Strains of Sorghum Mosaic Virus Causing Sugarcane Mosaic in Louisiana

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ABSTRACT

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The viruses found causing sugarcane mosaic in Louisiana during 1978–1988, 1990, and 1992 were strains H, I, and M of sorghum mosaic virus. The percentages of plant samples that were infected with the three strains within the three production areas of the sugarcane belt were determined (because approximately 4% of all plants sampled were infected by more than one strain, incidences totaled more than 100%). In the Bayou Lafourche area, strain H was found in 99% of infected plants, strain I in 1%, and strain M in 2%; in the Mississippi River area, strain H was found in 98% of infected plants, strain I in 1%, and strain M in 2%; and in the Bayou Teche area, strain H was found in 90% of infected plants, strain I in 12%, and strain M in 5%. Strains were identified annually by inoculating differential host plants (sugarcane cultivars CP 31-294 and CP 31-588, sweet sorghum cultivar Rio, and johnsongrass) with leaf juice from diseased sugarcane plants. The highest incidence of strain I (12–31% of samples assayed) occurred in the Bayou Teche area during 1978–1982. The subsequent decline in incidence of strain I in this area corresponded with the decline of cultivar NCo 310. Strain M appeared intermittently at low levels in all areas, but in 1987 and 1988 in the Bayou Teche area, strain M appeared in 17 and 13%, respectively, of the samples—most often those of the cultivar CP 79-318.

Sugarcane mosaic in combination with soilborne diseases, principally Pythium root rot and red rot, caused a near collapse of the Louisiana sugarcane industry in the 1920s (1). At that time, the cultivars being grown were *Saccharum officinarum* L., or noble canes. To control mosaic, interspecific hybrids of *Saccharum* that were tolerant to mosaic were introduced. The mosaic of the noble canes and early interspecific hybrids is believed to have been caused by strain E of sugarcane mosaic virus (SCMV) (12). Strain D appeared with the introduction of more resistant hybrids in the mid-1920s (12). Strain D and strain B, which appeared in commercial plantings in 1930, were the predominant strains during the 1930s and 1940s. Brief, isolated outbreaks of strain A occurred in the 1940s and 1950s (3,12).

Mosaic incidence was kept low in the 1940s and early 1950s by destroying all plants in fields with a high incidence of disease and by planting stalks from mosaic-free fields of any susceptible, recommended cultivars. Strain H became predominant following its discovery in 1956 (2,5). Strains I and M were identified in 1966 and 1973, respectively (11,18).

Recent taxonomic research of a large number of strains of potyviruses whose host ranges are limited to Poaceae led to the conclusion that most belong to one of four potyviruses (15,16). Among the virus strains that have caused mosaic in commercial sugarcane of Louisiana, strains A, B, D, and E are SCMVs and strains H, I, and M are sorghum mosaic viruses (SrMV).

The natural host range of SrMV is sorghum (7) and sugarcane (2,3,10). Prior to the taxonomic separation of SCMV and SrMV, several workers reported natural infection of SCMV on a number of cultivated and wild grasses, including maize and sorghum (11).

Summers and coworkers (17) were the first to use differential hosts to define strains of the virus causing sugarcane mosaic. Since 1966, virus strains causing sugarcane mosaic in Louisiana have been identified by means of a set of differential hosts proposed by Abbott and Tippett (3) and modified to provide descriptions of strains I and M (11,18). To date, the various serological and biochemical techniques cannot distinguish the strains of SCMV and SrMV (16); therefore, host reaction remains the method used to identify strains. Strains of viruses causing mosaic in sugarcane plants collected in Louisiana between 1978 and 1992 were identified by use of differential host plants.

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Table 1. Incidence of sorghum mosaic virus strains H, I, and M infecting sugarcane plants collected over 13 yr from three production areas in Louisiana[a]

	Plant collected											
	Bayou Teche				Mississippi River				Bayou Lafourche			
		Infected (%)				Infected (%)				Infected (%)		
Year	No.	H	I	M	No.	H	I	M	No.	H	I	M
1978	42	95	31	0	40	100	0	0	28	100	0	0
1979	32	97	25	0	19	100	0	0	25	100	0	8
1980	46	72	24	11	48	98	0	4	48	92	0	12
1981	24	96	12	0	22	100	0	0	18	100	4	0
1982	46	96	22	2	48	96	4	0	48	100	4	0
1983	47	100	4	0	48	100	0	4	47	100	2	4
1984	46	98	9	0	48	100	0	0	48	100	4	0
1985	47	81	26	0	45	96	2	2	47	98	2	0
1986	48	100	0	0	48	100	0	0	48	100	0	0
1987	48	81	6	17	48	100	0	0	48	98	0	2
1988	48	81	2	19	48	100	0	4	36	100	0	2
1990	43	100	0	0	42	95	0	5	52	100	0	0
1992	48	92	10	10	48	96	4	0	48	100	0	0
Av.	43	91 (7)[b]	12 (8)	5 (1)	42	98 (1)	1 (0)	2 (1)	42	99 (2)	1 (1)	2 (1)

[a] Incidence totaled more than 100% when plants were infected by more than one strain.
[b] Incidence when plants were infected by more than one strain.

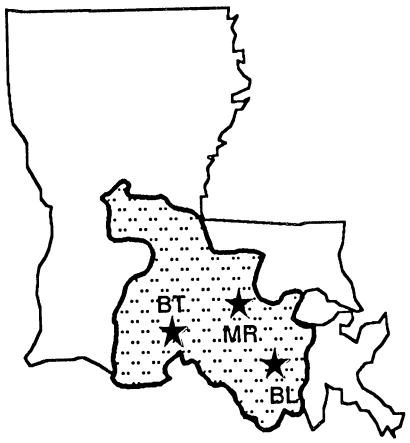

Fig. 1. The three primary sugarcane production areas within the Louisiana sugarcane belt (shaded) where mosaic-affected plants were collected during 1978–1988, 1990, and 1992: BT = Bayou Teche, MR = Mississippi River, and BL = Bayou Lafourche.

MATERIALS AND METHODS

Sugarcane plants 30–60 days old and expressing mosaic symptoms were transplanted from the field to the greenhouse each May between 1978 and 1992 except 1989 and 1991. In most years, 12 plants each of four cultivars were collected at each of three locations (Table 1). Plants occasionally died when transplanted from the field to the greenhouse. The locations represent the three primary sugarcane production areas of Louisiana, which follow the major waterways of the sugarcane belt, i.e., Bayou Teche in the west, Bayou Lafourche in the east, and the Mississippi River in the center (Fig. 1). Some general differences in soil type, cultivation practices, and cultivar selection exist among the three areas. The infected plants were from small plots located on cooperating commercial farms and consisted of recommended commercial cultivars or advanced candidate cultivars being evaluated in the cultivar selection program. An attempt was made to collect from the same cultivars at the three locations in a given year, but this was not always possible because the incidence of mosaic varied among locations. Cultivar selection shifted from year to year as cultivars in the testing program changed.

Plants of differential sugarcane cultivars CP 31-294 and CP 31-588 were germinated from single buds, and plants of sweet sorghum (*Sorghum bicolor* (L.) Moench 'Rio') and johnsongrass (*S. halepense* (L.) Pers.) were grown from seed. The leaves of the virus-infected plants were trimmed when transplanted from the field to the greenhouse. Inoculation of the differential host plants was timed so that new leaves on the virus-infected plants served as the source of inoculum for 2-wk-old differential sugarcane and johnsongrass plants and 1-wk-old sweet sorghum plants.

Inoculum was prepared by extracting juice from the leaves of each source plant with a grinding mill. The extracted juice was filtered through cheesecloth and mixed with 0.005 M sodium sulfite buffer (1:1, v/v) and silicon carbide particles. Plants were inoculated at the one- to two-leaf stage with the extract by the airbrush technique (14). Juice from each source plant was used to inoculate six plants of each sugarcane differential host and approximately 15 plants of sweet sorghum. Juice from two of the 12 diseased plants of each cultivar from each of the three locations was used to inoculate four to six johnsongrass plants. Sugarcane, sweet sorghum, and johnsongrass differential host plants were also inoculated with juice from sugarcane plants maintained in the greenhouse and known to be infected with strains A, B, and D of SCMV and strains H and I of SrMV and from Louisiana johnsongrass infected with maize dwarf mosaic virus strain A (MDMV-A). Plants not showing mosaic symptoms after 2 wk were inoculated a second time.

Plants were examined for mosaic symptoms 2 and 4 wk after the initial inoculation. A description of the symptoms on each differential host plant was recorded. Symptoms were compared with earlier symptom descriptions (3,10, 11,18) and symptoms of the differential host plants inoculated with known strains of SCMV and SrMV and with MDMV-A.

Plants were maintained in a screened (30-mesh) greenhouse at temperatures between 24 and 35 C. Plants were treated weekly with diazinon for insect control and fertilized weekly with a commercial 15-30-15 product (Miracle-Gro, Stern's Miracle-Gro Products, Inc., Port Washington, NY).

RESULTS AND DISCUSSION

Strain H of SrMV was the predominant virus strain causing mosaic of sugarcane during the course of this study (Table 1). Strain H became the predominant strain in Louisiana soon after its discovery in 1956 because the principal cultivar, CP 44-101, and two cultivars, NCo 310 and CP 52-68, released in 1954 and 1958, respectively, were susceptible (5). Most cultivars released since the appearance of strain H, including the most widely planted cultivar in the past 20 yr, CP 65-357, have been moderately to highly susceptible to infection by the virus (5,9; *unpublished*). Their yields, however, exceeded those of more resistant but less well-adapted cultivars. Consequently, little selection pressure has been placed on the virus to evolve new strains.

The second most frequently recovered strain of SrMV was strain I (Table 1). Strain I was most commonly recovered from the Bayou Teche area, where it was first recovered from a plant of NCo 310 in 1966 (18). Early surveys also found that strain I was most frequently recovered from the Teche area (5). The suggestion was made that the high incidence of strain I in the Teche was associated with cultivar NCo 310, which was widely grown in this area (12). The present study supports that suggestion because with the decline and eventual elimination of NCo 310 from the Louisiana industry, the frequency of strain I recovery also declined (Fig. 2). Although strain I was recovered from as many as 75% of the NCo 310 plants sampled between 1978 and 1983, the strain was also recovered from other cultivars throughout the study, and strains H and M were recovered from plants of NCo 310.

Strain M of SrMV was recovered intermittently at low levels from all areas throughout the years (Table 1) since it was first recognized in 1973 (4). The highest incidence of strain M was among samples of the cultivar CP 79-318 from the Teche collected in 1987 and 1988. Other collections of mosaic samples from CP 79-318 have confirmed that there is a higher probability of recovering strain M from this cultivar than from other Louisiana commercial sugarcanes (*unpublished*). However, strain M was recovered from several other cultivars, and strain H was the most frequently recovered strain from CP 79-318.

Strains A, B, and D of SCMV were not recovered from plants collected in this study and have not been reported from commercial sugarcane in Louisiana for more than 20 yr (5). Mosaic was of little concern during the 1940s and early 1950s because the dominant cultivars had high levels of resistance or immunity to these strains. With the appearance of strain H of SrMV, the disease again became widespread because of the lack of resistance to the new pathogen among recommended cultivars and parental clones. The level of resistance to strains A, B, and D, however, appears to have been sufficient to result in the elimination of these strains from commercial sugarcane.

Symptoms produced on the sweet sorghum cultivar Rio were used to differentiate strains of SrMV (3,11,18). Of all the sugarcane plants sampled, 64 (approximately 4%) were infected by more than one SrMV strain. Different Rio plants inoculated with the juice from the same source plant expressed symptoms of different SrMV strains. Of 1,592 sugarcane plants infected with strain H, 61 (4%) were also infected with a second strain. Similarly, 49 of 84 (58%) and 15 of 50 (30%) of the samples infected with strains I and M, respectively, were also infected with a second strain. The most common combination of mixed infections was strain I or M with strain H. In only one sample were symptoms of all three strains found among the inoculated Rio plants. The presence of mixed infections in several source plants was confirmed by inoculating a second set of Rio plants or additional sugarcane plants with juice from individual Rio plants expressing different symptoms. Some mixed infections may not have been detected because more severe symptoms caused by SrMV strains I or M on Rio plants may have masked milder symptoms caused by strain H (2,11,18).

No johnsongrass plants expressed symptoms of mosaic when inoculated with leaf juice from sugarcane expressing mosaic. Johnsongrass expressing mosaic symptoms was often found in or near sugarcane fields. The virus strain causing these infections has been identified as MDMV-A (8,10,19). This virus strain has not been observed to infect sugarcane naturally, and johnsongrass does not appear to be susceptible to the viruses causing sugarcane mosaic.

In 1980, mosaic and red leaf symptoms were observed on a MDMV-resistant cultivar of sorghum at Rio Hondo, Texas. Giorda et al (7) discovered that SrMV strain H was the causal agent. Sugarcane was introduced into the Rio Grande Valley from Louisiana in 1969 to initiate commercial sugarcane production, and SrMV strain H was soon discovered in the Texas sugarcane fields (20). The historical information and research results (7,20) suggest that sugarcane may pose a threat to sorghum as a reservoir of SrMV when the two are grown adjacent to each other (7,12).

Following the appearance of strain H of SrMV, sugarcane breeders recognized that much of the sugarcane germ plasm they were using was susceptible to this virus (5). Researchers later showed that strain H is a different virus (13,16) and not, as first thought, a variant of the SCMV strains that had been causing mosaic in Louisiana sugarcane. Efforts were initiated to find new sources of resistance from wild relatives of sugarcane (6,9). The incorporation of resistance from wild relatives into new cultivars is a long process. The average time from crossing of elite germ plasm to release of a sugarcane cultivar is 14 yr. Additional time is needed when backcrossing steps are added to recover the virus resistance from wild germ plasm. Progress in this program has been recently documented with the identification of resistant germ plasm (9), the development of mosaic-resistant parental germ plasm (13), and the release of four cultivars (TUCCP 77-42, LHo 83-153, LCP 85-384, and HoCP 85-845) initiated in the program (4,13; *unpublished*).

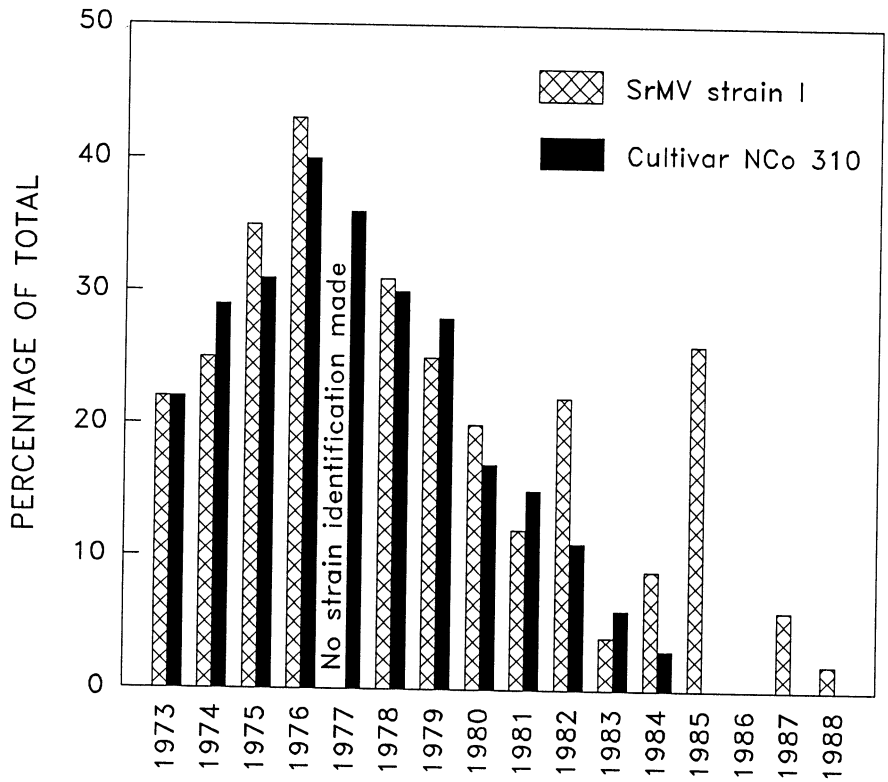

Fig. 2. Incidence of sorghum mosaic virus (SrMV) strain I in mosaic-affected sugarcane plants collected in the Bayou Teche production area of Louisiana compared with percentage of the area planted to cultivar NCo 310. Strain identification data from 1973 to 1976 collected by Breaux and Koike (5).

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