Effect of Interaction Between Two Viruses and *Rhizoctonia* on Pepper

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ABSTRACT

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An atypical strain of tobacco mosaic virus (designated TMV-P) isolated from pepper caused systemic infection of pepper cultivars with and without the L-gene for the local necrotic reaction. A typical isolate of TMV from tomato caused systemic symptoms on cultivars lacking the L-gene. Host range reactions indicated that TMV-P is probably synonymous with Samsun latent TMV. In mixed infections of TMV-P and pepper mottle virus (PeMV), the systemic movement of PeMV was increased in PeMV-tolerant Delray Bell peppers. Mixed infections with TMV-P did not cause a breakdown of resistance of Florida VR-2 peppers to potato virus Y or tobacco etch virus. Early Calwonder peppers infected with TMV-P and PeMV were more susceptible to Rhizoctonia damping-off. Mixed viral infections (TMV-P and PeMV) were no more effective than single infections in increasing pepper susceptibility to *Rhizoctonia*. However, in PeMV-tolerant Delray Bell, TMV-P and PeMV infections significantly increased susceptibility to *Rhizoctonia*, compared with single virus infections. TMV-Palone also increased susceptibility of Florida VR-2 to damping-off.

Additional key words: *Capsicum annuum*

Approximately 7,600 ha of bell peppers (*Capsicum annuum* L.) were grown in Florida during the 1977-1978 season, representing a farm value of $42.2 million (1). Viral diseases are a major constraint in pepper production, particularly in southern Florida where a large portion of the crop is grown. A virus complex endemic to that region contributes to annual yield reductions (14,15,17). The principal viruses making up the complex are tobacco etch virus (TEV), potato virus Y (PVY), and pepper mottle virus (PeMV). Tobacco mosaic (TMV) and cucumber mosaic viruses are rarely encountered. Frequently, two or more viruses can be isolated from individual plants collected from grower fields (15).

In recent years, virus resistant and tolerant pepper cultivars have been released and more are being developed with resistance to the major viruses (4,5). Field experiments with pepper breeding lines carrying resistance to TEV and PVY and tolerance to PeMV indicated that infection with an atypical strain of TMV increased the systemic movement of PeMV in PeMV-tolerant peppers. Further, it was noted that a PeMV-tolerant variety, when infected with TMV and PeMV simultaneously, was more susceptible to damping-off caused by *Rhizoctonia solani* Kühn than virus-free plants or plants infected with either virus alone.

This paper reports results of studies on the interaction between TMV and PeMV on the PeMV-tolerant pepper cultivar Delray Bell and the increased susceptibility of virus-infected peppers to Rhizoctonia damping-off.

MATERIALS AND METHODS

The atypical strain of TMV (TMV-P), PeMV, and *R. solani* were isolated from naturally infected peppers. In initial experiments, TMV-P was compared with a TMV isolate originating from tomato (TMV-70). TMV-P and TMV-70 reacted similarly when inoculated to Early Calwonder and Delray Bell. TMV-70 frequently caused seedling death when inoculated to Florida VR-2. Since the TMV-P isolate was involved in the initially observed interaction, only TMV-P was used in further studies.

Identity and recovery of all viruses were confirmed by immunodiffusion tests (11) or by host assays. The identity of TMV-P appears to coincide with a strain of TMV referred to by McKinney (9) and later described as Samsun latent strain (7). Our isolate, like the Samsun latent strain, failed to infect tomato, did not elicit local lesions when inoculated to pepper cultivars with the L-gene, and was seedborne in the pepper cultivars we studied. This seedborne nature has apparently contributed to distribution of

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this strain in other cultivars (6).

The viruses were maintained in the greenhouse by mechanical transfer in tobacco (*Nicotiana tabacum* L. 'Burley 21' or 'White Burley'). *R. solani* was maintained by periodic transfers on potato-dextrose agar (PDA) plates incubated at 22–25 C.

Seeds of Early Calwonder, Delray Bell, and Florida VR-2 peppers were surface-disinfested for 2 min in 0.5% NaOCl, rinsed in tap water, and planted in 12.5-cm-diameter plastic pots filled with steam-treated muck soil mixed with Jiffy Mix (4:1). Plants were thinned to five per pot.

Three weeks after seeding, Early Calwonder and Delray Bell plants were inoculated with TMV-P, or PeMV, or TMV-P and PeMV simultaneously. Florida VR-2 plants were inoculated with TMV-P.

For virus inoculations, infected tobacco leaves were triturated in 0.01 M phosphate buffer and the sap was rubbed on Carborundum-dusted leaves of the pepper plants. Two weeks after virus inoculation, peppers were inoculated with *R. solani*. Inoculum consisted of 4-mm-diameter mycelial disks from the margins of 48- to 72-hr-old cultures growing on PDA. One disk was placed at the base of each plant. Controls received disks of sterile PDA. After the inoculations, 40 cc of sterilized soil was added to each pot to cover the inoculum disks.

Experiments were conducted in a greenhouse at 23–29 C supplemented with 14 hr of Growlux and cool-white fluorescent light (9,000 lux) per day. Plants were watered daily and care was taken to keep the soil moist but not saturated. A complete liquid fertilizer was added to each pot weekly starting when the plants were 3 wk old. Each treatment was replicated seven to nine times and all tests were repeated.

Percent postemergence damping-off was recorded 1 and 2 wk after inoculation with *R. solani*. Data were subjected to analysis of variance, and means were separated by Duncan's multiple range test.

RESULTS

On Early Calwonder and Delray Bell, TMV-P induced systemic mosaic and plant stunting. PeMV caused similar symptoms on Early Calwonder and no symptoms on Delray Bell. Symptoms were more severe with mixed infections (TMV-P and PeMV), but plants did not die. On Florida VR-2, TMV-P induced mild systemic mosaic.

Because Delray Bell is only tolerant for PeMV, it was not surprising that addition of TMV-P enhanced systemic movement of PeMV. Florida VR-2, on the other hand, is immune to the ordinary strains of TEV and PVY, although susceptible to PeMV. Thus, when Florida VR-2 was inoculated with TMV-P plus PVY or TEV, only TMV-P was recovered, whereas both TMV-P and PeMV were recovered when this mixture was tested. When susceptible Early Calwonder was inoculated with the four viruses alone or combined, all viruses were recovered from the systemically infected plants.

Table 1. Effect of *Rhizoctonia solani* alone and combined with tobacco mosaic virus (atypical strain, TMV-P) and pepper mottle virus (PeMV) on damping-off in three pepper cultivars

Treatment	% Damping-off (wk after inoculation with *R. solani*)[a]					
	1[b]			2[b]		
	Early Calwonder	Delray Bell	Florida VR-2	Early Calwonder	Delray Bell	Florida VR-2
Control	0 c	0 c	0 c	0 c	0 c	0 c
TMV-P	0 c	0 c	0 c	0 c	0 c	0 c
PeMV	0 c	0 c	···	0 c	0 c	···
TMV-P, PeMV	0 c	0 c	···	0 c	0 c	···
Rhizoctonia	11 b	43 b	28 b	12 b	43 b	37 b
TMV-P, *Rhizoctonia*	55 a	51 b	72 a	59 a	53 b	76 c
PeMV, *Rhizoctonia*	59 a	51 b	···	66 a	51 b	···
TMV-P, PeMV, *Rhizoctonia*	57 a	77 a	···	64 a	77 a	···

[a] 3-wk-old plants were inoculated with the viruses; 2 wk later, plants were inoculated with *R. solani*.
[b] Data are averages for 35–45 plants in two experiments. Means in a column followed by the same letter do not differ significantly ($P = 0.05$) by Duncan's multiple range test.

The effect of virus infection on the susceptibility of three pepper cultivars to *R. solani* damping-off is shown in Table 1. Most damping-off occurred within 1 wk after inoculation of 5-wk-old plants with *R. solani*. Infection of Early Calwonder peppers with TMV-P, PeMV, or a combination of the two viruses increased the percentage of damping-off caused by *R. solani* (Table 1). Two weeks after inoculation with *R. solani*, 59, 66, and 64% of plants infected with TMV-P, PeMV, and TMV-P plus PeMV, respectively, had damped-off, compared with 12% for plants inoculated with *R. solani* alone. In Florida VR-2, infection of virus-free and TMV-P infected plants with *R. solani* resulted in 37 and 76% damping-off, respectively. Single virus infections did not significantly affect the amount of damping-off in PeMV-tolerant Delray Bell. Inoculation of virus-free plants and TMV-P- and PeMV-infected plants with *R. solani* resulted in 43, 53, and 51% damping-off, respectively. However, damping-off was significantly higher in plants infected with a combination of the two viruses before inoculation with *R. solani*.

DISCUSSION

Interactions between viral and fungal plant pathogens significantly influence disease severity in several crops (8). Root rot caused by *R. solani* has been reported to be more severe in white lupine infected with bean yellow mosaic virus (10). A virus disease in strawberries predisposes plants to Rhizoctonia root rot (13). Bateman (2) demonstrated that post-emergence damping-off caused by a *Rhizoctonia* species in cucumber was increased from 10–15% to 60–80% by cucumber mosaic virus infection. In our study, a similar increase in postemergence damping-off caused by *R. solani* was observed in Early Calwonder peppers infected with TMV and/or PeMV. Furthermore, Delray Bell peppers infected with both TMV and PeMV had more Rhizoctonia damping-off than did plants with single-virus-infection. This suggests that some cultivars may react differently to double virus infections that may weaken the plant more than single virus infections. This appeared to be true in this study since Early Calwonder did not react similarly to Delray Bell. One explanation is that Delray Bell appears to be less vigorous than Early Calwonder, thus more susceptible to Rhizoctonia damping-off in the no virus and mixed virus infection treatments.

Use of virus-tolerant cultivars to control disease is often mentioned as a potential way of selecting more virulent strains of a virus. Extensive field testing of breeding lines and advance progenies that led to the release of Delray Bell have so far failed to show any change in the level of tolerance to PeMV (16). Our results suggest that unrelated viruses such as TMV-P can also serve to reduce tolerance. Although TMV-P and other seedborne strains of TMV are probably rare in Florida peppers, they are of great concern to plant breeders (7). Infection with such isolates can lead to misidentification of suscepts during progeny screening and may also increase their susceptibility to other pathogens.

The nature of the increased susceptibility to *Rhizoctonia* in this study was not investigated. However, virus-infected plants were visibly weaker, with stunted growth compared with virus-free plants. Viruses can have considerable influence on host metabolic activities, and a number of factors may be involved in increasing the host's susceptibility to other pathogens (8). Bateman (2) suggested that increased movement of materials from the roots to the cotyledons infected with cucumber mosaic virus increased the susceptibility of cucumber seedlings to Rhizoctonia damping-off.

Others (3,12) have shown that increased exudations from underground parts of virus-infected plants increase the severity of disease caused by soilborne pathogens. Possibly the situation is similar in peppers infected with TMV and/or PeMV.

No information is presently available concerning the importance of virus-fungus interactions on peppers under field conditions. However, our findings indicate the potential for increased plant losses where viruses and soilborne pathogens are not controlled.

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LITERATURE CITED

1. Anonymous. 1978. Florida Agricultural Statistics, Vegetable Summary 1978. Fla. Dept. Agric. Consumer Serv., Tallahassee. 65 pp.
2. Bateman, D. F. 1961. Synergism between cucumber mosaic virus and Rhizoctonia in relation to Rhizoctonia damping-off of cucumber. (Abstr.) Phytopathology 51:574-575.
3. Beute, M. K., and Lockwood, J. L. 1968. Mechanism of increased root rot in virus-infected peas. Phytopathology 58:1643-1651.
4. Cook, A. A., Ozaki, H. Y., Zitter, T. A., and Blazquez, C. H. 1976. Florida VR-2, a bell pepper with resistance to three virus diseases. Fla. Agric. Exp. Stn. Circ. S-242. 6 pp.
5. Cook, A. A., Zitter, T. A., and Ozaki, H. Y. 1977. Delray Bell, a virus-resistant pepper for Florida. Fla. Agric. Exp. Stn. Circ. S-251. 5 pp.
6. Demski, J. W. 1977. Seed-borne tobacco mosaic virus in peppers. (Abstr.) Proc. Am. Phytopathol. Soc. 4:92-93.
7. Greenleaf, W. H., Cook, A. A., and Heyn, A. N. J. 1964. Resistance to tobacco mosaic virus in Capsicum, with reference to the Samsun latent strain. Phytopathology 54:1367-1371.
8. Matthews, R. E. F. 1970. Plant Virology. Academic Press, New York. 778 pp.
9. McKinney, H. H. 1952. Two strains of tobacco-mosaic virus, one of which is seed-borne in an etch-immune pungent pepper. Plant Dis. Rep. 36:184-187.
10. Patil, P. L. 1973. Interaction of fungal and virus infections in white lupine (*Lupinus albus* L.). Rev. Plant Pathol. 53:913.
11. Purcifull, D. E., Zitter, T. A., and Hiebert, E. 1975. Morphology, host range, and serological relationships of pepper mottle virus. Phytopathology 65:559-562.
12. Schroth, M. N., and Teakle, D. S. 1963. Influence of virus and fungus lesions on plant exudations and chlamydospore germination of *Fusarium solani* f. *phaseoli*. Phytopathology 53:610-612.
13. Skiles, R. L. 1953. The strawberry viruses in Minnesota. Diss. Abstr. 13:149.
14. Zitter, T. A. 1971. Virus diseases of pepper in south Florida. Proc. Fla. State Hortic. Soc. 84:177-183.
15. Zitter, T. A. 1973. Further pepper virus identification and distribution studies in Florida. Plant Dis. Rep. 57:991-994.
16. Zitter, T. A. 1975. Transmission of pepper mottle virus from susceptible and resistant pepper cultivars. Phytopathology 65:110-114.
17. Zitter, T. A., and Ozaki, H. Y. 1973. Reaction of susceptible and tolerant pepper varieties to the pepper virus complex in south Florida. Proc. Fla. State Hortic. Soc. 86:146-152.