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Existence of whip smut of sugar cane (*Ustilago scitaminea* syd) as nine different races in Nigeria

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ABSTRACT

Smut whips collections made from eleven locations in different parts of Nigeria were scrubbed to obtain smut tiliospores. These were sieved with 53µm mesh to dislodge specks and other impurities. The teliospores were then suspended in sterile distilled water and vigorously stirred to obtain homogenous spore suspension of 4 x 10^6 tiliospores/ml of each isolate with the aid of a heamocytometer. Five known differential sugar cane varieties and two national varieties were hot water treated at 52°C for 30 minutes and immersed in each of the eleven spore isolate concentrations and incubated in sterile jute bags in the shade for 12-14 hours. The test of pathogenicity trial was set up in a split plot design in three replicates in the glass house at Badeggi (Lat. 9° 045'N. Long. 6° 07'E, Alt. 70.57m above sea level) with the seven varieties as main plots and the 11 spore isolates as sub plots between 1999 and 2000. Results implicated 9 virulent isolates of *Sporisorium scitaminem* with distinct reactions on the five cane differentials. These were declared as nine races of S. *scitamineum* existing in Nigeria and accordingly named: Nig 1 race, Nig 2 race, Nig 3 race, Nig 4 race, Nig 5 race, Nig 6 race, Nig 7 race, Nig 8 race and Nig 9 race. The establishment of the existence of races of whip smut in Nigeria has laid the foundation for the development of new varieties with durable resistance to *U. scitaminea* in the country.

Keywords: *Sporisorium scitamineum*, pathogenic races, virulent isolates, sugar cane differential varieties, Nigeria

Whip smut of sugar cane (*Sporisorium scitamineum* Syd) remains a potentially important disease in almost all the sugar cane growing areas of the world because of its pathogenic variability which makes the management of the disease difficult even with the use of resistant varieties (Alexander, 1981 and Xu *et al*. 2004).

Reports around the world implicate generally two distinct races of S. *scitamineum* (A and B) from America, Australia, India, Brazil among others, except in Taiwan and Mainland China where three or more races have been reported (Xu *et al*. 2004). Gillaspie *et al*. (1983) reported that six races of whip smut exist in Argentina while Hirschhorn and Astiz-Gasso (1988) reported that there were only three races of whip smut from the same country.

Owing to the variation in the S. *scitamineum* pathogen, Alexander (1981) reported that this variation could be expressed for characters of morphology, pathogenicity, biochemical properties and ecological relationships. Consequently, Xu, *et al*. (2004) identified two and four distinct isolates or races based on ecological locations from Fujan and Guangxi, respectively in Mainland China. However, variations in morphology and pathogenicity are more useful in identifying pathogenic races of S. *scitamineum* (Alexander 1981).

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Co-operative foreign disease testing by Hawaiian Sugar cane planters' association (HSPA) with other sugar cane breeding and experimental stations around the world indicated the existence of different pathogenic races from Belize, Brazil, Guyana, Jamaica, Kenya, Philippines, Zembabwe and Hawaii (Comstock *et al*. 1983).

There has been no detailed and convincing report on the existence of pathogenic races of S. *scitamineum* in Nigeria, though Abo and Okunsanya (1996) allured that there probably existed more than one race of whip smut in the country and they denoted these as races X and Y. Kwon-Ndung *et al*. (1999) also opined on the possibility of *U. scitaminea* existing as different races. The reports by these workers, unfortunately did not involve pathogenicity test to pin down any of their claims to distinct races. Moreover, the rapid spread of whip smut on the local chewing sugar cane and other exotic varieties like 'Co 1001', 'Co 957' and 'Co 62175' calls for ascertaining which races of the pathogen are present in Nigeria with a view to developing new varieties with durable resistance to them. The present study was, therefore, set up to bridge this gap in knowledge and provide concrete information on the existence of physiologic races of S. *scitamineum* in Nigeria.

MATERIALS AND METHODS

Smut spore collections were made from Lafiagi, Bacita, Sunti and Savannah Sugar Companies on the plant or ratoon crops of 'Co 957', Lokoja on the plant crop of purple chewing sugar cane, Shendam on purple chewing sugar cane of Mr. Abubakar, Makurdi town from Mrs. Herbadoon Zege, Badeggi from chewing sugar cane of A.K. Gana's trial, Gada biyu (FCT) from Abdullahi Hassan's chewing sugar cane plant crop; Okeya po from Mr. Aliyu Ahmadu's chewing sugar cane farm and Doma town from Mr. Abubakar's plant crop of purple chewing sugar cane in August 1998. They were dried in the shade for one hour, scrubbed, sieved, weighed and prepared and stirred to form a homogeneous teliospore suspension as described by Nasr (1979) and their concentrations of 4 x 10^6 teliospores/ml was determined using a haemocytometer. Sugar cane varieties used as differentials ('CB 41-76', 'Co 312', 'Co331', 'Co 527', 'CP 70-1133') obtained from the National Germplasm Bank at Badeggi and the Museum of the then Savannah Sugar Company Ltd Numan as well as 'Bida local' and 'KRS – 06' national varieties (checks), were cut into 3-budded setts and hot water treated at 52°C for 30 mins and immersed in the different teliospore concentrations. They were removed and incubated in wet gunny jute bags for 12-14 hours as described by Nasr (1979). These were planted in sterile-soil filled plastic buckets each measuring 15cm in mouth diameter and 20cm deep in a split – plot design in three replicates with the differential varieties as main plots, while the spore collections were tested in the sub plots in the glass house at Badeggi in June 1999 to prove their pathogenicity. Observations were recorded on days to first whip appearance, disease incidence which was measured as percentage of smutted stools/stalks at 3 and 5 months after planting or ratooning (MAP or MAR). Other observations and data collection were made on yield related parameters and cane yield at harvest. All data were subjected to analysis of variance and mean separation done using Duncan's New Multiple Range Test (DNMRT).

RESULTS

Results presented in Table 1 show that there were significant differences among the differential varieties. Differential variety 'CB41–76' was least affected by whip smut as no whips emerged in its plant crop in 1999. The time taken for whips to emerge in the differential varieties also varied significantly. While it took only 28 days for whips to emerge in Bida local and less than 30 days in 'KRS-06', the two check varieties, the five other differentials showed symptoms of whip smut at times ranging from 14-39 days on ratoon crops. Variety 'KRS–06' was the earliest to produce whips in the ratoon crop cycle as was the case in the plant crop as whips emerged in the variety within 4 days of ratooning. Differential variety 'CP 70-1133' took 55 days to produce whips, which were significantly later than the time taken by differential varieties 'Co 312', 'Bida local', 'CB 41-76', 'Co 527'and 'Co 331'.

Table 1 Time taken for whip smut emergence in seven differential varieties of sugar cane inoculated with S. *scitamineum*, isolates, 1999 and 2000

Treatment	Time taken for whip emergence	
	1999 plant crop	2000 ratoon crop
Differential variety (V)		
'Bida Local'	28.0b	19.0e
'CB 41-76'	0.0e	34.0b
'Co 312'	14.0c	15.0f
'Co 331'	39.0a	32.0c
'Co 527'	38.0b	26.0d
'CP 70-1133'	36.0ab	55.0a
'KRS-06'	11.0d	4.0g
Mean	24.0	27.0
SE±	2.99	2.86
***Smut isolate* (I)**		
Bacita	18.0a	39.0ab
Badeggi	8.0a	17.0d
Doma	26.0a	24.0c
Gada-biyu (FCT)	32.0a	35.0b
Lafiagi	24.0a	23.0c
Lokoja	28.0a	34.0b
Makurdi	15.0a	27.0c
Numan	31.0a	19.0d
Okeya-Po	40.0a	46.0a
Shendam	21.0a	15.0e
Sunti	20.0a	20.0c
Mean	24.0	27.0
SE±	11.00	4.2
	NS	**
Interaction		
V*I	**	*

Means followed by similar letter(s) are not significantly different at P=0.01, P=0.05
According to Duncan's New Multiple Range Test (DNMRT)
NS = Not significant

The different whip smut isolates similarly significantly differed among themselves on time taken to produce whips. Thus, in the order of decreasing virulence, the isolates were listed viz. Okeya-Po, Gada biyu, Numan, Lokoja, Doma, Lafiagi, Shendam, Sunti, Makurdi, Bacita and Badeggi. Consequently, nine of the isolates were outstanding in their virulence on the differential varieties in terms of time taken by them to incite whip appearance in these differentials.

The test of pathogenicity on the differential varieties with the 11 smut isolates indicated that disease incidence measured as percentage smutted stools and stalks at 3 and 5 MAP, was significantly different, (Table 2). At 3 MAP, disease incidence was significantly higher in 'Co 527' than in the other six varieties. Disease was significantly less in the rest of the test varieties with 'CB 41–76' being the least infected by S.

Table 2 Disease incidence in differential varieties at 3 and 5 MAP, 1999

Treatment	%Smutted Stools		% Smutted Stalks	
	3 MAP	5 MAP	3 MAP	5 MAP
Differential Variety (V)	0.0e	0.0d	0.0d	0.0c
'Bida Local'	20.0a	20.7ab	19.0a	20.0a
'CB 41-76'	18.0a	22.8a	15.8b	24.7a
'Co 312'	14.3b	22.8a	8.3c	26.0a
'Co 331'	2.5e	7.0b	2.7b	2.5c
'Co 527'	7.0c	9.3b	3.4d	10.0b
'CP 70-1133'	5.0d	8.4b	6.7c	10.0b
'KRS-06'	9.7	8.1	12.8	12.8
Mean	1.57	2.62	2.61	5.06
SE±	**	**	**	**
***Smut isolate* (I)**	2.4e	13.4a	9.0a	13.3a
Bacita	8.6c	6.1a	10.0a	7.9a
Badeggi	11.3b	16.2a	12.7a	13.9a
Doma	15.3ab	16.2a	16.2a	18.9a
Gada-biyu (FCT)	0.0f	7.8a	8.3a	8.2a
Lafiagi	11.4b	6.8a	14.8a	14.3a
Lokoja	7.3c	9.2a	12.2a	14.9a
Makurdi	10.5b	10.0a	11.4a	14.9a
Numan	17.0ab	16.7a	18.9a	29.5a
Okeya-Po	5.7d	16.6a	17.1a	24.2a
Shendam	19.3a	11.5a	13.8a	23.2a
Sunti	9.9	9.8	13.2	15.3
Mean	2.12	3.34	3.78	1.74
SE±	**	NS	NS	NS
Interaction V*I	**	**	**	**

Means followed by similar letter(s) are not significantly different at P=0.01, P=0.05
According to Duncan's New Multiple Range Test (DNMRT)
NS = Not significant

scitamineum At 5 MAP, differentials 'Co 331', 'CP 7-1133' and 'Co 527' were the most infected by *U. scitaminea* than the other four sugar cane varieties. On the other hand, at 3 MAP, the Okeya – Po isolate of *U. scitaminea* significantly (P=0.01) produced the highest whip smut incidence than the other isolates in the 1999 plant cane. At 5 MAP, however, no significant differences in disease incidence expressed as percentage smutted stools were observed among the isolates. Similarly, no significant differences were observed in disease incidence expressed as per cent smutted stalks at 3 and 5 MAP in 1999, however, interactions of variety and smut isolates were highly significant (P=0.01) on smutted stools and stalks.

The test of pathogenicity was monitored on the ratoon crop in 2000. Table 3 shows that the differential and the check varieties had significant differences in whip smut incidence at 3 and 5 MAR. Disease incidence was however, significantly greater in 'Co 331', 'CP70-1133' and 'Bida local' check, than in 'CB 41–76' and 'Co 527' which in turn recorded greater incidence than other check variety 'KRS – 06'.

The development of whip smut in the differential sugar cane varieties at 3, 5 and 6 MAR shows that at 3 MAR, 5 MAR and at harvest (6 MAR), Okeya – Po, the doma and Numan isolates induced significantly (P=0.01) increased production of diseased stools than the other 9 isolates, which induced significantly the production of less disease. At all the three stages of growth, when disease incidence in terms of percentage smutted stools was assessed, there were significant varieties x isolate interactions in the 2000 ratoon crops. Table 3 also shows a similar result on incidence of disease on stalks of the test varieties as on stools at 3, 5 and 6 MAR, except that the Numan isolate replaced the Doma isolate at 5 MAR. Disease incidence was significantly higher in Bida local alone when assessed on stalks at 5 MAR.

The effects of the isolates were also assessed on yield – related parameters of the test varieties (Table 4). All the differential and the two check varieties had significant differences in plant height; stalk girth and number of internodes per stalk. They however, had no significant differences in

Table 3 Disease incidence in differential varieties at 3 and 5 Months After Ratooning (MAR), 2000

Treatment	% smutted stools			% smutted stalks		
	3 MAR	5 MAR	6MAR	3 MAR	5 MAR	6 MAR
***Differential Variety* (V)**						
'Bida Local'	52.8a	58.6a	59.8a	39.3b	56.2a	55.2a
'CB 41-76'	29.6bc	34.1bc	39.1b	28.6d	41.2b	42.8c
'Co 312'	16.2c	19.9c	21.7c	39.4b	21.7d	23.8e
'Co 331'	47.1ab	48.4b	48.7ab	20.7e	43.7abc	50.5b
'Co 527'	28.8bc	37.3bc	37.8bc	34.5c	35.1c	33.7d
'CP 70-1133'	38.8bc	48.7b	52.7ab	42.6a	51.5ab	53.0ab
'KRS-06'	6.1d	6.8d	7.1d	14.1f	7.7e	7.9f
Mean	31.3	36.3	38.1	31.3	36.7	38.1
SE	2.20	2.81	2.71	8.01	3.05	3.31
	**	**	**	**	**	**
***Smut isolate* (I)**						
Bacita	15.0h	29.1d	31.6e	13.4g	42.1bc	19.7f
Badeggi	29.1e	21.3f	21.6g	25.6e	16.7i	22.3e
Doma	43.7bc	47.6a	49.2b	44.3b	47.6b	47.1b
Gada-biyu	39.5cd	43.0b	40.3d	46.8ab	38.3f	49.7ab
(FCT)	28.3e	39.4c	45.7c	32.8c	45.5bc	36.0cd
Lafiagi	39.6cd	39.3c	38.7d	37.6c	34.0e	47.6b
Lokoja	31.2d	44.5b	46.8b	29.1d	43.3d	40.7c
Makurdi	14.7h	46.2ab	53.8a	17.8f	68.1a	68.1a
Numan	56.4a	44.0b	45.8c	47.7a	33.0g	36.0cd
Okeya-Po	24.7f	22.2e	26.0f	25.0e	19.4h	30.0d
Shendam	22.6g	22.6e	20.1h	24.5e	16.1i	21.9e
Sunti	31.3	36.3	38.1	31.3	36.7	38.1
Mean	2.37	4.93	5.05	4.64	3.22	3.40
SE±	**	**	**	**	**	**
***Interaction* V*I**	**	**	**	**	**	**

Means followed by similar letter(s) are not significantly different at P=0.01, P=0.05 according to Duncan's New Multiple Range Tests (DNMRT)

R = Resistant 0 - 15% infection, I = Intermediate 16 - 25% infection, S = Susceptible 26% and above infection

internode length, number of leaves per stalk, leaf length and width as well as single stalk weight at harvest. Differential cane variety 'Co 312' was significantly taller and had more internodes per stalk than the rest of the other test varieties, while the Bida local check had significantly bigger stalks than the others. Conversely, the smut isolates did not incite significant differences on the yield – related parameters measured. Similarly, there were no significant interaction of variety and smut isolate on the yield – related parameters assessed, except on internode length in 1999.

The effects of the whip smut isolates were also monitored on the ratoon crop in 2000. Table 5 shows significant differences among the differential test canes and the two check varieties on most of the parameters assessed except on the number of internodes per stalk and leaf width. Variety 'Co 312' and the Bida local check variety significantly produced greater number of internodes per stalk and wider leaves respectively than did other test cane varieties. Similarly, the smut isolates had no significant differences in their effects on the measured yield – related parameters and no significant variety and isolates interaction on any of the assessed parameters in 2000.

From the reaction of the differential varieties with the 11 smut isolates in terms of time taken for whip appearance, disease incidence and effect on yield – related parameters and cane yield as indicated in tables 1-5, nine distinctive isolates were established as smut races. Consequently, these were named as Nig 1 race for Okeya –Po isolate, Nig 2 race for Gada-biyu isolate, Nig 3 race for Numan isolate; Nig 4 race for Lokoja isolate, Nig 5 race for Doma isolate; Nig 6 race for Lafiagi isolate; Nig 7 race for Shendam isolate; Nig 8 race for Sunti isolate and Nig 9 race for Makurdi isolate, respectively.

DISCUSSION

In the investigation of smut races in Nigeria, known cane differentials, namely 'CB 41-76', 'Co 527', 'CP 70-1133',

Table 4 Effects of variety and isolate on yield-related parameters in different varieties in parameters in different varieties in pathogenicity test at Badeggi 1999

Treatment	Plant height (cm)	Stalk Girth (cm)	No of internodes/stalk	Int. N length (cm)	No of leaves/stalk	Leaf Length (cm)	Leaf with (cm)	Stalk weight (grammes)
Differential Variety (V)								
'Bida Local'	0.3d	2.3a	5.5e	3.1a	6.4a	1.1a	1.5a	0.2a
'CB 41-76'	0.5ab	1.5c	7.5ab	5.5a	6.4a	1.1a	1.7a	0.1a
'Co 312'	0.6a	1.6b	8.3a	4.9a	6.7a	0.5a	1.9a	0.1a
'Co 331'	0.5ab	1.6b	6.0ab	4.8a	6.7a	1.1a	1.7a	0.1a
'Co 527'	0.4b	1.6b	7.5ab	3.2a	6.8a	1.1a	2.0a	0.1a
'CP 70-1133'	0.4b	1.5b	4.8c	5.9a	6.6a	1.1a	1.3a	0.1a
'KRS-06'	0.5ab	1.4d	7.9b	3.6a	6.6a	1.7a	2.0a	0.1a
Mean	0.5	1.6	6.8	4.4	6.6	1.1	1.8	0.1
SE±	0.04	0.05	0.51	0.67	0.30	0.05	0.19	0.03
	**	**	**	NS	NS	NS	NS	NS
Smut isolate **(1)**								
Bacita	0.5a	1.6a	6.5a	4.3a	6.6a	1.0a	1.8a	0.1a
Badeggi	0.4a	1.6a	7.1a	4.1a	6.8a	1.0a	1.6a	0.1a
Doma	0.5a	1.7a	7.1a	4.5a	6.8a	1.1a	1.8a	0.1a
Gada-biyu (FCT)	0.5a	1.7a	6.8a	4.5a	6.3a	1.0a	1.7a	0.1a
Lafiagi	0.4a	1.7a	6.4a	4.5a	6.5a	1.1a	1.9a	0.1a
Lokoja	0.5a	1.6a	6.6	4.2a	6.3a	1.1a	1.8a	0.1a
Makurdi	0.4a	1.6a	6.2a	4.8a	6.9a	1.1a	1.9a	0.1a
Numan	0.5a	1.6a	6.6a	4.7a	6.7a	1.0a	1.9a	0.1a
Okeya-Po	0.5a	1.6a	7.4a	4.1a	6.7a	1.1a	1.9a	0.1a
Shendam	0.4a	1.6a	7.0a	4.9a	6.8a	1.1a	1.8a	0.1a
Sunti	0.5a	1.6a	7.0a	4.3a	6.2a	1.1a	1.8a	0.1a
Mean	0.5	1.6	6.8	4.4	6.6	1.1	1.8	0.1
SE±	0.03	0.4	0.35	0.31	0.21	0.03	0.09	0.02
	NS	NS	NS	NS	NS	NS	NS	NS
Interaction								
V*I	NS	NS	NS	*	NS	NS	NS	NS

Means followed by similar letter(s) are not significantly different at P=0.01, P=0.05
According to Duncan's New Multiple Range Test (DNMRT)
NS = Not significant

'Co 331' (Alexander 1981, Flores 1981, Comstock *et al.* 1983, Gillaspie *et al*. 1983. and Wataraitch 1982) used for physiologic differentiation of S. *scitamineum* were employed. Two sugacane varieties namely 'KRS – 06' and 'Bida local' were included as checks because of their importance to the Nigerian sugar cane industry.

Variation in the smut pathogen can be expressed for characters of morphology, pathogenicity, biochemical properties and ecological relationships among others (Alexander 1981). However, variations in morphology and pathogenicity have been more useful in identifying physiological specialization in *S. scitamineum* (Alexander, 1981). Several workers have utilized pathogenicity alone because there has been no distinctive conclusion from spore morphology in race identification studies (Alexander 1982, Alexander, and Rao 1981).

In line with reports by the above workers and Hirschhorn and Astiz Gasso (1988), only the pathogenicity of the isolates on known differential varieties as listed above was utilized in identifying races among the isolates in this study. Spore morphology studies were conducted but were not conclusive and are not reported here. Use of this has, however, not been definitive in pinning down smut races (Alexander and Rao 1981).

Significant differences were recorded among the differential varieties on the level of disease development in them. Significant differences were also observed on the extent of virulence among the isolates. Similarly, significant interaction effects were also observed between the differential test canes and the check varieties and the smut isolates. The significant effects of interaction observed between the differentials and the isolates in this study suggest the existence of physiologic

Table 5 Effects of variety and smut isolate on yield-related parameters of ratoon crop at Badeggi 2000

Treatment	Plant height (cm)	Stalk Girth (cm)	No of internodes/stalk	Int. N length (cm)	No of leaves/stalk	Leaf Length (cm)	Leaf with (cm)	Stalk weight (grams)
***Variety* (V)**								
'Bida Local'	0.4a	1.3a	6.0d	1.2a	5.5a	0.9a	2.6a	27.0a
'CB41-76'	0.5a	1.1a	7.3b	3.0a	5.4a	1.0a	2.2ab	14.7a
'Co 312'	0.5a	1.1a	11.3a	2.1a	5.7a	0.9a	1.9b	15.1a
'Co 331'	0.4a	1.1a	8.3b	2.1a	5.8a	0.8a	1.8c	18.7a
'Co 527'	0.3a	1.0a	7.0c	1.8a	5.9a	0.9a	1.9b	20.2a
'CP70-1133'	0.4a	1.2a	6.0d	1.9a	5.7a	1.0a	2.1b	20.2a
'KRS-06'	0.4a	0.9a	7.8ab	1.9a	5.6a	0.8a	1.7d	5.2a
Mean	0.4	1.1	7.7	2.0a	5.7a	0.9a	2.0	17.3
SE±	0.05	0.08	0.98	0.39	0.31	0.1	0.11	6.13
***Smut isolate* (I)**								
Bacita	0.4a	1.0a	7.5a	2.3a	5.9a	0.9a	2.1a	15.4a
Badeggi	0.4a	1.0a	7.9a	2.1a	5.6a	0.9a	2.0a	10.3a
Doma	0.4a	1.1a	7.9a	2.3a	5.9a	0.9a	1.9a	28.5a
Gada-biyu (FCT)	0.4a	1.0a	7.5a	2.1a	5.7a	0.8a	1.8a	23.8a
Lafiagi	0.4a	1.1a	7.5a	1.6a	5.4a	0.8a	1.9a	15.7a
Lokoja	0.4a	1.2a	7.8a	1.9a	5.4a	0.9a	1.9a	17.3a
Makurdi	0.4a	1.2a	7.1a	1.8a	5.6a	0.9a	2.1a	16.4a
Numan	0.5a	1.1a	8.7a	2.1a	5.6a	0.9a	1.9a	15.9a
Okeya-Po	0.4a	1.1a	7.6a	1.9a	5.8a	1.0a	2.2a	20.0a
Shendam	0.4a	1.2a	7.8a	2.2a	5.6a	0.9a	2.2a	15.6a
Sunti	0.4a	1.2a	7.4a	1.7	5.7a	1.0a	2.2a	11.3a
Mean	0.4	1.1	7.7	2.0	5.7	0.9	2.0	17.3
SE±	0.04	0.10	0.70	0.30	0.30	0.10	0.20	5.40
	NS	NS	NS	NS	NS	NS	NS	NS
Interaction								
V*I	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by similar letter(s) are not significantly different at P=0.01, P=0.05
According to Duncan's New Multiple Range Test (DNMRT)
NS = Not significant

races of whip smut in Nigeria, based on the following reasons:

- In a related study in France, Peros and Baudin (1983) did not observe significant effect on interaction between the test host and smut isolates and concluded that the isolates were homogenous in virulence and their pathogenicity and hence did not constitute different races. The present result is therefore, at variance with the report of these workers and suggests that different whip smut races have been established in Nigeria,
- Results on the effects of variety and inoculum concentration on disease incidence and time taken for smut whips to appear showed that only 'CB 41-76' that was not affected by any of the spore isolates, except in its ratoon in the present investigation in Nigeria. Subsequently, all the isolates showed high virulence in their effect on the other four differential varieties indicating that the smut races here are different from those reported from the other countries of the world (Alexander 1981, Flores 1981, Gillaspie *et al*. 1983 and Xu *et al*. 2004) and hence represent different physiologic races of *U. scitaminea* in Nigeria,
- The other four differential varieties manifested first smut whips in less than 100 days in plant cane and in the ratoon cane where all five differential varieties produced whips in less than 200 days. It has been reported that first whip manifestation in susceptible and highly susceptible varieties occurred within 60 days from India (Prasadarao *et al*, 1979) and within 143 and 132 days respectively, also from India (Kalamani *et al*. 2000). However, four of the differential varieties used in this study are either resistant or moderately resistant. Their manifestation of first whip in less than 100 days, therefore, confirm the existence of virulent smut races in Nigeria other than those reported by other workers in other parts of the world (Flores, 1981, Comstock *et al*. 1983, Gillaspie *et al*. 1983. and Wataraitch 1982). For 'Co 527' and 'Co 312' differential varieties, days for manifestation of first whip range from 64-103 while that for 'Co 312' is 75

days (Prasadarao *et al.* 1979l and Wataraitch 1982),

- One of the candidate varieties 'KRS-06' bred to be smut resistant also broke down to infection by the Nig 1 race (Okeya-Po isolate) in over 40 days, further confirming its virulence as a race. Surprisingly, 'Bida Local' cane, a known susceptible variety manifested first whip, on the average, later than known resistant varieties like 'CP 70-1133', 'Co 527' and 'Co 312'. The high degree of virulence of the test isolates on the differentials in the present study, is, also supported by report by Alexander (1981) that irrespective of the susceptibility rating of a variety in his study, the majority of the whips emerged within 120 days after planting the crop. In contrast, however, the present study shows that irrespective of the resistance rating of the differentials, four of them manifested first whips within 100 days. This suggests that the smut isolates used are different highly virulent races of smut occurring in Nigeria. Hence as reported by Comstock *et al*. (1983), these have the possibility of spreading to other areas to threaten the Nigerian sugar industry if care is not taken to restrict them.
- Gillaspie *et al*. (1983) described a greenhouse method for evaluating smut versus isolate differences under uniform conditions. The method was described as a valid, rapid method for isolate separation when the correct differential clones are used. Correct differential clones namely 'CB 41-76', 'Co 527', 'CP 70-1133', 'Co 331' and 'Co 312' with distinct reactions were used in the present study (Alexander 1981, Flores 1981, Comstock *et al*. 1983, and Wataraitch 1982). Therefore, the variability reactions exhibited by these differentials on inoculation with the 11-teliospores isolates may confirm the existence of different smut races in Nigeria.

Consequently, based on the five deductions above, nine races have been proved to exist in Nigeria namely; , Okeya-Po , Gada-biyu, Numan, Lokoja, Doma, Lafiagi, Shendam, Sunti Makurdi. In order to denote and represent them as Nigerian races of S. *scitamineum*, they were accordingly designated Nig 1 race, Nig 2 race, Nig 3 race, Nig 4 race, Nig 5 race Nig 6 race, Nig 7 race, Nig 8 race, and Nig 9 race for Okeya-Po, Gada-biyu, Numan, Lokoja, Doma, Lafiagi, Shendam, Sunti and Makurdi isolates respectively.

Clone 'KRS-06' offers a sure consolation to cane growers at Bacita, Lafiagi and Sunti, since it was not affected by isolates from these locations. This is because clone 'KRS-06' was developed as a smut resistant mutant under the Numan environment (Anon. 2001) and was not affected by the Nig race 3whip smut in this study, and that explains the importance of the clone to the Nigerian sugar cane industry. Knowledge of similarities and differences of smut races would aid in the development of resistant varieties in Nigeria as pointed out by Comstock *et al*. (1983).

The effect of the isolates on the differential clones was also evaluated on yield related parameters of selected canes. Significant differences were observed on such yield – related parameters of the assessed canes as plant height; stalk width and number of internodes per stalk at harvest. Morphological characters of infected cane varieties are negatively affected by S. *scitamineum*,in several countries (Glaz *et al*. 1989, Hoy *et al*. 1986, Nasr 1979, Hoy *et al*. 1986, Monhanraj *et al*. 1987, Msechu and Keswani 1982, Valladares and Gonazales 1986 and Villalon and Warfield 1988).

Thus the significantly reduced girth, plant height and number of internodes in selected canes at harvest in this study agree with the earlier reports by other workers (Agboire *et al*. 2000). Further studies are required on identifying collateral hosts to S. *scitamineum*, in Nigeria as this was initiated in the present study but could not be accomplished for want of logistics and time.

The result provides information on cane varieties that can be moved from one location or sugar estate to another without fear of introducing whip smut races to freer areas, or of devastating an already adapted commercial variety with new virulent whips smut races hitherto unknown in their environment (Wada *et al*. 2001).

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