9 Cucurbits (cucumber, melon, pumpkin, squash, zucchini)

Figures *9.1* to *9.22*

BACTERIAL DISEASES

▶ 9.1 Angular leaf spot *Figs. 9.1a,b; 22.1*

Pseudomonas syringae pv. *lachrymans* (E.F. Smith & Bryan) Young *et al.*
(syn. *Pseudomonas lachrymans* (E.F. Smith & Bryan) Carsner)

Angular leaf spot has been reported on field-grown cucurbit crops throughout Canada. It is fairly common and moderately severe on the pickling cucumber crops of southern Ontario, where it affects fruit quality.

The pathogen infects mainly cucumber, but all members of the Cucurbitaceae family are susceptible to some degree.

Symptoms The first symptoms are often noticed soon after crop emergence. Small, round or somewhat irregular water- soaked spots appear on the surface of the cotyledons. Under humid conditions, these spots may ooze droplets of liquid containing bacteria, mostly from the leaf underside. On older leaves, the spots spread until they are confined by the veins, giving them a characteristic angular appearance (*9.1a; 22.1)*.

After a few days, the spots dry and turn yellow-brown, and their centers may fall out leaving angular shot-holes *(9.1b)* and tattered leaves. Stems and petioles are also affected by water-soaked areas that later dry to form a whitish crust. Similar spots appear on developing fruit. These are minute and water-soaked at first but later dry and crack, revealing a chalky tissue below. The spots remain mostly superficial. Diseased plants grow poorly and yield losses are possible because of the reduced photosynthetic area. Affected fruit is unmarketable.

Causal agent *Pseudomonas syringae* pv. *lachrymans* is readily isolated from the margin of the lesion. It is an aerobic, non-sporing, motile rod with one to five polar flagella. The cells measure 0.8 by 1 to 2 µm. On beef-peptone agar, colonies are slightly raised, smooth, glistening, and transparent to white with the margin entire. On nutrient agar, levan production results in white mucoid colonies. Acid without gas is formed from glucose, fructose, mannose, arabinose, xylose, sucrose and mannitol. Starch is not hydrolysed and cellulose is not attacked.

Disease cycle Infection is usually initiated in the cotyledons from contaminated seed. It occurs through hydathodes, stomata and wounds when plants are wet. The bacteria multiply rapidly in the intercellular spaces. They also have been recovered from floral parts, suggesting flowers as portals for bacterial invasion of seed. The optimum temperature for disease development is 24 to 27°C. The disease spreads rapidly in rainy weather and when overhead irrigation is used. Bacteria ooze from the leaf spots and are dispersed readily by splashing water, machinery and workers moving through wet crops. Bacteria are washed from diseased leaves into soil by rainfall or overhead irrigation or enter soil when plant parts die or fall at the end of the season. They may survive in association with roots of the host plant and provide inoculum for seedling infection the following season. It is likely that insects also spread the bacteria. They may allow entry of secondary soft-rot organisms. As the fruit ripens, the tissue may rot to the seeds, contaminating them with bacteria. If the bacteria gain access to the vascular system, they can spread rapidly through the plant.

Management

Cultural practices — Pathogen-free seed should be used. Seed from infected crops should never be saved. A two-year rotation from cucurbit crops is recommended. Growers should avoid using fields with cold, wet soils and sites that are poorly ventilated. Infested crop residues should be turned under promptly after harvest to aid the decomposition of plant residue. Furrow irrigation should be used rather than overhead sprinklers. Growers should avoid working in cucurbit crops when the foliage is wet.

Resistant cultivars — Differences in susceptibility among cucumber, squash and melon cultivars have been noted. Seneca Trailblazer and Slice Nice cucumber are resistant to angular leaf spot. Seed catalogs should be consulted for current information on resistant cultivars.

Chemical control — Copper-based bactericides are registered for angular leaf spot control in Canada, but they are largely ineffective and may serve only to spread the bacteria. Chemical seed treatments also are not consistently effective.

Selected references

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(Original by W.R. Jarvis)

▶ 9.2 Bacterial wilt *Figs. 9.2a,b*

Erwinia tracheiphila (E.F. Smith) Bergey *et al.*

Bacterial wilt is quite common in field-grown cucurbit crops and can be locally severe wherever the beetle vector is prevalent. This disease is best known on cucumbers, but it also affects other cucurbits. Squash, watermelon and cantaloupe are generally less susceptible than cucumber.

Symptoms The disease first appears on leaves as dull green patches that rapidly increase in size. The leaf lobe wilts, soon followed by the rest of the leaf, the branch and then the whole plant. Typically, the centers of rows are worse affected. The vascular system becomes blocked by the build-up of wilt bacteria, causing the plants to wilt and die *(9.2a,b).* Leaves along infected runners wilt, one leaf at a time, until the whole runner is affected. Wilted plants may appear to recover at night but they wilt on successive sunny days, eventually turning yellow and dry. Significant losses in yield may result.

From petiole sections in water on a microscope slide, the bacteria can be seen oozing out as a milky exudate. Another diagnostic character is the stringing out of bacterial gum when a petiole is cut cleanly across and the two surfaces are touched together then slowly drawn apart. In cross sections, bacteria can be seen in the xylem.

Causal agent *Erwinia tracheiphila* is a Gram-negative, motile rod measuring 0.5 to 0.7 by 1.2 to 2.5 µm, with four to eight peritrichous flagellae. It grows poorly on nutrient agar but moderately well on glucose-yeast extract-calcium cabonate agar or glucose-nutrient agar. Colonies on most media are grayish white to cream, circular, smooth and glistening. They are levan-negative and neither domed nor mucoid on nutrient agar. Some strains utilize formate and citrate, but not tartrate, lactate or galacturonate. Acid but no gas is produced from glucose, fructose, galactose, sucrose and a-methyl D-glucoside.

Disease cycle The pathogen is entirely dependent on spotted and striped cucumber beetles for its transmission. Wilt bacteria overwinter in the gut of adult beetles, which can transmit them to the leaves while feeding. Beetle excreta may also contain the pathogen, which can infect plants through feeding punctures and other wounds made by insects, windblown sand or machinery. The bacteria must swim or otherwise be introduced directly into the vascular system of the plant. Because the beetles are less active in wet weather, the disease is spread from plant to plant mostly on dry days. Seed transmission is not known. Temperatures over 30°C retard disease development.

Management Prevention lies in control of cucumber beetles (see cucumber beetles, 9.21). Once the bacteria have invaded the vascular tissues of cucumber plants, control is impossible.

Cultural practices — Wild or volunteer cucurbits should be eliminated from areas adjacent to cucurbit fields.

Resistant cultivars — There are no highly resistant cultivars, but those that flower later tend to be less affected than early flowering types.

Selected references

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(Original by W.R. Jarvis)

FUNGAL DISEASES

▶ 9.3 Anthracnose *Figs. 9.3a-c*

Colletotrichum orbiculare (Berk. & Mont.) Arx
(syn. *Colletotrichum lagenarium* (Pass.) Ellis & Halst.)(teleomorph *Glomerella lagenaria* F. Stevens)

Anthracnose in the Cucurbitaceae is caused by a seed- and soil-borne fungus that is widespread and can cause severe losses, particularly in wet summers. The pathogen infects cucumber, watermelon, squash, pumpkin and a few other cucurbits. Marrow appears to be immune.

Symptoms All parts of the plant are attacked, although symptoms vary from host to host. On cucumber leaves, dry lesions first appear on a vein. They become somewhat angular and red-brown, sometimes with a translucent yellowish border *(9.3a).* Dead tissue may drop out of the center of the lesion. Young leaves with multiple lesions become crinkled and distorted *(9.3b).* Lesions on stems and petioles are elongate, slightly shrunken, water-soaked and yellowish. Their surfaces become dry and chalky, and the stem may easily break. Cucumber fruits have lesions that are roughly circular, sunken and water-soaked. Tiny, black, saucer-shaped fruiting bodies (acervuli) form along the veins. The acervuli are numerous and easily seen with a hand lens or the naked eye, particularly when the center of old lesions turns white.

Symptoms on melon and other cucurbits generally resemble those on cucumber. Melon is more severely attacked, with deeper, larger, more sunken lesions. A reddish gummy exudate may form on the lesions. Muskmelon may be completely defoliated because of the severity of lesions on the petiole. Fruit lesions are very conspicuous *(9.3c).* On watermelon leaves, the lesions are black rather than red or brown. Fruit may be infected early, becoming severely misshapen with black lesions. Lesions on older fruits are somewhat raised, flat-topped and circular, and are sometimes called nail-head spots. Under humid conditions, pink spore masses form on the black acervuli of the causal fungus.

Causal agent Acervuli of *Colletotrichum orbiculare* occur on a brown to black stroma on the surface of the host. Setae are not constant but, if present, they are two- to three-septate, brown, stiff, 90 to 120 µm, and taper to a point. Conidia are unicellular, hyaline, oblong or obovate-oblong, slightly pointed, somewhat variable in shape, and measure 13 to 19 by 4.6 µm. The conidia are borne singly on conidiophores. They form a slimy pink mass held by the setae until splash-dispersed. Sclerotia apparently form by the further development of stromatic tissue. Conidia germinate to produce a brown, thick-walled, ovoid to spherical appressorium. Infection occurs from the appressorium on which a round germ pore may be seen.

The pathogen is readily cultured on potato-dextrose agar and other routinely used media. Conidia may form all over the colony rather than on acervuli. Although there is considerable variation in cultural characters between isolates, colonies are usually hyaline at first, then become pink to black. Some isolates form black sclerotia in culture. Seven races have been described on the basis of pathogenicity. Race 1 attacks butternut squash moderately and is virulent on cucumber. Race 2 is moderately virulent on butternut squash and highly virulent to watermelon and cucumber. Race 3 causes flecks on Congo, Charleston Gray and Fairfax watermelon and is highly virulent on cucumber. Race 4 is unable to attack both watermelon and cucumber cultivars, while race 5 is weakly virulent on cucumbers and highly virulent on watermelons. Race 6 is weakly virulent on cantaloupes and highly virulent on watermelon, and race 7 is weakly virulent on Pixie cucumber, which distinguishes it from race 3.

Disease cycle The disease appears in the field rather late in most seasons, at first in isolated and restricted foci. Spread is largely dependent on splashing water. The disease spreads quickly after heavy, windy rainstorms typical of continental late summers. Spread is also rapid after overhead irrigation, and the disease will follow run-off down slopes. The optimum temperature for epidemic development is about 24°C. Generally, five or six days are required for symptom development. Lesions increase in size more rapidly and conidial production is greater on older versus younger leaves. Increases in the wetting period of leaves at night causes increased conidial production. Disease development that occurs later than 40 to 50 days after planting is unlikely to affect yield. Spores can be spread by workers and tools such as hoes. The fungus is seed-borne. It also overwinters in the field in crop residues, which accounts for about 90% of primary infections the following year. Seed becomes infested during extraction from infected fruit.

Management

Cultural practices — Crop rotation is the primary control for anthracnose, as is the use of pathogen- free seed. Infested crop residues should be plowed under promptly after harvest. Growers should avoid overhead irrigation and avoid working cucurbit crops when they are wet.

Resistant cultivars — Since the fungus exists in a number of specialized races, it is essential to know which races are prevalent in a given area before deciding which cultivars to grow. Resistance to race 2 has been incorporated into commercial cucumber cultivars for many years.

Chemical control — Fungicidal sprays are generally not very effective, because they fail to reach the fungus on the underside of leaves and fruit. Seed treatment fungicides may help to lower the risk of infection from contaminated seed.

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(Original by W.R. Jarvis)

▶ 9.4 Choanephora rot

Choanephora cucurbitarum (Berk. & Ravenel) Thaxt.

The fungus is principally a pathogen of squash, but it also attacks plants both within and outside the Cucurbitaceae family, for example chili peppers *(Capsicum* spp.) and *Amaranthus* sp. It is very uncommon on squash and has not been seen at all on other hosts.

Symptoms The fungus covers the flowers and fruits of squash. It first appears the day after the flowers open and by the second day, especially after a rain, it will have developed fully. Senescent flowers become covered by immature, white conidial heads that rapidly turn brown, then purple-black. Abscission of the male flowers occurs before the fungus reaches the pedicel. Female flowers remain attached, allowing the fungus to pass into the young fruit where it produces a soft, wet rot with profuse conidial development on luxuriant conidiophores that have a distinct metallic sheen.

Causal agent *Choanephora cucurbitarum* produces erect, aseptate conidiophores. The tip broadens into a capitate vesicle bearing several ramuli on which the conidia develop. Conidia are oval to elliptical with conspicuous striations, measure 15 to 25 by 7 to 11 µm, and are light brown to red- brown. The base of each conidium bears a hyaline appendage (the broken sterigma) and the vesicle retains the attachment scar. Sporangia also develop, usually at the center of the plate. They are pendant, white, globular swellings at first. The sporangium becomes separated from the sporan- giophore by a globular columella. At maturity, the sporangia are black, 35 to 160 µm, some being markedly smaller. The sporangia contain numerous light to red-brown, ovoid to elongate spores, which measure 18 to 30 by 10 to 15 µm. The spores lack striations but have two or three hyaline terminal appendages, each consisting of 12 to 20 hair-like hyaline processes in tufts, one to one-and-a-half times the length of the spore. Globose to oblong-ellipsoid chlamydospores form in chains in old cultures. Zygospores, the sexual stage, form between the tips of two hyphae. They also store food for survival. Zygospores are dark brown at maturity and measure 50 to 90 µm in diameter.

The fungus is easily cultured on standard media, such as potato-dextrose agar, but is very variable according to the medium. It forms two fruiting structures in culture: sporangia are formed at high temperatures (25 to 31°C), and conidia are formed in low sugar - high thiamine media in continuous low light or after a bright light - darkness regime.

Disease cycle The fungus produces thick-walled zygospores and chlamydospores that enable it to survive from season to season in crop residues. It is transmitted by bees, cucumber beetles, wind, rain and splashing water.

Management

Cultural practices — Crop rotation is the chief means of control. Adequate spacing of plants to allow for good air circulation within the crop canopy also is important. Growers should avoid the use of overhead irrigation where possible. Cucumber beetles should be controlled when present (see cucumber beetles, 9.21).

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(Original by W.R. Jarvis)

▶ 9.5 Fusarium foot rot *Fig. 9.5*

Fusarium acuminatum Ellis & Everh.
Fusarium equiseti (Corda) Sacc.
Fusarium poae (Peck) Wollenweb.
Fusarium redolens Wollenweb. (syn. *Fusarium oxysporum* var. *redolens* (Wollenweb.) W.L. Gordon)
Fusarium solani (Mart.) Sacc.
Fusarium solani f. sp. *cucurbitae* W.C. Snyder & H.N. Hans.

Fusarium solani may also attack greenhouse cucumber (see Greenhouse cucumber, crown and root rot, 22.7). All cucurbit crops are susceptible to *Fusarium solani* in the seedling stage. A new race of *F. solani* was isolated in 1987 in the Netherlands, first from zucchini then from nine cultivars of six species of Cucurbitaceae. Other *Fusarium* species also may attack cucurbits, but less commonly than *F. solani. Fusarium solani* f. sp. *cucurbitae* race 1 attacks the hypocotyl, causing a cortical stem rot; it also attacks mature fruit. Fusarium foot rots are not common.

Symptoms A cortical rot at the base of the stem and the upper part of the root system may occur at any time after seedling emergence, usually in cold wet soils. In severe cases, flats of seedlings may have a damped-off appearance similar to that caused by *Pythium* spp. Young tissue is water-soaked but older tissue displays little soft rot unless secondary organisms become established. The rot is frequently associated with stem splitting, perhaps a result of uneven growth and stem thickening. The affected area is yellow to pale gold-brown and usually girdles the stem and extends for several centimetres up mature stems. Discoloration extends to the center of the stem. The root system may decay to varying degrees (9.5) and adventitious root initiation may be stimulated.

Causal agent *Fusarium solani* f. sp. *cucurbitae* exists in two races: one attacks hypocotyls causing a cortical stem rot; the other attacks only fruit.

Fusarium solani forms a somewhat sparse, floccose, gray-white mycelium in culture, often with a bluish to blue-brown discoloration in the agar. Microconidia on long lateral phialides are abundant, hyaline, cylindrical to wedge-shaped, and measure 9 to 16 by 2 to 4 µm. Macroconidia form on branched conidiophores. They are cylindrical to falcate, slightly wider near the apex, have a conspicuous foot cell, and measure 40 to 100 by 5 to 7.5 µm. Chlamydospores are globose to ovoid, smooth or rough, intercalary or terminal, and measure 10 to 11 by 8 to 9 µm.

Isolation followed by inoculation tests are necessary to confirm the identity of the pathogen, especially where race 1 of *F. solani* f. sp. *cucurbitae* is suspected.

(For descriptions of other *Fusarium* spp., see Selected references.)

Disease cycle *Fusarium* species are soil inhabitants, surviving for five years or more in the absence of the host. *Fusarium solani* was shown to be seed-borne in zucchini in the Netherlands, where it attacked young plants faster than old ones, and wounded plants more severely than unwounded ones. There were differences in susceptibility among cultivars. Infection also occurred directly from residues in the soil. Generally, this fungus is a facultative parasite of wounds and of plants weakened by poor growing conditions, nematodes or other diseases. It is a cortical pathogen, rather than a xylem inhabitant like *Fusarium oxysporum.* It is spread by splashing rain and in irrigation water. Sand-blast pock marks often become infected in the field. This rot is most severe in dry soils at soil temperatures of 26 to 28°C.

Management

Cultural practices — Growers should maintain good even growth in their crops and follow rotations of at least three years, particularly if the specialized race of *Fusarium solani* is present. Adequate soil moisture is beneficial and irrigation, preferably by drip, should be provided in dry summers. Cucurbit crops should not be planted in fields where foot rot has been severe.

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(Original by W.R. Jarvis and R.J. Howard)

▶ 9.6 Fusarium wilt *Figs. 9.6a,b; 22.9a,b*

Fusarium oxysporum f. sp. *cucurbitacearum* Gerlagh & Blok
(syn. *Fusarium oxysporum* f. sp. *cucumerinum* J.H. Owen)
(syn. *Fusarium oxysporum* f. sp. *melonis* W.C. Snyder & H.N. Hans.)

The fungus may be present in symptomless hosts, including weeds, but it is pathogenic only to Cucurbitaceae. Fusarium wilt is not a common disease.

Symptoms The disease is expressed either as a slow wilt, with progressive yellowing (*9.6a; 22.9b)* of the foliage, or occasionally as a sudden wilt without previous yellowing. In either case, wilting is more severe at times of water or temperature stress on the plant *(9.6b).* Sometimes, very young plants may wilt. Typically, the veins of some leaves turn yellow on one side. This discoloration spreads to the lamina, which thickens and becomes brittle. On stems, longitudinal brown streaks appear *(22.9a),* often exuding gum. In the final stages of the disease, the fungus forms pinkish cushions of spores. The vascular tissue of infected stems is orange-red to brown. This discoloration is sometimes on the side of the stem corresponding to wilted leaves. Fruit does not develop properly and remains flaccid. In situations of high inoculum density and optimum soil temperature, pre- and post-emergence damping-off may occur.

In melon, a faint smell of violets on the leaves of affected plants is considered diagnostic.

Causal agent Earlier accounts of fusarium wilt attributed the disease to different pathogenic forms of *Fusarium oxysporum*, depending upon which cucurbit crops were attacked; for example, *F. oxysporum* f. sp. *melonis* on muskmelon and cantaloupe and f. sp. *cucumerinum* on cucumber, each divided into races depending on the groups of cultivars attacked. In 1988, all forms were merged into f. sp. *cucurbitacearum.*

Differentiation on the basis of pathogenicity of different isolates from cucurbit hosts cannot be done confidently. In seedling tests, isolates are not species specific, often attacking several genera. Mature plants are more exclusively attacked by the corresponding form but notable exceptions occur. For example, some isolates from cucumber cause more wilt on melon than on cucumber. Generally, but not invariably, cucumber and marrow are resistant to isolates from melon.

Fusarium oxysporum f. sp. *cucurbitacearum* is morphologically indistinguishable from many other forms of *F. oxysporum.* It has three- to five- septate, fusoid-falcate macroconidia measuring 27 to 60 by 3 to 5 µm with a somewhat hooked apex and a pedicillate base. The microconidia are borne on short, simple or sparsely branched conidiophores, are oval-ellipsoid, cylindrical, straight or slightly curved, and measure 5 to 12 by 2 to 3.5 µm. Chlamydospores, which are about 10 pm in diameter, are abundant in dead tissues and generally solitary, intercalary or terminal. The mycelium is white to peach-colored, sometimes with a purple tinge. It is sparse to abundant, floccose, and felty in older cultures. Optimum growth in culture occurs at 27 to 30°C. The fungus is readily isolated on general media, but selective media are available.

Disease cycle Soils that are regularly associated with plants having severe symptoms are known as conducive, while those that are not, even in the presence of the pathogen, are classed as suppressive. A much greater population of chlamydospores is required to induce disease in suppressive soils than in conducive soils. The potential of a soil to induce wilt can be assessed by infesting it artificially with *Fusarium* inoculum and growing susceptible plants in it. Suppressiveness is generally associated with soils high in montmorillonite clay and with the antagonistic microorganisms supported in these alluvial soils. The resting chlamydospores of the fungus survive for extremely long periods in soil. They can be killed only by heat or chemical fumigation.

In muskmelon, fusarium wilt is more severe in certain soils than in others. Wilt symptoms are most severe between 18 and 22°C and are rare at 30°C, even in infected plants. Poor light and a decreasing day length increase the severity of fusarium wilt. The disease is more severe in dry soils and when the air is relatively dry, with a relative humidity of 50 to 65%. Wilting is less severe at higher humidities. The pathogen is rarely seed-borne.

Management

Cultural practices — Excessive nitrogen from over-manuring favors this disease. Severity can be decreased by adding potassium, to induce a high K:N ratio, or calcium to the soil. In hot summers, solar heating of soil to 40°C for about 100 hours under polyethylene film mulch is effective, but the land will be out of production for at least four to six weeks. Soils intended for muskmelon production can be assayed for disease suppressiveness, as noted above. This is essential because crop rotation is not very effective.

Resistant cultivars — There are resistant cultivars of muskmelon of the type Delicious 51, e.g. Golden Gopher, Iroquois, Fairfax and Harvest Queen. However, at least three pathovars of the melon form of *Fusarium oxysporum* f. sp. *melonis* exist, so resistance depends on a cultivar having one or more resistance genes, of which two, *Fom1* and *Fom2,* are known. Persian Small Type, Chaca No. 1, Doublon and Orlinabel have *Fom1.* Many Asiatic cultivars have *Fom2.* Certain cultivars, such as Kogane, Nashi, Makuwa and Ogon 9, have a more general resistance, dependent on several genes.

Chemical control — Fumigation is very expensive and is feasible only for very early crops.

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(Original by W.R. Jarvis)

▶ 9.7 Gray mold *Figs. 9.7; 22.10a-d*

Botrytis cinerea Pers.:Fr.
(teleomorph *Botryotinia fuckeliana* (de Bary) Whetzel)
(syn. *Sclerotinia fuckeliana* (de Bary) Fuckel)

Gray mold can cause considerable damage on cucurbit crops in cool, humid conditions. It is a major disease throughout Canada in cool (12 to 20°C), wet summers. Nesting often occurs in packed produce in which the fungus passes quickly from fruit to fruit, making gray mold one of the most prevalent market diseases of cucurbit crops.

Symptoms On cucurbit leaves and stems, discolored pale gray to tan tissue, copious gray-brown sporulation, and sclerotial development are diagnostic. A water-soaked area is the first sign of infection, usually associated with a piece of dead tissue. This tissue dries and turns pale gray to beige-colored. In humid conditions, a gray-brown mass of fungal conidiophores forms (*22.10a*) and dry masses of conidia disperse in a cloud when touched. Black, hard, flat or somewhat rounded, resistant resting sclerotia, 2 to 5 mm in diameter, form in fleshy tissues (*22.10d*). Sporulation is sparse under very humid conditions, but there is copious development of an off-white cottony mycelium that can be confused with white mold (see white mold, 9.14).

On cucurbit fruit, infection almost always occurs at the flower end or from dead infected petals adhering to the fruit surface (9.7). When senescent flowers are severely affected, the fruit may abort. Infected fruit may deteriorate quickly with a wet rot fostered by secondary fungi and bacteria.

Causal agent (see Lettuce, gray mold, 11.10)

Disease cycle (see Lettuce, gray mold) *Botrytis cinerea* usually infects tissues that are damaged by salt, frost, insects, rough handling, poor pruning and misapplication of fertilizer. Infections are very common at the flower ends of fruits or at torn scars on stems made by careless handling.

Gray mold can become a serious post-harvest disease of cucurbit fruit if it escapes detection at picking and the fruit is stored in damp conditions, especially at sites where water condenses on the fruit. Gray mold is more severe in packing sheds and retail outlets where there are sources of ethylene such as ripening tomatoes or apples.

Management

Cultural practices — Cucurbit crops grown in open fields having well-drained soil with adequate calcium and without excessive nitrogen are seldom seriously affected by gray mold. Because *B. cinerea* has hundreds of hosts, trash piles of almost any plant material are potential sources of inoculum. Accordingly, growers should practice good sanitation. In field sites with cold, wet soils screened from winds, rows are best oriented parallel to the prevailing wind with the rows and plants spaced adequately to give as much ventilation as possible.

Resistant cultivars — Intrinsic genetic resistance is elusive but cultivars with a more open habit, leaving flowers exposed to drying conditions and with flowers that fall as soon as pollination has occurred, tend to be less affected.

Chemical control — Fungicides should be used with caution because the fungus quickly develops fungicide-tolerant strains. Benzimidazole and dicarboximide fungicides may only suppress natural competitors and make gray mold more severe.

Selected references

Coley-Smith, J.R., K. Verhoeff and W.R. Jarvis, eds. 1980. *The Biology of Botrytis.* Academic Press, London. 318 pp.

Ellis, M.B., and J.M. Walker. 1974. *Sclerotinia fuckeliana.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 431. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by W.R. Jarvis)

9.8 Leaf blights *Figs. 9.8a,b; 22.12a,b*

Alternaria leaf blight

Alternaria alternata (Fr.:Fr.) Keissl.
Alternaria cucumerina (Ellis & Everh.) J.A. Elliott
Alternaria tenuissima (Kunze:Fr.) Wiltshire
Stemphylium botryosum Wall.
(teleomorph *Pleospora herbarum* (Pers.:Fr.) Rabenh.)

Ulocladium leaf spot

Ulocladium atrum G. Preuss
(syn. *Stemphylium atrum* (G. Preuss) Sacc.)
Ulocladium consortiale (Thiim.) E. Simmons
Ulocladium cucurbitae (Letendre & Roum.) E. Simmons
(syn. *Alternaria cucurbitae* Letendre & Roum.)

Leaf blights of cucurbits are superficially similar. The causal agents have almost certainly been confused in the scientific literature. *Alternaria, Stemphylium,* and *Ulocladium* all have dark, more or less muriform spores and are variable in culture. *Alternaria alternata* and *A. tenuissima* are weak parasites, common on necrotic tissue in many plants. A specialized race of *A. alternata* f. sp. *cucurbitae* has been described in Europe; its pathogenicity seems limited to cucumber and melon. *Alternaria cucumerina* attacks watermelon, muskmelon, cantaloupe, cucumber and *Cucurbita* spp. and is a serious market pathogen.

Symptoms Small, yellow-brown flecks, often with a light green halo, appear on the upper surface of the leaves. These areas enlarge, grow together and sometimes develop concentric zonation *(9.8a,b; 22.12a,b).* Severely affected leaves die. Zonate lesions several centimetres in diameter may also occur on the fruit, where they are somewhat sunken and covered with a dark, olive-green, felty mass of fungal conidia.

Causal agents *Alternaria cucumerina* is distinctive because its conidia are long-beaked. In general though, fungi with *Alternaria*-like spores are very easily confused. Short-spored species of *Alternaria* are often mistaken for *Stemphylium* and *Ulocladium* species. For example, *Ulocladium cucurbitae* forms *Alternaria*-like conidia on the plant, but *Ulocladium*-like conidia in fresh axenic culture from which diagnosis is best made.

Identification depends on a study of conidium development (for details, see Selected references).

Disease cycle Most diseases caused by *Alternaria* are more prevalent in periods of hot, dry days and dewy nights. The fungus overwinters in infested plant residues and spreads by means of wind-blown spores. Seed may be contaminated during extraction from diseased fruit.

Management

Cultural practices — Pathogen-free seed should be used and also treated with a fungicide as an added precaution. Infected fruit, especially melon and squash, should not be shipped, because it can rot quickly in storage. Crop rotation is the best means of control. Growers should turn under infested crop residues promptly after harvest and avoid using overhead irrigation. Plants stressed by adverse growing conditions are more susceptible to opportunist pathogens of this type.

Resistant cultivars — Because of the multiplicity of fungi capable of causing very similar symptoms, it is impossible to suggest universally resistant cultivars.

Chemical control — Leaf blight diseases are rarely severe enough to warrant the expense of fungicide application.

Selected references

Booth, C., and K.A. Pirozynski. 1967. *Pleospora herbarum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 150. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.
Butler, D., M.J. Griffin and J.T. Fletcher. 1979. Leaf spot on cucumber caused by *Ulocladium atrum. Plant Pathol.* 28:96-97.
Ellis, M.B., and P. Holliday. 1970. *Alternaria cucumerina.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 244. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.
Simmons, E.G. 1982. *Alternaria* themes and variations (11-13). *Mycotaxon* 14:44-57.
Vakalounakis, D.J. 1990. *Alternaria alternata* f. sp. *cucurbitae,* the cause of a new leaf spot disease of melon (*Cucumis melo). Ann. Appl. Biol.* 117:507-513.
Zitter, T.A., and L.W. Hsu. 1990. A leaf spot of cucumber caused by *Ulocladium cucurbitae* in New York. *Plant Dis.* 74:824-827.

(Original by W.R. Jarvis)

▶ 9.9 Leaf rot (pink mold rot) *Fig. 22.13*

Trichothecium roseum (Pers.:Fr.) Link
(teleomorph *Hypomyces trichothecioides* Tubaki)

The fungus is more common in greenhouses (see Greenhouse cucumber, leaf rot, 22.13) than in the field. It affects all cucurbit crops in cool, wet summers but is usually overlooked as a pathogen because it is a common saprophyte on most decaying vegetation.

Symptoms On young leaves, the lesions remain small, first appearing water-soaked with a broad yellowish margin. The center dries, turns tan-brown and may fall out. On older leaves, the lesions appear large and irregular, and they coalesce *(22.13).* In severe cases, fruit is also attacked.

Large, tan-colored irregular spots with a pink tint are diagnostic as spores develop under continuing humid conditions. Frequently, the fungus is accompanied by *Alternaria* and lesions may be variously pink with spores of *Trichothecium* or black with spores of *Alternaria.* Initiation of the lesion from colonize substrates, such as insect excreta or fallen petals, is sometimes evident.

Causal agent (see Greenhouse cucumber, leaf rot, 22.13)

Disease cycle (see Greenhouse cucumber, leaf rot) Leaf rot is essentially a disease of high humidity environments.

It usually accompanies heavy insect infestations. The fungus is a very common saprophyte and can be found on any decaying vegetation throughout the year.

Management

Cultural practices — Growers can reduce humidity by increasing plant spacing in the field and ensuring good ventilation in the greenhouse. Insect pests should be controlled.

Selected references (see Greenhouse cucumber, leaf rot)

(Original by W.R. Jarvis)

▶ 9.10 Powdery mildew *Fig. 9.10*

Powdery mildew is not an important disease in field-grown cucurbits but is a major problem in greenhouse cucumber crops (see Greenhouse cucumber, 22.15).

▶ 9.11 Pythium fruit rot (leak)

Pythium acanthicum Drechs.
Pythium anandrum Drechs.
Pythium aphanidermatum (Edson) Fitzp.
Pythium debaryanum Auct. non R. Hesse
Pythium helicoides Drechs.
Pythium irregulare Buisman
Pythium mamillatum Meurs
Pythium periplocum Drechs.
Pythium ultimum Trow
Pythium spp.

All species of cucurbits are susceptible to fruit rots caused by various *Pythium* spp. These diseases are more prevalent in cool, rainy seasons.

Symptoms Infection of fruits almost always occurs in mature fruit and from the blossom end, probably through minute cracks left by incomplete closure of the stone cell layer at flower abscission. The rots are dark green and water-soaked, developing into a fast-spreading, watery rot of the whole fruit. Beneath a humid leaf canopy, profuse cottony growth of the fungi may be evident. The fruits become so watery that the disease is often called leak.

Causal agent One or more of several species of *Pythium* may be involved. Their identification requires expert diagnosis in the laboratory. (For more information on *Pythium* spp., see Selected references; also see Bean, root rot, damping-off, seed decay; Beet, pythium and rhizoctonia root rots; and Carrot, cavity spot and pythium root dieback.)

Disease cycle *Pythium* species all produce long-lived oospores that permit their survival through several years of adverse conditions. Infection, however, mostly occurs from rain- or irrigation-splashed propagules. Zoospores are produced in sporangia and swim in water films through cracks in the fruit surface. Once in the fruit, the fungus invades the tissues very quickly, producing oospores again when the fruit is fully rotted.

Management

Cultural practices — *Pythium* spp. are cosmopolitan soil inhabitants and fruit rots may be expected wherever growing conditions are poor. Growers should ensure the soil is well drained and the spacing of the plants is adequate to allow ventilation. In areas with poor natural air drainage, rows should be oriented parallel to the prevailing wind. Fertilization practices that foster luxuriant foliage and overhead irrigation should be avoided where crops are at risk from pythium fruit rot.

Selected references

Drechsler, C. 1925. The cottony leak of cucumbers caused by *Pythium aphanidermatum. J. Agric. Res.* 30:1035-1042.

Tompkins, C.M., P.A. Ark, C.M. Tucker and J.T. Middleton. 1939. Soft rot of pumpkin and watermelon fruits caused by *Pythium ultimum. J. Agric. Res.* 58:401-475.

Van der Plaats-Niterink, A.J. 1981. Monograph of the genus *Pythium. Stud. Mycol.* 21. Centraalbureau v. Schimmelcultures, Baarn, The Netherlands. 242 pp.

(Original by W.R. Jarvis)

▶ 9.12 Pythium root rot *Figs. 22.7a-d*

Pythium aphanidermatum (Edson) Fitzp.
Pythium irregulare Buisman
Pythium ultimum Trow
Pythium spp.

Watermelon, honeydew melon, muskmelon, squash and cucumber may be affected by *Pythium*-induced damping- off in cold, wet soils, especially when premature direct seedings have been made. The roots of more mature and bearing plants may also be attacked.

Symptoms Damping-off of seedlings newly emerged from cold, wet soils is characterized by a softening of the stem at or just above the soil line and by plants toppling over (*22.7a-c*). In wet conditions, profuse, white, cottony mycelial growth of one or more *Pythium* spp. may become evident.

In collapsed mature plants, the roots have light brown, depressed, water-soaked lesions from 3 to 15 mm in diameter. Lesions may grow together and cause rotting of long portions of the roots. Primary and secondary roots are all affected.

In Ontario, a sudden wilt (*22.7d)* has been attributed to "root-nibbling" by *Pythium* spp. In this disease, the plants collapse suddenly without any obvious macroscopic root damage. Tiny, necrotic feeder roots, however, consistently have *Pythium* spp. colonizing them. They are apparent only after culturing of diseased roots in a laboratory.

Causal agent *Pythium* spp. can be identified with certainty only after isolation in the laboratory. All species involved in cucurbit diseases form characteristic oospores and sporangia on agar media or on pieces of colony floating in water (see Selected references and pythium fruit rot, 9.11).

Disease cycle Pythium diseases are common and can be severe in cold, wet soils. *Pythium* species form sporangia in the soil which discharge swimming zoospores. These encyst at the host surface, germinate and colonize the host very quickly. "Root nibblers" seem to be restricted only to the feeder roots, although these species are the same as those forming gross lesions. When the infected tissues rot, they become full of thick-walled resistant oospores. These structures enable the pathogen to survive long periods of adverse conditions, for example, several years in dry soils.

Management

Cultural practices — Effective soil drainage is essential for the control of damping-off and root rotting of mature plants. A two-year rotation with non-cucurbit crops is suggested. Poorly drained and naturally cold soils should not be sown until the soil temperature is at least 15°C.

Chemical control — Seed treatment fungicides may aid in reducing seed decay.

Selected references

Gottlieb, M., and K.D. Butler. 1939. A *Pythium* root rot of cucurbits. *Phytopathology* 29:642-628.

McClure, T.T., and W.R. Robbins. 1942. Resistance of cucumber seedlings to damping-off as related to age, season of year, and level of nitrogen nutrition. *Bot. Gaz.* 103:684-697.

Van der Plaats-Niterink, A.J. 1981. Monograph of the genus *Pythium. Stud. Mycol.* 21. Centraalbureau v. Schimmelcultures, Baarn, The Netherlands. 242 pp.

Younkin, S.G. 1938. *Pythium irregulare* and damping-off of watermelon. *Phytopathology* 28:596.

(Original by W.R. Jarvis)

▶ 9.13 Scab (gummosis) *Figs. 9.13; 22.16*

Cladosporium cucumerinum Ellis & Arth.

Scab is a fungal disease with symptoms that resemble angular leaf spot. It is a widespread and occasionally severe disease, particularly in Ontario. Scab also occurs as a field disease on cucumber, melon, pumpkin, vegetable marrow and summer squash. It is also a serious market disease, especially in melon, pumpkin, squash and marrow.

Symptoms The fungus affects all parts of the leaves, stems and fruits. Numerous, pale, water-soaked leaf spots appear which turn ash-gray to white and are somewhat angular. Affected veinlets may turn brown. Internodes may be short causing a rosette reminiscent of cucumber mosaic disease. Elongate lesions develop on stems and petioles. At temperatures around 17°C, tip dieback may occur. Dead tissue cracks and badly affected leaves become tattered. Symptoms are most conspicuous on fruit at all stages of disease development. Sporulation is more profuse on fruit than on leaves. Young fruit is most susceptible.

On cucumber fruit, water-soaked spots enlarge and deepen rapidly to form irregular cavities about 1 cm across and 2 to 5 mm deep (9*.13).* Often, a golden brown, gummy exudate appears which may dry into brown beads. The fungus sporulates on the fruit and leaves and lines the lesion cavities with an olive-green felt. On older fruit and on more resistant cultivars, there is a corky, tan-colored layer that looks like an irregular scab; it may be slightly raised above the surrounding tissue *(22.16).*

On melon fruit, infection often occurs at the pedicel end in addition to the rest of the fruit surface. The flesh can rot to a depth of about 5 mm in cantaloupe. Rotting is less severe in honeydew melon.

Causal agent *Cladosporium cucumerinum* is a typical *Cladosporium,* resembling several saprophytic species. It has non- to bi-sepate ramoconidia that measure up to 30 by 3 to 5 µm. Aseptate conidia occur in long, branched chains. The conidia are smooth, cylindrical and rounded at the ends, or ellipsoid, fusiform or subspherical, and pale olive-brown. They measure 4 to 25 by 2 to 6 µm.

Colonies on potato-dextrose agar are pale olive-gray and felty with abundant sporulation. Hyphae are sometimes spirally twisted.

Disease cycle The disease is favored by cool, dry days and frequent rainy or dewy nights. The disease develops from mid-summer onward in cool seasons with heavy dews and fogs. The pathogen survives in plant residues. Dry spores may be windblown for considerable distances, although local inoculum is likely to be the most dangerous when cucurbits follow cucurbits. Prolonged high humidity induces sporulation. Spores are liberated and dispersed in dry conditions, but infection occurs in wet plants between 17 and 20°C. At 17°C, resistant plants can be infected. Above 21°C, the corky defence reaction of the host excludes the fungus. In stored melons, the disease develops well at 2 to 8°C.

Management

Cultural practices — Fields with fog pockets should be avoided, as should overhead irrigation in cool seasons. Growers should remove or turn under infested crop residues promptly after harvest. Rotation and the use of resistant cultivars are the primary means of control.

Resistant cultivars — Resistance is controlled by a single dominant gene, expression of which is dependent on temperature and tissue age. At 17°C, only restricted local lesions develop on resistant germplasm lines. On susceptible tissue, large water-soaked lesions and rapid death occur. Scab tolerance, rather than immunity, is usually quoted in seed catalogues.

Chemical control — Fungicides are available for scab control but none is completely effective. Control is very poor when night temperatures fall below 14°C. Dithiocarbamate fungicides may be successful if applied before fruit formation. The fungus is believed not to be seed-borne, but the use of fungicide-treated seed is advisable.

Selected references

Ellis, M.B., and P. Holliday. 1972. *Cladosporium cucumerinum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 348. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

Walker, J.C. 1950. Environment and host resistance in relation to cucumber scab. *Phytopathology* 40:1094-1102.

(Original by W.R. Jarvis)

▶ 9.14 White mold (sclerotinia rot) *Figs. 9.14a-c; 22.18a-d*

Sclerotinia minor Jagger
Sclerotinia sclerotiorum (Lib.) de Bary
(syn. *Whetzelinia sclerotiorum* (Lib.) Korf & Dumont)

White mold on cucurbits is caused chiefly by *S. sclerotiorum,* but *S. minor* sometimes occurs on cucumber crops. *Sclerotinia sclerotiorum* is widespread throughout Canada, but *S. minor* is confined mostly to southwestern Ontario, principally as a lettuce pathogen (see Lettuce, drop, 11.9).

Symptoms This disease affects the stem (*9.14a)* and fruit of cucurbit plants. Infection usually begins where the tissue is dead or dying, such as wilted cotyledons and especially flowers that remain attached to fruit or adhere to some other part of the plant after dropping off. Affected tissues become water soaked and may show profuse, cottony white growth of the pathogen on rapidly spreading lesions. On fruit, infection occurs mainly at the flower end (*9.14b),* where the symptoms often are mistaken for those of gray mold. However, in white mold, the mycelium is always pure white (*9.14b,c),* never shades of gray or brown. Eventually, the characteristic sclerotia are formed. Those of *S. sclerotiorum* are flattish, rounded, irregular, black, and measure 3 to 10 mm (*22.18d)* those of *S. minor* are smaller, 2 to 5 mm, and coalesced into expansive aggregates.

Causal agent (see Lettuce, drop, 11.9)

Disease cycle (see Lettuce, drop)

Management

Cultural practices — Weeds should be eradicated and trash piles removed and buried deeply. Field crop rows should be oriented parallel to the prevailing wind, with generous spacing in and between rows so that plants dry quickly after rain. Growers should avoid using overhead irrigation where this disease is prevalent.

Resistant cultivars — No resistant cucurbit cultivars are known but those with a more open growth habit are less susceptible than those with dense foliage in which water is slow to evaporate.

Chemical control — Dicarboximide and benzimidazole fungicides may be used, but fungicide tolerance may develop quickly. Efficacy should be closely monitored and spraying stopped at the first sign of tolerance.

Selected references

Mordue, J.E.M., and P. Holliday. 1976. *Sclerotinia sclerotiorum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 513. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by W.R. Jarvis)

VIRAL AND VIRAL-LIKE DISEASES

▶ 9.15 Cucumber mosaic *Figs. 9.15; 22.20a,b*

Cucumber mosaic virus

Cucumber mosaic is a widespread and sometimes severe disease of cucurbit crops when aphid populations are high and viruliferous weeds are present (see Greenhouse cucumber, cucumber mosaic, 22.20).

There are many fresh-market field and pickling cucumber cultivars that are moderately to highly resistant to this virus. Although not immune, these cultivars withstand infection well enough to produce a marketable crop.

(Original by J.G. Menzies and W.R. Jarvis)

▶ 9.16 Zucchini yellow mosaic *Figs. 9.16a-c; 22.24a,b*

Zucchini yellow mosaic virus

Zucchini yellow mosaic virus, previously known as muskmelon yellow stunt virus, occurs in melon, squash, watermelon, field cucumber and greenhouse cucumber, as well as in zucchini and some wild cucurbit hosts. The first report of this virus in Canada was in garden squash and greenhouse cucumber in British Columbia in 1988.

Symptoms In zucchini, symptoms include a prominent yellow mosaic, necrosis and foliar distortion (“shoestring”) *(9.16a; 22.24a*). Fruit symptoms depend on the stage of fruit development at the time of infection. Early infection may result in failure to set fruits; later infection results in fruits that are severely distorted (*9.16b,c; 22.24b*), small, and green with glossy yellow protuberances. In muskmelon, the flesh may be mottled and the seeds small and misshapen.

Causal agent Zucchini yellow mosaic virus is a potyvirus which has flexuous, filamentous particles of single-stranded RNA, about 750 nm long, and one coat protein. It is easily transmissible to a fairly wide range of hosts and is transmitted by aphids, particularly the green peach aphid, in a non-persistent manner.

Diagnostic hosts include *Chenopodium amaranticolor* Coste & Reynier and C. *quinoa* Willd. (chlorotic local lesions; no systemic infection); *Cucumis melo* L. (chlorotic local lesions; systemic vein clearing, yellowing, leaf distortion, stunting, and occasional necrosis); *Cucurbita pepo* L. (chlorotic local lesions; systemic vein netting, yellowing mosaic, and leaf distortion, often with necrosis and death of the whole plant); and *Gomphrena globosa* L. (well-defined local lesions; no systemic infection).

The virus is variable and several strains have been reported. A Canadian isolate from cucumber failed to react with antiserum to watermelon mosaic virus 1, reacted weakly with antiserum to watermelon mosaic virus 2, and strongly with antiserum to zucchini yellow mosaic virus.

Disease cycle The severity of symptoms depends on the stage of plant development at the time of infection. Early infections result in great crop losses because of failure to set fruit, while later infections cause substantial loss of fruit quality. Although the disease is spread by aphids, particularly the green peach aphid, spread from a single infected plant may be extensive in the absence of these pests. Such spread occurs as a result of transmission of sap from infected to healthy plants in the course of routine crop maintenance by workers. The virus can be seed transmitted but only at a very low rate.

Management Since aphids are vectors, rigorous aphid control is essential to control zucchini yellow mosaic in cucurbit crops.

Cultural practices — The virus can be spread in sap on fingers and tools during routine greenhouse procedures, so suspect plants should be rogued and buried. Wild cucurbit weeds and volunteer seedlings should be eliminated from fields and from the vicinity of greenhouses.

Chemical control — Although the use of insecticides for aphid control is appropriate, aphids are difficult to control (see Other insect pests, 9.22), and there is no other chemical control.

Selected references

Lisa, V., and H. Lecoq. 1984. Zucchini yellow mosaic virus. CMI/AAB Descriptions of Plant Viruses, No. 282. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England. 4pp.

Provvidenti, R., and D. Gonsalves. 1984. Occurrence of zucchini yellow mosaic virus in cucurbits from Connecticut, New York, Florida, and California. *Plant Dis.* 68:443-446.

Schrijnwerkers, C.C.F.M., N. Huijberts and L. Bos. 1991. Zucchini yellow mosaic virus; two outbreaks in the Netherlands and seed transmissibili- ty. *Neth. J. Plant Pathol.* 97:187-191.

Stace-Smith, R. 1989. Occurrence of zucchini yellow mosaic virus in greenhouse cucumbers and squash in British Columbia. Page 134 *in* B. Stennson (chm.)., *Rep. Comm. Hortic. Res. Council*, Ottawa, Ontario. 193 pp.

Stobbs, L.W., L.W. Van Schagen and G.M. Shantz. 1990. First report of zucchini yellow mosaic virus in Ontario. *Plant Dis.* 74:394.

(Original by W.R. Jarvis)

▶ 9.17 Other viral and viral-like diseases *Figs. 9.17a,b*

Aster yellows Aster yellows mycoplasma-like organism
Cucumber necrosis Cucumber necrosis virus
Watermelon mosaic Watermelon mosaic virus

Aster yellows is a minor disease of cucurbit crops in Canada (see Lettuce, aster yellows, 11.15).

Cucumber necrosis is an occasional disease of cucurbits in Ontario (see Greenhouse cucumber, cucumber necrosis, 22.21).

Watermelon mosaic *(9.17a, b)* is regarded as a minor disease of cucurbits in Canada (see Greenhouse cucumber, watermelon mosaic, 22.23).

(Original by W.R. Jarvis)

NON-INFECTIOUS DISEASES

▶ 9.18 Cold injury *Figs. 9.18a-c*

Field cucumbers require a temperature of between 18 and 24°C for optimum growth, with a minimum of 10°C and a maximum of 32°C. For seed germination, the minimum temperature is 16°C and the optimum is 35°C. Cucumber crops are very susceptible to freezing. When plants are injured by cold, affected leaves wilt *(9.18a)*, turn black and die. Frozen vines and fruit may appear water-soaked and feel soft when handled.

On the prairies, direct-seeded cucumbers are especially prone to cold injury in the spring. Chilled cotyledons appear bleached and often become prematurely dry. Plants may recover if the true leaves are not damaged *(9.18b).* However, if the true leaves are also injured, then growth is retarded and some plants may die. Chilled seedlings are usually more susceptible to post-emergence damping-off.

In some parts of Canada, particularly in southern Ontario, growers protect early cucumber seedlings with low plastic tunnels that are removed when the first leaves are too large to be contained. Once the plants are exposed, they are very susceptible to temperatures below 13°C. If chilled, growth is severely retarded and leaves become brittle and susceptible to wind damage. Chilled fruit can become pale green or yellow and mottled *(9.18c).* If cool conditions persist for more than two days, the fruit surface becomes pitted and brown. Fruit quality diminishes rapidly and the fruit becomes susceptible to scab, even in resistant cultivars. Necrotic tissue is susceptible to gray mold and white mold.

Management

Cultural practices — Plastic tunnels or polyester floating row covers will protect young cucurbit plants down to 0°C.

Selected references

Whitaker, T.W., and G.N. Davis. 1962. *Cucurbits.* Leonard Hill, London. 249 pp.

(Original by W.R. Jarvis and R.J. Howard)

NEMATODE PESTS

▶ 9.19 Northern root-knot nematode *Fig. 22.30d*

Meloidogyne hapla Chitwood

Cucurbits are highly susceptible to damage from this nematode.

Symptoms include conspicuous yellowing, stunting and early senescence. Fruits are fewer and smaller than normal. Prolific branching of rootlets, and production of small, spherical galls on roots are characteristic. For a complete description and management strategies, see Carrot, 6.20; see also Management of nematode pests, 3.12.

▶ 9.20 Root-lesion nematode *Fig. 16.38T1*

Pratylenchus penetrans (Cobb) Filip. & Stek.

Symptoms include wilting and stunting in patches in heavy infestations; leaves become yellow. Secondary roots become necrotic, with dried areas. For a complete description, see Potato, 16.38; see also Management of nematode pests, 3.12

INSECT PESTS

▶ 9.21 Cucumber beetles *Fig. 9.21*

Spotted cucumber beetle *Diabrotica undecimpunctata howardi* Barber
Striped cucumber beetle *Acalymma vittatum* (Fabricius)

The spotted cucumber beetle, also known as the southern corn rootworm, occurs from the Rocky Mountains eastward to Ontario and Quebec in Canada. The striped cucumber beetle occurs in central and eastern Canada. Within their respective ranges, both beetles are found wherever commercial field cucumber is grown. Yield losses caused by these beetles in Ontario are estimated at 15% if control measures are not implemented.

Adults of the striped cucumber beetle prefer such field cucurbits as cucumber, muskmelon, pumpkin, squash and watermelon, and they will feed on bean, corn, pea and the blossoms of other plants. The spotted cucumber beetle is a general feeder on many plants. Its adults feed extensively on all field cucurbits.

Damage Field-grown cucurbit plants are most susceptible to cucumber beetle damage when they are small. Soon after seedlings emerge, adult beetles chew small holes in the leaves and cotyledons, giving the affected plant parts a “shot-hole” appearance. Although many small holes may coalesce to form larger holes, the surrounding tissue remains relatively healthy. At this stage, feeding by adult beetles close to the ground often results in broken stems and eventual plant death. Later, the adult beetles attack flowers, which affects yield, and they may completely skeletonize leaves, leaving only the veins. The larvae of both cucumber beetles tunnel into the base of the plant stems, which may cause wilting. Damage from leaf, stem or root feeding by adults and larvae is generally minimal on older, established plants.

Cucumber beetles transmit bacterial wilt and cucumber mosaic virus, both of which can result in losses far greater than direct feeding by either species of beetle.

Identification Cucumber beetles belong to the family Chrysomelidae. Adults of the striped cucumber beetle (9.27) are 5 to 6 mm long with a black head, a yellow thorax and three longitudinal black stripes on yellow forewings (elytra). Adults of the spotted cucumber beetle *(9.21)* are about 6-7 mm in length and yellow-green with 12 large dark spots on the elytra.

Larvae of the two species of cucumber beetles are indistinguishable from each other, both being slender, legless, white, and less than 1 cm in length with reddish-brown heads. Cucumber beetle larvae can be differentiated from larvae of the squash vine borer because the latter exceed 1 cm in length and have thoracic and abdominal legs.

Adults of the striped cucumber beetle may be confused with western corn rootworm adults (see Maize, 12.15), which also are attracted to the yellow cucurbit flowers later in July. The adults of these two beetles can be distinguished by the elytral stripes, which are straight-sided only in the striped cucumber beetle. Also, the outer leg segments of the striped cucumber beetle are black, giving it the appearance of wearing black socks. In contrast, the western corn rootworm adult has elytra with a wavy central stripe and its legs are entirely black.

Life history Cucumber beetles overwinter as adults that hibernate in dense grass and under leaves and other plant residue. When spring temperatures reach 10°C or higher, the beetles leave their winter quarters and feed on pollen, petals and leaves of various plants. In early to mid-June, when cucumber, zucchini and other cucurbit seedlings emerge or are transplanted to the field, the beetles begin to feed on the leaves and stems, and they mate while feeding on the plants. Eggs are laid in the ground near the host plant. The larvae hatch in about 10 days, feed on the roots for about a month and pupate in the soil. Adults emerge within two weeks and may feed on the rind of cucurbit fruits until frost forces them to seek shelter. There is one generation per year.

Management The main concern is that adult cucumber beetles may transmit bacterial wilt and virus diseases while they feed. Because it is impossible to determine if adult cucumber beetles in the field contain the pathogens of bacterial wilt or virus diseases, control of the initial population of adult beetles is paramount for a successful crop.

Monitoring — Growers should monitor their fields in early spring. Early morning or evening scouting is best and both the foliage and soil-stem areas should be examined. Under windy conditions, the beetles may remain in difficult-to-find places; they often try to conceal themselves by moving around the plant. At each of five different sites within a field, 20 consecutive plants should be examined. Control is warranted if two or more beetles are found at three of the five sites.

Chemical control — If significant beetle populations are present, insecticidal treatments should start at plant emergence and be repeated 10 days later if necessary. Continual monitoring is essential.

(Original by R.E. Pitblado and R.N. Lucy)

▶ 9.22 Other insect pests *Figs. 9.22 a-c; see text*

European earwig *Forficula auticularia* L.
Melon (cotton) aphid *Aphis gossypii*
Glover Potato leafhopper *Empoasca fabae* (Harris)
Seedcorn maggot *Delia platura* (Meigen)
Squash bug *Anasa tristis* (DeGeer)
Squash vine borer *Melittia cucurbitae* (Harris)
Tarnished plant bug *Lygus lineolaris* (Palisot de Beauvois)
Cutworms
Wireworms

A number of insects that are general feeders, such as those listed here, are minor pests of field cucurbit crops in various areas of Canada. General suggestions for control include the use of trap crops and cultural practices, such as incorporating crop residue by cultivating soon after harvest. Applications of chemical insecticides as seed and foliar treatments, if used at all, should be properly timed.

European earwig

(see Crucifers, 8.43; *3.14T1; 8.43a-d)*

Melon aphid

(see Greenhouse cucumber, 22.33) The melon aphid is a pest on field cucurbits and other crops. Its eggs may overwinter on weeds in some parts of Canada, but winged females regularly invade from the United States and winged forms (*22.33a*) also disperse from populations developing locally during the growing season. The melon aphid affects young leaves, shoots, flowers and young fruits but on field cucurbits it is most important as a potential virus vector. In general, it is difficult to control aphids on field cucurbits with insecticides; growers should try to encourage naturally occurring biocontrol agents, such as green lacewings (see Beneficial insects, mites and pathogens, 3.7).

Potato leafhopper

(see Potato, 16.46) The potato leaf- hopper (*16.46b*) is occasionally a minor pest on field cucurbits. It feeds on the underside of cucurbit leaves and causes the leaf margins to turn yellow (“hopperburn”) *(16.46a).* This type of damage is most noticeable under dry conditions. Leafhoppers are readily controlled by foliar insecticides but treatments must be applied before the appearance of extensive yellowing.

Seedcorn maggot

(see Bean, 15B.18) The seedcorn maggot attacks cucumber and other field cucurbits early in the spring *(9.22a,b).* Seed treatments provide good control.

Squash bug

The squash bug (family Coreidae) occurs in southern British Columbia, Ontario and Quebec. It is primarily a pest of pumpkin and squash, although it also will attack other cucurbits. Nymphs and adults suck sap from the leaves, stems and vines, causing light-colored areas that later turn brown and die. Occasionally the nymphs and adults feed on the fruit, particularly in the fall after the leaves have been killed by frost. The squash bug over winters as an adult in sheltered places, under grass and plant residue, along fencerows and in buildings. In June, the adults fly into fields and lay large, yellow eggs in clusters on the foliage of susceptible plants. The eggs turn brown as they mature. Nymphs hatch in 7 to 17 days. The nymphs are pale at first, but soon turn gray. They feed throughout the summer and either become adult or perish before winter. There is one generation per year. Cultural control can be achieved in small field areas and home gardens by removing potential overwintering sites. Because adults tend to congregate under shelter at night, shingle or board traps can be placed near squash and pumpkin plants in June, followed by early morning inspection and hand removal of adults to reduce their numbers. In commercial or large field operations, insecticidal spray applications should be timed to control the nymphs when they are young.

Squash vine borer

is a clear-winged moth (family Sesiidae) *(9.22c)*. It occurs in southwestern Ontario chiefly on thickstemmed field cucurbits, such as gourd, pumpkin, squash and vegetable marrow. The larva is a fleshy white stem borer with three pairs of thoracic and five pairs of abdominal legs. At maturity, it exceeds 1 cm in length, thus differing from cucumber beetle larvae, which are less than 1 cm in length. Stems invaded by the squash vine borer eventually become filled with a moist, slimy frass, and affected plants wilt permanently. The larvae may be found inside the stems and in the pulp of maturing fruit. Adults can be monitored, using yellow-pan water traps (see McLeod & Gualtieri, 3.14). Control is best achieved by drenching the base of the plants with an insecticide in late June before larvae enter the stems, and repeating treatment on a weekly basis.

Tarnished plant bug

(see Celery, 7.21) The tarnished plant bug *(7.21b,d,e)* feeds on flowers, leaves and stems of field cucurbits, such as cucumber and squash. Plant bug feeding reduces flower set, although the bug itself is seldom noticed. Growers tend to ignore rather than control plant bugs.

Cutworms

(see Tomato, 18.35; *6.25a-c; 18.35c-g)* and

Wireworms

(see Maize, 12.21; *12.21a,b)* are incidental pests of field cucurbits and seldom require control. Replanting may be required and seed treatments are recommended, particularly against wireworms.

(Original by R.E. Pitblado, R.N. Lucy and J.A. Garland)

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