Maize Diseases

a guide for field identification

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Maize Program, CIMMYT, 1984

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Contents

Introduction

This booklet is designed as a quick guide for identifying maize diseases. It is intended for field use by agricultural technicians and maize producers, and therefore the taxonomic short forms of the various pathogens are deemed to be appropriate and adequate. The text comprises a brief description of some of the principal maize diseases, their causal agents, and their symptoms. Complementing this text, as an aid to identification, are numerous color photographs of diseased plants, and, in the center of the book, a diagnostic key. The text is divided according to the three causal agents for maize diseases: fungi, bacteria, and viruses. Most of these diseases are economically significant; some, however, are not economically significant but have the potential to become so.

Brown Spot

Physoderma maydis

Normally the disease occurs in areas of abundant rainfall and high mean temperatures. It attacks the leaves, leaf sheaths, stalk, and sometimes the outer husks.

The first noticeable symptoms develop on leaf blades and consist of small chlorotic spots, arranged as alternate bands of diseased and healthy tissue (Photo 1). Spots on the mid-ribs are circular and dark brown, while lesions on the laminae continue as chlorotic spots. Nodes and internodes also show brown lesions. In severe infections, these may coalesce and induce stalk rotting and lodging (Photo 2).

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Downy Mildews

Several species of the genera *Sclerospora* and *Sclerophthora* are responsible for downy mildews:

CRAZY TOP, YELLOW WILT OF RICE
Sclerophthora macrospora

BROWN STRIPE DOWNY MILDEW
Sclerophthora rayssiae var. zeae (Photo 3)

GRAMINICOLA DOWNY MILDEW OF MAIZE
GREEN EAR DISEASE
Sclerospora graminicola

JAVA DOWNY MILDEW OF MAIZE
Peronosclerospora maydis

PHILIPPINE DOWNY MILDEW OF MAIZE
Peronosclerospora philippinensis (Photo 4)

SUGARCANE DOWNY MILDEW OF MAIZE
Peronosclerospora sacchari (Photo 5)

SORGHUM DOWNY MILDEW OF MAIZE
Peronosclerospora sorghi (Photos 6, 7, 8)

These diseases are of serious concern to maize producers in several countries of Asia and Africa. Recent information indicates that their distribution is increasing throughout the American continent. Symptom expression is greatly affected by plant age, species of the pathogen, and environment. Usually, there is chlorotic striping of leaves and leaf sheaths, and dwarfing. Downy mildew becomes conspicuous after development of a "downy growth" on or under leaf surfaces. This condition is the result of conidia formation, which commonly occurs in early morning.

The disease is most prevalent in warm and humid regions. Some species causing downy mildew also induce tassel malformations. Consequently, no pollen is produced, and ears, if formed at all, are nubbins. Leaves may be narrow, thick, and abnormally erect.

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Tar Spot
Phyllachora maydis

The disease sometimes occurs in relatively cool, humid areas of the tropics, where *Turcicum* leaf blight is prevalent. Characteristic black, raised and shiny spots are produced early. At a later stage, necrotic areas develop around the "tar spot" (Photo 9). These necrotic lesions may coalesce and cause a complete burning of the foliage. Lesions start developing before tasseling time on lower leaves. If environment is favorable, infection continues upwards on younger leaves. Affected ears are light weight with loose kernels.

Maize Rusts

The three major leaf rusts on maize are common rust, Polysora rust, and tropical rust.

Common Rust

Puccinia sorghi

The disease is widely distributed throughout the world.

Common rust is most conspicuous when plants approach tasseling. It may be recognized by small, powdery pustules over both surfaces of the leaves (Photo 10). Pustules are brown in early stages of infection; later, the epidermis is ruptured and the lesions turn black as the plant matures. Plants of the alternate host *(Oxalis* spp.) are frequently infected with light orange-colored pustules (Photo 11). This is simply another stage of the same fungus.

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Polysora Rust

Puccinia polysora

Pustules are smaller, lighter in color, and more circular (Photo 12) than those produced by *P. sorghi*. They are also present on both leaf surfaces, but the epidermis remains intact longer than it does in *P. sorghi*-infected leaves. Pustules turn dark brown as plants approach maturity. No alternate host of the fungus is known. Southern rust, as Polysora rust is often called, is common in hot and humid regions.

Tropical Rust

Physopella zeae

Outbreaks of this rust are sporadic and confined to the American tropics.

Pustules vary in shape from round to oval. They are small and found beneath the epidermis. At the center of the pustule the lesion appears white to pale yellow and an opening develops (Photo 13). The pustule is sometimes black rimmed, but its center remains light. No alternate host of the fungus is known.

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Zonate Leaf Spot

Gloeocercospora sorghi

Zonate leaf spot is more commonly found in sorghum plants than in maize.

The disease is recognized by small necrotic lesions that enlarge and produce characteristic large concentric necrotic rings (Photo 14). Lesions may be as large as 5 to 6 cm. in diameter, and occur mainly on older leaves.

Leptosphaeria Leaf Spot

Leptosphaeria michotii

This disease has been reported in high, humid areas of the Himalayas. Other species of *Leptosphaeria* which produce different symptoms on maize leaves are also known in other regions of the world.

Symptoms consist of small lesions that become large and concentric, covering large areas of the leaves (Photo 15). It is most conspicuous on lower leaves at flowering time.

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Phaeosphaeria Leaf Spot

Phaeosphaeria maydis

This disease is restricted to certain areas of northern India and Brazil, Colombia, Ecuador and Mexico, where *Helminthosporium turcicum* is also prevalent. Conditions of high rainfall and relatively low night temperatures favor development. Lesions appear as small pale green areas, which later become bleached and finally necrotic, surrounded by dark brown margins (Photo 16). Spots on leaves are round to elongated.

Gray Leaf Spot

Cercospora zeae-maydis

This disease, also known as Cercospora leaf spot, may occur in temperate, humid areas. Lesions begin as small, regular elongated necrotic spots. They grow parallel to the veins (Photo 17). Occasionally, lesions may reach a size of 3.0 by 0.3 cm.

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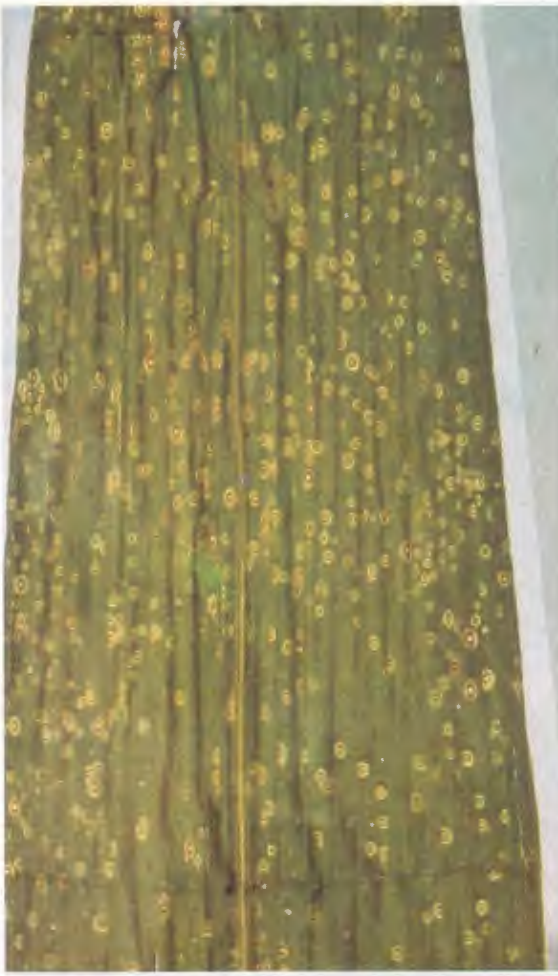

Curvularia Leaf Spot

Curvularia lunata and C. pallescens

These fungi produce small necrotic or chlorotic spots with a light colored halo (Photo 18). Lesions are about 0.5 cm in diameter when fully developed. The disease is prevalent in hot, humid maize growing areas and can damage crops significantly.

Carbonum Leaf Spot

Helminthosporium carbonum

This disease is more common in very moist areas with intermediate temperatures.

Different symptoms are produced on the leaves by two known races of the fungus. Race I produces oval, zonate, brownish lesions on all parts of the plants including the ears, which rot and turn black. Race II produces brown, slender, elongated lesions, mostly in the lower leaves, and can also produce ear rot (Photo 19).

Ear rot symptoms produced by Races I and II are very similar.

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Maydis Leaf Blight

Helminthosporium maydis

Young lesions are small and diamond shaped. As they mature, they elongate. Growth is limited by adjacent veins, so final lesion shape is rectangular (2 to 3 cm long). Lesions may coalesce, producing a complete "burning" of large areas of the leaves (Photo 20).

The symptoms described above correspond to the "O" strain of the fungus. Recently, a "T" strain caused severe damage to maize cultivars where the Texas source of male sterility had been incorporated. Lesions produced by the "T" strain (Photo 21) are oval and larger than those produced by the "O" strain. A major difference is that the "T" strain affects husks and leaf sheaths, while the "O" strain normally does not.

Maydis leaf blight (or southern maize leaf blight) is prevalent in hot, humid, maize-growing areas. The fungus requires slightly higher temperatures for infection than *H. turcicum;* however, both species are often found on the same plant.

Turcicum Leaf Blight

Helminthosporium turcicum

An early symptom is the easily recognized, slightly oval, water-soaked, small spots produced on the leaves. These grow into elongated, spindle-shaped necrotic lesions (Photo 22). They appear first on the lower leaves and continue increasing in size and number as the plant develops, until a complete "burning" of the foliage is conspicuous.

Turcicum blight, also known as northern leaf blight, is of worldwide distribution, and occurs particularly in areas where high humidity and low temperatures prevail during the growing season of the host. When infection takes place at silking stage and conditions are optimum, it may cause significant economic damage.

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Diplodia Macrospora Leaf Stripe

Diplodia macrospora

This disease has not been reported to cause economic damage, but it can be found causing some damage in commercial maize plantings in hot, humid areas. *D. macrospora* is mostly an ear-rotting agent, but under appropriate climatic conditions it may cause foliar damage.

Symptoms consist of necrotic lesions along the veins. These lesions resemble spotting produced by bacteria or by *Helminthosporium turcicum* (northern leaf blight). However, they can be differentiated by holding them against the light. *D. macrospora* lesions have a distinct narrow yellow margin which those caused by the other pathogens lack (Photo 23).

Leaf Anthracnose

Colletotrichum graminicola

This disease is minor and seldom encountered on maize. However, some reports indicate its increasing importance in certain areas. In general, symptoms consist of small and elongated spots which may coalesce and severely damage foliage (Photo 24). Stalks of young plants may also be infected.

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Septoria Leaf Blotch

Septoria maydis

The spotting mainly affects maize grown in rather cool, humid environments.

Symptoms first appear as small, light green to yellow spots on the leaves (Photos 25, 26). Lesions coalesce and produce severe blotching and necrosis of affected areas where many black pycnidia grow.

Eyespot of Maize

Kabatiella zeae

Commercial plantings in countries with cool, moist environments may be affected by eyespot.

The disease is recognized by small (1 to 4 mm), round, translucent lesions. Tan colored centers develop, surrounded by black-to-purple rings, with a yellow halo around them, thus producing the characterisitc "eyespot" (Photos 27, 28).

These symptoms are easily confused with physiological or genetical spots, which are non-infectious but widely observed in maize leaves. The symptoms are also similar to early spotting induced by *Curvularia* in some tropical areas.

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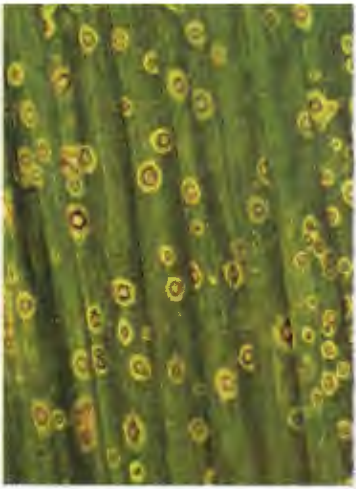

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Phyllosticta Leaf Spot

Phyllosticta maydis

In 1970, the disease, also known as yellow leaf blight, was associated with susceptibility in Texas male sterile cultivars, and several researchers linked this disease with yield losses and increased lodging. Humid, warm weather favors disease development.

Young diseased plants show symptoms similar to those observed in nitrogen deficient plants (Photos 29, 30). In mature plants, lesions are narrow, necrotic, and parallel to the veins (although not limited by them). In older leaves, lesions develop further and produce a characteristic blighting near the tip.

Banded Leaf and Sheath Spot

Rhizoctonia solani f.sp. sasakii

Symptoms of this disease (perfect stage: *Corticium solani.* syn. *Thanatephorus cucumeris.*) which develop on leaves and sheaths are characteristic concentric spots that cover large areas of infected leaves and husks (Photos 31, 32).

The main damage in the humid tropics is a brownish rotting of ears, which show conspicuous light brown cottony mold with small, round, black sclerotia.

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Pythium Stalk Rot

Pythium aphanidermatum, Pythium spp.

Pythium species cause stalk rots, seed rots and seedling blights. In some hot and humid tropical areas, and in temperate regions, pythium stalk rot may be observed.

Usually the basal internodes become soft, water soaked and dark, causing lodging. Damaged internodes commonly twist before the plants lodge. Diseased plants can remain alive until all vascular bundles become affected (Photo 33).

Isolations in culture media are necessary to differentiate Pythium from Erwinia stalk rots.

Head Smut

Sphacelotheca reiliana

Head smut may cause significant economic damage in dry, hot maize growing areas.

The infection is systemic; that is, the fungus penetrates seedlings and grows within the plant without showing symptoms until plants reach tasseling and silking stages.

The most conspicuous symptoms are: (a) abnormal development of tassels, which become malformed and overgrown (Photo 34); (b) black masses of spores, which develop inside individual male florets; and (c) masses of black spores which also grow instead of the normal ear, leaving the vascular bundles exposed and shredded (Photo 35).

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Black Bundle Disease and Late Wilt

Cephalosporium acremonium, Cephalosporium maydis

Black bundle disease is caused by *Cephalosporium acremonium* and is widely distributed (Photo 36). The late wilt disease, caused by *C. maydis*, has been reported only in Egypt and India (Photo 37). Both diseases kill the plants near pollination time. They are most common in rather humid, heavy soils in hot areas. The pathogens are soil and seed-borne.

Infected plants do not show symptoms until they reach tasseling stage and start wilting, generally beginning from the top leaves. Diseased plants produce only nubbins or ears with underdeveloped, shrunken kernels. When split, diseased stalks show brown vascular bundles starting in the underground portion of the roots. Similar symptoms may be observed in plants damaged by *Fusarium moniliforme*. Kernels that become infected by *C. acremonium* and *F. moniliforme* show conspicuous white streaks on the pericarp.

Charcoal Stalk Rot

Macrophomina phaseoli

Charcoal stalk rot is most common in hot, dry environments. Incidence increases rapidly when water stress and high temperatures prevail near tasseling stage.

The pathogen invades seedling roots. When plants approach maturity, the internal parts of stems show a black discoloration and shredding of the vascular bundles (Photo 38). This occurs mainly in lower stalk internodes. Careful examination of rind and vascular bundles of infected plants easily reveals small black sclerotia (Photo 39) which can overwinter and infect the next crop. The fungus may also infect kernels and will cause them to blacken completely.

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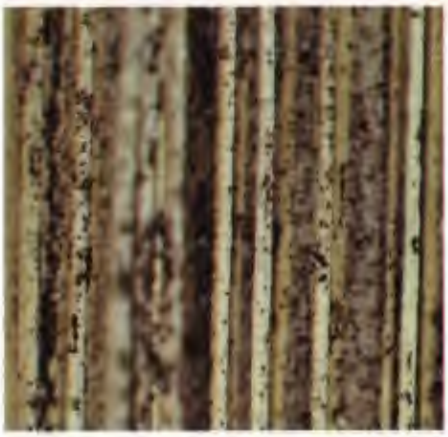

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False Head Smut

Ustilaginoidea virens

False head smut occurs very rarely in hot, dry or humid areas in isolated parts of the world. The fungus commonly infects rice flowers more than maize.

Symptoms differ from those caused by other smuts of maize. False head smut does not produce tassel malformation or ear infection as does true head smut *(Sphacelotheca reiliana);* only a few isolated male florets in the tassel show dark-green masses of spores (sori) (Photo 40). It also differs from common smut *(Ustilago maydis)* in that no galls are produced.

Botryodiplodia Stalk Rot

Botryodiplodia theobromae

The disease was first reported in India, but has been found in several other countries in Asia, Africa, and the Americas. It develops in hot, humid environments.

Diseased plants dry prematurely. Split-open stalks show some shredding of the pith and a dark gray to black discoloration of the vascular bundles. Abundant grayish mycelia are conspicuous in the rotten areas, confined mostly to the lower internodes above ground (Photo 41).

Unlike charcoal rot, *Botryodiplodia* stalk rot does not produce black pin-head-like sclerotia in the rotten areas, but it does produce abundant gray-blackish cottony mycelium in cavities formed in the pith of affected internodes.

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Diagnostic Key

Stalk

Black discoloration of stem; shredding of interior; bundles of black material.	Charcoal rot	50
Broken stalks; brownish pith; later, abundant fruiting bodies.	Diplodia stalk rot Gibberella stalk rot Fusarium stalk rot	63 64 64
Brown lesions; rotting.	Brown spot	2
Brown interior, starting in roots; wilting of plant at flowering.	Black bundle disease	49
Bushy plant; many tillers, chlorotic and reddish; stunting.	Maize bushy stunt disease	95
Dry plant; stalk interiors shredded and discolored; black, cottony masses.	Botryodiplodia stalk rot	54
Stunting; chlorosis; death around flowering time.	Maize lethal necrosis	103
Stunting; shortened internodes; green patches.	Maize chlorotic mottle virus	99
Stunting; chlorosis.	Maize chlorotic dwarf virus	96
Stunting, shortened internodes; axillary bud development; excessive root branching; chloritic streaks at bases of leaves.	Corn stunt disease	112
Twisting; dark internodes, soft and water soaked; lodging.	Pythium stalk rot	45
Water-soaked, dark areas at base of stalk; unpleasant odor.	Erwinia stalk rot	88

Leaf

Downy growth on leaf undersides; chlorosis; narrow, abnormally erect leaves.	Downy mildew	5
Lesions, with brown centers, about 2 mm in diameter.	Curvularia leaf spot	25
Lesions, beginning as small, regular, elongated, necrotic spots, and growing parallel to the veins.	Cercospora leaf spot	22
Lesions, coalescing to produce severe blotching and necrosis.	Septoria leaf blotch	37
Lesions, elongated, spindle-shaped, and necrotic; may coalesce to "burn" plant.	Turcicum leaf blight	30
Lesions, necrotic, elongated, with narrow yellow margins, along the veins.	Diplodia macrospora leaf stripe	33
Lesions, oval, necrotic, and parallel to the veins, later blighting the leaf.	Phyllosticta leaf spot	41
Lesions, oval, zonate, and brownish, or brown slender, and elongated.	Helmintho-sporium carbonum leaf spot	26
Lesions, pale green, along veins.	Bacterial leaf stripe	92
Lesions, round and translucent, developing tan centers, black-to-purple rings, and yellow haloes.	Eyespot of maize	38

Lesions, small, necrotic, coalescing into concentric necrotic spots.	Leptosphaeria leaf spot	18
Lesions, small, elongating along secondary veins, and often coalescing.	Maydis leaf blight	29
Lesions, spindle shaped.	Turcicum leaf blight	30
Lesions, water soaked, spreading along veins onto the stem.	Stewart's wilt	91
Mosaic pattern on youngest leaves; chlorotic streaks and general chlorosis, then purple-red; some stunting.	Maize dwarf mosaic	100
Pustules, small, round, light orange; later, turning black.	Southern rust	13
Pustules, small, powdery, dark brown; later, turning, black.	Common rust	10
Pustules, small, round-to-oval, surrounded by black epidermis.	Tropical rust	14
Rings, large, concentric, necrotic.	Zonate leaf spot	17
Spots, concentric, on leaves and sheaths; filamentous masses develop on lesions.	Banded leaf and sheath spot	42
Spots, shiny, raised and black; later, coalescing and drying foliage.	Tar spot	9
Spots, brown, small, and chlorotic.	Brown spot Leaf anthracnose	2 34
Spots, small, light green to yellow, turning brown.	Septoria leaf blotch	37

Spots, small and necrotic, with light colored haloes.	Curvularia leaf spot	25
Spots, small, oval, and water soaked.	Turcicum leaf blight	30
Spots, small and pale green, later becoming bleached, then necrotic, with a dark brown margin.	Phaeosphaeria leaf spot	21
Spots, small and whitish, coalescing into a line.	Fine stripe virus	108
Streaking, broken and yellow, beginning as small, round, spots.	Corn streak virus	111
Striping, becoming conspicuous.	Bacterial leaf stripe	92
Striping, chlorotic.	Maize chlorotic mottle virus Fine stripe virus	99 108
Striping, chlorotic; leaves appear crowded and erect; leaves rough, fleshy, dark purple.	Maize mosaic virus I	104
Striping, yellow and broad, turning purple toward leaf tips.	Corn stunt disease	112
Wilting, from top leaves, at tasseling stage.	Black bundle disease	49

Ear

Barrenness, or poor seed set.	Corn stunt disease	112
Black, shiny kernels; husks black and shredded.	Botrydiplodia (black kernel rot)	67
Blue-green powder on cob; streaked and bleached kernels.	Penicillium ear rots	75

Brown-green streaks on kernels, starting at cob base.	Cladosporium ear rot	84
Cottony, white-to-pink mold; some germination on the cob; streaks on the pericarp.	Gibberella ear rots	68
Lesions, oval, and larger than 2.3 cm on husks and leaf sheaths.	Maydis leaf blight, "T" strain	29
Lightweight, chaffy ears; loose, discolored kernels; black specks on kernels and cob.	Nigrospora ear rot	83
Lightweight ears; loose kernels; germination of seed on cob.	Tar spot	9
Nubbins, or ears with underdeveloped, shrunken kernels.	Black bundle disease	49
Nubbins or no ears at all.	Maize dwarf mosaic	100
	Downy mildew	5
Pink kernels, starting at ear tip.	Gibberella ear rots	68
Rotten and blackened ears.	Helminthosporium carbonum ear rot	26
Rotten ears; light brown cottony mold; filamentous masses on kernels and cob.	Banded leaf and sheath spot	42
Slimy, soft, pale, masses; hardening toward harvest.	Horse's tooth (ergot of maize)	72
Spore masses, black and loose, instead of ear.	Head smut	46
Spore masses, black, yellow-green, or whitish.	Aspergillus ear rots	76

Spots, concentric, on husks; white mold; filamentous masses.	Banded leaf and sheath spot	42
Underdevelopment of ear.	Maize stripe virus	107
White galls, closed; later, black spore masses.	Common smut	80
White-gray mold between kernels; husks bleached and adhering to each other.	Gray ear rot	79
White mold; gray-brown ear; black fruiting bodies; husks adhering to ear.	Diplodia ear rot	87
Yellow, loose kernels; black filamentous masses.	Charcoal ear rot	71

Tassel

Malformation and enlargement; black spores in florets.	Head smut	46
Malformation; sterility.	Downy mildew	5
Malformation.	Maize chlorotic mottle virus	99
Rotten tassel, enclosed in dead leaves.	Bacterial leaf stripe	92
Spore masses, hard and black on a few florets.	False head smut	53
Sterility; some male florets in tip of ear.	Corn stunt disease	112
Stunting and bending.	Maize stripe virus	107

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Diplodia Stalk Rot

Diplodia maydis

Susceptible cultivars of maize grown in cool, humid temperate areas are commonly affected, characteristically by browning of the pith of basal internodes (Photos 42, 43). They are weakened and break easily during strong winds and rains. Late in the season, the most conspicuous symptom is abundant pycnidia on the surface of damaged internodes where rotting has occurred.

Gibberella and Fusarium Stalk Rots

Fusarium spp.

Two species of *Fusarium* are responsible for stalk rots in maize:

Fusarium moniliforme (perfect stage *Gibberella fujikuroi)* is most common in dry, warm areas; it is particularly severe when plants approach tasseling (Photo 44).

Fusarium graminearum (perfect stage *Gibberella zeae)* is prevalent in cool regions. It is one of the most potentially damaging stalk-rotting agents (Photo 45).

Symptoms produced by these pathogens resemble those caused by *Diplodia* and by *Cephalosporium*, and cannot be differentiated until fruiting bodies are observed. Wilted plants remain standing when dry, and small, dark-brown lesions develop in the lowest internodes. When infected stalks are split, the phloem appears dark brown, and there is a general conspicuous browning of tissues.

In the final stages of infection, pith is shredded and surrounding tissues become discolored.

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Botryodiplodia or Black Kernel Rot

Botryodiplodia theobromae

The disease has been reported in Nigeria, India, Pakistan, and Thailand, and to a lesser extent in the Americas. The same fungus can also produce stalk rot with a conspicuous black discoloration in moist, hot environments.

Affected ears develop deep black shiny kernels (Photos 46, 47), and husk leaves can also turn black and be shredded.

There are no reports indicating economic losses due to this disease where it has been identified.

Gibberella Ear Rots

Gibberella zeae
(Imperfect stage *Fusarium graminearum*)

Gibberella fujikuroi
(Imperfect stage *Fusarium moniliforme*)

In maize, these two species of fungi cause ear rots, stalk rots and seedling blights. *Gibberella zeae* is most common in cool and humid areas of the world and produces a reddish-pink color in infected kernels, starting at ear tips (Photo 48).

Gibberella fujikuroi is known as fusarium kernel rot. It is likely the most common pathogen of maize ears throughout the world, in hot and humid, or in dry weather. In contrast to that of *G. zeae*, damage by *G. fujikuroi* occurs mainly on individual kernels, or on limited areas of the ear (Photos 49, 50). Infected kernels develop a cottony mold, and they may germinate while still on the cob. Kernels infected late in the season develop streaks on the pericarp, and ears invaded by earworms are usually infected with *G. fujikuroi*. The fungus produces organic compounds toxic to mammals and birds.

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Charcoal Ear Rot

Macrophomina phaseoli

Like charcoal stalk rot, the disease can be found in hot, humid areas with dry periods, mainly during flowering time. At harvest, the kernels are pale yellow, and the ear is loose and chaffy. Kernels are easily removed from the cob, and they show small, round, black, pin-head-like sclerotia growing on the surface (Photos 51, 52, 53).

Plants affected by charcoal stalk rot do not necessarily develop ear rot by the same pathogen.

Horses's Tooth, Ergot of Maize

Claviceps gigantea

This disease (imperfect stage *Sphacelia* spp.) is endemic to certain high, cool humid areas of the central plateau of Mexico. Infected kernels grow modified as large sclerotia along with normal healthy kernels (Photo 54). In early stages of infection, sclerotia are pale colored, soft and slimy, finally hardening towards harvest time. These sclerotia do not produce the black powder characteristic of common smut. When sclerotia are dropped on the ground, they germinate and develop many head-like structures (stromata) which will release new spores when maize plants are silking next season (Photo 55).

The pathogen is closely related to the one that causes ergot of rye, and it also produces toxic alkaloids.

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Penicillium Ear Rots

Penicillium spp.

Damage is most frequently caused by *Penicillium oxalicum;* occasionally, other species may be involved. In many instances, infection is associated with ear damage by insects.

A conspicuous light blue-green powder grows between kernels and on the cob surface (Photos 56, 57). Kernels with fungal growth normally become bleached and streaked.

Aspergillus Ear Rot

Aspergillus spp.

The disease may be a serious problem when infected ears are stored with a high moisture content. In the field, several species of *Aspergillus* can infect maize (Photo 58). *A. niger* is the most common; it produces black powdery masses of spores covering both kernels and cob. In contrast, *A. glaucus*, *A. flavus* and *A. ochraceus* normally form yellow-green masses of spores.

Most *Aspergillus* species produce organic compounds known as aflatoxins, which are toxic to birds and mammals.

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Gray Ear Rot
Physalospora zeae

Hot, humid weather for several weeks after pollination favors development of this ear rot. Early symptoms are very similar to those caused by *Diplodia* ear rot; a white-gray mold develops between kernels, and husks become bleached and glued together. In later stages of infection, the two fungi can be readily identified:

(a) Gray ear rot. Ears have a distinct black color; mold is also dark and develops small sclerotia (specks) scattered throughout the cob (Photo 59, courtesy Dr. A.J. Ullstrup).

(b) *Diplodia* ear rots (see page 81). Ear is gray-brown and mold is white, with small black pycnidia on cob and kernels

Common Smut

Ustilago maydis

Common smut occurs throughout most maize growing regions, but can be more severe in humid, temperate environments than in hot, humid areas.

The fungus attacks stalks, leaves, ears, and tassels (Photos 60, 61, 62). Conspicuous closed white galls replace individual kernels. In time, the galls break down and release black masses of spores which will infect maize plants the following season. The disease is most severe in young, actively growing plants and may stunt or kill them.

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Nigrospora Ear Rot

Nigrospora oryzae

The disease is widely distributed, and the causal fungus normally overwinters on plant refuse.

Infected ears are chaffy and lightweight. Kernels are discolored and can easily be removed from the cob. Under close examination, cob tissues and kernel tips show small black masses of spores (Photos 63, 64).

Cladosporium Ear Rot

Cladosporium herbarum (syn. *Hormodendrum cladosporoides*)

The disease has not been reported to be of economic importance.

Dark brown-green streaks, on kernels, start at kernel and cob bases. When damage is complete, ears look dark and lightweight (Photo 65). In some instances, fungal penetration is associated with mechanical injury to kernel tips.

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Diplodia Ear Rot

Diplodia maydis, D. macrospora

Diplodia ear rots are commonly found in hot, humid maize-growing areas.

Maize ears show characteristic development of irregular bleached areas on husks. These areas enlarge until the husks become completely dried, although the plant is still green. If husks are torn apart, ears appear chaffy and bleached, with a white cottony growth between the kernels (Photo 66). Late in the season, many small black pycnidia form on kernels and cob tissues (Photo 67). These pycnidia serve as sources of inoculum for the following crop.

Stalk Rot

Erwinia carotovora f. sp. *zeae*

The pathogen spreads rapidly and quickly kills the host plant in areas with high relative humidity and temperature.

Infected plants show dark color and water soaking at the base of the stalk (Photos 68, 69). Plants die shortly after tasseling.

The bacterial decomposition produces an unpleasant odor.

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Stewart's Wilt

Erwinia stewartii

The pathogen is transmitted by seed and by certain maize beetles *(Chaetocnema pulicaria)*. Infection occurs in early stages of plant development; infected plants grow abnormally and often die shortly after tasseling.

Feeding wounds from the insect vectors serve as pathogen points of entry. Water-soaked, oval lesions develop on leaves around these entry points. Water soaking continues along the veins, and lesions coalesce and cause complete leaf necrosis. Damage may spread into stems and cause a general wilting of the plant (Photos 70, 71).

Bacterial Leaf Stripe

Pseudomonas rubrilineans

No substantial crop damage has been reported from this disease, although it may be of concern where susceptible germplasm is being utilized in certain hot and humid areas of the world.

Bacterial stripe affects susceptible maize plants from seedling to post-pollination stages. Leaves develop several small, pale-green lesions. Under optimum weather conditions, lesions expand along veins producing a conspicuous striping, mainly in the youngest leaves; stripes later dry and brown (Photos 72, 73). Severe damage of the top leaves results in tassel rotting because the tassel is enclosed by dead leaves.

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Maize Bushy Stunt Disease (MBSD)

This disease has been reported only in some countries of Central and South America, the Caribbean, and southern United States. Originally, the causal agent was identified as the "Mesa Central" strain of the corn stunt virus ("Achaparramiento"), but recently it has been reidentified as a non-helical mycoplasma.

MBSD is more common in relatively cooler areas; the "Rio Grande" strain is favored by hot and humid environments.

Infected plants show marginal chlorosis on young leaves, and tips gradually turn purple-red as they approach maturity. The most conspicuous symptom is the bushy appearance due to proliferation of tillers, which also become chlorotic and reddish (Photo 74). Axillary buds develop into barren shoots. Plant and root development are decreased, and yield is greatly reduced.

The disease is transmitted by the cicadellid leafhoppers *Dalbulus maidis* (De L. and Wolc.), *D. elimatus* (Ball.), and *Graminella nigrifrons* (Forbes).

Maize Chlorotic Dwarf Virus (MCDV)

Infected plants initially show small chlorotic spots developing later into a general chlorosis in the whorl leaves (Photo 75). Plants become stunted due to shortening of internodes, and leaves may become reddish late in the season, resembling the reddening symptoms of corn stunt disease. So far, this disease has been found only in continental United States, but probably has a wider distribution. It is known to be transmitted by the leafhoppers *Graminella nigrifrons* (Forbes) and *G. sonora* (Ball).

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Maize Chlorotic Mottle Virus (MCMV)

In early stages, the youngest leaves show fine chlotoric spots which coalesce and develop into broad chlorotic stripes along the veins. These chlorotic stripes contrast with dark green tissue when observed against the light (Photos 76, 77). Leaves showing chlorosis finally die. Plants are stunted because of shortened internodes. Infected plants produce fewer and smaller ears. In most cases, male inflorescence is malformed.

The virus is mainly transmitted by several chrysomelid flea beetles, such as *Chaetocnema pulicaria* Melsh. and *Diabrotica* spp. Reports indicate that it is not seed transmitted.

When MCMV is in combination with maize dwarf mosaic virus (MDMV) or wheat streak mosaic (WSMV), they produce a severe reaction known as maize lethal necrosis (MLN).

Maize Dwarf Mosaic Virus (MDMV)

The virus is transmitted by sap and by aphids, mainly *Rhopalosiphum maidis*. This pathogen is closely related to sugar cane mosaic virus and affects other grass and cereal hosts, such as maize, sorghum, Johnson grass, and sugarcane. No infection occurs on broad-leaf plants. Infected plants develop a distinct mosaic (irregularities in the distribution of normal green color) on the youngest leaf bases. 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 (Photos 78, 79). As plants approach maturity, the foliage turns 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. Axillary buds proliferate in some cases.

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Maize Lethal Necrosis (MLN)

This disease is caused by a combination of two viruses, maize chlorotic mottle virus (MCMV) and either maize dwarf mosaic virus (MDMV) or wheat streak mosaic virus (WSMV), infecting simultaneously the same plant. (No lethal necrosis will develop if MDMV and WSMV occur together.) Infected plants are short. The leaves show chlorosis and die at about flowering time (Photo 80). There is no ear development in plants infected during early stages of growth.

Maize Mosaic Virus I (MMV)

The disease has been found in Cuba, Hawaii, Trinidad, Venezuela, and Puerto Rico. *Peregrinus maidis* (Ashm.), a leafhopper, transmits the virus to maize and a few other graminaceous hosts. Plants are most susceptible when inoculated 4 to 6 weeks after emergence. The most conspicuous symptom is dwarfing of infected plants and striping along the veins (Photos 81, 82).

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 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.

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Maize Stripe Virus (M Stp V)

This disease has been reported in several tropical countries in Africa, the Americas, 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 extend from the base to the tip of the leaves (Photos 83, 84). Infected plants usually show stunting and bending of the tassel. Normally ear development and yield are reduced.

The virus is transmitted mainly by the leafhopper *Peregrinus maidis* (Ashm.). Neither sap nor seed transmission of the disease agent has been reported.

Maize Fine Stripe Virus (MRFV)

"Rayado fino," or fine stripe, is caused by a virus transmitted by the leafhopper *Dalbulus maidis* (De L. and W.), which is also a vector of corn stunt disease. This virus has been observed, in Central America, to reduce yields by as much as 43 percent.

Symptoms develop about 2 weeks after plants have been inoculated. They begin as small isolated chlorotic spots easily observed by holding leaves against the light. Later, the spots become more numerous and fuse, forming 5 to 10 cm stripes which advance along the veins (Photos 85, 86). If infected at tasseling time, plants may not show symptoms.

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Corn Streak Virus (CSV)

The disease, reported first from East Africa, has now extended to many other African countries. The virus is transmitted by *Cicadulina* spp. leafhoppers; *C. mbila* (Naudé) is the most prevalent vector. Early disease symptoms consist of very small, round, scattered spots in the youngest leaves. 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 87, 88).

Corn Stunt Disease (CSD)

Corn stunt was originally reported from California, USA, in 1942. Since then it has been observed in hot humid lowlands of several countries of Central and South America, the Caribbean, and southern USA. Although the disease was originally reported to be caused by the Rio Grande strain of the corn stunt virus ("Achaparramiento"), the pathogen has been reidentified as a helical mycoplasma or *Spiroplasma.*

Infected plants show broad yellow stripes at the base of younger leaves, which might turn purple-red towards the tip. Normally, plants become stunted due to shortening of internodes; axillary buds develop as barren shoots, and there is excessive root branching (Photos 89, 90). In severe cases, plants are barren or there is poor seed set. Plants die prematurely. The disease is transmitted by the cicadellid leafhoppers *Dalbulus maidis* (De L. and Wolc.), *D. elimatus* (Ball.), *Graminella nigrifrons* (Forbes) and others less important.

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