



MOSAIC DISEASES OF CUCURBITS

Many viruses affect vine crops or cucurbits and cause mosaic diseases. The most important of these viruses in the Midwest are cucumber mosaic virus (CMV), squash mosaic virus (SqMV), watermelon mosaic virus (WMV), and tobacco ringspot virus (TRSV). The viruses differ in the range of host plants they infect, how they survive between crops, and the ways in which they are transmitted. Since control programs are based on this information, it is important that the virus or viruses involved be identified. This virus complex has caused growers in certain areas to stop growing these crops.



Figure 1. Cucumber mosaic virus (CMV) affecting cucumber leaf (Courtesy British Ministry of Agriculture).

The symptoms caused by different cucurbit viruses are commonly very similar. It is impossible to identify these viruses with certainty based on symptoms alone. Usually special laboratory and greenhouse investigations are required to correctly identify a cucurbit virus.

CUCUMBER MOSAIC VIRUS (CMV)

Cucumber mosaic is the most destructive and widespread disease of cucumber and muskmelons worldwide. All vine crops as well as a wide range of annual, biennial, and perennial crop and weed plants in about 40 families are attacked (Table 1). The virus is made up of many and varied strains that differ in a number of aspects including host range, symptoms, and means of transmission. The strains of CMV are differentiated on the basis of symptoms on indicator host plants.

Symptoms

Cucurbit plants may become infected at any stage of growth, from emergence of the seedling to near maturity. External symptoms may develop within four or five days after young plants become infected, but may take up to 14 days to develop when the foliage is older and more mature. Symptoms develop more rapidly at 79° to 89°F (26° to 32°C) than at 61° to 75°F (16° to 24°C). The severity of symptoms is at least partially related to the virus concentration. CMV symptoms in cucumber are more severe on plants exposed to short days or reduced light than on plants exposed to long days and bright light. Cucurbit plants rarely become infected in the seedling stage. When this happens, the cotyledons may turn yellow and wilt. New leaves are slightly mottled a yellowish green, remain small, wrinkled, and distorted. Plants infected in the seedling stage remain dwarfed or may die, and seldom produce fruit.

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When vigorous vine crops become infected in the 6- to 8-leaf stage, the symptoms first appear on the youngest, still expanding leaves which develop a greenish yellow to dark green mottling of the leaves (Figure 1). In mild form, a leaf may have to be held to the light to see the mosaic or mottling. Leaves are often stunted, distorted, crinkled, and curled downward. Vines are sometimes dwarfed and may be yellowish near the center of the hill and "bunchy" because of shortening of the stem between the leaves. In severe cases all except the youngest leaves at the runner tips (rosettes) may rapidly turn brown and die. When a plant becomes infected in midseason, previous growth remains normal and produces healthy fruit. All leaves, petioles, and stems formed after the first symptoms appear are dwarfed. Such plants produce few fruit. Typical mosaic symptoms develop only on actively growing leaves. New leaves with mosaic symptoms appear slowly.

Cucumber fruit may show yellow and green mottling or have dark green "warts" on pale green fruit (Figure 2). Cucumber fruit produced in the later stages of the disease is sometimes smooth and pale whitish green (called "white pickle") and more blunted at the ends than fruit produced on healthy vines. Watermelon, muskmelon, and winter squash fruit may be mottled and warty with raised areas lighter in color than surrounding tissue.

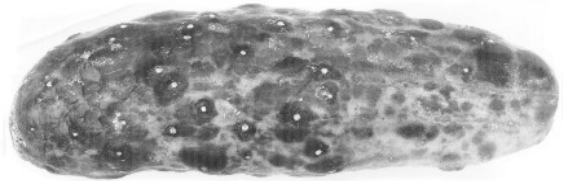


Figure 2. Cucumber mosaic virus (CMV) caused "warts" on cucumber fruit.

Few fruit set on plants infected early in the growing season. The fruit that do develop are often of poor quality. Mosaic-affected cucumbers when eaten raw have a bitter taste, while those that are pickled in brine become soft and soggy.

If CMV-affected plants also have a root rot, caused by soilborne fungi including species of *Pythium* and *Fusarium*, they wilt, collapse, and die within seven to ten days of showing the first symptoms. This suggests that these pathogens have a synergistic effect.

Disease Cycle

CMV survives over winter in reservoir hosts (Table 1) including such perennial weeds as bur-cucumber, burdock, catnip, flowering spurge, horsenettle, Jimsonweed, milkweed, mock-cucumber, motherwort, nightshades, pigweed, pokeweeds, white cockle, wild-cucumber, and wild groundcherry. The virus also survives in the seed of at least 19 species of plants including bur- and wild-cucumber, chickweeds, corn spurry, gourds, red deadnettle, vegetable-marrow, and a few inbred lines of muskmelon.

CMV is usually introduced into cultivated vine crop fields and gardens by more than 60 species of aphids (especially the green-peach aphid, *Myzus persicae*) after they pick up the virus by feeding on reservoir hosts for a few seconds to a minute (non-persistent transmission). Primary infection can also occur from mechanical inoculation, especially in greenhouses on workers' hands and pruning knives when plants are handled, from use of infected seed, and from the feeding of virus-infected, striped and 12-spotted cucumber beetles. Secondary spread of disease within a crop is usually the result of aphid vectors, but may occur when workers handle healthy plants after handling infected plants, and by the feeding of cucumber beetles. The cycle is completed when reservoir hosts are infected, usually by the feeding of virus-contaminated aphids, but sometimes from infected weed seed (especially chick-weed) or very rarely when seed of cultivated cucurbits is planted.

Epidemics of CMV and other cucurbit viruses, which are spread by aphids in a nonpersistent manner, depend on the abundance of virus-reservoir weed, wild, and crop host plants, the abundance of insect vectors, and the closeness of virus-infected source plants to cucurbit plants in fields and gardens. When aphids are abundant and source plants are present near vine crops, many cucurbit plants can become infected from an outside source(s) of CMV within a short period of time during the primary disease cycle. When virus-source plants are scarce or a long distance from cucurbit plants, aphids are present, and after CMV is introduced from outside the planting to a relatively few plants within the cucurbit planting, most vine crop plants become infected during secondary disease cycles from CMV-infected plants within the field or garden. This first results in a slow increase in the number of infected plants followed by a rapid increase since the source of CMV is no longer a limiting factor.

SQUASH MOSAIC VIRUS (SQMV)

Squash mosaic virus is much less common than cucumber mosaic virus. SqMV affects most cucurbits; however, most isolates or strains do not affect watermelon. Other plants infected by SqMV include garden and sweet peas, coriander, and salad chervil. SqMV may cause considerable loss in late-season squash and muskmelon crops. Various SqMV isolates can be divided into two groups based on serology. Group I infects watermelon, causes severe symptoms on muskmelon but only mild symptoms on pumpkins. Group II does not infect watermelon, produces only mild symptoms on muskmelon, and causes severe symptoms on pumpkins.



Figure 3. Squash plant dwarfed by squash mosaic virus (SqMV).

Symptoms

The first symptoms on squash, pumpkin, and vegetable-marrow include vein clearing and a yellowish spotting of the younger leaves. Infected leaves tend to cup upward and develop a light and dark green mottling (Figure 3). Squash leaves may appear severely distorted, even threadlike, with regular marginal projections from the veins. Leafy outgrowths or enations may develop on the lower leaf surface. Summer squash fruit are malformed with raised, domelike swellings. The first true leaves of cucumber plants develop a yellow spotting followed by prominent yellow veins and vein-banding. Young leaves may be curled and cupped upward. Leaves that form later develop few or no symptoms and the original symptoms fade as the weather gets hot so that it may be difficult to detect infection.

A slight vein yellowing followed by mottling, yellow spotting, and a green banding along the veins is common on infected muskmelon plants. Other muskmelon leaves develop a yellow streaking, spotting, or general yellowing along the veins. A few leaves become slightly distorted with the veins extending beyond the margins of the leaves.

Disease Cycle

SqMV survives between vine crop plantings in infected cucurbit weed hosts, in infected seed (up to 4.5 percent depending on the isolate and crop), and in overwintering beetles. Long-distance spread, of course, is possible with seed.

Insect vectors of SqMV include the 12-spotted, western striped, and banded cucumber beetles as well as the beetles *Acalyma thiemei thiemei* and *Epilechna chryssomelina*. Cucumber beetles can become infective after feeding on an infected plant for only five minutes and can then transmit the virus from plant to plant for 4 to 20 days depending on the species of beetle. The beetles transmit the virus as they regurgitate fluid as they feed. Aphids and other insects are **not** vectors of the squash mosaic virus.

The planting of infected seed is considered the most important primary source of inoculum. Plants grown from infected seed serve as inoculum for secondary disease cycles.

WATERMELON MOSAIC VIRUS (WMV)

Watermelon mosaic virus is primarily a problem in the southern and western states. Synonyms of WMV include cantaloupe and melon mosaic and yellow watermelon mosaic. There are at least two strains of the virus called WMV-I (= papaya ringspot virus, Type W) and WMV-II. WMV-I affects only 38 species in the cucumber family (Cucurbitaceae) while strain II affects cucurbits and a few other plants including alfalfa, crimson clover, a mallow (*Malva parviflora*), pea, snow-on-the-mountain, sour clover, and common vetch. The virus strains can be distinguished serologically, by host range tests, and on specific indicator plants. Losses of 50 percent or more in yield and fruit quality may occur in watermelon, muskmelon, summer and winter squash, and pumpkin when infection occurs early.



Figure 4. Severe malformation of two pumpkin leaves caused by watermelon mosaic virus (WMV-1).

Symptoms

All parts of infected plants can be affected. The symptoms depend on the host plant and its age when infected. Watermelon and muskmelon plants are commonly stunted or dwarfed with yellow or light green mottling, leaf deformation, blistering, and marginal yellowing. When muskmelons are infected when young, they are severely dwarfed and produce few if any marketable fruit. Watermelon fruit on virus-infected vines are often dwarfed, misshapen, mottled, or spotted.

The leaf symptoms on winter squash range from a faint green to a severe yellowish mottle. The leaves are malformed, puckered, or blistered. Sometimes the veins protrude beyond the normal leaf margin (Figure 4). Affected plants vary from being only mildly affected to severely distorted. Blue Hubbard and butternut squash may become stunted and bushy due to a shortening of the internodes and form stunted lateral stems. Knobby overgrowths cover the fruit which are sometimes severely distorted (Figure 5). The symptoms on summer squash are similar to those on winter squash. In addition, the stem internodes are commonly elongated resulting in a vine-type plant. Infected yellow fruits develop conspicuous green overgrowths.

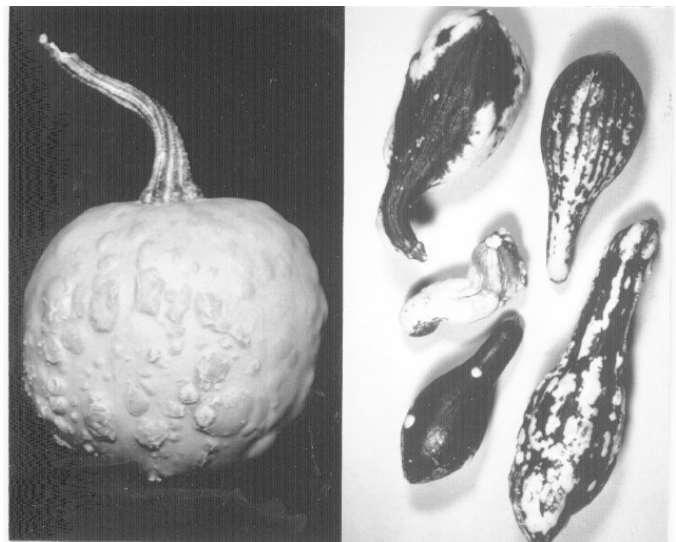


Figure 5. Knobby overgrowths on pumpkin fruit (left) and squash fruit (right) caused by watermelon mosaic virus 1 (SMV-1) (right photo courtesy Dr. F.W. Zettler).

A uniform green to dark green mosaic may develop in cucumber leaves (Figure 6). The fruit are stunted, curled, gnarled, and sometimes knobby. The uniformity of symptoms can be confused with herbicide injury or another abiotic disorder.

Disease Cycle

Fortunately, the primary weed, crop, and wild reservoir hosts of the watermelon mosaic virus do not occur in Illinois. The viruses are generally considered not to be seedborne or to be seedborne in very low amounts.

By far the most important means of spread in nature is by numerous species of aphids, especially the green-peach aphid (*Myzus persicae*). This aphid can pick up the virus from an infected plant in less than 15 seconds and can transmit it to a healthy plant after feeding for as few as 9 seconds. Symptoms usually appear in one to two weeks after inoculation.

Primary disease cycles usually start with the virus carried from reservoir hosts to cucurbit plants often from a considerable distance. Secondary disease cycles develop when aphids transmit the virus to healthy plants from plants infected during the primary cycle.

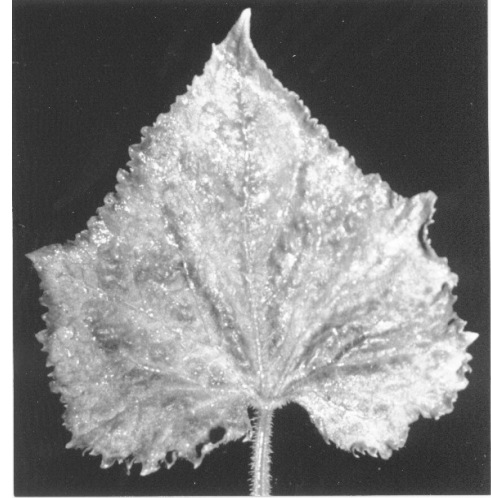


Figure 6. Cucumber leaf distorted by watermelon mosaic virus 1 (WMV-1).

TOBACCO RINGSPOT VIRUS (TRSV)

The tobacco ringspot virus, which occurs as many strains, infects all cucurbit vegetables. The virus has a wide host range including at least 260 species of plants in 54 families. It affects many cultivated and weed plants (Table 2). A cucumber strain differs from the tobacco strain and induces more severe symptoms on cucumber than does the common tobacco strain.

Symptoms

Muskmelon plants are stunted to dwarfed with yellowish green, mottled and deformed leaves. Halo-like spots may develop in young leaves shortly after becoming infected. The spots have pinpoint centers that appear water soaked. Definite rings commonly develop. Fruit numbers and size are reduced. The symptoms caused by TRSV become masked several weeks after plants become infected.

Watermelon plants are dwarfed and yellowish. The tips of infected vines are often **upright** instead of the normal prostrate position on healthy plants. The leaves are coarsely mottled and speckled with irregular black spots that somewhat resemble anthracnose lesions. Severely affected leaves become tattered and brittle. Plants tend to recover slightly as they mature with the symptoms being more persistent on watermelon than on muskmelon. Virus-affected plants usually do not produce marketable fruit. The fruit are often warty and may exude small drops of a liquid at affected areas on the surface. Pumpkin fruit commonly develop concentric rings (Figure 7).

Squash plants are severely stunted. The leaves are sometimes distorted with some blistering and yellowing of the veins. Ringspots and yellow patches associated with the veins sometimes appear. The

symptoms become masked on older plants and affected plants appear to recover. The symptoms, however, persist longer in squash than in other cucurbit vegetables.

Tiny yellow spots appear on cucumber leaves. New leaves that form are mottled and appear like those infected with cucumber mosaic virus. When temperatures rise and plants are growing rapidly and producing fruit, the symptoms on newly formed leaves are masked. The plants appear to recover. The fruit, however, become mottled.

Disease Cycle

TRSV survives between cucurbit plantings in numerous crop, weed, and wild host plants (Table 2), in infected seed, and possibly in a common dagger nematode (*Xiphinema americanum*) vector. Seed transmission is rare in cantaloupe, cucumber and muskmelon. It has been detected in up to 2.5 percent of butternut squash seed from infected plants, but has not been detected in other cucurbit seed. Seed transmission, however, occurs in dandelion, globe-amaranth, lettuce, petunia, soybean, and tobacco. The nematode vector is known to retain the virus and remain viruliferous for up to 49 weeks at 50°F (10°C).



Figure 7. Tobacco ringspot virus (TRSV). Affected pumpkin fruit (right); close-up of ringspot on squash fruit (left) (courtesy Purdue University).

The nematode is spread about by any agency that moves infested soil such as farm equipment and implements and drainage water. Nematodes rarely move over 30 inches on their own in a growing season. The optimum temperature for virus acquisition and transmission to cucumber is 82°F (28°C) which may be related to the degree of nematode attraction to the roots. Other vectors of TRSV that have been implicated include species of mites, thrips, grasshoppers, and flea beetles.

Other methods of spread in a cucurbit field or garden include mechanical transmission by cutting tools and diseased leaves rubbing against healthy leaves. Infected squash pollen can infect healthy plants. Symptoms appear as early as three days after mechanical inoculation.

The pattern of symptom development in some crops is from the edge of a field inward which strongly suggests that the dagger nematode is not always the principal vector. Insects and mites are believed to pick up TRSV from reservoir host plants near a field or garden and transmit it to crop plants as they spread into the area. Spider mites and thrips are the main suspect vectors in such cases.

Control

1. **Eradicate all biennial and perennial weeds and wild reservoir hosts in and around greenhouses, seedbeds, gardens, and fields.** It is especially important to eradicate bur- and wild-cucumbers, catnip, chickweeds, clovers, curly dock, dandelions, fleabane, flowering spurge, groundcherries, horsenettle, Jimsonweed, milkweed, motherwort, nightshades, pokeweeds, and white cockle. An area at least 10 feet wide immediately surrounding a greenhouse should be kept completely free of **all** vegetation. In a field or garden, a distance of at least 100 yards between susceptible crops and diseased weeds and susceptible wild plants is recommended. Include plants in ditch banks, hedge or fence rows, and other locations.

2. Fumigate greenhouses regularly to control aphids and other insects. Keep ventilators and other openings well screened. If possible, do not grow cucumbers or other cucurbits in seedbeds or sections of greenhouses where flowers and bedding plants are produced.
3. Apply insecticides regularly in and around the greenhouse, garden, or field to eliminate aphids, cucumber beetles, and other insects. It is important to kill insects **before** they have an opportunity to infect vine crops and move from plant to plant in a cucurbit planting.
4. **Grow resistant varieties of cucumbers.** Most new varieties carry resistance to CMV. Consult current seed catalogs and trade publications for that information.
5. Plant certified, virus-free seed whenever possible. Do **not** grow a cucurbit crop adjacent to a mosaic-affected one.
6. Do **not** plant cucurbits, especially late fall summer squash, near fields planted earlier with other vine crops.
7. Where feasible, pull up and destroy the **first** infected plants, but only after first spraying these plants thoroughly with an insecticide to kill any insects that the plants may be harboring.
8. Avoid touching healthy plants after handling mosaic-affected plants. If this is necessary, first wash hands thoroughly with hot running water and strong soap. Better still, use a solution of trisodium phosphate (2 tablespoons dissolved in 1 quart of water).
9. The rate of spread of CMV and WMV mosaic viruses may be reduced by the use of (a) an aluminum reflective mulch to repel aphid vectors, (b) one or two weekly applications of a mineral oil emulsifier combination (e.g. JMX Stylet-Oil as a 0.75 percent emulsion [7,500 parts per million] using 3 quarts per 100 gallons in a tank mix at 400 pounds per square inch of pressure), and (c) wheat grown in and around cucurbit plantings as a "protection crop". The wheat attracts the infectious aphids and their feeding presumably dilutes the virus during successive probes so much of its infectivity is lost. The wheat causes little shading, is attractive to aphids, does not serve as a host for aphid reproduction, is not a host for most cucurbit viruses or other vine crop pests, and can be easily removed.
10. Seed treatment, crop rotation, and spraying with fungicides are **not** effective in the control of mosaic diseases.

Information concerning insecticides, weed control, varieties, and other recommendations can be found in the Illinois Homeowners' Guide to Pest Management, available at your nearest Extension office.

Table 1. Partial List of Plants Susceptible to Cucumber Mosaic Virus (CMV)

alfalfa	daffodil	mock-cucumber
amaranth, green	dahlia	morning-glory
<i>Anchusa</i> spp.	dames violet	motherwort, common
apple-of-Peru	<i>Daphne</i> spp.	muskmelon
balsam-apple	datura, sacred	nasturtium
balsam-apple, wild	dayflower, Asiatic	nettle spp
balsam-pear	dayflower, creeping	New Zealand spinach
banana	deadnettle	nightshade, black
beans	<i>Delphinium</i> spp	nightshade, deadly
beet, garden and sugar	dill	onion
belladonna	eggplant	pansy
bindweed	false Jerusalem-cherry	parsley
broadbean	fennel	parsnip
bryonopsis	flowering spurge	passion fruit
bryony, common and white	Gentian sage	pea, garden
<i>Buddleia</i> spp.	geranium, florists'	<i>Penstemon</i> spp
buckwheat	gherkin, West Indian	peppers
bur-cucumber	<i>Gilia</i> spp	periwinkle (myrtle)
burdock	gladiolus	<i>Petunia</i> spp
cabbage	globe-amaranth	<i>Phacelia</i> spp
<i>Calendula</i> spp.	goosefoot	<i>Phlox</i> spp
cantaloupe	gourds	<i>Physalis</i> spp
cape-gooseberry	Greek valerian	physedra
cardinal flower	groundcherries	<i>Phytolacca</i> spp
carpetweed	heliotrope, garden	pigweed
carrot	henbane	pineapple
catnip	horsenettle	pokeweed, common
celery	houndstongue	pokeweed, southern
charlock	husk tomato	polyanthus
chayote	hyacinth	potato
chickweeds	<i>Impatiens</i> spp	primrose spp
chicory	Jimsonweed	privet
China-aster	kedrostis	proboscisflower
Chinese lantern plant	lambquarters, common	pumpkin
<i>Chrysanthemum</i> spp.	larkspur	ragweeds
citron	lettuce	rhubarb
clover, crimson	lilies	rye
cockscomb	lima bean	safflower
columbine	lobelia, edging	salvia
<i>Commelina</i> spp.	lupine spp	scabiosa
coneflower	<i>Lychnis</i> spp	shell-flower
(<i>Rudbeckia</i> spp)	mallows	snakeweed
corn	Manila help	snapdragon
corn spurry	marigold, African	<i>Solanum</i> spp
cowpea	marigold, French	<i>Sorghum</i> spp
cowslip	<i>Martynia Louisiana</i>	spiderflower
crane's bill, Carolina	<i>Melothria</i>	spiderwort
crown-of-thorns	<i>Mesembryanthemum</i> spp	spinach
cucumber	milkweed	squashes
cucumber, squirting	mints	stock

sunflowers	tulips	watermelon
sweetpea	turnip	watermelon, Chinese
sweet potato	vegetable-marrow	wheats
tasselflower	vegetable sponge	white cockle
teasels	<i>Viola</i> spp	wild bluebell
Teosinte	violets	wild-cucumber
tobacco spp	wandering jew	wild groundcherry
tomato	watercress	<i>Zinnia</i> spp

Table 2. Partial List of Plants Susceptible to Tobacco Ringspot Virus (TRSV)

beans (except lima)	fleabane	<i>Petunia</i> spp
beet, garden and sugar	geranium, florists'	pigweed
begonia	gherkin, West Indian	Plantain spp
blueberry	gladiolus	potato
cantaloupe	globe-amaranth	pumpkin
carnation	gourds	purslanes
carrot	groundcherries	ragweeds
castorbean	guar	rhubarb
celery	honeydew melon	sheep sorrel
chayote	hydrangea	snapdragon
chickweed	Iris spp	soybean
China-aster	Jimsonweed	spinach
citron	lettuce	squashes
clover, red	<i>Luffa acutangula</i>	sunflowers
corn	marigold	sweet clover, white
cowpea	mints	sweet clover, yellow
crenshaw melon	muskmelon	sweet potato
cucumber	nightshade spp	Swiss chard
curly dock	okra	tobacco spp
dahlia	onion	tomato
dandelion	papaya	tulips
Easter lily	pea, garden	vegetable-marrow
eggplant	peanut	watermelon
elderberry	peppers	<i>Zinnia</i>
endive		