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Varietal Response of Sugarcane to Pests, Diseases and Water Stress in a Rain Forest Agro-ecology

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ABSTRACT— This study evaluated 10 sugarcane cultivars for their response to some biotic and abiotic factors limiting sugarcane cultivation in Nigeria. Cane setts of the cultivars were supplied by the National Cereal Research Institute (NCRI) Badeggi, Niger state, Nigeria. Planting was done on ploughed and harrowed soil, at the rate of 40 setts/plots and 1 m spacing. The total land area was 61 m x 19 m (1,159 m^2). It was divided into 30 plots of 5 m x 5 m (25 m^2). Cultivars were allocated to the plots randomly in a randomized complete block experimental design having three replicates. Data were collected for six months on sett germination, termite infestation, sett rot infection, disease incidence/severity and drought tolerance. All data were subjected to statistical analysis and mean separation using Minitab software. The results obtained showed a high percentage of sett germination for most cultivars, only N27 had below 50%. All cultivars were susceptible to termite infestation and sett rot infection, but the percentage termite infestation was low across cultivars, the highest being 10.83% (B991114 and B881104), while percentage sett rot infection was high in a few cultivars, as much as 55.00% in N27. Seven cultivars showed susceptibility to at least one of red rot, sugarcane white leaf and sugarcane mosaic diseases. Three cultivars were extremely susceptible to drought, while only two (BBZ951034 and B881104) exhibited tolerance. Two cultivars, B991114 and SP81-3250, had no incidence of any disease and were moderately tolerant to drought. There is a need for further work on them.

KEYWORDS: Sugarcane cultivars, sett germination, termite infestation, disease incidence, drought tolerance

1. INTRODUCTION

Sugarcane *Saccharum officinarum* L. is a tropical crop with immense importance. It is rich in carbohydrate and other vital nutrients [1] and can be consumed raw. Sugarcane is reported to have some medicinal value and is important in the treatment of several ailments [2], [3]. Sugar, obtained from sugarcane after processing, is important in food, beverage, brewery and pharmaceutical industries. Ethanol, a byproduct of sugarcane processing, is invaluable in science, medicine, automotive and cosmetic industries. Bagasse, left-over fibre, after processing of sugarcane, is an important source of energy, pulp and organic manure. Sugarcane production in Africa is done mostly by small scale growers. In Nigeria, South Africa and many parts of the continent, there has been a steady decline in the production of the crop in the last few years by these peasants [4], [5]. The decline is occasioned by several factors like pests, diseases, inadequate water supply, poor industrial utilization amongst other challenges. This has resulted in most of these countries not being able to meet their sugar needs. Nigeria is one of the worst-hit countries, with a near-total dependence on imported sugar. Millions of dollars are spent annually on the importation of sugar and related products [6]. One way to solve this problem is to embark on massive sugarcane cultivation in the country. Presently, some private establishments (Flour Mills Nig. Ltd and Dangote group of companies) have taken up this challenge. There is however a need to enlist peasant farmers that abound all over the country, as out- growers. Numerous challenges remained to be overcome for this dream to be a reality. Sugarcane is susceptible to a host of pests and diseases. Termites are serious pests of sett cane [7], [8]. They eat up planted setts and can cause 100%

germination failure. Sett rot caused by *Ceratocystis paradoxa*, whip smoot caused by *Sporisorium scitamineum*, red rot caused by *Physalospora tucumanensis*, sugarcane white leaf caused by phytoplasma and sugarcane mosaic, caused by sugarcane mosaic virus, are common field diseases of sugarcane. Some of these diseases are extremely difficult to manage [9- 12]. Drought is another very important limiting factor in sugarcane cultivation [13]. The crop requires lots of water during the different phases of its life cycle, which can be from 12 to 18 months. Inadequate water supply can lead to substantial loss of cane stands, especially during the germination and tillering stages. This loss may not only be from death and drying out of setts, as a result of inadequate moisture, but from increased infestation from termites that thrives in dry soils and eats up cane setts.

Effective management of these biotic and abiotic challenges requires the use of cultivars that are not only resistant/tolerant of the most devastating diseases, but that can also thrive with minimal water requirement. Disease resistance will discourage indiscriminate use of hazardous chemicals by sugarcane farmers, while tolerance to drought will bring about a reduction in the need for irrigation. These will ultimately lead to a reduction in the overall cost of production. Peasant farmers will then be encouraged to go into the cultivation of the crop, with the net result of increased production. It is to this end that the National Cereal Research Institute (NCRI) and the National Sugar Development Council (NSDC) has been at the forefront of research to develop new sugarcane cultivars in the last few years. The goal is to develop industrial grade sugarcane cultivars that will be adaptable to the different agro-ecological zones of the country. Special emphasis is laid on the development of cultivars that are resistance to whip smot (and other major diseases), drought tolerance, high Brix value and yield. The present study evaluated 10 new sugarcane cultivars, received from NCRI, for their response to pests and diseases in the rain forest agro-ecological zone of Nigeria. Their ability to survive during the dry season, with minimal irrigation was also evaluated. The aim is to increase sugarcane cultivation, and by extension, sugar production in the country, while the objectives are to; i. determine the response of each cultivar to common on-field pests and diseases ii. evaluate each cultivar for their response to drought.

2. Materials and methods

2.1 Location of experiment

The site of the study was the teaching and research farm (TRF) of The Federal University of Technology, Akure (FUTA). Akure is on longitude 5°06′ E to 5°38′ E and between latitude 7°07′N to 7°37′N. It is in the rain forest agro-ecological zone of Nigeria and is characterized by a distinct raining and dry seasons. The raining season is from March to early November, while the dry season is from late November to March. The mean annual rainfall is around 1,500 mm, and the mean temperature is about 22°C (December to February) and 32°C (March to November) [14].

2.2 Site selection

The site of the study was a well-drained soil about 40 m away from TRF mini-dam. Recent study had reported the soil type to be sandy loam alfisol [15]. The cropping history consisted of three years' sugarcane cultivation, followed by two years' fallow. Some sugarcane stands, a few Shrubs, herbs and grasses, were the predominant vegetation on the site at the time of clearing.

2.3 Land preparation and field layout.

A large portion of the land area was cleared, ploughed twice and harrowed. Thereafter, a 61 m x 19 m (1,159 m^2) portion was marked out (Plate 1a). The marked portion was divided into 30 plots of 5 m x 5 m (Plate 1b), and three replicates of 10 plots each. Inter-plot and border spaces were 1 m each. (Fig. 1a).

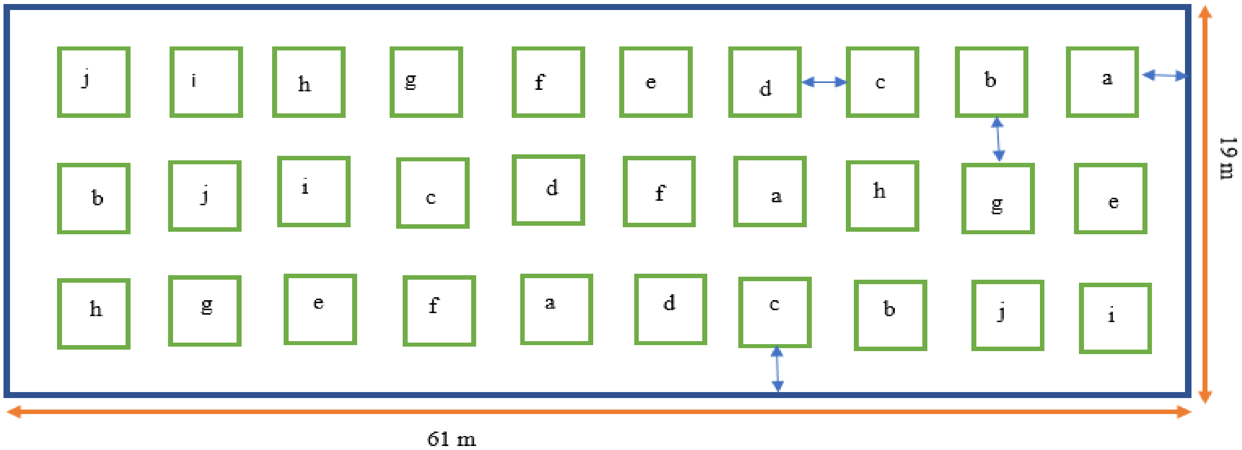

Fig. 1a. Field layout and experimental design

Total land area = 61 m x 19 m = 1,159 m^2

Legend: ⟷ = 1 m

a.= BBZ92653, b = B991114, c = B881104, d = BBZ951034, e = BBZ921101, f = BD1354-17, g = BD1388-31, h = N27, i = SP81-3250, j = B47419.

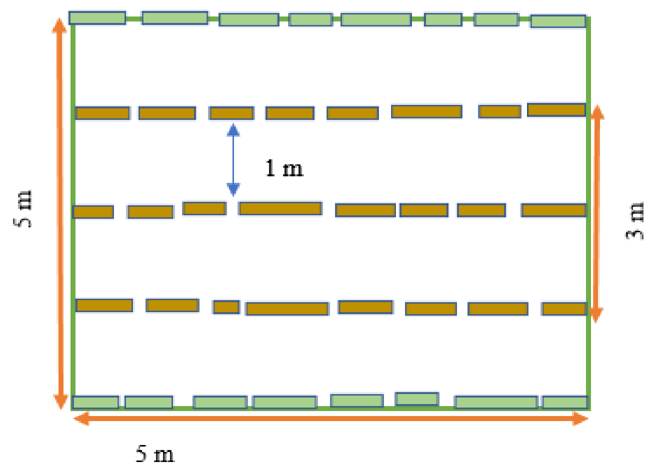

Fig. 1b. Plot size and plant spacing

Gross plot = 5 m x 5 m (25 m^2), Net plot = 3 m x 5 m (15 m^2).

2.4 Collection and planting of cane setts

Cane setts from ten cultivars were received, late September 2018, from NCRI, Badeggi in clearly labelled bags. Each bag had over 40 cane setts for each cultivar, and planting was done 2 days after collection. Cultivars were assigned to plots randomly (Fig. 1a), after which planting was done at one cultivar, and 40 setts, per plot (Fig. 1b). Five rows of setts, at 1 m apart and 8 setts per row, were laid horizontally in shallow grooves of about 5 cm depth (Fig. 1b). The first dose of fertilizer was applied after which the setts were covered up lightly with soil.

2.5 Irrigation of settlings

Cane setts were planted a few weeks before the onset of the dry season. By December 2018, 0.00 mm rainfall was recorded (Table. 1). Irrigation was done for two months, late November 2018 to late January 2019. This was to ensure that canes were properly established and to enhance their chance of survival. The water source was from the TRF dam close by and overhead sprinklers were used. Wetting regime was at three days' intervals. Wetting was done continuously until the soil was sufficiently moistened, about two hours, on each irrigation day.

Table 1. Weather data for some months in 2018 and 2019, during the planting and early growth phase of the 10 sugarcane cultivars.

Year/Month	Average monthly precipitation (mm)	Average relative humidity (%)	Average monthly temperature (^{O}C). Max.	Mean daily radiation $MJm^{-2}d^{-1}$
2018				
September	2.88	92.13	24.87	121.09
October	3.31	90.35	25.51	125.68
November	2.15	87.23	26.28	136.02
December	0.00	65.24	25.31	148.16
2019				
January	1.90	70.04	26.57	136.69
February	0.81	73.81	27.37	123.60
March	0.20	82.90	27.19	146.11
April	0.80	86.25	26.92	160.20
May	5.51	86.99	26.31	163.32

Source: West African Science Service Centre on Climate Change and Adapted Land use (WASCAL), Federal University of Technology, Akure (FUTA) Station.

2.6 Fertilizer application

Nitrogen, Phosphorus and Potassium (NPK) fertilizer at the rate of 120 kg/ha. N, 60 kg/ha. P and 90 kg/ha K, as recommended by NCRI, was applied in two halves split dose. The first application was at planting, while the second was at 9 weeks after planting. At first application, the fertilizer was placed in the shallow grooves beside the sett canes, after which they were covered with soil. At the second application, it was placed at about 6 cm away from each cane stand.

2.7 Weeding

Rapid and intense weed growth was a common feature on the cane field. This was largely connected with the wide (1 m) spacing adopted. Weed management was through manual weeding with hoe and cutlass. The frequency was about twice in three months.

2.8 Earthing-up

Earthing up was done at four months after planting. A long hip of soil was pilled, making use of hoe, at the base of each row of cane to create a long and unbroken bed. This led to the creation of grooves between each row. The grooves were blocked at both ends. Earthing up provided support for the base of cane stands and prevented lodging during the latter growth phase, while the groove retained water, ensuring a longer period of water availability after rainfall or irrigation.

2.9 Data collection

Data collection was for six months and were on the following parameters;

i. Cane germination:

The number of germinated setts were counted weekly, starting from the 2nd to the 5th week after planting. The values obtained were converted to and expressed in percentage sett germination using the formula;

$$psg = \frac{gs}{ps} x \frac{100}{1}$$

Where psg = percentage sett germination
gs = germinated setts
ps = planted setts

ii. Germination and settling failure resulting from pest and diseases
a. Germination and settling failure from pest infestation
Setts and settlings infested by insect pest were determined by digging up un-germinated setts and failed settlings. The values obtained were converted to percentage pest infestation with the formula;

$$ppi = \frac{is}{ps} x \frac{100}{1}.$$

Where;
ppi = percentage pest infestation
is = number of infested setts and settlings
ps = number of planted setts

b. Germination and settling failure from infection by pathogens.
Un-germinated setts and failed settlings resulting from infection were also determined as described for termite infestation. The values were converted to percentage sett infection with the formula;

$$pis = \frac{dis}{ps} x \frac{100}{1}.$$

Where;
pis = percentage of disease infection on setts and settlings
dis = disease infected setts and settlings
ps = number of planted setts

iii. Disease incidence
Cane stands were examined for signs and symptoms of diseases as from the second month after germination. Disease incidence was determined and expressed in percentage with the formula;

$$di = \frac{ic}{sc} x \frac{100}{1}.$$

Where;
di = disease incidence
ic = number of infected stands
sc = total number of stands sampled

iv. Disease severity index
The severity of diseases encountered in the cane field for each cultivar was determined and expressed in percentage with the formula;

$$dsi = \frac{\sum(ab)}{NK} x \frac{100}{1}$$

Where;
dsi = disease severity index
a = disease rating from the disease rating scale
b = number of infected stands
N = total number of stands sampled
K = highest value on the disease rating scale.

Three diseases were encountered in the cane field during the study. A separate rating scale was adopted/developed for each disease. The diseases and their rating scales are as listed;

a. Sugarcane mosaic
The rating scale of [9] was adopted. It consisted of a 9-rating scale as listed.
1 = no symptoms
2 = 1 - 2.5% of leaf area showing symptoms of sugarcane mosaic
3 = 2.6 – 5% of leaf area showing symptoms of sugarcane mosaic
4 = 5.1 – 10% of leaf area showing symptoms of sugarcane mosaic
5 = 10.1 – 20% of leaf area showing symptoms of sugarcane mosaic
6 = 20.1 – 35% of leaf area showing symptoms of sugarcane mosaic
7 = 35.1 – 50% of leaf area showing symptoms of sugarcane mosaic
8 = 50.1 – 75% of leaf area showing symptoms of sugarcane mosaic
9 = 75.1 – 100% 0f leaf area showing symptoms of mosaic

b. Sugarcane white leaf disease
No suitable rating scale for sugarcane white leaf disease was found from literature, consequently, a 6-rating scale was developed.
0 = no symptom of sugarcane white leaf disease
1 = 0.1 - 20% of leaf area is white
2 = 40.1 – 60% of leaf area is white
3 = 60.1 – 80% of leaf area is white
4 = 80.1 – 100% of leaf area is white
5 = Death of sugarcane shoot

c. Sugarcane red rot disease
The rating scales found from literature for sugar cane red rot disease could not be adopted because the size of the lesions were smaller than the scale could accommodate. Hence, a 6-rating scale was also developed to allow for adequate and appropriate representation of what was observed on the field. The scale is as presented
0 = no red rot lesion
1 = 0.1 – 1.0 cm lesion on cane plant
2 = 1.1 – 2.0 cm lesion on cane plant
3 = 2.1 – 3.0 cm lesion on cane plant
4 = 3.1 – 4.0 cm lesion on cane plant
5 = 4.1 cm and above lesion on cane plant

v. Drought tolerance

Data on drought tolerance were collected once in a month for two months, February (5 MAP) and March (6 MAP). Data collection on drought tolerance started about one month after irrigation stopped. Survival of cane stand for a few months during the dry season without irrigation was the ultimate goal. The fewer the number of dead canes, the more a cultivar was perceived to be tolerant of drought. Cane stands were examined carefully and the number of dead stands was determined through visual count. The response of each cultivar was expressed as percentage tolerance to drought with the simple equation;

$$dt = \frac{(a-b)}{c} x \frac{100}{1}$$

Where;
a = number of dead cane stands
b = number of dead cane stands not caused by drought drought
c = number of cane stands 4 MAP when irrigation stopped.

A 5-rating scale was developed to group the 10 cultivars, based on percentage cane death, into;

i. tolerant to drought
ii. moderately tolerant of drought
iii. susceptible to drought
iv. highly susceptible to drought
v. extremely susceptible to drought. The scale is as listed;

0 – 20% cane death = tolerant to drought
21 – 40% cane death = moderately tolerant to drought
41 – 60% cane death = susceptible to drought
61 - 80% cane death = highly susceptible to drought
81% cane death and above = extremely susceptible to drought

All data were collected from the net plot where applicable or 60% of standing canes that were picked randomly. Collected data were analyzed statistically using Minitab, version 17, software. Mean separations, at 5% level of probability, were carried out with the aid of Tukey's test

3. Results

3.1 Varietal response to termite infestation

All the cultivars were susceptible to termite attack, but infestation was minimal and differed significantly among the cultivars. The highest value of termite infestation was 10.83% on B881104 and B8811104 cultivars (Fig.2). This value was however not different, statistically, from 10.00% infestation on BBZ92653. B47419 was the least susceptible as only 0.83% of the setts were infested by termite. It was however not different statistically from SP81-3250 that had 2.50% infestation.

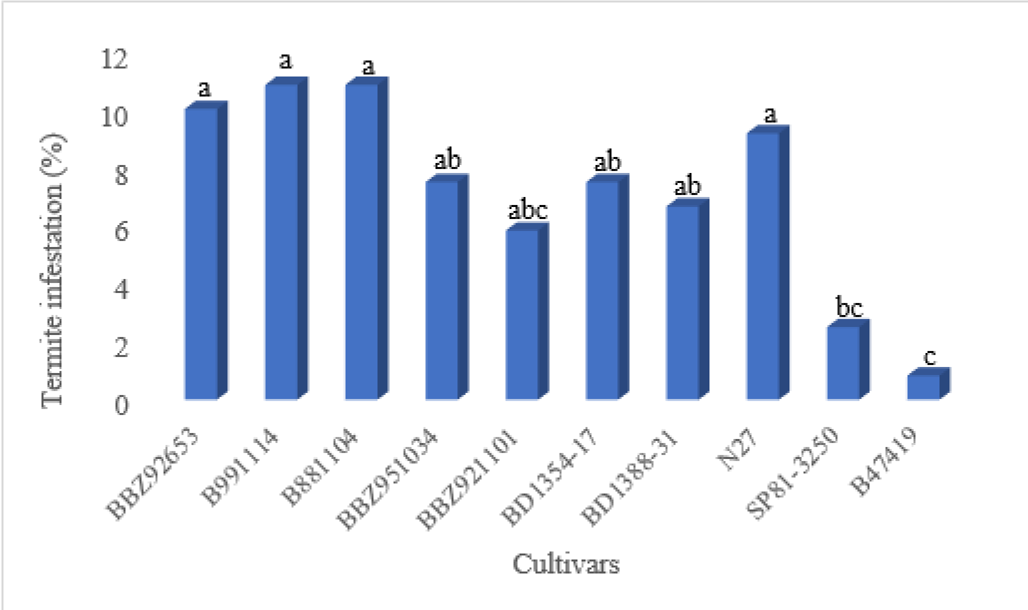

Fig. 2. Varietal response to termite infestation

3.2 Varietal response to sett rot infection

The percentage of sett rot infection was significantly different among the 10 cultivars. The least susceptible cultivar was BD1388-31. Only 2.50% setts of the cultivar were lost to the sett rot pathogen (Fig. 3). N27 was the most susceptible. A total of 55.00% of its setts were infected by *Ceratocystis paradoxa*. BBZ92653 recorded 20.86% sett rot infection. It was statistically similar to B991114, BBZ951034 and B47419 (Fig. 3). Similarly, as was observed for termite infestation, all cultivars were susceptible to sett rot infection.

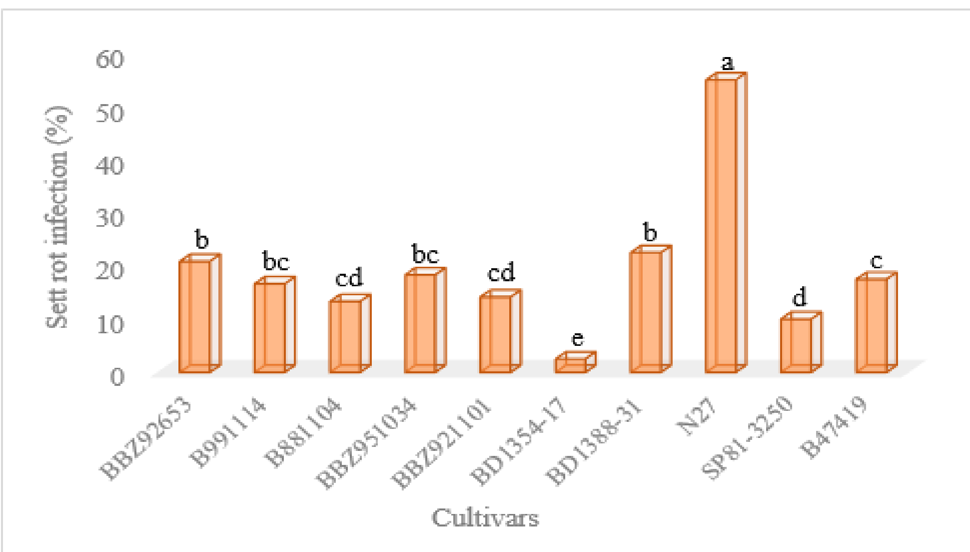

Fig. 3. Varietal response to sett rot infection

3.3 Varietal effect on sett germination

The germination percentage differed significantly among the 10 cultivars from the 2nd to the 5th week after planting (WAP). By the second WAP, 75.83% of BD1354-17 setts had already germinated (Table. 2). This was the highest germination percentage at this period. Four cultivars, B881104, BBZ951034, SP81-3250 and BBZ921101 recorded 59.16%, 53.33%,53.33% and 52.50% germination respectively. They were all statistically similar. N27 had 0.00% germination (Table 1). BD1354-17 had significantly highest germination percentage at 3 and 5 WAP, while N27 produce significantly lowest germination all through the data collection period. Overall germination was impressive though, as all cultivars, aside N27 and BBZ92653, had at least 70% germination and above (Table 2).

Table 2. Varietal effect on sett germination (%).

Cultivar	Germination (%)/ Weeks after planting			
	2	3	4	5
BBZ92653	35.58c	59.66c	69.10c	69.10c
B991114	36.11c	61.58c	70.00c	73.66c
B881104	59.16b	71.66b	75.00bc	75.33bc
BBZ951034	53.33b	70.00b	74.33bc	74.06bc
BBZ921101	52.50b	75.33b	80.16ab	80.16b
BD1354-17	75.83a	80.83a	89.33a	89.33a
BD1388-31	29.16cd	57.50c	68.33c	70.50c
N27	0.00d	25.83d	34.33f	35.00d
SP81-3250	53.33b	80.00a	85.83a	87.00a
B47419	25.83d	60.83c	71.66c	81.50b

Note. Means in the same column followed by the same alphabet are not significantly different ($p < 0.05$) according to Tukey's test.

3.4 Varietal response to diseases

Sugarcane white leaf diseases, sugarcane mosaic and sugarcane red rot were the three diseases encountered during the study.

3.5 Incidence of sugarcane white leaf disease (SWLD)

Only four, out of the ten cultivars evaluated showed symptoms of infected with SWLD. There was an increase in disease severity at the 4th month after planting (MAP), above what was recorded at the 3rd MAP and SWLD incidence differed significantly among the cultivars. BBZ951034 had the highest incidence of 20.92% and 28.83% at the 3rd and 4th MAP respectively (Table 3). B881104 and BD1388-31 were not significantly different in the two-period, while BBZ921101 had significantly lowest incidences in the same period (Table 3)

3.6 Incidence of sugarcane mosaic disease (SMD)

The incidence of SMD was recorded in three cultivars. The values obtained were significantly different at the 3rd and 4th MAP. BBZ92653 and BBZ951034 had 10.77% and 10.89% incidences respectively at 3 MAP. The two values were statistically similar. BD1354-17 had the least value at this period, 5.17%. Disease incidence values increased in the three cultivars at 4 MAP. BBZ951034 had significantly highest value, 20.62%, while BD135417 and BBZ92653 were statistically similar (Table 3).

3.7 Incidence of sugarcane red rot disease (SRRD)

A trend of increased disease incidence from the 3rd to the 4th MAP, very similar to what was recorded for SWLD and SMD was also recorded for SRRD. Four cultivars showed symptoms of the disease and the values recorded for disease incidence differed significantly among the cultivars. N27 had the highest incidences of 18.63% and 25.16% at 3 and 4 MAP (Table 3). BBZ92653 had the least incidences at both periods, 7.63% and 10.63%. Both values were however not statistically different from those recorded for BD1354-17 at the same periods (Table 3).

Table 3. Varietal effect on disease incidence among the 10 sugarcane cultivars (%)

Cultivars	Disease incidence (%)/ Months after planting					
	White leaf		Sugarcane mosaic		Red rot	
	3	4	3	4	3	4
BBZ92653	0.00	0.00	10.77a	11.30b	7.63c	10.63c
B991114	0.00	0.00	0.00	0.00	0.00	0.00
B881104	6.84b	14.52b	0.00	0.00	0.00	0.00
BBZ951034	20.92a	28.83a	10.89a	20.62a	0.00	0.00
BBZ921101	3.69c	9.74c	0.00	0.00	0.00	0.00
BD1354-17	0.00	0.00	5.17b	11.48b	9.26bc	11.70c
BD1388-31	7.07b	14.39b	0.00	0.00	10.56b	20.31b
N27	0.00	0.00	0.00	0.00	18.63a	25.16a
SP81-3250	0.00	0.00	0.00	0.00	0.00	0.00
B47419	0.00	0.00	0.00	0.00	0.00	0.00

Note. Means in the same column followed by the same alphabet are not significantly different ($p < 0.05$) according to Tukey's test.

3.8 Varietal effect on disease severity

3.8.1 Severity of sugarcane white leaf disease (SWLD)

Sugarcane white leaf disease was most severe in BBZ951034. The cultivar had 10.36% and 13.05% severity at 3 and MAP respectively. These values were statistically significant at both periods. BBZ921101 had 3.15% severity at 4 MAP. It was the lowest value, but it was not significantly different from 5.09% and 4.01% recorded for B881104 and BD1388-31 cultivars respectively (Table 4). By the 4th MAP, the severity of SWLD had increased to 13.05% in BBZ2951034 (the highest value), 7.76% in B881104, 7.51% in BBZ921101 and 4.98% in BD1388-31(the least value) (Table 4).

3.8.2 Severity of sugarcane mosaic disease (SMD)

Sugarcane mosaic was not very severe among the infected cultivars. The highest value of severity recorded was 5.42% (BBZ951034) at 4 MAP. At 3 MAP, there was no significant difference in mosaic severity among the cultivars, while at 4 MAP, BD1354-17 and BBZ92653 had 2.92% and 3.06% severity respectively and were statistically not different (Table 4).

3.8.3 Severity of sugarcane red rot disease (SRRD)

Red rot disease severity was significantly different among the infected cultivars at 3 and 4 MAP. N27 was particularly highly susceptible and disease severity was significantly the highest at the times data were collected, 19.51% (3 MAP) and 28.60% (4 MAP). BD1388-31 and BBZ92653 had statistically similar severity at 3 MAP, while BD1354-17 and BD1388-31 were not significantly different at 4 MAP (Table 4).

Table 4. Varietal effect on disease severity index among sugarcane cultivars (%)

Cultivars	Disease severity index (%)/ Months after planting					
	White leaf		Sugarcane mosaic		Red rot	
	3	4	3	4	3	4
BBZ92653	0.00	0.00	2.71a	3.06b	4.76c	6.93c
B991114	0.00	0.00	0.00	0.00	0.00	0.00
B881104	5.09b	7.76b	0.00	0.00	0.00	0.00
BBZ951034	10.36a	13.05a	3.09a	5.42a	0.00	0.00
BBZ921101	3.15b	7.51b	0.00	0.00	0.00	0.00
BD1354-17	0.00	0.00	2.05a	2.92b	6.66b	8.74b

BD1388-31	4.01b	4.98c	0.00	0.00	4.09c	9.55b
N27	0.00	0.00	0.00	0.00	19.51a	28.60a
SP81-3250	0.00	0.00	0.00	0.00	0.00	0.00
B47419	0.00	0.00	0.00	0.00	0.00	0.00

Note. Means in the same column followed by the same alphabet are not significantly different ($p < 0.05$) according to Tukey's test.

3.9 Varietal response to drought

Weather data for the period covered by this study showed 4 months with less than 1 mm of rainfall (Table 1). Irrigation was carried out to ensure canes were properly established, after which the ability of each cultivar to survival in the face of very scanty rainfall was determined. Data collected on the response of the 10 cultivars to drought showed significantly different values. The number of cane stands decreased with the increasing length of exposure to water stress in most of the cultivars (Fig. 4). N27 recorded the highest percentage cane death, 83.47% at 5 MAP. This was followed closely by B47419 with 70.53% cane death. BD1388-31 was third, 68.19% of cane stands were lost to drought. B991114 had the least percentage of cane death. Only 7.26% was recorded for the cultivar. This value was however not statistically different from 10.63% and 8.94% recorded for B881104 and BBZ951034 respectively. By the 6 MAP, substantial percentages of cane were already lost in three cultivars, namely; N27, BD1388-31 and B47419, with 91.67%, 89.64% and 88.58% cane deaths respectively. (Fig. 4). The three values were similar statistically but differed significantly from the number of cane deaths recorded for the other cultivars. The least percentage of cane death was from BBZ951034. Only 15.65% was lost to drought. It compared favourably with B881104 and B991114 that recorded 18.17% and 21.55% cane deaths respectively (Fig. 4).

3.10 Classification of cultivars based on drought tolerance

Five groups, based on susceptibility to and tolerance of drought was created. The percentage cane death in each cultivar, resulting from drought, was the criterion used for this classification (Table 5). BBZ951034 and B881104 had less than 20% cane death and were regarded as tolerant of drought. B47419, BD1388-3 and N27 all had more than 80% cane death and were grouped as extremely susceptible to drought. The remaining 5 cultivars were grouped as moderately tolerant of drought (Table 5).

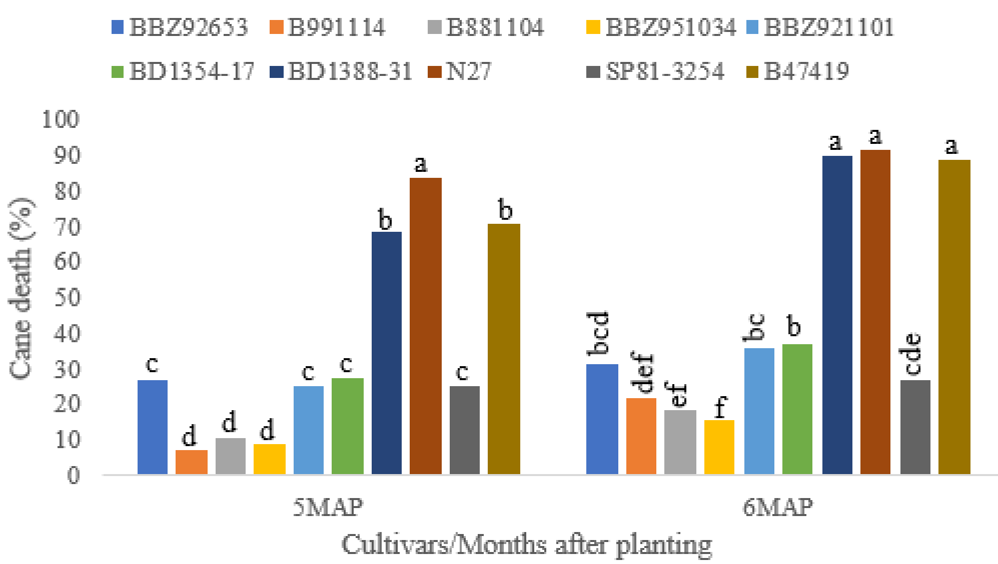

Fig. 5. Varietal response to drought

Table 5. Classification of cultivars based on drought tolerance

Tolerant of drought (0-20% cane death)	Moderately tolerant of drought (21-40% cane death)	Susceptible to drought (41-60% cane death)	Highly susceptible to drought (61-80% cane death	Extremely susceptible to drought (81% and above cane death)
BBZ951034 B881104	B991114 SP81-3250 BBZ92653 BBZ921101 BD1354-17	Nill	Nill	B47419 Bd1388-31 N27

3.11 Summary of the general performance of the 10 sugarcane cultivars

Only three cultivars, B991114, SP81-3250 and B47419, had no symptoms of infection on standing canes (Table 6). B47419 was however extremely susceptible to drought and almost all the cane stands were lost. BBZ951034 and B881104 were the only cultivars with less than 20% cane loss to drought, and can, therefore, be said to be drought tolerant. Unfortunately, however, both were susceptible to SWLD in addition to the susceptibility of BBZ951034 to SMD. N27 was a disaster. It had a very high percentage of sett rot infection and was extremely susceptible to drought. The entire cultivar was almost wiped out during the study (Table 6).

Table 6. Summary of the performance of the 10 sugarcane cultivars evaluated

Cultivars	Parameters									
	GR (%)	TI (%)	SI (%)	IWL (%)	SWL (%)	ISM (%)	SSM (%)	IRR (%)	SRR (%)	CWS (%)
BBZ92653	69.10c	10.00a	20.86b	0.00	0.00	11.30b	3.06b	10.63c	6.93c	31.59bcd
B991114	73.66c	10.83a	16.66bc	0.00	0.00	0.00	0.00	0.00	0.00	21.55def
B881104	75.33bc	10.83a	13.33cd	14.52b	7.76b	0.00	0.00	0.00	0.00	18.17ef
BBZ951034	74.06bc	7.50ab	18.33bc	28.83a	13.05a	20.62a	5.42a	0.00	0.00	15.65f
BBZ921101	80.03b	5.83abc	14.16cd	9.74c	7.51b	0.00	0.00	0.00	0.00	35.65bc
BD1354-17	89.50a	7.50ab	2.50e	0.00	0.00	11.48b	2.92b	11.70c	8.74c	37.22b
BD1388-31	70.50c	6.66ab	22.50b	14.39b	4.98c	0.00	0.00	20.31b	9.55b	89.64a
N27	35.00d	9.16a	55.00a	0.00	0.00	0.00	0.00	25.16a	28.60a	91.67a
SP81-3250	87.00a	2.50bc	10.00d	0.00	0.00	0.00	0.00	0.00	0.00	26.68cde
B47419	81.50b	0.83c	17.50bc	0.00	0.00	0.00	0.00	0.00	0.00	88.58a

Note. Means in the same column followed by the same alphabet are not significantly different ($p < 0.05$) according to Tukey's test.

Legend: GR= Germination, TI= Termite infestation, SI= Sett rot infection, IWL= Incidence of sugarcane white leaf, SWL= Severity of sugarcane white leaf, ISM= Incidence of sugarcane mosaic, SSM= Severity of sugarcane mosaic, IRR= Incidence of red rot, SRR= Severity of red rot, CWS= Cane death from water stress.

4. Discussion

All the cultivars evaluated were susceptible to termite infestation and sett rot infection. The cheering news, however, was that overall percentage termite infestation was low, the highest value was only 10.83% (BBZ92653 and B881104). Sett rot, *Ceratocystis paradoxa*, infection was more severe in a few cultivars and a significant percentage of setts, as much as 55.00% in N27, were lost to the pathogen. Termites and C. *paradoxa* are major limiting factors in the germination and establishment of sugarcane. Termites have been reported to cause significant sett and settling failure in many sugarcane fields all over the world. [16] reported that termite infestation on setts may be up to 50% in some cases, while it may be up to 10-20% in standing canes. In a study to evaluate *Metarhizium anisopliae* var. *anisopliae* as a biological control agent against sugarcane sett infesting termite in Pakistan, [17] recorded a significantly high infestation of termite on the untreated plot, control, with very low sett germination percentage of 23.70% - 24.60%. Sett rot (pineapple disease of sugarcane) has also been reported to cause significant germination failure of cane setts [18], [12]. Termites that infest cane setts are usually subterranean, while C. paradoxa may be soil or sett borne. The incidence of termite infestation on cane setts is common during the dry season when there is very little moisture in the soil. Pineapple disease, on the other hand, can be very severe if setts are planted in waterlogged soils. Any factor that delays setts germination has the adverse effect of increasing the number of infested/infected setts, bringing about an increased percentage of germination failure in susceptible varieties. It is not surprising, therefore, that N27 had the highest percentage infestation of C. *paradoxa*. The cultivar had the slowest rate of germination and the least overall germination percentage. On the other hand, BD1354-17 had the fastest rate of germination and also had the least percentage, 2.50%, sett rot infection. The incidence of three diseases; red rot, sugarcane mosaic and sugarcane white leaf were observed during the research work. Seven out of the ten cultivars were susceptible to at least one of these diseases. Sugarcane white leaf and red rot diseases were the most common. Four cultivars were susceptible to each disease. Sugarcane mosaic disease was the least common and the least severe, while BB951034 was the most susceptible. Sugarcane white leaf, red rot and mosaic are some of the most common and most serious diseases of standing cane. These diseases have been reported to cause significant losses in sugarcane yield globally [10], [11], [19]. Successful management of SWLD on cane setts with hot water and antibiotic have been reported [10]. Other than that, very few management options are available once there is an onset of infection from any of these three diseases. The best line of defense is the use of resistant varieties of cane for propagation. The incidence of these diseases on some of the cultivars evaluated may be an indication that their adoption and large-scale cultivation may not be a wise decision. Only 2 cultivars, BBZ951034 and B881104 could be regarded as tolerant to drought. The high-water requirement of sugarcane and the fact that it is a perennial crop means that some form of irrigation will be required at certain stages in its life cycle [20]. This water need is particularly critical during the early stages of planting and establishment. Cultivars with minimal water need stand at an advantage of others, especially in countries where availability of water and the cost of making it available to crops are major limitations to the practice of irrigation.

5. Conclusion

This report represents the first of a two-part study. While it may be too early to recommend any cultivar for adoption and large-scale cultivation, because there was no information on their growth and yield performance, it is safe to say that two cultivars, B991114 and SP81-3250 deserve further study. They were both moderately tolerant to drought, but most importantly, no incidence of disease was recorded on their standing canes. Sett rot and termite infestation of their setts and settlings, which were observed during the study, can be ameliorated with the adoption of suitable management practices.

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