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Pathogenic Interactions Between Sorghum Yellow Banding Virus and Other Viruses Infecting Sorghum

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Abstract

A pathogenic interaction between sorghum yellow banding virus (SYBV) and maize dwarf mosaic (MDMV-A) virus was proved. Inoculation of MDMV-A 3 days before inoculation with SYBV resulted in a more severe disease and the resultant disease symptoms were different from those caused by either virus alone. Both viruses were serologically detected in a treatment in which MDMV-A preceded SYBV. Inoculation with SYBV 3 days before inoculation with MDMV resulted in the multiplication of SYBV only. When SYBV was mixed in equal proportion to MDMV-A and then inoculated onto healthy sorghum plants, which are susceptible to SYBV, MDMV-A was the only virus that was serologically detected. SYBV infected root tissue revealed the presence of SYBV particles in the mitochondria and not in the nucleus. Maize dwarf mosaic strain O also produced a pathogenic synergistic interaction similar to that produced by MDMV-A and SYBV.

Introduction

Pathogenic interactions between viruses have been observed before in different crops, but not in sorghum. The only interactions known in cereals are those in corn lethal necrosis and wheat streak mosaic virus, barley stripe mosaic virus, and brome mosaic virus (2,3). Theu in 1991 reported a pathogenic interaction in sorghum between sorghum yellow banding virus and MDMV-A. A mathematical model also was developed for determining a pathogenic interaction. Other viruses which infect sorghum were not tested.

The previous synergistic disease was corn lethal necrosis caused by synergistic interaction of maize chlorotic mottle virus (MCMV) in combination with

either maize dwarf mosaic virus (MDMV) or wheat streak mosaic virus (WSMV) (2,3). Theu (1991) reported the first interaction of the viruses sorghum yellow banding virus and MDMV-A and proposed a mathematic model for identifying pathogenic interaction.

This experiment was designed to determine whether there are other viruses which interact with SYBV to produce a pathogenic effect and to determine a pathogenic interaction by measuring root lengths.

Materials and Methods

Maize leaf tissue of SYBV-infected Silver Queen variety of corn (*Zea mays*) was harvested and serologically tested for the presence of SYBV particles. Leaf material that was positive to SYBV antiserum only, was homogenized in 0.1 M potassium phosphate buffer pH 7.0 (1:3 w/v) in a Waring blender and homogenate was squeezed through four layers of cheesecloth. Silicon carbide (600 mesh) was added (1% w/v) and the sap inoculated onto healthy sorghum cultivar Hegari (6). Plant height of green tissue was recorded from day 0 to 17 after inoculation. The root length was also measured over the same period. ANOVA was conducted to determine if significant differences existed among treatments. A multiple regression analysis was conducted to determine any synergism and proportionate effects were calculated (4,6).

Results

Effects of plant heights and root lengths for the interaction between MDMV-A and SYBV infected plants were smaller than their corresponding proportionate effects values for either MDMV-A or SYBV alone. The proportionate effects values were even smaller than those values for M*S (Tables 1, 2). This observation was true for both root lengths and plant heights. The synergistic effect was observed on the 5th day after inoculation with SYBV-infected sap in

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Table 1. Proportionate effects for all treatments with reference to control, based on mean plant heights.

Day	Treatment						
	C	M	S	M+S	S+M	MS	M*S
1	1.00	0.91	0.94	0.91	0.92	0.91	0.86
5	1.00	0.51	0.72	0.52	0.73	0.53	0.37
9	1.00	0.85	0.73	0.87	0.75	0.44	0.62
12	1.00	0.58	0.67	0.60	0.69	0.25	0.39
17	1.00	0.56	0.63	0.53	0.60	0.00	0.35

C = Control, M = MDMV-A, S = SYBV; M+S = MDMV-A AND SYBV mixed sap applied at the same time; S+M = SYBV inoculated 3 days prior to inoculation with MDMV-A; MS = MDMV-A inoculated 3 days prior to inoculation with SYBV; M*S = Multiplication of Proportion for M by proportion for S.

Table 2. Proportionate effects for all treatments with reference to control, based on mean root lengths.

Day	Treatment						
	C	M	S	M+S	S+M	MS	M*S
1	1.00	0.92	0.95	0.91	0.92	0.91	0.87
5	1.00	0.80	0.85	0.52	0.73	0.53	0.68
9	1.00	0.85	0.74	0.87	0.75	0.44	0.63
12	1.00	0.58	0.69	0.60	0.69	0.25	0.40
17	1.00	0.57	0.69	0.53	0.60	0.00	0.39

C = Control, M = MDMV-A, S = SYBV; M+S = MDMV-A and SYBV mixed sap applied at the same time; S+M = SYBV inoculated 3 days prior to inoculation with MDMV-A; MS = MDMV-A inoculated 3 days prior to inoculation with SYBV; M*S = multiplication of proportion for M by proportion for S.

roots, while this was observed on day 9 when plant heights were used.

Proportionate effects values for the interaction between MDMV-A and SYBV and proportionate effects for the interaction between MDMV-O and SYBV were smaller than proportionate effect multiplication products of any of the three viruses (Table 3). Proportionate effects for all viruses (treatments 3, 4) were significantly different for the multiplication product (Table 3). There were no significant differences between proportionate effects for SCMV and SYBV and their multiplication product (Table 3).

Leaf sizes were reduced more in the interaction between MDMV-O and SYBV than in the interaction between MDMV-A and SYBV by 14 days after inoculation. Leaves that were infected by MDMV-A and SCMV were the same size and showed the same symptoms. SYBV-infected leaves were smaller than those infected by MDMV-O and showed different symptoms. Leaf symptoms from the plant with all viruses looked the same as those infected with MDMV-A alone and plant tissue was serologically positive to MDMV-A.

Table 3. Comparison of proportionate effects for the assumed interactions and their assumed additive multiplication values based on mean plant height.

Day	Treatment							
	1	2	3	4	5	6	7	8
1	1.07	1.12	1.18	1.35	1.10	1.30	1.01	1.06
3	1.23	1.17	1.05	0.32	0.86	0.86	0.57	0.60
6	1.17	1.17	0.60	0.08	0.52	0.45	0.59	0.26
9	0.26	0.78	0.93	0.18	0.53	0.53	0.65	0.78
12	0.74	0.76	0.40	0.02	0.24	0.25	0.26	0.65
15	0.09	0.11	0.27	0.01	0.18	0.08	0.09	0.28
18	0.00	0.09	0.03	0.01	0.18	0.07	0.00	0.04

1. = Maize dwarf mosaic virus sap inoculated 3 days before inoculating with SYBV - infected plant sap.
2. = Multiplication of proportionate effect for MDMV-A by SYBV.
3. = Maize dwarf mosaic virus sap inoculated 3 days before inoculating with MDMV-O, and finally inoculated with SYBV 3 days after inoculation with MDMV-O.
4. = Multiplication of proportionate effect for MDMV-A, SCMV, MDMV-O, and SYBV.
5. = SCMV-infected sap inoculated 3 days before inoculating with SYBV-infected sap.
6. = Multiplication product of proportionate effects for SCMV by SYBV.
7. = MDMV-O sap inoculated 3 days before inoculation with SYBV.
8. = Multiplication product of proportionate effects for MDMV-O by SYBV.

Serological reactions could not distinguish between SCMV, MDMV-A, and MDMV-O.

Discussion

The fact that the proportionate effect for the pathogenic interaction between sorghum yellow banding virus and maize dwarf mosaic virus (MS) is smaller than the product of multiplication between the proportionate effect of MDMV-A by SYBV (M*S) implies that the interaction has a pathogenic synergistic effect on plant height and root length in sorghum. This is derived from comparing the regression equation proportionate effects. The maximum value would be attained by multiplying the proportionate effects of the viruses believed to be interacting when they are acting in an additive manner. When the viruses are acting in a synergistic manner, their product of multiplication will be less than the maximum value attained in the additive effect.

The proportionate effects of MDMV-A interacting with SYBV and MDMV-O interacting with SYBV show the existence of a pathogenic synergistic interaction in that proportionate effect values for both virus combinations are smaller than those of their multiplication product.

Since there are differences in leaf sizes between the interaction in which MDMV-O is involved and the interaction between SYBV and MDMV-A, this difference could be attributed to strain specificity between MDMV-A and MDMV-O. MDMV-A and SCMV showed the same symptoms, probably because they are serologically related. The smallest leaf size was that of SYBV-infected plants, this shows that SYBV is not serologically related to any of the viruses tested in the interaction. The healthy control plant was the largest and had the most green tissue. All the viruses tested in this experiment produce chlorosis of the infected plants.

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