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Evaluation of Cane Genotypes Under Sprinkler Irrigation at Early Selection Stage for Tolerance to Sugarcane Streak Mosaic Virus (SCSMV) at Ferké Sugar Estates in Ivory Coast

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Abstract

Sugarcane streak mosaic virus (SCSMV) became the major endemic disease of economic importance in Ivorian sugar estates almost two years ago, which spreads very fast across plantations and varieties. The study aimed to determine resistant sugarcane genotypes against SCSMV in Ferké sugar estates. It involved five experiments conducted at first selection stage under sprinkler irrigation, following a randomized complete block design (RCBD) with 20 to 30 different genotypes, two check varieties included, all in 4 replicates. Experiments were planted in October or December 2018, and expected to be harvested in November/December 2019 and 2020 as plant cane and first ratoon, respectively. Disease incidence and severity across all experiments were determined at 3 to 4 months, i.e. at early formative growth stage where symptoms due to SCSMV could be easily observed and recognized in the field. In each of the five selection trials conducted on both Ferké 1 & 2 sugar estates, highly significant differences in disease incidence and severity were observed between genotypes as well as crop cycles (plant cane and first ratoon). Except for one trial (B3-24 in Ferké 1), Genotype x crop cycle interactions were significant or highly significant, which showed that the majority of genotypes tested behaved differently from plant cane to first ratoon towards the disease. Particularly, the percentage of resistant genotypes decreased from 50 to 3.4% whereas that of highly susceptible ones increased from 4.2 to 92.4%. This shows the level of challenge to be tackled in the control of SCSM disease through sugarcane breeding and selection. At the end of the current selection stage under way, i.e. after harvest of first ratoon, only the best yielding genotypes among the resistant ones will undergo the advanced selection stage.

Keywords: natural infection, disease susceptibility, varietal resistance, growth stage, insect vector, yield loss, disease epidemiology.

1. Introduction

Sugarcane is one of the important cash crops grown in Ivory Coast, covering approximately 35,500 ha of land surface with an average yield of 70-75 t of cane/ha irrigated and rainfed crops combined. Sugarcane is mostly cultivated under irrigated conditions contributing to around 90% of Ivorian sugar production, i.e. about 200,000 t/year provided from four different factories.

Sugarcane streak mosaic (SCSM) is a newly emerging disease in the country, which has been infecting that crop since 2017. The virus was known about fifteen years ago in Asian and Latino American sugarcane producing countries where it was first reported in 2004 and 2005 respectively in Brazil (Gonçalves et al, 2004; Gonçalves et al, 2007a; Gonçalves et al, 2007b; Gonçalves et al, 2011; Gonçalves et al, 2012) and Java, Indonesia (Chatenet et al, 2005; Kristini et al, 2006). It was reported that at least two strains of SCSMV were infecting sugarcane in Asia (Putra et al, 2015a). SCSMV is a Poacevirus from the Potyviridae family, which is easily transmitted through plant extracts and vertically through sugarcane cuttings. It infects a limited species of Poaceae family such as sugarcane, sorghum, maize, *Dacttyloctenium aegyptium*, *Pennisetum glaucum, Digitaria delilis* as reported by several investigators (Hema et al, 2001; Xu et al, 2010; Putra & Damayanti, 2012; Putra et al, 2014). However, no insect vector of the pathogen was reported so far (Putra et al, 2015a, Addy et al, 2017). Several species of aphids have been tested including *Aphis cracivora*, *Rhopalosiphum maidis* and *Ceratovacuna lanigera* and it was reported that they could not transmit the virus (Hema et al, 2001; Putra & Damayanti, 2012; Putra et al, 2014). It was reported that SCSMV could be detected using RT-PCR on sugarcane aphid colony (*Melanaphis indosacchari*), and still the mechanism of virus transmission needs to be studied so as to develop an integrated pest management strategy (Brown, 1997).

Across Ivorian sugar estates, except for a limited number of varieties like M2593/92, M1400/86, SP70-1143, R584 and R91-2021, all main cultivars were found moderately or highly susceptible to the disease. It is the case of varieties like FR80-69, R579, SP70-1006, SP71-1406, SP71-8210, SP81-3250, R573, R570, Co997 and R575. Cane and sugar yield losses due to SCSMV occurred in Zuénoula sugar estate in central Ivory Coast where the disease broke out in 2017 on variety R575, were estimated to 20 to 30% over the last two cropping seasons (2017-18 and 2018-19). The disease expansion was so fast in Zuénoula plantations that 20% of land under cultivation with moderately or highly susceptible varieties were replanted every year instead of 10% as usual (Béhou & Péné, 2019). The disease broke out in Ferké sugar estates of northern Ivory Coast in June 2018 on variety FR80-69, a highly susceptible one, and within 12 months, it has spread to all major varieties cultivated like R579, SP71-1406, SP70-1006 and SP71-8210, with a severity score of 2 or 3, 4 being the highest symptom level. Total cropped land concerned was estimated to 2000 ha, i.e. about 25%. The threat on sugar production was so crucial that a replantation strategy was planned to be implemented over the next three or four years.

The study aimed to determine under irrigation resistant sugarcane genotypes of Reunion and Ivorian origin against SCSMV.

2. Materials and Methods

2.1 Site Characteristics

The study was carried out on four sugarcane plantations (B3-13, B3-24, V4-43, V8-01) and an experimental station (P3-61), at Ferké 1 and Ferké 2 sugar estates, in northern Ivory Coast (9°20' – 9°60' N, 5°22' – 5°40' O, 325 m a.s.l.). The prevailing climate is tropical dry with two seasons: one, from November to April, is dry and the other, from May to October, is wet. The dry season is marked by the northern trade wind, which blows over mid-November to late January. The rainfall pattern is unimodal with a focus on August and September which total amount of rainfall reaches almost half of the average annual rainfall (1200 mm) with an average daily temperature of 27 °C. Average maximum and minimum daily air temperatures are 32.5 and 21 °C, respectively. To meet sugarcane crop water requirements, the total amount of irrigation water required reaches 700 mm/year (Konan et al, 2017a,b). Both Ferké sugar mill plantations cover around 15 500 ha with 10 000 ha under irrigation and 3 500 ha of rainfed village plantations, lie mainly on shallow or moderately deep soils built up on granites. Main soil units encountered are ferralsols and temporally waterlogged soils in valley bottoms of Bandama and Lokpoho river basins with a sandy-clay texture.

2.2 Experimental Design

All experiments were carried out over 12 months as plant cane following a randomized complete block design (RCBD) with 20 to 30 cane genotypes and two commercial varieties as control (M2593/92 and R579), in 3 replicates. Each sugar estate was equipped with a weather station where parameters required to determine crop ET_0 like solar radiation, average daily air temperature, relative air moisture, and wind speed were measured. Rainfall data were recorded from different rain gauges L1-105, but also P3-61, V4-15 and V8-32 located close to Ferké 1 and Ferké 2 experiments, respectively. Ferké 1 experiments were planted on October 25 and December 11, 2018 were expected to be harvested 11 or 12 months later, i.e. in November or December 2019 and 2020, respectively, as plant cane and first ratoon. Those of Ferké 2 were planted on October 12, December 20 and 29, 2018 and expected to be harvested in November or December 2019 and 2020, respectively. Each plot was composed of 5 dual rows of 5 m long with 0.50 m and 1.90 m of row spacings. Field management in terms of fertilizer and herbicide applications were done according to usual practices in commercial plantations. NKP fertilizer (16-8.5-23%) was applied mechanically at the routine rates of 500 kg/ha in rainfed plant cane. Pre-emergence chemical weeding based on pendimethalin combined with clorimuron-ethyl (3.5 l/ha) was achieved mechanically two days after planting.

2.3 Genotype Infections Investigated

Three to four months after planting, all genotypes being tested were observed for symptom detection of SCMV (sugarcane streak mosaic Virus) under natural conditions. Ratings recorded were based on symptoms observed on sugarcane leaves. Four different levels of SCSM disease symptoms were as follows: (1) mild streak, (2) moderately streak, (3) high streak and (4) very high streak.

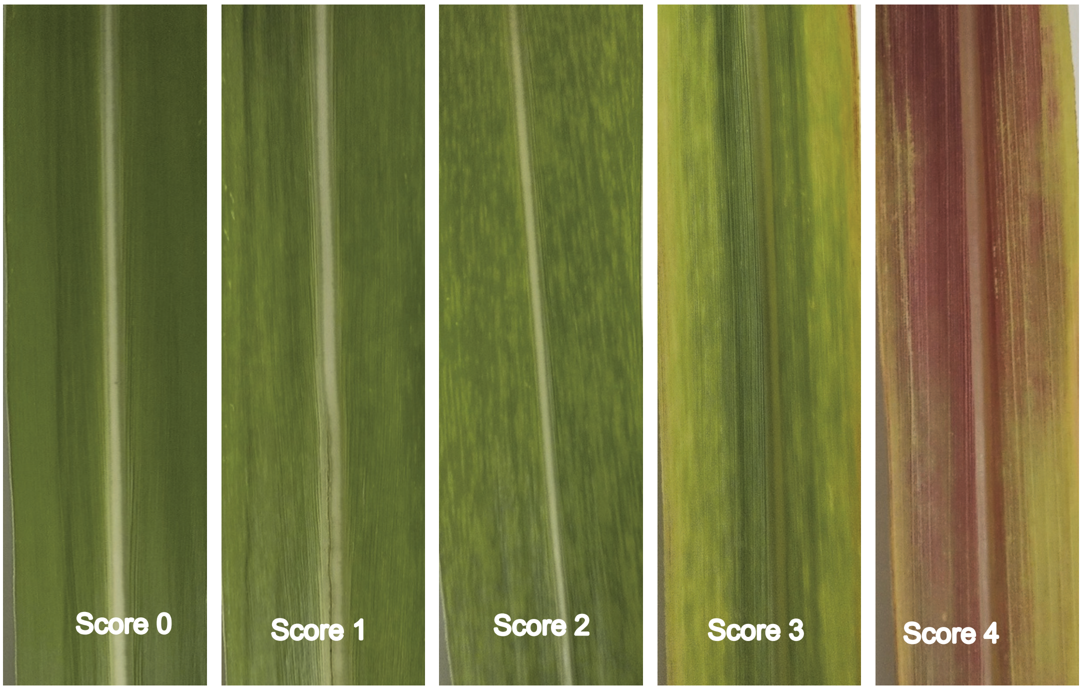

Figure 1. Severity scale of SCSMV infection in sugarcane. Leaf 0 is asymptomatic and Leaf 4 very highly infected. Variety R579 leaves collected in Ferké. Scale adapted from Putra et al (2014).

Disease incidence (Inc) is defined as the percentage of infected tillers, no matter the severity, over the total number of tillers observed within two central micro-plots made of one dual row of 5 m long with respect to each genotype and replication.

$$\text{Inc (\%)} = (\text{Nb of Infected tillers / Total Nb of tillers}) \times 100 \quad (1)$$

Disease incidence was classified as highly resistant or asymptomatic (0%), moderately resistant (<10%), susceptible ([10-40%[) and highly susceptible (≥40%).

Disease severity (Sev) is defined as the average score or rating of infected tillers with respect to their severity over the total number of tillers observed within two central micro-plots made of one dual row of 5 m long (9.5 m²) with respect to each genotype and replication.

$$\text{Sev (-)} = (N_0x0 + N_1x1 + N_2x2 + N_3x3 + N_4x4)/(N_0+N_1+N_2+N_3+N_4) = (N_1x1 + N_2x2 + N_3x3 + N_4x4)/(N_0+N_1+N_2+N_3+N_4) \quad (2)$$

Where N_0: Nb of asymptomatic tillers; N_1: Nb of mild streak tillers, N_2: Nb of moderately streak tillers, N_3: Nb of higly streak tillers, N_4: Nb of very highly streak tillers.

2.4 Statistical Analyses

The quantitative data recorded in this study were subjected to the analysis of variance, using statistical procedures described by Gomez and Gomez (1984) and reported by Shitahum et al (2018) with the assistance of R software package version 3.5.2. Differences between means of treatments were determined from HSD's test.

3. Results and Discussion

3.1 Climatic Conditions Over Plant Cane and First Ratoon Crop

As expected, both experimental sites presented a similar rainfall patterns with a per-humid season taking place from June to October (Fig 1). The dry season which took place from November 2018 to May 2019, and from October 2019 to February 2020, was marked by irrigation applications.

In Ferké 1 experiments, total rainfall and reference evapotranspiration (ETo) recorded across crop cycle gave 1538.5 mm on average regarding two locations and 2188 mm, respectively. Total rainfall deficit over crop growing season from October 2018 to February 2020 gave 895-961 mm and the average daily temperature across crop cycle varied from 24.4 to 34.5 °C.

In Ferké 2 experiments, total precipitation and reference evapotranspiration (ETo) recorded across crop cycle gave 1656 mm on average regarding three locations and 2075 mm, respectively. Total rainfall deficit obtained over crop growing season from October 2018 to February 2020 gave 904-958 mm whereas the average daily temperature across crop cycle varied from 24.7 to 30.5 °C.

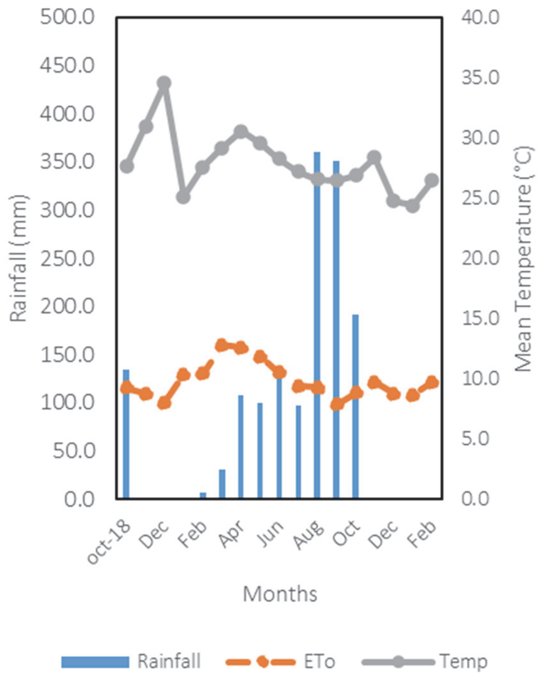

Figure 1a. Climate on Ferké 1 experimental sites (B3-13/24).

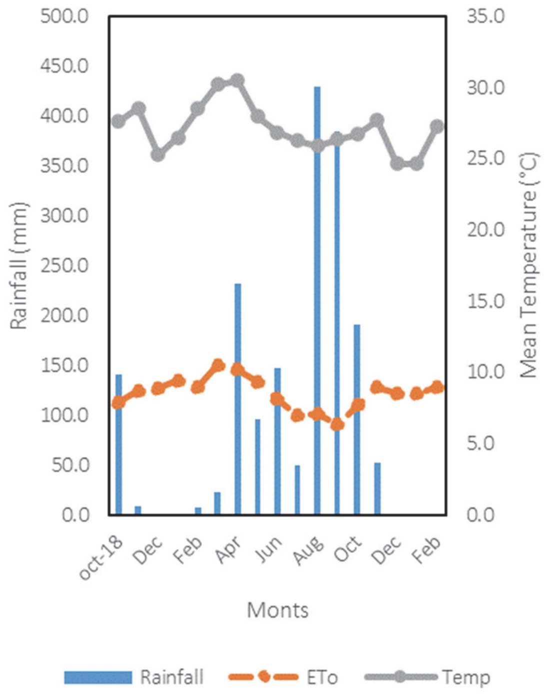

Figure 1b. Climate on Ferké 2 experimental site of P3-61.

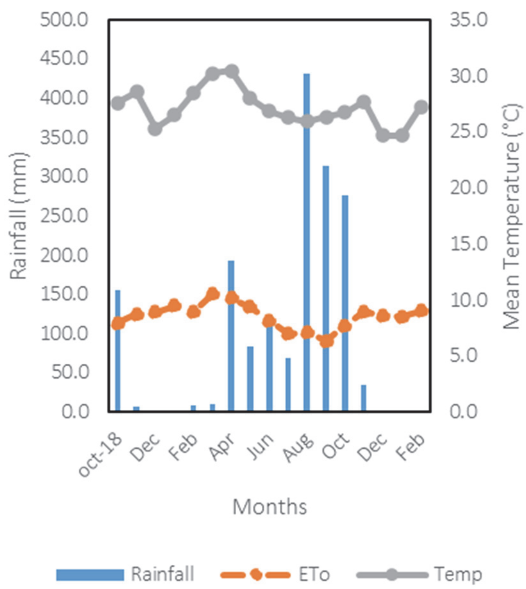

Figure 1c. Climate on Ferké 2 experimental site of V4-43.

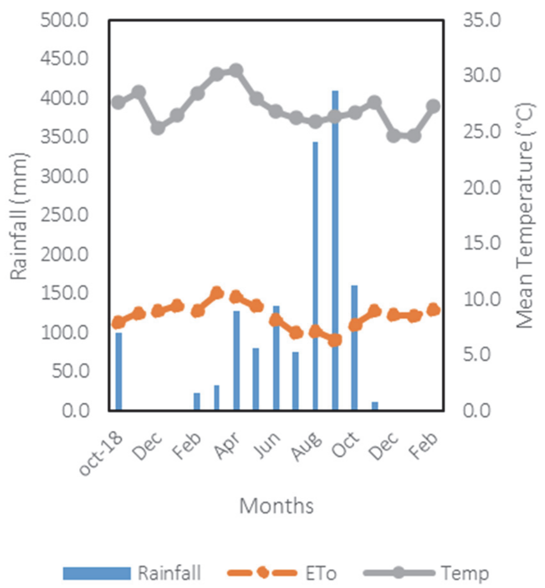

Figure 1d. Climate on Ferké 2 experimental site of V8-01

Figure 1. Prevailing climate on Ferké 1 and Ferké 2 experimental sites in plant cane and first ratoon crop, Ivory Coast

3.2 Cane Genotypes as Affected by SCSM Disease in FerkÉ 1 Experiments

In both Ferké 1 trails (B3-13 and B3-24 field plots), highly significant differences (P<0.1) in disease incidence and severity were observed between genotypes as well as crop cycles (Table 1). Genotype x crop cycle interactions were significant or highly significant in B3-13 trial, while not significant in B3-24 trial. This shows that in B3-13 trial, cane genotypes behaved differently from plant cane to first ratoon towards the disease. Particularly, many asymptomatic genotypes assumed to be tolerant or resistant in plant cane became susceptible in first ratoon. In contrast, for the B3-24 trial, genotypes tested behaved similarly over both crop cycles in terms of their ranking, although the disease symptoms worsened sometimes in first ratoon.

High values of coefficient of variation determined in both experiments (70-87%) could be explained by natural infection of disease, although that one became endemic over the last two years in Ferké sugar estates. Similar values were reported in survey on major endemic diseases conducted in the same agro-ecology (Béhou & Péné, 2018; 2019).

Table 1. SCSM disease incidence and severity on cane genotypes at 3 months in plant cane and first ratoon regarding Ferké 1 experiments, Ivory Coast

Ferké 1 Trial B3-13			Ferké 1 Trail B3-24		
Genotypes	% Incidence	Severity	Genotypes	% Incidence	Severity
M2593-92	36.3bc	0.5bc	M2593/92	31.9cd	0.3cd
RCI10/164	26.3de	0.3ef	RCI11/1110	35.1bc	0.4bc
RCI11/163	47.8bc	0.5bc	RCI11/1111	43.7ab	0.5ab
RCI11/167	41.5bc	0.4cd	RCI11/1112	44.8ab	0.4ab
RCI11/168	41.4bc	0.4bc	RCI11/1113	49.6ab	0.5ab
RCI11/169	40.8bc	0.4bc	RCI11/1114	47.8ab	0.5ab
RCI11/170	24.4ed	0.2fg	RCI12/1115	25.0de	0.3ef
RCI13/172	55.7ab	0.6bc	RCI12/1116	27.5de	0.3de
RCI13/175	54.3ab	0.6bc	RCI13/1117	31.6cd	0.3cd
RCI13/176	40.3	0.4cd	RCI13/1118	55.9ab	0.6ab
RCI13/178	75.4a	0.9a	RCI13/1119	39.4bc	0.4ab
RCI13/181	30.9	0.3de	RCI13/1120	40.5ab	0.4ab
RCI13/182	42.5ab	0.7ab	RCI13/1121	22.0f	0.2f
RCI13/183	19.3	0.2g	RCI13/1122	36.4bc	0.4bc
RCI13/184	32.8	0.3de	RCI13/1123	41.5ab	0.4ab
RCI13/185	44.9	0.5bc	RCI13/1124	30.3cd	0.3cd
RCI13/186	58.3ab	0.6bc	RCI13/197	22.6ef	0.2f
RCI14/158	38.4	0.4bc	RCI13/198	52.4ab	0.6ab
RCI14/160	56.1ab	0.6bc	RCI14/1100	52.2ab	0.5ab
RCI14/161	38.8	0.4cd	RCI14/1101	44.5ab	0.5ab
			RCI14/1102	52.1ab	0.6ab
			RCI14/1103	61.0ab	0.6ab
			RCI14/1104	52.4ab	0.6ab
			RCI14/1105	49.0ab	0.5ab
			RCI14/1106	57.7ab	0.6ab
			RCI14/1107	47.4ab	0.5ab
			RCI14/1108	45.5ab	0.5ab
			RCI14/1109	43.5ab	0.4ab
			RCI14/1125	67.2a	0.7a
			RCI14/199	39.0bc	0.4ab
Replications	**	**	Replications	Ns	Ns
Genotypes (G)	***	***	Genotypes (G)	**	**
Crop cycle (Y)	***	***	Crop cycle (Y)	***	***
G x Y	*	**	G x Y	Ns	Ns
Mean	43.3	0.5	Mean	43.0	0.4
CV (%)	74.8	70.1	CV (%)	86.8	86.4
SD	32.4	0.3	SD	37.3	0.3

3.3 Cane Genotypes as Affected by SCSM Disease at Three Months in Ferké 2 Experiments

In the three trails of Ferké 2 location (P3-61, V4-43 and V8-01 field plots), highly significant differences ($P<0.1$) in disease incidence and severity were observed between genotypes as well as crop cycles (Table 2). Genotype x crop cycle interactions were significant in the P3-61 trial and highly significant in V4-43 and V8-01 trails. This corroborates the fact the majority of genotypes tested behaved differently from plant cane to first ratoon towards the disease. Particularly, many asymptomatic or moderately resistant genotypes in plant cane became susceptible or highly susceptible in first ratoon. Similarly to both Ferké 1 trails, high values of coefficient of variation determined in both experiments (78.5 - 101%) could be explained by natural infection of disease.

Table 2. SCSM disease incidence and severity on cane genotypes in plant cane and first ratoon at 3 months regarding Ferké 2 experiments, Ivory Coast

Ferké 2 Trial P3-61			Ferké 2 Trial V4-43			Ferké 2 Trial V8-01		
Genotypes	Incid.(%)	Severity	Genotypes	Incid.(%)	Severity	Genotypes	Incid.(%)	Severity
M2593/92	20.4cd	0.2	M2593/92	50.3	0.8	R579	53.5	0.7
RCI12/149	42.2	0.4	RCI11/112	32.5	0.3	RCI11/1128	59.4	0.7
RCI13/138	38.3	0.5	RCI11/134	38.1	0.5	RCI11/1129	55.4	0.6
RCI13/140	46.4	0.5	RCI11/135	26.1	0.3	RCI11/1146	58.9	0.6
RCI13/141	50.3	0.6	RCI11/162	45.0	0.5	RCI12/1130	60.8	1.0
RCI13/142	31.9	0.3	RCI11/165	58.5	0.7	RCI13/1131	61.6	0.7
RCI13/143	49.5	0.6	RCI11/166	54.6	0.7	RCI13/1132	2.3	0.0
RCI13/144	38.1	0.5	RCI11/190	57.2	0.8	RCI13/1133	72.9	0.8
RCI13/145	1.4	0.0	RCI12/191	47.1	0.6	RCI13/1134	54.5	0.6
RCI13/150	33.7	0.3	RCI12/192	12.6	0.1	RCI13/1135	70.6	0.8
RCI13/151	39.3	0.4	RCI13/110	33.6	0.4	RCI13/1136	40.2	0.4
RCI13/152	45.0	0.5	RCI13/13	37.4	0.4	RCI13/1148	58.7	0.8
RCI13/153	26.3	0.3	RCI13/139	32.0	0.3	RCI14/1126	66.5	0.9
RCI14/146	50.1	0.6	RCI13/16	3.5	0.0	RCI14/1127	55.2	0.7
RCI14/147	42.0	0.5	RCI13/173	51.0	0.8	RCI14/1137	53.3	0.7
RCI14/148	54.2	0.6	RCI13/174	54.6	0.9	RCI14/1138	53.5	0.9
RCI14/154	39.0	0.4	RCI13/177	64.6	1.1	RCI14/1139	48.1	0.7
RCI14/155	48.2	0.8	RCI13/179	66.6	0.8	RCI14/1140	49.2	0.5
RCI14/156	44.3	0.5	RCI13/180	59.8	1.0	RCI14/1141	48.6	0.5
RCI14/157	29.2	0.3	RCI13/187	2.2	0.0	RCI14/1142	52.1	0.7
			RCI13/193	35.4	0.4	RCI14/1143	57.3	0.8
			RCI13/194	17.3	0.2	RCI14/1144	57.2	0.9
			RCI13/195	48.2	0.6	RCI14/1145	36.6	0.4
			RCI13/196	43.5	0.5	RCI14/1147	52.5	0.7
			RCI14/111	36.3	0.4			
			RCI14/128	35.4	0.3			
			RCI14/159	24.5	0.3			
			RCI14/171	55.8	0.6			
			RCI14/188	47.7	0.5			
			RCI14/189	51.2	0.8			
Replications	***	***	Replications	Ns	Ns	Replications	Ns	Ns
Genotyp (G)	***	***	Genotyp (G)	***	***	Genotyp (G)	***	***
Crop cycle (Y)	***	***	Crop cycle (Y)	***	***	Crop cycle (Y)	***	***
G x Y	*	*	G x Y	***	***	G x Y	***	***
Mean	38.5	0.4	Mean	40.7	0.5	Mean	53.3	0.7
CV (%)	90.0	84.0	CV (%)	94.3	101.1	CV (%)	78.5	86.0
SD	34.6	0.3	SD	38.4	0.5	SD	41.8	0.6

3.4 Cane Genotypes Resistance or Susceptibility to SCSM Disease at Three Months

3.4.1 Plant Cane

Higher percentage of disease resistant genotypes were observed in V4-43 and P3-61 experiments conducted in Ferké 2 with 72 and 52%, respectively (Fig. 2). The lowest percentage of resistant genotypes was observed in B3-13 experiment conducted in Ferké 1, with 37%. Highly susceptible genotypes were observed in B3-13 and V8-01 experiments carried out in Ferké 1 and Ferké 2, respectively, with 16 and 9% of genotypes tested.

Among all genotypes tested (N=119), 50.4% were resistant, 22.7% moderately resistant, 22.7% susceptible and 4.2% highly susceptible (Fig. 3). About 5% of genotypes were asymptomatic and therefore supposed to be highly resistant, namely RCI12/1116, RCI13/145, RCI14/157, RCI12/192, RCI13/187 and RCI14/159 (Table 3). Their agronomic performances will be carefully checked across the selection process, as resistance to SCSMV became recently a top ranking criterion followed by sugar yield in Ferké sugar estates agro-ecology. Five genotypes, namely RCI13/172, RCI13/182, RCI13/178 RCI13/1135 and RCI13/1133, found highly susceptible alongside with susceptible and moderately resistant ones will therefore be eliminated in first ratoon after harvest for the advanced selection stage irrespective of their sugar yield performances and other agro-morphological traits like erect and self-defoliating stalks for easy mechanized green harvesting.

Symptom observations in this study were made at three or four months, therefore at early grand growth stage of sugarcane where infection could be recognized visually without any virus detection equipment like ELISA chain (Enzyme Linked Immuno Sorbent Assay) or RT-PCR (Reverse Transcription - Polymerase Chain Reaction). However, observations made later at that growth stage (5-9 months) and the formative growth stage (10-12 months) showed much higher values of disease severity ranging from 2 to 3 (-) on susceptible genotypes compared with 0.1 to 0.5 (-) determined at early grand growth stage. That is why our suggestion would be to observe at 5-7 months, where sugarcane fields are still easily accessible for growth measurements and disease control.

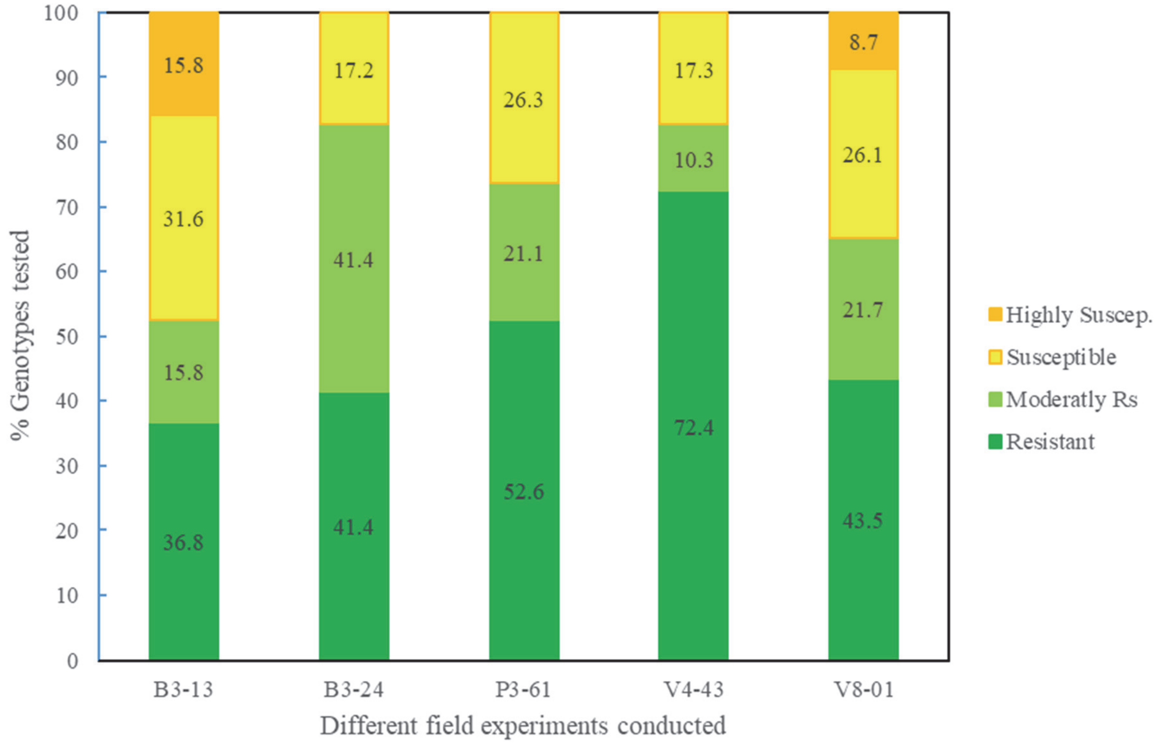

Figure 2. Sugarcane genotype resistance or susceptibility to SCSM disease in plant cane, at 3-4 months across field experiments carried out in plant crop at Ferké Sugar estates, Ivory Coast

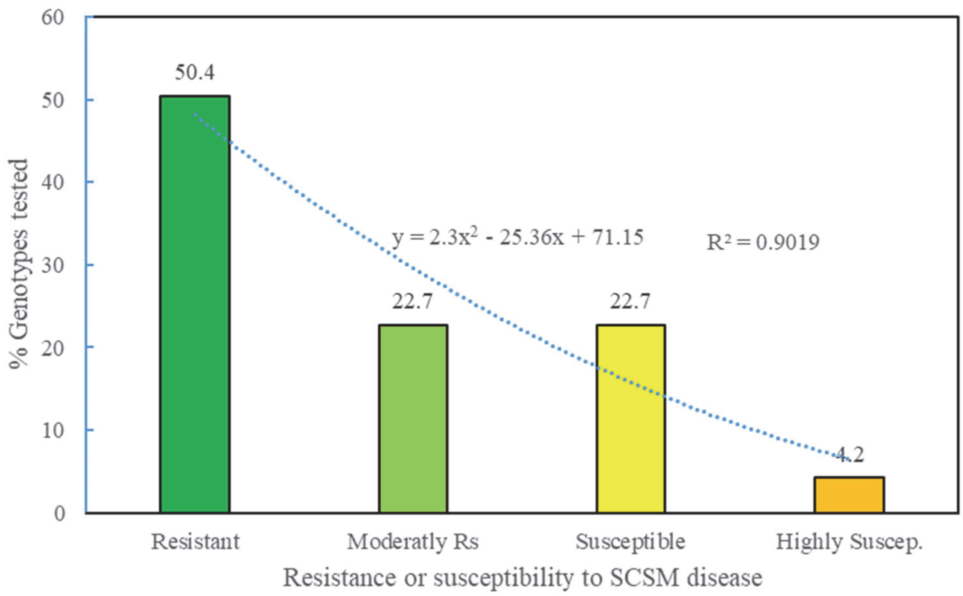

Figure 3. Percentage of genotype resistant or susceptible to SCSM disease in plant cane at early selection stage at Ferké sugar estates, Ivory Coast

Table 3. Resistant and highly susceptible cane genotypes to natural infection of SCSM disease in plant cane at Ferké sugar estates, Ivory Coast

	Cane genotypes	
Field experiments	Resistant	Highly susceptible
B3-13/Ferké 1	RCI11/170 ; RCI14/158 RCI13/183 ; RCI13/184 RCI11/163 ; RCI14/161 ; RCI10/164	RCI13/172 ; RCI13/182 ; RCI13/178
B3-24/Ferké 1	RCI12/1116* ; RCI13/1121 RCI14/1109 ; RCI14/1105 ; RCI14/1101 ; RCI13/1123 ; RCI13/1124 ; RCI13/1119 ; RCI13/197 ; RCI14/1108 ; RCI13/1117 ; RCI14/1107	-
P3-61/Ferké 2	RCI13/145* ; RCI14/157* ; RCI14/147 ; RCI13/153 ; RCI13/151 ; RCI14/154 ; RCI13/144 ; RCI14/156 ; RCI13/138 ; RCI13/142	-
V4-43/Ferké 2	RCI12/192* ; RCI13/187* ; RCI14/159*; RCI14/128 ; RCI13/13 ; RCI13/194 ; RCI13/139 ; RCI13/173 ; RCI11/135 - RCI13/16 ; RCI14/188 ; RCI13/110 ; RCI13/193 ; RCI11/162 ; RCI11/112 ; RCI12/191 ; RCI13/195 ; RCI14/189 ; RCI14/111 ; RCI11/134 ; RCI13/196	-
	RCI13/1136 ; RCI13/1132 ;	

V8-01/Ferké 2	RCI14/1140 ; RCI14/1139 ; RCI14/1138 ; RCI14/1145 ; RCI14/1147	RCI14/1141 ; RCI14/1142 ; RCI14/1137 ;	RCI13/1135 ; RCI13/1133

*: asymptomatic genotypes (n=6)

3.4.2 First Ratoon Crop

In the first ratoon crop, higher percentage of highly susceptible genotypes to SCSM disease (86-95.7%) were observed in all experiments conducted in both sugar estates (Fig. 3). Percentage of resistant genotypes observed in Ferké 2 ranged from 4.3 to 6.9% while none of them was observed in both Ferké 1 trials. That of susceptible genotypes ranged from 5.3 to 6.9% observed in both Ferké 1 trials as well as V4-43 trail of Ferké 2. In total, about 92% of genotypes tested were highly susceptible whereas 4.2 and 3.4% were susceptible and resistant, respectively (Fig 4, table 4).

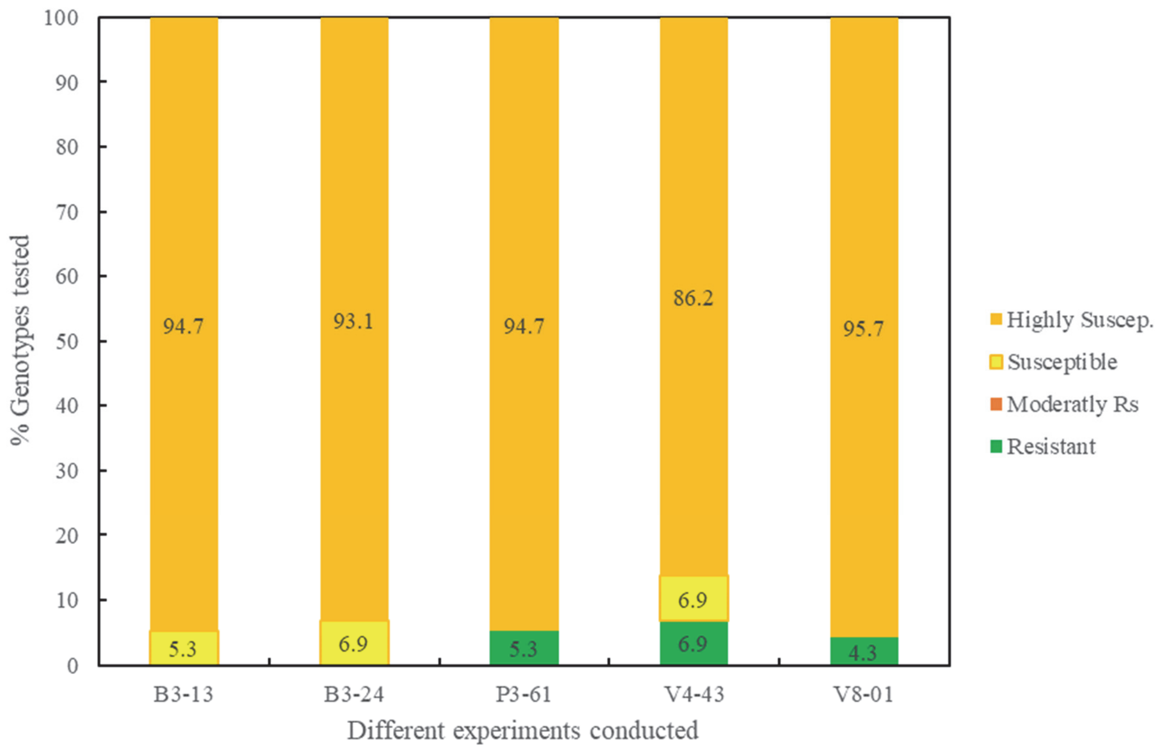

Figure 3. Sugarcane genotype resistance or susceptibility to SCSM disease in first ratoon crop at 3-4 months, across experiments carried out in plant crop at Ferké Sugar estates, Ivory Coast

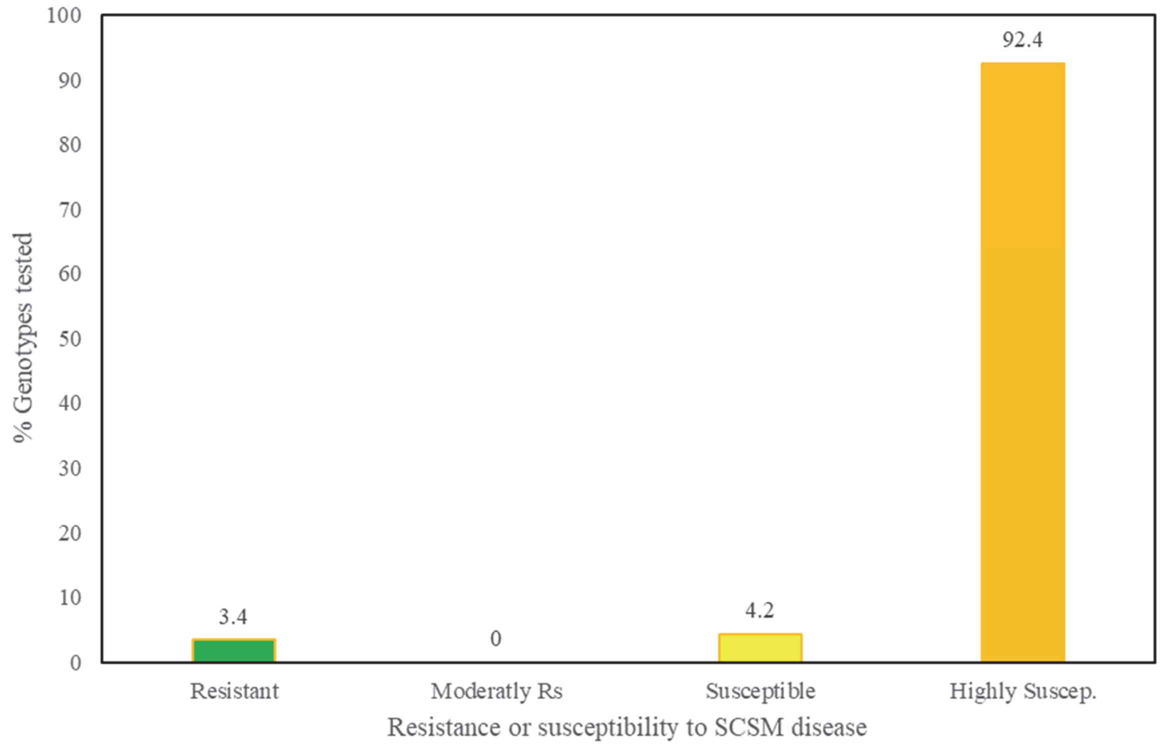

Figure 4. Percentage of genotype resistant or susceptible to SCSM disease in first ratonn crop at early selection stage at Ferké sugar estates, Ivory Coast

Table 4. Resistant and highly susceptible cane genotypes to natural infection of SCSM disease in first ratoon crop at Ferké sugar estates, Ivory Coast

	Cane genotypes	
Field experiments	Resistant	Highly susceptible
		RCI10/164 - RCI11/163 -
B3-13/Ferké 1	-	RCI11/167 - RCI11/168 -
		RCI11/169 - RCI11/170 -
		RCI13/172 - RCI13/175 -
		RCI13/176 - RCI13/178 -
		RCI13/181 - RCI13/182 -
		RCI13/184 - RCI13/185 -
		RCI13/186 - RCI14/158 -
		RCI14/160 -
		RCI14/161
		RCI13/1121 - RCI13/1122 -
B3-24/Ferké 1	-	RCI13/1117 - RCI13/1124 -
		RCI12/1116 - RCI11/1110 -
		RCI11/1112 - RCI13/1120 -
		RCI14/199 - RCI13/1119 -
		RCI11/1111 - RCI13/1123 -
		RCI14/1108 - RCI14/1109 -
		RCI11/1113 - RCI14/1101 -
		RCI14/1107 - RCI11/1114 -
		RCI13/198 - RCI14/1102 -
		RCI14/1100 - RCI14/1104 -
		RCI13/1118 - RCI14/1103 -

		RCI14/1105 - RCI14/1106 - RCI14/1125
P3-61/Ferké 2	RCI13/145	RCI13/150 - RCI13/153 - RCI13/142 - RCI14/157 - RCI12/149 - RCI14/146 - RCI13/138 - RCI13/144 - RCI14/154 - RCI13/151 - RCI13/143 - RCI13/152 - RCI14/155 - RCI14/148 - RCI13/140 - RCI14/156 - RCI14/147 - RCI13/141
V4-43/Ferké 2	RCI13/16; RCI13/187	RCI11/135 - RCI14/159 - RCI11/112 - RCI13/110 - RCI13/139 - RCI14/111 - RCI13/193 - RCI11/134 - RCI14/128 - RCI13/13 - RCI13/196 - RCI11/162 - RCI12/191 - RCI11/190 - RCI13/195 - RCI11/165 - RCI13/180 - RCI14/188 - RCI14/189 - RCI13/177 - RCI13/174 - RCI11/166 - RCI14/171 - RCI13/173 - RCI13/179
V8-01/Ferké 2	RCI13/1132	RCI14/1145 - RCI13/1136 - RCI13/1134 - RCI14/1139 - RCI14/1141 - RCI14/1144 - RCI13/1133 - RCI14/1140 - RCI11/1128 - RCI14/1147 - RCI11/1129 - RCI14/1142 - RCI14/1143 - RCI14/1137 - RCI14/1126 - RCI11/1146 - RCI12/1130 - RCI13/1131 - RCI13/1135 - RCI13/1148 - RCI14/1127 - RCI14/1138

3.5 Disease Epidemiology

Some weed species like *Rottboellia exaltata* L, *Dactyloctenium aegyptium*, *Imperata cilyndrica, Pennisetum pupureum, Paspalum* spp., *Bracharia moliniformis* and *Panucum repens*, as well as cereal crops like maize (*Zea mays* L) and sorghum (*Sorghum bicolor*) are respectively highly endemic and commonly cultivated across Ivorian sugar estates. Several investigators reported that they were host plants for SCSMV (Putra et al, 2014; Prabowo et al, 2014).

Although investigations were made on suspected insect vectors of the disease like *Ceratovacum lanigera* Zeh., *Rhopalosiphum maydis*, *Saccharicocus sacchari* Cock., and *Melanaphis sacchari* Zeh. (a sugarcane aphid) (Damayanti & Putra, 2011; Putra & Damayanti, 2012; Béhou & Péné, 2018), no evidence of disease transmission from a vector was made to our knowledge.

Under Ivorian field conditions, two insect species (*Locris rubra* and L. *maculate*) were suspected as possible SCSMV vectors. They were frequently observed on susceptible varieties namely R579, SP81-3250, and R570. Beside them, numerous possible vectors used to be observed on leaves of susceptible varieties such as *Zonecerus variegatus, Paracinema tricolor, Stenohippus aequus, Oxya hyla* and *Conocephalus longipennis*. In addition to the fact that SCSM disease is spread very fast, similarly to the case of rice yellow mottle virus, it could be hypothesized that a complex biocenosis of pests could be possible vectors of the disease (Koudamiloro et al, 2015).

SCSMV constitutes a great challenge for geneticists, breeders, pathologists, agronomists as well as cane growers. In the sense that it is not eliminated by hot water treatment (HWT), in contrast to most economically important diseases in sugarcane frequent in sub-Saharan Africa and elsewhere like leaf scald (*Xanthomonas albinineans*), smut (*Sporisorium scitamineum*), yellow leaf disease (SCYLD), orange rust (*Puccinia kuehnii*), RSD (*Leifsonia xyli* subsp. Xyli), and brown rust (*Puccinia melanocephala*). Other challenges lie in the fact that no insect vector of SCSMV is formally identified yet, its transmission mechanism from vector to crop being still unknown and it spreads very fast across sugarcane fields and varieties, with significant yield reduction as reported in Brazil, Indonesia and Ivory Coast (Gonçalves et al, 2007b; Magarey et al, 2018; Béhou & Péné, 2019. Prophylactic measures based on agricultural practices regarding sanitation of planting and harvesting tools or machinery as well as search for resistant cane varieties must be given a top priority. In this regard, sugarcane selection starting from true seed constitutes a great opportunity to broaden the genetic diversity of plant material being tested in line of SCSMV thread. This program is being under way since 2014-15 in Ivory Coast, and much earlier in Senegal and some Central African countries (Cameroon, Tchad and Congo), in collaboration with R&D institutes like eRcane (Reunion Island) and MSIRI (Mauritius).

4. Conclusions

In each of the five selection trails conducted on both Ferké 1 & 2 sugar estates, highly significant differences in disease incidence and severity were observed between genotypes as well as crop cycles (plant cane and first ratoon). Except for one trial (B3-24 in Ferké 1), Genotype x crop cycle interactions were significant or highly significant, which showed that the majority of genotypes tested behaved differently from plant cane to first ratoon towards the disease. Particularly, the percentage of resistant genotypes decreased from 50 to 3.4% whereas that of highly susceptible ones increased from 4.2 to 92.4%. This shows the level of challenge to be tackled in the control of SCSM disease through sugarcane breeding and selection. At the end of the current selection stage under way, i.e. after harvest of first ratoon, only the best yielding genotypes among the resistant ones will undergo the advanced selection stage.

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