Grasses Differentiating Sugarcane Mosaic and Maize Dwarf Mosaic Viruses

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ABSTRACT

Many new hosts for sugarcane mosaic (SCMV) and maize dwarf mosaic viruses (MDMV) are reported. A set of grasses is suggested as a means of identifying and separating these viruses, especially where all these viruses have been known to occur in the same locality. We have resolved some of the differences of opinion reported in the literature by testing all the SCMV and MDMV strains under identical conditions on the hosts in question.

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Many grasses are susceptible to maize dwarf mosaic (MDMV) and sugarcane mosaic (SCMV) viruses; thus, they provide a wide host range for these viruses (2, 3). No definitive study has been made to resolve all the differences of opinion in the literature concerning susceptibility of certain grass species to one or more of these viruses.

We studied all hosts that we could obtain which had been reported both susceptible and not susceptible to a particular virus strain (3). Also, we have attempted to resolve the question of maize dwarf mosaic and sugarcane mosaic virus relationships, based on their host range. We collected many of the grasses in question from various sources, all the sugarcane mosaic virus isolates, and representative collections of MDMV-A and -B, B, then tested them under identical conditions. From these tests, we propose a possible differential host set to separate the sugarcane mosaic virus strains from maize dwarf mosaic A and B strains. We did not attempt to separate the SCMV strains, since a differential set of sugarcane cultivars is already used for that purpose (1).

MATERIALS AND METHODS.—We maintained all the virus isolates in sweet corn (either Golden Bantam or Seneca Chief). Stock isolates were transferred monthly. The 10 MDMV-A isolates were obtained from researchers in several states, or isolated from corn and Johnson grass in Iowa, and kept in regularly trimmed Johnson grass plants in a greenhouse. The 3 MDMV-B isolates (1 each from Iowa, Pennsylvania, and Ohio) were kept in sweet corn. The SCMV strains were obtained (from A. G. Gillaspie, Jr., U.S. Sugarcane Field Sta., Houma, La.) specifically for this comparative experiment. SCMV-E was not obtained in time to test with most the grasses, so unfortunately, its comparison must be made separately. SCMV-Jg (the Johnson grass-infecting strain) is the isolate from R. J. Shepherd, Davis, Calif. We obtained this isolate after these tests were started; thus, about one-third of the grasses were not inoculated with it. SCMV-Jg is identical in all respects to the other MDMV-A isolates used in this study.

We obtained all inocula from corn 3 weeks after inoculation by grinding leaves in a mortar with pestle, then expressing the crude sap through gauze and diluting about 1:10 with neutral phosphate buffer.

All grass seed was planted in a steam-sterilized soil:peat:sand (2:1:1) mixture in sterilized 4-inch clay pots, placed on greenhouse benches at about 25 C, and watered daily.

TABLE 1. Comparative grass host range of maize dwarf mosaic virus (MDMV) and sugarcane mosaic virus (SCMV) strains

Test plants[a]	Inoculated with[b]			Symptoms
	MDMV-A	MDMV-B	SCMV	
Aegilops cylindrica Host.	1/7[c,d]	3S-	A, D, H, I, Jg, S-	C streaks
Agropyron elongatum (Host.) Beauv.	-	-	-	
Agropyron repens (L.) Beauv.	-	-	-	
Agropyron smithii Rydb.	-	-	-	
Agrostis alba L.	-	-	-	
Agrostis nebulosa Boiss. & Reut.	9[d]	3	A, B, D, H, I, Jg	Mot, Mos
Alopecurus carolinianus Piper.	-	-	-	
Alopecurus pratensis L.	-	-	-	
Alopecurus utriculatus Banks & Sol.	2	-	B, D	Mild Mos
Andropogon gerardii Vitman	10	3	A, B, D, H, I, Jg	Mot, Mos, N
Bothriochloa ambigua Blake	-	-	H, I	Mos, N
Bothriochloa caucasica (Trin.) C.E. Hubb.	1	1	H, I	Mild Mos, s
Bothriochloa ischaemum (L.) Keng	10	3	A, B, D, H, I, Jg	Mild Mos
Brachiaria platyphylla (Griseb.) Nash	10	3	A, B, D, H, I, Jg	Spot Mos
Braza maxima L.	-	-	-	
Bromus arvensis L.	10	2	A, B, D, H, Jg	Mot, C streaks
Bromus auleticus Trin. ex Griseb.	-	-	-	
Bromus danthoniae (Desf.) Trin.	2/5	2	A, H, Jg	C streaks
Bromus japonicus Thunb.	10	2	A, B, D, Jg	Mot, Mos
Bromus lanceolatus Roth	4 S-	-	B	C streaks
Bromus macrostachys Desf.	10	3	A, B, D, H, I, Jg	Streak Mos
Bromus mollis L.	0/8	2	Jg	C streaks
Bromus oxydon Schrenk	6	1	A, D, H, Jg	s
Bromus rigidus Roth	5	3	D, H	C streaks
Bromus rubens L.	-	1	H	s
Bromus scoparius L.	-	-	Jg	s
Bromus tectorum L.	7	3	A, B, H, I, Jg	Mot
Chloris virgata Swartz.	1[e]	1	I	Spot Mos
Dactyloctenium aegyptium (L.) Beauv.	10	3	A, B, D, H, I, Jg	Mos
Danthonia unarede Raoul	6	3	A, H, Jg	Mild Mos, N
Digitaria horizontalis Willd.	6	3	A, B, D, H, I	Veinbanding Mos, s
Digitaria ischaemum (Schreb.) Schreb. ex Muhl.	10	3	A, B, D, H, I, Jg	Mos
Echinochloa frumentacea (Roxb.) Link	9	3	A, B, D, H, I, Jg	Mos
Ehrharta calycina J. E. Smith	3	2	A, Jg	Stripe (spindle) Mos, purple
Eleusine coracana Gaertn.	10	3	A, B, D, H, I, Jg	White stripe Mos; SCMV-A = s
Elymus canadensis L.	-	-	-	
Elymus villosus Muhl.	-	-	-	
Eragrostis amabilis (L.) Wight & Arn. ex Nees	8	3	A, B, D, H, I, Jg	Mos; SCMV-B and -I = mild Mos or s
Eragrostis diffusa Buckl.	1	2	A	Mos
Eragrostis trichodes (Nutt.) Wood	5	2	B, H	s, mild Mos
Eremopoa persica (Trin.) Roshev.	10	3	A, B, D, Jg	Mot
Eremopyrum orientale Joub. & Spach.	4	2	B, H	s
Erianthus ravennae (L.) Beauv.	1	3	A, B, D, H	Mos, stripe
Euchlaena mexicana Schrad.	9	3	A, B, D, H, I, Jg	Mos
Heteranthelium piliferum Hochst. ex Joub. & Spach.	-	1	-	
Hordeum vulgare L. 'Reno'	-	-	-	
Hordeum vulgare L. 'Betzes'	-	-	-	
Lagurus ovatus L.	10	3	A, H, Jg	Mot, mild Mos, s
Leptochloa dubia (H.B.K.) Nees	10	3	A, B, D, H, I, Jg	Mos = dark streaks on light background
Lolium perenne L.	9	-	A	s
Miscanthus sinensis Anderss.	4	3	A, B, D, I, Jg	Spot Mos (I)
Muhlenbergia frondosa (Poir.) Fern	7	3	Jg	Mot, C lines
Muhlenbergia mexicana (L.) Trin.	9	2	D	Mot, C lines
Muhlenbergia racemosa (Michx.) B.S.P.	10	-	-	C spots become N
Oryza sativa L. 'Bluebelle'	4	-	A, I, Jg	s, Y stripes
Oryza sativa L. 'Bluebonnet 50'	3	2	A, B, I	s, Y stripes

(Table 1 continued on next page)

Table 1 (continued)

Test plants[a]	Inoculated with[b] MDMV-A	MDMV-B	SCMV	Symptoms
Oryza sativa L. 'Calora 61'	6	2	A, B, D, H, I	s, Y stripes
Oryza sativa L. 'Gulfrose 245'	-	-	I	s
Oryza sativa L. 'Taiman'	1	2	A, B, D, H, I	s, Mos stripes
Panicum antidotale Retz.	3	2	A, H, Jg	Mot, Mos
Panicum capillare L.	10	3	A, B, D, H, I, Jg	Mos
Panicum coloratum Walt.	-	-	-	
Panicum longijubatum Stapf	2[e]	3	A, B, D	Mos
Panicum maximum Jacq.	2	2	B, H	LS, Mot
Panicum miliaceum L.	10	1 LS	A, H, I, Jg	Mos
Panicum miliare L.	10	3	A, B, D, H, I, Jg	Stripe Mos
Panicum ramosum L.	10	3	A, B, D, H, Jg	Mos (mild or spot)
Panicum stapfianum Foure	9	3	A, B, D, H, I, Jg	Mot, Mos
Panicum texanum Buckl.	8	2	A, B, D, H, I, Jg	Mos
Panicum turgidum Forsk.	9	3	A, B, D, H	Mild Mos, s
Panicum virgatum L.	7	2	A, B, H, I, Jg	Mos
Paspalum boscianum Flugge	8	1	H	Mos
Paspalum conjugatum Berg.	10	2	A, B, D, H, Jg	Mot, mild Mos
Paspalum dilatatum Poir	10	-	A, B, D, H, I, Jg	Mos
Paspalum notatum Flugge	1	2	A	Mos
Pennisetum glaucum (L.) R. Br.	6	3	A, B, D, H, Jg	Mos
Pennisetum purpureum Schumach.	10	1	A, H, I, Jg	Mild Mot, Mos
Pennisetum typhoides (Burm.) Stapf & C. E. Hubb.	8	3	A, D, I	Mos
Phacelurus digitatus Griseb.	6	2	A, D, H, I	Mos, Mot
Phalaris aquatica L.	-	-	-	
Phalaris arundinacea L.	-	-	-	
Phalaris minor Retz.	6	-	-	s
Phalaris paradoxa L.	3	2	-	Mos
Phalaris platensis Parodi	5	-	H, I	Y stripe
Phleum subulatum (Savi) Aschers. & Graebn.	10	3	A, B, D, H, I, Jg	C streaks, Mos
Polypogon monspeliensis (L.) Desf.	8	3	A, B, D, H	s
Rottboellia exaltata L.	-	1	-	Mos
Saccharum officinarum L. 'CP 31588'[f]	1	-	-	Mild Mos
Secale cereale L.	-	-	-	
Setaria glauca (L.) Beauv.	9	3	A, D, H, I, Jg	Mos, Y, N
Setaria italica (L.) Beauv.	10	3	A, B, D, H, I, Jg	Mos
Setaria viridis (L.) Beauv.	10	3	A, B, D, H, I, Jg	Mos
Sorghum almum Parodi	10	-	I, Jg	Mos
Sorghum bicolor (L.) 'Moench 305081'	10	-	I, Jg	Mos (I)
Sorghum bicolor (L.) 'Moench 289675'	10	3	A, B, D, H, I, Jg	Mos (I)
Sorghum bicolor (L.) 'Moench 276808'	10	3	A, B, D, H, I, Jg	Mos. purple (I)
Sorghum bicolor (L.) 'Moench Atlas'	10	3	A, B, D, H, I, Jg	Mos, LL, N
Sorghum caudatum (Hack.) Stapf	10	3	A, B, D, H, I, Jg	Mos (I, H)
Sorghum cernuum (Ard.) Host.	10	3	A, B, D, H, I, Jg	Mos (I)
Sorghum miliforme (Hack.) Snowden	8	1	A, B, H, I, Jg	Mos (I)
Sorghum nigricans Tuizet Pavon	1	1	A, I	Mos (I)
Sorghum verticilliflorum Stapf	10	1 L	D, H, I, Jg	Mos (I)
Sorghum halepense (L.) Pers.	10	-	-	Mos
Sorghum saccharatum (L.) Pers.	10	2	A, B, D, H, I, Jg	Mos, (I)
Sporobolus aeroides (Torr.) Torr.	1[e]	1	-	s
Sporobolus asper (Michx.) Kunth.	10	3	A, B, D, H, I	Spot Mos
Sporobolus poiretii (Roem. & Schult.)	5	-	Jg	Mild Mos
Stipa spartea Trin.	8	-	A, H, Jg	s
Stipa viridula Trin.	-	-	-	
Tricholaena monachne (Trin.) Stapf & Hubb.	10	3	A, B, D, H, I	Mos
Tricholaena repens (Willd.) Hitchc. = *Rhynchelytrum repens* (Willd.) C. E. Hubb.	-	-	-	
Tridens muticus (Torr.) Nash	3	1	D	Mos
Tripsacum dactyloides L.	-	-	-	

(Table 1 continued on next page)

Table 1 (continued)

Test plants[a]	Inoculated with[b] MDMV-A	MDMV-B	SCMV	Symptoms
Triticum vulgare Host. 'Genesse'	-	-	-	
Triticum vulgare Host. 'Lakota'	-	-	-	
Urochloa mosambicensis (Hack.) Dandy	3	3	A, B, D, H	
Zea mays L. 'Kansas 1859', 'Novosad. d. corn 28', '239108', '184285', 'Senetex K-1639'	10	3	A, B, D, H, I, Jg	Mos
Zea mays L. '514'	-	-	-	

[a] Ten to 20 plants/pot were inoculated with each virus isolate (except larger plants like sorghum, corn, and sugarcane, where only 5-10 plants were inoculated).

[b] The total number of isolates involved were 10 of MDMV-A, 3 of MDMV-B, and strains A, B, D, H, I, and Jg of SCMV.

[c] Where a fraction appears, the numerator represents the number of positive reinoculations and the denominator represents the number of pots of plants with symptoms.

[d] Each number represents the number of isolates that infected the test plants of the total inoculated, where symptoms developed and virus was recovered on sweet corn assay plants.

[e] There were only this number of pots available for testing, and they were all infected.

[f] *Saccharum officinarum* was inoculated with five isolates of MDMV-A and two isolates of MDMV-B; only one isolate of MDMV-A was infective and developed symptoms, and recovery assay was positive.

Symbols: - = no symptoms and negative reinoculation; C = chlorosis or chlorotic; I = SCMV-I isolate caused usually more severe symptoms on these plants including mosaic, purple coloration, stunting, necrosis, and death of plants than any other SCMV isolate; Mos = mosaic; Mot = mottle; N = necrotic or necrosis (occasionally whole plant); s = no symptoms but positive reinoculation; S- = symptoms but negative reinoculation; Y = yellowing; L = infection restricted to inoculated leaves without symptoms; LL = local lesions; and LS = infection of inoculated leaves with symptoms.

In testing the grasses for susceptibility to maize dwarf mosaic and sugarcane mosaic virus, we inoculated mechanically all plants, generally at the two- to three-leaf stage, by rubbing infective sap on Carborundum-dusted leaves with a pestle. When infection did not occur after the first inoculation, a second, or, if necessary, a third inoculation was made. Before the third inoculation, test plants were cut back to start younger shoots for inoculation. All symptomless plants were tested for infectivity after each inoculation by assay to sweet corn.

RESULTS AND DISCUSSION.—A broad range of grasses is susceptible to MDMV-A, MDMV-B, and the SCMV strains A, B, D, H, I, and Jg (Table 1).

All SCMV strains almost invariably infect a grass species when that grass is susceptible to one of the strains. The main differences occur with SCMV-I, which seems to react quite differently from the other SCMV strains (Table 1).

Atlas sorghum responded quite differently to the different virus groups. MDMV-A isolates consistently caused occasional small, purple, local lesions and a bright, systemic mosaic within 1 week. MDMV-B caused large, necrotic, local lesions within 1 week, and eventually (about 30 days), systemic mosaic symptoms appeared in fewer than half of the plants. The SCMV isolates caused necrotic local lesions, systemic mosaic, and usually, also, systemic necrosis. SCMV-I killed Atlas sorghum within 10 days, similar to its reaction on many susceptible grasses. Snazelle et al. (5) was most probably working with an isolate of the SCMV-I strain, rather than the H strain. Based on our experience and on the severe reactions he described for strain H on sorghum, among all the MDMV and the SCMV strains, SCMV-I is unique in causing the very severe reaction leading to rapid death.

Seldom were significant symptom differences observed on grasses between or among the isolates. Some differences in intensity were seen, but they were not diagnostically usable, as has been described for MDMV strains in corn (4).

MDMV-A is the same virus strain as SCMV-Jg. In all instances where MDMV-A and SCMV-Jg were tested on the same grass species, the reactions were

TABLE 2. Host set for separating sugarcane mosaic virus strains (SC) from maize dwarf mosaic viruses A (M-A) and B (M-B)

Grass differential	Virus M-A	M-B	SC
Muhlenbergia frondosa	+[a]	+	–
Muhlenbergia racemosa *Sorghum almum* (except SC-I = +) *Sorghum halepense* *Sporobolus poiretii*	+	–	–
Paspalum dilatatum *Stipa spartea*	+	–	+
Bromus rubens (except SC-H = +) *Heteranthelium piliferum*	–	+	–

[a] + = susceptible; – = not susceptible.

identical. We postulate that the early one-third of the grasses not inoculated with SCMV-Jg would react the same as they did to the other MDMV-A isolates tested.

Panicum miliaceum and *Sorghum verticilliflorum* were easily infected by MDMV-A, but they were infected only with difficulty by MDMV-B, and, rarely, by SCMV isolates. Generally, those virus strains that infected with difficulty, or rarely, did so successfully only after the second or third inoculation attempt. We experienced this phenomenon with several of the grasses studied earlier (2).

Many of the grasses, such as *Bothriochloa* spp., *Eragrostis trichodes, Lagurus ovatus,* and *Saccharum officinarum*, exhibited a very mild mosaic. Often the symptoms could not be seen. Many grasses (some *Bromus* spp., *Eremopyrum orientale, Lolium perenne, Phalaris minor, Polypogon monspeliensis, Sporobolus aeroides*, and *Stipa spartea*) were always symptomless under our experimental conditions. Occasionally, a grass produced symptoms of infection by all virus isolates, except one which would be symptomless (e.g., *Panicum turgidum* was symptomless to one MDMV-A isolate [Ia. Hamburg] only).

Our supply of *Saccharum officinarum* was so limited that the results for it are suggestive rather than conclusive. One plant/pot each was inoculated with five different MDMV-A isolates and two different MDMV-B isolates. None was inoculated with SCMV strains, because these are already well characterized (1).

Based on the susceptibility of the grasses reported in Table 1, a differential system could be devised with any of several grasses (Table 2) to distinguish between the SCMV strains and MDMV-A and -B.

It is noteworthy that there are no instances where SCMV strains are infective and MDMV-A and -B are not infective (Table 1).

LITERATURE CITED

1. ABBOTT, E. V., & R. L. TIPPETT. 1966. Strains of sugarcane mosaic virus. U.S. Dep. Agr. Tech. Bull. 1340. 25 p.
2. FORD, R. E. 1967. Maize dwarf mosaic virus susceptibility of Iowa native perennial grasses. Phytopathology 57:450-451.
3. FORD, R. E., & M. TOSIC. 1973. New hosts of maize dwarf mosaic virus and sugarcane mosaic virus and a comparative host range study of viruses infecting corn. Phytopathol. Z. (in press).
4. LOUIS, R., & J. K. KNOKE. 1970. Evidence for strains of maize dwarf mosaic virus in southern Ohio. Phytopathology 60:1301 (Abstr.).
5. SNAZELLE, T. E., J. B. BANCROFT, & A. J. ULLSTRUP. 1971. Purification and serology of maize dwarf mosaic and sugarcane mosaic virus. Phytopathology 61:1059-1063.