



VIRAL DISEASES OF TOMATO IN ILLINOIS

Viral diseases are the most common diseases of tomatoes in Illinois. Almost all tomato plantings have at least some virus-infected plants before harvest is complete. These diseases are often overlooked, however, because the symptoms may be inconspicuous or the damage attributed to some other cause.

Losses from viral diseases depend largely on when plants become infected, the variety, the virulence of the virus strain, and the environment. Infection by severe strains before or during transplanting may reduce yield as much as 90 percent (40 percent with a mild strain). In the greenhouse, plants infected before any fruits are set may yield 20 percent less than healthy plants. Yields of plants infected after fruit set may be reduced 4 or 5 percent in field-grown, virus-infected tomatoes. The monetary loss to the grower comes primarily from reduced number and size and increased distortion of fruit in the first three clusters, because they usually bring higher prices than fruit produced later. Every effort should be made to prevent virus infection or to delay its appearance as long as possible.



Figure 1. Common tobacco (tomato) mosaic.

SYMPTOMS

COMMON TOBACCO (TOMATO) MOSAIC. Light and dark green mottled areas, which are usually somewhat raised and puckered, develop in the leaves (Figure 1). The young leaves at the tips of the growing shoots tend to bunch and unfold unevenly. Plants infected when young are commonly stunted and have a yellowish cast. Leaflets on young plants growing under glass or plastic are often long, pointed, and narrow. Symptoms appear about 10 days after the plants become infected.

Stem streaking can be caused by one or more virus strains. The streaks are dark and longitudinal and may be short or long. Affected stems are brittle, easily broken, and contain brown areas in the pith and cortex.

Ordinarily the fruit does not show any marked disfiguration. Both the number and size of the fruit are reduced, however, resulting in only about half the yield of healthy plants. The earlier plants become infected, the greater the loss. Occasionally fruit mottling, bronzing, and internal browning (see page 2) develop. Distinct mottling is associated with severe strains of the virus. The symptoms may be masked in hot weather, but the plants remain infected. The symptoms reappear when cool, cloudy weather returns.

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Aucuba or yellow mosaic. Leaves develop a striking, bright yellow mottling (Figure 2a). The foliage may be curled downward, distorted or crinkled, and dwarfed. Fruit may be mottled, light and dark green when immature, and yellow and red when ripe, and are generally not acceptable for marketing (Figure 2b).



Figure 2a. Aucuba or yellow mosaic.

Over 150 strains of the common tobacco mosaic virus (TMV) are recognized. A few of these strains include the common (ordinary, green, or vulgare) strain, severe (aucuba or yellow) strain, streak strain, ribgrass or plantain strain, and rosette strain. A new method of classifying strains of TMV is based on the ability of the virus to overcome specific tomato genes for TMV resistance. For example, strain 0 is not able to overcome any resistance genes; strain 1 is able to overcome resistance gene TM-1; strain 2 is able to overcome resistance gene TM-1 and TM-2; and strain 2² (=2^a) is able to overcome resistance to TM-2² (=TM-2^a). A number of strains of TMV may be found in a state at any one time.



Figure 2b. Aucuba mosaic affecting the fruit.

Cucumber mosaic. Plants infected when young are yellowed, bushy, and stunted. The leaves may be mildly mottled, suggestive of common mosaic. The most pronounced symptom is the extremely distorted, shoestring-like leaves (Figure 3). Sometimes the leaves are so distorted that little remains but the midrib. This symptom in its extreme form is characteristic only of certain strains of the virus. Severely affected plants produce few fruit, which are usually smaller than the fruit from healthy plants, and they may be mottled and “warty.” In tomatoes, cucumber mosaic is much less prevalent than tobacco (tomato) mosaic.

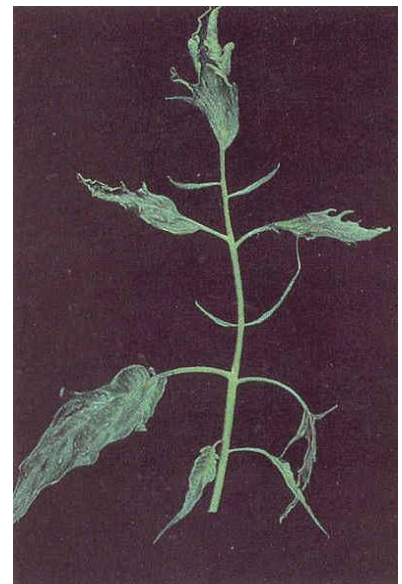


Figure 3. Cucumber mosaic or “shoestring.”

Internal browning. This disease of tomato fruits is caused by late infection of plants by one or more strains of the common tobacco mosaic virus (TMV). The symptoms are often indistinguishable from those of gray-wall or blotchy-ripening, both of which are noninfectious.

When infected fruit are cross sectioned approximately 1/2 inch below the stem, the tissues close to the vascular bundles appear brown and are often corky. In severely diseased fruit, much of the fleshy wall tissue is brown. The discoloration extends into the inner walls and sometimes into the central column. These symptoms are most common in fruit that are well developed. Usually only fruit at one stage of maturity on a plant are severely affected. These fruit are those that are most rapidly growing when newly introduced virus replicates and is translocated to the fruit.

External symptoms vary with maturity of the fruit. The internal gray or grayish brown discoloration is faintly visible through the translucent skins of larger green fruit which are severely affected. This discoloration appears in the shoulder of the fruit as blotches or as broad streaks within well-defined margins. In ripe red fruit, the symptoms range from a slight yellowing at the shoulder to large, yellow areas that blend into the normal red. When browning is severe, the brown tissue of the wall may be visible through the skin. Sunken blotches and broad brown streaks form in the shoulder of mature green to ripe fruit. Symptoms may be limited to one or several fruit clusters on a plant. Earlier or later pickings may not be affected.

Sources and Transmission

Common tobacco mosaic virus (TMV) and cucumber mosaic virus (CMV) infect a wide variety of crop plants and weeds (Tables 1 and 2). These viruses remain virulent at least until the infected plants die. Such weeds as horsenettle, plantains, and chickweed are important virus reservoirs and may serve as sources of early infection in the greenhouse, seedbed, and field.

A number of species of aphids are capable of transmitting CMV from overwintering weed hosts to tomatoes. Insects are not important in the transmission of TMV.

Common tobacco mosaic virus. TMV is extremely infectious, being spread easily by persons touching a healthy tomato plant after touching an infected plant. Plant-to-plant contact during pulling or pricking-out of young seedlings, transplanting, cultivating, weeding, and wind-whipping of the leaves are other very common ways of spreading the virus. Hand operations, such as pruning, tying, pollinating, spraying, watering, and picking fruit are also important in transmission, especially in greenhouse-grown tomatoes. This secondary spread, very common in greenhouses about 10 weeks after planting, can occur very rapidly once inoculum is available from plants infected in the seedling stage. The time from mechanical inoculation of leaves to the development of symptoms can be as short as a week and newly infected plants are a ready source of virus for additional spread even before symptoms are evident. In a greenhouse, earliest symptoms commonly occur near entrances, sources of water, and other service areas. The most rapid spread occurs along rows due to mechanical spread by workers.

The timing of infection is important in the development of internal browning (or bronzing) of the fruit. For symptoms to develop, the fruit must be formed before inoculation. Symptoms appear on some fruit within two to three weeks after inoculation.

The virus has been transmitted from one plant to another when infected sap was diluted a million times with water. The virus withstands heating in water or in fresh tissue to 200°F for 10 minutes. In dried tissue TMV will withstand dry heat up to 300°F for 20 minutes.

TMV has remained infective in dried leaves and stems for over 50 years, longer than any known virus. It may persist at least 12 months in moist heavy soils, probably in the debris from the preceding crop, and 24 months or longer in dry soils. Common tobacco mosaic virus has been known to remain active in root refuse for 6 months. The time from root inoculation to the appearance of symptoms on tomato foliage is approximately 3 to 5 weeks for seedlings and 4 to 13 weeks for plants inoculated at the 5 to 7 leaf stage. Upward movement of virus in a plant is much slower than downward movement. It may remain virulent in contaminated clothing, trellis materials, greenhouse structures, and boards containing infected tomato sap for as long as 3 years if kept in the dark. Normally, however, TMV persists in an active state for only

1 to 2 weeks when exposed to light. In untreated soil, 10 percent of the transplants set out within 3 to 10 days after the crop is removed may become infected. After 30 days, there is usually little infection. This source of infection is believed important only for greenhouse crops, especially where one crop of tomatoes follows another almost immediately.

Up to 50 percent of seed from infected tomato fruit may carry TMV. The virus is located in and on the seed coat and in a small percentage of endosperms of the seed. The virus is not located in the embryo. Seed transmission is common when seeds are planted immediately after harvest. Seedlings grown from seeds that are fermented, washed, dried, treated with hot water, and stored for 8 months or longer before planting are free of virus.

The use of tobacco products by persons handling plants may result in TMV infection, since this virus is often found in tobacco tissue.

Aucuba Mosaic Virus. This strain of TMV is introduced and spread among tomato plants in much the same way as the common tobacco mosaic virus, except that the aucuba strain is not quite so easily transmitted by contact. It is not spread by insects.

Cucumber Mosaic Virus. This virus, unlike TMV, is not easily transmitted to tomato by persons brushing against or handling plants. Also, it does not persist in the soil or crop refuse and does not remain active for any great length of time on the hands or clothing. Most of the infection in tomatoes occurs through transmission by insects, particularly aphids. CMV is usually introduced to cultivated tomato and other plantings by aphids after they feed on reservoir wild hosts (see Table 2).

Tobacco Etch Virus. This virus is becoming more common in tomatoes. Tomato transplants may be infected when they are small. The virus is often transmitted by aphids. Plants may also be infected with a combination of viruses. The tobacco etch virus is not seedborne.

Combinations of Viruses. Symptoms caused by infection by more than one virus may be much more severe than either virus might cause alone.

CONTROL

1. Before planting, during, and after the growing season, eradicate all perennial and biennial weeds from the seedbed, garden, field, greenhouse, and the area surrounding the greenhouse. It is especially important to get rid of ground-cherry, horsenettle, plantains, Jimson weed, and nightshades.
2. Do **not** grow tomatoes out of doors next to crops such as potato, pepper, vine crops, tobacco, and related plants that are likely to carry viruses capable of infecting tomatoes. If possible, do not grow tomato plants in seedbeds or sections of greenhouses where flowers are produced.
3. Do **not** plant vine crops (such as cucumbers, melons, squashes, pumpkins, gourds, and gherkins), celery, potatoes, or peppers next to greenhouses in which tomatoes are to be grown as a fall or spring crop. Otherwise, virus-carrying aphids may move into the greenhouse as the plants mature. An area at least 10 feet wide immediately surrounding a greenhouse should be kept completely free of all vegetation.

4. Set out certified, virus-free transplants, or start with virus-free seed. Seed should be fermented, washed, dried, and treated with hot water (exactly 122°F for 25 minutes) and should be at least 8 months old before planting.
5. Before seedlings are pricked-out and transplanted, spray the plants to runoff with skim milk or with milk reconstituted from a powdered or condensed form. In addition, frequently dip hands in a milk solution when working with plants (but do **not** dip the seedlings into a milk solution). This treatment, like the trisodium orthophosphate solution described in the following section inhibits or inactivates the viruses.
6. If you use tobacco in any form or have been working with plants of any kind, wash your hands in a solution of trisodium orthophosphate (1 teaspoon dissolved in 1 quart of water) before handling tomato plants. This treatment inhibits or inactivates the viruses. Insist that others who may be handling tomato seedlings, transplants, or older plants in any way do likewise. Avoid the use of tobacco in any form while working with plants.

The trisodium orthophosphate solution is also useful for cleaning tools, containers, and equipment used when working with tomatoes. Clothing that brushes against plants should be laundered frequently in soapy water. When possible, reduce the number of service alleys in greenhouses and spray rows in fields.

7. Destroy infected plants found at pulling or transplanting time. The spread of mosaic in the greenhouse may be delayed by roguing virus-affected plants 2 weeks after transplanting and again a week later. Do **not** touch healthy plants while roguing diseased plants.
8. Keep visitors out of greenhouse sections containing virus-free plants. Put up signs warning people not to smoke or chew tobacco and not to touch the plants.
9. In greenhouses where TMV is most serious, artificial inoculation of tomato plants in the seedling stage with a “weak” or avirulent strain of the virus has been successfully used in Europe since the early 1970s. The weak strain protects or strongly inhibits infection by a second more virulent strain of the virus. Commercial production of a weak TMV isolate (MII-16) has enabled growers to increase yields up to 14 percent. Unfortunately weak isolates can become more virulent and this form of “cross protection” is now on the decrease in Europe.
10. Steam-sterilize the soil before planting tomatoes in the greenhouse. Sterilizing is especially important in the winter, when plants for the spring crop are transplanted within a few days after the fall greenhouse crop is removed. Also steam-sterilize all containers in which plants are to be grown. This is important since TMV may survive in old root tissue for long periods of time. Formaldehyde is not effective against viruses.
11. Fumigate, spray, or dust greenhouse-grown tomatoes with insecticides at frequent intervals to control aphids and other insects. Follow current suggestions given in Circular 1354, Illinois Homeowner’s Guide to Pest Management. This practice is most valuable if begun in the fall, before freezing weather forces the insects to move into the greenhouse. Aphid control is also important in preventing the spread of virus diseases after they have become established on a few plants in the greenhouse. Aphids multiply rapidly. It may take only a single aphid feeding for only

a few seconds on a healthy plant to infect it with a virus. Once infected, the plants cannot be cured.

12. A few greenhouse hybrid tomatoes resistant to several strains of the common tobacco mosaic virus are available. For a listing of resistant varieties read Circular 1373 Midwest Vegetable Production Guide for Commercial Growers (revised annually).

For information on how to obtain the publications mentioned above, contact your nearest Extension adviser or ITCS, University of Illinois P345, 1917 S. Wright St., Champaign, IL 61820.

Viral Diseases

Table 1. A partial list of plants infected by Common Tobacco Mosaic Virus (TMV)

amaranthus	figwart	New Zealand spinach
apple	fleabane, daisy	nierembergia
apple-of-Peru	foxglove	nightshades
beans	galinsoga	orchids
bedstraw	gerneria	pear
beet, garden	gilia	pennyroyal, American
beggarticks	gloxinia	penstemon
bindweed	goosefoot (lambsquarters)	peppers
black nightshade	grapevine	peppergrass
browallia	groundcherry	petunia
buckwheat	gypsophila	phacelias
bugleweed	hawkweed	phlox
butter-and-eggs	hedgemustard	physalis spp.
calendula	helianthus	Pigweed
California bluebell	henbane	plantains
California rose	henbits	pokeweed
campion, evening	horsenettle	polygonums
cape-gooseberry	horseweed	potato
cape-marigold	hounds tongue	proboscisflower
carpetweed	husk tomato	purslane
carrot	iberis	reseda
celandine	Indian tobacco	ribgrass
celosia	Jerusalem-cherry	salpiglossis
centaurea	Jimson weed	scabiosa
chickweed	Kenilworth ivy	sheep sorrel
China-aster	knotweed	shepherds-purse
Chinese forget-me-not	kochia	smartweed
Chinese lanternplant	ladysthumb	snapdragon
chrysanthemum	larkspur	solanums
cleome	lobelia	speedwell
cowpea	lunaria	spinach
cranesbill, Carolina	lycium	sugar beet
cress	malcolmia	sunflowers
currants, red and black	marigold, French	tasselflower
delphiniums	marshgrass	tobaccos
dock	mesembryanthemum	turnip
dracocephalum	Mexican-tea	verbena, white
eggplant	morning-glory	water-horehound, stalked
elder	mouse-eared chickweed	wisteria
euphorbia	mullein	zinnia
false jerusalem-cherry	mustards	

Viral Diseases

Table 2. A partial list of plants infected by Cucumber Mosaic Virus (CMV)

alfalfa	cucumber, wild	lupine, blue	pumpkins
amaranth, green	cucumis spp.	lychnis	ragweeds
amaryllis	daffodils	marigold, African	rhubarb
anchusa	dahlia	marigold, French	rye
apple-of-Peru	dames-violet	martynia	safflower
balsam-apple	daphne	melothria	salvia
balsam-apple, wild	datura, sacred	mesembryanthemum	scabiosa
balsam-pear	dayflower, Asiatic	milkweed	shellflower
bean, snap	dayflower, creeping	mints	shepherd's-purse
beet	delphiniums	mock-cucumber	snakeweed
belladonna	dill	morning-glory	snapdragon
bindweed	eggplant	motherwort, common	solanums
bryonopsis	false Jerusalem-cherry	muskmelon	sorghums
bryony	fennel	nasturtium	sowthistle
buddleia	flowering spurge	nettles	spiderflower
buckwheat	gentian sage	New Zealand spinach	spinach
bur-cucumber	geranium, florists'	nightshade, black	squashes
burdock	gherkin, West Indian	nightshade, deadly	stock
cabbage	gilia	onion	sugar beet
calendula	gladiolus	pansy	sunflowers
cape-gooseberry	gomphrena	parsley	sweet potato
cardinalflower	goosefoot	parsnip	tasselflower
carpetweed	(lambsquarters)	passionfruit	teasel
carrot	gourds	pea	teosinte
catnip	Greek valerian	penstemon	tobaccos
celery	ground cherry	peppers	tulip
charlock	heliotrope, garden	periwinkle (myrtle)	turnip
chayote	henbane	petunias	vegetable-marrow
chickweed, common	henbits	phacelia	vegetable-sponge
china-aster	hop	phlox	violas
Chinese lanternplant	horsenettle	physalis spp.	violets
chrysanthemums	hounds tongue	physedra	wandering jew
clover, crimson	husk tomato	phytolacca	watercress
cockscomb	hyacinth	pigweeds	watermelon
columbine	impatiens	pineapple	watermelon, Chinese
coneflower	Jimson weed	pokeweed	wheat
corn	kedrostis	polyanthus	white cockle
cowpea	larkspur	potato	wild bluebell
cowslip	lettuce	primroses	wild cucumber
cranesbill, Carolina	lilies	privet	zinnias
crown-of-thorns	lima bean	proboscisflower	
cucumber	lobelia, edging		