7 Celery, celeriac

BACTERIAL DISEASES

▶ 7.1 Bacterial leaf spot (northern bacterial blight) *Figs. 7.1a,b*

Pseudomonas syringae pv. *apii* (Jagger) Young, Dye & Wilkie (syn. *Pseudomonas apii* Jagger)

Bacterial leaf spot is sporadic and of relatively minor economic importance on celery, although it has been found repeatedly on transplants imported into British Columbia from California. Celery is the only host on which bacterial leaf spot has been reported to be a problem.

Symptoms The first symptoms appear on the leaves in the form of small, bright yellow, circular spots, 1 to 2 mm in diameter *(7.1a).* These enlarge, turn rusty brown and are usually surrounded by a yellow halo. When the spots are numerous, they merge, kill the leaves and give them a blighted appearance *(7.1b).* Petiole infections are rare.

This disease is distinguished from septoria blight by the absence of tiny black fungal fruiting bodies (pycnidia) scattered across the spots, and from cercospora blight by the absence of spores (conidia) on lesion surfaces.

Causal agent *Pseudomonas syringae* pv. *apii* is a Gram-negative, rodshaped bacterium with one to three polar flagella. Colonies produce a fluorescent green pigment on King's B medium under ultraviolet light. This bacterium can be distinguished from other fluorescent pseudomonads by LOP AT tests.

Newly developing lesions free from adhering soil particles and in which contaminating or secondary pathogenic microorganisms are absent or few in number should be used for isolations. A loopful of a suspension of plant tissue in sterile water may be streaked on the surface of a plate containing King's B medium. Colonies produce a fluorescent green pigment on King's B medium under ultraviolet light. Discrete, well-separated colonies may be transferred to nutrient agar for inoculum increase and further tests.

Disease cycle The pathogen can survive for one year in seeds and can also overwinter in infected plants. In seedbeds and fields, the bacterium is spread by splashing water, tools and workers. Development of bacterial leaf spot is favored by cool, wet conditions. At least 10 hours of leaf wetness are needed for disease establishment. Pathogenicity and growth of the bacterium are optimum at 20 and 25°C, respectively.

Management

Cultural practices — Disease-free seed should be used. If in doubt, seed that is at least two years old should be selected or it should be soaked in hot water at 48°C for 30 minutes. Seed beds should be disinfested through steam pasteurization or fumigation. A two-year rotation with non-susceptible crops is suggested. High plant densities, which promote disease development by increasing relative humidity and leaf wetness, should be avoided. Infected crop residues should be destroyed after harvest.

Resistant cultivars — Selections of Utah 52-70 may be resistant to bacterial leaf spot.

Selected references

Jagger, I.C. 1921. Bacterial leaf-spot disease of celery. *J. Agric. Res.* 21:185-188.

Thayer, P.L. 1965. Temperature effect on growth and pathogenicity to celery of *Pseudomonas apii* and *P. cichorii. Phytopathology* 55:1365.

Lelliott, R.A., and D.E. Stead. 1987. *Methods for the Diagnosis of Bacterial Diseases of Plants.* Blackwell Scientific Publ., Oxford, England. 216 pp.

Thayer, P.L., and C. Wehlburg. 1965. *Pseudomonas cichorii*, the cause of bacterial blight of celery in the Everglades. *Phytopathology* 55:554-557.

(Original by L.M. Tartier and R.F. Cerkauskas)

FUNGAL DISEASES

▶ 7.2 Brown spot *Fig. 7.2*

Acremonium apii (M.A. Smith & Ramsey) W. Gams (syn. *Cephalosporium apii* M.A. Smith & Ramsey)

This disease has been observed occasionally in Ontario and Manitoba, especially following warm weather. Moderate infection, sufficient to render the celery unacceptable for soup purposes, has been reported. *Acremonium apii* has been found on celery but not on celeriac.

Symptoms Shallow, dry, rusty-brown lesions, which are circular to oblong and up to 1 cm long by 0.5 cm wide, are found on the inner, concave surface of the petiole (7.2). On the outer, convex surface, the lesions are smaller, more reddish-brown and occur along the ridges. The lesions are more numerous on the inner surface and more conspicuous on the outer petioles than on the leaves. They may grow together and affect the entire stalk, resulting in curling and distortion. Secondary invasion by bacteria into affected areas of older petioles produces wet, sunken, dark-brown lesions. On leaves, lesions are yellowish-brown, circular and 0.5 cm in diameter.

Causal agent *Acremonium apii* produces abundant hyaline conidia, which are variable in form. They measure 4.6 to 11.5 by 1.7 to 2.3 µm on V-8 agar after 16 days of growth. On malt agar, they are cylindrical to ellipsoidal, aseptate, occasionally with a truncate base, 3 to 6 by 1 to 2.5 µm, sometimes occurring in slimy heads. On potato-carrot agar, conidia may be up to 10 µm long and sometimes one-septate. Conidia produced on diseased celery plants may be considerably larger than those in culture. The conidiophores are not distinct from the hyaline hyphae. Conidiogenous cells arising from single hyphae may be aggregated in strands, but are usually solitary and sometimes branched. Each conidiogenous cell has a short, indistinct collarette and produces conidia from the apex in succession without increasing in length. Chlamydospores are 3.6 to 8.8 by 6.2 to 9.3 µm. Colonies on malt agar or potato-carrot agar are white, fluffy, raised, later turning grayish-white, showing restricted growth, and attaining a diameter of 20 mm in 10 days at 22°C. Optimum growth on potato-dextrose agar occurs at pH 6.5 and at 25°C; no growth occurs at pH 4.0.

After surface disinfestation of infected tissue pieces, the fungus can be isolated on potato-dextrose agar (pH 5.0) amended with aureomycin (200 ppm) or on water agar. Alternatively, diseased petioles can be washed and placed in a moist chamber to induce sporulation.

Disease cycle The fungus may be present in seedlings in both the seedbed and field. However, the disease is serious only when unusually high temperatures occur during the growing season. Infections may occur during cool summers, but high temperatures are required for rapid lesion development. The disease develops more quickly at 25 than at 13°C, requiring 6 as opposed to 11 days from time of infection to symptom development. Plants weakened by poor nutrition, excessive salinity or waterlogged soil are more susceptible to infection. The fungus survives in soil or crop residues as chlamydospores, and initial inoculum is likely from these sources since the disease is most common when rotation is not practiced. Dispersal of inoculum is probably by wind, splashing water, workers and implements.

Management

Cultural practices — A four-year rotation with onion, lettuce or potato will reduce initial inoculum. Conditions that favor optimum growth of celery, including adequate nitrogen supply, prevention of waterlogging, and avoidance of excessive salinity, will reduce the susceptibility of celery plants to infection. Growers are advised to reduce the movement of workers and machinery through crops, minimize late cultivation, and use transplants that have been grown in disinfested soil or soilless media.

Resistant cultivars — Selections of Tall Utah 52-70 may be resistant to brown spot.

Selected references

Lewis, G.D. 1959. Effects of temperature and crop rotation on the occurrence of brown spot of celery in southern New York. *Plant Dis. Rep.* 43:1079-1080.

Segall, R. 1951. Brown spot disease of celery found in New York. *Plant Dis. Rep.* 35:164.

Sheridan, J.E. 1964. Brown-spot of celery in England. *Plant Pathol.* 13:161-163.

Smith, M.A., and G.B. Ramsey. 1951. Brown-spot disease of celery. *Bot. Gaz.* 112:393-400.

Williams, M.A.J. 1987. *Acremonium apii.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 932. CAB Internat. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.F. Cerkauskas)

▶ 7.3 Cercospora blight (early blight) *Figs. 7.3a,b*

Cercospora apii Fresen.

Cercospora blight has been reported from all the major celery-growing areas of Canada. It can cause serious losses in yield and quality, particularly if it attacks early in the season. Defoliation and stunting often occur, necessitating extra labor and time to trim affected leaves and petioles from diseased plants. Celeriac may also be affected.

Symptoms Symptoms appear primarily on the foliage and petioles, starting from the outside and progressing inward and upward. On the leaves, round chlorotic spots are visible on the upper and lower surfaces. The spots enlarge rapidly up to 1 cm or more and turn brownish-gray. They have a dry, papery texture and are generally without a distinct border *(7.3a).* Under humid conditions, the lesions contain large numbers of conidiophores with conidia. Leaves containing a few spots become chlorotic and wither. Under favorable environmental conditions for disease development, affected plants quickly appear blighted *(7.3b).* The lesions on petioles are elongate and parallel to the long axis of the stalk.

Causal agent *Cercospora apii* has a septate, pale brown, torulose mycelium, generally 2 to 4 µm in diameter, and often forms hyphal knots or pseudostromata in the substomatal cavities. Brown, septate conidio- phores in groups of up to 30 emerge through the stomata from these structures. They are unbranched, usually 30 to 70 µm long, and taper from a width of 5 to 9 µm at the base to 3 to 4 µm at the apex. Several conidia are produced separately near the apex of each conidiophore and a scar is left at each site where the conidium has detached. The conidia are straight or curved, slightly obclavate at the base, with a diameter of 3.5 to 5 µm below the middle, and taper toward the apex. They are hyaline, smooth, 9- to 17-septate, usually 60 to 200 µm long, but sometimes longer with a conspicuous hilum.

Cross-inoculations of various hosts with many *Cercospora* species have not been performed, although it is probable that this pathogen occurs on many other plants and has many names. The fungus is easily distinguished from *Septoria apiicola* by the absence of pycnidia within the spots and by the larger lesions evident with cercospora blight.

The fungus is easily isolated from infected tissues; however, sporulation is somewhat sparse on potato-dextrose agar and V-8 agar. Colonies are smooth or with radial folds and measure 16 to 18.5 mm in diameter after seven days at 25°C on V-8 agar.

Disease cycle The fungus is both seed- and soil-borne, and it can survive more than two years in seed. It can also overwinter in infected plant residues in the soil. Primary inoculum arises from seeds and diseased plant material in seedbeds or fields, but the amount of blight on transplants has a major influence on disease development in the field. Cercospora blight generally appears before septoria blight in the field, although the latter is a more frequent problem.

Cercospora blight is favored by a relative humidity near 100% and temperatures from 15 to 30°C. Sporulation is significantly enhanced when these conditions occur for more than 10 hours per day, except when temperatures are below 12°C. Conidium germination and penetration of leaves occur under conditions of high relative humidity, heavy dew or light rain. High temperatures following penetration favor establishment of the fungus and sporulation generally occurs 5 to 14 days later.

Conidia are readily released during periods of decreasing relative humidity, less than 90%, especially during the morning. Daytime cloudiness and rain reduce the number released; however, enhanced leaf wetness periods increase conidium production. Conidia are spread by wind, splashing water, workers and implements. Unlike *Septoria* conidia, which are “sticky” and disseminated only over several metres, conidia of C. *apii* are dispersed over greater distances. Heavy rain will wash them from leaves, thereby reducing their availability for dispersal by wind.

Management The use of healthy transplants is the key to control of this disease.

Cultural practices — (see septoria blight, 7.7)

Resistant cultivars — Most celery cultivars are susceptible. Tolerant cultivars include Emerson Pascal, June-Belle and Earlibelle.

Chemical control — (see septoria blight, 7.7) The time for fungicide application may differ for the two diseases because optimum environmental conditions for development of cercospora blight differ from those for septoria blight. Cercospora blight usually appears first.

Selected references

Berger, R.D. 1973. Early blight of celery: analysis of disease spread in Florida. *Phytopathology* 63:1161-1165.

Berger, R.D. 1975. Disease incidence and infection rates of *Cercospora apii* in plant spacing plots. *Phytopathology* 65:485-487.

El-Gholl, N.E., S.A. Alfiere, Jr., W.H. Ridings and C.L. Schoulties. 1982. Growth and sporulation *in vitro* of *Cercospora apii, Cercospora arachidicola, Cercospora kikuchii,* and other species of *Cercospora. Can. J. Bot.* 60:862-868.

(Original by R.F. Cerkauskas)

7.4 Damping-off *Fig. 7.4*

Pythium debaryanum of authors, not R. Hesse
Pythium ultimum Trow
Rhizoctonia solani Kühn
(teleomorph *Thanatephorus cucumeris* (A.B. Frank) Donk)

Damping-off can cause serious losses in celery and celeriac seedbeds in greenhouses and in the field. The damping-off pathogens have wide host ranges.

Symptoms Young seedlings are the most susceptible to damping-off, although the problem can occur at any time during the production cycle. There are two types of damping-off, depending on whether the disease occurs before or during germination (pre-emergence) or after emergence (post-emergence).

Pre-emergence damping-off is characterized by seed decay or death of the celery seedling before emergence. The failure of seedlings to emerge from the soil results in well-defined circles or areas without plants *(7.4).* Since there may be no obvious symptoms, this problem is often attributed to poor seed vigor.

Post-emergence damping-off also appears as well- defined areas of seedlings showing visible symptoms of the disease. Plants are attacked at the soil level or on the underground parts. Tissues at the soil level become spongy and water-soaked. As the disease progresses, the stem is girdled and the plants wilt and fall over.

Damping-off progresses quickly. When ambient conditions are favorable, young infected plants may die overnight. When infection occurs after the plants have already begun to harden, they are rarely killed. These plants reveal a girdled, dry, hard, blackish collar. This is the black stem symptom of damping-off. Surviving plants are generally unmarketable.

Causal agents (see Beet, pythium and rhizoctonia root rots, 5.7, 5.8; and Carrot, pythium root dieback, 6.13)

Disease cycle The fungi that cause damping-off are soil- borne. They commonly develop on young seedlings in the seedbed or field during the spring, when ambient conditions are unfavorable to rapid vigorous celery growth. (For further details, see Beet, pythium and rhizoctonia root rots, 5.7, 5.8; and Carrot, pythium root dieback, 6.13.)

Management

Cultural practices — In the greenhouse or seedbed, the soil must be disinfested by pasteurization,

fumigation or by incorporating a fungicide. Where sterilized growing media are used, all precautions are needed to prevent contamination by tools, water and containers. These items should be thoroughly disinfested before use. Good lighting will prevent etiolation, which predisposes seedlings to damping-off.

Promotion of rapid, vigorous seedling growth, reduction of plant density, and reduction of soil moisture through adequate drainage help to minimize damping-off. Plants should be watered before noon, and the greenhouses or seedbeds should be sufficiently ventilated so that the plants are dry by sunset. Healthy seed treated with a protective fungicide should be used for planting.

Chemical control — Registered fungicides are available but only for seed and soil treatment. When the disease appears, a protective fungicide should be applied in a high- volume water drench.

Selected references

Cox, R.S. 1958. Etiology and control of celery diseases in the Everglades.*Univ. Fla. Agric. Exp. Stn. Bull.* 598. 30 pp.

Guzman, V.L., H.W. Burdine, E.D. Harris, Jr., J.R. Orsenigo, R.K. Showalter, P.L. Thayer, J.A. Winchester, E.A. Wolf, R.D. Berger, W.G. Genung and T.A. Zitter. 1983. Celery production on organic soils of south Florida. *Univ. Florida. Agric. Exp. Stn. Bull.* 757. 79 pp.

Johnson, S.R., and R.D. Berger. 1972. Nematode and soil fungi control in celery seedbeds on muck soil. *Plant Dis. Rep.* 56:661-664.

(Original by L.M. Tarder and R.F. Cerkauskas)

▶ 7.5 Fusarium yellows *Figs. 7.5a-c*

Fusarium oxysporum f. sp. *apii* (R.R. Nelson & Sherb.) W.C. Snyder & H.N. Hans.

Race 1 of the fusarium yellows pathogen caused extensive losses to celery growers from about 1920 until the late 1950s when the resistant celery cultivar Tall Utah 52-70 was introduced. In recent years, significant yield and quality losses due to race 2 of the fungus have occurred on muck soils in British Columbia and Ontario. Only celery is susceptible to this pathogen.

Symptoms Slight stunting, stiffening of the outer petioles, and a brown discoloration of the vascular system of the host plant occur with mild or late infections. The leaves generally become brittle, develop a rough texture and curl upward. In severe infections, the outer leaves become chlorotic first *(7.5a)* and the yellowing spreads to other leaves as the disease progresses throughout the vascular system of the roots and crown. In later stages of disease development, the foliage becomes necrotic *(7.5b).* Also, there is extensive reddish-brown discoloration of the crown and vascular system of the roots and petioles, and plants are severely stunted. The internal crown discoloration may be seen by splitting the plant in half lengthwise *(7.5c).* Bacteria and other microorganisms often invade the affected crown and root tissues and cause secondary rot. Occasionally, dry rot of the crown follows and a cavity may form. Plants may die in the final stages of disease development.

Causal agent On potato-dextrose agar at pH 6.5 to 7, the mycelium of *Fusarium oxysporum* f. sp. *apii* is initially white, becoming pale vinaceous to somewhat purple or mauve. Microconidia are elliptical, generally 5 to 12 by 2.2 to 3.5 µm, produced in abundance, generally non- to one-septate or rarely two-septate. They are borne on simple phialides arising laterally on the hyphae or from short, sparsely branched conidiophores. The macroconidia are sparse, generally three- to five-septate, less than 4 µm wide, usually fusoid-subulate, and pointed at both ends. Chlamydospores are often abundant, both smooth and rough walled, and may be both terminal and intercalary, and generally solitary. They may occasionally be in pairs or in chains.

It is important to use a wild-type culture in identifying and testing this pathogen. Isolations from diseased celery plants yield mycelial cultures that produce abundant microconidia and few macroconidia, in contrast to intermediate, pionnotal and appressed cultural forms that are rare in nature and are less pathogenic to celery. The latter forms often arise from the mycelial isolates after prolonged storage in culture and repeated transfers. Culture propagation by single microconidial transfer, followed by incubation in either complete darkness or diffuse light, will maintain mycelial characteristics true to the wild-type isolates. Isolations from root or crown tissue and determinations of soil populations are possible using Komada's medium or a sorbose-based selective medium.

Race identification based on reactions of yellow and green cultivars in greenhouse virulence tests may be inconclusive and misleading due to variation with environmental conditions, methods of inoculation and host age. Laboratory tests based on colony size of isolates on special sorbose media and heterokaryon (vegetative) compatibility in conjunction with virulence tests may be necessary.

Disease cycle The severity of fusarium yellows in the field depends on the degree of infection and whether the plants are infected early or late in the season. Early infection often leads to severe losses in yield and quality. Other factors, such as the spore populations in the soil and weather during the growing season, are also important. As the population of spores increases, more severe symptoms develop. The disease is most severe during warm seasons and on heavy wet soils.

The distribution of affected plants in fields may appear patchy, probably due to the uneven distribution of spores in the soil. The fungus is spread when infested soil is carried from contaminated to pathogen-free fields by farm equipment or on workers' shoes. It may also be introduced by use of infected transplants or by infested soils used to grow transplants. Fungal spores can be spread in irrigation and flood water and by windblown soil.

The fungus persists in soil for many years in the absence of celery as dormant spores or by colonizing the roots and stems of non-susceptible hosts such as sweet corn, cabbage and especially carrot. The roots of many symptomless host weeds, such as lamb's-quarters, smartweed, barnyard grass and purslane, also are colonized. Crop plants and weeds can allow the fungus to multiply. Thus, population levels increase in the soil in the absence of celery, making shortterm fallowing of infested fields ineffective as a control measure. Populations increase quickly if susceptible celery cultivars or carrots are grown in infested fields. Continuous celery production and incorporation of celery trimmings back into the soil at harvest will greatly increase spore populations and enhance disease development in the subsequent celery crop because the crop residues serve as a food source for the fungus. Sometimes, however, even low spore populations in the soil may cause crop failures.

Management

Cultural practices — Celery trimmings should not be returned to infested fields after harvest.

Growers are advised to practice a two- to three-year rotation with onion or lettuce to reduce *Fusarium* populations in infested fields. Carrot and sweet corn should be avoided in rotations, and weeds should be controlled because they allow the fungus to multiply in the root zone.

Introduction of fusarium yellows on transplants can be prevented by sanitation in the greenhouse: 1) steaming or fumigating soil and flats; 2) disinfesting work benches and surfaces before seeding; 3) using a disease-free commercial potting mix or soil that has been steamed or fumigated; 4) following the recommendations for cleanliness and sanitation, bench and equipment sterilization, and soil pasteurization for greenhouse crops; and 5) avoiding use of field- grown transplants from areas where fusarium yellows has been reported. To avoid introduction of infested soil, non- infested fields should be worked before entering infested fields, and caution should be exercised in allowing machinery and people into infested fields. Soil washed from machinery should be collected and disposed of. Machinery should not be borrowed from areas where fusarium yellows is present or suspected. Flood and drainage water should be prevented from moving from infested to non-infested fields. Pallet boxes and containers used for packing celery where fusarium yellows has been reported should be washed with hot water or disinfested before being cycled to other growers.

Resistant cultivars — Resistant (Picador, Matador, Starlet) or moderately resistant (Tall Utah 52-70 HK strain, Deacon) cultivars provide the cheapest and easiest method of control in fields infested with race 2 of *Fusarium oxysporum* f. sp. *apii*. Moderately resistant cultivars yield well in fields with light to moderate soil infestations of this pathogen, but yield losses will occur in heavily infested soils. Other cultivars, such as Tendercrisp, are also moderately resistant. Resistant or moderately resistant cultivars should always be grown in infested fields. The use of susceptible cultivars, in addition to resulting in yield and quality losses in infested fields, will exacerbate the disease situation in future years by increasing populations of the pathogen in the soil.

Chemical control — Fungicidal drenches at the time of transplanting or later have been unsuccessful in controlling fusarium yellows. Fumigation of seedbeds may be successful initially, but complete prevention of spread of the pathogen involves frequent cleaning of equipment and control of windblown soil.

Selected references

Awuah, R.T., and J.W. Lorbeer. 1986. A sorbose-based selective medium for enumerating propagules of *Fusarium oxysporum* f. sp. *apii* Race 2 in organic soil. *Phytopathology* 76:1202-1205.

Awuah, R.T., and J.W. Lorbeer. 1988. Nature of cultural variability in *Fusarium oxysporum* f. sp. *apii* Race 2. *Phytopathology* 78:385-389.

Awuah, R.T., J.W. Lorbeer and L.A. Ellerbrock. 1986. Occurrence of *Fusarium oxysporum* f. sp. *apii* Race 2 in New York and its control. *Plant Dis.* 70:1154-1158.

Gaye, M.M., D.J. Ormrod, F.M. Seywerd and W.J. Odermatt. 1991. Occurrence of fusarium yellows on celery in southwestern British Columbia and evaluation of cultivars for disease tolerance. *Can. J. Plant Pathol.* 13:88-92.

Puhalla, J.E. 1984. Races of *Fusarium oxysporum* f. sp. *apii* in California and their genetic interrelationships. *Can. J. Bot.* 62:546-550.

(Original by R.F. Cerkauskas)

▶ 7.6 Pink rot (white mold) *Figs. 7.6a,b*

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

This fungal disease is generally of minor economic significance to celery. It can occasionally cause damage in the seedbed, field and in storage. Pink rot also affects celeriac and a variety of other vegetable crops. On the latter, the disease is commonly referred to as white mold (see also Carrot, sclerotinia rot, 6.15).

Symptoms All stages of field celery as well as the stored product can be attacked. The disease causes damping-off in seedbeds, attacking the seedling stems at ground level. A soft rot develops and causes seedlings to collapse. Affected tissues become covered with a fluffy white mold sprinkled with large black resting bodies (sclerotia).

In the field, the fungus also invades the celery plant at the soil level and causes a watery soft rot *(7.6a)*. The diseased tissue takes on a characteristic pinkish color *(7.6b)* and becomes covered with white mold and sclerotia. Eventually, the heart of the celery rots and the entire plant wastes away. Other rot-causing organisms may invade the diseased tissues, leading to rapid destruction of the plant.

Celery with latent pink rot infection may develop disease symptoms in storage. Lesions first appear as water-soaked spots, turning soft as the tissues decay. Lesions are generally light brown with pinkish borders but no odor. Advanced lesions may be covered with a white, more or less appressed mycelial growth of the causal fungus with various stages of sclerotial formation.

Phytophotodermatitis, a blistering disorder of the skin, has sometimes occurred in people working in celery fields, especially in crops affected by pink rot, and in some grocery workers. Celery plants may contain furanocoumarins, which when placed on the skin and exposed to sunlight produce a blistering lesion. Phytophotodermatitis also has been associated with exposure to various fruits, flowers and vegetables, including dill, parsley, lime, parsnip, bergamot and chrysanthemum.

Causal agent (see Bean, white mold, 15B.9)

Disease cycle (see Bean, white mold) Pink rot development is more serious during cool, moist weather. High humidity and poor air movement within the crop canopy will promote the disease. In British Columbia, the prolonged use of floating row covers has been observed to increase the incidence of pink rot.

Management

Cultural practices — Pink rot is difficult to control. The only economical method is to reduce the level of initial inoculum by following a three-year rotation with non-susceptible crops such as onion, corn and cereal grains. Infected crop residues must also be destroyed in order to avoid more serious soil contamination. Deep plowing to bury the sclerotia may help to control pink rot if other cultivation practices do not bring these sclerotia back up to the soil surface. Celery should be stored at high humidity and between 0 and 1°C. Plants harvested from affected crops should not be stored for long periods.

To protect against phytophotodermatitis, workers should wear protective clothing such as long-sleeved shirts and gloves when harvesting or handling celery or other fura- nocoumarin-containing crops. They also should wash exposed skin with soap and water after handling these crops.

Selected references

Anonymous. 1985. Phytophotodermatitis among grocery workers - Ohio. *Morbidity Mortality Weekly Rep.* 34:11-13.

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

Scheel, L.D., V.B. Perone, R.L. Larkin and R.E. Kupel. 1963. The isolation and characterization of two phototoxic furanocoumarins (psoralens) from diseased celery. *Biochemistry* 2:1127-1131.

(Original by L.M. Tartier, A.A. Reyes and R.J. Howard)

▶ 7.7 Septoria blight (late blight)*Figs. 7.7a-g*

Septoria apiicola Speg.
(syn. *Septoria apii* F. Chester)
(syn. *Septoria apii-graveolentis* Dorogin)

Septoria blight of celery has been reported from all provinces. It causes yield losses by defoliating and stunting the plants. It also increases harvest costs because of the labor required to trim diseased leaves and petioles. Other losses occur during storage when secondary organisms and other diseases, especially pink rot, occur in association with late blight. The pathogen is restricted to celery and celeriac.

Symptoms Small black pycnidia may be present on the surface of infected seed. Symptoms on the foliage begin on the older outer leaves and later on younger inner leaves. Chlorotic spots and flecks develop, turning reddish brown or brownish black and becoming necrotic *(7.7a).* The necrotic areas usually have a definite margin and are surrounded by chlorotic halos that merge gradually into uninfected tissue. Most lesions are round, but shape may vary near veins or other lesions. Lesions remain less than 3 mm or expand up to 10 mm in diameter with several lesions growing together *(7.7b).* Mycelium is present in the lesions and surrounding tissue. Numerous small, black pycnidia are scattered in the smaller lesions, but in larger lesions they are less numerous and more concentrated near the center. In severe cases, when large numbers of lesions and pycnidia appear, the entire leaf may be destroyed. Older outer petioles have more severe symptoms than inner petioles *(7.7c,d).* Infections arise along the length of the petiole when cirrhi of conidia are extruded from pycnidia in leaves *(7.7j)* and carried down the petioles by rain or dew.

Causal agent The brown to black pycnidia of *Septoria apiicola* are immersed in leaf or petiole tissue *(7.7e).* They have a diameter of 75 to 195 µm with pycnidial walls three cells thick, composed of pale brown pseudoparenchymatous tissue that is darker and thicker near the ostiole. The pycnidia are membraneous when fresh, carbonaceous when dry and are not beaked. The conidia are hyaline, needle-shaped, straight to curved or flexuous, generally three-septate (range one to five septa), with a slight taper toward the apex *(7.7g).* They measure 22 to 56 (mean 35 µm) by 2 to 2.5 µm. The conidia develop as phialospores from hyaline, septate conid- iophores formed from the innermost layer of cells of the pycnidium. The conidiophores measure 8 to 10 by 3 to 3.5 µm. The conidia are extruded in white to tan cirrhi when pycnidia are wet.

On potato-dextrose agar, most strains are initially yeast-like and slow- growing. The sub-surface mycelium is brownish black, sometimes producing a diffusible brown to pink pigment. Aerial mycelium is white. Pycnidia with oozing masses of conidia are often scattered over the colony surface.

Disease cycle Infested seed is the major source of primary inoculum. Pycnidia, mycelium and conidia may occur on seed, but the fungus is absent from embryos and endosperms, even though the mycelium can penetrate pericarps and testas. Seed-borne conidia remain viable for at least 15 months but not beyond two years.

In seedbeds, primary inoculum originates from infected seeds and crop residues, and can be spread by contaminated tools and workers. When the seed germinates, the seed coat containing pycnidia may remain partially attached to the cotyledons. This allows the conidia to ooze onto the cotyledons and infect them. Young leaves are soon infected under favorable conditions, although the spotting on seedling foliage may not always be obvious. The movement of workers and implements, particularly when seedlings are wet, also may introduce the fungus and enhance dissemination within the seedbed.

In fields, primary inoculum originates from the use of diseased transplants, infested soil, contaminated plant containers, implements and workers. Dissemination of primary and secondary inoculum within the field arises by splashing rain, irrigation water and movement of workers and implements, especially when the foliage is wet.

Optimum temperatures for germination of conidia are between 5 and 27°C over a 48-hour period and between 20 and 22°C for germ tube growth. Free water is not essential either for germination or for infection of celery leaves, but relative humidity below 90% significantly limits infection. The time for infection to symptom appearance is seven to eight days at 21 to 27°C and 12 days at 18°C. The time from inoculation to production of secondary inoculum is 10 to 12 days.

The disease often appears during the latter part of the growing season. The greatest disease development occurs when the fungus develops more rapidly than the growth of the celery plant. Such conditions prevail when dry weather prevents rapid plant growth, and when cool, misty nights or heavy dews are followed by dull days. Under these conditions the leaves and petioles remain wet for considerable periods of time, allowing the pathogen to develop more rapidly than the host.

Management

Cultural practices — The use of disease- free seed will prevent introduction of primary inoculum to the seedbed. Control of the disease in the seedbed is easier and less costly than control in the field. Celery and celeriac seed can be disinfested with hot water (48°C for 30 minutes). If diseased plants are noticed in the greenhouse or seedbed, they should be pulled. Crowding of plants and planting in fields and outdoor seedbeds where the disease has occurred for at least two years should be avoided. If fresh land is not available for seedbeds, the remains of each year's crop should be removed as soon as possible to eliminate the survival of self-set plants that may become infected later in the season. Unless treated with a fungicide, infested seed should not be planted until it is three years old because the fungus cannot survive in seed beyond two years.

Resistant cultivars — No cultivars have a high level of resistance, but Emerson Pascal, Florida Green Pascal, Earligreen, Green Giant and June-Belle are somewhat tolerant.

Chemical control — Celery and celeriac seed should be treated with a protective fungicide before planting. Protective foliar fungicides are important in seedbeds where long periods of leaf-wetness and high relative humidity due to high plant density create conditions for rapid disease development. Timing of protectant fungicide spray applications in production fields is also important. More frequent applications may be necessary under conditions that favor the disease.

Selected references

Gabrielson, R.L., and R.G. Grogan. 1964. The celery late blight organism *Septoria apiicola. Phytopathology* 54:1251-1257.
Maude, R.B. 1970. The control of Septoria on celery seed. *Ann. Appl. Biol.* 65:249-254.
Sheridan, J.E. 1968. Conditions for germination of pycnidiospores of *Septoria apiicola* Speg. *N.Z. J. Bot.* 6:315-322.
Sheridan, J.E. 1968. Conditions for infection of celery by *Septoria apiicola. Plant Dis. Rep.* 52:142-145.
Sutton, B.C., and J.M. Waterston. 1966. *Septoria apiicola.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 88. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.F. Cerkauskas)

VIRAL AND VIRAL-LIKE DISEASES

▶ 7.8 Aster yellows *Figs. 7.8a,b*

Aster yellows mycoplasma-like organism

This disease is common but generally of little economic importance on celery because of its low incidence. Aster yellows affects several other vegetable crops, including carrot, lettuce and potato.

Symptoms Young celery plants affected by aster yellows form more petioles than normal plants (*7.8b).* The outer petioles are rigid, while the petioles at the heart become chlorotic and deformed, remain stunted, grow tendrils and sometimes become tangled. These initial symptoms are followed by an overall yellowish to whitish discoloration of the plant (*7.8a).*

Causal agent (see Lettuce, aster yellows, 11.15)

Disease cycle (see Lettuce, aster yellows)

Management (see aster leafhopper, 7.18, 11.23)

Cultural practices — Growers are advised to eradicate weeds around fields and along ditches bordering celery fields.

Selected references

Chiykowski, L.N. 1977. Transmission of a celery-infecting strain of aster yellows by the leafhopper, *Aphrodes bicinctus. Phytopathology* 67:522-524.
Chiykowski, L.N. 1978. Delayed expression of aster yellows symptoms in celery. *Can. J. Bot.* 56:2987-2989.
George, J.A., and J.K. Richardson. 1957. Aster yellows on celery in Ontario. *Can. J. Plant Sci.* 37:132-135.

(Original by L.M. Tarder)

▶ 7.9 Heart mosaic *Figs.7.9a-c*

Cucumber mosaic virus

Several strains of cucumber mosaic virus can attack celery. It is a disease of little significance, usually affecting only a few scattered plants in a field. The virus also infects other vegetables, such as cucurbits, tomato, spinach, pepper, turnip, carrot, potato and lettuce.

Symptoms Leaves of affected plants are mottled and yellow-veined (*7.9b).* They also are often deformed, appearing stretched and crinkled. The petioles at the heart are curved downward, giving the plant an open appearance. Sometimes, there are no visible symptoms on the foliage, but characteristic elongate, brownish, translucent, slightly sunken spots occur on the petioles (*7.9a).* Marketability is reduced if the spots cover the entire length of the petioles (7.9c).

Causal agent (see Greenhouse cucumber, cucumber mosaic, 22.20)

Disease cycle (see Cucurbits, cucumber mosaic, 9.15) The virus overwinters in weeds along the edges of fields and ditches. It is spread into celery crops by aphids (7.17).

Management Control of aphids helps to reduce the build-up and spread of the disease in celery crops.

Cultural practices — Growers should eradicate weeds along the edges of the fields to eliminate the reservoir of virus available to infect celery crops. After harvest, infected crops should be destroyed by discing or plowing.

Selected references

Bruckhart, W.L., and J.W. Lorbeer. 1975. Recent occurrences of cucumber mosaic, lettuce mosaic and broad bean wilt viruses in lettuce and celery fields in New York. *Plant Dis. Rep.* 59:203-206.

Bruckhart, W.L., and J.W. Lorbeer. 1976. Cucumber mosaic virus in weed hosts near commercial fields of lettuce and celery. *Phytopathology* 66:253-259.

Francki, R.I.B., D.W. Mossop and T. Hatta. 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 L.M. Tartier)

NON-INFECTIOUS DISEASES

▶ 7.10 Blackheart *Figs. 7.10a,b*

This major disorder can seriously affect the marketability of celery and celeriac crops and has been reported in most provinces. In individual cases, entire fields have been lost.

A similar disease also affects tomato and pepper (blossom- end rot, 18.21) and lettuce (tipburn, 11.19).

Symptoms Blackheart affects the interior of the plant. Initially, the younger leaves appear waterlogged, then wilt and turn black (*7.10a).* If the disorder is temporary, the plants can recover and produce new hearts. When this occurs, affected leaves take the form of blackened tips at the end of lengthened petioles *(7.10b).* If the disorder persists, the growing point dies and the plant is unmarketable. The outer ring of leaves is not affected and appears normal. Diseased leaves are often subject to attack by soft rot bacteria that completely destroy the heart of the plant.

Causal agent Blackheart is a physiological disorder resulting from poor calcium assimilation in the plant. It is also related to fluctuating soil moisture conditions. This disorder appears when environmental conditions stimulate rapid plant growth, such as when heavy rain or irrigation follows a prolonged drought. Available calcium in the soil cannot meet plant requirements and a deficiency develops. High soil nitrogen, a low calcium to nitrogen ratio, and high levels of potassium and sodium, which can reduce calcium absorption, may also be associated with this disorder. Conditions favoring blackheart can occur several times during a season. The disorder becomes more difficult to correct when the plant is in a period of rapid growth or approaching maturity.

Management

Cultural practices — Blackheart can be prevented by encouraging steady plant growth through well-balanced fertilization and a regular supply of water. During periods of drought and stress for the plant, calcium nitrate or calcium chloride sprays should be applied before symptoms appear. Fertilizers can be used to provide a high calcium to potassium ratio.

Resistant cultivars — Selections of Tall Utah 52-70 are more susceptible than Florida 683.

Selected references

Foster, A.C. 1934. Black-heart disease of celery. *Plant Dis. Rep.* 18:177- 185.

Geraldson, C.M. 1954. The control of blackheart of celery. *Proc. Am. Soc. Hortic. Sei.* 63:353-358.

(Original by L.M. Tartier)

▶ 7.11 Chlorosis *Fig. 7.11*

Magnesium deficiency
Manganese deficiency

This disorder is quite often encountered on isolated celery plants in soils that have been cultivated for many years. Nevertheless, it is usually considered a minor problem. In the muck soils of coastal British Columbia, large sections of celery fields are sometimes affected and the overall appearance of these areas may resemble a fusarium yellows infection. The disorder has not been reported on celeriac.

Symptoms Yellowing (chlorosis) symptoms first appear on the oldest leaves. Manganese deficiency produces chlorosis between the leaf veins and eventually affects the entire leaf. In extreme cases, the disease can affect overall growth. Magnesium deficiency takes the form of a much more obvious chlorosis of the older leaves, which then extends to the youngest leaves. Chlorosis begins at the leaf margins *(7.11)* and progresses steadily until the affected leaf turns white. In acute cases, the leaves turn brown, dry out, die and drop off.

Causal agent Chlorosis is caused by a deficiency of manganese or magnesium. Manganese deficiency appears to be more common in alkaline soils, where manganese is often present in a form that cannot be assimilated by the plant. Magnesium is an element that leaches away easily, so a deficiency is often encountered after prolonged heavy rains.

Management

Cultural practices — Celery should be grown in a slightly acid soil where possible. Excessive liming should be avoided. In addition, the soil should be adequately fertilized by incorporating manganese sulfate or magnesium into the fertilizer. Symptoms of these deficiencies on celery crops can be corrected by spraying the leaves with manganese or magnesium sulfate.

Selected references

Johnson, K.E.E., J.F. Davis and E.J. Benne. 1961. Occurrence and control of magnesium deficiency symptoms in some common varieties of celery. *Soil Sei.* 91:203-207.

Pope, D.T., and H.M. Munger. 1953. Heredity and nutrition in relation to magnesium deficiency and chlorosis in celery. *Proc. Am. Soc. Hortic. Sei.* 61:472-480.

Yamaguchi, M., F.H. Takatori and O.A. Lorenz. 1960. Magnesium deficiency of celery. *Proc. Am. Soc. Hortic. Sei.* 75:456-462.

(Original by L.M. Tartier)

▶ 7.12 Cracked stem (boron deficiency) *Figs. 7.12a,b*

Boron deficiency

This is a serious disorder that is most often encountered on celery and celeriac crops grown in freshly broken organic soil and in old fields. A similar problem affects other vegetables, especially crucifers (see Crucifers, boron deficiency, 8.23).

Symptoms The symptoms are very characteristic and easily identifiable. Brown, cross-wise cracks appear on the ribs of the petioles. These vary in number according to the intensity of the disease. Their margins are often raised and develop a brown color. The plants remain small and bushy with rigid and brittle petioles when the deficiency is pronounced. Elongate brown translucent spots are sometimes found on the inner surface of stalks. Beginning with the leaves, the petioles bend, become tangled, turn brown and dry out. The growing point is often destroyed and a dry rot gradually destroys the petioles at the heart to the base *(7.12a,b).* Most often, only a crown of outer petioles surrounding a cavity with a brown base remains at the end of the season. Affected plants may be attacked by secondary rot organisms.

Causal agent Cracked stem is caused by a deficiency of available boron in the soil. It is more severe on soils with excess lime, which prevents assimilation of boron by the plant. High levels of potassium and ammonium nitrogen also seem to be associated with this problem. Boron deficiency is often more serious on deeply cultivated soils. Drought promotes this disorder.

Management

Cultural practices — To ensure that there is sufficient boron in the soil, growers should incorporate borax into the fertilizer and maintain a slightly acidic soil pH, where practical. When the first symptoms appear or when drought ensues, the leaves should be sprayed with boron. A well-balanced fertilizer program, especially in potassium, nitrogen and calcium, will help to prevent cracked stem.

Resistant cultivars — Selections of Utah 52-70 differ in their susceptibility to cracked stem.

Selected references

Kendrick, J.B., R.T. Wedding, J.T. Middleton and J.B. Hall. 1954. Some factors affecting development and control of adaxial crack stem of celery. *Phytopathology* 44:145-147.

Yamaguchi, M., F.W. Zink and A.R. Spurr. 1953. Cracked stem of celery. *Calif. Agric.* 7(5): 12.

(Original by L.M. Tartier)

▶ 7.13 Spongy petiole (pithiness) *Fig. 7.13*

This physiological problem is commonly encountered on celery during some seasons, but is of little economic significance.

Symptoms Affected plants have hollow petioles that can be easily crushed by applying pressure with the fingers. These petioles are light in weight and, when cut, the interior appears spongy *(7.13).* All petioles are affected and the disorder may even appear early in the growth of the plant. More frequently, however, only the outer petioles are affected.

Causal agent Spongy petiole is related to unfavorable growing conditions. It is more common in late July and August when plants are growing rapidly and growth is interrupted by cool conditions. The appearance of spongy petiole is more frequent a week or a few days before maturity when available nitrogen and potassium are usually low. Other stress factors, such as an irregular supply of water or unbalanced or poorly timed fertilization, may also encourage this disorder. Spongy petiole can continue to develop in storage.

Management

Cultural practices — A uniform rate of plant growth should be maintained by providing optimal growing conditions. Mature crops should be harvested promptly and stored at temperatures that inhibit senescence.

Resistant cultivars — Selections of Utah 52-70 are more susceptible than Florida 683.

Selected references
Hall, J.B., and H.W. Burdine. 1958. Evaluation of factors determining celery quality. *Florida Agric. Exp. Stn. Annu. Rep.* pp. 113-281.
White-Stevens, R.H. 1937. Carbohydrate and cellular changes in relation to pithiness of celery in cold storage. *Proc. Am. Soc. Hortic. Sei.* 35:649-653.

(Original by L.M. Tartier)

▶ 7.14 Stringiness

This is a physiological problem affecting the quality of the celery stalk but rarely resulting in economic loss. It can develop in the newer, “stringless” cultivars of celery.

Symptoms Petioles of affected plants have thickened, fibrous strands around the circumference of the outside edge close to the epidermis. The fibers occur along the length of the petiole and may be found within externally visible ridges. All petioles can be affected, although the disorder more commonly affects the mature, outer petioles.

Causal agent Stringiness is caused by secondary wall thickening of the supporting collenchyma tissue. The condition is related to low nitrogen availability and may appear as the plants reach maturity. Plants subjected to wind stress also may have earlier and greater wall thickening of collenchyma. To some extent, stringiness is an inheritable characteristic.

Management

Cultural practices — Adequate nitrogen availability should reduce the incidence of the disorder. Timely and balanced fertilization and regular irrigation should be followed. Harvest should not be delayed.

Selected references
Esau, K. 1977. *Anatomy of Seed Plants.* J. Wiley & Sons, New York. 550 pp.
Nonnecke, I.L. 1989. *Vegetable Production.* Van Nostrand Reinhold, New York. 657 pp.

(Original by M.M. Gaye)

NEMATODE PESTS

▶ 7.15 Northern root-knot nematode *Figs. 7.15a,b*

Meloidogyne hapla Chitwood

Symptoms on celery and celeriac include yellowing and stunting of stalks, prolific branching of rootlets, and production of small, spherical galls on roots (*7.15a,b*). For a complete description and management strategies, see Carrot, 6.20; see also Management of nematode pests, 3.12.

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

Pratylenchus penetrans (Cobb) Filip. & Stek.

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

Selected references
Townshend, J.L. 1962. The root-lesion nematode, Pratylenchus penetrans (Cobb, 1917) Filip. & Stek. 1941, in celery. Can. J. Plant Sci. 42:314-322.

INSECT PESTS

▶ 7.17 Aphids Figs. 16.41a,b

Green peach aphid *Myzus persicae* (Sulzer)
Other aphids

Aphids, primarily the green peach aphid (see Potato, 16.41), occur on celery but their abundance varies greatly with seasonal conditions, location and control programs. When abundant, aphids cause leaf distortion. The presence of their molted skins (exuviae) and honeydew can make celery heads unmarketable. In Quebec, a reduction of insecticide use, resulting from management programs for the tarnished plant bug, has led to an increase in aphid problems on some farms.

Selected references

Beirne, B.P. 1972. Pest insects of annual crop plants in Canada. VI. Hemiptera - Homoptera. *Entomol. Soc. Can. Mem.* 85. 73 pp.

(Original by A.B. Stevenson)

▶ 7.18 Aster leafhopper *Figs. 11.23a,b*

Macrosteles quadrilineatus (Forbes)
(syn. *Macrosteles fascifrons* of authors, not Stål)

The aster leafhopper infests celery and is economically important on celery as a vector of aster yellows (for further detail, see Lettuce, aster leafhopper, 11.23).

Selected references

Miller, L.A., and A.J. DeLyzer. 1960. A progress report on studies of biology and ecology of the six-spotted leafhopper, *Macrosteles fascifrons* (Stal), in southwestern Ontario. *Proc. Entomol. Soc. Ontario* 90:7-13.

(Original by A.B. Stevenson)

▶ 7.19 Carrot rust fly *Figs. 6.23a,c,e*

Psila rosae (Fabricius)

Celery is very attractive to carrot rust fly (see Carrot, 6.23). The adults are likely to be present on celery grown in locations where carrot also is grown. In Ontario, economic damage to celery by the carrot rust fly is rare and crop losses, in general, are insignificant. However, carrot rust fly populations in celery fields are a threat to nearby carrot and parsnip crops.

Celeriac is also a host of the carrot rust fly, with damage and susceptibility similar to that of celery.

Damage Larvae of the carrot rust fly feed on the roots of celery. The first-generation larvae can develop on early celery with no visible indication of above-ground attack. If larvae are abundant, wilting or stunting can occur on plants that are small and under moisture stress. Such damage is more likely to occur near the periphery of fields. Adult carrot rust flies from early celery crops will supplement the population attacking carrot in late summer and early autumn. By that time, celery is well developed and second- generation larvae are unlikely to cause significant injury to the crop. In general, carrot rust fly is not a major economic pest of celery in Canada and significant injury rarely occurs.

Management

Monitoring — Carrot rust fly adults are monitored with yellow sticky traps (*3.2T1*) (see Carrot, 6.23). No action threshold is available but any threshold on celery would be considerably higher than for carrot.

Cultural practices — Growers should rotate crops, avoid fields with a history of damage the previous year, and remove bolted plants because adults are attracted to the flowers.

Chemical control — Insecticide should be applied sparingly, preferably only to the perimeter of celery plantings early in the growth period.

Selected references

Hanson, A.J., and R.L. Webster. 1941. The carrot rust fly. *Wash. State Agric. Exp. Stn. Bull.* 405. 24 pp.

(Original by A.B. Stevenson)

▶ 7.20 Carrot weevil *Fig. 7.20*

Listronotus oregonensis (LeConte)

Carrot is the major host of the carrot weevil (see Carrot, 6.24) but celery is readily attacked and, under certain circumstances, it can be severely injured. Reports of damage have been mainly from the Holland and Thedford marshes in Ontario and from Quebec.

Celeriac is also a host of the carrot weevil, with damage and susceptibility similar to that of celery.

Damage The adult carrot weevil punctures and lays one to several eggs in the petioles of celery. Upon hatching, larvae either tunnel in the petiole or move to the crown or roots to feed. Celery transplants are susceptible from the time of planting. Injury varies with the number of weevils ovipositing in the plant and the stage of development of the host at the time of attack. Soil moisture also may be a factor; inadequate soil moisture increases the chance of wilting and plant death. In extreme cases, root systems are severely reduced and the plants wilt and die *(7.20).* Instances of severe injury have occurred in smaller plantings or close to overwintering sites. Normally, celery can withstand heavier attack than carrot because much of the weevil's tunneling and feeding occur on petioles that are not part of the marketed plant. Tunneling at the base of the celery stalks can make them unmarketable but serious injury occurs only occasionally.

Management

Monitoring — The carrot weevil in celery is monitored in the same manner as in carrot. Root pieces are placed in the soil near the plants to detect oviposition, or wooden plates are used to trap adults (*3.2T2*). Celery can tolerate a higher level of carrot weevil oviposition than carrot but no action threshold has been determined.

Cultural practices — Location is important; growing celery on or near sites of previously infested carrot or celery crops could increase the level of weevil attack on celery.

Chemical control — An organophosphate insecticide is registered for use against carrot weevil on celery. If celery is planted in late May or early June, the first application should be made immediately after transplanting. Celery planted later than mid-June is not likely to require an insecticidal treatment.

Selected references

Stevenson, A.B. 1977. Seasonal history of the carrot weevil, *Listronotus oregonensis* (Coleoptera: Curculionidae) in the Holland Marsh, Ontario. *Proc. Entomol. Soc. Ontario* 107:71-78.

(Original by A.B. Stevenson)

▶ 7.21 Tarnished plant bug *Figs. 7.21 a-e; 18.42b-e*

Lygus lineolaris (Palisot de Beauvois)

The tarnished plant bug occurs throughout Canada, including the Yukon. Early in the season, oviposition occurs on strawberry, alfalfa and red clover, and on such weeds as chickweed, dandelion and brown knapweed. Later breeding may occur on native hosts, such as lamb's-quarters *(Chenopodium album* L.), ox-eye daisy (*Chrysanthemum leucanthemum* L.), ragweed *(Ambrosia* spp.), fleabane *(Erigeron* spp.), plantain *(Plantago* spp.), and goldenrod *(Solidago* spp.). Besides celery, the adult feeds on other vegetables, resulting in reduced fruit set on bean, pepper and eggplant; cloudy spot blemishes on tomato fruit; necrotic spots on the florets and curd of broccoli, cauliflower and heads of lettuce; dead leaves on potato; stings and gummosis on fruit of zucchini; and foliar injury to cucumber.

Damage Adult tarnished plant bug feeding on the main stalks of celery causes lesions about the feeding sites, ranging from stings to ovoid cavities where sub-epidermal tissues have collapsed *(7.21a).* This type of injury may appear early in the season and most of it, being on petioles that will drop or be trimmed at harvest, may not be economically significant. Nearer harvest, tarnished plant bug damage (commonly called black joint) is sometimes confused with blackheart. Feeding on the leafy parts of the petiole causes necrosis of leaflets and leaf bases *(7.21c),* which in extreme cases can lead to the destruction of the entire petiole by secondary organisms such as bacteria. Just a few petioles damaged to this extent can make the entire plant unmarketable. This type of injury is partly attributable to feeding by nymphs (*7.2lb),* so any control measures that prevent plant bugs from breeding on celery usually prevent the damage from becoming economically important. In general, damage on celery varies, depending on conditions and management strategies. If left untreated, up to 80% of the crop can be unmarketable.

Identification *Lygus* bugs (family Miridae) are elongate-oblong and red-brown. The tarnished plant bug (*7.21d,e*) is distinguished by a submedian, oblique bar on the front of the head, pale or reddish lateral areas on the mid-thorax, and dense, yellow pubescence (setae) on the forewings. Adults are 4.9 to 6 mm in length and 2.3 to 3 mm in width.

Life history The tarnished plant bug overwinters as an adult in sheltered sites, such as hedgerows and under fallen leaves and crop residue. It is present throughout the growing season in Ontario and Quebec, where there are two (and a partial third) generations per year. Overwintered adults become active in mid- to late April and infest and lay eggs on clover and weed hosts. Later in the season, adults breed on various crops, weeds and native plants. Nymphs and adults feed on flowers and shoot tips. First-generation adults appear in Ontario about two months after the overwintered adults become active, which corresponds to about 214 degree-days above 9.3°C. In Quebec, first-generation adults start to appear on celery at the beginning of July regardless of the date of transplanting, nymphs are present from mid-July until the end of September, and second-generation adults appear around mid-August.

Management

Monitoring — A monitoring program in the muck soil area south of Montreal, where the amount of insecticide used on celery has been reduced by nearly 50%, is done by bi-weekly visual inspection of individual plants, beginning when they are less than 10 cm tall; 20 plants per field is sufficient and insecticide is applied if one or more bugs (adult or nymph) per plant are found. When plants exceed 10 cm in height, the threshold is six bugs (adult or nymph) per 30 plants; within three weeks of harvest, the threshold changes to four bugs (adult or nymph) per 40 plants.

In general, growers should monitor from mid-June or early July until harvest. As harvest approaches, the importance of injury increases; therefore, the number of plants examined should be increased and the action threshold should be lowered. The choice of insecticides also becomes more limited because of the requirement for specific intervals between application and harvest. The presence of insects, whether alive or dead, must be avoided in the harvested produce.

Cultural practices — Thorough, year-round weed control in and around celery fields helps to reduce the potential for plant bug infestation.

Biological control — The wasps *Peristenus pallipes* (Curtis) and *P. pseudopallipes* (Loan) are common parasites of the tarnished plant bug in Canada. Other, naturally occurring parasites have been reported but none is available commercially.

Chemical control — The currently recommended insecticide programs for celery insects in Ontario and Quebec prevent serious plant bug injury when carried out properly. Insecticidal treatments in the latter part of crop growth are most important because plant bug injury involves mainly petioles that develop at that time. Several insecticides are registered for control of plant bugs on celery in Canada. Pyrethroids are very effective on celery crops.

Selected references

Boivin, G., J.-P.R. LeBlanc and J.A. Adams. 1991. Spatial dispersion and sequential sampling plan for the tarnished plant bug (Hemiptera: Miridae) on celery. *J. Econ. Entomol.* 84:158-164.

Khoury, H., and R.K. Stewart. 1976. Chemical control of *Lygus lineolaris* (P. de B.) (Hemiptera: Miridae) on growing crops of celery and potato in Quebec. *Ann. Entomol. Soc. Quebec* 21:39-48.

Richardson, J.K. 1938. Studies on blackheart, soft-rot, and tarnished plant bug injury of celery. *Can. J. Res.* 16:182-193.

Schwartz, M.D., and R.G. Foottit. 1992. Lygus bugs on the prairies. Biology, systematics, and distribution. *Agric. Canada Res. Br. Tech. Bull.* 1992-4E. 44 pp, and Table 1 (2 pp).

Stewart, R.K., and H. Khoury. 1976. The biology of *Lygus lineolaris* (Palisot de Beauvois) (Hemiptera: Miridae) in Quebec. *Ann. Entomol. Soc. Quebec* 21:52-63.

(Original by A.B. Stevenson)

▶ 7.22 Other insect pests *Figs. 7.22a,b; 8.40b-f*

Caterpillars
- Cabbage looper *Trichoplusia ni* (Hübner)
- Celery looper *Anagrapha falcifera* (Kirby)
- Celery stalkworm *Nomophila nearctica* Munroe

A number of caterpillars occasionally infest celery. These include the cabbage looper (see Crucifers) (*8.40b-f*), the celery looper (family Noctuidae) (*7.22a)* and the celery stalkworm (family Pyralidae) (*7.22b).* These insects sometimes cause problems and damage has been reported, particularly in Newfoundland and Quebec.

(Original by A.B. Stevenson)

OTHER PESTS

▶ 7.23 Slugs *Figs. 11.27a-c*

Slugs (see Lettuce, 11.27) may be found on celery. Damage has been reported, particularly in Newfoundland and Quebec.

(Original by A.B. Stevenson)

ADDITIONAL REFERENCES

Schneider, R.W. 1985. Common names for plant diseases: celery *(Apium graveolens* L. var. *dulce* (Miller) Pers.). *Plant Dis.* 69:655.