

Maize chlorotic dwarf virus (MCDV)

Infected plants initially show small chlorotic spots developing later into a general chlorosis in the whorl leaves (Photo 86). Plants become stunted due to shortening of internodes, and leaves may become reddish late in the season, resembling the reddening symptoms caused by corn stunt and maize bushy stunt. MCDV is transmitted by the leafhoppers *Graminella nigrifrons* and *G. sonora* for an extended period of time after they have fed on infected plants. Johnsongrass serves as a reservoir host for the virus and the vector when maize is not being grown. So far this disease has been found only in the continental United States, but probably has a wider distribution.

Maize chlorotic mottle virus (MCMV)

In early stages, the youngest leaves show fine chlorotic spots that coalesce and develop into broad chlorotic stripes along the veins. These chlorotic stripes contrast with dark green tissue when observed against the light (Photos 87, 88). Leaves showing chlorosis finally die. Plants are stunted because of shortened internodes. Infected plants produce fewer and smaller ears. In most cases, the male inflorescence is malformed.

The virus is transmitted mainly by several chrysomelid leaf beetles such as *Chaetocnema pulicaria* and *Diabrotica* spp., over a short period of time. Reports indicate that it is transmitted at very low rates via infected seed.

When MCMV occurs in combination with maize dwarf mosaic virus (MDMV) or wheat streak mosaic (WSMV), it produces a severe reaction known as maize lethal necrosis (MLN; see page 96).



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Maize dwarf mosaic virus (MDMV)

Sugarcane mosaic virus (SCMV)

These viruses are transmitted by several genera and species of aphids, including *Rhopalosiphum maidis* (Fitch) and also by seed at low rates (Photo 89). After feeding on an infected plant, the aphid can immediately transmit the virus. These pathogens can infect other grass and cereal hosts, such as sorghum, Johnsongrass, and sugarcane. No infection occurs in broad-leaf plants. Infected plants develop a distinct mosaic—irregularities in the distribution of normal green color—on the youngest leaf bases (Photo 90). Sometimes the mosaic appearance is enhanced by narrow chlorotic streaks extending parallel to the veins. Later on, the youngest leaves show a general chlorosis, and streaks are larger and more abundant (Photo 91). As plants approach maturity, the foliage can turn purple or purple-red. Depending on time of infection, there may be severe stunting of the plant. Plants infected early may produce nubbins or be totally barren.

In China, SCMV has been reported as seriously affecting maize production.

Maize lethal necrosis (MLN)

This disease results from combined infection by two viruses: maize chlorotic mottle virus (MCMV) and either maize dwarf mosaic virus (MDMV) or wheat streak mosaic virus (WSMV). No lethal necrosis will develop if only MDMV and WSMV occur together. Infected plants are short. The leaves show chlorosis and die at about flowering time (Photo 92). There is no ear development in plants infected during early stages of growth.





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Maize mosaic virus I (MMV)

The disease has been found in many countries worldwide. The vector is the planthopper *Peregrinus maidis*, which will transmit the virus for most of its life after feeding on an infected plant. The vector also transmits maize stripe virus. Hosts for MMV include maize, sorghum, and a few other graminaceous species. Plants are most susceptible when infected 4 to 6 weeks after emergence. The most conspicuous symptoms are dwarfing and striping along the veins (Photos 93, 94).

Degree of dwarfing depends on plant age at infection. Because internodes are shortened, leaves appear “crowded” and erect. Fine continuous stripes develop along the veins beginning at leaf bases. Later symptoms include shorter-than-normal leaves with a rough and fleshy appearance. Stripes may be dark yellow, and may finally become necrotic. Prior to total necrosis of the tissues, foliage turns red or dark purple.

Maize stripe virus (M StV)

This disease has been reported in tropical locations in Africa, Asia, and the Americas, including Hawaii, India, and Australia.

Initial symptoms on the leaves are small chlorotic specks that later develop into narrow parallel chlorotic stripes along the younger leaves. The chlorotic bands can vary in width and extend from the base to the tip of the leaves (Photos 95, 96). Infected plants usually show stunting and bending of the tassel. Normally ear development and yield are reduced.

The virus is transmitted by the planthopper *Peregrinus maidis*, and the vector will transmit the virus for most of its life after feeding on an infected plant. The vector can also transmit maize mosaic virus.

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Maize streak virus (MSV)

The disease, reported first from East Africa, has now extended to many other African countries. The virus is transmitted by *Cicadulina* spp. leafhoppers. *Cicadulina mbila* (Naude) is the most prevalent vector, and will transmit the virus for most of its life after feeding on an infected plant. Early disease symptoms begin within a week after infection and consist of very small, round, scattered spots in the youngest leaves. The number of spots increases with plant growth; they enlarge parallel to the leaf veins. Soon spots become more profuse at leaf bases and are particularly conspicuous in the youngest leaves. Fully elongated leaves develop a chlorosis with broken yellow streaks along the veins, contrasting with the dark green color of normal foliage (Photos 97, 98). Severe infection causes stunting, and plants can die prematurely or are barren. Many cereal crops and wild grasses serve as reservoirs of the virus and the vectors.

Maize rough dwarf virus (MRDV)

This virus has been known for several years in countries in Europe and Asia, as has its variant, “Mal de Rio Cuarto,” in central Argentina and Uruguay. Infected plants show stunting; secondary veins become chlorotic and thick. The leaves become leathery and younger leaves roll upwards with characteristic overgrowths (enations) on the veins on the underside (Photo 99). Symptoms can be detected in seedlings at approximately one month of age. In later stages, infected plants develop a reddish color and form either no ear or simply nubbins which are often bent at the tip. The tassels and upper leaves are malformed and underdeveloped (Photo 100).

The virus is transmitted by several delphacid planthoppers including *Laodelphax striatellus* for MRDV and *Delphacodes kuscheli* for MRCV. Transmission is for most of the life of the vector after feeding on an infected plant, and females can pass the virus to the next generation through the eggs.

Mal de Rio Cuarto Virus in central Argentina and MRDV in northern China have been reported as seriously affecting maize production.

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Maize fine stripe virus

(*Maize rayado fino virus*, or MRFV)

“Rayado fino”, or fine stripe, is caused by a virus transmitted by the leafhopper *Dalbulus maidis*. The vector will transmit the virus for most of its life after feeding on an infected plant. *Dalbulus maidis* is also a vector of the corn stunt spiroplasma and maize bushy stunt phytoplasma. This virus is found from southern North America to South America, including the Caribbean, and has been observed in several Central American countries to reduce yields by as much as 43%.

Leafhoppers can vector more than one of these pathogens at a time, and mixed infections are common. Symptoms develop about 2 weeks after plants have been infected. They begin as small, isolated chlorotic spots easily observed by holding leaves against the light (Photo 101). Later, the spots become more numerous and fuse, forming 5 to 10 cm stripes that advance along the veins (Photo 102). If infected at tasseling, plants may not show symptoms. Poor grain set and grain filling are observed with infection at the seedling stage.

Maize bushy stunt (MBS)

Maize Bushy Stunt phytoplasma, syn. Maize Bushy Stunt mycoplasma

This disease has been reported in several countries from the southern USA to Argentina. The pathogen is transmitted by the cicadellid leafhoppers *Dalbulus maidis*, *D. elimatus*, and other species of *Dalbulus* and will be transmitted for most of the life of the vector, after it feeds on an infected plant. The same vectors can transmit MRFV and the corn stunt Spiroplasma, where mixed infections in the plant are common.

The pathogen is a non-helical mollicute known as a phytoplasma, earlier referred to as a mycoplasma. MBS is more common in relatively cooler areas, whereas corn stunt is favored by hot and humid environments.

Infected plants show diverse symptoms, depending on the maize genotype. The most common symptoms are marginal chlorosis on young leaves, and tips gradually turn purple-red as they approach maturity.

A conspicuous symptom is the bushy appearance due to a proliferation of tillers, which also become chlorotic and reddish (Photo 103). It is more common in highland germplasm. Foliar symptoms are more obvious close to flowering time. Axillary buds develop into barren shoots. With early infection ears are produced at many nodes, but with reduced ear diameter and grain size, greatly reducing yield (Photo 104).

Simple observation in the field will not allow one to distinguish between symptoms caused by the maize bushy stunt phytoplasma and those resulting from corn stunt Spiroplasma.

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Corn stunt (CS)

Spiroplasma kunkelii, syn. Corn Stunt Spiroplasma

The disease is known in hot humid lowlands of several countries of Central and South America, the Caribbean, southern USA, and Mexico, but can also be found up to elevations of more than 2000 meters above sea level. The disease is transmitted by the cicadellid leafhoppers *Dalbulus maidis*, *D. elimatus*, and other, less important *Dalbulus* spp. Vectors can transmit the pathogen for most of their lives after feeding on an infected plant. The same vector can transmit MRFV and MBS, and mixed infections are common. The pathogen is the helical mollicute *Spiroplasma kunkelii*.

Infected plants show diverse symptoms, depending on maize genotype, the most common being leaf reddening or purpling, yellowing (Photo 105), and the presence of chlorotic stripes at the base of younger leaves, which might turn purple-red toward the tip (Photo 106). Foliar symptoms normally appear close to flowering time. Plants are stunted due to the shortening of internodes; axillary buds develop as barren shoots or ears at many nodes, and there is excessive root branching. In severe cases, plants are barren, or there is a significant reduction in ear diameter or poor seed set. Plants die prematurely.

Diagnostic key

Symptoms	Disease	Page
Stalk		
Black discoloration of stem; shredding of interior; bundles of black material.	Charcoal rot	57
Narrow elongated brown lesions on the stem turning black, wilting with dark brown shredded vascular tissue.	Anthracnose stalk rot	54
Broken stalks; brownish pith; later, abundant spore-producing structures.	Stenocarpella stalk rot	61
	Gibberella stalk rot	46
	Fusarium stalk rot	46
Brown lesions; rotting.	Brown spot	2
Brown vascular bundles extending across the internodes starting in roots; wilting of plant beginning at flowering.	Black bundle disease and late wilt	53
Chlorotic and reddish leaves; stunting; plant may be bushy with many tillers.	Maize bushy stunt	108
Dry plant; stalk interior shredded and discolored; black, cottony masses.	Botryodiplodia stalk rot	58
Stunting; chlorosis; death around flowering time.	Maize lethal necrosis	96
Stunting; shortened internodes; green patches on leaves.	Maize chlorotic mottle virus	92
	Maize chlorotic dwarf virus	91

Symptoms	Disease	Page
Stunting, shortened internodes; axillary bud development; excessive root branching; leaf reddening and/or marginal yellowing, chlorotic streaks at bases of leaves.	Corn stunt	111
Twisting; dark internodes, soft and water soaked; lodging.	Pythium stalk rot	45
Water-soaked, dark areas at base of stalk; unpleasant odor, lodging.	Bacterial stalk rot	84
Leaf		
Downy growth on upper or lower leaf surface, striping, partial leaf symptom or general chlorosis; narrow, abnormally erect leaves.	Downy mildew	5
Lesions, with brown centers, about 2 mm in diameter.	Curvularia leaf spot	33
Lesions, beginning as small, regular, elongated brownish gray necrotic spots, and growing parallel to the veins.	Gray leaf spot	34
Lesions, coalescing to produce severe blotching and necrosis.	Septoria leaf blotch	38
Lesions, elongated, spindle-shaped, and necrotic; may coalesce to "burn" plant.	Turcicum leaf blight	17

Symptoms	Disease	Page
Lesions, necrotic, elongated, with narrow yellow margins, along the veins.	Macrospora leaf stripe	42
Lesions, oval, necrotic, and parallel to the veins, later blighting the leaf.	Yellow leaf blight	25
Lesions, oval, zonate, and brownish, or brown slender and elongated.	Carbonum leaf spot	21
Lesions, pale green along veins developing to stripes, later becoming grayish white to brown and shredding.	Bacterial leaf stripe	88
Lesions, round and translucent, developing tan centers, black-to-purple rings and yellow halos.	Eyespot	41
Lesions, small, necrotic coalescing into concentric necrotic spots.	Leptosphaeria leaf spot	29
Lesions, small, light brown in color, elongating along secondary veins, and often coalescing.	Maydis leaf blight	18
Lesions, water-soaked with irregular margin spreading along veins, often turning yellow and moving to the stem.	Stewart's wilt	87

Symptoms	Disease	Page
Mosaic pattern on youngest leaves; chlorotic streaks and general chlorosis, then purple-red; some stunting.	Maize dwarf mosaic virus	95
	Sugarcane mosaic virus	95
Pustules, small, round, powdery light orange; later, turning black.	Polysora rust	10
Pustules, small, elongate, powdery, dark brown; later, turning black.	Common rust	9
Pustules, small, round-to-oval, surrounded by black rim.	Tropical rust	10
Rings, large, concentric, necrotic.	Zonate leaf spot	37
Spots, concentric, on leaves and sheaths; filamentous masses develop on lesions.	Banded leaf and sheath blight	26
	Borde blanco	13
Spots, shiny, raised and black; later with necrosis coalescing and drying foliage.	Tar spot complex	14
Spots, chlorotic on leaf lamina and brown spots on leaf midribs, sheaths, and stems.	Brown spot	2
Irregular oval to elongate lesions with yellow to reddish-brown margins on young and very old leaves.	Anthracnose leaf blight	22
Spots, small, light green to yellow, turning brown.	Septoria leaf blotch	38
Spots, small and necrotic, with light colored halos.	Curvularia leaf spot	33

Symptoms	Disease	Page
Spots, small, oval, and water-soaked, enlarging to elliptical necrotic lesions.	Turcicum leaf blight	17
Spots, small and pale green, round to slightly elongate later becoming bleached, then necrotic, with a dark brown margin.	Phaeosphaeria leaf spot	29
Small, round spots on leaves turning to brown necrotic lesions (3-4 cm) with concentric rings surrounded by chlorosis.	Hyalothyridium leaf spot	30
Necrotic, elongated bicolor lesions on the border of the leaf with small white mushrooms formed on the lower surface.	Borde blanco	13
Spots, small and whitish, coalescing into a line.	Maize fine stripe virus	107
Streaking, broken and yellow, beginning as small, white, round spots.	Maize streak virus	103
Striping, chlorotic.	Maize chlorotic mottle virus	92
	Maize fine stripe virus	107
	Maize streak virus	103
Striping, chlorotic; leaves appear crowded and erect; leaves rough, fleshy, dark purple.	Maize mosaic virus I	99
Striping, white to yellow and broad, turning purple toward leaf tips, leaf reddening and/or marginal yellowing.	Corn stunt	111

Symptoms	Disease	Page
Wilting, from top leaves, at tasseling stage.	Black bundle disease and late wilt	53
Firing of upper leaves beginning at tasseling.	Charcoal rot	57
Ear		
Barrenness, or poor seed set.	Downy mildew	5
	Corn stunt	111
	Maize bushy stunt	108
	Stewart's wilt	87
Black, shiny kernels; husks black and shredded.	Botryodiplodia (black kernel rot)	79
Blue-green powder on cob; streaked and bleached kernels.	Penicillium ear rots	63
Brown-green streaks on kernels, starting at cob base.	Hormodendrum ear rot	80
Cottony, white-to-pink growth; some germination on the cob.	Gibberella ear rot	67
	Fusarium moniliforme ear rot	67
	Cephalosporium kernel rot	80
White streaks on the pericarp.	Fusarium moniliforme ear rot	67
	Cephalosporium kernel rot	80
Lesions, oval, and larger than 2.3 cm on husks and leaf sheaths.	Maydis leaf blight "T" strain	18
Lightweight, chaffy ears; loose, discolored kernels; black specks on kernels and cob.	Nigrospora ear rot	72
	Charcoal ear rot	71
Lightweight ears; loose kernels; germination of seed on cob.	Tar spot complex	14

Symptoms	Disease	Page
Nubbins, or ears with underdeveloped, shrunken kernels.	Black bundle disease	53
Nubbins or no ears at all.	Maize dwarf mosaic virus	95
	Sugarcane mosaic virus	95
	Downy mildews	5
	Stewart's wilt	87
	Maize rough dwarf virus	104
Pink/ red kernels, starting at ear tip.	Gibberella ear rot	67
Scattered kernels on the ear with pink fungal growth.	Fusarium moniliforme ear rot	67
Rotten and blackened ears.	Carbonum ear rot	21
Rotten ears; light brown cottony fungal growth ; filamentous masses on kernels and cob producing small, round, black sclerotia on husk leaves.	Banded leaf and sheath blight	26
Slimy, soft, pale, masses replacing kernels; hardening toward harvest.	Ergot	68
Spore masses, black and loose, instead of ear.	Head smut	49
Damaged kernels with black, yellow-green, ivy green or whitish, powdery spore masses.	Aspergillus ear rots	64
Starts as fine stripes going often to broad bands of chlorosis. Often the top of the plant bends. Underdevelopment of ear.	Maize stripe virus	100

Symptoms	Disease	Page
White galls, closed replacing kernels; later, black spore masses.	Common smut	76
White-gray fungal growth between kernels; husks bleached and adhering to each other, later turning black with sclerotia.	Gray ear rot	75
White fungal growth; gray-brown ear; black pycnidia ; husks adhering to ear.	Stenocarpella ear rot	83
Yellow, loose kernels; black filamentous masses.	Charcoal ear rot	71
Tassel		
Malformation and enlargement; black spores in florets.	Head smut	49
Malformation and enlargement; sterility.	Downy mildews	5
Malformation and frequently reduced or aborted.	Maize chlorotic mottle virus	92
	Maize rough dwarf virus	104
	Maize bushy stunt	108
Rotten tassel, enclosed in dead leaves.	Bacterial leaf stripe	88
Spore masses, hard and dark green to black on a few florets.	False head smut	50
White galls closed on the tassel, later black spore masses.	Common smut	76
Male sterility; some male florets in tip of ear.	Corn stunt	111
	Maize bushy stunt	108
Stunting and bending.	Maize stripe virus	100