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Cucumber diseases

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Cucumber diseases

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Recommendations for pesticide use in this publication are intended as guidelines only. Any application of a pesticide must be in accordance with directions printed on the product label of that pesticide as prescribed under the Pest Control Products Act. **Always read the label.** A pesticide should also be recommended by provincial authorities. Because recommendations for use may vary from province to province, consult your provincial agricultural representative for specific advice.

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Diagnostic key

1	Symptoms predominantly on seedlings	2
	Symptoms predominantly on mature plants	4
2	Water-soaked translucent spots on cotyledons	angular leaf spot
	White powdery fungal growth on cotyledons	powdery mildew
	Stem topples or is severely constricted	3
3	Lesion on stem soft, water-soaked	pythium damping-off
	Lesion not water-soaked; stem constricted	rhizoctonia damping-off
4	Lesions on leaves	5
	Lesions on stems	27
	Lesions on fruit	32
	Symptoms on roots	39
5	Leaves, at least young leaves, abnormally dark green	6
	Leaves with uniform yellowing, or vein-banding, or mottling	9
	Leaves with angular, round, or indefinite spots	15
6	Leaves distorted	watermelon mosaic herbicide injury
	Not so	7
7	Young leaves dark green, the older leaves yellow with green veins, the terminal leaves clustered	beet curly top
	Area between veins necrotic, becoming white and papery	manure burn
	Leaves with purplish tinge underneath	phosphorus deficiency
	Not so; plants wilt	8
8	Whole plant wilts on hot days	black root rot
	Lobes of leaves wilt first	bacterial wilt
	Permanent and often sudden wilt or severely stunted growth	25
9	Leaves with conspicuous vein clearing or yellowing	10
	Leaves mostly or entirely chlorotic	11
	Leaves with yellow or green-yellow mottling or flecking	13
10	Leaves distorted, possibly flecked, possibly with bright green mosaic	watermelon mosaic
	Leaves not distorted	cucumber vein-yellowing

11	Young leaves more or less uniformly pale, weak, flabby, distorted	calcium deficiency
	Chlorosis starting in veins; plant stunted	nitrogen deficiency
	Terminal leaves dwarfed, rolled upwards at margin; chlorosis mostly interveinal	12
12	Leaves remaining small; interveinal areas whitish	manganese deficiency
	Interveinal areas with yellow-bronze coloring; margins dried out	potassium deficiency
13	Leaves distorted, with bright to dark green mosaic with flecking	watermelon mosaic
	Leaves not distorted	14
14	Leaves small, with greenish yellow mottle; veins slightly translucent	cucumber mosaic
	Leaves with irregular, interveinal, yellowish mottle; veins remain green	beet pseudo-yellows
15	Lesions angular, defined by veins	16
	Lesions more or less restricted, circular	17
	Lesions spreading and indefinite	19
16	Lesions small, water-soaked, with centres becoming dry, whitish, and chalky; veinlets inconspicuous	angular leaf spot
	Lesions at first small, enlarging, with centres pale brown; veinlets remain brown	scab
	Lesions yellowish above, purple-brown fungal growth below	downy mildew
17	Lesions small or up to 1 cm across, more or less circular, usually over small veins	18
	Lesions pinpoint in size, with yellowish-brown centre and bright yellow margin	tobacco ringspot
	Lesions at first small, angular, water-soaked, rapidly enlarging, pale brown; veinlets remain brown	scab
18	Lesions yellowish green, sometimes only on one side of the midrib, the pinpoint centre falling out	cucumber necrosis
	Lesions initially pale green, water-soaked, becoming angular, reddish brown, with yellow margin	anthracnose
19	Lesions mostly on leaflamina, extending inwards in pale yellow V-shape; leaf edges may be curled down and in, and reddish brown	stem blight
	Lesions mostly on leaf blade	20

20	Lesions dull brown, water-soaked, with broad yellow margin, and associated with insect excreta	leaf rot
	Lesions as above but not associated with insect excreta; centre of lesion sometimes with pinpoint black bodies	stem blight
	Lesions grayish, tan, or some shade of white	21
21	Lesions some shade of white	22
	Lesions grayish or tan	23
22	Lesion covered with pure white powdery growth on either side of leaf	powdery mildew (*Erysiphe*)
	Lesion covered with dingy white powdery growth, and sometimes scattered with brown pinhead bodies	powdery mildew (*Sphaerotheca*)
23	Lesions grayish	24
	Lesions tan, also occurring on stem	tobacco ringspot cucumber strain
24	Lesions water-soaked at first, 2-3 mm in diameter, often with concentric blackish zones	leaf spot
	Lesions as above but enlarging to 1 cm	leaf blights
25	Plant severely stunted	low-temperature injury high-temperature injury impeded drainage
	Plant wilts slowly but permanently, with no recovery at night; stem may rot at the base	fusarium wilt and foot rot
	Plant wilts suddenly and irreversibly	26
26	No other visible symptom	pythium sudden wilt
	Leaves and fruit malformed	beet curly top
	Leaves and fruit also show symptoms of cucumber mosaic virus	pythium–cucumber mosaic complex
27	Lesions mostly between leaf nodes	28
	Lesions at leaf nodes	29
28	Stem slender, tough, fibrous	potassium or nitrogen deficiency
	Areas on stem, leaf, fruit stalks, and tendrils oily, dark green, with black pinpoint fungal bodies in parallel rows	black rot

29	Nodal area soft; stem top can fall over..	30
	Nodal area remains more or less firm	31
30	Greenish blue fungal growth outside and inside the stem	penicillium stem rot
	Pure white fungal growth outside and inside the stem, with large (5-10 mm across) irregular black bodies inside the hollowed stem	white mold
31	Nodal area bleached to pale fawn color, covered with grayish brown powdery mass of fungal spores	gray mold
	Nodal area bleached, with numerous black pinpoint fimgal bodies; sometimes with drops of amber-colored gum	stern blight
32	Fruit mottled green-yellow, with bumpy feel	cucumber mosaic
	Fruit deformed	33
	Fruit with discrete lesions	35
	Fruit soft or rotting..	36
33	Fruit pale, tapered at blossom end	nitrogen or calcium deficiency
	Fruit tapered at stalk end	potassium deficiency
	Fruit severely distorted	34
34	Fruit remains small	beet curly top
	Fruit shortened but stout	watermelon mosaic
35	Tiny water-soaked spots with water-soaked rim, 2-3 mm deep; fruit dark green	tobacco ringspot
	Lesions sunken, grayish, water-soaked, enlarging to 1 cm across and 5 mm deep; cavity lined with olive green mass of fungal spores	scab
	More or less large fawn lesions occurring anywhere on fruit, sometimes with black, pinpoint fungal bodies .....*.....	stem blight
36	Fruit soft at flower or stalk end; flesh discolored brownish black inside; sometimes with black, pinpoint fungal fruiting bodies	stem blight
	Fruit very soft and wet, evil-smelling	bacterial soft rot
	Fruit rotted at flower end; black pinpoint fungal bodies occurring in parallel rows; distinct lemon odor	black rot
	Fruit with more or less conspicuous cottony or powdery fungal growth	37

37	Fungal growth cottony, pure white, with irregular black bodies 5-10 mm across	white mold
	Fruit like a pincushion, mostly at flower end; conspicuous black heads on cottony fungal threads	blossom blight
	Rotten area covered with a mass of powdery fungal spores	38
38	Spore mass gray-brown	gray mold
	Spore mass greenish blue with white margin	penicillium fruit rot
39	Roots with numerous galls up to 1 cm	root-knot nematode
	Roots rotten, with microscopic black mosaic pattern and/or with concentric blackish banding	black root rot
	Roots in nutrient film technique hydroponic system disintegrating suddenly	root death

Introduction

Field and greenhouse cucumbers are an important vegetable in the Canadian horticultural industry. About 65 000 t of field cucumbers and 2.6 million dozen greenhouse cucumbers are produced annually in Canada. These crops are worth about $16.4 million and $26 million, respectively. Nevertheless, Canada must still import about $2 million worth of cucumbers for processing each year.

Cucumbers grown for the production and processing industries are seriously affected by several diseases. For example, powdery mildew and scab can cause losses of 45% in field cucumbers, and scab reduces both quality and **shelf** life. Although an accurate estimate is difficult to obtain, the annual crop loss is probably between 20 and 30%. In addition, the diseases that affect cucumbers also affect other crops in the cucurbit family, such as the various melons, squashes, gourds, and pumpkins.

A healthy high-quality crop can be produced only from cucumber plants that are free from disease. This publication will help the grower to recognize, prevent, and control the many diseases that infect cucumbers.

Causes of diseases

Cucumbers are affected by various disorders caused by fungi, bacteria, viruses, mycoplasmas, nematodes, nutritional deficiencies, and toxic materials.

Fungi

A fungus is a type of plant that lacks chlorophyll. Fungi live on green plants or dead organic matter. Mushrooms and toadstools are fungi, but those that cause plant diseases are usually microscopic or are visible as a whim cottony growth, as tiny black specks, or as powdery masses of spores. Most fungi produce spores, such as the white dusty spores of powdery mildews or the contents of the small black bodies, which spread the disease from plant to plant through the air or in water. Some fungi produce microscopic thick-walled spores, or larger bodies called sclerotia, that help them to survive in the soil between crops. Sclerotia are easy to see in the advanced stages of certain diseases.

Bacteria

In many ways bacteria resemble fungi, except that bacteria are single-celled microorganisms. They are visible with the help of a microscope or as a gelatinous mass that exudes from lesions on plants. New lesions often have a water-soaked appearance, but later they dry up.

Viruses

Much smaller that bacteria, viruses are seen only with the help of an electron microscope. They can grow and multiply only in a host plant, though some, such as the tobacco mosaic virus, can persist outside the plant for long periods. Viruses can be spread from plant to plant in infected sap on clothing, hands, and implements, and by various insects and nematodes.

Mycoplasmas

Mycoplasmas are the smallest organisms capable of independent growth and reproduction, lying somewhere between the bacteria and the viruses in size and properties. In plants they cause the yellows diseases, which for a long time were thought to be caused by viruses. Mycoplasmas are usually spread among plants by leafhoppers.

Nematodes

Nematodes are small colorless worm-like animals that live in plants or in soil. Some nematodes that live on dead plant material in the soil are visible to the naked eye, but parasitic nematodes are not. In addition to the damage they cause directly to plants, such as the galls on roots by the root-knot nematode, several nematodes can transmit some viruses from plant to plant.

Deficiency diseases

Some plant disorders are caused by deficiencies of soil nutrients, especially nitrogen, phosphorus, potassium, magnesium, calcium, and iron. Usually these disorders are easily remedied.

Toxicity diseases

Toxicity diseases are caused by too much of any material and are less easily remedied than deficiency diseases. In this category are manure burn (too much ammonia gas given off by half-decayed manure), copper toxicity, and herbicide damage.

Control of diseases

Good disease control is closely linked with good husbandry. Any extra measures for control, such as fungicide sprays, add considerably to the cost of production. Therefore, carefully observe all the basic precautions in crop hygiene from seeding, to harvesting, to crop clearing. These principles are emphasized throughout the disease descriptions that follow.

Pesticides are coming to be regarded as disease controls of last resort. Using disease-resistant cultivars and clean seed from a reputable source, in addition to observing good sanitation practices in the seedling and transplant stages of crop production, can reduce or eliminate the need for pesticides. Many greenhouse growers rely solely on biological control for insects and on hygiene and sound environment management for disease control.

In most provinces pesticides can be applied to commercial crops only by licensed operators trained in their safe use. In commercial crops and in home gardens, mix and apply pesticides strictly in accordance with the instructions on the label, and dispose of containers in ways set out in provincial and local regulations. Never deviate from the rates given on the label; twice as much will usually do twice the amount of damage. Pesticides applied as insurance sprays, in anticipation of disease outbreaks, are seldom justified. Your provincial agricultural representative is in the best position to give specific advice if epidemics threaten.

Bacterial diseases

Angular leaf spot

Angular leaf spot, caused by the bacterium *Pseudomonas syringae* pv. *Zachrymans,* is fairly common in field crops (Fig. 1). The first symptoms can appear on the cotyledons as soft, water-soaked, translucent, round, or irregular spots. On older leaves these spots are usually confined by the leaf veins and so are distinctly angular. They are brown, and in humid conditions they coalesce to cover the whole leaf. Drops of bacteria in suspension often ooze from the undersides of the spots, especially in the early morning. After a week or so the spots dry out to a whitish, yellow, or brown color, and the dry tissue falls out. Stems and leaf petioles can also be affected by water-soaked areas, which dry out and form a white crust. Similar spots occur on the fruit, both in the field and after picking; immature fruit can fall off the plant. At first the spots are small, round, and soft, and as they dry out they crack open to reveal a white chalky centre. Such spots can remain fairly superficial, but they allow other soft-rotting pathogens to enter the cucumber. In mature fruit these spots can also extend as a brown rot in the underlying fleshy tissue, right down to the seeds and along the vascular system in the

seed region. In this way the disease becomes seed-borne. The growth of the whole plant is slowed, reducing the quantity and quality of the yield.

The bacterial secretions are highly infective to other parts of the same plant, to other plants, and to neighboring crops. The bacteria are spread mostly by rain or water splashed from irrigation, and possibly by insects. The disease develops rapidly at temperatures of 24–27°C and when the plants are waterlogged after long rains. The seed can become contaminated with bacteria during extraction, and the bacteria can invade the seed coat to a limited extent. Some seedlings from untreated seed can be killed, and seedlings that survive are unhealthy and act as centres for future epidemics.

Control

Clean seed is essential to a good crop, because the bacteria apparently do not survive well in the soil. Obtain seed from an arid area where the disease is usually absent. To clean up contaminated seed, soak it for a few minutes in a chemical sterilant. Consult your provincial agricultural representative for the appropriate treatment.

Avoid working in the crop during heavy dew or rain because the bacteria are readily spread by wet implements, clothing, and hands. Fruit from affected crops do not transport well, and infections can later appear in storage. These infections are usually followed by organisms that cause cucumbers to rot quickly.

Some cultivars are highly tolerant of angular leaf spot and should be used where the disease is a problem. As yet no cultivar provides complete resistance to this disease. There is no good chemical control; indeed, spraying the crop with ineffective pesticides serves only to spread the bacteria.

Bacterial wilt

This bacterial disease (Fig. 2), caused by *Erwinia tracheiphila*, is common in field crops in North America. However, the disease is not usually severe in Canada if its insect vectors, the striped and the spotted cucumber beetles, are well controlled.

Infection begins on one or two leaves, on which dull green patches appear and spread rapidly. The infected leaves wilt almost immediately, and the bacteria, which move rapidly in the vascular system of the petioles and stems, soon cause the entire plant, including the fruit, to wilt and shrivel. The presence of the bacteria can usually be detected by cutting cleanly across a wilted stem and pressing out a milky, sometimes sticky, secretion that strings out when the two portions of stem are slowly drawn apart.

The causal bacterium passes the winter in adults of the striped cucumber beetle, *Acalymma uittatum*, and the spotted cucumber beetle, *Diabrotica undecimpunctata howardi*. The disease is introduced directly into the vascular system when the beetles feed on the cucumber

plant or when contaminated feces of beetles come in contact with lesions made by other insects, such as grasshoppers. The beetles carry the bacteria from plant to plant, though because they do not migrate much in rainy weather, the disease is not spread then. Neither is the disease spread in very dry weather, because the bacterium requires free water in which to swim from the wound surface to the interior vascular system if it is not directly introduced into the plant. Thus epidemics are a result of poor beetle control.

Control

The beetles emerge during the 3-5 weeks after direct seeding or transplanting. Chemicals can control the bacteria directly to some extent, but the disease is most easily prevented by controlling the beetles. For details of suitable insecticides, consult your provincial agricultural representative. Completely resistant cultivars are not available, but some, especially the late flowering ones, are more resistant than others.

Bacterial soft rot

A soft, postharvest rot of fruit can be caused by several bacteria, of which the commonest is ***Erwinia curotouoru*** ssp. ***curotouoru.*** Bacterial spot rot is prevalent in overripe fruit damaged during harvest and shipped wet and dirty. In greenhouse produce, rotting is more prevalent in fruit that has flesh torn from the shoulder during picking or is marked by fingernails or sharp box edges, and shrink-wrapped in plastic when wet (Fig. 3). Fruit becomes wet in humid packing sheds when it is cooled too fast, and the subsequent rot is accelerated by ethylene gas given off by other ripening fruit, such as apples and tomatoes, in the same packing shed. Bacterial soft rots are often seen following other fruit-rotting diseases, such as stem blight, gray mold, and penicillium fruit rot.

Control

Fruit should always be shipped clean and dry with a minimum of mechanical damage. In greenhouse packing sheds, fruit should be cooled gradually in a dry atmosphere so that dew does not form. Other ripening fruit should be handled separately, away from cucumbers, and the shed should be well ventilated. Cucumbers are best stored and shipped at 12-13°C. Truckloads of harvested cucumbers should never be allowed to stand in the sun.

Fungus diseases

Anthracnose

The fungus Colletotrichum orbiculare is common on cucumbers in areas and seasons of heavy rainfall. The fungus also attacks watermelon and muskmelon but not squash or pumpkin. Anthracnose is one of the most destructive cucumber diseases.

Anthracnose attacks all parts of the cucumber plant (Fig. 4). It usually appears first over a leaf vein as a pale green water-soaked spot. The disease spreads rapidly and causes a reddish brown angular or roughly circular lesion with a yellowish margin up to 1 cm or more across. These lesions are considerably larger than the lesions of scab and angular leaf spot. They are initially water-soaked, but later they dry up and often fall out. If the lesions coalesce, they distort and destroy the whole leaf, thus reducing crop yield.

The lesions on leaf petioles and stems are long, shallow, and yellowish to tan, becoming powdery when they dry out. The lesions on fruit, however, are the most severe. When the fruit is almost ripe they appear as pale green spots, which rapidly become larger, roughly circular, deeply sunken, pale brown, and eventually cracked. The flesh underneath is not usually discolored, as it is in angular leaf spot, but the cracks allow other organisms, such as soft-rotting bacteria, to enter the fruit. In the centre of the lesion, tiny black bodies of the fungus produce fawn or pinkish masses of spores, which are dispersed in large numbers by either rain or water splashed by irrigation. Seedlings are occasionally attacked at soil level and collapse as the tissues shrivel and die.

Control

This disease is more severe in wet seasons in the field and in underventilated and overwatered greenhouses, particularly at temperatures of 21–27°C. When it occurs in the field, reduce overhead irrigation. In the greenhouse, water with care to avoid splashing spores into neighboring plants. Keep the greenhouse properly ventilated.

Because the fungus survives on plant debris on and in the soil, and on wood and straw, crop and greenhouse hygiene and crop rotation are essential control measures. Do not plant cucumbers in the field directly after cucumbers, muskmelon, or watermelon. Because the fungus can be carried with the seed, a seed dressing is useful if the seed is known to have come from an anthracnose-infested area. It is best, however, not to use such seed at all. Consult your provincial agricultural representative on the use of fungicides.

Black root rot

Black root rot is caused by the soil-borne fungus *Phomopsis sclerotioides* and as its name implies, it survives in soil and thick root tissue by means of environment-resistant tiny black sclerotia. Two distinct symptoms occur on the roots; usually both occur on the same plant and even on the same root. These symptoms are best seen with a good hand lens. First, a black, tidemark symptom appears on medium-sized roots that are just turning fawn. The marks are about 0.5–1.0 mm wide in irregular, more or less concentric bands. The second symptom, not usually side by side with the first, is a tiny mosaic pattern of rectangular areas, only about 0.1 mm long and wide. These are the fungal sclerotia (Fig. 5).

The disease the fungus causes is rather insidious. The first sign is a somewhat darker green foliage than usual; also, the plant may wilt at first with nightly remission but later the wilt is permanent. Less than perfect soil sterilization can easily leave the sclerotia intact in thick root tissue, the disease building up in intensity with the years. Because its effects are worse in cold soils, soil temperatures should be around 20°C at planting in the greenhouse.

Control

Sterilizing the soil is the only known control for this disease, although certain fungicides drenched into soil may give some relief The disease is common in greenhouse crops planted into too cold a soil, with the temperature often as low as 10–12°C. The trouble is exacerbated by putting on a straw mulch too soon, which effectively insulates the soil, keeping it cold for longer. If the mulch is pulled back and the base of the stem is mounded with a peaty soil mix, new adventitious roots grow out from the stem, enabling the plant to survive on a new root system. If the disease builds up year after year in soil, the only recourse in greenhouse production is to switch to hydroponic production. The disease is uncommon in field crops.

Black rot

This disease, caused by *Phomopsis cucurbitae,* appears as cankers or lesions on the stem, as a leaf and petiole rot, and as a fruit rot. Its symptoms resemble those of stem blight caused by *Didymella bryoniae.* Black rot is essentially a greenhouse disease and is seldom seen in the field.

Infections first appear as water-soaked, oily green areas on old and dying tendrils, fruit stems, petioles, and suckers at the stem nodes, where amber-colored gummy exudates are formed. The node lesions spread in both directions, at first superficially, but later attacking the deeper vascular tissues. The stem is girdled, and the shoot above the lesion dies. The disease progresses fastest in soft-grown plants.

Fruit may be attacked through the flowers, and the flesh quickly becomes soft, rotted, and water-soaked. Finally the fruit becomes shrunken and mummified, and smells of lemon. On all affected tissues, the tiny black spore-bearing bodies of the fungus break through the outer epidermis, often in long, parallel rows on the blanched, tattered, and dried outer tissues.

The method of survival between crops is unknown, although the disease is considered unlikely to be seed-borne.

Control

No fungicide control can be recommended. Good ventilation controls the spread of the disease, drying out old parts of the plant rapidly and preventing the establishment of the fungus. Sound hygiene practices remove the sources of the fungus.

Blossom blight

This disease, caused by ***Choanephora cucurbitarum,*** appears occasionally on cucumber flowers in the United States but has not yet been reported in Canada; it is included here for the sake of completeness.

Blossom blight is a fairly noticeable fungus on wet, dying flowers. Although the fungus does not attack cucumber fruit, it does affect other cucurbit fruit and leaves, especially of summer squash. The affected fruit resembles pincushions stuck with minute black-headed pins; the tissue beneath becomes wet-rotted.

Damping-off

Damping-off, caused by ***Pythium*** species, ***Rhizoctonia solani,*** and other fungi, is the common name for a number of diseases with similar symptoms that affect seedlings. Poor-quality, low-vigor seed gives a poor rate of emergence from soil, despite high germinability in laboratory tests. These seedlings are particularly susceptible to several fungi, some of which are carried on or in the seed. However, most fungi are present even in sterilized soil, because reinfestation with damping-off organisms occurs if soil mixes are prepared on dirty headerhouse floors or with contaminated well or creek water. Both poor-quality and good-quality seed sown too thickly in cold, wet, unsterilized soil either fails to produce an acceptable stand or produces seedlings that soon damp off.

Infection occurs at the soil line in the hypocotyl, the zone between stem and root. Water-soaked lesions constrict the stem so that it usually collapses (Fig. 6). Frequently, damping-off is caused by one or more species of ***Pythium*** or by ***Rhizoctonia solani,*** visible with a good hand lens or even to the naked eye, as a weft of very fine metallic-colored threads over the surface of the lesion. Occasionally, ***Botrytis cinerea*** causes a seedling rot if the plants have been roughly handled.


1


2


3


4


5


6

Control

In the greenhouse, grow seedlings in the best possible conditions of warmth, light, and watering, in sterilized soil, and in sterilized containers. Use only good-quality seed. Never put seeding flats on an earthen floor; keep them on a well-ventilated bench. Water as lightly as possible with warm water. Avoid creek water or any other soil-contaminated water.

Pretreatment of the seed with a fungicide is desirable, especially for cold wet soils, and fungicide treatments for the young plants may save many from infection. For information on fungicides, consult your provincial agricultural representative.

Because ***Pythium*** species and ***Rhizoctonia solani*** are normal soil inhabitants and parasites of many plants in the field, crop rotation is not a control measure. The most effective control measures are crop and soil hygiene.

Downy mildew

The fungus ***Pseudoperonospora cubensis*** attacks cucumber and most other cucurbits, including a few wild species. Angular, yellowish to pale green areas appear on the upper surface of the leaf (Fig. 7). These areas are much larger than those of the angular leaf spot. The pale areas are separated by dark green islands, somewhat like mosaic mottle. In moist conditions the sparse, faintly purple, spore-bearing growth of the fungus appears on the lower leaf surface (Fig. 7). Badly affected leaves die, and the whole plant may be stunted and killed. The fungus rarely attacks the fruit directly, but the fruit is small and of poor quality.

The disease occurs over a wide range of temperatures but is especially favored by a moist environment. Surface water on the foliage from fog, dew, or rain is essential for the fungus to infect the plant. Once established, the fungus is able to spread rapidly by spores blown through the air and is perhaps carried by insects.

Fig. 1 Angular leaf spot. At first the leaf lesions are round; as they enlarge, they are confined in small angular areas by the veins.

Fig. 2 Symptoms of bacterial wilt.

Fig. 3 Bacterial soft rot in long English greenhouse cucumbers, shrink-wrapped in plastic.

Fig. 4 Anthracnose appears as small yellowish circular spots and causes some leaf distortion.

Fig. 5 Symptoms of black root rot.

Fig. 6 Damping-off. The stem is constricted and softened at or just above the soil level so that the plant topples over. In this case, the casual agent is a *Pythium* species, which has produced a white, cottony growth on the lesion.

Control

As with most diseases caused by fungi, the chances of infection increase the longer the plant stays wet. To promote rapid drying after dew and rain, plants and rows should be well spaced, and weeds, which impede drying air currents, should be eradicated. Fungicides are useful; ask your provincial agricultural representative about up-to-date recommendations. Some resistant cultivars are known. Because both wild and cultivated cucurbits are susceptible, observe a long rotation and keep cucurbit fields as far apart as possible. In greenhouses, especially those constructed in plastic, ventilate as thoroughly as possible, providing adequate heat at night to avoid dew deposition.

Gray mold

This disease, caused by *Botrytis cinerea,* mainly attacks poorly managed greenhouse crops. As with white mold, the causal fungus almost invariably uses old, dead tissue as a food base from which to attack healthy tissue. Thus, the lesions produced by this fungus are usually associated with dead or dying material, such as a broken leaf petiole (Fig. 8), a fallen flower, or a dead flower remaining on the fruit. The fungus is also associated with unduly humid and cool conditions.

The lesions are usually brown and soft and covered with gray-brown powdery masses of spores, which are spread from plant to plant through the air and in splashed water. The tissue becomes bleached, and the lesions often have characteristic concentric light and dark zones. Hard black resting bodies, 2-5 mm and irregular to spherical, are formed on fleshy tissue and on older lesions. These resting bodies, the sclerotia, fall to the ground, where they may survive for long periods. They give rise to new crops of spores in suitable moist, moderately warm conditions.

Control

Often the symptoms of gray mold may not be apparent for several days or even weeks after infection has occurred. Flowers that are infected may not show symptoms themselves, yet they can transmit the fungus to the fruit. The symptoms finally appear when the fruit is ripe. This condition is known as latent infection. Thus, fungicide sprays applied when the symptoms appear are usually far too late, and are a waste of time and material.

In the greenhouse, crowded, soft, and damaged plants, and plants in poorly ventilated houses, are particularly susceptible, but in clean, well-managed houses no fungicide should be necessary. Unfortunately, removing the old dying lower leaves, which harbor the fungus, removes the white fly predator *Encarsia formosa.* This lower leaf zone should always be well ventilated to prevent fungal growth. Reduce the humidity (but not so much as to prevent good growth), ventilate well,

and keep the air moving. Avoid overdense plantings and too much nitrogen, which produces susceptible, soft, luxuriant, vegetative growth.

The disease begun in the growing crop, perhaps unnoticed, continues as a postharvest rot. Where the disease has occurred in some fruit, the fungus grows slowly from fruit to fruit in storage boxes. This situation occurs particularly when latent infections have been established at the flower end.

Because *Botrytis cinerea* can survive in old straw, clean, fresh, preferably sterilized straw should be used as a mulch. The fungus also occurs on almost all crop plants and weeds and can readily change hosts. Crop hygiene, especially careful weed control, is therefore essential; it both removes sources of infection and permits better ventilation through the crop.

Leaf blights

Leaf blights, caused by one or more rather similar fungi belonging to *Alternaria (A. alternata* and *A. cucumerina), Stemphylium, or Ulocladium,* occur mainly on muskmelon, but occasionally they are reported on cucumber when the crop is poorly grown. Disease symptoms (Fig. 9) first appear on leaves near the crown of the plant around the middle of the growing season, especially when the weather is warm and damp. Small, water-soaked, circular, gray-tan spots on the upper surface enlarge in concentric rings; on the lower surface they are less distinct. The lesions can be up to 1 cm wide and eventually may coalesce. On both leaf surfaces the greenish black spores of the fungus are formed in chains. They are dispersed through the air, by splashed water, and by pickers. Leaves curl downwards, and defoliation can occur, which exposes the fruit to sun scald and to other organisms that cause fruit rot.

The disease mainly affects plants that are weakened by heavy cropping or by mineral deficiences, or those that are growing in very alkaline soils.

Control

Because the fungi may be seed-borne, a fungicide seed dressing is recommended. The fungi also overwinter in cucumber debris; *Alternaria alternata* is a widespread fungus capable of overwintering in almost any plant debris. A long rotation of cucurbits is therefore advisable, together with sound hygiene and seed treatment.

The disease can be controlled to some extent by a fungicide in programs similar to those for scab and anthracnose and according to current recommendations. Use only disinfested seeds where the disease is troublesome. Improved growing conditions make the crop far less susceptible to leaf blight.

Leaf rot

Trichothecium roseum, the fungus that causes leaf rot, is usually, found on dead and dying plant material, and has been reported to cause rot in several fruits. In cucumber greenhouses it occurs on dead material, such as insect excreta and fallen blossoms (Fig. 10). In moderately high humid conditions the fungus causes lesions, which almost always start from bee excreta or from fallen blossoms lying on leaves. On the upper leaves the lesions remain small, but on the lower leaves they are larger and more numerous. At first the spots are water-soaked and have a fairly broad yellowish margin; later the centre of the lesions dries to a brownish tan color and may fall out. On thin leaves the lesions spread fast and may coalesce to cover a third or more of the leaf.

Although it has been reported to rot stems elsewhere, in Canada, specifically in Ontario, the disease seems to attack only leaves. The same fungus can often be seen on rotting fruit together with other soft-rot organisms.

Control

Like gray mold, leaf rot is essentially a disease of high humidity. The most effective remedy is proper ventilation. No fungicide control is known, nor should one be necessary with good management.

Leaf spots

Several fungi, notably ***Alternaria*** species and *Ulocladium* ***consortiale, can*** cause leaf spots (Fig. 11) in cucumber, but they are rarely severe enough in Canada to warrant fungicidal control measures. In general the spots begin as tiny water-soaked areas and enlarge to spots 2-3 mm or sometimes larger, with dry brown to gray centres. Some fungi, for example ***Cercospora*** and ***Septoria*** species, produce tiny black spore-containing fungal bodies on the spots. Their spores are usually rain-dispersed, and the diseases are spread most rapidly in wet seasons or

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Fig. 7 Downy mildew. On the underside of the leaf the purplish brown growth of the fungus can usually be seen alongside the veins.

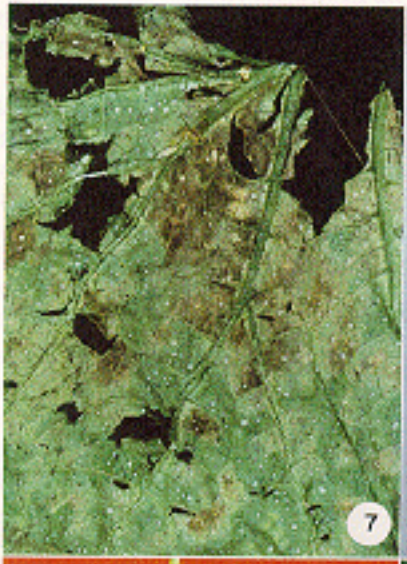
Fig. 8 Gray mold, caused by *Botrytis cinerea*. A brownish gray fungal growth appears, accompanied by abundant airborne spores.

Fig. 9 Leaf blight. The lesions are large and irregular, gray-tan, and occasionally have concentric bands.

Fig. 10 Leaf rot is most often associated with insect excreta or fallen blossoms. In this case, the large irregular lesions are associated with tunneling damage caused by a leaf miner.

Fig. 11 A leaf spot caused by an *Alternaria* species.

Fig. 12 Symptoms of penicillium stem rot may superficially resemble those of stem blight, gray mold, or white mold, but the fungal growth is especially apparent when the stem is split open (*left*).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through excessive overhead irrigation. Other fungi, such as *Alternaria* and *Ulocladium* species, are wind-dispersed but require a water film on leaves to infect the plant.

A few of the fungi that cause leaf spots are listed here, but they usually require laboratory examination to identify them with accuracy: *Alternaria cucumerina, A. alternata* and other species, *Ascochyta* species, *Cercospora* species, *Septoria cucurbitacearum, Stemphyllium* species, and *Ulocladium consortiale.*

Penicillium stem rot and penicillium fruit rot

These diseases are caused by the fungus *Penicillium oxalicum*. Because they always occur together, they should be treated as one disease. Somewhat resembling gray mold or stem blight, the nodal area of the stem becomes bleached, and a lesion extends upwards and downwards. The tissue is water-soaked and becomes so soft that the stem often collapses at the lesion. This disease is readily distinguished from the other stem diseases by a characteristic greenish blue velvety fungal growth, usually with a white border. This fungal growth is also seen when the stem is split open, usually releasing a cloud of spores (Fig. 12).

The same fungus is often seen on aborted fruit, though it is uncertain whether it causes abortion. The fungus certainly infects ripening fruit at the flower end, causing a soft, brown rot, with a characteristic greenish blue growth appearing externally. Fruit pulled off the plant leaving exposed flesh at the shoulder is similarly infected. Such infections may escape notice at harvest and are likely to progress in the marketed fruit, especially when shrink-wrapped in plastic film.

Penicillium stem rot and penicillium fruit rot (Fig. 13) tend to occur in overly humid, poorly ventilated greenhouses and in over-fertilized crops, where growth is soft and succulent. The diseases have also been noted in pickling cucumber fruit in the field and in fruit awaiting processing.

Control

No fungicidal control is registered, and so control lies in sound crop management-avoiding practices that give soft growth and providing adequate ventilation. This advice applies both in greenhouses and in field crops, where adequate row spacing and orientation parallel to prevailing winds keep the plants naturally ventilated.

Powdery mildew

Two fungi, *Sphaerotheca fuliginea* and *Erysiphe cichoracearum*, have been recorded to cause powdery mildew. They are difficult to distinguish, but S. *fuliginea* has a slightly brown tinge, whereas *E. cichoracearum* is pure white and is sparser on the leaves. *Sphaerotheca fulrginea* seems to be a common pathogen in southwestern Ontario, *whereas E. cichoracearum* occurs in Alberta.

The disease symptoms are very conspicuous (Fig. 14); the first sign is a fine web of white threads spreading out from centres anywhere on the leaf. These centres coalesce, and the whole leaf becomes covered with a white loosely woven mat of fungus threads. The threads bear spores that stand up in short chains that fall when the leaf is disturbed. The spores are carried from plant to plant through the air.

Severely affected leaves eventually turn yellow, become brown, and shrivel. Powdery mildew also occurs on the stem and on leaf petioles. Fruit is only rarely infected, but yield and quality are reduced because of damaged leaves. A strip of yellow, brown, and shriveled leaves down the centre of the row is characteristic of this disease in the field.

Control

Powdery mildew thrives in rather dry air and soil, moderate temperatures, low light, fertile soil, and soft plant growth. Under these conditions control measures are needed. On the other hand, powdery mildew is seldom a problem in rainy seasons.

In tests, powdery mildew has been controlled by spraying the affected plants with water. Spray in the morning so that the plants can dry off within 2-3 h before other fungi infect the plant.

Powdery mildew develops best at temperatures between 26 and 28°C. Although little can be done to reduce temperatures in the field, those in the greenhouse should be maintained at about 21°C by ventilating and fogging systems; these systems also raise the humidity, which tends to suppress powdery mildew.

Avoid conditions that cause heavy soft growth, such as overcrowding, overshading, and excess fertilizer and water. Delaying seeding of the spring greenhouse crop until the beginning of December helps to prevent infection.

Keep greenhouses and their surroundings clear of other susceptible crops, weeds, and trash piles. Keep fields free from weeds and trash. Do not plant successive crops of cucumbers, or cucumbers after squash or melons.

Some fungicides help in controlling powdery mildew, but many can damage the plants, especially at high temperatures. Consult your provincial agricultural representative for current recommendations. However, a prerequisite for cucumbers free from powdery mildew is crop sanitation and good temperature control in greenhouse crops.

Some cultivars of cucumber are tolerant of powdery mildew; consult your seed supplier.

Pythium sudden wilt

Occasionally, mature greenhouse cucumber crops may wilt suddenly and irreversibly with no warning symptom. The cause is the infection of the tiny feeder rootlets by one or other species of the fungus ***Pythium.***

The only symptom on the roots is a slight discoloration and soft rotting of the ultimate feeder rootlets, which are often left behind, and unnoticed, when a plant is dug out of the soil.

Control

Soil sterilization or switching to hydroponic production are the only controls for this disease. *Pythium* species are soil-borne fungi that are often carried into greenhouses by boots, machinery, and floodwater from a high water table outside. Well or creek water may be contaminated.

Root death

Root death is a disorder particularly conspicuous in cucumbers grown by the nutrient film technique (NFT). Symptoms appear suddenly; the plant collapses, and the roots become completely disintegrated, the tissues separating and floating away in the flowing nutrient solution. No organism is consistently associated with this condition; it is generally believed that a nutrient imbalance is caused by shunting nutrients to the developing fruit at the expense of the roots. Lack of sufficient oxygen dissolved in the nutrient solution may be another contributing factor. Root death almost certainly occurs to some extent in rockwool and soil where drainage is impeded, but it usually escapes notice. There is no plant collapse in those media, but production may be reduced.

Control

Close and frequent monitoring of the nutrients in NFT is essential and best done by computer. More oxygen can be dissolved in the nutrient solution by allowing the solution to splash vigorously into a collecting tank before recirculation. Avoid overloading the plant with stem fruit, which robs the roots of adequate nutrition.

Fig. 13 Penicillium fruit rot usually starts at the flower end but can also rot the fruit from a torn shoulder.

Fig. 14 Powdery mildew first appears as small white spots on stems and leaves. These spots eventually enlarge to powdery spore masses that cover the entire plant.

Figs. 15 and 16 Scab. The lesions on the leaf begin as water-soaked areas that enlarge in an irregular shape and dry out (Fig. 15). On the fruit (Fig. 16) the lesions also begin as pale water-soaked depressions that enlarge and deepen.

Figs. 17 and 18 Stem blight. The fungus usually attacks the leaf at the margin (Fig. 17). A soft, brownish black rot, extending into the internal tissues, often occurs at the blossom end of the fruit (Fig. 18). The fruit is initially more tapered at the tip than usual.


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Scab

Scab, caused by ***Cladosporium cucumerinum,*** can be severe and epidemic in cool, foggy, wet seasons with cold nights and in poorly ventilated and underheated greenhouses. It appears on leaves in mid season as small, circular, angular spots, water-soaked, and pale brown. This disease is sometimes difficult to distinguish from angular leaf spot, but scab lesions do not have a whitish crusty covering and the veinlets remain brown against a paler background (Fig. 15). In very humid conditions the fungus causes lesions on leaves and stems, which have an olive green covering of spores in a velvety mat. These spores extrude through the stomata. Stems and young leaves become water-soaked and soon wilt and die back. At the vine tip the disease sometimes resembles cucumber mosaic virus disease.

However, the most serious damage occurs on the fruit (Fig. 16). Small fruits have slightly sunken, water-soaked gray spots. These spots sometimes exude a gummy brown material that dries to a brown bead. As the fruit expands, the cavities enlarge, often up to 1 cm in diameter and as much as 0.5 cm deep. Later, the fungus produces its spores in the velvety, olive green lining of the enlarged lesions. New lesions on larger fruit become corked over, and the shallow cavity is lined with a tan-colored scab.

Control

The use of resistant cultivars provides the best means of control. Consult your provincial agricultural representative for the cultivars suitable in your area. However, because no cultivar is completely immune, genetic resistance must be supplemented by adequate crop hygiene. Follow a long rotation after cucurbits, because the fungus overwinters in cucumbers and other cucurbit debris, including seed. Because it can also overwinter in greenhouses, follow strict hygiene measures there. Several fungicides that control scab are available. They are listed in various provincial publications, but they are ineffective when night temperatures are lower than 14-15°C.

In the greenhouse maintain the temperature around 27°C for a few days, and keep the vines dry and the soil well drained. This should prevent the disease from occurring.

Stem blight

The fungus that causes stem blight, ***Didymelba bryoniae***, also occurs on other members of the cucurbit family, such as squash, pumpkin, watermelon, Chinese melon, balsam pear, chayote, muskmelon, crookneck squash, and various wild genera.

Several symptoms appear on cucumbers in the field (Figs. 17 and 18). Water-soaked lesions that enlarge to indefinite size appear on leaves and fruit. On leaves the lesions may have a yellowish halo and become light brown and irregular in shape. On fruit the lesions become

dark olive green, cracked, and sunken, and have an extensive brownish rot beneath. Many infections appear at the blossom end.

The disease can also appear on marketed fruit, particularly if the crop has been harvested in wet weather. These infections probably have their origin in the field and develop later, especially where the fruit skin has been punctured or the shoulder of the fruit has been torn during picking.

The fungus also attacks the stems, and deep cankers appear in the cortex, which sometimes girdle the stem so that a wilt results. Because the lesions sometimes exude a great amount of gum, this disease is often called gummy stem blight, but this symptom is by no means exclusive; almost any injury or disease on the stem can be accompanied by a golden brown gum.

The disease can also attack seedlings, with circular, tan, or black spots appearing on the cotyledons and stems. Deep lesions soon kill the seedlings outright, but shallower lesions may allow the plant to survive for some time. These shallower lesions provide a source of spores for infecting neighboring plants.

In seedless greenhouse cucumbers, pale yellow V-shaped lesions extend back across the leaf from the margin and turn dry and fawn-colored (Fig. 17). Eventually, the leaf lamina hangs in tatters from the leaf stalk. On the stem a bleached, pale fawn area extends upward and downward from the nodes, mostly about halfway up the stem but occasionally at very low nodes where the stem has been infected at transplanting time. Like the field-grown cucumbers, seedless fruit can be infected at either end or in the middle, where a dead pale brown area causes the fruit to bend. At the blossom end the fruit is firmer than usual, and on cutting the fruit open, the flesh is dark gray or brown. On all these lesions, tiny pinpoint fungal bodies indicate the presence of the disease.

The fungus produces two kinds of spore. First, it produces pycnospores in tiny black bodies on the lesions early in the season. In humid conditions these spores ooze out in long gelatinous tendrils that are dispersed to neighboring plants by splashed water. Later, ascospores are produced in similar bodies on the lesions, but they are spread through the air. The fungus can also be dispersed on pruning knives in the greenhouse and by wet hands and clothing in the field.

Control

Because *Didymella bryoniae* survives for a long time in trash in the soil and in the greenhouse, a scrupulous level of hygiene, including full soil sterilization, is essential.

When the disease occurs in the greenhouse, prevent spores from spreading by avoiding overhead irrigation and ventilate the crop adequately so that a film of water does not persist on plants.

Handle fruit picked from infected crops carefully to avoid puncturing the skin; fruit that is held for long periods should be stored cool. The rot

is almost completely stopped at 7°C, although prolonged storage at this temperature is detrimental to quality. A useful compromise is 12°C.

For fungicide programs consult your provincial agricultural representative.

White mold

This disease, caused by the fungi *Sclerotinia sclerotiorum* and rarely by *Sclerotinia minor*, affects the stem and fruit of the cucumber plant. Infection usually begins where the tissue is dead or dying, such as wilted cotyledons, and especially flowers that remain attached to the fruit or adhere to some other part of the plant after dropping off. Affected tissue becomes water-soaked, and the fungus appears as a profuse white cottony growth (mycelium) on a rapidly spreading lesion. *Sclerotinia sclerotiorum* forms hard black bodies (sclerotia) in the pith cavity of the stem and on the surface of the fruit (Fig. 19). These bodies are usually irregularly shaped and 5-10 mm or larger. The sclerotia of S. *minor* are always superficial in the cottony mycelium, are aggregated into flat masses, and are smaller, usually 2-3 mm. In both cases the sclerotia fall to the ground, where they can survive for very long periods, sometimes as long as 20 years. In suitable conditions of soil moisture and temperature and from a depth of less than 2.5 cm, the sclerotia produce tiny toadstool-like bodies (apothecia). The apothecia produce a large number of spores on their upper surfaces, which are discharged into the air and infect surrounding plants. If infected fruit escapes detection at picking, this disease can spread rapidly in boxes.

Control

Like gray mold, this disease is essentially a result of bad management in the greenhouse. Steam sterilization (but not always fumigation) kills the sclerotia in the soil, but spores can be blown in from the outside. However, if the plants are kept free from persistent water drops and film, especially at flowering, the disease should not occur.

In the field, where soil sterilization is impracticable, effective protection depends on knowing when the apothecia are produced, usually in May. Because the apothecia are pale brown and very small (3-5 mm across), they are often hidden among the soil particles. Consult your provincial agricultural representative for the appropriate field remedy.

Both fungi have a wide host range, including lettuce, beans, carrots, potatoes, rutabagas, celery, tomatoes, sunflowers, cole crops, and many weeds. Where a susceptible crop has been affected in the previous year or two, another cucumber crop should be avoided. Many of the sclerotia break down in the soil, but plenty usually survive, no matter how deeply they are plowed in. With renewed cultivation, many appear near the surface again, where they germinate. Good weed control, both in the field and around greenhouses, is a control measure; it reduces both the hosts of the fungus and, by encouraging better air movement, it also

reduces the likelihood of water film persisting on foliage for long periods and thus encouraging infection. For the same reasons, avoid crowding plants unnecessarily and encouraging vigorous soft growth. Trash should not be piled at any time in the greenhouse or in the field.

Wilt and foot rot

Several species of *Fusarium* have been associated with cucumber wilt and basal stem rot, but only two seem to be primary pathogens. Other species of *Fusarium* may be present, but their role in disease initiation is uncertain. *Fusarium cucumerinum* causes a wilt in field and greenhouse cucumbers, but it is not often reported in Canada. *Fusarium solani* f. sp. *cucurbitacearum* causes a basal stem rot and sometimes a fruit rot; it, too, is not often seen in Canada, but it occurs on other members of the cucumber family, such as squash.

Control

All the *Fusarium* species are soil-borne and are best combated by sound crop rotation, good drainage, and in greenhouses, by soil sterilization.

Fungal fruit rots

Several fungi and bacteria cause rots of mature fruit, both on the plant and during marketing (Figs. 3, 13, and 18).

The fungal pathogens *Botrytis cinerea, Sclerotinia sclerotiorum* (Figs. 16 and 18), and *Choanephora cucurbiturum* begin as a blossom blight and then spread the rot into the ripe fruit. Other fungi are wound parasites, found in soil and in dirty containers. They enter the fruit through skin punctures caused by insects or by careless picking and packing. Such fungi include *Rhizopus, Pythium, Mucor, Penicillium* (Fig. 13), *Aspergillus,* and *Fusarium* species; and *Trichothecium roseum*. Bacteria such as *Erwinia carotovora* ssp. *carotovora,* a widespread soft-rotting organism readily picked up from the soil, may also be implicated in storage and marketing rots (page 16).

Control

Except when already established as a blossom blight, such organisms can be prevented from spoiling the fruit by careful picking and handling. Be sure to remove the field heat immediately after picking by cooling the crop to 12°C and maintaining this temperature throughout transit and marketing. Cucumbers, however, are susceptible to chilling injury below 7°C, particularly over periods of 6 days or more. Rigorously exclude damaged and diseased fruit from packs, because rots spread rapidly to all surrounding fruit. Cucumbers are particularly susceptible to ethylene damage; ethylene induces susceptibility to several soft-rot organisms, especially *Botrytis cinerea.* Ethylene is a gas produced by

ripening fruit, such as tomatoes and apples; cucumbers should therefore be packed on their own in cool, well-ventilated stores and shipped separately.

Virus diseases

Beet curly-top virus

This virus occurs in most of the cucurbits. Cucumber plants that are infected after the first true leaves develop remain stunted. The youngest leaves become deep green, whereas the older ones turn yellow, at first along the margin and then between the veins, extending to the midrib. The veins and the base of the leaf remain green. The terminal leaves are dwarfed, slightly cupped, and tightly clustered together. The fruit are small and malformed. At a late stage the base of the stem collapses, and the plant wilts and dies. The virus is found in a wide range of crop plants, ornamentals, and weeds. It is not easily sap-transmitted but is spread by two leafhoppers, *Circulifer tenellus* and C. *opacipennis.*

Control

Control lies in the isolation of cucumbers from all other plants and in good insect control.

Beet pseudo-yellows virus

This virus is not uncommon in greenhouse crops with heavy infestations of the greenhouse whitefly *Trialeurodes vaporariorum*. It causes a yellow, irregular mottling of the leaves and interveinal yellowing (Fig. 20), not unlike the symptoms of magnesium deficiency. The plants are unthrifty, yield poorly, and die prematurely.

Control

It is important to monitor whitefly populations with yellow sticky traps and to introduce biological control insects in good time. The virus occurs in many herbaceous hosts, including melon, squash, spinach, lettuce, and carrots, as well as in many weeds such as shepherds-purse, sow-thistle, and groundsel. It is therefore important to keep greenhouses and their surroundings clear of weeds. A 10-m band of lawn around greenhouses is sound husbandry.

Cucumber green mottle mosaic virus

One or two cases of this virus in Canada have perhaps occurred, but they remain unconfirmed. Leaves of infected plants are mottled, blistered, and distorted, and the whole plant is stunted. The virus also

affects watermelon with slight mottling but with serious internal fruit discoloration. It is sap-transmissable, but no biological vector is known.

Cucumber mosaic virus

Symptoms of cucumber mosaic virus (CMV) first appear in plants 6-8 weeks old both in the field and in the greenhouse, when the plants are beginning to elongate quickly. The young leaves develop small greenish yellow, slightly translucent areas, 1 or 2 mm in diameter, which are usually confined by the small veins. Later, a yellow mottle develops on all leaves, with some leaf distortion and plant stunting. Sometimes only the leaf tip turns yellowish, and the sharply defined mottle does not appear. The leaves curl downward gradually, and the leaf surface is finely wrinkled. All growth is then stunted and the internodes are shortened. In older leaves a V-shaped dead area may appear, extending from the margin toward the midrib (Fig. 21).

Few fruits set; the stem end becomes a mottled yellowish green that spreads over the whole fruit (Fig. 22). As this condition develops, the fruit becomes a light yellowish green, with dark green raised spots. The fruit feels lumpy. Sometimes the later fruit is smooth, greenish white, and somewhat misshapen, with irregular green areas. This condition is known as white pickle.

In some highly susceptible cultivars, infection by CMV causes the plants to wilt rapidly and die within 7 days, without the usual mosaic symptoms. Rapid death also occurs when the roots are infected by the fungus ***Pythium*** (page ***40***).

The virus is found in most cucurbits and in all wild members of the same family, as well as in other crop plants, such as celery, spinach, tomato, bean, cowpea, tobacco, ornamentals, and weeds.

The virus is systemic and is readily transmitted from plant to plant in sap by more than 60 species of aphids, especially by the green peach aphid, ***Myzus persicae*** and, the melon aphid, ***Aphis gossypii.*** Cucumber mosaic virus may be seed-borne, but this form of transmission is probably not common.

Control

Grow cucumbers from certified seed away from aphids and from other plants. Carefully rogue isolated infected plants into plastic bags and carry them out of the crop without touching other plants. Wash your hands, tools, and clothing frequently.

Most fresh-market field cucumber cultivars and pickling cultivars are moderately to highly resistant to CMV, but European seedless cultivars have little or no resistance. For suitable cultivars in your region, consult your provincial agricultural representative.

Cucumber necrosis virus

This virus is most severe in the greenhouse in the autumn and winter. As the days lengthen, the symptoms are mild and indistinct; plants severely infected in the spring may recover almost completely by the summer. Field cucumbers may also become infected.

In severely infected plants the leaves are malformed. As the virus becomes systemic throughout the plant, young leaves become upright and yellowish, the youngest leaves have a purplish tinge as the tissue dries out and dies. Yellowish green to tan-colored areas, 1–8 mm across, appear on the leaf blade, often on the smaller veins. Within 2-3 days the pinpoint centre dies and falls out, leaving a shot hole. As the virus moves through the vascular system, symptoms appear in other leaves, sometimes on only one side of the midrib. Enations, which are little flaps or funnels of dark green tissue, develop on the lower surface of the leaves. These enations often occur around a shot hole or along a vein 2-3 weeks after the first appearance of the systemic symptoms. Enations are often the only symptoms that appear during the summer. The virus can be transmitted from plant to plant by rubbing abraded leaves with infected sap, which probably occurs in cultural operations. The disease is also picked up by the roots in soil contaminated with infective debris or sap. In commercial greenhouses, plants are usually infected by contaminated soil. The virus is transmitted by a soil-inhabiting fungus, *Olpidium radicale*, which may be carried in irrigation water from runoff-contaminated reservoirs, thus contaminating hydroponic systems.

Control

Carefully rogue infected plants into plastic bags and carry them out of the crop without touching other plants. They should be burned, not buried. Heat sterilize sap-contaminated tools, wash hands, and change clothes before working in the clean crop again. Because the virus is soil-borne, steam sterilize groundbeds, plotting soil, and all associated pots. Chemical fumigation is ineffective. Avoid using well or creek water, or water from a reservoir susceptible to soil contamination, the source of the fungus vector.

Cucumber vein-yellowing virus

Infected plants show a conspicuous vein-clearing and yellowing; in the later stages of the infection the plant dies. This virus is transmitted in the sap and by the sweet potato whitefly, *Bemisia tabaci.*

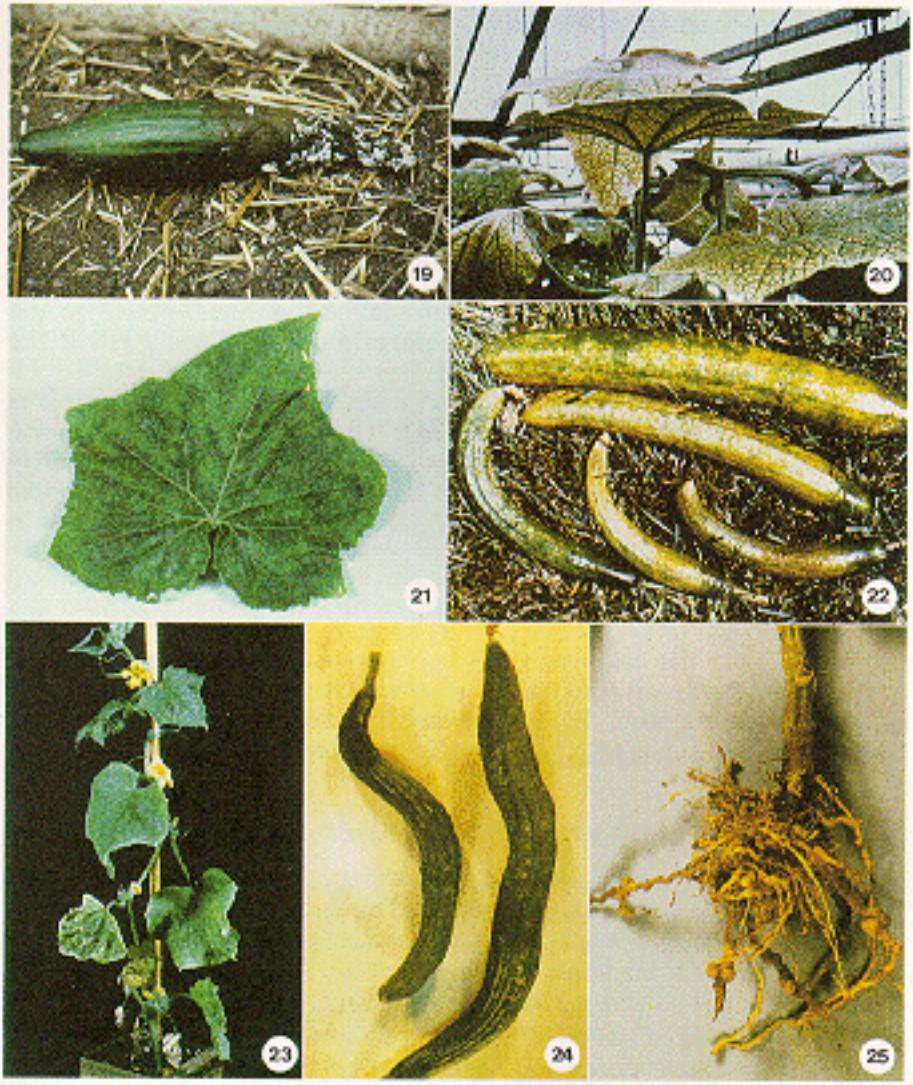

Fig. 19 White mold on a cucumber fruit is characterized by prolific white fungal growth and by large, resistant sclerotia.

Fig. 20 Beet pseudo-yellows virus. The leaves are finely mottled with yellow.

Figs. 21 and 22 Cucumber mosaic virus causes a mottled appearance in the leaves (Fig. 21). The fruit is also characteristically mottled and bumpy (Fig. 22).

Figs. 23 and 24 Watermelon mosaic virus causes severe distortions and discoloration in the leaves (Fig. 23) and fruit (Fig. 24).

Fig. 25 Root-knot nematode causes severe galling on roots.

Tobacco ringspot virus

Cucumber, pumpkin, vegetable marrow, and cantaloupe are extremely susceptible to this virus. It has wide host range in crop plants, such as bean, cowpea, easter lily, hydrangea, iris, geranium, blueberry, soybean, lettuce, ornamentals, and weeds.

Tiny pinpoint spots appear on the leaves, yellowish brown at the centre and surrounded by a bright yellow margin or halo. Sometimes definite rings appear. Infection spreads rapidly through the whole plant, and numerous halos occur on all the new leaves. Tiny water-soaked spots surrounded by a water-soaked rim also appear on the fruit. The spots are often 2-3 mm deep and occasionally reach the seeds. The fruit tissue is deep green.

The virus is transmitted in sap on tools, hands, and clothing. It is also transmitted by the following: the nematode *Xiphinema americanurn* onion thrips, *Thrips tabaci;* species of the mite *Tetranychus;* grasshoppers of the genus *Melanoplus;* and the tobacco flea beetle, *Epitrix hirtipennis.* It can be seed-borne, but is rarely so in cucumber.

Control

Control in both the field and the greenhouse lies in sound crop hygiene with stringent weed and insect control. Ornamentals or perennial plants, such as grape, fig, and oleander, should not be grown in the same greenhouse.

Tomato ringspot virus (cucumber strain)

A lethal strain of the tomato ringspot virus causes tan-colored lesions when inoculated into cucumber leaves. The lesions slowly enlarge until they reach a vein, when the virus becomes systemic, and expanding dead areas appear on stems and other leaves. At soil level dead lesions are readily invaded by various soil fungi, such as *Pythium* and *Fusarium* species, which can rot the base of the already weakened plant.

The virus is sap-transmitted through the soil by the nematode *Xiphenema americanum.* It does not long survive desiccation in infected, dying tissues. However, it occurs in many crop plants, such as tomato, tobacco, peach, soybean, grapevine, and raspberry; in ornamentals, such as gladiolus, geranium, and hydrangea; and in several weeds.

Control

Carefully rogue out affected plants without allowing them to touch neighboring plants. Carry the infected plants out of the crop in bags and bury them, Thoroughly wash tools, clothes, and hands before entering the clean crop again. Do not save seed from affected crops. In the

greenhouse sterilize the soil and carry out a full hygiene program in the house and its surroundings. Do not grow cucumbers with any other plants.

Watermelon mosaic virus

This virus was reported on cucumber for the first time in Canada in 1975, and it also causes mosaic and mottle diseases of cantaloupe, pumpkin, and squash. In greenhouse cucumbers the fruit is severely shortened, curled, and gnarled; the symptoms on the leaves are similar to herbicide damage (Fig. 23). Yellow vein-clearing and yellow flecking appears, followed by a bright green to dark green uniform mosaic. The leaf margins turn up, and subsequently further leaf distortion and hooding occurs, with the edges downward. There is irregular venation, dark green vein-banding, and dark green blistering between the veins. The disease also affects the fruit (Fig. 24).

The sources of infection are not yet fully identified, but seed transmission is not suspected. It can be transmitted by at least 38 species of aphid in 19 genera. Control insects and weeds, and observe long rotations among cucurbit crops.

Suspected cases of this disease should be brought to the attention of your provincial agricultural representative.

Miscellaneous diseases

Aster yellows

Once thought to be caused by a virus, aster yellows is caused by a mycoplasma and is transmitted by leafhoppers of several genera. This disease affects cucumbers and its relatives, as well as other crop plants, ornamentals, and weeds.

Infected cucumber plants become stunted and chlorotic, and the terminal leaves are dwarfed. Intermediate leaves become yellow and roll upwards at the margin. The affected plants wilt and die very quickly, within 5-10 days after infection.

The disease is readily transmitted to and from other cucurbit crops and a wide variety of other cultivated and wild plants.

Control

Stringent leafhopper and weed control is the key to avoiding this disease.

Root knot

Root knot, caused by the nematode *Meloidogyne incognita,* is common in unsterilized greenhouse soil, This nematode can be found at depths of 150 cm, and possibly deeper in sandy greenhouse soils. It may be accompanied by other nematodes, of which only *Pratylenchus* species may play a small role in pathogenesis.

The symptoms (Fig. 25) are distinctive. Above the ground the plants appear generally unthrifty, yellowish, stunted, low in production, poor in quality of fruit, sometimes nutrient-deficient (especially in nitrogen), wilted on hot days, and more than usually susceptible to foliage and wilt diseases. Below the ground the roots are grossly enlarged and distorted by galls induced by the nematodes. However, very light infestation may result in a temporary spurt in growth. Where leaves and stems touch the ground, small galls may also appear. The roots are considerably shortened, and the whole root system has a greatly reduced efficiency.

Control

In the greenhouse, soil sterilized by steam or chemicals is the only effective method of controlling root-knot nematodes, especially in sandy soils. This control is generally effective for only one crop. In most commercial systems the nematode lives at depths greater than the sterilant can reach. The nematode can reinvade the upper soil levels within the life of one crop, though not enough to affect its yield. A second crop, however, would be severely affected. Because the nematode also affects tomatoes and many ornamental plants, greenhouse rotation is not an effective control measure. Where production in soil is regularly reduced by this pest, the only recourse is to switch to a hydroponic system. Consult your provincial agricultural representative.

In the field a program of crop rotation with periodic soil fumigation is effective in controlling nematodes, but choosing the correct rotation and fumigant is difficult. Obtain expert advice from your provincial agricultural representative.

The disease is seldom of consequence in the field because the root-knot nematode does not usually over-winter in Canada. However, do not grow field transplants in infested greenhouse soil.

Sudden wilt

In the greenhouse, seedless cucumbers may suffer a sudden and irreversible wilt while showing few visible symptoms, or none. This wilt is caused by an interaction of cucumber mosaic virus with a fungus of the genus ***Pythium*** in the roots, which causes no appreciable root rot or damping-off on its own.

Avoid conditions that contribute to cucumber mosaic virus (page 35) and pythium sudden wilt (page 27).

Dodder (*Cuscuta* species)

Dodder is one of several parasitic seed plants that are leafless and lack chlorophyll, but that bear profuse flowers and seeds. These plants depend almost entirely on their host plant for nutrients, which they obtain by twining around the stem of the host plant and penetrating it with root-like organs (haustoria). Some viruses are transmitted from plant to plant by dodder. Dodder-parasitized plants lack vigor and have poor productivity.

Dodder is occasionally reported on cucumber and is best controlled by mowing plants closely and burning them in affected patches well before the dodder seeds. If it has seeded, then plow in green cover crops to clear the land.

Physiological disorders

Heat damage

If cucumbers are seeded beneath a plastic mulch, they may well be scorch-damaged by undue heat reflected from the plastic (Fig. 22).

High-temperature wilting

Temperatures over 32°C, especially in bright sunlight, can also cause temporary wilt, both in the field and in the greenhouse. Ventilation in the greenhouse should begin at 24-27°C because if high temperatures persist, the margins of the lower leaves may die.

A temporary wilt often occurs in the early part of the season, before an adequate root system has developed, and when warm, sunny days follow prolonged dull periods. Most plants recover, but some that lose lower leaves may die. In this case, mounding the base of the plant with peaty soil and watering with overhead sprinklers help recovery.

Chilling damage

Chilled fruit has delicate scratch-like longitudinal pale fawn scarring (Fig. 26) and is often malformed.

Low-temperature wilting

In the greenhouse, cucumbers require a minimum temperature of 21°C. If the temperature drops suddenly, alarming wilt symptoms may appear, but the plants usually recover. If cool conditions persist, for example, near the wall of an uninsulated house, plants will be permanently stunted.

Irregular watering

Wilting, yellowing, injured roots, and slow growth can result from poor drainage, overwatering of new transplants, or watering on cold dull days (Fig. 27). These conditions are more likely to occur if soils are cold or contain excess amounts of poor-quality manure.

Underwatering also causes temporary wilting and plant death if the watering program is not corrected soon enough.

Nutrient deficiencies

Balancing nutrients in the soil in amounts available to plants is a delicate matter. Any nutrient deficiency or imbalance represents a potential loss in crop production. Nutrient levels in soils, especially sterilized soils, and in crops should be properly assessed at regular intervals by your provincial agricultural representative. Although a certain latitude in nutrient imbalances in soil can be tolerated, their effects in hydroponic systems are immediate and often catastrophic.

Nitrogen deficiency

Early symptoms of nitrogen deficiency are stunted leaf growth and a lighter color of foliage, especially in the veins, through several shades of green to yellow (Fig. 28). Severe cases represent total chlorophyll breakdown. The stems remain thin and become tough and fibrous. Fruit is pale and does not fill out at the blossom end. A lack of an adequate and continuous nitrogen supply is one of the most common reasons for reduced yield, especially in rainy seasons. Heavy applications of farmyard manure often prevent nitrogen from reaching the plant, though this condition is usually temporary.

Nitrogen deficiency is corrected by frequent applications of ammonium nitrate, calcium nitrate, urea, or sodium nitrate. The choice of the nitrogen source depends on many factors, such as soil type and the stage of crop growth and production. Consult your provincial agricultural representative.

Phosphorus deficiency

Phosphorus deficiency usually occurs in acid soil after several years of heavy cropping. The stems are slender and woody, and growth is restricted. The leaves are a darker green than usual and often have a purplish tinge on the underside. Fibrous roots are poorly developed, and fruit setting and ripening are delayed.

Diammonium phosphate or high-analysis complete fertilizers should correct any phosphorus deficiency.

Calcium deficiency

Calcium deficiency is not often a problem except in high-salt, low-calcium soils and after long use of high-analysis fertilizers, which are low in calcium. Because calcium is not easily translocated, the plant extremities are most affected. The young upper leaves are pale, weak, and flabby; the flower end of the fruit is poorly developed, and growth is generally retarded (Figs. 29 and 30).

A soil analysis by your provincial soil-testing laboratory should detect calcium deficiency. This condition is easily remedied by the addition of limestone or super-phosphate.

Potassium deficiency

Plants deficient in potassium are not very vigorous and are usually more susceptible to some diseases than are well-nourished plants. When plants also have an excess of nitrogen a dark bluish color often appears in the foliage. Otherwise the leaves are yellow to bronze, at first between the veins and then over the whole leaf surface. The margins of the leaves dry out. The fruit enlarges at the blossom end but remains underdeveloped at the stalk end (Fig. 31).

This deficiency is best corrected with potassium nitrate. Other potassium salts, such as chloride and sulfate, may raise the soil salts to damaging levels.

Magnesium deficiency

The symptoms of magnesium deficiency can be confused with those of beet pseudo-yellows virus. Magnesium deficiency is fairly common in heavily cropped vegetable soils, especially in those that sandy. Symptoms often appear after potassium or sodium salts have been applied as fertilizers. The older leaves become yellow in areas between the dark green veins (Fig. 32). This deficiency is readily corrected by foliar sprays of magnesium sulfate when the symptoms first appear or by soil supplements when the soil is known to be deficient.

Seek advice on the correct rate, because an overapplication can be toxic to the plant.

Manganese deficiency

The availability of manganese to plants is determined mostly by soil pH and by the form of manganese in the soil. Deficiencies tend to occur in soils that are calcareous, or overlimed, or in acid and sandy soils that have been heavily leached.

The symptoms in cucumber plants are the yellow-white areas between the green leaf veins, the small leaves, and the weak slender stems. Often the blossom bud is yellow.

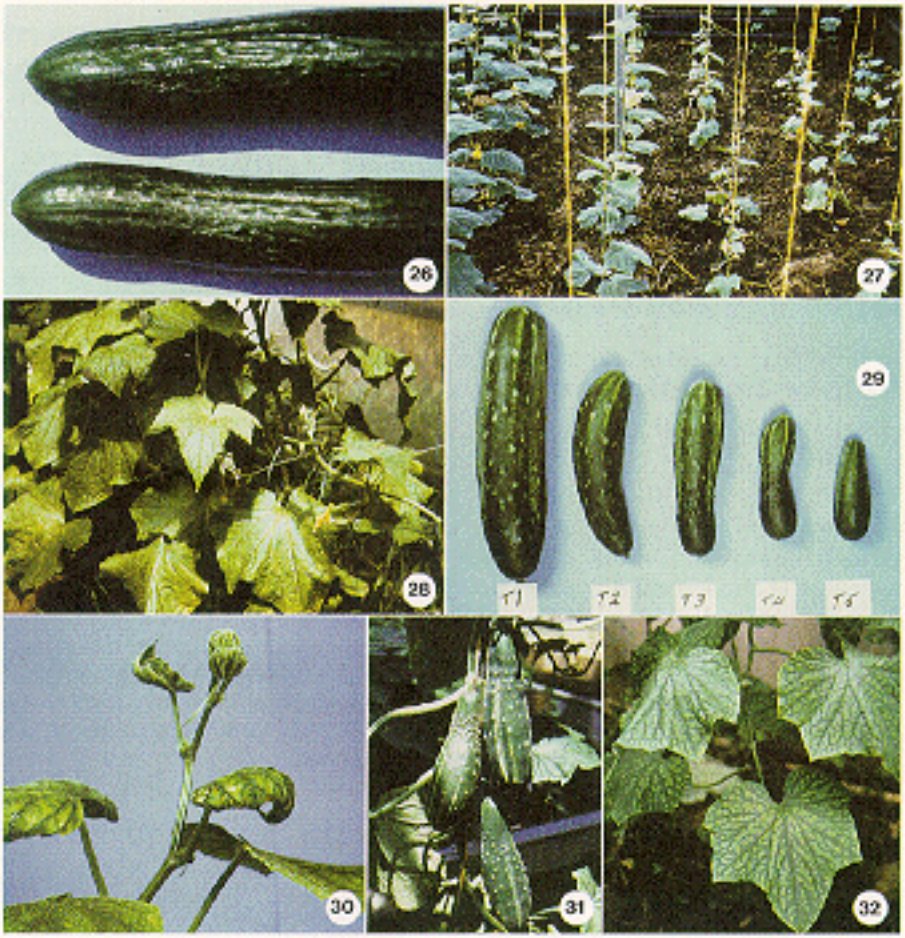

Fig. 26 Chilling damage results in longitudinal scratch-like markings on the fruit.

Fig. 27 Impeded drainage and overwatering result in plants that are yellowish, thin, and stunted.

Fig. 28 Nitrogen deficiency results in small, yellow leaves and severe tapering in fruit at the blossom end.

Figs. 29 and 30 Increasingly deficient levels of calcium result in increasingly smaller and distorted fruit (Fig. 29, T2 –T5). This deficiency also causes severe leaf distortion (Fig. 30).

Fig. 31 Potassium deficiency produces distinct tapering in the stem end of the fruit.

Fig. 32 Magnesium deficiency causes the leaves to turn yellow between the veins.

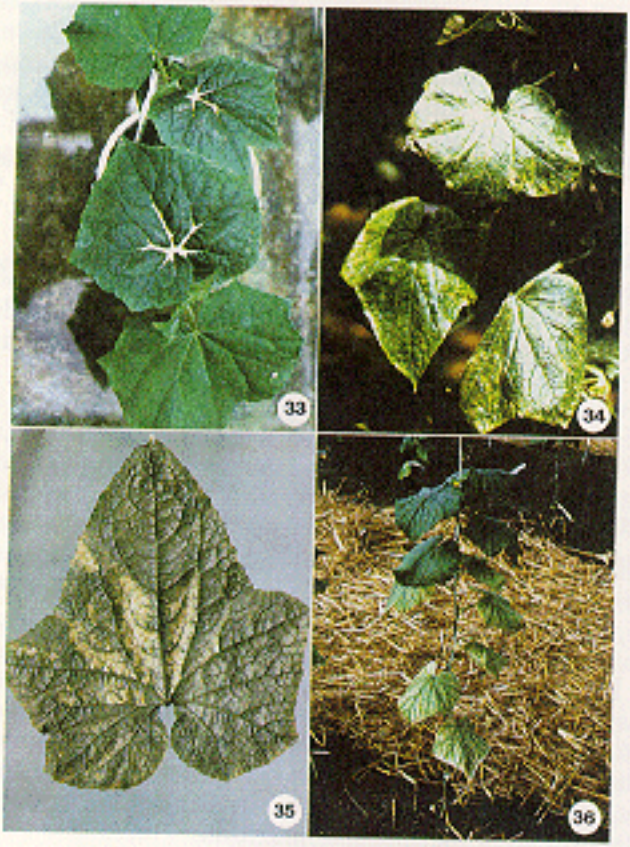

Fig. 33 Injury caused by an overdose of etridiazole, an illegal chemical in Canada. The veins are white and the plant is stunted.

Fig. 34 A mistake in measuring the dose of thiodan resulted in leaf yellowing and severe damage to the growing point.

Fig. 35 Copper toxicity causes brittleness and yellowing of leaves.

Fig. 36 A cucumber plant showing the effects of a high level of salts in the soil. Plants are thin, poorly grown, and yellowish.

Molybdenum deficiency

Unlike most other elements, the availability of molybdenum to plants increases with soil pH. The deficiency is more severe in sandy, acid soils and in neutral soils that are overcropped.

The early symptoms are similar to those of nitrogen deficiency; later, the leaves have interveinal mottling and puffy, dead areas. The leaves become cupped and scorched, and the younger leaves may be twisted and distorted.

Molybdenum deficiency is corrected by adding sodium molybdate to the transplanting water and by liming the soil according to the recommendations of your provincial agricultural representative.

Chemical injury

Nutrients and pesticides

If incorrectly applied, most pesticides can cause injury and even death to cucumber plants, especially in the greenhouse. Before applying herbicides, soil fertilizers, foliar nutrients, fungicides, or insecticides, it is essential to know whether the plant's health depends on a particular chemical. Insurance sprays applied according to the calendar are not always justified, and many pesticides actually reduce yield. It is also essential to know which chemicals are compatible when mixed together and whether temperature, time of day, available soil moisture, water on the foliage, and condition of the crop are compatible with a particular chemical treatment or method of application.

A high proportion of disease-like symptoms, such as the residual effects of pesticides (Figs. 33 and 34), soil fumigants, or spray drift, are caused by the misuse of chemicals. Simple arithmetical errors often result in the wrong dilution of chemicals, which can be either fatal (Fig. 34) or completely ineffective. Double-check all calculations, and if in the slightest doubt, seek expert advice. Copper sprays are often damaging to cucumbers (Fig. 35). Consult your provincial agricultural representative for the correct use of individual chemicals. Further advice is provided by the labels on chemical containers; always adhere strictly to the specified amounts. Never apply any other chemicals from equipment that has been used for herbicides.

High salts

Cucumbers planted too soon into freshly steamed greenhouse soil or unleached soil may suffer from high concentrations of inorganic salts (Fig. 36). These salts damage the roots and result in poor growth and small blossoms. Furthermore, the plant is unable to respond to subsequent fertilizer treatments. Before planting, send soil samples to an analytical laboratory for salt assessments, and then leach and

fertilize according to provincial recommendations. In general, avoid potassium nitrate, calcium nitrate, ammonium phosphate, high-analysis complete fertilizers, and early fertilizers that build up high salt levels. Ammonium fertilizers are unnecessary for 2 months after planting. In the greenhouse, have two or three soil samples analyzed during the growing season to ensure that fertilizers are being correctly applied.

Manure burn

Large amounts of raw, undecomposed manure or manure mixed with materials such as wood shavings or sawdust can result in crop problems. Ammonia is given off in toxic amounts and causes a condition known as manure burn. The plants wilt, the leaf tissue between the veins dies, and the margins become papery white and dead. The lower leaves-the first affected-are unduly dark green, and the fine rootlets become discolored and die. Use well-rotted manure only, apply it on a bright sunny day, and augment it with liberal applications of superphosphate. Water cautiously; in the greenhouse, ventilate to allow the ammonia to escape.

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