Sugarcane Mosaic Virus in Kenya

RAYMOND LOUIE, Research Plant Pathologist, USAID/USDA-SEA, Plant Pathology and Nematology Division, Kenya Agriculture Research Institute, Nairobi, Kenya

ABSTRACT

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Surveys for sugarcane mosaic virus (SCMV) in maize (*Zea mays* L. subsp. *mays*) were made in 34 of 41 districts in Kenya. SCMV was found in 20 districts and only in the western plateaus, Central Highlands, and Rift Valley. Provinces with high incidence of SCMV included Nyanza (15.2%), Rift Valley (15.8%), and Western (19.6%). SCMV was not found in Coast or Nairobi provinces. The incidence of SCMV was higher in late-planted maize planted for the April–May rains or the October–November rains than in early plantings. This is the first report of natural infection with SCMV in *Cynodon dactylon*, *C. nlemfuënsis*, *Digitaria nuda*, *D. abyssinica*, *Eragrostis exasperata*, *Paspalum notatum*, *P. scrobiculatum*, *Rhynchelytrym repens*, and an unknown *Tripsacum fasciculatum* cross. The distribution of SCMV in maize appeared to be related to the distribution of sources of inoculum, but the periodicity of disease development appeared to be related to vector populations. Maize streak and maize mosaic viruses were most often found in Central (4.5%) and Coast (13.8%) provinces.

Additional key words: corn, maize dwarf mosaic virus, weed hosts

In 1973, Kulkarni (14) reported sugarcane mosaic virus (SCMV) in sugarcane (interspecific hybrids of *Saccharum*) and maize (*Zea mays* L. subsp. *mays*) in six of 41 districts of Kenya and in Tanzania and Uganda. Because SCMV causes serious losses in maize (14, 16), which is grown in most parts of Kenya (1), more information was needed to delineate the distribution of SCMV and determine its possible overseasoning hosts.

We report on the distribution of SCMV in maize in Kenya, the seasonal development of the disease at Muguga and Kitale, and the possible sources of inocula. SCMV includes strains specially adapted to sugarcane, maize, or sorghum (*Sorghum* spp.) that are difficult to transmit from one grass host to another; for example, maize dwarf mosaic virus strain A is easily transmitted to johnsongrass (*S. halepense* (L.) Pers.) but not to sugarcane (23). No attempt was made in this paper to identify strains. A preliminary report on weed hosts has been published (18).

MATERIALS AND METHODS

One-hundred maize plants along an edge row of each field and 100 plants from the 10th row within each field were examined for SCMV symptoms. In fields where maize was intercropped, 100–200 maize plants were examined at random. Information on growth stage, plant height, leaf number, and cultivar was collected whenever possible and used to modify judgment on disease incidence when conflicting data were taken within a district.

Weed hosts in fields and gardens were examined for symptoms of viral infection. Suspect weeds were collected, bioassayed for SCMV infection, planted in the glasshouse, and later identified at the Kenya Herbarium.

At least two sites were surveyed in each district. The site location was identified by the name of the nearest town or village. Because the best time to survey SCMV in a district was not known, surveys were made during an entire maize-growing season. Although SCMV in maize was the main virus investigated, the occurrence of other viral diseases, including those caused by maize streak virus (MSV) and maize mosaic virus (MMV), was also recorded. Because specific vector transmission is often used to identify MSV and MMV and because we did no insect transmission studies, plants with symptoms resembling either disease were recorded as infected with either virus.

One percent of the field diagnoses of SCMV infections in maize were confirmed by rub-inoculations to H512 maize test plants. Pathogenicity and symptomatology of virus isolates selected from samples of maize and weed hosts were studied by rub-inoculations on 'Atlas' sorghum (*S. bicolor* (L.) Moench), Columbus grass (*S.* × *almum* Parodi), and johnsongrass. (We destroyed the johnsongrass test plants 21–35 days after inoculation by heating them in an oven at 185 C for 6–8 hr.) A total of 109 samples of maize (field plants and trap plants [17]), sugarcane, and weed hosts were preserved in liquid nitrogen for future studies.

Trap plants of H512 maize were used to determine the disease intensity (17) caused by SCMV, MSV, and MMV. Twenty-five pots of 14-day-old maize plants were exposed for 7 days in the field as trap plants at the Muguga and Kitale locations.

Yellow water pans were used to trap aphids. Aphids were collected weekly, counted, and stored in 70% alcohol for later identification.

RESULTS AND DISCUSSION

Distribution of SCMV in Kenya. SCMV, MSV, or MMV was found in maize in 28 districts of eight Kenyan provinces surveyed (Table 1). During the survey period (1977–1978), SCMV was found most often in maize in Nyanza (15.2%), Rift Valley (15.8%), and Western (19.6%) provinces, and MSV or MMV was found most often in Central (4.5%) and Coast (13.8%) provinces. The North Eastern province was not surveyed. SCMV-infected maize, sorghum, sugarcane, or weed hosts were found only in the western plateaus, the Central Highlands, and the Rift Valley. Elevation in the areas where SCMV-infected plants were most common ranged from 900 to 2,700 m, but some were found at 300–900 m (1).

The distribution and incidence of SCMV suggest that resistance in maize is needed primarily in the major maize production areas of Kenya. The incidence of SCMV within these areas, however, is not uniform; the virus seems to be more prevalent in the Kiambu district in Central Province, the Kisii and Homa Bay districts in Nyanza Province, the Kericho and Trans Nzoia districts in the Rift Valley Province, and perhaps the Kakamega district in Western Province than in other districts in the same provinces. Despite obvious trends in virus distribution, our conclusions are limited by the small fraction of maize surveyed in any district.

Lack of data on disease development in maize at all surveyed sites also limits the interpretation of the survey results. Because the incidence data indicate SCMV distribution only at the time of survey, the incidence of SCMV in maize

Present address of the author: AR, SEA, USDA, Department of Plant Pathology, Ohio Agricultural Research and Development Center, Wooster, OH 44691.

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in some districts could be higher than indicated in Table 1. For example, when 10% of the maize at the Maize Genetics Division overhead-irrigated nursery at Kitale was surveyed in August 1977, a 4.2% incidence of SCMV was found. In October and November, the incidences were 41.3 and 97.7%, respectively. In 1978, SCMV incidences at the same nursery were 0.6 and 47.5% in June and November, respectively.

Similarly, MSV or MMV in maize in Coast Province varied from season to season and year to year; in 1977, incidence of MSV or MMV averaged 7.3% (nine fields) and 3.6% (six fields) in July and December, respectively; in September 1978, incidence averaged 28.8% (12 fields) and ranged from 1.7% at Matuga to 74.2% at Mtwapa. Finally, disease may be overlooked. For example, we could not confirm the presence, previously reported (14), of SCMV in maize at Kinoo and Machakos.

Disease incidence in trap plants. The epiphytotic of sugarcane mosaic in the Maize Genetics Division nursery at Kitale closely followed the incidence of SCMV in trap plants and the number of aphids trapped (Fig. 1). In 1977, the average incidence in trap plants was highest (18%) in October. This finding agrees with observations of more severe disease problems in late-planted nurseries than in early-planted nurseries (L. L. Darrah, *personal communication*). In 1978, peak disease incidence in the nursery was also reached by the first week in November but was lower than in 1977 (48 vs. 98%). However, since the incidence of SCMV in trap plants at Kitale was also less than 1% after August 1978, the lower incidence in the nursery plants was expected. The Maize Genetics Division nursery is considered suitable for screening for SCMV resistance under natural conditions provided that maize entries are planted in late August or early September and aphid vectors are numerous. To ensure sufficient inoculum in the test nursery, spreader rows of inoculated susceptible maize such as H512 should be planted between every 10 rows of test plants.

Disease incidence in maize appears to depend on the species as well as the number of aphids. In 1977, the incidence of SCMV in trap plants at Muguga was highest in June, with another, smaller peak in November (Fig. 1A). The number of aphids caught in the yellow water-pan trap followed a similar pattern (Fig. 1B). Eastop (6) reported similar data for aphid populations at Muguga in 1953-1954. In 1978, however, the aphid catch was lower during June–July and was nil by the end of the year. In contrast with the occurrence of high disease incidence at aphid population peaks in 1977, the highest incidence of SCMV in trap plants in 1978 occurred from January to March, when aphid catches were lowest. These

Table 1. Distribution of sugarcane mosaic virus (SCMV) and maize streak virus (MSV) or maize mosaic virus (MMV) in maize in Kenya, 1977–1978

		No. of fields examined		Infected plants (%)			
				SCMV		MSV/MMV	
Province	**District**	**1977**	**1978**	**1977**	**1978**	**1977**	**1978**
Central	1. Nyandarua	4	2	2.8	6.3	0.0	0.0
	2. Nyeri	2	2	0.0	0.0	11.6	8.2
	3. Kirinyaga	2	6	0.0	0.7	1.0	7.3
	4. Murang'a	...[a]	3	...	0.0	...	1.3
	5. Kiambu	10	10	11.7	41.7	1.6	9.6
Nyanza	6. Kisii	3	2	30.2	21.7	0.0	0.0
	7. Kisumu	0	3	0	1.5	0	0.5
	8. Siaya	...	5	...	1.3	...	1.0
	9. Homa Bay	3	3	25.7	25.8	1.0	0.0
Western	10. Bungoma	0	0	0	0	0	0
	11. Busia	...	4	...	18.2	...	5.4
	12. Kakamega	2	1	78.3	1.3	0.9	0.0
Coast	13. Taita	2	1	0.0	0.0	1.9	7.2
	14. Kilifi	3	5	0.0	0.0	11.1	37.0
	15. Kwale	10	6	0.0	0.0	3.5	22.2
Mombasa	16. Mombasa	...	1	...	0.0	...	11.0
Rift Valley	17. Kericho	1	2	42.0	46.0	0.0	0.0
	18. Nandi	...	2	...	39.8	...	3.8
	19. Kara Pokot	7	...	2.0	...	9.5	...
	20. Baringo	4	2	4.5	2.0	0.0	2.0
	21. Elgeyo-Marakwet	...	2	...	33.3	...	0.0
	22. Trans Nzoia	10	9	48.5	23.0	0.0	0.1
	23. Uasin Gishu	3	3	0.0	5.6	0.0	1.0
	24. Nakuru	7	4	6.6	24.8	0.1	0.6
	25. Liakipia	1	2	49.0	3.5	0.0	0.0
	26. Narok	4	2	0.5	0.0	0.0	0.0
	27. Kajiado	1	1	0.0	0.0	0.0	0.0
	28. Samburu	0	0	0	0	0	0
Eastern	29. Embu	2	2	0.0	1.0	2.0	12.4
	30. Meru	2	3	1.7	4.9	0.0	0.0
	31. Kitui	...	3	...	0.0	...	0.0
	32. Machakos	10	3	0.0	0.0	1.9	0.0
	33. Isiolo	0	1	0	0.0	0	0.0
Nairobi	34. Nairobi	1	2	0.0	0.0	0.0	0.0
Tanzania		3	...	37.9	...	4.5	...
Total, Kenya		94	97				
Mean, Kenya				11.2	9.2	1.7	4.0

[a]... = not surveyed; 0 = no maize grown at time of survey.

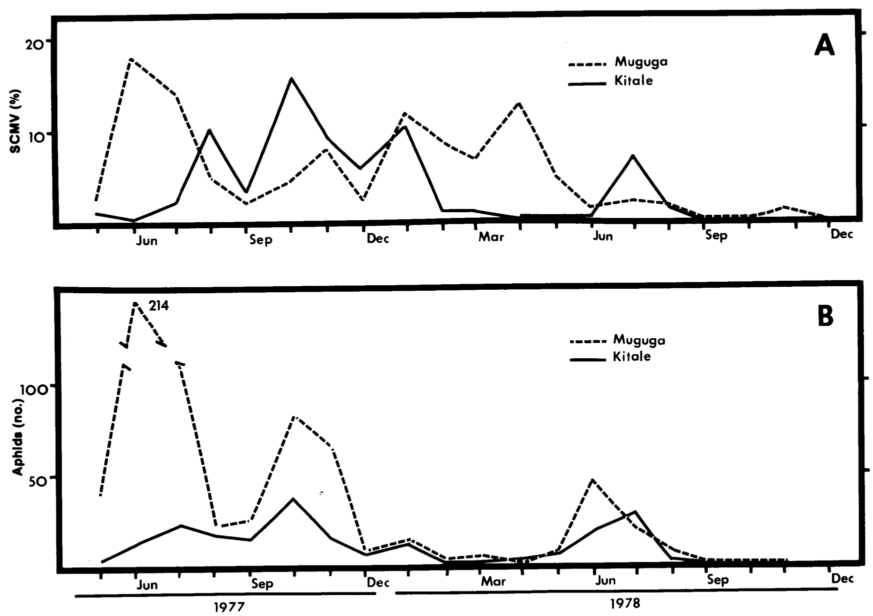

Fig. 1. Average monthly **(A)** incidence of sugarcane mosaic virus (SCMV) in 14-day-old H512 maize seedlings and **(B)** aphid catches in yellow water-pan traps at Muguga and Kitale, Kenya, 1977–1978.

data suggest that some aphid species transmit the virus more efficiently than others. Species identification of aphids remains to be completed.

Overseasoning hosts of SCMV. Many graminaceous hosts of SCMV are known (2,4,8,11,15,20–23,25). Most of these are included as hosts on the basis of rub- or aphid-inoculation results or field observations; some are included based on the recovery of virus from field-infected plants. Because we wanted to identify possible sources of inoculum in the field, we were interested in naturally infected plants.

Species found to be naturally infected with SCMV are listed in Table 2. This is the first report of such infection in *Cynodon nlemfuënsis* Vanderyst, *Eragrostis exasperata* Peter, *Digitaria nuda* Schumach., *D. abyssinica* (A. Rich) Stapf, a cross of *Tripsacum fasciculatum* Trin. ex Aschers., *Cynodon dactylon* (L.) Pers., *Paspalum notatum* (L.) Fluegge, *P. scrobiculatum* L., and *Rhynchelytrum repens* (Willd.) C. E. Hubb. The last five hosts named have also been reported as susceptible to SCMV infection by rub-inoculation (15,20–23).

All isolates except that from *C. dactylon* were typical of SCMV in pathogenicity and symptomatology (Table 2). However, the isolate from *C. dactylon*, collected from Kakamega district, closely resembled the johnsongrass strain of SCMV (SCMV-Jg or maize dwarf mosaic virus strain A) of the United States. Kulkarni's studies (13,14) indicate that SCMV isolates in Kenya are generally related to SCMV-A, -B, and -D, reported in the United States.

Reactions on *S.* × *almum* of isolates from Muguga (Kulkarni's original isolate) and Kitale were also unexpected. Transmission of the Kitale isolate to *S.* × *almum* was greater than that of the Muguga isolate (15 vs. 2%) but still was comparatively low. Tosic and Ford (23) reported that only maize dwarf mosaic virus strain A, SCMV-I, and SCMV-Jg were transmissible to *S.* × *almum*. Our data suggest that variations in SCMV populations in Kenya may be more involved than previously reported.

Perennials listed in Table 2 should be prime candidates for overseasoning hosts. Field observations, however, did not always support this conclusion. For example, sugarcane is grown perennially alongside maize in many small gardens and is suspected of being a source of inoculum for disease development in maize. Symptomless infection with SCMV also occurs in sugarcane (9,14). Our surveys and assays of sugarcane plants from 10 small gardens in the Kiambu district, where the incidence of SCMV in maize was high, failed to reveal or isolate SCMV from symptomless plants. Bioassays of apparently healthy plants of sugarcane cultivars B51415, CO281, CP31-294, M423/51, and NCO310 (reported as symptomless hosts [14]) at the Kenya Agriculture Research Institute's plant quarantine plots were also negative. One sugarcane plant with SCMV symptoms in the field yielded SCMV on bioassay.

Pennisetum purpureum Schumach., another perennial, is also widely grown in maize-growing areas. However, of six plants with symptoms resembling viral infections, only one yielded SCMV on bioassay. SCMV was not transmitted to or recovered from apparently healthy *P. purpureum* by rub- or airbrush-inoculations. Several grass hosts; eg, *Digitaria velutina* (Forsk.) Beauv. and *Paspalum notatum*, were infected with other viruses besides SCMV. *Melinis minutiflora* Beauv., a reported host of SCMV in Africa (14), was not encountered in this survey.

Epiphytology. The distribution of SCMV in maize in Kenya may be affected by the availability of inoculum sources, maize genotypes, aphid vectors, and environmental conditions. The availability of inoculum most likely limits SCMV in maize despite the prevalence of naturally infected weed hosts and secondary sources such as infected maize, sorghum, and sugarcane. SCMV is found in the southwest highlands of Kenya but not in areas southeast of the highlands. However, SCMV was found in maize in Tanzania around Arusha, Moshi, and Kahe, southeast of the Kenyan highlands. Further east, along the Coast Province in Kenya and south along Tanzania's coastal districts, SCMV was not found. If SCMV were introduced into areas like the Coast Province, it probably would become established and important in maize and sugarcane.

The availability of susceptible maize does not appear to limit SCMV, especially at higher elevations (above 2,000 m), where a normal season for maize may extend from late March to mid-November. At present, no maize grown in Kenya is resistant to SCMV (14,16). Incidence of SCMV commonly was higher in late-planted (August–October) maize nurseries than in the normal season crop planted in April or May, but maize planted in early April was still susceptible to SCMV by rub-inoculation as late as 63 days after planting (16).

The occurrence of SCMV in maize primarily in the southwestern highland areas of Kenya also suggests that disease development, as opposed to distribution, is limited by elevation, temperature, and rainfall. These factors determine the species and amount of natural vegetation (10,24), which in turn influence vector development and migration (12). Data from the SCMV and weed host surveys (Tables 1 and 2) and preliminary evidence

Table 2. Reaction of maize (*Zea mays* L. subsp. *mays* H512), sorghum (*Sorghum bicolor* (L.) Moench. 'Atlas', and johnsongrass (*S. halepense* (L.) Pers.) to bioassays of grasses with viral symptoms collected near maize fields in Kenya

Tribe Species	Infection in assay host[a] H512 maize	'Atlas' sorghum	Johnsongrass
Festuceae			
Eragrostis exasperata Peter	Sy	LL	0
E. superba Peyr.	0	...	...
Chlorideae			
Chloris gayana Kunth	0	...	...
Cynodon dactylon (L.) Pers.	Sy	Sy	Sy
C. nlemfuënsis Vanderyst	Sy	LL	0
Paniceae			
Acroceras macrum Stapf	0	...	...
Brachiaria rugulosa Stapf	0	...	...
Digitaria abyssinica (A. Rich.) Stapf	Sy	LL	0
D. nuda Schumach.	Sy	LL	0
D. velutina (Forsk.) Beauv.	Sy	LL	0
Panicum maximum Jacq.	0	...	...
Paspalum notatum (L.) Fluegge	Sy	LL	0
P. scrobiculatum L.	Sy	LL	0
Pennisetum purpureum Schumach.	Sy	LL	0
Rhynchelytrum repens (Willd.) C. E. Hubb.	Sy	LL	0
Setaria verticillata (L.) Beauv.	Sy	LL	0
Andropogoneae			
Saccharum officinarum L.	Sy	LL	0
Sorghum × *almum* Parodi[b]	Sy	LL	0
S. bicolor (L.) Moench	Sy	LL	0
Tripsaceae			
A cross of *Tripsacum fasciculatum* Trin. ex Aschers.	Sy	LL	0
Zea mays L. subsp. *mays*	Sy	LL	0

[a] Sy = systemic infection; LL = local lesions; 0 = no infection; ··· = not tested.
[b] Not found naturally infected.