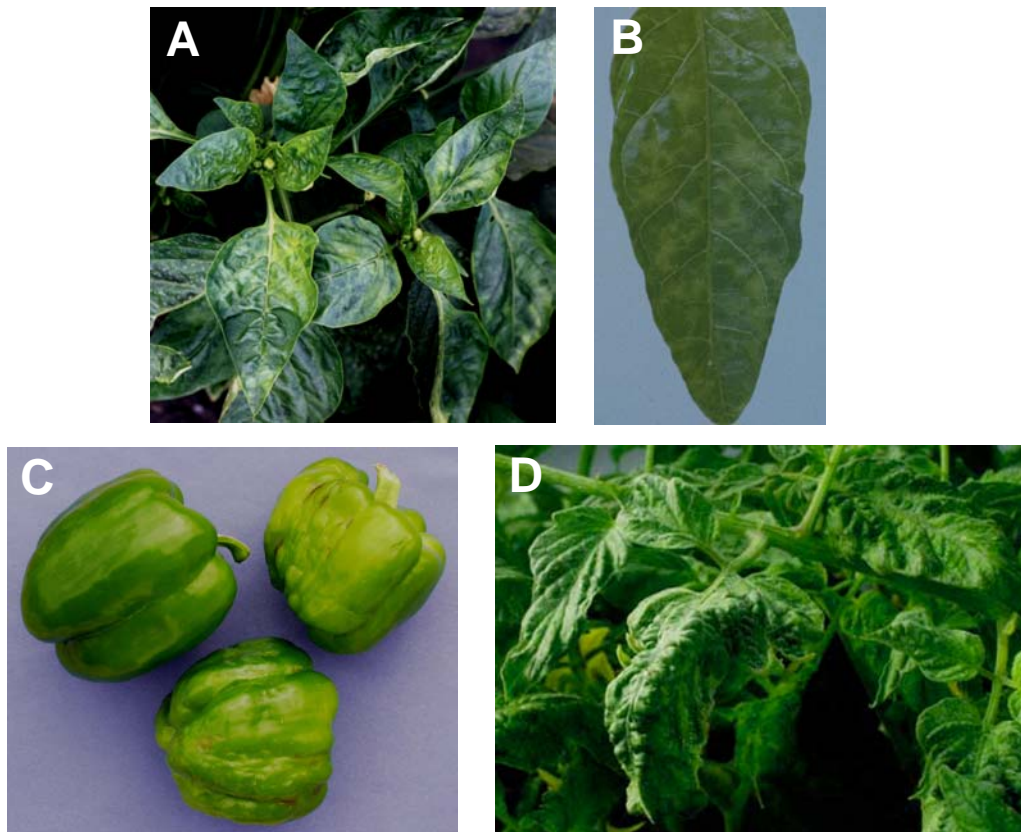


## Peppers, Tomatoes, and Tobamoviruses<sup>1</sup>

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**INTRODUCTION:** At least four different tobamoviruses naturally infect and cause disease in peppers (*Capsicum* spp.). These include *Tobacco mosaic virus* (TMV), *Tomato mosaic virus* (ToMV), *Tobacco mild green mosaic virus* (TMGMV), and *Pepper mild mottle virus* (PMMoV) (Wetter 1984). TMV and ToMV can also infect and cause disease in tomato (*Lycopersicon esculentum* Mill.). These viruses can cause serious economic losses in both field and greenhouse-grown crops. All four tobamoviruses have been diagnosed in various plants in Florida.



**Fig. 1.** Symptoms of *Pepper mild mottle virus* in pepper leaves (A and B), and fruit (C – fruit from an uninfected plant is at the upper left). Symptoms of a tobamovirus infecting tomato (D) (Photography credit: A, C and D: Scott Atkins; B: Jeff Lotz)

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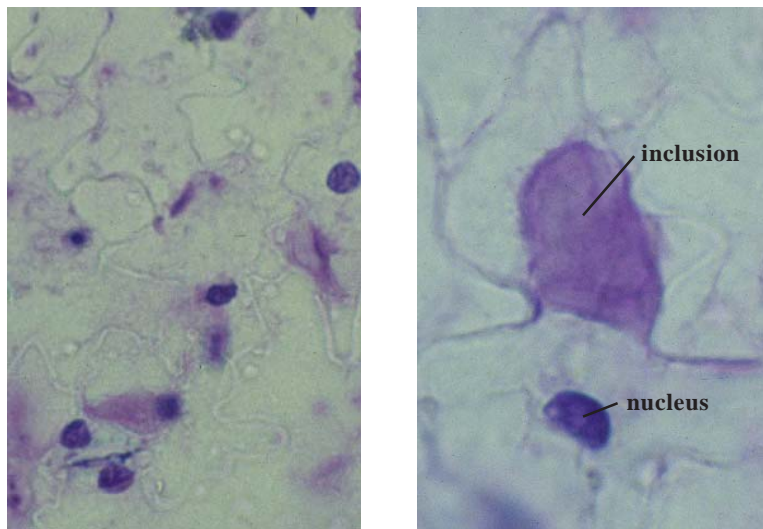
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**PATHOGENS:** Tobamoviruses are rigid rod-shaped plant viruses that are very easily transmitted to healthy plants by mechanical inoculation and contact between plants. They are exceptionally stable viruses that are known to survive for years in plant debris in the soil and for weeks or months on greenhouse structures, pots and horticultural tools. They persist on clothing and, most importantly, on workers' hands. TMV is known to survive in cigarettes and cigars made from infected tobacco leaves and to be transmitted from the hands of a smoker to susceptible plants. In addition, TMV, ToMV and PMMoV can be transmitted on the surface of seeds harvested from infected plants. There is no known insect vector for these viruses. The predominant method of spreading a tobamovirus is the handling of plants. This makes human beings the main "vector" of these viruses.

**SYMPTOMS:** Symptoms consist of various degrees of mottling, chlorosis, curling, distortion and dwarfing of leaves, flowers, fruits and entire plants (Fig. 1 A, B and D). In some cases necrotic areas develop on leaves and fruit (Fig. 1 C). Symptoms are most easily seen on new growth and are usually more pronounced on plants infected when young than on those infected when mature.

**DISTRIBUTION:** These four tobamoviruses are found worldwide.

**DETECTION AND DIAGNOSIS:** The structure of tobamovirus particles makes them easy to detect in the electron microscope using leaf dips. In addition, the virus makes such large numbers of particles in its hosts that virus inclusion bodies are easily seen in the light microscope when epidermal strips are stained in Azure A and heated (Fig. 2). The necessity for heat differentiates tobamovirus inclusions from other plant virus inclusions that will stain in Azure A without heat (Christie and Edwardson 1994).



**Fig. 2.** Inclusions of *Pepper mild mottle virus* in a pepper leaf cell stained in Azure A with heat. (Photography credit: Carlye Baker)

These two techniques will only indicate if the infection is caused by a tobamovirus. This may be all that is needed since control measures are the same for all tobamovirus. To identify the specific tobamovirus other techniques, such as ELISA, are necessary. Virus-specific antisera are available commercially for three of the four viruses (TMV, ToMV, and PMMoV). The viruses can also be separated by inoculation to indicator plants.

**CONTROL:** The best defense against tobamoviruses is **avoidance**. The first line of defense is to grow plants with resistance to tobamoviruses. When that is not possible the second best defense is to grow plants only from certified virus-free seed. Growers of specialty peppers or tomatoes may not be able to obtain seed certified to be virus free. These growers can protect their crop by treating seeds before planting as follows:

1. Mix 2 pints of 5.25% sodium hypochlorite solution (household bleach, *e.g.*, Clorox®) in 8 pints of water. (Prepare fresh bleach solution for each batch of seed.)
2. Wash one pound of cleaned, fresh or dry, seed in one gallon of the mixture for 40 minutes. Provide gentle and continuous agitation.
3. Remove seed promptly and spread on paper to air dry. Place dry seed in a clean container. (Do not recontaminate the seed by placing in used containers.) (Averre and Gooding 2000.)

Because seed treatment can reduce germination, it is wise to treat a small batch of the seed before doing the whole lot. Research has also shown that prewashing seed with a surfactant such as trisodium phosphate (one ounce of TSP in two quarts of water) for 15 minutes can enhance the treatment (Gooding 1957).

If resistant plants or certified virus-free seed is not available, and if seed treatment is not possible, then the next best defense is to handle the plants sparingly. In general, the less the plants are handled the less likely they will become infected with a tobamovirus. Studies on the seed transmission of tobamoviruses have indicated that virus particles on the external seed coat are responsible for the later infection of seedlings. These virus particles move from the seed coat onto the roots and shoots of the plant as it germinates and grows. These studies also show that wounding of the plant is necessary for the virus particles to enter the plant tissue (Demski 1981). Wounding can occur with transplanting and any other time the plants are handled.

In addition to using certified or treated seeds, follow rigid sanitation procedures. All workers that handle the plants, especially smokers, should wash their hands, fingernails, and forearms thoroughly with 70% alcohol or strong soap before handling plants. The outer garments used by workers should be washed regularly with detergent and hot water.

If suspicious symptoms appear, isolate the plant or plants and send a sample to a plant disease diagnostic lab. If a tobamovirus is diagnosed, carefully remove the infected plants and thoroughly clean all equipment and surfaces involved with a solution of sodium hypochlorite (0.26% NaOCl – household bleach such as Clorox® with or without 0.01% dishwashing liquid). One study (Pategas *et al* 1989) indicated that treating pruning shears for 10 minutes was necessary to inactivate ToMV and that several (not just one) treatments of exposed surfaces were required to remove the threat of reinfection.

If the infection is found in a field, carefully remove the infected plants only if additional contact to adjacent healthy plants can be avoided. Remove symptomless plants on either side of the infected plant or plants since the virus may have already spread to those plants by contact with the infected plants. If the infected plants are not removed, stake, tie or harvest the infected field last to avoid further spread. Discard stakes from infected fields or soak them in 3% trisodium phosphate before reuse (Adkins *et al* 2001). Do not plant susceptible plants in an infected field for at least two years.

**SUMMARY:** In Florida, the production of pepper and tomato transplants and the production of fresh market peppers and tomatoes are multi-million dollar industries. Because yield losses to tobamovirus infection can be anywhere from 20-100%, it is very important to the Florida pepper and tomato industries to have and maintain plants free of tobamovirus infections both in the greenhouse and in the field. Tobamoviruses are very easy to spread but exceedingly difficult to eliminate. Avoidance is the best option. Control of these diseases is literally and figuratively in the hands of the growers themselves.

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