Effect of Field Distribution of Maize Dwarf Mosaic-Diseased Corn Plants on Yield

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ABSTRACT

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The grain yields of healthy corn (*Zea mays* L.) plants bordered by healthy or by maize dwarf mosaic (MDM)-diseased plants and of MDM-diseased plants bordered by healthy or by MDM-diseased plants were determined in order to separate the total yield loss caused by maize dwarf mosaic virus into two components, the direct effect on the yielding ability of diseased plants and the indirect effect of the reduced competitiveness of MDM-diseased plants growing next to healthy plants. In the experimental hybrid Mp490 × Mo12, diseased plants bordered by diseased plants yielded 11 and 27% less than healthy plants bordered by healthy plants in 1978 and 1979, respectively. Yields from diseased plants bordered by healthy plants were reduced an additional 16% in each year. Healthy plants flanked by diseased plants did not show compensating yield increases from the reduced competitiveness of the adjacent diseased plants. Our results indicate that in fields with comparable MDM incidence, yield reductions would be greater when diseased plants are randomly distributed than when they are concentrated in pockets in the field.

Additional key words: maize, maize dwarf mosaic virus strain A, plant-to-plant competition

Maize dwarf mosaic (MDM) has caused serious yield losses in corn (*Zea mays* L.) in the United States for the past 15 yr. Under experimental conditions, yield reductions have ranged from slight to 40% (1,2,4–6). In Mississippi, maize dwarf mosaic virus (MDMV) has been known to occur in corn and johnsongrass (*Sorghum halepense* (L.) Pers.) since 1964 (3).

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In a diseased plant growing without competition from other plants, any reduction in yield would be attributable to the direct effect of the causal agent on the plant's growth and development. Crop plants, however, are normally grown at population densities high enough to produce plant-to-plant competition. Therefore, yield reduction in a diseased plant in the field is the result of the direct effect of the pathogen on the host plant plus any indirect effects the disease has on lowering the competitive ability of the plant to secure the necessary elements for growth and development.

On the other hand, reduced competition from diseased plants may contribute to yield increases in adjacent healthy plants. This relationship may be expressed as $L = DE + (RC - CH)$, where L is total yield loss caused by a disease, DE is the direct effect of a pathogen in reducing yield, RC is the yield loss associated with reduced competitiveness of diseased plants competing with healthy plants, and CH is any yield increase associated with a possible competitive advantage of healthy plants growing in competition with diseased plants.

In a previous study (4) where corn plants were inoculated with MDMV strain A (MDMV-A) at different leaf stages, we found that plants inoculated in the five-leaf stage had the highest disease incidence and the most yield loss. In the present study, the reductions in grain yields of MDM-diseased corn plants growing next to other diseased or healthy plants were determined in order to separate the direct effect of the virus on yield of the host plants from the indirect effect of the disease on the ability of diseased plants to compete with healthy plants. In addition, we wanted to determine if any compensating yield increases occurred in healthy corn plants flanked by MDM-diseased plants.

MATERIALS AND METHODS

Two corn genotypes were used in this study. The single cross Mo12 × CI21 was grown only in 1979, and the more MDMV-susceptible single cross Mp490 × Mo12 was grown in 1978 and 1979. In both years, the experiment was arranged as a randomized complete block design with six replicates. A plot consisted of two adjacent 5.08-m rows of 20 plants each. The rows were spaced 0.97 m apart. This plant density corresponded to 40,800 plants per hectare. Plots were assigned at random to receive one of three treatments: all plants inoculated, every

other plant inoculated, or no plants inoculated.

The virus used was MDMV-A isolated from johnsongrass and maintained in sweet corn cultivar Seneca Chief. Inoculum was prepared from sweet corn leaves with pronounced mosaic symptoms by grinding the tissue in a blender while gradually adding 0.05 M potassium phosphate buffer, pH 7.0, at the rate of 2 ml/g of plant material. The pulp was strained through several layers of gauze, and 600-mesh (22-μm) silicon carbide was added at the rate of 5 g per 350 ml of inoculum. Seedlings were inoculated at the three- to five-leaf stage of growth with an artist's airbrush mounted on a tractor and operated at a constant air pressure of 7.03 kg/cm^2 (100 lb/in^2).

Shortly after the silking stage, each plant was examined for mosaic symptoms. In plots that had not been inoculated, any plant with mosaic symptoms was marked as naturally infected with MDMV, and the ears from such plants and from healthy plants immediately adjacent to them were not harvested. Similarly, in plots in which all plants had been inoculated, plants that did not show symptoms were tagged, and the ears from these plants and from the immediately adjoining diseased plants were not harvested. In plots in which every other plant had been inoculated, all plants with mosaic symptoms were tagged. At harvest, only tagged plants flanked by nontagged plants were harvested in one bag, and only nontagged plants flanked by tagged plants were harvested in another bag. Ears were dried and shelled, and grain weights per plant were calculated at 15.5% moisture.

RESULTS

The incidence of MDM was 88% in inoculated plots of Mp490 × Mo12 in 1978 and 78 and 79% in inoculated plots of Mp490 × Mo12 and Mo12 × CI21, respectively, in 1979. These figures are lower than the 93 and 92% diseased plants of these two hybrids found in a preliminary field test in which many experimental hybrids were inoculated with MDMV-A with the same inoculation technique. In plots in which every other plant was inoculated, however, the desired infection rate of about 50% was obtained. Incidence of natural infection by MDMV of 2% (1978) and 7–9% (1979) did not interfere appreciably with our objectives.

In the case of Mp490 × Mo12, comparing the yield from healthy plants bordered by healthy plants with that from diseased plants bordered by diseased plants shows that the direct effect of MDMV was to reduce yields 11 and 27% in 1978 and 1979, respectively (Table 1). In both years, yields from diseased plants bordered by healthy plants were reduced an additional 16%. Thus, the decreased competitive ability of MDMV-infected corn plants vis-à-vis adjacent healthy plants may contribute as much to the total yield loss as does the direct effect of the virus on the host plant. In 1979, total grain yield in diseased plants flanked by healthy plants was reduced 43% (27% from the direct effect and 16% from the indirect effect). No significant compensating yield increases were apparent in healthy plants bordered by diseased plants.

Table 1. Grain yields of maize dwarf mosaic-diseased and healthy plants bordered by diseased or healthy plants

		Mp490 × Mo12				Mo12 × CI21	
		1978		1979		1979	
Plants evaluated	Border plants	Grain weight per plant[z] (g)	Percentage of check	Grain weight per plant[z] (g)	Percentage of check	Grain weight per plant[z] (g)	Percentage of check
Diseased	Diseased	140 b	89	87 b	73	100 b	96
Diseased	Healthy	116 c	73	68 c	57	104 b	100
Healthy	Diseased	154 ab	97	123 a	103	118 a	113
Healthy (check)	Healthy	158 a	100	120 a	100	104 b	100

[z] Means within a column not followed by the same letter differ significantly from each other (P = 0.05).

In 1979, yield of Mo12 × CI21 plants was not reduced by MDMV. When plants of this hybrid were being examined for symptoms, we noted that diseased plants showed only very faint mosaic symptoms, although symptoms had been more pronounced earlier in the season. Apparently, reductions in chlorophyll in the diseased plants of this hybrid were not enough to affect grain yield.

DISCUSSION

The yield reduction in MDM-diseased Mp490 × Mo12 plants growing in competition with healthy plants was surprising. Yield of diseased plants adjoining healthy plants was reduced 16% more than yield of diseased plants adjoining other diseased plants. This difference may be attributable to the decreased ability of diseased plants to compete with neighboring healthy plants for the essential elements needed for growth and development.

Usually, the mosaic symptoms of MDM are most pronounced early in the life of the corn plant, when plant-to-plant competition is still relatively low. These leaf symptoms tend to become diffused by the time pollination takes place. The decreased competitiveness of MDM-diseased plants in relation to adjacent healthy plants cannot be accounted for by dwarfing; maximum reductions in heights of MDM-diseased corn plants of only 8% (4,5) and 14% (1) have been reported in tests that also determined yield.

From a practical standpoint, it may appear unimportant to know what proportion of yield loss is caused by the direct effect of the pathogen on the host plant and what proportion is caused by reduced competitiveness of the diseased plant. However, when one attempts to assess or predict the yield reduction in a cornfield with a given disease incidence, the distribution of the diseased plants within that field may take on added significance. If all yield loss resulted from the direct effect of the pathogen on the host plant, the only data needed to determine loss would be the separate grain yields from healthy and diseased plants and the percentage of diseased plants. If, however, reduced competitiveness of diseased plants also affects yield, then the percentage of diseased plants bordering other diseased plants and the percentage of diseased plants bordering healthy plants must also be established.

Our tests with Mp490 × Mo12 indicate that in fields with comparable MDM incidence, grain yield will be lower when diseased plants are distributed randomly than when they are concentrated in a few areas of the field. If the reduced competitiveness of MDM-diseased plants found for Mp490 × Mo12 is also found in other corn hybrids, the development of a predictive disease-loss model for MDM becomes more complicated than previously envisioned.

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