Reactions of Maize (*Zea mays*) Accessions to Maize Rayado Fino Virus

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ABSTRACT

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Fifty-eight North American maize accessions were evaluated for their sensitivity to maize rayado fino virus (MRFV) on the basis of percent infection and symptom expression, including stunting. No immunity or resistance was observed in any accession tested, only different degrees of susceptibility. The accessions were classed into four susceptibility groups. Seven entries were moderately susceptible, 17 were intermediately susceptible, 13 were susceptible, and 21 were highly susceptible. No commercially acceptable level of resistance was found in the North American germ plasm tested. North American maize germ plasm seems very vulnerable to this disease.

Maize rayado fino virus (MRFV) was first described by Ancalmo and Davis (1) in 1961 as a strain of the corn stunt pathogen, but in 1969, Gamez (5) correctly identified the pathogen as a virus. MRFV is an RNA-containing isometric particle about 31 nm in diameter. It sediments into two components. The top component is composed of empty protein shells and the bottom component contains infective nucleoprotein particles (7).

Two additional strains of MRFV have been recognized: maize rayado Colombiano virus (9) and Brazilian maize streak virus (3). The properties of these two strains are similar, but they are serologically distinguishable. The disease MRF is restricted to the Gramineae. The virus is found naturally in maize (*Zea mays* L.) and has been experimentally transmitted with leafhoppers to annual and perennial teosintes, *Zea* spp., *Tripsacum australe* Cutler & Anderson, and *Rottboellia exaltata* L. (11). The virus is not mechanically transmissible. It is prevalent in Central America and Mexico (6). In South America, it has been reported in Brazil, Colombia, Peru, and Uruguay (7). In the United States, MRFV was first observed in the Lower Rio Grande Valley of Texas in 1976 and in Homestead, FL, in 1977 (2).

After inoculation, symptoms appear on maize within 7–14 days as small chlorotic spots that become elongated and more numerous with age. Later, a general chlorosis may develop. Ears are reduced in size, which contributes to reduction in grain yield.

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The principal vector in the field is the leafhopper *Dalbulus maidis* (DeLong & Wolcott), although four other leafhoppers, *D. elimatus* (Ball), *Baldulus tripsaci* Kramer & Whitcomb, *Stirellus bicolor* (Van Duzee), and *Graminella nigrifrons* (Forbes), experimentally transmit the virus (11). With *D. maidis*, the minimum acquisition and inoculation feeding periods are 6–8 hr. MRFV has a latent period (LP) of 8–37 days at 20–25 C, with an average LP of 12.5 days at 25 C. Females are more efficient vectors than males (10,11). Although the insect retains the virus through the moult, there is no transovarian transmission (8).

MRFV causes heavy losses in maize in many Central American countries. MRFV is second in importance only to corn stunt in the major corn-producing areas of most of Central America. Actual yield reductions in early-infected individual plants vary from 40 to 50%. Yields in locally grown Central American cultivars also are reduced. Yields in recently introduced or newly developed cultivars have been reduced as much as 100% (6).

Because MRFV could pose an immediate threat to maize production in Texas and Florida, the potential exists for outbreaks of this disease throughout the major maize-producing areas of the United States (2). This study was designed to evaluate and characterize the effect of the Texas isolate MRFV on selected U.S. maize genotypes.

MATERIALS AND METHODS

The primary vector of MRFV, *D. maidis*, was identified using the characters proposed by DeLong (4). Leafhoppers were collected from maize fields near College Station, TX, and transferred to rearing cages. Leafhoppers were reared at 23 ± 3 C with a 12-hr photoperiod on Silver Queen hybrid sweet corn seedlings in a walk-in growth chamber (8).

Adult leafhoppers were allowed to oviposit for 1 wk on sweet corn, then they were attracted by light to the rear of the cage while the seedlings were transferred to another cage. Fresh seedlings were supplied to the adults for oviposition. Eggs were allowed to hatch in an adjoining cage. Plants with newly hatched nymphs were clipped at soil level and placed in a cage with uninfected seedlings.

Each 30-day-old colony of *D. maidis* was assayed for virus by placing both nymphs and adults on seedlings (25.5 cm tall) of Tx5855 for 14 days. After the leafhoppers were removed, the plants were transferred to the greenhouse and observed for 3 wk for possible symptom development. If symptoms developed, the colony of hoppers was considered viruliferous and destroyed.

To build up MRFV-inoculative leafhoppers, both nymphs and adults were allowed to feed for 48 hr on MRFV (Texas isolate)-infected maize-leaf cuttings obtained from L. R. Nault, Ohio Agricultural Research and Development Center, Wooster. Thereafter, these leafhoppers were serially transferred to sweet corn seedlings every 14 days to maintain MRFV viruliferous leafhoppers and infected plants. Plants were held in the greenhouse to await symptom expression.

To expeditiously screen large numbers of plants in a relatively short period of time, several thousand 1- to 7-day-old virus-free nymphs were transferred to a large, screened cage containing several pots of young MRF-diseased maize plants with severe symptoms. Nymphs were allowed to feed on these plants for at least 4 days, then healthy plants were added as vector infectivity controls. Two to 3 wk after initial exposure of the leafhoppers, the screening of genotypes was conducted by serially transferring viruliferous leafhoppers to three replicates of seedlings. Each replicate consisted of 72 test seedlings representing 12 plants of each of five test accessions and one susceptible control (Tx5855). After 2 days, an insecticide (cismethrin) was applied. Plants were then transferred to the greenhouse for symptom development. The experiment was duplicated for each set of accessions. This inoculative process was repeated until all 58 accessions were tested. For a healthy control, a parallel replicate of each accession was planted at the same time and treated the same as the

test plants, with the exception of exposure to inoculative leafhoppers.

In the initial study, host reactions were classified into five types on the basis of symptoms, where 1 = no disease symptoms; 2 = small, chlorotic flecks (typical reaction in Tx6252); 3 = bright, chlorotic flecks that merged into continuous lines along leaf veins (typical reaction in Mo17); 4 = vivid symptoms, as in class 3 plants but with necrosis of leaf tissue, especially along the leaf margins and tips, or chlorotic lines along the leaf veins accompanied by severe wilting (typical reaction in B73); and 5 = disease symptoms accompanied by death of plant or development of a necrotic growing point (typical reaction in Tx5855).

The corrected mean percent stunting was calculated as follows: corrected mean percent stunting = (mean percent stunting of susceptible Tx5855 in 72-plant replicate)/(mean percent stunting for Tx5855, all replicates) × mean percent stunting of a given accession in a given replicate.

RESULTS AND DISCUSSION

Because symptoms reached maximum severity by 21 days after inoculation, germ plasm evaluations were made at 3 wk. The degree of stunting, as measured by comparison with uninoculated controls, was not always correlated with severity of leaf symptoms at 3 wk postinoculation. However, test plants with a symptom severity rating of 2 or 3 were generally less stunted than those with a rating of 4 or 5.

The inoculation procedure was successful inasmuch as the susceptible control cultivar, Tx5855, averaged 93.1% diseased plants. In these screening tests, 58 maize accessions were evaluated for their reactions to MRFV and percent disease. The incubation period in accessions ranged from 4 to 11 days and was not significantly different from the susceptible controls. Of the 58 maize accessions tested, no immunity was observed. All accessions tested demonstrated symptom development, including stunting.

The reactions to MRFV fell into four susceptibility groups: The first group had a severity rating of 2 or lower, mean percent stunting of 21–42, and a range of 58–100% disease. This group was the least affected by MRFV and was considered moderately susceptible (MS). Cultivars in this group included Tx3038, Tx508, Tx6252, Tx173D, Tx303 × Tx6252, Tx6252 × Tx508, and Tx403 × Tx5855.

The second group was classified as intermediately susceptible (IS), had a severity rating of 3, mean percent stunting of 40 or less, and a range of 50–100% disease. It consisted of Mo17, Tx29A, Tx601 × Tx602, Tx441 × Tx203-2, Tx5855 × Tx127C, Tx303 × Tx203-2, Tx81, Lt601, Mo43, Oh513, T232, Tx Exp 312766, Tx Exp 4101, Mo22, N35, L108 × CI66, and Tx403.

The third group was classified as susceptible (S), had a severity rating of 3, mean percent stunting of 41 or more, and a range of 42–100% disease. It consisted of Tx203-2, L108, Va35, Tx602, A634, Tx61M, Ga209, L336, Mp442, Oh7B, NC232, N25, and CI66.

The fourth group was very susceptible (VS), had a severity rating of 4 or higher, mean percent stunting of 36–70, and a range of 63–100% disease. Accessions in this group were the most severely diseased and included Tx441, B73, N28, B14A, H100, Tx466, T143, Tx240, SC229, Tx127C, PI 167976117, Ky21, Tx Exp 50202, ArkH77, Mp305, Ab408A, SC152, Tx80, F416-1, Mo3, and H93. Mean ratings for the 12 Tx5855 controls were 9 days of incubation, 93.1% infection, disease severity rating of 5, and mean percent stunting of 45.

Although no immunity or resistance was found, the lowest disease incidence was 42% for L108. Seven entries were classed as MS, 17 as IS, 13 as S, and 21 as VS. Specific information on accessions is available from the first author.

These tests indicate that no acceptable level of resistance exists in the North American germ plasm tested and that there is a high degree of vulnerability to MRFV in U.S. maize germ plasm. It is possible, however, that MS × MS crosses and selection for less susceptible individual progeny could result in accumulating minor-effect genes and increasing the level of resistance.

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