrelationship between sucrose yields with sugar quality parameters in the three years. The sugar quality parameters (percent brix, percent fibre, percent purity and percent polarity) had positive and direct contribution to the stalk yield. The relative direct and indirect contributions of sugar quality parameters showed percent brix as the highest of both direct and percentage contributor of (0.4512 and 20.36 to sucrose yield in 2004 - 2005, 0.4762 and 22.62 in 2005 - 2006 and 0.4809 and 22.03 in 2006 - 2007). This was followed with percent polarity next to percent brix with 0.3499 and12.24, 0.3590 and 12.89 and 0.3731and 13.92 of both direct and percentage contribution to sucrose yield in each of the three years respectively. While the lowest individual percentage contribution was obtained from percent purity of 1.72 in 2004-2005, 3.98 in 2005 - 2006 and 3.99 in 2006 - 2007. The contribution of percent fibre to the sucrose yield was negative throughout the periods of the experimentation.

Keywords:-Sugarcane, direct and indirect contribution, sugar quality, sucrose yield.

Introduction

Estimation of path coefficient analysis of various agronomic characters provides good information necessary for sugarcane breeders, when selection is based on two or more traits simultaneously. Path coefficient analysis provides and / or presents a picture of the interrelationship between agronomic (qualitative and quantitative) characters. According to Wright (1934), path analysis technique partitions correlation into direct and indirect effects; and differentiate between correlation and causation.

In agriculture, path analysis has been used by plant breeders and agronomists to assist in identifying traits that are useful as selection criteria to improve crop yield (Dewey and Lu, 1959; Milligan *et al*. 1990).

In sugarcane variety development, the technical strategy is to obtain reliable agronomic traits in the crop. These co-efficient are then subjected to apprehensive path analysis to measure and know the magnitude of the relative direct and indirect effect of these yield components traits on yield and predict their response to selection. Summarily, correlation and path co-efficient analysis have been quite useful in formulating an effective selection programme (Xie *et al*. 1991).

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This paper therefore, provides information on direct and indirect contributions of soil chemical properties along with their percentage contributions to the stalk yield of chewing sugarcane.

Materials and Methods

Field trials were conducted at the upland sugarcane experimental field of the National Cereals Research Institute Badeggi (Lat. 9°45′N, Long.06°07′E, 70.5 metres above sea level) in the Southern Guinea Savannah ecological zone of Nigeria in 2004 - 2007 wet and dry seasons.

The soil of the experimental site has been classified as ultisol and sandy loam in texture with bulk density of $1.49m^{-1}$ (Ayotade and Fagade, 1993). It has an average annual rainfall of 1124mm and mean temperature 23°C - 33°C respectively. The treatments tested consist of seven fertility rates and four weed control measures.

The treatment therefore include:- F_0 = control (no cow dung, no inorganic fertilizer), F_1 = 120N - $60P_2O_5$ - $90K_2O$kg/ha alone (NCRI recommended rate for sole sugarcane), F_2 = 10tonnes/ha of air dried cow dung (NCRI recommended rate), F_3 = 10tonnes/ha of air dried cow dung + 120N - $60P_2O_5$ - $90K_2O$kg/ha,), F_4 = 10tonnes/ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$kg/ha,), F_5 = 5tonnes/ha of air dried cow dung + 120N - $60P_2O_5$ - $90K_2O$kg/ha and F_6 = 5tonnes/ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$kg/ha constituted the main plot, while the weed control treatments W_0 = Weedy check, W_1 = hoe weeding at 1, 2, 3, 4, 5, 6 and 9MAP, W_2 = atrazine 2.0kga.i./ha (P.E) + dimethametryne 3.0kga.i./ha (Post.E) + Supplementary hoe - weeding at 3, 6 and 9MAP and W_3 = Diuron 2.0kga.i./ha (P.E) + dimethametryne 3.0kga.i./ha (Post.E) + supplementary hoe-weeding at 3, 6 and 9MAP were the sub plot.

Each treatment was accommodated in a plot area of $15m^2$ (5 x 3m) and each plot contained 6 rows of chewing sugarcane. Bida Local or Ajax was the chewing sugarcane variety that was used for the experiment. Air dried cow dung was incorporated into the soil manually using short handle hoe a month before establishing the trial. While the inorganic fertilizer was applied split at planting (½N - $½P_2O_5$ - $½K_2O$ base application) and at 6MAP during earthing up half ½N - $½P_2O_5$ - $½K_2O$ was applied. Pre-emergence herbicides were applied a day after planting, while the post - emergence was applied at 5 weeks after planting (WAP). Herbicides were applied using knapsack (CP_3) sprayer in a spray volume of 250L/ha. The supplementary hoe - weeding was carried out at 2, 4, 5, 6 and 9MAP using short handle hoe. Harvesting was done at 10MAP using cutlass. The sugarcane stalks from the net plot were tied into bundles and weighed on 50kg scale.

Chemical analysis of the sugar quality

Laboratory brix, percent fibre, percent reducing sugar, percent polarity, percent purity and percent N in sugar were determined at harvest in the NCRI laboratory after crushing five sugarcane stalks per treatment from the net plot using Jeffco Cutter / Grind (Busari, *et al*., 2000).

Laboratory percent brix

This was determined by using hand – refractometer.

Percent fibre

This was determined using Bag washing method:

$$\text{Percent fibre} = \frac{\text{Weight of dried sample}}{\text{Weight of sample + Loss during preparation}} \times 100$$

Percent reducing sugar

The reducing value of a sugar product calculated as invert sugar.

Invert sugars: The equimolecular mixture of glucose and fructose resulting from the hydrolysis or inversion of sucrose (Payne, 1968).

Percent reducing sugar was calculated as follows:

$$\frac{\text{mg reducing substance x 10}}{\text{titration x ml sample per 100ml of final solution x d}}$$

where d = density

Percent polarity

The value determined by single polarization of normal weight of a sugar product made up to a total volume of 100ml at 20°C. It is read using the Bates Jackson Saccharimeter scale (Payne, 1968).
Polarity % bagasse = Saccharimeter reading x 2.73.

$$\frac{\text{mg reducing substance x 10}}{\text{titration x ml sample per 100ml of final solution x}}$$

Percent purity

Expected final molasses. Theoretically attainable refractometer sucrose. Purity as indicated by the reducing substances - ash or the reducing substances conductivity (Payne, 1968).

$$\text{B. Purity} = \frac{\text{Reducing substances \% refractometer solids}}{\text{Specific conductance x 1,000}}$$

$$\text{A. Purity} = \frac{\text{Reducing substances}}{\text{ash (carbonate)}}$$

Statistical Analysis

The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1994).

Results and Discussion

Figures 1-3 show the interrelationship between sucrose yield (t/ha) with sugar quality parameters in 2004 - 2005, 2005 - 2006 and 2006 - 2007. The sugar quality parameters (percent brix, percent fibre, percent purity and percent polarity) studies exception of percent fibre that negatively contributed the sucrose yield all others had positive and direct contribution to the sucrose yield.

The relative direct and indirect contribution of sugar quality parameters to the sucrose yield as presented in Tables 1-3 showed percent brix as the highest direct contributor to the sucrose yield 0.4512 in 2004 -2005, 0.4762 in 2005 - 2006 and 0.4809 in 2006 - 2007. While percent polarity was next to percent brix with 0.3499, 0.3590 and 0.4731 in 2004 - 2005, 2005 - 2006 and 2006 - 2007.

Table 1: The direct and indirect contributions of different growth parameters to stalk yield (ton/ha) in 2004 – 2005.

Sugar quality parameter	**Percent brix**	**Percent fibre**	**Percent purity**	**Percent pol**	**Total correlation**
Percent brix	0.4512	-0.2978	0.2852	0.3408	0.7794
Percent fibre	-0.1789	-0.2712	-0.1584	-0.1785	-0.7870
Percent purity	0.0820	-0.0760	0.1313	0.0864	0.2240
Percent polarity	0.2543	-0.3126	0.2302	0.3499	0.5318

Direct effect underlined

Table 2: The direct and indirect contributions of different sugar quality parameters to sucrose in 2005 – 2006.

Sugar quality parameter	**Percent brix**	**Percent fibre**	**Percent purity**	**Percent pol**	**Total correlation**
Percent brix	0.4762	-0.4201	0.3046	0.3108	0.6715
Percent fibre	-0.2004	-0.2941	-0.2023	-0.2764	-0.9732
Percent purity	0.1476	-0.1372	0.1994	0.1572	0.3670
Percent polarity	0.2739	-0.3375	0.2829	0.3590	0.5783

Direct effect underlined

Table 3: The direct and indirect contributions of different sugar quality parameters to sucrose in 2006 – 2007.

Sugar quality parameter	**Percent brix**	**Percent fibre**	**Percent purity**	**Percent pol**	**Total correlation**
Percent brix	0.4809	-0.4295	0.2617	0.3700	0.7841
Percent fibre	-0.2236	-0.2951	-0.2338	-0.2416	-0.9941
Percent purity	0.1503	-0.1786	0.1998	0.1974	0.3689
Percent polarity	0.1174	-0.3590	0.3687	0.3731	0.5002

Direct effect underlined

Table 4: Percent individual and combined contribution of some sugar quality parameters to sucrose yield.

Parameters	2004-2005	2005-2006	2006-2007	2004-2007
Individual contribution				
Percent brix	20.36	22.68	23.13	22.03
Percent fibre	-7.35	-8.65	-8.71	-8.23
Percent purity	1.72	3.98	3.99	2.06
Percent polarity	12.24	12.89	13.92	13.01
Total	26.97	30.9	32.33	28.87
Combined contribution				
Percent brix and Percent fibre	-16.15	-19.08	-25.34	-16.97
Percent brix and Percent purity	7.49	14.06	14.45	7.45
Percent brix and Percent polarity	23.85	26.09	28.03	25.95
Percent fibre and Percent purity	-0.99	-8.07	-10.54	-5.94
Percent fibre and Percent polarity	-19.55	-19.85	-21.19	-16.79
Percent purity and Percent polarity	1.44	11.28	14.73	8.40
Total	-3.91	4.43	0.14	2.1
Residual	76.94	64.67	67.53	69.03
Grand Total	100.00	100.00	100.00	100.00

The percentage contribution of sugar quality parameters was examined in the three trials Tables 4. Among the sugar quality parameters, percent brix made the highest individual contribution of 20.36 in 2004 - 2005, 22.68 in 2005 - 2006 and 23.13 in 2006 - 2007.

This was followed by the contribution of percent polarity of 12.24, 12.89 and 13.92 in the three trials. While the lowest individual contribution was obtained percent purity 1.72, 3.98 and 3.99 in each of the three trials. Negative percent contribution was obtained from percent fibre of -7.35,-8.65 and -8.71 in 2004 - 2005, 2005 - 2006 and 2006 – 2007.

The percent brix and percent polarity made the highest combined contribution of 23.85 in 2004 - 2005, 26.09 in 2005 - 2006 and 28.03 in 2006 - 2007.

The path analysis and percentage contributions show that the percent brix and percent polarity made their highest individual contribution to sucrose yield. This observation indicated that percent brix and percent polarity are strong contributors to sucrose yield.

Conclusion

From this study it can be concluded that percent brix and percent polarity gave the highest contribution to sucrose yield. Therefore, these sugar quality parameters are very important to be considered when selecting sugarcane or sugar yields especially in determining possibility of obtaining optimal yield from chewing sugarcane particularly for this ecology.