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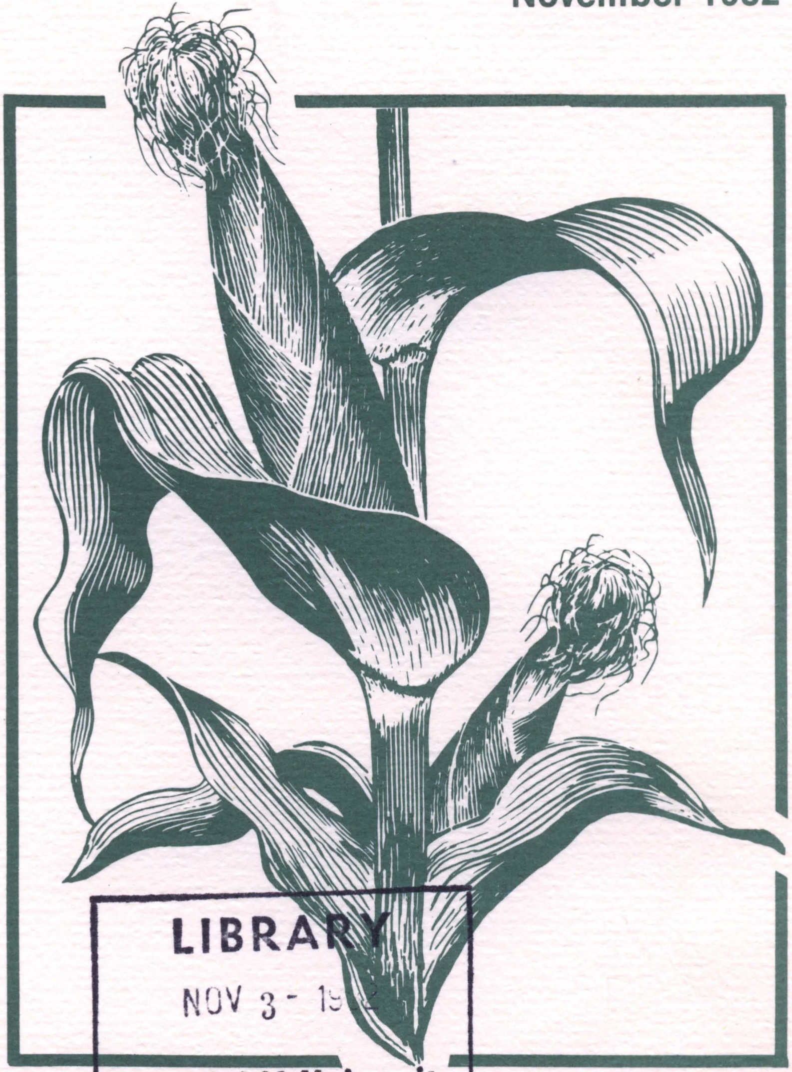

Maize Dwarf Mosaic Virus:

Effect of Strain A on Corn Inbreds, Single- and Double-Cross Hybrids

The Texas Agricultural Experiment Station, Neville P. Clarke, Director, The Texas A&M University System, College Station, Texas

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MAIZE DWARF MOSAIC VIRUS: EFFECT OF STRAIN A

ON CORN INBREDS, SINGLE- AND DOUBLE-CROSS HYBRIDS

R. W. Toler, A.J. Bockholt and F. G. Alston*

*Respectively, Professor, Department of Plant Sciences, Associate Professor, and Graduate Research Assistant, Department of Soil and Crop Science, Texas Agricultural Experiment Station, College Station.

KEY WORDS: Maize dwarf mosaic virus / resistance / corn / hybrid mechanisms

CONTENTS

SUMMARY

Five Texas corn double crosses, the single-cross parents, and the inbreds used to make the single crosses were studied for their reaction to inoculation of maize dwarf mosaic virus strain A (MDMV). Characteristics studied included: days to silk, plant height, ear height, disease ratings, yield, shelling percent and test weights.

Significant differences occurred between inoculated diseased vs. uninoculated healthy single crosses and double-cross hybrids due to the effects of susceptible inbred lines. No significant differences occurred with the crosses among the resistant lines. MDMV caused differences among hybrid entries for each characteristic considered.

All entries generally showed the same disease symptoms, to different degrees. Maize dwarf mosaic virus delayed maturity, reduced plant and ear heights, and reduced yields. There was no effect on shelling pecent, test weights, ear length, or seed set. When three susceptible inbred lines were in a double-cross hybrid, MDMV significantly affected the performance of the hybrid.

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INTRODUCTION

Maize dwarf mosaic virus strain A (MDMV) is the most widespread virus attacking corn, bringing damage to all areas where corn is grown (2,6,7). The disease causes characteristic stunting and mottling in stricken plants but symptom expression varies greatly by genotype. The most promising means of MDMV control is through host resistance (1). Hybrids and inbred lines of corn have been screened for their reaction to MDMV in Arkansas, Ohio, Georgia, Missouri, and Tennessee (3, 4, 9, 11, 16, 17). Several Texas inbred lines were screened in Illinois, and two lines showed a high degree of tolerance (12). Virus rating systems have been developed to compare the degree of tolerance of hybrids and inbred lines (15). Zuber et al. (16, 17) rated corn strains in 1967 and 1968 in Missouri; however, only in 1968 was a Texas inbred (Tx 601) rated (17). Tx 601 was found to be highly tolerant by Dale and York (5) in 1967-rated inbred lines and single crosses developed from the most tolerant inbreds. Tx 602 was entered in the screening and also rated high in tolerance to MDMV.

Studies on inheriting tolerance to MDMV were conducted with inbred lines in Missouri and Tennessee (10,12). By crossing a tolerant inbred line, an intermediate degree of tolerance resulted. Studies in Missouri conducted by Loesch and Zuber (12) indicated that tolerance was controlled by more than one gene, and the progeny responded differently to a heterogeneous virus population. Josephson, Hilty, and Arnold (10) in Tennessee found that tolerance to MDMV could be transferred to a susceptible inbred by backcrossing. Also, Zuber et al. (unpublished data) reported on a study of methods to predict MDMV reactions in double crosses which differ in the number of tolerant or susceptible inbreds.

This study was designed to determine the effects of MDMV on yield and agronomic characteristics and to assess the effects of susceptible inbred lines or single crosses on the performance of double crosses which differ in the number of tolerant or susceptible inbreds.

MATERIALS AND METHODS

These studies included five Texas single crosses and the single-cross parents as well as the inbreds used to make the single crosses (Table 1). The inbreds included resistant and susceptible lines. The tests were planted on chips or clay loam with 448 kg of 17-11-6 fertilizer applied per hectare at planting and 336 kg of ammonium nitrate per hectare applied at the five-leaf stage of growth. A randomized split-plot design with three replications was employed. Each plot consisted of six rows 6.1 m x by 102 cm and replications of a single variety at a density of 32,310 plants per hectare. One half of each plot (three rows) was inoculated, and the other half served as the control.

Plants were inoculated in the three-leaf stage of growth with an artist's airbrush (13) using 7.06 kg/cm^2 pressure a flow rate of 10 ml/min and a leaf distance of 2.5 cm. Inoculum consisted of infected sorghum sudan hybrid homogenized in a Waring blender with equal volume of phosphate buffer pH 7.5 with one percent 600 mesh carborundum added after filtering. The inoculum was refrigerated until used. Data were collected on stand, symptoms, days to silk, plant height, ear height, root lodging and plant breakage, disease incidence, yield, shelling percent, seed set, and test weight. Days to silk was determined by calculating the number of days from planting to the time 50 percent of the plants in a plot showed silk. Plant height was measured from the ground level to the tip of the tassel after vegetative growth had stopped. Ear height was measured from the ground level to the base of the upper ear. Plants were rated visually during the boot stage for disease symptoms and stunting according to the following scale:

<u>Virus rating</u>

1 = No apparent infection of plant.

2 = Mottling in whorl of plant only.

3 = Mottling of entire plant.

4 = Chlorosis of entire plant.

5 = Discoloration of plant other than chlorosis.

6 = Severe chlorosis, mottling, or discoloration of plant.

<u>Stunting</u>

1 = No apparent stunting of plant.

2 = Slight stunting of plant.

3 = Stunting of plant with reduced ear size.

4 = Stunting of plant with no ear present.

5 = Death of plant.

Data were collected from the middle rows of the inoculated and uninoculated plots to reduce border effects. Stand counts were taken to correct yield per plot. Root lodging and plant breakage were taken before harvest to determine standability. Plants that were leaning more than 30 degrees from an erect position were considered lodged. Any plant with the stalk broken below the upper ear was considered broken. Yield was determined by converting the shelled corn weight per plot into hectoliters of shelled corn per hectare. Shelling percent was determined by dividing the shelled corn weight by the ear corn weight and converting to percent. Test weights were taken on a standard test weight scale for the hybrid test and for the plots of the inbred test that had sufficient shelled corn to make a measurement.

Ear length and ear width measurements, and seed set ratings were taken on the hybrid test only. Ear length was measured in cm from tip to butt. Ear width was measured in cm through the middle of the ear. Seed set was rated visually at the time of harvest, according to the following scale:

Seed set rating

1. No apparent effect of MDMV - 95 to 100 percent.
2. Slight reduction in seed set - 75 to 95 percent.
3. Severe reduction in seed set - 25 to 75 percent.
4. Very poor seed set - Less than 25 percent.

Analysis of variance was computed for days to silk, plant height, ear height, yield, shelling percent, ear length, ear width, and seed set in hybrid tests.

The appropriate F-tests were used to indicate significant differences with varieties considered as the main plot and the treatment (inoculated vs. uninoculated) as the sub-plot. If the F-test indicated significance, the means were then separated with Duncan's Multiple Range Test. Data were collected on the inbred lines in an attempt to determine if MDMV effects on yield and other agronomic characteristics of corn hybrid could be predicted from inbred line response.

RESULTS

Days to Silk

The analysis of variance for days to silk showed highly significant differences among mean squares of varieties, treatment, and interaction between treatment and varieties (Table 2). The MDMV-infected plots were delayed at maturity on an average of 2.0 days. All but one of the inbred lines (Tx 585, a highly virus-tolerant inbred) had delayed maturity, ranging from 5.3 days for Tx 441 to 0.3 days for Tx 127C. The inbred lines K 55, K 64, TX 441, Tx 303, TX 325, and TX 508 were all significantly delayed at maturity by the virus.

MDMV caused a significant delay in maturity among hybrids (Table 3). The average delay in days to silk in the inoculated plots was 1.2 days. The effects of single crosses on double crosses are also shown in Table 3. The double cross Tx 28A was delayed in maturity by inoculation with MDMV; however, only one parent, TX 303 X Tx 325, was delayed by the effects of MDMV. Texas 40 also showed a significant difference between inoculated and uninoculated treatments as did the parental TX 303 X Tx 508. Tx 34 and Tx 30 showed no significant differences between inoculated and uninoculated plots, but both parents (Tx 203 X Tx 303 and Tx 601 X Tx 602; Tx 303 X 325 and Tx 173D X Tx 203, respectively) showed a significant difference between inoculated and control.

Plant Height

Differences in the effect of MDMV on plant height were observed among the inbred lines (Table 4). Average plant height of the inoculated inbreds was reduced 9.4 cm. Also, the mean square of interaction between treatment and inbreds showed a significant difference. Duncan's Multiple Range Test indicated that K 55, K 64, Tx 303, and Tx 325 were significantly reduced in plant height by MDMV, with Tx 303 reduced the most (27.8 cm). Plant height of Tx 585, Tx 601, and Tx 602 was not reduced, indicating a high degree of tolerance to the virus. Tx 127C also showed a high degree of tolerance against stunting.

Analysis of variance was highly significant for the effect of MDMV on plant height of hybrids tested (Table 5). The treatment effect was highly significant as was the mean square of the interaction between MDMV treatment and hybrids. Two double crosses, Tx 17W and Tx 40, and three single crosses, K 55 X K 64, Tx 303 X Tx 325, and Tx 303 X Tx 508, showed significant height reductions when inoculated with MDMV. A reduction in plant height of 14.5 cm for the three single crosses was significant while a reduction of 3.56 cm or less in single crosses was not significant. Degree of effect of single crosses on plant height of double-cross hybrids is also shown in Table 5. Tx 17 W and Tx 40 were reduced 18.6 cm or more in height compared to 5.2 cm for the other double crosses. Only one parental single cross, however, for Tx 17W and Tx 40 (K 55 X K 64 and Tx 303 X Tx 508, respectively) showed a significant reduction in plant height between virus-inoculated and control. Significant reduction in plant height occurred between inoculated and control for inbreds Tx 303 and Tx 325 (Table 4), but neither Tx 28A nor Tx 30 showed a reduction in height (Table 5). However, crosses involving Tx 303 generally were affected more by the virus than crosses involving the other inbred lines.

Ear Height

MDMV significantly reduced ear heights for the inoculatd inbred plots (Table 6). The average drop was 5.99 cm. Again, the inbred lines K 55, K 64, Tx 61M, Tx 441, Tx 303, and Tx 325 were affected significantly. Tx 508, Tx 585, and Tx 127C, however, all showed a high degree of tolerance.

Ear height of double crosses was not affected by MDMV when only one or two inbreds were susceptible, but if three susceptible inbreds were used, MDMV significantly reduced ear height (Table 7). Tx 17W showed a significant reduction, but only one of its parental single crosses, K 55 X K 64, was susceptible. Three of the parental inbreds for Tx 17W (K 55, K 64, and Tx 61M) all had significant reduction in ear height due to MDMV inoculation. The ear height of Tx 28A was significantly reduced, but neither of its parental single crosses was significantly reduced. Three of its parental inbred lines, however (Tx 441, Tx 303, and Tx 325), were affected significantly.

Disease ratings

Stunting ratings verified the results of the plant heights previously discussed. The virus reduced plant height of all inbred lines except Tx 585, Tx 601, and Tx 602 (Table 8). No inbred line was totally resistant to MDMV, but degree of tolerance varied, with Tx 601, Tx 602, Tx 585 and Tx 173D the most tolerant. Inbred lines K 55, K 64, Tx 508, Tx 61M, Tx 303, Tx 441, and Tx 325 were most affected by MDMV.

All the single crosses and Texas hybrids showed at least a mottling of the whorl, and all hybrid entries showed stunting at the boot stage (Table 9). K 55 X K 64, Tx 303 X Tx 508, and Tx 17W showed mottling of the entire plant. When the final plant height was measured, Tx 30 and Tx 601 X Tx 602 showed a slight increase in plant height of the inoculated rows. The difference, however, was not significant.

Yield

MDMV reduced yields of all susceptible inbred lines. Yields ranged from 31.83 hectoliters/hectare (hl/ha) for the control plots of Tx 61M to 5.08 hl/ha for the infected plots of TX 602 (Table 10). Uninoculated plots had an average yield of 11.82 hl/ha, and the uninoculated plots had a mean yield of 17.58 hl/ha for the inbreds. An average difference of 5.76 hl/ha per acre was obtained between inoculated and uninoculated plots. Yields of single- and double-cross hybrids ranged from 84.66 hl/ha for Tx 303 X Tx 508 to 29.11 hl/ha for Tx 601 X Tx 602 (Table 11). The mean yield of inoculated plots was 61.30 hl/ha, and for the uninoculated plots 67.70 hl/ha. Four single crosses yielded below the overall mean of the inoculated and uninoculated treatments. The five Texas double-cross hybrids yielded above the overall mean yield, except for inoculated plots of Tx 17W. The only entry that was significantly reduced in yield was Tx 303 X Tx 508 which had a difference of 27.45 hl/ha between the inoculated and uninoculated treatments.

Shelling Percent

None of the inbred lines were significantly reduced in shelling percent by the effect of MDMV (Table 12). A range for shelling percent from 84.2% for both the inoculated and the uninoculated plots of Tx 303 to 54.8% for the uninoculated plots of Tx 601 was observed. Inbred lines K 64, Tx 303, and Tx 601 either were not affected or were increased in shelling percent for the inoculated plots, but not significantly. MDMV did not significantly lower the shelling percentages of the hybrids (Table 13). A range from 87.43% for the uninoculated plots Tx 303 X Tx 325 to 73.17% for the inoculated plots of K 55 X K 64 was obtained. The arc sin was used to make the analysis of variance, converting percentages to angles. Shelling percent of only one entry, K 55 X K 64, was significantly decreased by the effects of MDMV.

Test Weights

For the inbreds, test weight was not determined due to missing data caused by some plots producing insufficient shelled corn to perform the test. Maize dwarf mosaic virus did not significantly reduce the test weights of hybrids. A range of 75.70 kg/hl for the uninoculated plots of Tx 17W to 67.4 kg/hl for the uninoculated plot by Tx 127 X Tx 441 was obtained (Table 14). The test weights of Tx 28A and Tx 173D X Tx 203 were significantly increased by inoculation.

DISCUSSION

Data obtained in the tests indicated MDMV caused differences among hybrid entries for each characteristic considered. MDMV delayed maturity, reduced plant and ear heights, and reduced yields.

The effect of MDMV on susceptible inbred lines could be seen in the single crosses and double-cross hybrids by a significant difference between the inoculated vs. uninoculated groups. With the crosses among the resistant lines, no significant differences occurred. All the entries generally showed the same disease symptoms, to different degrees. Tx 601 and Tx 602 are sister lines selected from yellow Tuxpan, both having late maturity, which may explain their low yields. No consistent effect of the susceptible or tolerant single cross on the performance of the double-cross hybrid could be determined from this study. The effect of having one or two susceptible inbred lines in a double-cross hybrid did not generally affect the susceptibility of the hybrid. However, when three susceptible inbred lines were in a double-cross hybrid, MDMV affected the performance of the hybrid. Differences could not be seen on the effect of susceptible single crosses on the performance of the double-cross hybrid.

Maize dwarf mosaic virus causes substantial economic losses in corn production . At present, the main factor of control is the tolerance of the hybrids grown. The data from this study contributes to information needed to develop resistant or highly-tolerant hybrids available that are adapted to the growing areas of Texas.

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Table 1. Inbreds and hybrids test for effect of MDMV.

Hybrid	Single Cross	Inbred
Tx 30	Tx 303 X Tx 325	Tx 303
		Tx 325
	Tx 173D X Tx 203	Tx 173D
		Tx 203
Tx 28A	Tx 127C X Tx 441	Tx 127C
		Tx 441
	Tx 303 X Tx 325	Tx 303
		Tx 325
Tx 34	Tx 203 X Tx 303	Tx 203
		Tx 303
	Tx 601 X Tx 602	Tx 601
		Tx 602
Tx 40	Tx 127C X Tx 441	Tx 127C
		Tx 441
	Tx 303 X Tx 508	Tx 303
		Tx 508
Tx 17W	K 55 X K 64	K 55
		K 64
	Tx 61M X Tx 585	Tx 61M
		Tx 585

Table 2. Summary of mean days to silk for the plots inoculated with MDMV and the uninoculated plots for the inbred test.

Inbred Lines	Days to Silk* Inoculated	Uninoculated
K 55	77.3 g	74.1**
K 64	78.8 efg	75.7 h**
Tx 61M	79.8 def	79.2 def
Tx 585	78.3 efg	78.4 efg
Tx 127C	74.8 h	74.5 h
Tx 441	83.2 bc	77.9 de**
Tx 173D	79.3 def	78.2 efg
Tx 203	78.8 efg	78.0 fg
Tx 303	84.1 bc	79.3 def**
Tx 325	85.0 b	80.8 d**
Tx 508	83.0 c	79.7 def**
Tx 601	84.8 bc	84.2 bc
Tx 602	91.1 a	90.0 a

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significant difference between the inoculated and uninoculated treatments of the inbred lines.

Table 3. Summary of mean days to silk for the plots inoculated with MDMV and the uninoculated plots for the hybrid test.

Varieties	Days to Silk* Inoculated	Uninoculated
K 55 X K 64	69.7 nop	69.0 p
Tx 17W	69.3 op	69.6 op
Tx 61M X Tx 585	70.8 klmn	70.3 lmno
Tx 173D X Tx 203	72.0 ghij	70.8 klmn**
Tx 30	72.2 ghij	71.1 jklm
Tx 303 X Tx 325	77.3 c	75.6 d**
Tx 28A	72.6 gh	71.3 ijkl**
Tx 127C X Tx 441	72.7 fgh	71.7 hijk
Tx 40	71.4 ijkl	70 .0 mno**
Tx 303 X Tx 508	75.2 d	72.1 ghij**
Tx 203 X Tx 303	73.7 ef	72.3 ghi**
Tx 34	73.8 e	73.0 efg
Tx 601 X Tx 602	81.7	80.4 b**

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the single crosses or Texas hybrids.

Table 4. Summary of mean plant heights for the plots inoculated with MDMV and the uninoculated plots for the inbred test.

Inbred Lines	Plant Heights (Cm.)* Inoculated	Uninoculated
K 55	123.4 k	139.2 ij**
K 64	130.ijk	146.4 hi**
Tx 61M	155.9 fgh	165.1 efg
Tx 585	151.1 ghi	149.0 ghi
Tx 127C	149.8 ghi	149.9 ghi
Tx 441	188.2 cd	201.9 abc
Tx 173D	170.0 ef	177.5 de
Tx 203	162.8 fgh	169.3 ef
Tx 303	185.1 d	212.9 ab**
Tx 325	122.7 k	145.0 hi**
Tx 508	157.8 fgh	167.4 ef
Tx 601	215.1 a	212.9 ab
Tx 602	201.3 bc	200.7 bc

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the inbred lines.

Table 5. Summary of mean plant heights for the plots inoculated with MDMV and the uninoculated plots for the hybrid tests.

Varieties	Plant Height (Cm.)* Inoculated	Uninoculated
K 55 X K 64	189.2 k	206.2 j**
Tx 17W	211.7 j	232.1 ghi**
Tx 61M X Tx 585	223.6 j	230.0 hi
Tx 173D X Tx 203	228.9 hi	229.1 hi
Tx 30	248.2 cde	245.9 cdef
Tx 303 X Tx 325	231.1 hi	245.1 cdefg**
Tx 28A	250.6 bcd	261.8 ab
Tx 127C X Tx 441	235.0 efghi	235.4 efghi
Tx 40	237.4 efgh	255.3 bc**
Tx 303 X Tx 508	203.0	238.5 defgh**
Tx 203 X Tx 303	234.1 fghi	245.0 cdefg
Tx 34	266.7 a	273.5 a
Tx 601 X Tx 602	251.2 bcd	251.1 bcd

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the single crosses or Texas hybrids.

Table 6. Summary of mean ear heights for the plots inoculated with MDMV and the uninoculated plots for the inbred test.

Inbred Lines	Ear Height (Cm.)* Inoculated	Uninoculated
K 55	32.28 l	42.95 k**
K 64	38.71 kl	48.54 j**
Tx 61M	57.48 gh	65.74 ef**
Tx 585	62.59 de	65.61 ef
Tx 127C	51.08 ij	48.54 j
Tx 441	60.50 fgh	72.64 cd**
Tx 173D	60.73 fgf	61.98 fg
Tx 203	56.39 ghi	59.11 gh
Tx 303	57.56 gh	74.40 c**
Tx 325	42.32 kl	57.51 gh**
Tx 508	56.95 gh	55.70 hi
Tx 601	81.03 b	84.68 b
Tx 602	95.89 a	97.03 a

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the inbred lines.

Table 7. Summary of mean ear heights for the plots inoculatd with MDMV and the uninoculated plots for the hybrid test.

	Ear Height (Cm)*	
Varieties	Inoculated	Uninoculated
K 55 X K 64	65.91 o	79.86 n**
Tx 17W	84.46 mn	94.03 jkl**
Tx 61M X Tx 585	93.68 jkl	37.02 jkl
Tx 173D X Tx 203	101.27 hi	99.11 ij
Tx 30	108.53 efg	112.52 cdef
Tx 303 X Tx 325	92.00 kl	98.48 ijk
Tx 28A	106.63 fgh	114.25 cde**
Tx 127C X Tx 441	90.68 lm	87.10 lm
Tx 127C X Tx 441	90.68 lm	87.10 lm
Tx 40	109.47 defg	116.15 bcd
Tx 303 X Tx 508	84.10 mn	108.07 ifg**
Tx 203 X Tx 303	99.11 ij	104.67 ghi
Tx 34	119.20 abc	123.04 ab
Tx 601 X Tx 602	123.55 a	124.16 a

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the single crosses or Texas hybrids.

Table 8. Summary of MDMV ratings at boot stage with only inoculatd plots rated for the inbred test.

Inbred Lines	Virus Rating* 1-5	Stunting Rating** 1-5
K 55	4.0	2.7
K 64	5.0	2.0
Tx 61M	3.7	2.0
Tx 585	2.0	1.0
Tx 127C	2.3	2.0
Tx 441	2.3	2.7
Tx 173D	2.0	1.7
Tx 203	2.7	2.0
Tx 303	3.0	2.3
Tx 325	2.3	2.3
Tx 508	3.7	2.3
Tx 601	1.7	1.0
Tx 602	2.0	1.0

* 1 = No apparent infection of plant.
2 = Mottling in whorl of plant only.
3 = Mottling entire plant.
4 = Chlorosis of entire plant.
5 = Discoloration of plant other than chlorosis.
6 = Severe chlorosis, mottling or discoloration of plant.

** Stunting
1 = No apparent stunting of plant.
2 = Slight stunting of plant.
3 = Stunting of plant with reduced ear size.
4 = Stunting of plant with no ear present.
5 = Death of plant.

Table 9. Summary of virus ratings at boot stage on the hybrid test for inoculated split-plot only.

Varieties	Means at Boot Stage	
	Virus Rating*	Stunting**
K 55 X K 64	3.0	2.7
Tx 17W	2.7	2.0
Tx 61M X Tx 585	2.0	1.3
Tx 173D X Tx 203	2.0	2.0
Tx 30	2.0	2.3
Tx 303 X Tx 325	2.0	2.0
Tx 28A	2.0	2.3
Tx 127C X Tx 441	2.0	1.7
Tx 40	2.0	2.3
Tx 303 X Tx 508	3.0	3.0
Tx 203 X Tx 303	2.0	2.7
Tx 34	2.0	1.7
Tx 601 X Tx 602	2.0	1.3

* 1 = No apparent infection of plant.
2 = Mottling in whorl of plant only.
3 = Mottling entire plant.
4 = Chlorosis of entire plant.
5 = Discoloration of plant othr than chlorosis.
6 = Severe chlorosis, mottling or discoloration of plant.

** Stunting
1 = No apparent stunting of plant.
2 = Slight stunting of plant.
3 = Stunting of plant with reduced ear size.
4 = Stunting of plant with no ear present.
5 = Death of plant.

Table 10. Summary of mean yields in shelled bushels for the plots inoculated with MDMV and the uninoculated plots for the inbred test.

Inbred Lines	Yield (Hectoliters/Hectare)	
	Inoculated	Uninoculated
K 55	8.12 hijk	21.67 cd**
K 64	7.79 ijk	17.28 def**
Tx 61M	20.32 cde	31.83 a**
Tx 585	24.62 bc	23.71 bcd
Tx 127C	13.89 efghi	15.24 defg
Tx 441	7.11 jk	12.87 fghij
Tx 173D	16.94 def	24.04 bc**
Tx 203	11.17 fghijk	13.55 efghij
Tx 303	14.90 defgh	29.47 ab**
Tx 325	5.14 k	9.60 ghijk
Tx 508	5.43 k	11.17 fghijk
Tx 601	13.21 fghij	12.53 fghij
Tx 602	5.08 k	5.56 k

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments for the inbred test.

Table 11. Summary of mean yields for plots inoculated with MDMV and the uninoculated plots for the hybrid test.

	Yield (Hectoliters/Hectare)	
Varieties	Inoculated	Uninoculated
K 55 X K 64	51.81 gh	64.00 defgh
Tx 17W	59.93 defgh	75.52 abcd
Tx 61M X Tx 585	65.39 cdefg	67.05 bcdefg
Tx 173D X Tx 203	65.45 cdefg	73.20 abcde
Tx 30	68.38 bcdef	70.42 abcdef
Tx 303 X Tx 325	48.41 h	56.89 fgh
Tx 28A	71.81 abcdef	70.88 abcdef
Tx 127C X Tx 441	58.23 efgh	62.52
Tx 40	82.98 ab	80.24 abc
Tx 303 X Tx 508	57.21 efgh	84.66 a**
Tx 203 X Tx 303	71.02 abcdef	71.17 abcdef
Tx 34	66.73 cdefg	74.88 abcd
Tx 601 X Tx 602	30.13 i	29.11 i

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculatd treatments of the single crosses of Texas hybrids.

Table 12. Summary of mean shelling percent for the plots inoculated with MDMV and the uninoculated plots for the inbred test.

Inbred Lines	Shelling Percent*	
	Inoculated	Uninoculated
K 55	67.2 abcd	69.0 abcd
K 64	76.7 abc	75.9 abcd
Tx 61M	76.0 abc	78.3 abc
Tx 585	78.0 abc	80.5 ab
Tx 127C	72.1 abcd	75.1 abcd
Tx 441	59.3 cd	70.9 abcd
Tx 173D	74.5 abcd	76.7 abc
Tx 203	73.8 abcd	79.4 abc
Tx 303	84.2 a	84.2 a
Tx 325	61.9 bcd	75.0 abcd
Tx 508	59.0 cd	60.8 bcd
Tx 601	61.7 bcd	54.8 d
Tx 602	64.2 abcd	67.5 abcd

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

Table 13. Summary of mean shelling percents and test weights for the plots inoculated with MDMV and the uninoculated plots of the hybrid test.

Varieties	Shelling Percent* Inoculated	Shelling Percent* Uninoculated
K 55 X K 64	73.17 e	80.43 cd**
Tx 17W	82.70 abcd	82.90 abcd
Tx 61M X Tx 585	81.10 bcd	84.57 abc
Tx 173D X Tx 203	81.17 bcd	76.83 de
Tx 30	84.90 abc	83.20 abc
Tx 303 X Tx 325	85.90 ab	87.43 a
Tx 28A	84.20 abc	84.53 abc
Tx 127C X Tx 441	82.80 abcd	82.40 abcd
Tx 40	85.90 ab	82.80 abcd
Tx 303 X Tx 508	81.70 bcd	85.33 abc
Tx 203 X Tx 303	85.17 abc	85.27 abc
Tx 34	81.17 bcd	85.80 abc
Tx 601 X Tx 602	86.13 ab	84.30 abc

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the single crosses or Texas hybrids.

Table 14. Summary of mean test weights for the plots inoculated with MDMV and the uninoculated plots of the hybrid test.

Varieties	Test Weight (Kg/hl)* Inoculated	Uninoculated
K 55 X K 64	75.4 a	74.5 abc
Tx 17W	74.7 abc	75.7 a
Tx 61M X Tx 585	74.9 ab	75.4 a
Tx 173D X Tx 203	75.6 af	73.9 bcde**
Tx 30	72.7 efg	73.1 de
Tx 303 X Tx 325	71.1 hijk	70.5 ijk
Tx 28A	71.4 hij	70.2 k**
Tx 127C X Tx 441	68.0 l	67.4 l
Tx 40	70.3 jk	70.8 hijk
TX 303 X Tx 508	72.9 ef	72.0 fgh
Tx 203 X Tx 303	74.5 abc	74.5 abc
Tx 34	73.6 cde	74.9 ab**
Tx 601 X Tx 602	71.7 ghi	74.1 bcd**

* Duncan's Multiple Range Test - any two means having any one of the same letters are not significant.

** Indicates significance between the inoculated and uninoculated treatments of the single crosses or Texas hybrids.

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