

Elevation & Temperature Effects on Severity of Maize Dwarf Mosaic Virus in Sorghum

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Sorghum (*Sorghum bicolor*) is one of the most important agronomic crops in Arizona. During 1968 and 1969 sorghum for grain was grown on about 200,000 irrigated acres at elevations ranging from near sea level to over 5,000 feet (2). The annual sorghum acreage is about equally divided between the southeastern and central parts of the state. Cochise and Graham counties at 4,000 to 4,500 feet are in the southeast while Maricopa and Pinal counties are centrally located at 1,000 to 1,500 feet.

Full season hybrids are planted at the higher elevations. These hybrids are usually planted in May and harvested in October or November. Sorghum yields at the higher elevations usually exceed 6,000 pounds per acre, well

above the state average of 4,400 pounds. Many different planting and harvest dates are possible at the lower elevations.

Many parasitic diseases have been described for sorghum in Arizona (10) but in general the crop was grown without serious problems until a Maize Dwarf Mosaic (MDM) virus epidemic occurred in 1968 (5). In that year the disease was found in all sorghum producing counties in Arizona. Although the virus was widespread in Arizona during 1968 and 1969 it caused serious losses only in 1968 at elevations over 4,000 feet. In many fields at the higher elevations disease incidence was more than 90% and severe red-leaf streaking resulted in extensive loss of leaves. Yields in Cochise County were about 30% less than normal on most sorghum producing farms in 1968. It was also observed in 1968 that certain hybrids growing adjacent to other obviously infected hybrids developed little or no red streaking and that yields were normal.

The MDM outbreak in Cochise County in 1968 seemed related to four factors: (1) unusually high aphid vector populations, (2) prevalence of Johnsongrass (*Sorghum halepense*) as a virus reservoir, (3) an unusually cool summer, and (4) large acreages planted to susceptible hybrids. Although widespread, MDM was not an important factor in production during 1969 and 1970 at any location in Arizona.

The object of this paper is to report studies that explain the differences in disease severity at different elevations and times in Arizona.

MATERIAL AND METHODS

During the spring of 1969 several replicated field plots were established in areas of high and low elevation to evaluate the response of certain sorghum hybrids to MDM. The high elevation plots in Cochise County were at two locations, Kansas Settlement and Pearce, Arizona, at approximately 4200 and 4400 feet elevations, respectively. These tests were planted the first week in May and harvested the second week in October. The low elevation test, at approximately 1200 feet, was planted at Tolleson in April and harvested in September. Hybrids thought to differ in susceptibility to MDM, from observations in 1967 and 1968, were included in all tests.

During 1969 some of the hybrids were artificially inoculated using a previously described technique (4).

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FIGURE 1. RELATIONSHIP BETWEEN MEAN MAXIMUM JULY TEMPERATURE AND ELEVATION IN ARIZONA

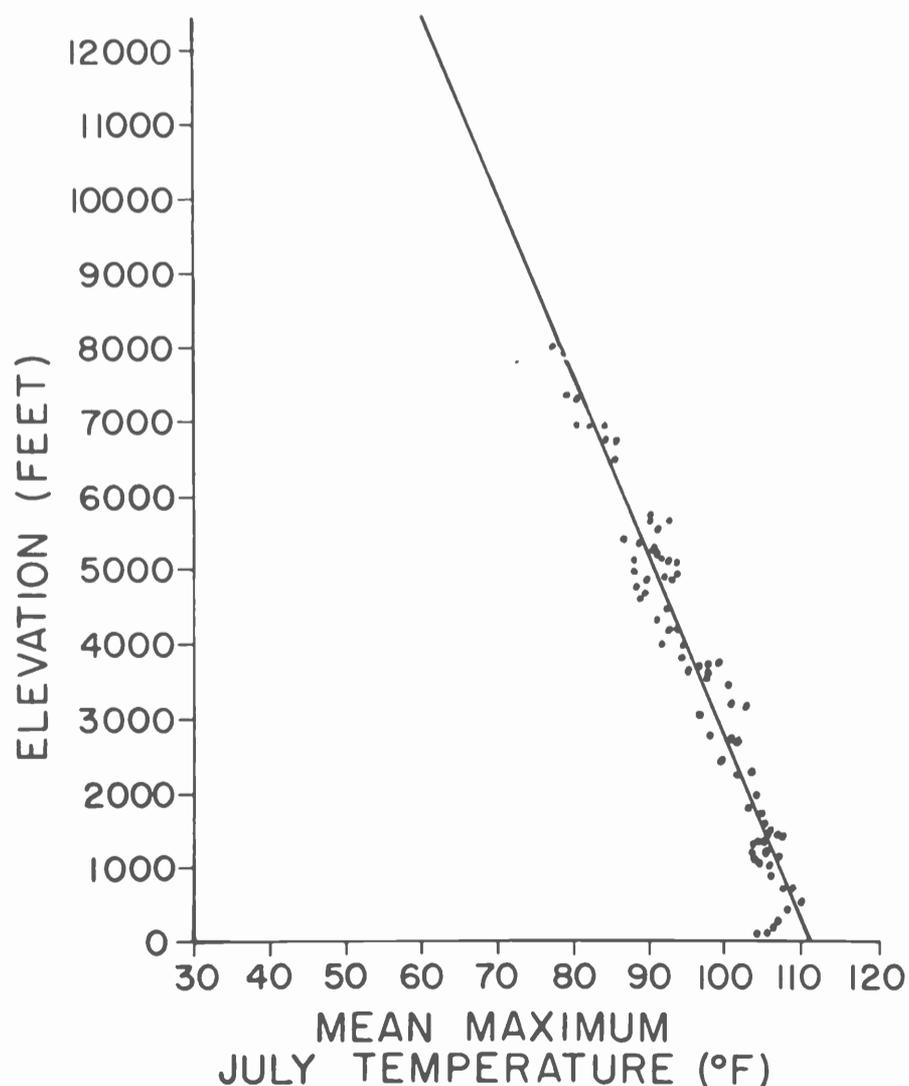


Table 1. Yield and reaction to MDM of 11 sorghum hybrids grown at Pearce, Arizona (4420 foot elevation) during 1969.

Hybrids	Yield ^a	% Moisture at harvest	Bushel weight	MDM rating ^b
Acco R109	6087 ^a	11.59	59.6	1
Pioneer 828	5926 ^a	9.99	58.4	1
Asgrow TTX	5614 ^{ab}	10.19	58.5	1
Frontier 409	4699 ^b	10.03	58.7	1
Excel 707	4388 ^c	9.63	57.0	1
NK 280	4345 ^c	9.67	58.0	1
Asgrow Jumbo L	4312 ^c	11.15	59.7	1
Lindsey 788 A	4183 ^c	11.10	57.6	4
De Kalb F64	4151 ^c	10.03	59.1	1
PAG 655	3979 ^c	9.77	58.2	1
Taylor-Evans 77	3947 ^c	9.99	58.3	4

^a Yield converted to 10% moisture. Weights followed by a different letter are significantly different at the 1% level.

^b 1 Slight mosaic pattern in leaves.

4 Mottling and red-streaking (necrosis) in leaves.

Johnsongrass inoculated with a strain of MDM from Kansas Settlement, Arizona and grown in the greenhouse was used as a source of inoculum. Periodic disease ratings were made using a scale proposed in Texas (1). Temperature data were collected from recording stations at Willcox (elevation 4200 feet), Pearce (4420 feet), Casa Grande (1405 feet), and Mesa (1225 feet) for May, June, July, August and September, 1968 and 1969. Field observations were made at these locations for MDM severity and incidence during 1968, 1969 and 1970.

RESULTS

Field Studies — field plots. — Yield data and MDM ratings of 11 hybrids adapted to high elevation areas in Arizona are shown in Tables 1 and 2. The three highest yielding hybrids at both test locations were Pioneer 828, Asgrow TTX, and Acco R-109. Taylor-Evans 77 and Lindsey 788-A were the only hybrids that gave a susceptible, red-leaf reaction. Disease incidence was approximately 10-20% in the plots at Kansas Settlement and Pearce. In the replicated test at Tolle-son there was no difference in reaction to the MDM virus between the susceptible hybrids Taylor-Evans 77 and Lindsey 788-A and the tolerant hybrids NK 280, Pioneer 828, Pioneer 846, Rico, PAG 515, Amak R-12, Lindsey 765W, and Excel 505. The disease incidence at this site was approximately 80%, but all hybrids exhibited only a very slight mosaic pattern with no stunting or red-leaf symptoms. During 1968, Lindsey 788-A, Taylor-

Table 2. Yield and reaction to MDM of 11 sorghum hybrids grown at Kansas Settlement, Arizona (4200 foot elevation) during 1969.

Hybrids	Yield ^a	% Moisture at harvest	Bushel weight	MDM rating ^b
Pioneer 828	6621 ^a	12.28	59.6	1
Asgrow TTX	6302 ^{ab}	12.33	59.1	1
Acco R109	6022 ^{bc}	16.30	58.7	1
DeKalb F-64	5990 ^{bc}	16.25	60.7	1
Taylor-Evans 77	5833 ^{bcd}	12.04	60.5	4
Excel 707	5618 ^{cd}	12.39	59.5	1
NK 280	5547 ^{cd}	12.99	59.1	1
Asgrow Jumbo L	5456 ^d	12.44	60.2	1
PAG 655	5444 ^d	12.55	60.4	1
Lindsey 788 A	5419 ^d	14.03	59.5	4
Frontier 409	5342 ^d	15.61	57.9	1

^a Yield converted to 10% moisture. Weights followed by a different letter are significantly different at the 1% level.

^b 1 Slight mosaic pattern in leaves.

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Evans 77, DeKalb 65, and Taylor-Evans 88 were used for much of the acreage at the higher elevations. The disease was serious in these four susceptible hybrids and red-leaf symptoms were common. However, during the warm summer of 1969 symptoms were mild in all four susceptible hybrids. These hybrids also are known to be susceptible to MDM from tests and observations in Texas (1, R. W. Toler, personal communication).

Elevation, temperature and disease severity. — A graph (see Fig. 1) of the mean maximum July temperature at 91 weather stations located at various locations in Arizona shows almost a straight line relationship for elevation and temperature with approximately a 4° F drop in temperature for every 1000 foot increase in elevation. Serious disease losses have been noted only at elevations over 4000 feet and only during the cool summer of 1968. Two factors probably reduced disease severity in the summer of 1969 at high

elevations: higher summer temperatures than in 1968 and widespread use of resistant hybrids. Susceptible hybrids planted in Cochise County in the warm summer of 1969 were not as severely damaged as in 1968. Comparisons of minimum temperatures at Willcox (4200 feet) and Pearce (4420 feet) between 1968 and 1969 are shown in Table 3. There were 52 nights at Pearce during July and August 1968 (when the MDM epiphytotic occurred) when minimum temperatures were 62° F or below, as contrasted to 14 nights in 1969 when disease severity was low. Also, during a nine day period in 1968 (August 10-19) the minimum temperatures averaged 51° F with a range from 43 to 57° F. The minimum temperatures at the low elevation areas (500-1200 feet), where MDM incidence is high but severity low, are approximately 10-12° F higher than those recorded for Pearce and Willcox.

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Table 3. A comparison of minimum temperatures during July and August, 1968 and 1969.

Night temperatures at or below (F.)	Location							
	Pearce (4420 feet)				Willcox (4200 feet)			
	1968		1969		1968		1969	
	July	Aug.	July	Aug.	July	Aug.	July	Aug.
62	22 ^a	30	7	7	27	27	15	15
60	7	23	1	0	17	23	6	10
58	1	8	0	0	11	16	4	4
55	0	4	0	0	6	9	0	0
50	0	1	0	0	1	4	0	0

^a 22 nights during July, 1968 when minimum temperatures were 62° F. or below.

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DISCUSSION

Observations from 1967-1970 indicated that low air temperatures were related to serious disease development in susceptible sorghum hybrids grown in Arizona. Although MDM was common at low elevations during this period it was serious only at elevations above 4000 feet, and only during the cool summer of 1968. Also, stunting, red-leaf streaking, and yield reductions have been seen only in susceptible hybrids growing at elevations above 4000 feet.

Several researchers have noted this disease-temperature relationship. In New Mexico, unseasonably cool average temperatures (maximum 73° F, minimum 57° F) for several days in August, 1966, were correlated with destructive red-leaf symptoms of the disease (6). Studies in Texas also indicate that the red-leaf discoloration is associated not only with genotype but also with environment. In environmental growth chambers red-leaf symptoms were induced in certain diseased hybrids by lowering growing temperatures from 75-85° F to 55-65° F for 72-96 hours (9, 11).

Data from 91 weather stations in Arizona show an approximate 4° F decrease in temperature for every 1000 foot increase in elevation (3, 7, 8). The mean maximum July temperatures at elevations of 4000 feet are approximately 12° F lower than temperatures at 1000 foot elevations.

The four factors apparently necessary for serious outbreaks of MDM in sorghum are: susceptible hybrids, aphid vectors, infected Johnsongrass as a virus reservoir, and cool temperatures. The control of aphids and Johnsongrass is possible but difficult and expensive. The third factor, temperature, is uncontrollable and unpredictable. Only one of the factors, choice of hybrid, may be completely controlled by the grower. Currently, most of the 15 hybrid sorghums rec-

ommended by the University of Arizona for high elevation planting (12) are known to have a high degree of tolerance for the MDM virus. Therefore, the most effective and least expensive method of control of MDM will be achieved by selecting and planting hybrids of sorghum that have tolerance to the disease.

Temperature effects on severity of MDM were also noted in sweet corn in the Phoenix area during the spring of 1970. Plantings of Golden Cross Bantam T, a susceptible variety, were made on February 18, March 14 and 24, and April 6, 14, and 26. Periodic observations throughout the growing season indicated that disease incidence was nearly 100% in all plantings. Severe leaf-edge scorching, stunting and yield reduction, however, occurred primarily in the plantings made in February and March. February and March minimum and maximum average temperatures at Phoenix were 35 and 65° F and 45 and 74° F, respectively. April, May, and June minimum and maximum average temperatures were 46 and 80° F, 60 and 96° F, and 68 and 103° F, respectively. The plantings made in April developed a typical leaf mottle but no leaf-edge scorching or stunting.

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