Susceptibility of Representative Native Mississippi Grasses in Six Subfamilies to Maize Dwarf Mosaic Virus Strains A and B and Sugarcane Mosaic Virus Strain B

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ABSTRACT


A representative collection of the Mississippi grass flora, consisting of 42 annual and 71 perennial grasses, contained 79 host species and 34 nonhost species of maize dwarf virus strain A (MDMV-A), strain B (MDMV-B), and sugarcane mosaic virus strain B (SCMV-B). Of the 79 host species, 68 were new hosts which were divided into 63 species susceptible to MDMV-A, 47 species susceptible to MDMV-B, and species susceptible to SCMV-B; 40 species were susceptible to all three strains. Among the 34 susceptible species, 29 were new nonhosts. Host species were found in all six subfamilies of the Gramineae, in 14 of 16 tribes, and in 40 of 51 genera included in this study. The subfamily Festucoideae had the highest percentage of species with latent infection, and the festucoid species also exhibited the least differential reaction to the three virus strains. The tribe Andropogoneae in the subfamily Panicoideae had the highest proportion of hosts to nonhosts, but species with the greatest susceptibility were in the tribe Paniceae. The subfamily Eragrostioideae had twice as many species susceptible to MDMV-A as to MDMV-B or SCMV-B. Of the two Mississippi species in the subfamily Bambusioideae, one was latently susceptible to MDMV-A, the other insensitive to all three strains. Eight of the nine species in the subfamily Oryzoideae occurring in Mississippi were hosts of MDMV or SCMV. Species in the subfamily Arundinoideae were evenly divided between hosts and nonhosts. Host species made up 88% of the annual and 61% of the perennial grasses tested. Infectivity profile of MDMV-B resembled more closely that of SCMV-B than that of MDMV-A. Genera with the closest taxonomic position to corn seem less susceptible to these viruses than genera somewhat more distant to corn in the phylogeny of the Gramineae.

Additional key words: corn, differential host, host range, symptomless host, Zea mays.

Maize dwarf mosaic virus (MDMV) causes an important disease in a major crop and has an extensive geographic distribution in the USA. Of the two principal strains, strain A (MDMV-A) occurs over a larger area and infects more species in the Gramineae than strain B (MDMV-B) (21). The latter strain tends to have a more northern range than MDMV-A. Only 66 genera of the 122 grass genera with representative species in the USA have been tested for reaction to MDMV. Even fewer genera have been included in host range studies of the closely related sugarcane mosaic virus (SCMV), which also infects corn (Zea mays L.).

Previous investigations of the host ranges of MDMV and SCMV emphasized festucoid grasses (4,5,12,15,16,22,23,25) and panicoideae (5,12,15,16,17,19). Therefore, reaction of species in the subfamilies Eragrostioideae, Bambusioideae, Oryzoideae, and Arundinoideae requires further evaluation. Eragrostioideae constitute 28.5% of all U.S. grass species and are widely distributed in all parts of the USA (6).

Mississippi grass flora includes ~315 grass species. Half of them belong to the subfamily Panicoideae, one quarter to the subfamily Eragrostioideae; the remainder are distributed unevenly among the other four subfamilies, with the greatest number of these belonging to the Festucoideae. This investigation provides information on the reaction to MDMV and SCMV of grass species in subfamilies and tribes that received insufficient attention in earlier studies.

The objectives of this research were: to locate and identify as many wild grass species as possible not yet tested for reaction to MDMV and SCMV; to produce wild grass seed in the greenhouse; to concentrate the testing on species from the previously underrepresented subfamilies Eragrostioideae, Bambusioideae, Oryzoideae, and Arundinoideae; to determine the concentration and distribution of the susceptible species in the six subfamilies of Gramineae; to further characterize MDMV-A, MDMV-B, and strain B of SCMV (SCMV-B) by host range studies; to search for potential overwintering hosts of MDMV-B; to find more suitable differential hosts for these viruses; and to gain a better understanding of the relationship among the three virus strains.

MATERIALS AND METHODS

Except for Choris floridana and Heteropogon melanocarpon found by the author in Alabama and six species (Brachiaria plantaginea, Chloris gayana, Ergragis curvula, Ergragosis diffusa, Leptochloa scabra, and Setaria adhaerans) acquired from various sources, all grasses were collected by the author in the wild in Mississippi. The plants were dug with sufficient soil around the roots to fill a 15- to 20-cm (6- to 8-inch)-diameter clay pot and grown in a greenhouse for seed production. The grasses were identified with the help of A. S. Hitchcock's Manual of the Grasses of the United States (9), F. W. Gould's The Grasses of Texas (10), or A. E. Radford's et al. Manual of the Vascular Flora of the Carolinas (14). Uncertain identifications were verified by S. T. McDaniel, Department of Biological Sciences, Mississippi State University.

The harvested seeds were stored at 3°C for a minimum of 6 mo to break the dormancy of perennial grasses, then plated out on moist, sulfur-free germination paper in petri dishes, and placed in a germinator programmed for 30°C (light 10 hr and 20°C (dark 14 hr). Germination ranged from 0% to 100%. Seedlings were transplanted individually into round 7.5-cm (3-inch)-diameter peat pots containing a soil-sand-peat moss mixture (3:1:1, v/v) and were fertilized weekly with a 12-6-6 (N-P-K) liquid fertilizer. The few grasses that did not produce viable seed in the greenhouse were propagated vegetatively.

Two isolates of MDMV-A, one from Mississippi and one from Ohio; an MDMV-B isolate from R. E. Ford, University of Illinois, Urbana; and an isolate of SCMV-B from the U.S. Sugar Crops Field Station, Meridian, MS, were used in the tests described. Strain B of SCMV was selected because it is the most common strain of SCMV in MS. The MDMV strains were maintained in...
RESULTS

This collection of 113 grass species in 51 genera, 16 tribes (of 19 represented in Mississippi), and all six subfamilies of the Gramineae contained 79 hosts and 34 nonhosts. Nine of the grasses were tested in the preceding study (19) but are included here to assemble all Mississippi species in the three small subfamilies Bambusoideae, Oryzioideae, and Arundinioideae. Of the 79 host grasses, 68 were new hosts, and these were composed of 63 species susceptible to MDMV-A, 47 species susceptible to MDMV-B, and 48 species susceptible to SCMV-B. The three virus strains had 40 new hosts in common. Among the 34 grasses that reacted with immunity to all virus strains, 29 were new nonhosts.

Species in this study were distributed among 51 genera of the 89 grass genera represented in Mississippi. The 89 genera gathered into 19 tribes, which comprise the Mississippi grass flora, are arranged in Table 1. This is the first time that species in the following 13 genera have been tested for reaction to MDMV and SCMV: Aira, Anthaenantia, Cinna, Glyceria, Hackelochloa, Heteropogon, Hydrochloa, Luziola, Sphenopholis, Tripasis, Zizania, Zizaniopsis, and Zoysia. All of these genera, except Cinna and Sphenopholis, include species susceptible to MDMV or SCMV. Besides Cinna and Sphenopholis, other genera that had no susceptible species were Arundo, Axonopus, Danthonia, Hordeum, Melica, Paspalum, Tripsacum, Trisetum, and Vulpia. Thus, the 51 genera represented in this investigation can be classified into 40 genera with host species and 11 without.

Grasses with various degrees of susceptibility to MDMV and SCMV were found in all six subfamilies and in 14 of 16 tribes (Table 2). Member species of the subfamily Festucoideae exhibited the least variability in their response to the three virus strains. If a festucoid grass was susceptible to one virus strain, it usually was susceptible to all three, and conversely, if a species was immune to one strain, it generally was immune to all three. Of the 23 festucoid species tested, the only exceptions were Festuca rubra, a symptomless host of only MDMV-A, and Lolium multiflorum which produced weak symptoms on very few plants only in response to SCMV-B. The Festucoideae also had the highest percentage of species with latent infection of any subfamily. Nine of the 13 host species found in this taxon were symptomless hosts.

Panicoideae, the largest subfamily of the Mississippi grass flora, is classified into two tribes, Paniceae and Andropogoneae. The 38 species in the tribe Paniceae separated into 26 hosts and 12 nonhosts. Of the 10 species belonging to Andropogoneae, nine were hosts and one was not. Although the Panicoideae had species with the greatest susceptibility to MDMV and SCMV of any subfamily, some genera (Axonopus, Paspalum, and Tripsacum) contained only immune species. The only panicooids with sufficiently different reactions to MDMV and SCMV to qualify as differential hosts were Andropogon virginicus and Setaria glauca, both of which were susceptible to MDMV-A and MDMV-B but immune to SCMV-B.

The 25 species of the subfamily Eragrostioideae tested were distributed among nine genera, all of which contained host species. However, the 18 host species found were differentially susceptible to the three virus strains. MDMV-A infected all 18 species, whereas MDMV-B infected nine and SCMV-B infected eight of the same grasses. Thus, the infectivity data of MDMV-B in the Eragrostioideae resembled more closely those of SCMV-B than those of MDMV-A. Unlike festucoid grasses, eragrostoids showed no tendency for symptomless infection. Only one species, Leptochloa panicoides, was latently infected with MDMV-A while being immune to MDMV-B and SCMV-B.

Bambusoideae is the smallest of the six subfamilies of Gramineae, and is represented in the USA by only three species in two genera. Of the two species of Arundinaria endemic to Mississippi, A. tecta was infected by only MDMV-A (latently), whereas A. gigantea was immune to all three virus strains. It is remarkable that a bamboo would support the multiplication of...
TABLE 2. Response of native Mississippi grasses in all six subfamilies of Gramineae to inoculation with maize dwarf mosaic virus strain A (MDMV-A) and strain B (MDMV-B) and sugarcane mosaic virus strain B (SCMV-B)

<table>
<thead>
<tr>
<th>Grass subfamilies, tribes, species, and common names</th>
<th>Growth habit</th>
<th>MDMV-A (Miss.)</th>
<th>Back assay to corn</th>
<th>MDMV-A (Ohio)</th>
<th>Back assay to corn</th>
<th>MDMV-B</th>
<th>Back assay to corn</th>
<th>SCMV-B</th>
<th>Back assay to corn</th>
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<tr>
<td><em>Agrostis elliotiana</em> Schult. Elliott bentgrass</td>
<td>A</td>
<td>14/17</td>
<td>10/10</td>
<td>11/17</td>
<td>10/10</td>
<td>13/17</td>
<td>10/10</td>
<td>9/17</td>
<td>10/10</td>
</tr>
<tr>
<td><em>A. hiemalis</em> (Walt.) B.S.P. Winter bentgrass</td>
<td>P</td>
<td>0/22</td>
<td>0/10</td>
<td>0/22</td>
<td>0/10</td>
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<td>0/10</td>
<td>0/22</td>
<td>0/10</td>
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<td><em>Aira elegans</em> Wild. ex Gaud. Annual hairgrass</td>
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<td>0/24</td>
<td>10/10</td>
<td>0/24</td>
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<td>0/24</td>
<td>6/10</td>
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<tr>
<td><em>B. japonicus</em> Thunb. Japanese chess</td>
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<td>10/10</td>
<td>0/23</td>
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<td>8/10</td>
<td>0/23</td>
<td>6/10</td>
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<tr>
<td><em>B. tectorum</em> L. Downy chess</td>
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<td>3/10</td>
<td>0/19</td>
<td>6/10</td>
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<td>3/10</td>
<td>0/19</td>
<td>2/10</td>
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<tr>
<td><em>Cinna arundinacea</em> L. Stout woodreed</td>
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<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
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<td>0/24</td>
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<td>5/10</td>
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<td><em>Hordeum pusillum</em> Nutt. Little barley</td>
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<td>0/10</td>
<td>0/24</td>
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<tr>
<td><em>Lotium multiflorum</em> Lam. Italian ryegrass</td>
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<td>0/24</td>
<td>0/10</td>
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<tr>
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<tr>
<td><em>Sphenopholis nitida</em> (Biehler) Scribn. Shiny wedgescale</td>
<td>P</td>
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<td><em>S. obtusata</em> (Michx.) Scribn. Prairie wedgescale</td>
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<tr>
<td><em>Stipa avenccea</em> L. Blackseed needlegrass</td>
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<td>0/17</td>
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<td>Tribe Panicae</td>
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<tr>
<td><em>Cenchrus echinatus</em> L.</td>
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<tr>
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<td><em>Digiria ciliaris</em> (Reitz.) Koel. Southern crabgrass</td>
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<tr>
<th>Grass subfamilies, tribes, species, and common names</th>
<th>Growth habit&lt;sup&gt;b&lt;/sup&gt;</th>
<th>MDMV-A (Miss.)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Back assay to corn&lt;sup&gt;d&lt;/sup&gt;</th>
<th>MDMV-A (Ohio)</th>
<th>Back assay to corn</th>
<th>MDMV-B</th>
<th>Back assay to corn</th>
<th>SCMV-B</th>
<th>Back assay to corn</th>
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<td><em>E. walteri</em> (Pursh) Heller Walter barnyardgrass</td>
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<td>4/10</td>
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</tr>
<tr>
<td><em>P. gymnocarpon</em> Ell.</td>
<td>P</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. lancearium</em> Trin.</td>
<td>P</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. lanuginosum</em> Ell.</td>
<td>P</td>
<td>10/22</td>
<td>...</td>
<td>14/22</td>
<td>...</td>
<td>3/22</td>
<td>...</td>
<td>10/22</td>
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</tr>
<tr>
<td><em>E. muricata</em> (Beauv.) Fern. Rough barnyardgrass</td>
<td>P</td>
<td>10/16</td>
<td>...</td>
<td>5/16</td>
<td>...</td>
<td>4/16</td>
<td>...</td>
<td>13/16</td>
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</tr>
<tr>
<td><em>P. longifolium</em> Turr. Longleaved panicum</td>
<td>P</td>
<td>0/19</td>
<td>0/10</td>
<td>0/19</td>
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<td>0/10</td>
<td>0/19</td>
<td>0/10</td>
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<tr>
<td><em>P. oligosanthes</em> Schult. Few-flowered panicum</td>
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<td>5/24</td>
<td>...</td>
<td>11/24</td>
<td>...</td>
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<td>...</td>
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<td><em>P. paludicola</em> Bern. ex Trin. Philadelphia witchgrass</td>
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<td>3/15</td>
<td>...</td>
<td>5/15</td>
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<td>5/15</td>
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<tr>
<td><em>P. scabriacaulum</em> Ell.</td>
<td>P</td>
<td>2/23</td>
<td>...</td>
<td>1/23</td>
<td>...</td>
<td>0/23</td>
<td>10/0</td>
<td>0/23</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. Scriberianum</em> Nash Scribners panicum</td>
<td>P</td>
<td>18/20</td>
<td>...</td>
<td>18/20</td>
<td>...</td>
<td>14/20</td>
<td>...</td>
<td>20/20</td>
<td>...</td>
</tr>
<tr>
<td><em>P. sphaerocarpum</em> Ell.</td>
<td>P</td>
<td>10/17</td>
<td>...</td>
<td>3/17</td>
<td>...</td>
<td>7/17</td>
<td>...</td>
<td>4/17</td>
<td>...</td>
</tr>
<tr>
<td><em>P. virginicus</em> L. Broomsedge</td>
<td>P</td>
<td>0/16</td>
<td>0/10</td>
<td>0/16</td>
<td>0/10</td>
<td>0/16</td>
<td>0/10</td>
<td>0/16</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. villosissimum</em> Nash Hairy panicum</td>
<td>P</td>
<td>6/10</td>
<td>...</td>
<td>5/10</td>
<td>...</td>
<td>1/10</td>
<td>...</td>
<td>2/10</td>
<td>...</td>
</tr>
<tr>
<td><em>Paspalum distichum</em> L. Knottgrass</td>
<td>P</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. laeve var. pilosum</em> Scribn.</td>
<td>P</td>
<td>0/12</td>
<td>0/10</td>
<td>0/12</td>
<td>0/10</td>
<td>0/12</td>
<td>0/10</td>
<td>0/12</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. rubellum var. glabrum</em></td>
<td>P</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. quadrispathum</em> Lam.</td>
<td>P</td>
<td>0/17</td>
<td>0/10</td>
<td>0/17</td>
<td>0/10</td>
<td>0/17</td>
<td>0/10</td>
<td>0/17</td>
<td>0/10</td>
</tr>
<tr>
<td><em>P. setaceum</em> var. longipedinulatum (Le Conte) Wood</td>
<td>P</td>
<td>0/19</td>
<td>0/10</td>
<td>0/19</td>
<td>0/10</td>
<td>0/19</td>
<td>0/10</td>
<td>0/19</td>
<td>0/10</td>
</tr>
<tr>
<td><em>Setaria adhara</em> (Forsk.) Chiov.</td>
<td>A</td>
<td>1/21</td>
<td>...</td>
<td>1/21</td>
<td>...</td>
<td>15/21</td>
<td>...</td>
<td>15/21</td>
<td>...</td>
</tr>
<tr>
<td><em>S. faberi</em> Herrm. Nodding foxtail</td>
<td>A</td>
<td>18/18</td>
<td>...</td>
<td>18/18</td>
<td>...</td>
<td>18/18</td>
<td>...</td>
<td>18/18</td>
<td>...</td>
</tr>
<tr>
<td><em>S. glauca</em> (L.) Beauv. Yellow foxtail</td>
<td>A</td>
<td>5/19</td>
<td>...</td>
<td>6/19</td>
<td>...</td>
<td>4/19</td>
<td>...</td>
<td>0/19</td>
<td>...</td>
</tr>
<tr>
<td><em>S. magna</em> Griseb. Giant foxtail</td>
<td>A</td>
<td>15/15</td>
<td>...</td>
<td>15/15</td>
<td>...</td>
<td>15/15</td>
<td>...</td>
<td>15/15</td>
<td>...</td>
</tr>
</tbody>
</table>

**Triangle Andropogoneae**

| *Andropogon echioides* Chapm. Elliott beardgrass | P | 0/20 | 2/10 | 0/20 | 1/10 | 0/20 | 0/10 | 0/20 | 0/10 |
| *A. maritimus* Chapm. Sea beardgrass | A | 1/20 | 0/10 | 1/20 | 0/10 | 1/20 | 0/10 | 1/20 | 0/10 |
| *A. mohrii* Hack. Mohr's beardgrass | P | 0/15 | 0/10 | 4/15 | 0/10 | 4/15 | 1/10 | 0/15 | 0/10 |
| *A. tracyi* Nash | P | 1/24 | 10/10 | 1/24 | 10/10 | 0/24 | 0/10 | 0/24 | 0/10 |
| *A. virginicus* L. Broomsedge | P | 13/14 | ... | 7/14 | ... | 8/14 | ... | 0/14 | ... |
| *Hackelochloa granularis* (L.) Kuntze Hackelgrass | A | 4/12 | ... | 1/12 | ... | 2/12 | ... | 6/12 | ... |
| *Heteropogon melanocharpin* (Ell.) Benth. Sweet tanglehead | A | 2/12 | ... | 2/12 | ... | 0/12 | 0/10 | 1/12 | ... |
| *Manisuris cylindrica* (Michx.) Kuntze Carolina jointgrass | P | 1/18 | ... | 1/18 | ... | 1/18 | ... | 1/18 | ... |

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<sup>a</sup> Fraction expresses disease incidence in response to manual inoculation; the numerator denotes the number of plants with symptoms and the denominator the number of plants inoculated.

<sup>b</sup> Abbreviations: A = annual species, p = perennial species.

<sup>c</sup> Two isolates of MDMV-A, one from Mississippi and one from Ohio, were used.

<sup>d</sup> Back assay to Seneca Chief sweet corn was made from each inoculated grass species that remained symptomless or showed uncertain symptoms; in the fraction, the numerator indicates the number of corn plants with symptoms and the denominator (constant: 10) the number of corn seedlings inoculated; each such fraction refers to the virus isolate to its left.
TABLE 2. (continued). Response of native Mississippi grasses in all subfamilies of Gramineae to inoculation with maize dwarf mosaic virus strain A (MDMV-A) and strain B (MDMV-B) and sugarcane mosaic virus strain B (SCMV-B).

<table>
<thead>
<tr>
<th>Grass subfamilies, tribes, species, and common names</th>
<th>Growth habit</th>
<th>Number of plants showing symptoms following inoculation with:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MDMV-A (Miss.)</td>
</tr>
<tr>
<td>Trisetum dactyloides L.</td>
<td>P</td>
<td>0/11</td>
</tr>
<tr>
<td>Zea mays L.</td>
<td>A</td>
<td>20/20</td>
</tr>
<tr>
<td><em>Z. caroliniensis</em></td>
<td>P</td>
<td>0/13</td>
</tr>
<tr>
<td>Subfamily Eragrostoideae</td>
<td>A</td>
<td>12/21</td>
</tr>
<tr>
<td>Aristida intermedia Scribn. &amp; Ball</td>
<td>P</td>
<td>0/14</td>
</tr>
<tr>
<td><em>A. virgata</em> Trin.</td>
<td>P</td>
<td>0/13</td>
</tr>
<tr>
<td>Slender three-awn</td>
<td>P</td>
<td>2/10</td>
</tr>
<tr>
<td><em>Bouteloua curtipendula</em> (Michx.) Torr.</td>
<td>P</td>
<td>6/20</td>
</tr>
<tr>
<td><em>C. gayana</em> Kunth</td>
<td>P</td>
<td>14/20</td>
</tr>
<tr>
<td><em>Eragrostis capillaris</em> (L.) Nees</td>
<td>A</td>
<td>15/22</td>
</tr>
<tr>
<td>Lacegrass</td>
<td>A</td>
<td>0/20</td>
</tr>
<tr>
<td><em>E. curvula</em> (Schrad.) Nees</td>
<td>A</td>
<td>15/18</td>
</tr>
<tr>
<td><em>E. evertii</em> S. Wats.</td>
<td>P</td>
<td>24/24</td>
</tr>
<tr>
<td><em>E. intermedia</em> Hitchc.</td>
<td>P</td>
<td>22/24</td>
</tr>
<tr>
<td><em>E. pectinacea</em> (Michx.) Nees</td>
<td>A</td>
<td>17/22</td>
</tr>
<tr>
<td><em>E. spectabilis</em> (Pursh) Steud.</td>
<td>P</td>
<td>0/21</td>
</tr>
<tr>
<td><em>Lepidochloa fascicularis</em> (Lam.) A. Gray</td>
<td>A</td>
<td>10/22</td>
</tr>
<tr>
<td><em>L. filiforms</em> (Lam.) Beauv.</td>
<td>A</td>
<td>7/22</td>
</tr>
<tr>
<td><em>L. panicoides</em> (Presl) Hitchc.</td>
<td>A</td>
<td>0/10</td>
</tr>
<tr>
<td><em>L. scabra</em> Nees</td>
<td>A</td>
<td>7/10</td>
</tr>
<tr>
<td><em>L. unineria</em> (Presl) Hitchc. &amp; Chase</td>
<td>A</td>
<td>14/14</td>
</tr>
<tr>
<td><em>M. expansa</em> (DC) Trin.</td>
<td>P</td>
<td>0/15</td>
</tr>
<tr>
<td><em>Spartina p联网</em> (Trin.) Merr.</td>
<td>P</td>
<td>2/24</td>
</tr>
<tr>
<td><em>Tripsacum aestivum</em> Beauv.</td>
<td>P</td>
<td>0/15</td>
</tr>
<tr>
<td><em>T. purpurea</em> (Walt.) Chapm.</td>
<td>A</td>
<td>14/21</td>
</tr>
</tbody>
</table>

MDMV, a "panicoid virus," while many species belonging to the Panicoideae, where the virus apparently originated, are immune to it.

All six U.S. genera and nine of the 12 U.S. species of the subfamily Oryzioideae (6) are represented in Mississippi. Data are presented on all nine species. Only *Leersia oryzoides* was immune to all the virus strains that were tested. The other three *Leersia* species, *L. hexandra*, *L. lenticularis*, and *L. virginica*, were susceptible to MDMV-A, MDMV-B, and SCMV-B, as was wild rice, *Zizania aquatica*. The two aquatic grasses, *Leersia oryzoides* and *L. virginica*, were was immune to all three strains.

The grass collection for this study was composed of 42 annual species, and common names habitb (Miss.)c to corn (Ohio) to corn MDMV-B to corn SCMV-B to corn MDMV-A assay MDMV-A assay assay assay multiplication of MDMV or SCMV while three species did not. There was a wide diversity in the response to these viruses among four species of one genus. *Chasmanthium latifolium* was susceptible to MDMV-A, MDMV-B, and SCMV-B; *C. sessiliflorum* was susceptible to MDMV-A and MDMV-B but immune to SCMV-B; *C. laxum* was immune to MDMV-A but susceptible to MDMV-B and SCMV-B; and *C. ornithorhynchum* was immune to all three strains.

The grass collection for this study was composed of 42 annual and 71 perennial species. More annual species (88%) than perennial grasses (61%) were susceptible to MDMV and SCMV. Among the host species, the annuals also showed a greater susceptibility in terms of both disease incidence and disease severity than the perennials. All four grasses (*Echinochloa walteri*, *Setaria faberi*, *S. magna*, and *Zea mays*) that reacted with 100% infection to all four virus isolates were annuals, as were two additional grasses (*Brachiaria plantaginea* and *Eriochloa gracilis*) that were 100%
TABLE 2 (continued)

<table>
<thead>
<tr>
<th>Grass subfamilies, tribes, species, and common names</th>
<th>Growth habit (^a)</th>
<th>MDMV-A (^b) (Miss.)</th>
<th>Back assay to corn (^a)</th>
<th>MDMV-A (Ohio)</th>
<th>Back assay to corn</th>
<th>MDMV-B</th>
<th>Back assay to corn</th>
<th>SCMV-B</th>
<th>Back assay to corn</th>
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</thead>
<tbody>
<tr>
<td><strong>Zoysia japonica</strong></td>
<td>P</td>
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<td>0/10</td>
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<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
</tr>
<tr>
<td><strong>Z. matrella</strong></td>
<td>P</td>
<td>0/12</td>
<td>2/10</td>
<td>0/12</td>
<td>3/10</td>
<td>0/12</td>
<td>0/10</td>
<td>0/12</td>
<td>0/10</td>
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<tr>
<td><strong>Subfamily Bambusoideae</strong></td>
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</tr>
<tr>
<td><em>Arundinaria gigantea</em> (Walt.) Muhl. Giant cane</td>
<td>P</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
<td>0/13</td>
<td>0/10</td>
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<tr>
<td><em>A. tecta</em> (Walt.) Muhl. Switch cane</td>
<td>P</td>
<td>0/20</td>
<td>10/10</td>
<td>0/20</td>
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<td></td>
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<tr>
<td><em>Hydrochloa caroliniensis</em> Beauv. Southern watergrass</td>
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<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
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<td>8/24</td>
<td>7/10</td>
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<tr>
<td><em>Leersia hexandra</em> Swartz Southern cutgrass</td>
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<td>18/23</td>
<td>...</td>
<td>20/23</td>
<td>...</td>
<td>6/23</td>
<td>...</td>
<td>15/23</td>
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<tr>
<td><em>L. oryzoidea</em> (L.) Swartz Rice cutgrass</td>
<td>P</td>
<td>4/18</td>
<td>...</td>
<td>3/18</td>
<td>...</td>
<td>2/18</td>
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<td>2/18</td>
<td>...</td>
</tr>
<tr>
<td><em>L. virginica</em> Willd. Whitegrass</td>
<td>P</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
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<td>0/10</td>
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<tr>
<td><em>Luziola bahiensis</em> (Steud.) Hitchc.</td>
<td>P</td>
<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
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<td>0/24</td>
<td>0/10</td>
<td>0/24</td>
<td>7/10</td>
</tr>
<tr>
<td><em>Oryza sativa</em> L. Rice 'Labelle'</td>
<td>A</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
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</tr>
<tr>
<td><strong>Zizania aquatica</strong> L.</td>
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<td>1/18</td>
<td>2/10</td>
<td>0/18</td>
<td>0/10</td>
<td>0/18</td>
<td>0/10</td>
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</tr>
<tr>
<td><em>Zizaniopsis miliacea</em> (Michx.) Doll. &amp; Aschers., Southern wildrice</td>
<td>P</td>
<td>11/20</td>
<td>...</td>
<td>17/20</td>
<td>...</td>
<td>19/20</td>
<td>...</td>
<td>7/20</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Arundo donax</em> L. Giant reed</td>
<td>P</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
<td>0/10</td>
<td>0/20</td>
<td>0/10</td>
</tr>
<tr>
<td><em>Chasmanthium latifolium</em> (Michx.) Yates Broadleaf uniolia</td>
<td>P</td>
<td>8/19</td>
<td>...</td>
<td>6/19</td>
<td>...</td>
<td>3/19</td>
<td>...</td>
<td>3/19</td>
<td>...</td>
</tr>
<tr>
<td><em>C. laxum</em> (L.) Yates Loose spanglegrass</td>
<td>P</td>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
<td>0/10</td>
<td>1/10</td>
<td>6/10</td>
<td>2/10</td>
<td>10/10</td>
</tr>
<tr>
<td><em>C. ornithophyllum</em> (Steed.) Yates Birdsbeak spanglegrass</td>
<td>P</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
<td>0/15</td>
<td>0/10</td>
</tr>
<tr>
<td><em>C. sessiliflorum</em> (Poir.) Yates Shortflower spanglegrass</td>
<td>P</td>
<td>6/20</td>
<td>...</td>
<td>2/20</td>
<td>...</td>
<td>1/20</td>
<td>...</td>
<td>0/20</td>
<td>...</td>
</tr>
<tr>
<td><em>Danthonia spicata</em> (L.) Beauv. Poverty oatgrass</td>
<td>P</td>
<td>0/18</td>
<td>0/10</td>
<td>0/18</td>
<td>0/10</td>
<td>0/18</td>
<td>0/10</td>
<td>0/18</td>
<td>0/10</td>
</tr>
</tbody>
</table>

\(^a\) Fraction expresses disease incidence in response to manual inoculation; the numerator denotes the number of plants with symptoms and the denominator the number of plants inoculated.

\(^b\) Abbreviations: A = annual species, P = perennial species.

\(^c\) Two isolates of MDMV-A, one from Mississippi and one from Ohio, were used.

\(^d\) Back assay to Seneca Chief sweet corn was made from each inoculated grass species that remained symptomless or showed uncertain symptoms; in the fraction, the numerator indicates the number of corn plants with symptoms and the denominator (constant: 10) the number of corn seedlings inoculated; each such fraction refers to the virus isolate to its left.

susceptible to both isolates of MDMV-A and to MDMV-B (but not to SCMV-B). By comparison, of the 42 perennial hosts, only two species showed complete susceptibility to one or two virus strains but not to all three. *Eragrostis elliotii* was 100% susceptible to MDMV-A while *Digitaria villosa* was 100% susceptible to MDMV-B and SCMV-B. A few minor differential host responses to the two isolates of MDMV-A were observed. Four species (*Anthaenantia rufa*, *Arundinaria tecta*, *Oryza sativa* 'Lebonnet,' and *Spartina spartinae*) reacted with susceptibility to MDMV-A from Mississippi but not to MDMV-A from Ohio, whereas two species (*Andropogon mohrii* and *Zizaniopsis miliacea*) exhibited immunity to MDMV-A from Mississippi, but susceptibility to MDMV-A from Ohio. Since the percentage of plants with symptoms among the six species (two species with symptomless infection) was relatively small, it is likely that the apparent differential responses would have disappeared upon inoculation of a larger number of plants than was available.

A taxonomic grouping of the grass flora of Mississippi into the six subfamilies shows the number of host species of MDMV and SCMV in each subfamily (Table 3). From these data it is evident that MDMV can infect every major taxon of the grass family. These and other (19) data seem to indicate that about two-thirds of the Mississippi grasses would be susceptible to MDMV-A. A summary of the number of new hosts and new nonhosts of the three viruses in each of the six subfamilies of the Mississippi Gramineae is contained in Table 4.

**DISCUSSION**

The native grass species chosen for this investigation approximate the relative taxonomic distribution of the Mississippi
grass flora among the six subfamilies of the Gramineae (Table 3). For example, members of the subfamily Eragrostidoideae constitute 24% of the Mississippi grass species and represent 22% of the species tested. Hosts of MDMV or SCMV were found throughout the entire phylogenetic spectrum of the grass family, from the native bamboos to the oryzoid aquatic grasses to corn.

The infectivity profile of MDMV-B among many diverse taxa showed a greater resemblance to that of SCMV-B than to that of MDMV-A. Ten species reacted similarly to MDMV-B and SCMV-B while five species reacted similarly to MDMV-B and MDMV-A. In the first group, eight species were susceptible to MDMV-A but immune to MDMV-B and SCMV-B, and two species were immune or highly resistant to MDMV-A but susceptible to MDMV-B and SCMV-B. In the second group, three species were susceptible to MDMV-A and MDMV-B but immune to SCMV-B, and two species were immune to MDMV-A and MDMV-B but susceptible to SCMV-B. Although most grasses responded similarly to all three virus strains, either with susceptibility or immunity, there were many instances of similar infectivity of MDMV-B and SCMV-B to suggest a closer relationship between MDMV-B and SCMV-B than between MDMV-B and its "sister" strain, MDMV-A.

Strain MDMV-B has a narrower host range, especially in the Eragrostidoideae, than strain MDMV-A. In this investigation, 18 species susceptible to MDMV-A were immune to MDMV-B. In two other studies, there were 22 species in the same category (18,19). Furthermore, many grasses that are hosts of both strains are susceptible to a lesser extent to MDMV-B than to MDMV-A. The infectivity data from wild grasses contrast with the reaction of annual symptomless hosts of MDMV-B, most were colonized by aphids in the greenhouse (observed on plants for seed production), and all have a very extensive distribution in the USA wherever corn is grown. Some of the annual as well as perennial hosts reacted with only latent infection to MDMV-B. Among the annual symptomless hosts of MDMV-B, attention should be focused on B. japonicus and especially on B. tectorum, as suggested by the author (18,21), because they are hardy winter annuals with geographic distributions that coincide with that of MDMV-B. Recently MDMV-B has been isolated from wild, symptomless plants of B. tectorum in Kansas (3).

Symptomless hosts of a virus can be particularly troublesome if they act as overwintering hosts and remain unknown. The majority

<table>
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<tr>
<th>Subfamily (tribe)</th>
<th>Species in MS (no.)</th>
<th>Percent of MS species (%)</th>
<th>Species tested (no.)</th>
<th>Percent of species tested (%)</th>
<th>Hosts of MDMV and/or SCMV (no.)</th>
<th>Hosts of MDMV-A (no.)</th>
<th>Hosts of MDMV-B (no.)</th>
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<td>26</td>
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<td>22</td>
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<tr>
<td></td>
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<td>12.4</td>
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<td>100.0</td>
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of the 17 symptomless hosts found among the 113 species tested are members of the Festucoideae, and among these, most are annuals. However, the three perennial festucoids that are symptomless hosts (Festuca rubra, Glyceria striata, and Stipa avenacea) are widely distributed and may be important in the epiphytology of MDMV. The eight nonfestucoid symptomless hosts are of limited distribution and may be endemic to the genera Festuca, Glyceria, and Stipa, contain more than one species that react to MDMV or SCMV with symptomless transmission studies of maize chlorotic mottle virus in grasses suggest that the virus may have originated in a taxon more remote from Zea than those close neighbors mentioned above, perhaps in Saccharum or Sorghum, and later became adapted to corn.

**LITERATURE CITED**


