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Evaluation of sugarcane hybrid clones for cane and sugar yield in Nigeria

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Field experiment was conducted in year 2015/2016 at the National Cereals Research Institute Badeggi, Niger State (sugarcane research field) to evaluate the performance of sixteen sugarcane genotypes. The clones were planted in a Randomized Complete Block Design (RCBD) and replicated three times. Analysis of variance showed significant differentiation among studied genotypes. The results revealed that among the evaluated genotypes ILS 708-05 was characterized by highest potential cane yield (105.54 t/ha). BD 1576-14 significantly had highest brix (24.90%) among the tested clones. Genotypes that performed better than the Check ([Standard] B 47419) in terms of cane yield, less flowers and tolerance to smut should be advance to multi-location trials.

Key words: *Saccharum officinarum*, hybrid clones, brix and morpho-agronomic traits.

INTRODUCTION

Sugarcane (*Saccharum* spp.) is one of the most important species cultivated in the tropics and subtropics. It belongs to the genus *Saccharum* of the family *Poaceae*. The genus comprises six species that include *Saccharum spontaneum, Saccharum officinarum, Saccharum robustum, Saccharum edule, Saccharum barberi* and *Saccharum sinensis* (D' Hont et al., 1998). Cox et al. (2000) reported that modern sugarcane varieties that are cultivated for sugar production are found among interspecific hybrids between *S. spontaneum* and *S. officinarum.* In Nigeria sugarcane is an important industrial cash crop (Olaoye, 2006). Nigeria is the largest consumer of sugar in Africa after South Africa. However, the country only produces 2% of its requirement, estimated as 1.7 million tons while imports up to 98% of the commodity. Statistics have shown that Nigeria spends ₦200 billion on sugar importation and consumes 1.43 trillion metric tonnes of sugar yearly.

The goal of sugarcane breeding programme is to increase sugar yield by increasing sugar production per unit area. According to Glaz and Gilbert (2000), sugarcane production can only be improved through the adoption of promising varieties and technologies. Increased cane yield is a function of higher genetic potential of the variety (Nazir et al., 1997). According to Olaoye (2005), production of sugarcane seedlings from genetically diverse parents or breeding clones is essential for developing high yielding, disease and insect resistant cultivars for industrial production or by local chewing cane farmers. Increasing sugar content in sugarcane crop is closely associated with height, diameter and number of the stalks, along with sugar

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accumulation in the stalk as reported by Katia et al. (2012). Sugar yields have been generally improved by increased total biomass rather than directly by increasing sugar concentration in stalks (Jackson, 2005). Aitken et al. (2008) reported that important traits to be considered in increasing sugar yield are crop vigor and productivity of the ratoon crop. Oni (2016) reported that sugar industries in Nigeria rely more on cultivars brought from overseas rather than those developed in Nigerian Research Institutes, due to inadequate information about the performance of the cultivars that were bred in the country. Assessment of performance, adaptation of different sugarcane genotypes to different environments and evaluation of their traits are necessary before a variety is released for commercial cultivation. Clone selection at pre-commercial stage can help in the identification of improved genotypes for commercial production of sugarcane (Glaz and Gilbert, 2000). This study was undertaken to evaluate some exotic hybrid clones to reveal their yield and industrial potentials over the existing varieties.

MATERIALS AND METHODS

The field evaluation study of fifteen promising sugarcane hybrid clones was conducted at sugarcane research field of the National Cereals Research Institute (N 09° 04' 14.0, E 006° 05' 26.9, Elevation: 103 m), Badeggi, Niger State, Nigeria. The fifteen clones (ILS_1576-02, ILS_1576-20, BD_1576-31, BD_1576-07, BD_1354-17, BD_1576-14, ILS_708-05, 1LS_169-06, BD_1354-20, ILS708-02, BD_1388-23, ILS_1260-03, BD_1388-31, BD_1388-33, BD_1388-43) were hybrids of crosses originated from Mauritius that were raised and evaluated through series of selection process at National Cereals Research Institute Badeggi and University of Ilorin Sugar Research Institute. The fifteen clones were promising genotypes selected to advance yield trial in the year 2016. The clones were planted in a Randomized complete block design (RCBD) and B-47419 (a prominent commercial variety) was used as a Check (Standard). Each clone was planted on 5 m x 5 m plot and replicated three times. Each plot was made up of 6 rows with inter row distance of 1 m. Ten setts were planted per row and each sett comprise of three buds. Agricultural practices for sugarcane production were adopted from the recommendations of NCRI Badeggi. Data were collected on germination and establishment of leaves at 21 and 42 days after planting respectively, tiller count at 4 months after planting; stalk girth, stalk length, number of stools per plot, number of millabe canes per plot and cane yield per plot at maturity before harvest. Percentage germination was assessed at 21 days after planting. The total number of emerged buds per net plot was counted.

$$\text{Germination (\%)} = \frac{\text{No of sprouted buds per net plot}}{\text{Total number of buds on the setts planted per net plot.}} \times 100$$

Tiller count: It is the number of the secondary growth taken from the gross plots at 3 month after planting.
Plant height: 3 and 6 months after planting plant height was recorded using a graduated meter rule from the base (ground level) of the plant to the tip of the last unfolded leaf of selected tagged sugarcane plants within the net plots.
Stalk length: this was measured from the base of the stalk to the last node with the aid of a graduated meter rule.
Number of millabe cane: Sugarcane stalk with internodes that can be milled were counted from the net plot at 12 months after planting.
Stalk girth: (cm) a veneer caliper was used for measuring the stalk girth.

Brix (sugar content) was measured by refractometer at 8th and 12th months after planting. Brix is the percentage of weight of soluble solids in juice measured by a hand refractometer (Payne, 1968). Hand refractometer is graduated in percent (1 to 30) and used to determine the level of soluble sugar in the juice squeezed out of crushed sugarcane stalk. Other parameters include flowering behavior, and smut incidence per plot. The extent of flowering was recorded on a rating scale of 1 to 3 (3 = Profuse flowering, 2 = Shy flowering and 1= No flowering). Observation of flowering starts from August to December since, that is the period sugarcane flowers in our environment (Nigeria). Smut incidence was checked every month (starting from germination to harvesting) and the numbers of smutted stalks are taken.

$$\text{Smut per plot (\%)} = \frac{\text{Number of smutted stalk per plot}}{\text{Total number of stalk per plot}} \times 100$$

The collected data were used for analysis of variance (ANOVA) using Crop Stat (version 7.2) package. LSD (least significant difference at 5% level of probability) used for means was significant.

RESULTS AND DISCUSSION

The results showed significant ($P \leq 5\%$) differences among the tested genotypes for most of the studied traits except germination and establishment count, tiller number, plant height (six months after planting), millable canes/plot and number of stalks/stool (Tables 1 and 2). B 47419 variety was characterized by the tallest plants (161.27 cm) and was significantly different from the other genotypes except BD 1354-17, ILS 169-06, BD 1354-20, ILS 708-02, BD 1388-23, ILS 1260-03, BD 1388-31and BD 1388-43. BD 1576-14 had the highest percentage germination (52.8). BD 1354-17 showed higher establishment number (144.3), which was significantly the same with other genotypes. The significant differences noted among the studied genotypes was in accordance with the findings of Arain et al. (2011), who recorded significant differences for plant height while evaluating 11 sugarcane clones for qualitative and quantitative traits under the agro-climatic condition of Thatta.

Table 2 shows the mean values of yield parameters for the hybrid clones at maturity (12 months after planting MAP). The highest number of cane stools per plot was presented in ILS 708-02 genotype which was significantly the same with B47419 and the least cane stools/plot was recorded in BD 1576-31 genotype. The significant variation in stalk length and number of millable canes per plot in this study is in accordance with the result of Muhammad et al. (2014), who reported assessment of sixteen sugarcane varieties in Pakistan. Maximum stalk girth (2.90 cm) was recorded for ILS 708-05 genotype, which is comparatively better than the stalk girth (1.93

Table 1. Mean values of hybrid sugarcane clones at vegetative stage.

GENOTYPE	GERM	EST	TILLER	PLH3	PLH6
B 47419	40.9	128.7	173.3	161.3	287.5
ILS 1576-02	36.1	48.7	61.7	96.5	271.4
ILS 1576-20	40.5	114.3	95.3	88.3	285.9
BD 1576-31	19.5	67.3	67.0	91.5	274.4
BD 1576-07	39.6	125.0	99.3	102.5	293.4
BD 1354-17	36.9	144.3	96.0	126.2	360.8
BD 1576-14	52.8	124.7	158.0	105.5	289.5
ILS 708-05	25.9	76.7	87.7	114.6	264.3
ILS 169-06	35.7	47.3	25.7	124.6	276.4
BD 1354-20	44.9	102.3	114.7	140.3	290.2
ILS 708-02	37.6	117.3	146.7	142.0	291.4
BD 1388-23	33.2	138.3	86.7	144.1	286.7
ILS 1260-03	44.5	73.3	53.7	125.3	285.3
BD 1388-31	51.3	88.3	54.3	141.6	303.3
BD 1388-33	32.1	54.7	33.0	112.9	277.5
BD 1388-43	46.3	69.00	98.0	131.8	288.5
Significances	ns	ns	ns	*	Ns
LSD (P<5%)	30.5	68.5	97.8	42.2	68.9
CV (%)	47.4	43.2	64.7	20.8	14.3

GERM= Germination (%), EST= Establishment Number, Tiller= Number of Tillers, PLH3= Plant height (cm) at 3 months after planting, PLH6= Plant height (cm) at 6 months after planting, ns= not significant, *, **= significant, CV= coefficient of variation. Data represents Means with LSD at P≤5%.

Table 2. Mean values of the yield parameters among hybrid sugarcane clones at maturity.

Varieties	MILLAB	STALKS	STOOLP	STALKG	STALK LNT	SINGLES	CANEY
B47419	196.3	8.7	28.7	1.9	187.2	0.6	89.2
ILS 1576-02	138.3	9.6	20.0	2.2	152.9	0.5	60.2
ILS 1576-20	165.7	7.5	26.0	2.2	186.1	0.8	64.2
BD 1576-31	111.3	7.8	15.0	2.3	174.4	0.9	46.3
BD 1576-07	152.3	8.6	31.0	2.1	170.4	0.5	84.3
BD 1354-17	167.3	9.1	32.7	2.2	206.1	0.8	103.4
BD 1576-14	140.0	7.5	26.0	2.2	179.9	0.7	74.3
ILS 708-05	153.0	7.5	21.3	2.9	202.7	0.9	105.5
ILS 169-06	134.7	9.7	27.7	2.1	213.3	0.8	70.1
BD 1354-20	151.3	8.6	29.7	2.4	211.1	1.0	89.4
ILS 708-02	155.7	5.3	35.0	2.7	214.9	1.1	80.5
BD 1388-23	179.0	7.4	28.3	2.3	203.1	0.8	85.6
ILS 1260-03	103.0	6.0	29.0	2.3	206.5	0.8	77.4
BD 1388-31	124.7	7.7	32.3	2.4	199.8	1.0	102.5
BD 1388-33	76.7	7.9	21.7	2.4	212.7	0.9	65.7
BD 1388-43	141.0	9.5	27.3	2.3	204.1	0.7	83.4
Significances	Ns	ns	*	**	**	*	**
LSD (P<5%)	70.9	2.8	9.0	0.3	13.5	0.3	23.4
CV (%)	29.7	20.9	20.0	7.9	9.6	21.6	17.5

Data represents Means with LSD at P≤5%. Millab= Millable canes/plot, STALKS= Stalks/stool, STOOLP= Stools/plot, STALKG= Stalk girth (cm), STALK LNT= Stalk length (cm), SINGLES= Single stalk weight (kg), CANEY= Cane yield (t/ha), ns= not significant, *, **= significant, CV= coefficient of variation.

Table 3. Mean values of the sugar content (Brix) of the hybrid clones at 10 and 12 months after planting.

Varieties	Brix at 10 months	Brix at 12 months
B47419	19.3	20.7
ILS 1576-02	20.9	24.07
ILS 1576-20	18.0	21.3
BD 1576-31	20.6	23.9
BD 1576-07	22.0	23.8
BD 1354-17	17.9	19.9
BD 1576-14	23.7	24.9
ILS 708-05	18.7	20.9
ILS 169-06	19.7	22.5
BD 1354-20	17.7	20.9
ILS 708-02	21.2	23.7
BD 1388-23	20.5	20.7
ILS 1260-03	19.9	20.2
BD 1388-31	17.6	19.7
BD 1388-33	17.7	21.0
BD 1388-43	19.2	19.9
Significances	**	**
LSD (P<5%)	2.2	1.6
CV (%)	6.8	4.3

BRIX 10= Brix at 10 months (%), BRIX 12= Brix at 12 months (%), ns= not significant, *, **= significant, CV= coefficient of variation
Data represents Means with LSD at P≤5%.

cm) of the commercial Check variety (B47419). ILS 708-02 had the heavier single stalk weight which was significantly not differrent from BD 1576-31, ILS 708-05, BD 1354-20, BD 1388-23, BD 1388-31 and BD 1388-33. The highest cane yield (105.54 t/ha) was recorded in ILS 708-05 genotype, while ILS 1576-02 genotype gave the lowest cane yield (60.22 t/ha) among the other genotypes. The high cane yield expressed by some genotypes in this study can be attributed to diverse genetic composition of the clones which arose from the wide genetic differences of their parents. Maqbool et al. (2001) reported that higher cane yield is the function of higher genetic potential of a variety. The result of cane yield in this study was similar to the work of other researchers that reveal significant differences in cane yield among some sugarcane genotypes. Khan et al. (2003, 2002), Junejo et al. (2002) and Muhammad et al. (2014) reported high cane yield of different sugarcane genotypes in their respective studies.

At ten twelve months after planting, the highest brix (23.70 and 24%, respectively) indicating the sugar content was recorded in BD 1576-14 hybrid clone. This was significantly at par with BD1576-07 and greater than those recorded for other genotypes (Table 3). The results also revealed that sugar content of some genotypes improves with sugarcane crop age between ten to twelve months. This can sometimes be used to identify maturity period of the sugarcane variety. The variation among the studied clones in brix percentage agrees with the report of a study carried out in Nigeria by Kwajaffa and Olaoye (2014); this showed significant variation among 20 genotypes (from 17.8 to 25.0%). Mohammed et al. (2014) reported non-significant differences among some sugarcane varieties for brix percentage and stated that it may be due to the uniform expression of genes for these attributes.

The results in Table 4 showed smut incidence of the studied hybrid clones. It revealed that not all genotypes were affected by the smut disease in the first plant crop including the Check (B47419) when smut incidence was scored at 3, 6 and 10 months after planting. However, eight hybrid clones were infected with smut whip at one time or more during this study. Similar trend had also been reported by Hafiz et al. (2009) that there exist differences in reaction to smut disease among tested cultivars/lines. It was confirmed that the source of resistance against smut exist among the genotypes studied and can be utilized to evolve new high yielding sugarcane varieties.

Table 5 showed differences observed among the studied genotypes for flowering attribute. It was observed that four genotypes (ILS 1576-20, BD 1576-07, BD 1388-23 and BD 1388-33) flower less and three genotypes (B47419, ILS 1576-02 and BD 1388-33) do not flower in

Table 4. Smut incidence observed in the study genotypes at 3, 6 and 10 months after planting.

Varieties	SMUT 3	SMUT 6	SMUT 10
B47419	N	N	N
ILS 1576-02	N	N	N
ILS 1576-20	N	N	1
BD 1576-31	N	N	N
BD 1576-07	N	N	N
BD 1354-17	N	N	N
BD 1576-14	N	N	N
ILS 708-05	N	N	1
ILS 169-06	N	N	1
BD 1354-20	N	N	N
ILS 708-02	N	1	N
BD 1388-23	N	2	1
ILS 1260-03	N	2	1
BD 1388-31	N	N	N
BD 1388-33	1	2	1
BD 1388-43	1	1	2

Note: N= no smut observed, 1-3= smutted stalks/plot (%).

Table 5. Flowering behavior of the hybrid sugarcane clones at 12 months after planting.

Genotypes	Flowering observation at 12 Months
B47419	Nil
ILS 1576-02	Nil
ILS 1576-20	Shy
BD 1576-31	Profuse
BD 1576-07	Shy
BD 1354-17	Profuse
BD 1576-14	Profuse
ILS 708-05	Profuse
ILS 169-06	Profuse
BD 1354-20	Profuse
ILS 708-02	Profuse
BD 1388-23	Shy
ILS 1260-03	Profuse
BD 1388-31	Shy
BD 1388-33	Nil
BD 1388-43	Profuse

this environment (NCRI sugarcane field). The genotypes that flowered profusely were not advanced to multi-locational trial, because flowering is an undesirable attribute under commercial sugarcane production. Flowering results in progressive reduction in cane and sucrose yield if harvesting is delayed in such varieties (Fadayomi et al., 1995).

Conclusion

The genotypes (BD_1354-17, BD_1354-20 and BD_1388-31) that showed tolerance to diseases/pests, high yielding and flower less can be selected for more evaluation under different ecologies. Those genotypes (BD_1576-31, BD_1576-07, BD_1576-14, and ILS_708-

02) that have better sucrose/cane yield but susceptible to diseases/pest and flower profusely can be maintained and used as parents in germplasm for further improvements.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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