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PERFORMANCE OF SOME SUGARCANE (*SACCHARUM OFFICINARUM*) ACCESSIONS FOR RESISTANCE TO SMUT DISEASE AT NATIONAL CEREALS RESEARCH INSTITUTE, BADEGGI, NIGERIA

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ABSTRACT

There is a need for continuous assessment and development of smut-resistant sugarcane varieties, as the sugar estates in Nigeria depend heavily on exotic cultivars that are susceptible to pests and diseases, and suffer rapid yield decline due to non-adaptability in their new environment. A study was conducted to assess the performance of 35 sugarcane accessions under smut infestation at the National Cereals Research Institute (NCRI), Badeggi, Niger State, Nigeria. The clones were planted using a Randomized Complete Block Design (RCBD) with three replications. Analysis of variance reveals significant differences among the clones for some traits. The highest cane yield (112.80, 111.10, and 104.43 t/ha) was recorded for NCS-009, NCS-003, and NCS-002, respectively, in the accessions (1st plant crop). The maximum cane yield for the ratooned crop was observed in NCS-002 (74.43 t/ha), which was significantly heavier than the yield documented for many of the studied accessions, except for NCS-003, DB75159, NCS-001, B-2, NCS-009, and B 245/B0197. Generally, there was a noticeable yield decline in the ratoon crop of the studied accessions, except for B881602 and DB75159, which deviate from the trend above. The best brix of 23.00 % was recorded for Cp72-2086-1 in the plant crop, while BR 971007 and Cp72-2086-1 *had the best brix mean value of 23.87 and 23.70 % in the ratooned crop. NCS-002, NCS-007, KNB9218, NCS-003, DB75159, BR971007 and B 245/B0197 proved to be highly resistant to smut infestation during the plant crop in the year 2019 and the ratooned of sugarcanes accessions in year 2020 reveals that NCS-002 was highly resistant to smut and NCS-007, KNB9218, B51410, NCS-003, DB75159, NCS-009 were also resistant to the disease. This evaluation has revealed the potential of some sugarcane accessions and their response to smut disease, paving the way for their utilization in the breeding program.*

Key Words: smut, accession, resistant, susceptible

INTRODUCTION

Sugarcane (*Saccharum* spp.) is one of the most important grass species cultivated in the tropics and subtropics (Solomon *et al*., 2019). It belongs to the genus *Saccharum* of the family Poaceae. The crop has recently been utilised for a wide range of value-added products that extend beyond food, including bioethanol, bioelectricity, biohydrocarbons, and biochemicals. It contributes approximately 75% of the World's sugar production, with sugar beets producing the remainder (Mani *et al*., 2019). Sugarcane is a significant industrial cash crop in Nigeria (Olaoye, 2006), and its cultivation is highly beneficial as it yields numerous products and makes a substantial contribution to the national economy.

Sugarcane whip smut (*Sporisorium scitamineum*) is a highly destructive disease in all sugarcane-growing areas of the World, including Nigeria (Sarmad, 2016; Wada *et al.,* 2016). It was first reported in Natal, South Africa, in 1877, and for many years, it was mainly restricted to the Old World, where it caused repeated outbreaks (Mohammed, 2016). According to Mohammed (2016), the disease was first noted on *Saccharum sinense*. To date, it remains the most devastating fungal disease problem in many African sugarcane plantations, often posing a serious menace in sugarcane-growing areas. It is a severe disease of sugarcane which causes significant quantitative and qualitative losses to cane farmers worldwide. According to Braithwaite *et al.* (2008), yield losses may be 39-56 % in the planted crop and 52-73 % in the ratoon crop. The most effective and sustainable means of containing the pathogen is through the use of resistant varieties (Sundravadana *et al.,* 2011; Philip *et al*., 2010).

Evaluation and screening of promising smut resistance clones from diverse sugarcane germplasm to serve as parents in hybridisation programs, which will result in the development of smut-resistant and high-quality varieties, is paramount. Different sugarcane clones are grown by farmers worldwide, and scientists in Nigeria have made efforts to collect, evaluate, and screen this germplasm for yield performance and sources of disease and pest resistance in existing collections. However, due to varietal degeneration and changes in smut races, it has become crucial for continuous hybridisation activities to generate smut-resistant genotypes that will replace any obsolete clones. Variety resistance is retained for a few years, while a known resistant variety may succumb to a new physiological strain (or race) of smut due to changes in climatic conditions (Mansoor *et al*., 2016). The disease-resistant germplasm of sugarcane plays a leading role in assessing resistant varieties through breeding programs (Begum *et al*., 2007). Resistant genotypes of sugarcane could play a vital role in reducing the yield loss caused by the disease. There is evidence that selecting resistant parents for hybridisation programmes would improve the level of resistance in progenies (Glyn, 2004). Therefore, screening sugarcane genotypes against smut disease is a prerequisite in varietal development activities before hybridisation and releasing varieties for commercial purposes.

MATERIALS AND METHODS

The experiment was conducted at the sugarcane research field of the National Cereals Research Institute (NCRI) in Badeggi (Latitude 9° 3' 0" N, Longitude 6° 9' 0" E), Niger State. Thirty-five sugarcane accessions were sourced from the National Sugarcane Germplasm at NCRI, Badeggi.

The sugarcane accessions were used as the experimental treatments. The experiment was conducted in a randomised complete block design with three replications. The mass multiplication of the pathogen *(Sporisorium scitaminea)* was achieved by culturing the broth on 0.2 % Yeast Extract Sucrose Broth (YESB). In a 2-litre round-bottom flask, 1 litre of distilled water was added to 20 g of sucrose and 2 g of yeast extract. The flask was then autoclaved at 121 °C and 15 kPa pressure for 20 minutes. After cooling under aseptic conditions, the media were inoculated with a one-week-old pure culture of *Sporisorium scitaminea* and stored at room temperature for 10 days. The mycelial mat from the day-old broth was collected, ground using a grinder, and examined for spore load using a Haemocytometer. The minimum spore load of approximately 2 × 10^6 was achieved by diluting the ground product with distilled water. This culture was used for inoculation of sugarcane sets.

Finally, the inoculum density was adjusted to 4 × 10^6 spores/ml with the help of a haemocytometer (Nasr, 1977). The planting materials (setts) were wholly immersed in the smut inoculum for an hour. The sets were then removed and put into a sack under shade for 14 hours before planting. Ten inoculated sets were planted (laid end to end) per row at a depth of 6-7 cm and covered with topsoil. The stalks were cut into three budded setts and grown in a single row, 5 m long, with an inter-row spacing of 1 m. The experiment covers a total area of 18 m x 34 m (612 m2). The plant crop was established on 11 February 2019, and the accessions were ratooned on 15 January 2020.

Data were collected on sprout (%) count at 21, tiller count at 3 months after planting, plant height at 3 and 6 months after planting, stalk length, Milleable stalk per plot and cane yield ton/ha at maturity. Brix (sugar content) was measured with the aid of a refractometer at 12th months after planting. The smut index was expressed by reaction types evaluated using a numerical rating scale of 1-9, where 1 indicated highly resistant and 9 indicated highly susceptible, as described by Satya and Beniwal (1978). The data collected were used for analysis of variance (ANOVA) using the Crop Stat package (version 7.2). Means were separated using LSD (P<5%) where significant differences occurred among the genotypes.

RESULTS AND DISCUSSIONS

There were significant differences among the studied accessions in sprout percentage (Table 1). D 8687 yielded the best sprout per cent (67.80%), while accessions B 9054 and B-2 had very low sprout performance (16.23% and 24.47%, respectively) in their plant crop. However, with the establishment of ratoon crops, NCS-009 and NCS-007 were significantly ($P < 0.05$) better in sprouting (67.67% and 63.33%, respectively) than all the screened accessions, except NCS-002, B85266, BR00001, and B245/B0197. NCS-007 produced more tillers in the plant crop, which was significantly ($P < 5\%$) better in the number of tillers recorded for some of the studied accessions, except B85266, KNB9218, NCS-003, B-2, BBZ951034, SP81-3250, NCS-009, RB86-7512, BR971007, B47419, and B245/B0197. The ratoon crop results showed that NCS-002 maintained the best number of tillers (60.67) and is significantly similar to the number of tillers recorded for NCS-007, B85266, NCS-003, NCS-009, B47419, and B245/B0197. The lowest mean number of tillers was observed in BOO 270. According to Sharma and Agarwal (1985), good sprouting and tillering, with synchronised millable canes of average thickness, are desired selection parameters to evaluate the agronomic performance of sugarcane varieties. Diseased plants produced tillers, some of which were of no use, as the emerging tillers were very weak and later revealed smut, thereby terminating their growth. Sugarcane smut disease had been noted to cause a reduction in sprout percentage of sugarcane sets and an increase in the number of tillers, contrary to healthy plants (Ferreira and Comstock, 2001).

The plant height at six months after planting differs significantly ($P < 0.05$) among the accessions, with KNB9218 exhibiting the maximum plant height (266.67 cm). During the ratoon crop cycle, DB75159 had the tallest plant height at six months after planting, which did not significantly differ from the plant height documented for NCS-002, KNB9218, NCS-003, NCS-001, SP81-3250, N27, RB86-3129, NCS-006, NCS-009, RB86-7512, NCS-008, BBZ92653, and B 245/B0197.

Table 2 reveals significant differences among some sugarcane accessions under smut infestation for yield parameters. NCS-003 has more average millable stalks than all the evaluated entries except NCS-002, NCS-007, KNB9218, N27, RB86-3129, NCS-009, and B 245/B0197. The milleable stalks of ratooned crop were higher in NCS 002, which did not significantly differ from the number of milleable stalks recorded for NCS-007, NCS-003, B-2 NCS-003 and B 245/B0197. A very high reduction in the number of milleable stalks of the ratoon crop was noticed in B85266, Boo 270, B881602, B96399, and B93220. Additionally, some of the screened accessions (NCS-002, B-2, SP71-618, NCS-006, NCS-009, and NCS-008) exhibit a greater number of milleable stalks in the ratoon crop above the plant crop. The increase in the number of tillers at the early stage of growth and the reduction in stalk population during sugarcane growth are characteristics of several gramineous species. The phenomenon of cane stalk mortality may be related to factors that induce competition for growth conditions (light, moisture, and nutrients), and the survival of tillers after competition is a characteristic of a variety (Getaneh *et al.,* 2015). However, in this study, the survival of the tillers might also depend on the inherent disease resistance of the accessions and the smut strain pathogen present in the environment.

RB86-3129, NCS-006 and NCS-009 show longer stalks (236.7, 233.3 and 230.30 cm) in the plant crop result, which were similar to the stalk length of KNB9218, B881602, NCS-001, B96399, SP81-3250, N27, NCS-005, B93220, BBZ 921101, NCS-008, 0535, BBZ92653 and B 245/B0197. B9054 had the shortest stalk length (149.23 cm) during the plant crop. The ratoon result reveals that NCS-009 and B 245/B0197 perform better in stalk length (186.10 & 186.0cm), while the shortest stalks were observed in B85266, B51410 and Cp72-2086-1 (107.23, 106.90 & 109.0 cm). There was a general reduction in stalk length of the ratooned crop as against what was observed for the plant crop.

A maximum Brix of 23.00% was recorded for Cp72-2086-1, which was significantly the same as the Brix mean values of B51410, NCS-003, BR00001, RB94-2291, SP71-618, B93220, and BR971007. Many of the studied accessions show an increase in Brix of the ratooned crop. BR 971007 and Cp72-2086-1 had the best Brix mean values of 23.87% and 23.70%, respectively. NCS-006 performed poorly in terms of brix (17.13 %) in the ratoon crop. Khan *et al*. (2017) have also reported differences in brix among some evaluated sugarcane varieties in Ethiopia.

The thirty-five studied accessions show highly significant disparities in their cane yield per hectare. Three accessions, such as NCS-009, NCS-003, and NCS-002, yielded higher cane yields (112.80, 111.10, and 104.43 t/ha) and were better than some of the evaluated entries. The lowest cane yield of the plant crop was recorded in B881602 (22.57 t/ha). The maximum cane yield mean value for the ratooned crop was observed in NCS-002 (74.43 t/ha), which was significantly heavier than the yield documented for many of the studied accessions, except for NCS-003, DB75159, NCS-001, B-2, NCS-009, and B 245/B0197. The variability observed in cane and other studied traits among the accessions confirms that the accessions differ in their genetic make-up due to diverse parents. El-Geddaway *et al*. (2002) stated that sugarcane varieties are greatly affected by genetic make-up. Several authors (Bahadar *et al*., 2000; Getaneh *et al*., 2015) have reported variations in cane yield among accessions from diverse parents across different ecologies. According to Keerio *et al.* (2003), unless the genetic potential of a variety is high, merely providing growing conditions, such as manuring and irrigation, will not lead to appreciable improvement in cane or sugar yield.

Table 1: Mean values of growth performance of sugarcane accessions screened for smut resistant at NCRI Badeggi (2019-2020 and 2020/2021)

Note: PC= plant crop, RC = ratooned crop, PLH 3 MNT= plant height at 3 months after planting, PLH 6 MNT= plant height at 6months after planting.

ACCESSIONS	SPROUT		TILLER		PLH 3 MNT(cm)		PLH 6 MNT(cm)	
	PC	RC	PC	RC	PC	RC	PC	RC
NCS-002	58.90	55.00	26.00	60.67	155.43	174.10	243.43	198.57
NCS-007	41.13	63.33	40.33	57.33	144.20	129.77	221.53	152.10
B 85266	64.47	48.67	29.33	49.33	126.63	134.67	226.43	141.77
B 9054	16.23	28.67	17.00	23.00	141.00	133.13	186.23	136.00
KNB 9218	45.53	34.33	33.67	39.33	163.80	186.90	266.67	188.67
B 51410	41.10	29.33	26.67	26.67	136.77	140.67	220.63	186.30
NCS-003	56.70	42.00	29.00	49.67	165.77	179.20	245.33	207.53
BR 00001	62.20	56.33	22.67	30.67	153.53	166.47	239.53	186.47
BOO 270	42.23	17.67	23.00	7.67	125.43	111.67	226.80	156.00
B 881602	42.23	21.00	15.33	12.67	109.00	117.53	214.57	133.57
DB 75159	34.43	15.00	10.67	19.67	134.90	171.80	235.13	229.10
NCS-001	42.20	32.33	23.00	30.67	145.57	158.00	219.70	194.30
B-2	24.47	33.67	27.33	35.33	134.87	145.43	226.00	184.20
B 96399	34.43	32.67	16.33	13.67	147.00	128.87	225.23	173.53
BBZ 951034	54.47	33.00	28.00	16.67	147.87	137.00	232.23	168.33
SP81-3250	46.70	37.00	38.67	32.33	147.33	161.47	233.37	213.67
D 8687	67.80	29.67	17.00	24.00	166.97	171.23	245.53	219.87
N 27	56.70	36.33	21.00	23.33	146.10	162.10	225.43	200.67
RB 94-2291	44.43	31.67	25.00	22.33	142.77	146.13	244.67	177.90
NCS-005	40.00	28.00	16.00	16.67	148.10	130.57	224.30	185.37
SP71-618	38.90	36.33	22.33	27.67	141.43	142.00	219.77	178.10
RB 86-3129	38.90	29.00	19.00	22.00	160.77	153.33	231.30	227.57
NCS-006	47.80	40.00	24.67	36.00	157.00	156.33	231.30	200.43
NCS-009	57.80	67.67	34.33	44.33	153.87	177.67	250.20	211.43
CP 72-2086-1	35.53	9.00	23.00	9.00	139.00	142.23	226.90	187.00
B 93220	45.53	26.00	25.33	19.00	152.53	132.77	221.33	146.57
RB 86-7512	63.37	30.67	36.00	22.33	165.00	181.33	241.53	199.47
BR 971007	41.10	32.33	27.33	25.33	160.77	151.10	227.77	170.47
BBZ 921101	37.80	31.67	12.00	29.33	157.00	151.30	244.57	173.43
B 47419	41.10	30.67	35.33	34.00	123.00	122.23	218.00	180.57
NCS 008	44.43	51.67	22.00	46.00	188.57	171.20	238.00	209.13
RB 82-5211	45.60	30.33	14.67	24.33	161.77	154.87	228.67	181.70
O535	54.43	38.67	17.33	36.67	136.90	167.20	233.33	175.87
BBZ 92653	63.33	47.33	26.00	39.33	150.77	160.80	249.47	198.67
B 245/B 0197	46.67	51.00	25.67	46.33	152.57	158.20	243.23	192.47
CV %	29.9	33.0	35.1	34.2	11.9	11.9	7.9	13.6
LSD @ 5 %	22.53	19.30	13.90	16.76	28.78	29.53	29.97	40.90

Generally, there was a noticeable yield decline in the ratoon crop of the studied accessions, except for B881602 and DB75159, which deviate from the trend above. This disease reduces the length and weight of canes (Solomon *et al.,* 2000).

Getaneh *et al*. (2015) stated that the inherent genetic make-up of a variety may have contributed to higher or lower cane yield and sugar content. They suggested that genetically improved varieties may have the ability to produce satisfactory results in terms of per-hectare yield and sugar percentage under a given set of environmental conditions. The incidence rating and reaction type of the studied accessions to smut inoculation are documented in Table 2. The resistance to smut disease caused by *S. scitamineum* and subsequent whip smut development greatly varied among sugarcane accessions in different regions. NCS-002, NCS-007, KNB9218, NCS-003, DB75159, BR971007, B 245/B0197, B9054, B51410, B-2, N27, SP71-618, NCS-009, NCS-008 and B 245/B0197 proved to be resistant to smut infestation during the plant crop.

The incidence of smut disease in ratoon sugar cane accessions reveals that NCS-002, NCS-007, KNB9218, B51410, NCS-003, DB75159, and NCS-009 were resistant, while all the remaining 28 accessions exhibited different susceptibility reactions to smut infestation. The results of this study confirm the report by Hossain *et al.* (2020) that many genotypes exhibited different reactions to smut infestation in two consecutive years. They further stated that it may be due to environmental variations and changes in races, strains, or pathotypes over the next two years. The researchers believed that the sudden breakdown of the previous resistance accessions to smut disease is a pointer to the possibility of the existence of more virulent races of *S. scitaminea* than those previously obtained.

According to Croft and Braithwaite (2006), ratooning can induce symptom development in plants that are latently infected. Marchelo *et al.* (2008) had also reported the buildup of smut in successive ratoons of cane, especially in susceptible varieties. Sundar *et al.* (2015) stated that the breakdown of disease resistance is attributed to the possible emergence of new virulent pathotypes. The variation in smut resistance among the studied accessions aligns with the report by Sabalpara *et al*. (2002), who demonstrated that the source of resistance to smut exists among sugarcane genotypes and can be manipulated through breeding to develop new, promising sugarcane varieties.

Table 2: Mean values of yield performance of sugarcane accessions screened for smut resistant at NCRI Badeggi (2019-2020 and 2020/2021)

GENOTYPES	MILEABLE/PLOT		STLK LNT (cm)		BRIX %		YIELD ton/ha		Reaction type to smut	
	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC
NCS-002	40.33	42.67	169.67	148.10	19.07	21.13	104.43	74.43	HR	HR
NCS-007	38.00	36.33	163.67	118.10	18.10	21.23	64.43	43.30	HR	MS
B 85266	30.00	5.00	161.23	107.23	18.90	21.17	56.67	36.67	HS	HS
B 9054	21.00	11.00	149.23	134.10	17.43	19.43	32.23	37.77	R	HS
KNB 9218	41.33	22.33	195.67	159.00	19.20	22.17	74.43	40.00	HR	R
B 51410	23.67	23.00	179.23	106.90	21.50	20.67	39.00	39.97	R	R
NCS-003	44.33	38.00	175.67	158.03	20.93	21.30	111.10	72.03	HR	R
BR 00001	29.00	24.67	190.37	183.47	20.90	22.40	70.00	48.30	S	HS
BOO 270	19.33	6.33	178.90	117.20	17.53	21.67	33.77	25.53	HS	HS
B 881602	13.33	5.33	197.13	130.80	20.13	20.57	22.57	27.77	HS	HS
DB 75159	17.33	17.00	195.00	158.53	20.03	19.77	48.90	54.43	HR	R
NCS-001	23.33	20.67	202.87	154.80	17.30	20.67	62.97	51.10	S	HS
B-2	30.67	38.00	183.67	168.43	18.00	20.57	78.90	52.20	R	MS
B 96399	19.00	9.33	208.87	153.80	19.97	21.20	38.90	18.90	S	HS
BBZ 951034	21.33	10.00	191.23	128.90	15.87	18.00	58.90	39.97	HS	HS
SP81-3250	23.33	22.00	206.67	159.10	19.57	20.70	62.23	38.87	MS	S
D 8687	21.00	17.33	211.43	156.37	18.87	21.30	76.67	49.97	S	HS
N 27	34.67	23.33	204.20	165.87	19.00	19.60	76.67	47.80	R	MS
RB 94-2291	24.67	13.33	185.00	137.10	21.70	19.20	71.67	25.57	MS	HS
NCS-005	20.67	13.33	199.67	139.10	17.43	19.03	52.23	34.43	HS	HS
SP71-618	24.67	27.00	190.57	143.00	20.67	19.80	66.67	40.00	R	S
RB 86-3129	32.33	14.67	236.67	152.10	18.70	21.50	80.00	48.90	MS	HS
NCS-006	21.67	22.67	233.33	153.57	15.67	17.13	80.00	48.90	HS	HS
NCS-009	37.67	46.00	230.30	186.10	18.80	21.23	112.80	62.23	R	MS
CP 72-2086-1	27.33	14.67	156.33	109.00	23.00	23.70	87.77	31.10	S	S
B 93220	22.67	8.67	195.87	138.57	20.77	22.57	46.30	34.47	HS	HS
RB 86-7512	23.67	14.00	187.00	154.10	18.67	22.10	63.33	37.80	S	HS
BR 971007	26.33	20.33	179.67	137.97	21.63	23.87	66.67	33.37	HR	MS
BBZ 921101	17.67	14.67	196.33	153.20	18.43	22.63	50.47	31.13	MS	HS
B 47419	21.33	21.67	191.67	118.10	15.67	20.03	88.33	37.77	HR	MS
NCS 008	23.33	26.67	201.67	171.43	18.30	21.53	85.57	46.67	R	MS
RB 82-5211	17.00	19.33	178.90	148.97	18.17	20.63	64.43	38.90	MS	MS
O535	21.33	21.67	209.43	170.57	18.43	21.50	54.00	36.67	S	HS
BBZ 92653	28.67	25.67	205.67	147.33	18.63	22.03	82.67	45.57	MS	HS
B 245/B 0197	37.33	34.67	210.33	186.00	17.67	22.23	78.87	62.20	R	HS
CV %	30.1	30.3	13.2	12.7	7.6	5.0	37.2	34.7		
LSD @ 5 %	12.87	10.32	41.53	30.49	2.53	1.70	40.65	24.12		

Note: PC= plant cropRC = ratooned crop, STLK LNT= stalk length

CONCLUSION AND RECOMMENDATION

Based on the results of this evaluation, it is concluded that the studied accessions exhibit different reactions to smut infestation depending on the crop cycle. Variation in response to smut infestation, as revealed by the studied accessions, suggests that the accessions differ in their genetic make-up, thus providing good opportunities for sugarcane improvement. The observed variability suggests opportunities for breeding programs that aim to combine desirable traits from different accessions to develop cultivars specifically adapted to our environment.

Released varieties (NCS 002, NCS 003, and NCS 009) that are resistant to smut should be used for large-scale production by the sugar estates in Nigeria. Some of the exotic accessions (KNB9218, B51410 and DB75159) that perform better should be evaluated in different environments

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