BACTERIAL DISEASES

▶ 23.1 Butt rot (head rot) *Figs. 11.3a-d*

Pseudomonas fluorescens Migula
(syn. *Pseudomonas marginalis* (Brown) Stevens)

Butt rot is most often seen in lettuce plants growing under conditions of low light and excessive leaf wetness. It occurs both in soil and in soilless production by the nutrient film technique (NFT).

Symptoms Infected stems develop a black to green, firm rot that may spread along the veins of the lower leaves and progress down to the roots. Secondary organisms cause wilt or collapse of the plant and storage rots of marketed heads.

Causal agent (see Lettuce, pseudomonas diseases)

Disease cycle (see Lettuce, pseudomonas diseases, 11.3)

Management

Cultural practices — Most greenhouse lettuce cultivars are susceptible; however, severity varies among cultivars. Growers should adjust fertilizer programs to ensure that the plants are not unduly soft, and avoid frequent wetting of the foliage. Careful regulation of ventilation and heating helps to reduce humidity and prevent condensation, which favors bacterial diseases. In NFT production the disease is more severe when the system is contaminated by soil or when soil starter blocks are used for transplants.

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

▶ 23.2 Stem rot

Pseudomonas cichorii (Swingle) Stapp
Pseudomonas cichorii has been implicated in a stem rot of hydroponically grown lettuce in Ontario.

Symptoms Near-mature plants in NFT production systems have firm, dark brown rot, and petioles of the inner leaves are streaked. This disease may be similar to varnish spot reported from California. Ontario isolates of *P. cichorii* are also pathogenic to chrysanthemum, celery and tomato.

Causal agent (see Lettuce, pseudomonas diseases)

Disease cycle (see Lettuce, pseudomonas diseases, 11.3)

Management (see butt rot, 23.1)

Selected references

Dhanvantari, B.N. 1990. Occurrence of bacterial stem rot caused by *Pseudomonas cichorii* in greenhouse-grown lettuce in Ontario. *Plant Dis.* 74:394.
Grogan, R.G. 1977. Varnish spot, destructive disease of lettuce in California caused by *Pseudomonas cichorii*. *Phytopathology* 67:957-960.

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

▶ 23.3 Other bacterial diseases *Figs. 11.1a,b*

There are a number of other diseases of greenhouse lettuce caused by pathogenic bacteria (see Lettuce, bacterial soft rots, 11.1). Control of these diseases in the greenhouse can be enhanced by proper heating, ventilation and sanitation.

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

FUNGAL DISEASES

▶ 23.4 Anthracnose (ring spot), fire of endive *Fig. 11.4*

Microdochium panattonianum Sutton, Galea & Price in Galea, Price & Sutton
(syn. *Marssonina panattoniana* (Berl.) Magnus)

This fungal disease, which is common in field lettuce, also affects greenhouse lettuce. It tends to occur in plants located under gutters and in other areas of the greenhouse where water drips onto the plants. It also is common in unheated greenhouses that have a history of monocropping to lettuce or endive. In endive the disease is called fire.

Symptoms (see Lettuce, anthracnose, 11.4)

Causal agent (see Lettuce, anthracnose)

Disease cycle (see Lettuce, anthracnose)

Management

Cultural practices — Control measures usually are not necessary, because of the infrequent occurrence of the disease. However, trimmings and trash piles should be properly composted or destroyed, because the fungus can survive for long periods in dry residues. Headerhouse floors, machinery, flats and other surfaces should be cleaned of soil and plant residues. Growing media should be disinfested before use.

Selected references

Galea, V.J., and T.V. Price. 1988. Survival of the lettuce anthracnose fungus *(Microdochium panattonianum)* in Victoria. *Plant Pathol.* 37:54-63.
Galea, V.J., T.V. Price and B.C. Sutton. 1986. Taxonomy and biology of the lettuce anthracnose fungus. *Trans. Br. Mycol. Soc.* 86:619-628.
Sutton, B.C., and M. Holderness. 1991. *Microdochium panattonianum.* IMI Desccriptions of Fungi and Bacteria, No. 1034. Internat. Mycol. Inst., Kew, Surrey, England. 2 pp.

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

▶ 23.5 Bottom rot *Figs. 11.6a,b*

Rhizoctonia solani Kühn
(teleomorph *Thanatephorus cucumeris* (A.B. Frank) Donk)

In greenhouses, the fungus rapidly colonizes sterilized soil if hygienic practices are not strictly observed. It can be introduced in peat and loam composts and from contaminated planting trays and tools. Bottom rot is one of the major head rot diseases of field lettuce (see Lettuce, bottom rot, 11.6). Generally, it is less common in hydroponic crops than in those grown in soil.

Management

Cultural practices — Seedling flats should be raised on benches out of the range of splashing water or soil. Once the fungus has infested growing media, thorough disinfestation is necessary after the crop has been cleared. ***Rhizoctonia solani*** and most soil-borne pathogenic fungi can be eliminated by steam heat (60°C for 30 min). Above 80°C, microorganisms antagonistic to pathogens are destroyed and severe outbreaks can ensue.

Chemical control — Growers should disinfest growing media with registered fumigant chemicals, but methyl bromide should be avoided because lettuce tissues may accumulate excess bromine from treated soil.

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

▶ 23.6 Damping-off, stunt *Figs. 23.6a,b*

Pythium spp.
Other fungi

In greenhouses *Pythium* species are the most important causal agents of this disease (see Lettuce, damping-off, 11.7). Once the disease is established *(23.6a,b),* fungicides may not give satisfactory control. Although pythium damping-off in soil is usually associated with chilled plants, lettuce produced by the nutrient film technique (NFT) is attacked by *P. aphanidermatum* at temperatures above 23°C, and *P. dissotocum* Drechs. is a dominant pathogen at 17 to 22°C. *Pythium* species can attack the tiny feeder roots and cause substantial losses in yield without obvious damage to the root system.

Management

Cultural practices — Damping-off can be controlled by treating seed with a protectant fungicide and by sowing into a pasteurized growing medium. Growers should avoid overwatering and overcrowding seedlings. Adequate ventilation helps keep the growing medium dry. Water for irrigation should be warm. (See bottom rot, 23.5, for methods of disinfesting growing media.) In soilless cultivation, soil starting blocks should never be used and strict hygiene should be maintained to avoid contamination by soil. Species of ***Pythium*** are often present in water from creeks, wells and outdoor reservoirs, so growers using these sources for irrigation should consider installing filters and an ultraviolet water sterilizer or some other type of disinfestation equipment.

Chemical control — Post-emergence fungicide treatment may be effective in controlling the spread of damping-off fungi.

Selected references

Bates, M.L., and M.E. Stanghellini. 1984. Root rot of hydroponically grown spinach caused by *Pythium aphanidermatum* and *P. dissotocum. Plant Dis.* 68:989-991.

Van der Plaats-Niterink, A.J. 1981. Monograph of the Genus *Pythium. Stud. Mycol.* No. 21. Centraalbureau v. Schimmelcultures, Baarn, The Netherlands. 242 pp.

Stanghellini, M.E., and W.C. Kronland. 1986. Yield loss in hydroponically grown lettuce attributed to subclinical infection of feeder rootlets by *Pythium dissotocum. Plant Dis.* 70:1053-1056.

Zinnen, T.M. 1988. Assessment of plant diseases in hydroponic culture. *Plant Dis.* 72:96-99.

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

▶ 23.7 Downy mildew *Figs. 11.8a,b*

Bremia lactucae Regel

This disease (see Lettuce, downy mildew, 11.8) can be a major problem on greenhouse lettuce.

Management

Cultural practices — Greenhouse climate control is important to prevent the formation and retention of free water on plant surfaces and to avoid periods of high humidity. Dew should be prevented from forming on the foliage by keeping the night temperature above 16°C and by expelling humid air through ventilation. Growers should remove crop residues completely from the greenhouse, use steam for disinfesting growing media, and avoid planting new lettuce crops near those showing symptoms of the disease. Overhead irrigation should be curtailed where downy mildew is a problem.

Resistant cultivars — These are available and should be evaluated on a local basis to determine their suitability and resistance to the locally prevalent race(s) of *B. lactucae.*

Chemical control — Chemical disinfestation of growing media can be useful, but methyl bromide should be avoided because lettuce tissues accumulate excess bromine from the soil after fumigation. The daily dietary intake of bromine is regulated for health reasons, and heavy consumption of leafy vegetables from bromine-fumigated soil is not generally recommended. Foliar fungicide sprays should be applied as soon as symptoms appear.

Selected references

Crute, I.R. 1988. Lettuce downy mildew: A case study in integrated control. Pages 30-53 *in* K.J. Leonard and W.E. Fry, eds., *Plant Disease Epidemiology.* Vol. 2. McGraw-Hill Publ. Co., New York, New York. 300 pp.

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Morgan, W.M. 1984. Integration of environmental and fungicidal control of *Bremia lactucae* in a glasshouse lettuce crop. *Crop Prot.* 3:349-361.
(Original by J.G. Menzies and W.R. Jarvis)

▶ 23.8 Drop *Figs. 11.9a-e*

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

Drop (see Lettuce, drop, 1 1.9) is common in greenhouse lettuce grown in soil under conditions of high humidity and temperatures above 22°C. The disease can be common during the summer and it is not easy to control, particularly if sclerotia infest the soil. The disease is not common in hydroponic production but can occur if ascospores are carried into greenhouses by air currents from trash piles outside.

Management

Cultural practices — Diseased plants and trimmings should be removed from greenhouses, taking care to ensure that sclerotia of the fungi do not remain. Chemical and steam disinfestation of soil can be used to kill the sclerotia (see bottom rot, 23.5).

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

▶ 23.9 Gray mold *Figs. 23.9; 11.10a-f*

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

Gray mold (see Lettuce, gray mold, 11.10) is the most common disease of greenhouse lettuce and is often said to be a disease of poor management. Upright-growing types of lettuce are generally less susceptible than cabbage types in which the cotyledons and outer leaves often lie on the soil.

Symptoms In greenhouses, the pathogen can infect seedlings that have been weakened by damping-off organisms. A soft brown rot (25.9) may appear on the stems and at the bases of older leaves on older plants and it may extend through the stems. When this occurs, the leaves turn gray-green and the plant eventually wilts and dies. Under humid conditions, the lesions become covered by a gray mold (*11.10c,f).* Black sclerotia form on decaying tissue (11.10*d).*

Management

Cultural practices — Cultural practices should promote optimum growth of lettuce while avoiding damage to plant tissues. To reduce mechanical damage, lettuce seedlings should be transplanted before they get too large. Prompt removal of crop residue and disinfestation of growth media help limit infection and spread. Proper heating and ventilation of greenhouses will reduce periods of high humidity, particularly at night, thereby minimizing sporulation and infection by the fungus. Growers should avoid overcrowding and excessive use of nitrogen fertilizer. Overhead irrigation should not be used, particularly in poorly ventilated greenhouses.

Chemical control — Growers should apply a registered fungicide before the onset of disease when cool (15 to 20°C) and moist conditions prevail.

Selected references
Jarvis, W.R. 1977. Botryotinia and Botrytis Species: Taxonomy, Physiology and Pathogenicity. Can. Dep. Agric. Res. Br. Monogr. 15. 195 pp.
Morgan, W.M. 1954. The effect of night temperature and greenhouse ventilation on the incidence of Botrytis cinerea in a late planted tomato crop. Crop Prot. 3:243-251.
(Original by J.G. Menzies and W.R. Jarvis)

▶ 23.10 Powdery mildew *Fig. 23.10*

Erysiphe cichoracearum DC.

Powdery mildew (see Lettuce, powdery mildew, 11.12) has occasionally been a serious disease of lettuce grown in nutrient film hydroponic greenhouses in Ontario. Abundant conidia form on the white colonies on leaves *(23. JO)* and are dispersed on air currents to plants all over the greenhouse. Cleistothecia and thick-walled mycelium in dry crop residues are suspected to be the main survival stages between successive crops.

Management

Cultural practices — Crop residues should be removed and disposed of regularly.

Selected references

Crute, I.R., and I.G. Burns. 1983. Powdery mildew of lettuce *(Lactuca sativa). Plant Pathol.* 32:455-457.
Dhanavantari, B.N., and W.R. Jarvis. 1985. Powdery mildew *(Erysiphe cichoracearum)* of greenhouse lettuce in Ontario. *Plant Dis.* 68:177.
Kapoor, J.N. 1967. *Erysiphe cichoracearum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 152. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

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

VIRAL AND VIRAL-LIKE DISEASES

▶ 23.11 Aster yellows *Figs. 11.15a,b*

Aster yellows mycoplasma-like organism

This disease (see Lettuce, aster yellows, 11.15) is a minor problem in greenhouse lettuce and only in poorly managed crops where weeds are prevalent in and around the greenhouse, and where leafhoppers are permitted to enter.

(Original by W.R. Jarvis)

▶ 23.12 Big vein *Fig. 11.16*

Big-vein virus

This virus (see Lettuce, big vein, 11.16) is not common on greenhouse lettuce, but if plants become infected while being grown in a nutrient film system, the pathogen and its fungal vector *(Olpidium brassicae* (Woron.) Dangeard) can quickly spread through a crop.

Management

Cultural practices — Partial control can be obtained by disinfestation of growing media, watering systems and all equipment, but this will not completely eradicate the vector or the virus. Growers of hydroponic lettuce should consider the installation of a water sterilizer if water is drawn from a creek or outside reservoirs.

Selected references

Campbell, R.N., A.S. Greathead and F.V. Westerlund. 1980. Big vein of lettuce: Infection and methods of control. *Phytopathology* 70:741-746.
Tomlinson, J.A., and E.M. Faithfull. 1980. Studies on the control of lettuce big-vein in recirculated nutrient solutions. *Acta Hortic.* 98:325-332.

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

▶ 23.13 Cucumber mosaic

Cucumber mosaic virus

This disease (see Cucurbits, cucumber mosaic, 11.18) fluctates from season to season. On greenhouse lettuce, symptoms vary with the stage of growth at the time of infection, time of year, cultivar and strain of the virus. Transmission occurs mechanically or by aphid vectors. The virus is not known to be seed transmitted in lettuce.

Symptoms Infected lettuce plants are stunted, with a yellow mottle or necrotic spotting on the leaves. These symptoms are indistinguishable from those of lettuce mosaic. Occasionally, the two viruses infect the same plant, resulting in severe stunting, yellowing and necrosis.

Management

Cultural practices — Growers should rogue infected plants and control aphids (see aphids, 23.17).

Selected references

Francki, R.I.B., D.W. Mossop and T. Hatte. 1979. Cucumber mosaic virus. CMI/AAB Descriptions of Plant Viruses, No. 213. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England. 6 pp.

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

▶ 23.14 Lettuce mosaic *Figs. 23.14; 11.17a,b*

Lettuce mosaic virus

Lettuce mosaic (see Lettuce, lettuce mosaic, 11.17) is the most important viral disease of greenhouse lettuce. It can infect plants at any stage, affecting both size and quality *(23.14).* It is most severe where lettuce is grown successively in blocks, the virus being transmitted from older to younger crops by aphids. As aphid populations increase, virus spread becomes more rapid. Commercial diagnostic kits are available for lettuce mosaic virus.

Management

Cultural practices — Control of this virus in the greenhouse involves the use of mosaic-indexed seed combined with a scheme of isolating blocks of lettuce to minimize the spread of the virus from crop to crop. Diseased plants should be removed and destroyed and aphids should be controlled (see aphids, 23.17).

Selected references
Grogan, R.G. 1980. Control of lettuce mosaic with virus-free seed. *Plant Dis.* 64:446-449.
Tomlinson, J.A. 1970. Lettuce mosaic virus. CMI/AAB Descriptions of Plant Viruses, No. 9. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England. 4 pp.

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

▶ 23.15 Other viral diseases *Fig. 23.15*

Beet western yellows virus
Lettuce infectious yellows virus
Tomato spotted wilt virus

These viruses (see Lettuce, other viral diseases, 11.18) are not common in greenhouses, but they can cause damage if they become established in reservoir plant hosts of the viruses and their vectors. Commercial diagnostic kits are available for the lettuce strain of tomato spotted wilt virus *(23.15)* and for beet western yellows virus.

Management

Cultural practices — Growers should remove crop residues from the vicinity of the greenhouse, avoid growing ornamental plants in lettuce greenhouses, and control insect vectors and weeds.

Selected references
Duffus, J.E. 1972. Beet western yellows virus. CMI/AAB Descriptions of Plant Viruses, No. 89. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England. 4 pp.
Ie, T.S. 1970. Tomato spotted wilt virus. CMI/AAB Descriptions of Plant Viruses, No. 39. Commonw. Mycol. Inst./Assoc. Appl. Biol., Kew, Surrey, England. 4 pp.
Walkey, D.G.A., and D.A.C. Pink. 1990. Studies on resistance to beet western yellows virus in lettuce (*Lactuca sativa*) and the occurrence of field sources of the virus. *Plant Pathol.* 39:141-155.
Van Doist, N. Huijberts and L. Bos. 1983. Yellows of glasshouse vegetables, transmitted by *Trialeurodes vaporariorum. Neth. J. Plant Pathol.* 89:171-184.

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

NON-INFECTIOUS DISEASES

▶ 23.16 Tipburn *Figs. 23.16; 11.19c*

This is a major disease of greenhouse lettuce (see also Lettuce, tipburn, 11.19).

Symptoms Tipburn affects the inner leaves of head lettuce and results from calcium deficiency in the growing tissues of the inner leaves. The first symptoms are necrotic spots near the leaf tips that expand until the entire edge of the leaf is brown *(23.16, 11.19c).* Many inter-related factors contribute to calcium uptake and tipburn.

Management The condition can be reduced to some extent by assuring that calcium levels in the soil are high relative to competing elements, such as potassium and magnesium, by reducing nitrogen applications to limit growth, especially during warm weather, by harvesting slightly before maturity and by keeping the nighttime humidity high in the greenhouse. Cultivars differ in tolerance to tipburn.

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

INSECT PESTS

▶ 23.17 Aphids *Figs. 8.39; 11.24T1,T2;15A.14; 16.41; 16.43T1*

Black bean aphid *Aphis fabae* Scopoli
Cabbage aphid *Brevicoryne brassicae* (L.)
Green peach aphid *Myzus persicae* (Sulzer)
Lettuce aphid *Nasonovia ribisnigri* (Mordvilko)
Pea aphid *Acyrthosiphon pisum* (Harris)

These aphids are widely distributed in Canada. Winged females develop and disperse to new host plants during early summer. Once air-borne, they may be blown long distances, eventually entering greenhouses wherever lettuce is grown. They may be black, yellow, or pink but most are a shade of green. They often develop large colonies on the undersurface of leaves. A colony can consist of winged and wingless adults and nymphs in various sizes and stages of growth.

All of these aphids attack lettuce and other vegetable crops. They overwinter as eggs on woody plants.

Damage Aphid populations can increase very quickly, particularly under warm, moist conditions in greenhouses. Their feeding can discolor the foliage, curl the leaves and damage developing buds. The plants may be covered by their honeydew and molted skins (exuviae), and large numbers of aphids can cause severe yield reductions or even crop failure. By their presence, even small numbers may make the crop unmarketable.

Some of the above aphids may transmit viruses to greenhouse lettuce.

Life history (see Crucifers, 8.39; Lettuce, 11.24; Pea, 15A.14; Potato, 16.41, 16.43)

Management The short time from seeding to harvest makes biological control impractical and, because the entire above-ground part of the plant is sold, high levels of chemical control are necessary for aphids infesting greenhouse lettuce. Early infestations must be controlled to avoid later crop damage, and infestations close to harvest must be controlled to avoid contamination of the marketable produce.

Cultural practices — Cultural practices are very important in reducing or eliminating aphid infestations. Growers should screen greenhouse vents, maintain a weed- and garden-free area around the greenhouse, and refrain from growing woody and other host plants in the same greenhouse.

Chemical control — The usual procedure is to apply chemical insecticides as high volume sprays. A number of applications may be needed for satisfactory control.

(Original by R.A. Costello)

▶ 23.18 Caterpillars *Figs. 8.40b-f*

Cabbage looper *Trichoplusia ni* (Hübner)
Other caterpillars

Various species of caterpillars, especially the cabbage looper (see Crucifers, 8.40), can be pests of greenhouse lettuce. Their life histories in the greenhouse are similar to those on field vegetables but shorter and the number of seasonal generations is greater.

Caterpillars feed on a wide range of plants including many vegetable crops.

Damage Caterpillars eat large holes in lettuce foliage. Once the inner leaves are damaged, the plant is unmarketable.

Management

Cultural practices — Vents should be screened, and doorways and other openings should be kept closed during the late evening and nighttime to exclude the adult, egg-laying moths.

Biological control — Caterpillars in greenhouses can be effectively controlled by use of the bacterium *Bacillus thuringiensis* Berliner. Additional feeding damage can be expected after application of the bacterium before the pests are killed. Growers should apply the microbial biocontrol agent as soon as caterpillars or their damage are detected on lettuce leaves.

(Original by R.A. Costello)

▶ 23.19 Other insect pests *Figs. 22.31 a-c; 26.29T1*

Fungus gnats

Fungus gnats Several species of fungus gnats (see Greenhouse cucumber *(22.31a,b)* and Mushroom (*26.29T1*)) occur in greenhouse lettuce wherever it is grown. Fungus gnats are not usually a problem in the production of this crop. The main problem is that they annoy people working the crop.

Fungus gnats can be controlled during preparation of the growth medium, whether by steam sterilization or by chemical fumigation.

(Original by R.A. Costello)

OTHER PESTS

▶ 23.20 Slugs *Figs. 11.27a-c*

Various species of slugs (see Lettuce, 11.27) are widely distributed throughout Canada, thriving in areas of moderate temperature and high humidity. These conditions occur in greenhouses that receive liberal amounts of overhead irrigation. Slug eggs, immatures and adults usually are brought into the greenhouse on material formerly stored outdoors. They are usually a minor and easily controlled pest of greenhouse lettuce. Slugs feed on a wide range of plants, including many vegetables and weeds. Lettuce is highly favored.

Damage Silvery slime trails, which can be found on damaged plants as well on the soil surface, distinguish slug damage from that caused by cutworms and other caterpillars. Roots fed on by slugs will have smooth-sided pits, 3 to 12 mm deep and usually less than 12 mm in diameter. Foliage damage typically involves removal of tissue between the veins. On greenhouse lettuce, leaf skeletonization can be extensive.

Management Routine steam-sterilization of greenhouse beds should kill all life stages of slugs. Although some organisms prey on slugs, none is available commercially, so poison bait is the only other control option in greenhouse lettuce.

Chemical control — Commercial metaldehyde-based preparations are available for use at the base of plants but not on the foliage. These products paralyze slugs for about 48 hours. Under moist greenhouse conditions, slugs may recover and escape. However, the chemical induces excessive production of slime, revealing the presence of poisoned slugs that can then be hand-picked and destroyed in soapy water. There is no reported resistance of slugs in Canada.

(Original by R.A. Costello)

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