/// Vegetables
by Bayer

Seminis De Ruiter

BRASSICA DISEASE FIELD GUIDE

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Vegetables by Bayer is committed to helping our customers grow their businesses so that together we can foster a healthier, more sustainable world. We work with growers and other partners to develop innovative products that balance agronomic traits with the demands of the market. We also go beyond the seed to provide solutions for our customers — like this disease field guide which can be used as a reference for common brassica diseases and disorders, as well as their control.

We developed the brassica disease field guide for use by a wide range of professionals involved in the vegetable industry including growers, agricultural advisors, private consultants, farm managers, agronomists, food processors, and members of the chemical and vegetable seed industries. It does not include every brassica disease, but we have included the diseases that are currently most prevalent worldwide in open field production.

The guide offers descriptions and photographs of the more common global brassica diseases and disorders, including the common name, causal agent, distribution, symptoms, conditions for disease development and control measures.

Even the most experienced plant pathologist relies on laboratory and greenhouse techniques to confirm a plant disease and/or disorder diagnosis. Therefore, diagnosis of diseases and disorders using only this guide is not recommended or encouraged, and it is not intended to be substituted for the professional opinion of a producer, grower, agronomist, plant pathologist or other professionals involved in the production of brassica vegetables. Always read and follow label directions for any herbicide, fungicide, insecticide or any other chemical used for treatment or control.

We are grateful to our many academic and private industry partners who contributed photographs for this guide. The photographs illustrate characteristic symptoms of diseases and disorders; however, it's important to note that many factors can influence the appearance and severity of symptoms. A glossary can be found at the end of this guide, along with a list of references for additional information on the diseases and disorders described in this publication.

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BLACK ROT

SCAB

XANTHOMONAS LEAF SPOT

Causal Agent

Pseudomonas cannabina pv. *alisalensis*

Distribution

Worldwide

Symptoms

The symptoms begin on the lower foliage as water-soaked lesions. Later they expand and produce a yellow halo. The disease progresses and begins to coalescence into irregular shaped brown lesions.

Conditions for Disease Development

Wet conditions and heavy winds enhance disease progression.

Control

Crop rotation to a non-host is recommended. Avoid cover crops and rotations with timothy, oat, Californian brome and sorghum as these are hosts for this pathogen.

6 / BACTERIAL LEAF BLIGHT

Advanced bacterial leaf blight on several heads of lettuce.
(Courtesy L. Fucikovsky—© APS. Reproduced, by permission, from Schroth, M. N., Hecht-Poinar, E. I., and Alvarez, A. M., eds. 2010. Plant Diseases Caused by Bacteria: An Image Database and Educational Resource CD-ROM. American Phytopathological Society, St. Paul, MN.)

Bacterial leaf blight on single leaf
(Courtesy P. R. Brown—© APS. Reproduced, by permission, from Harveson, R. M., Hanson, L. E., and Hein, G. L., eds. 2009. Compendium of Beet Diseases and Pests, 2nd ed. American Phytopathological Society, St. Paul, MN.)

Causal Agent

Pseudomonas syringae pv. *maculicola*

Distribution

Worldwide

Symptoms

The disease occurs mainly on cauliflower, though broccoli, cabbage, Brussels sprouts and turnips can also be affected. Symptoms consist of leaf spots that begin as small, water-soaked pinpoint lesions. Later, these lesions become dark brown or purple with translucent haloes. Individual spots are slightly sunken and up to 3 mm (1/8 in.) in size. Often, spots will coalesce to form an irregular angular lesion, giving a puckered, ragged appearance to the leaf. With severely affected plants, leaves may become chlorotic and senesce. The bacterium causes small, grey-to-brown spots on the cauliflower curd, which can affect both surface and underlying tissues. Peppery spot symptoms may also occur on stems, petioles and seed pods. This disease can be mistaken for bacterial blight caused by *Pseudomonas cannabina* pv. *alisalensis*

Conditions for Disease Development

This bacterium can survive in soil and in crop debris for at least one year. The organism can also be seedborne. It is spread by splashing rain or irrigation water. Insects may also spread this disease. Bacterial leaf spot is most severe during cool, wet weather.

Control

Use seed free of *Pseudomonas syringae* pv. *maculicola* and sow into seed beds free from the organism. If the disease occurred previously in the seed bed, the soil should be sterilised before planting. Rotate to a non-host seed bed for at least one year following a brassica crop.

Bacterial leaf spot on cabbage.

Angular leaf spots forming on the edges of leaves.

Pinpoint lesions developing in early infection.

Chlorosis (yellowing) emanating from bacterial lesions.

Advanced rotting of cauliflower crown and coalescence of lesions.

Causal Agent

Pectobacterium spp. (Formerly: *Erwinia* spp.), *Pseudomonas marginalis* pv. *marginalis*

Distribution

Worldwide

Symptoms

Symptoms first appear on leaves as small, water-soaked lesions that quickly enlarge. Affected tissue turns brown and becomes soft and mushy with an accompanying foul odor. Eventually, leaves, stems and roots may decay entirely. This disease may be found in the field on cabbage, Chinese cabbage, broccoli and cauliflower curd, swedes and turnips, but post-harvest soft rot during shipping or storage accounts for the majority of losses from this pathogen.

Conditions for Disease Development

Soft rot bacteria survive in soil and decaying plant material, and infect plants through wounds, stomata or hydathodes. Cultivation, harvesting, handling, freezing or insect injuries are often points of initial infection. The pathogen is generally spread by irrigation water, rain, several species of maggot flies and other insects. Disease development is usually favoured by warm [25-30°C], humid conditions or following periods of wet weather that lead to free moisture on plant tissues.

Erwinia spp. and *Pseudomonas* spp. may also act as secondary pathogens, following other diseases such as black rot or black leg.

Control

To help minimise soft rot losses, control insects, try to avoid mechanical injury during harvest, packing and shipping, and do not pack produce when wet. Additionally, store and ship produce at temperatures near 4°C.

Bacterial soft rot on broccoli.

Bacterial soft rot on cabbage.

Bacterial soft rot on cauliflower.

Causal Agent

Xanthomonas campestris pv. *campestris*

Distribution

Worldwide

Symptoms

Symptoms manifest as localised wilting at leaf margins. Wilted tissue becomes chlorotic and progresses to form the characteristic V-shaped lesion associated with this disease. Within chlorotic tissue, leaf veins turn black, giving the disease its name – black rot. At advanced stages, affected tissue becomes brown and necrotic. Black leaf veins may extend from the affected leaf into the main stalk where the darkened vascular system may be visible. As the disease progresses into the vascular system, lesions resulting from systemic invasion may appear along leaf midribs and between leaf veins. Systemically infected plants may be stunted and develop more severe symptoms on one side of the plant. In affected cabbage, heads are smaller and outer leaves may senesce. The disease can progress on cabbage during storage, making the heads unmarketable. Under cool conditions, symptoms may be confused with those caused by *Pseudomonas syringae* pv. *maculicola* (Bacterial leaf spot) or *Xanthomonas campestris* pv. *armoraciae* (Xanthomonas leaf spot).

Conditions for Disease Development

The black rot organism can survive in crop residue for up to two years. The bacterium can also infect cruciferous weeds, such as pepper grass *(Lepidium virginicum)*, wild radish *(Raphanus raphanistrum)*, black mustard *(Brassica nigra)*, wart cress *(Coronopus didymus)*, wild turnip *(Brassica campestris)* and others. These weeds, as well as nearby brassica crops, can serve as reservoirs for the bacterium, which may subsequently spread to healthy crops. Though hydathode infection is most common, stomatal entry may occur when plants are subjected to heavy rains or irrigation. The organism can also enter through natural wounds in the root system during periods of soil saturation. With warm temperatures of 27-30°C, symptoms may appear in 10 to 12 days. However, under cool conditions, an infected plant may not show symptoms. Spread of the disease in the field generally occurs by wind-blown rain, irrigation water, cultivation, insects or animals. The bacterium can be seedborne, which may result in seedling infection. Secondary infection from black rot-infected seedlings may occur in nurseries or seed beds and the disease generally spreads rapidly during transplant/growing operations.

Control

Use high-quality seed free of X. *campestris* pv. *campestris*. Implement a three-year rotation to non-brassica crops. Seed beds should be geographically isolated from commercial brassica crops. Do not mow or clip transplants. Plant crops in well-drained soils and use irrigation practices that minimise leaf wetness. Keep fields free of cruciferous weeds. Disinfect seed beds and equipment with steam or germicidal sprays before use. Control insects to help minimise spread of the pathogen.

Black rot symptoms on cabbage.

Black rot on a leaf of broccoli.

Black rot symptoms on a brassica leaf.

Black rot symptoms in a field of cabbage.

Typical black rot symptoms on brassica leaves.

Causal Agent

Streptomyces scabies

Distribution

Worldwide

Symptoms

This disease is most commonly on radishes, but also infects turnips and swedes. As the root swells, small (1mm) white lesions develop on the root surface. A ridge of light-coloured tissue forms at the margin, while the centre of the lesion darkens, giving it a crater-like appearance. Secondary infections of lesions by other organisms may cause discolouration and softening of the root.

Conditions for Disease Development

The bacterium survives host-free for many years in alkaline to neutral soils. Dry soil and poorly fertilised soils favour disease development. Infection occurs when the air temperature reaches 27°C.

Control

Implement long crop rotations to non-hosts. Eradicate fleshy, rooted weeds, such as pigweed (Amaranthus sp.). Avoid the use of soil amendments that increase soil pH. Apply acid-producing fertilisers. Irrigate during periods of warm, dry weather to help reduce infection.

Scab on radishes.

Scab on radishes.

Causal Agent

Xanthomonas campestris pv. *armoraciae*

Distribution

Africa, Asia, Australia, Brazil, Japan, Ukraine and United States.

Symptoms

Cabbage, cauliflower, broccoli, radishes and turnips are susceptible to this disease. Symptoms first appear as depressed, translucent flecks on leaves. These flecks develop into circular or angular lesions up to 5mm across that are yellowish-white to brown or black in colour and are surrounded by translucent haloes. Centres of lesions often break down, giving the leaf a shot-hole appearance. Symptoms are generally restricted to the tissue between the veins, although, dark streaks are often present along the veins. Lesions on leaf margins often result in tipburn-like symptoms, which later give a tattered appearance to the leaf.

Conditions for Disease Development

The organism can be soil or seed-borne. Infected plant debris is also a source of inoculum. The organism invades via stomata and requires long periods of free moisture on the leaf surface to infect. Prolonged periods of dew formation, or rain, favour disease development. The disease often appears during the cooler temperatures of fall or winter, although, the organism will infect and cause symptoms over a wide range of temperatures.

Control

Use seed-free of *Xanthomonas campestris* pv. *armoraciae*. Plant crops in well-drained soils and use irrigation practices that minimise leaf wetness. Rotate to a non-host crop for at least three years following a brassica crop.

Xanthomonas leaf spot on a brassica species.

Xanthomonas leaf spot on a cabbage leaf.

Xanthomonas leaf spot on a leaf of cabbage.

Xanthomonas leaf spot on a head of cabbage.

FUNGAL DISEASES

ALTERNARIA DISEASES

BLACK LEG

BLACK ROOT

BOTTOM ROT

CERCOSPORA LEAF SPOT

CLUBROOT

DAMPING-OFF AND WIRESTEM

POWDERY MILDEW

RING SPOT

SCLEROTINIA STALK ROT AND WATERY SOFT ROT

VERTICILLIUM WILT

WHITE LEAF SPOT

WHITE RUST

YELLOWS

Causal Agent

Alternaria alternata, A. brassicae, A. brassicicola, A. japonica, A. raphani

Distribution

Worldwide

Symptoms

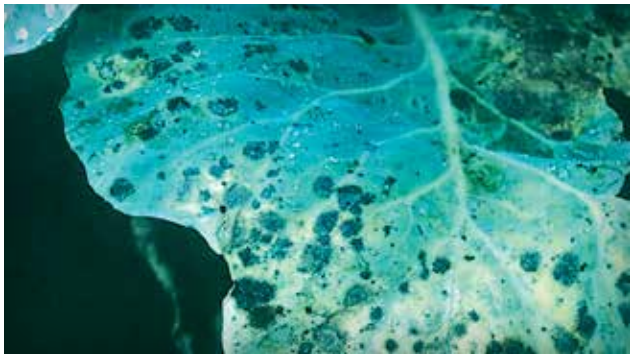
These *Alternaria* species cause leaf spots that appear on older tissue and often begin as small, circular lesions. These lesions expand and develop concentric rings with chlorotic haloes. Lesion centres may break apart, giving a shothole appearance to the leaf or, if conditions are favourable, become covered with a sooty black mass of spores. These fungi may also infect seedlings with symptoms appearing as black streaks on cotyledons and hypocotyls, which may result in damping-off. *Alternaria* spp. may also infect the base of cabbage heads and cause browning of cauliflower and broccoli heads, rendering the heads unmarketable. Flower clusters may also become infected during seed production, affecting seed quality.

Conditions for Disease Development

Brassica crop residues are commonly the primary source of inoculum. Cruciferous weeds may also harbor these fungi. *Alternaria* species may be seedborne. Conidia of *Alternaria* spp. are disseminated by wind and water. Disease development is favoured by free moisture on plant surfaces and temperatures between 20-27°C.

Control

Use high-quality seed free of these three *Alternaria* species. Incorporate brassica residues, practice crop rotation and apply foliar fungicides to help manage this disease.



Black fungal growth on cabbage leaf.

Target spot with concentric rings, a yellow halo, and a necrotic centre on leaf.

Alternaria spots on Brussels sprouts.

Black speck on cauliflower curd.

Causal Agent

Leptosphaeria maculans (anamorph: *Plenodomus lingam;* syn: *Phoma lingam)*

Distribution

Worldwide

Symptoms

Symptoms manifest as oval, sunken, light-brown cankers with purple-to-black margins near the base of stems. Cankers enlarge and girdle stems, causing plant collapse. Lesions may also develop on cotyledons and hypocotyls of young seedlings and appear on leaves as pale, irregular spots. Leaf spots gradually enlarge, becoming circular with grey centres. Under favourable conditions, small black fruiting structures (pycnidia) develop in stem cankers and leaf spots. Severely infected plants are stunted and often wilt. The leaves remain attached and the plant turns a dull blue-red colour. The root system may be destroyed, although new roots may form above the stem cankers, allowing the plant to remain alive. When infected cabbage heads are stored, the infection can spread to the base of leaves where brown to black spots develop. On root crops, a dark, dry rot can occur in storage.

Conditions for Disease Development

The fungus can survive in crop debris and cruciferous weeds. Infected seed, however, may also be a source of primary inoculum. In seed beds, infected seedlings generally develop symptoms in two to three weeks. Irrigation water can spread the spores of the fungus to surrounding healthy seedlings. Secondary infection may also occur when the young plants are dipped in water prior to transplant. The disease may also spread by splashing rain, workers and equipment.

Control

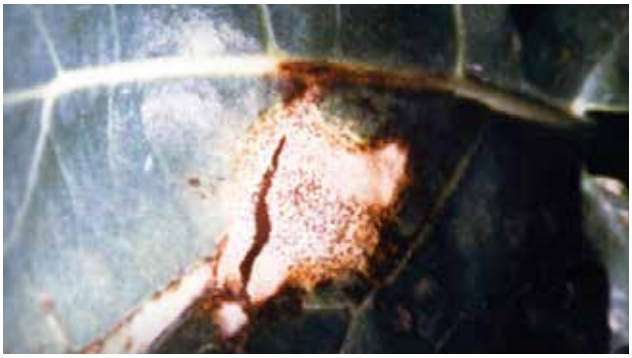
Use *Leptosphaeria maculans*-free seed. Eradicate cruciferous weeds, remove or deep plow plant debris and practice a three-to-four year rotation to non-host. Fumigate, solarise or flood infested fields to help reduce field inoculum levels.

Stunted and wilted plants.

Plants showing wilting symptoms.

Fungi infecting the seedling, resulting in damping-off.

Plant tissue showing pycnidial fruiting bodies.



Black leg symptoms on leaves.

Causal Agent

Aphanomyces raphani

Distribution

Worldwide

Symptoms

Root lesions develop where secondary roots emerge from the tap root. These bluish-grey to black lesions girdle the root, but infected tissue remains firm. Icicle-types of radishes may be severely affected by this disease, with yield losses approaching 100 percent. If infection occurs beneath the salable portion of a globe-type of radish, a crop may be harvested with minimal loss.

Conditions for Disease Development

Aphanomyces raphani can survive for more than one year as oospores in crop residues and soil. The fungus is generally not seedborne, but may be carried in debris associated with seed. Abundant soil moisture is required for zoospores to swim to and infect host tissues. Warm temperatures [20-27°C] favour infection and subsequent disease development.

Control

Use high-quality seed free from crop residues. Implement good field sanitation practices, manage irrigation water, practice three-to-four year crop rotations to non-host and apply chemical soil treatments to help manage black root.

Deformed matured root and black both inside and outside.

Black root *(Aphanomyces raphani) of radish (Raphanus raphanistrum subsp. sativus).* (Courtesy R. Rowe—© APS. Reproduced, with permission, from The Randall Rowe Legacy Image Collection.)

Radish root showing symptoms of black-root disease.

Causal Agent

Rhizoctonia solani

Distribution

Worldwide

Symptoms

Infection generally occurs in cabbage after head formation as the fungus enters leaves and stems that are in contact with infested soil. Symptoms first appear as tan-to-brown, well defined lesions. *Rhizoctonia solani* then invades the centre of the head, with complete rot often occurring within 10 days. Leaves may wilt and senesce after the head is colonised.

Conditions for Disease Development

Disease development is favoured by damp to wet soil, wet foliage and temperatures ranging from 20-28°C.

Control

Maintain plant health and provide adequate fertiliser. Avoid excessive soil moisture, and plant on raised beds to help ensure adequate drainage. Rotate to a non-host crop to help manage this disease.

Bottom rot on cabbage.

Casual Agent

Choanephora cucurbitarum

Distribution

Generally tropical and subtropical regions

Symptoms

Leaf spots vary in colour from pale green to white and are bordered by brown tissue and general chlorosis. Lesion may be circular or angular in appearance. Severely affected plants may defoliate.

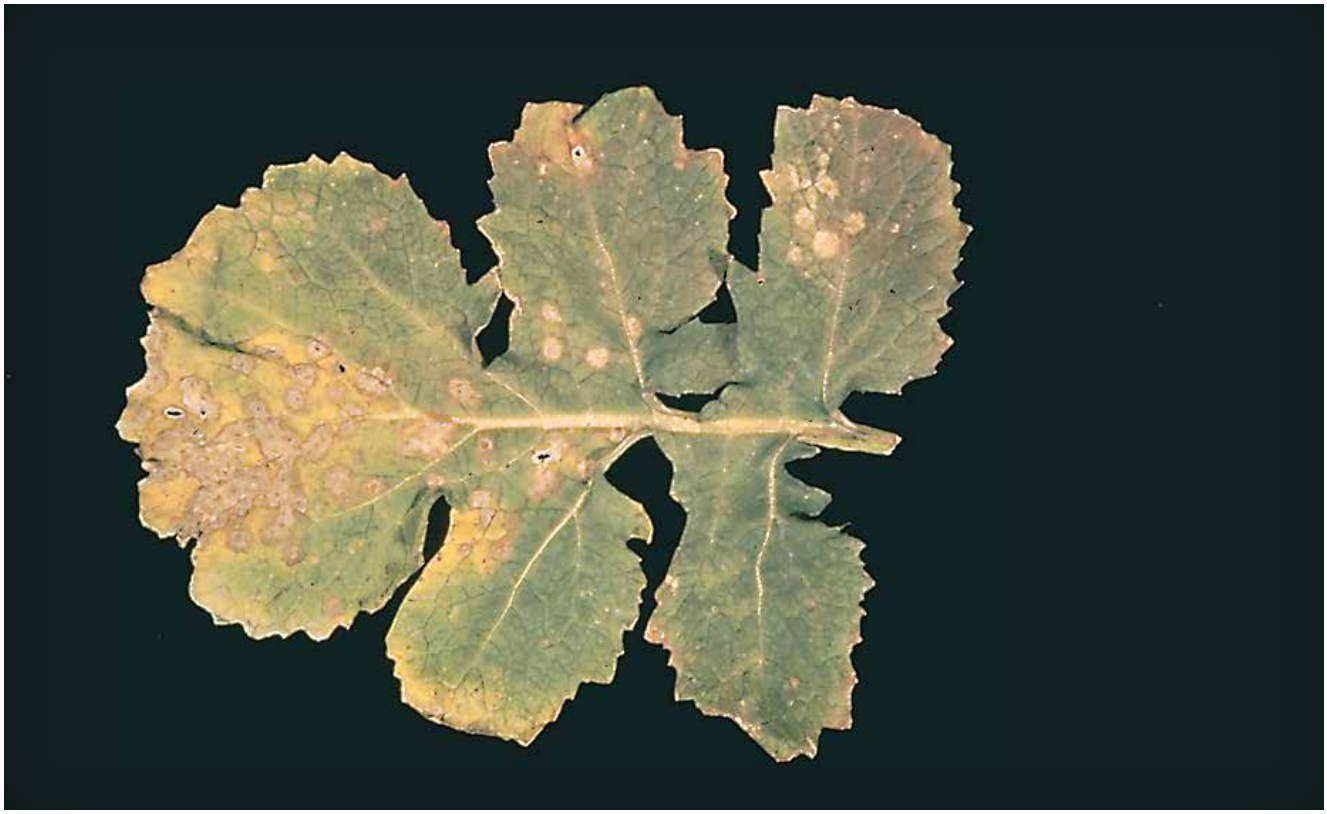
Conditions for Disease Development

The fungus can be seedborne, but more commonly survives in volunteer plants and weeds. Spores are spread by wind, rain and irrigation water, or mechanically by equipment and people. High relative humidity and temperatures between 13-18°C generally encourage disease development.

Control

Eradicate cruciferous weeds and volunteers. Apply fungicides early and often to help manage disease.

18 / CERCOSPORA LEAF SPOT



Circular or angular lesions bordered by brown tissue and general chlorosis.

Causal Agent

Plasmodiophora brassicae (Many races have been identified)

Distribution

Worldwide

Symptoms

This soilborne protist pathogen infects nearly all cultivated brassica vegetables. Many races of *Plasmodiophora brassicae* have been identified. The disease can be difficult to detect as affected plants wilt on hot days but may recover after sundown. *Plasmodiophora brassicae* enters through root hairs, and root cells stimulated by the pathogen multiply rapidly in size and number, forming club-like galls on roots. Deformed roots no longer function normally and are susceptible to rot by secondary soilborne organisms. Young plants affected by this disease often die. Older plants grow to maturity, but are unable to produce a marketable product.

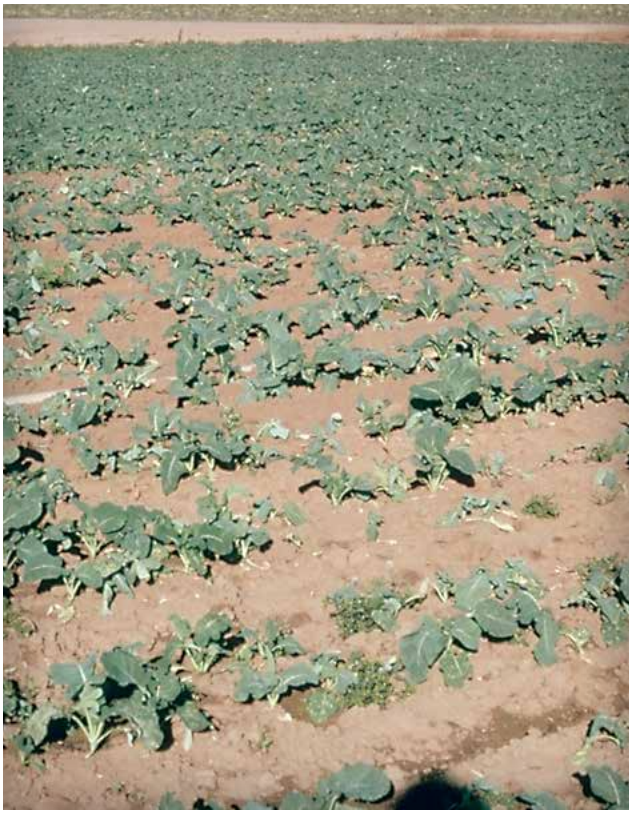
Conditions for Disease Development

Infected roots serve as the major source of inoculum and release zoospores, which infect root tissue. Zoospore-contaminated irrigation water, equipment and people may spread this disease. Propagation of the pathogen may occur if asymptomatic, infected seedlings are transplanted into clean fields. Acidic soils and temperatures ranging from 12-27°C allow for rapid disease development.

Control

Eradicate cruciferous weeds and volunteers. Cultivate to promote breakdown of crop residues. Implement five-to-seven year crop rotations to non-hosts, lime soil to a pH of 7.3 or greater, and fumigate soil or sow into *Plasmodiophora brassicae*-free soil medium.

Plants showing stunting with deformed roots.



Stunting of plants.

Close-up photo of clubs on root system.

Close-up photo of clubs on root system.

Casual Agent

Fusarium spp., *Rhizoctonia solani*

Distribution

Worldwide

Symptoms

Pre-emergence damping-off is generally caused by the invasion of the host by the fungus prior to plant emergence from soil. This is due to conditions that inhibit or slow seed germination, while allowing the pathogen to grow. Post-emergence damping-off occurs on young seedlings at or near the soil line. The host tissue appears water-soaked and constricted, eventually leading to seedling collapse. Damping-off becomes less of a problem as the host plants mature. A hypocotyl or stem infection of older plants by *Rhizoctonia solani* may produce a canker. Infected stems may be somewhat smaller in diameter than normal, but tough and wiry; hence, the name "wirestem." This disease is most problematic on slow-growing and deep-seeded plants.

Conditions for Disease Development

These fungi may be present in the soil for a long time, but will not generally affect plants until the right environmental conditions, such as wet soils and cool temperatures, are met. Disease damage is generally greater in soil with infected, non-decomposed plant debris.

Control

Fumigate, manage irrigation water and rotate to non-hosts to help reduce inoculum levels. Sow fungicide-treated seed to help manage these pathogens.

Post emergent damping-off near the soil line.

Constriction of hypocotyl with water-soaked.

Dark lesions on the lower stem, girdling or thin, dark tap roots.

Stand loss in cabbage caused by severe wirestem.

Casual Agent

Erysiphe cruciferarum

Distribution

Worldwide

Symptoms

Symptoms begin as star-shaped, white lesions on the upper surface of the foliage. Lesions gradually coalesce, and leaf surfaces appear dusted with white powder. Infection on cabbage or cauliflower can reduce head or curd size. On Brussels sprouts, the disease moves onto the stems where sporulation is accompanied by a purplish discolouration of host tissues. Sprout buds may be heavily infected, resulting in an unmarketable product.

Conditions for Disease Development

This obligate pathogen overwinters as cleistothecia on dead host tissue or as mycelium in living tissue. Weed species serve as alternate hosts in the off-season and commonly serves as an inoculum source for subsequent disease cycles. Disease development is generally favoured by dew and moderate temperatures [15-20°C] and conidia are easily spread by wind or by harvesting the crop. Water stress within the host also favours infection.

Control

Apply preventive fungicidal sprays and eradicate cruciferous weeds and volunteers to help manage this disease. Plant resistant varieties if available. Avoid drought stressed growing conditions and continuous cropping of susceptible brassica vegetables. Practice crop rotation with non-susceptible crops.

Star-shaped, white diffused colonies of superficial white mycelium on the surface of the leaf.

White mycelium on the leaf surface.

Casual Agent

Mycosphaerella brassicicola
(anamorph: *Astromella brassicae)*

Distribution

Worldwide in cool, moist climates

Symptoms

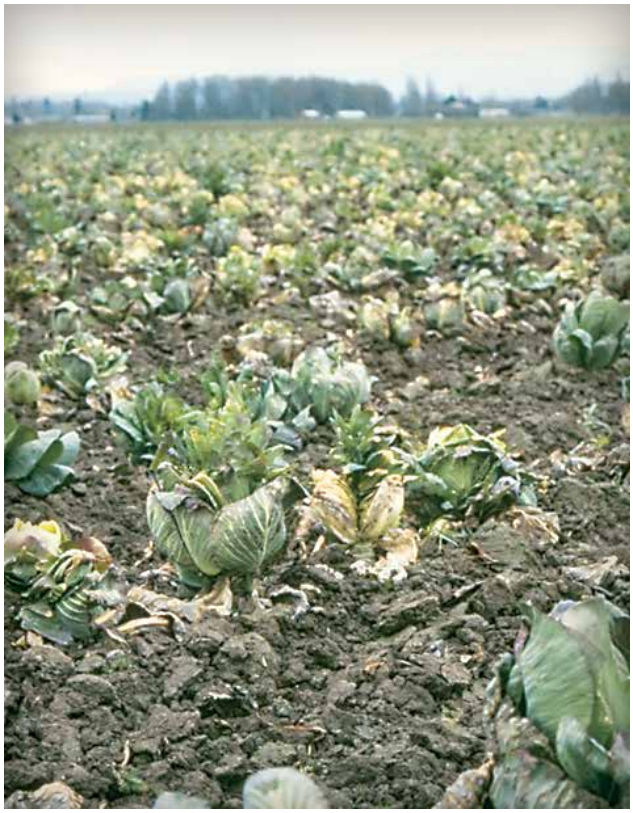
Lesions manifest as water-soaked areas surrounded by chlorotic haloes, which are visible on both leaf surfaces and stems. On leaves, lesions can expand in size to 2.5cm in diameter. Fruiting bodies often form concentric rings within lesions. Lesions may coalesce, giving leaves a yellow, tattered appearance. On stems, lesions are often rectangular to oval. The disease may also cause a storage rot of cabbage, leaving it shriveled and leathery.

Conditions for Disease Development

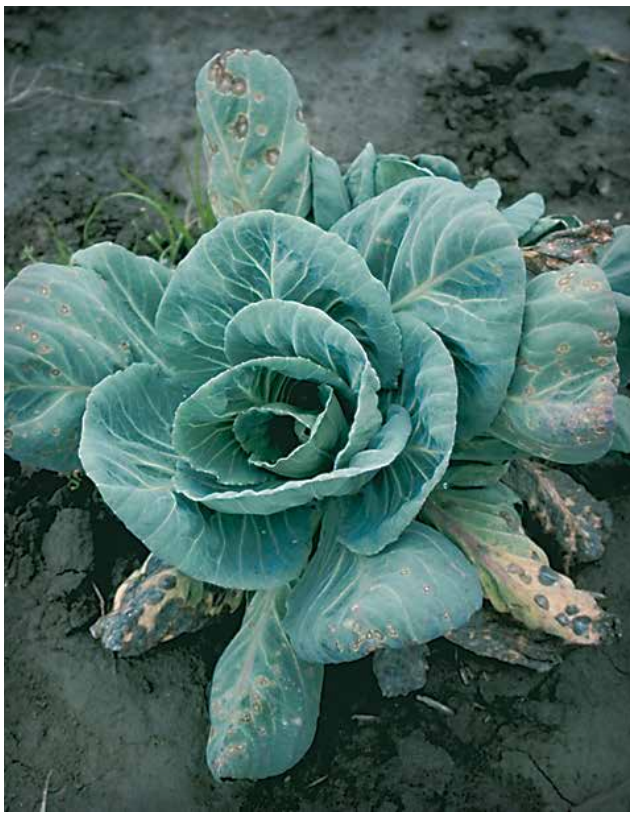
Infected debris serves as the primary inoculum source. The fungal spores (ascospores) are spread by wind, and infection occurs through the stomata. Cool [15-21°C], moist weather generally favours disease development.

Control

Remove and destroy crop refuse. Locate seed beds away from existing brassica crops. Apply preventive fungicide sprays to help manage this disease.



Severe infestation of ring spot on brassica crop.



Ring spot symptoms on cabbage plant.

Individual lesions have dark concentric rings, from black fruiting body, with definite edge surrounded by a yellow halo.

Causal Agent

Sclerotinia sclerotiorum

Distribution

Worldwide, except in the warmest areas of the tropics

Symptoms

In moist weather, stem infections spread rapidly downward to decay the roots and expand upward wilting leaves, resulting in plant collapse. A white, cottony growth and black, seed-sized sclerotia may be visible on or embedded in the affected tissues. When dry weather follows infection, brown cankers form on stems without progressing further. This disease may also cause losses during storage and transportation.

Conditions for Disease Development

Sclerotia of this fungus are long-lived, allowing it to persist in soil for many years. Disease development is generally favoured by abundant soil moisture and temperatures ranging from 10-25°C. Sclerotia that come in contact with the stem or foliage may directly infect host tissue. However, the ascospores of Sclerotinia sclerotiorum require a supply of nutrients to infect. Pollen and flower parts from the host crop or adjacent weeds, such as common ragweed *(Ambrosia artemisiifolia)*, serve as a nutrient source and permit the fungus to develop specialised structures which then penetrate the brassica host. Brassica vegetables, especially cabbage, that come in contact with colonised plant tissue may then become infected.

Control

Implement good sanitation practices and long rotations to non-host crops. Cultivate to help promote good soil drainage. Flood fields for a long period of time during warm weather to destroy sclerotia. Manage weeds and apply fungicide sprays to help manage this disease.

A white, cottony grown and black, seed-sized sclerotia is visible in the affected tissue.

A white, cottony grown and black, seed-sized sclerotia is visible in the affected tissue.

Watery soft rot on cauliflower curd.

Upword wilting leaves.

Casual Agent

Verticillium dahliae, V. albo-atrum

Distribution

Worldwide

Symptoms

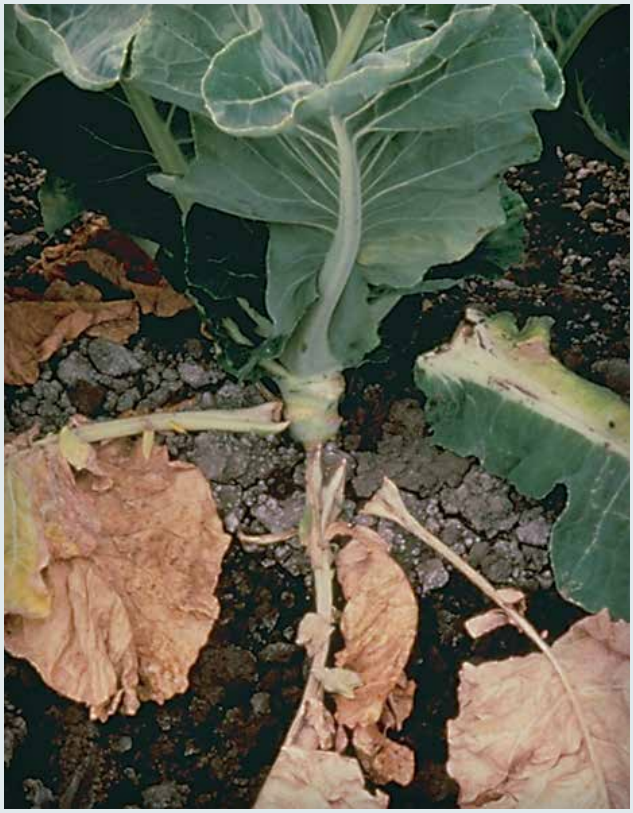
This disease is most commonly seen on cauliflower and Chinese cabbage. V-shaped lesions with yellow borders form along leaf margins of lower leaves. Vascular tissue develops a dark brown discolouration, which can extend from the roots into the stem. Symptoms may be easily confused with those of black rot.

Conditions for Disease Development

This fungus survives in soil, and continuous cropping can lead to the buildup of inoculum levels. Cool weather and moist soil generally favour disease development.

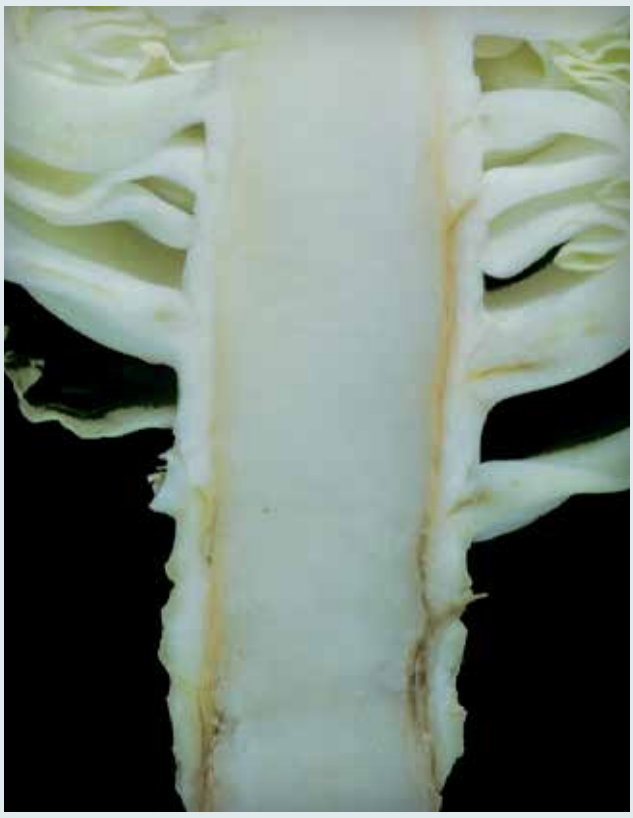
Control

Implement long rotations to non-susceptible crops or fumigate soil.



Verticillium wilt in cauliflower field.

Vascular discolouration on stem.



Vascular discolouration from the roots into the stem.

Casual Agent

Pseudocercosporella capsellae (teleomorph: *Mycosphaerella capsellae)*

Distribution

Worldwide

Symptoms

White leaf spot occurs on turnips, Chinese cabbage, Chinese mustard, cabbage and broccoli, and infrequently on cauliflower. Oval lesions with grey, brown or nearly white centres and dark margins form on cotyledons, leaves and petioles. When lesions are numerous, affected foliage may turn yellow and senesce.

Conditions for Disease Development

This fungus may be seed-borne and overwinters in volunteer plants or perennial weeds. The ascospores are spread by wind and rain. Disease development is generally favoured when air temperatures are cool [13-18°C] and moisture is abundant.

Control

Eradicate cruciferous weeds and volunteers. Cultivate to help promote good soil drainage, and implement crop rotation to non-host species.

Lesions are less regular shape, larger and darker with well defined margins.

White spot infecting a turnip leaf.

Casual Agent

Albugo candida (Many races have been identified)

Distribution

Worldwide

Symptoms

White rust affects every known brassica crop. However, this disease is most common on radishes, horseradish, mustard and turnips. Symptoms manifest as chlorotic or necrotic spots on upper leaf surfaces. Later pustules form on abaxial leaf surfaces, small stems and floral parts. Pustules rupture the host epidermis and expose a white, chalky dust of sporangia in small, zonate areas. Occasionally affected portions of leaves are swollen and distorted. On radishes, A. *candida* causes clubroot-like swellings on the roots. On flower stalks, distorted stems and flowers result in a staghead appearance.

Conditions for Disease Development

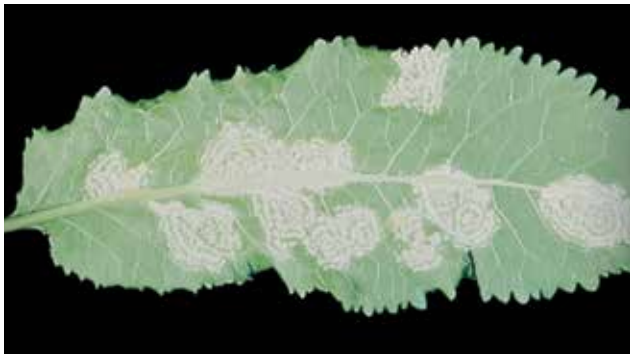
Oospores serve as primary inoculum for this disease and can survive for many years in soil or as a contaminant of seeds. Infection is generally favoured by cool [13-18°C], wet weather in the form of prolonged dews or fog. Sporangia are produced in the pustules and are spread by wind, rain or insects to neighbouring plants.

Control

Use *Albugo candida*-free seed. Incorporate crop debris and eradicate cruciferous weeds. Where practical, implement long rations to non-host species. Apply fungicides to help manage this disease.

White blisters on broccoli head.

Chlorotic or necrotic spots on upper leaf surface.



Pustules on bottom side of the leaf, with chalky dust of sporangia in small, zonate areas.

Infected plants showing twisted and deformed stem and leaves.

Casual Agent

Fusarium oxysporum f. sp. conglutinans (Two races have been identified), *F. oxysporum f. sp. raphani*

Distribution

Worldwide

Symptoms

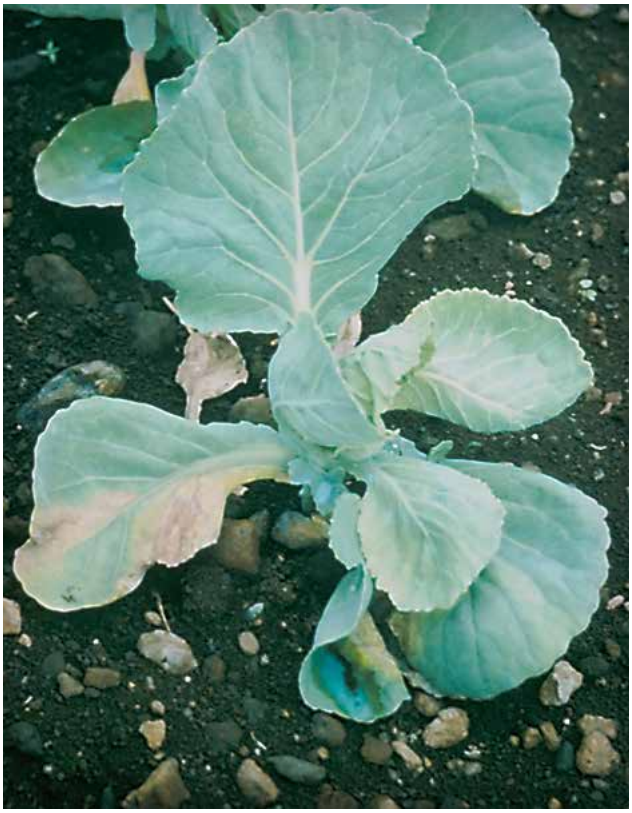
Affected foliage turns dull and chlorotic. Some leaves appear distorted due to uneven growth. Leaves may die prematurely and senesce, starting at the base of the plant. This pathogen invades the vascular system of host plants, turning the vascular tissue brown or yellow. Plants which do not die are often stunted and have one-sided yellowing of the leaves or stem.

Conditions for Disease Development

This fungus survives in the soil and produces spores which can persist in the soil for many years. The fungus enters the plant through the roots and moves into the vascular system. Host susceptibility and the environment affect disease development. The disease is generally favoured by warm temperatures. At temperatures below 20°C, disease development is greatly reduced.

Control

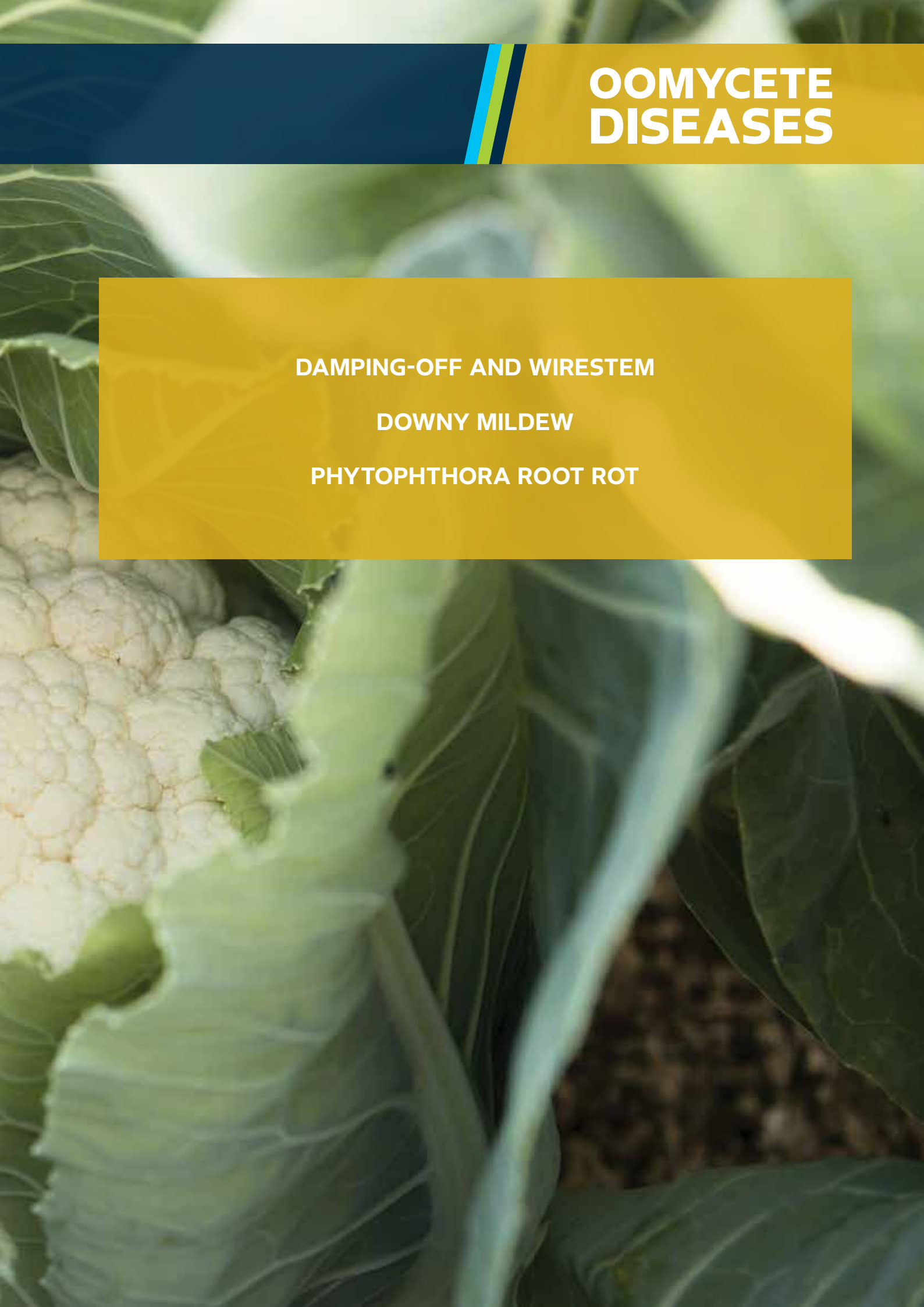
Resistant varieties help provide the most effective management of this disease.



Fusarium wilt infecting the cauliflower plant.

Fusarium wilt causing dropping of leaves from plant.

OOMYCETE DISEASES



DAMPING-OFF AND WIRESTEM

DOWNY MILDEW

PHYTOPHTHORA ROOT ROT

Causal Agent

Pythium spp.

Distribution

Worldwide

Symptoms

Pre-emergence damping-off is generally caused by the invasion of the host by the oomycete prior to plant emergence from soil. This is due to conditions that inhibit or slow seed germination, while allowing the pathogen to grow. Post-emergence damping-off occurs on young seedlings at or near the soil line, although, *Pythium* spp. may infect at the roots or root hairs. The host tissue appears water-soaked and constricted, eventually leading to seedling collapse. Damping-off becomes less of a problem as the host plants mature. Infected stems may be somewhat smaller in diameter than normal, but tough and wiry; hence, the name "wirestem." This disease is most problematic on slow-growing and deep-seeded plants.

Conditions for Disease Development

These oomycete may be present in the soil for a long time, but will not generally affect plants until the right environmental conditions, such as wet soils and cool temperatures, are met. Disease damage is generally greater in soil with infected, non-decomposed plant debris.

Control

Fumigate, manage irrigation water and rotate to non-hosts to help reduce inoculum levels. Sow fungicide-treated seed to help manage these pathogens.

Post-emergence damping-off.

Post-emergence infection leading to wirestem.

Symptoms of wirestem.

Growth reduction of mature plants.

Causal Agent

Hyaloperonospora brassicae (ex Peronospora/ Hyaloperonospora parasitica subsp. brassicae/2023)

Distribution

Worldwide

Symptoms

This disease manifests as yellow, purple or brown irregular-shaped areas on upper leaf surfaces, which correspond to white to grey, “downy” fungal spore masses on abaxial leaf surfaces. Defoliation, dwarfing or killing of young shoots, flowers and fruits. Under heavy disease pressure, sporangia develop on the upper leaf surfaces, as well, which may lead to seedling death. Early infections by this obligate pathogen may invade the vascular system, turning it black. Cauliflower curds, broccoli florets, radish roots and cabbage heads may all be unmarketable if infected. In cabbage, these spots expose the heads to soft rot. In cauliflower, curds look brownish at the top.

Conditions for Disease Development

Heavy fog, light rains, prolonged leaf wetness and night temperatures between 8-16°C, with day temperatures below 24°C, generally favour disease development.

Control

Eradicate cruciferous weeds and volunteers. Furrow or drip irrigate, and transplant at densities that promote good aeration and reduced humidity. Heat treatment of seeds for 20 minutes and treating them with fungicides is also effective. Apply fungicides early and often to help achieve adequate management. Avoid thick sowing and excessively moist conditions.

Downy mildew discolouration in stem and on curds.

Leaf symptoms of downy mildew.

Discolouration of cauliflower curd.

Sporangia on leaf surface.

Internal infection of downy mildew.

Causal Agent

Phytophthora megasperma

Distribution

Worldwide

Symptoms

All brassica crops and many cruciferous weeds are affected by this disease. Plants first develop symptoms as temperatures fall and soil moisture increases. Leaf margins discolour red to purple beginning at the leaf tips and progressing to the stem, resulting in leaf dieback. Stem lesions appear grey when compared to healthy tissue. Lateral roots are absent or entirely decayed. Tap roots are entirely decayed or show dark lesions along their entire length. Infected plants generally wilt and often die.

Conditions for Disease Development

This pathogen overwinters as oospores inside root tissue of diseased plants. Oospores give rise to zoospores, which are motile and infect roots of susceptible plants. Wet, poorly drained soils and temperatures between 13-25°C generally favour this disease.

Control

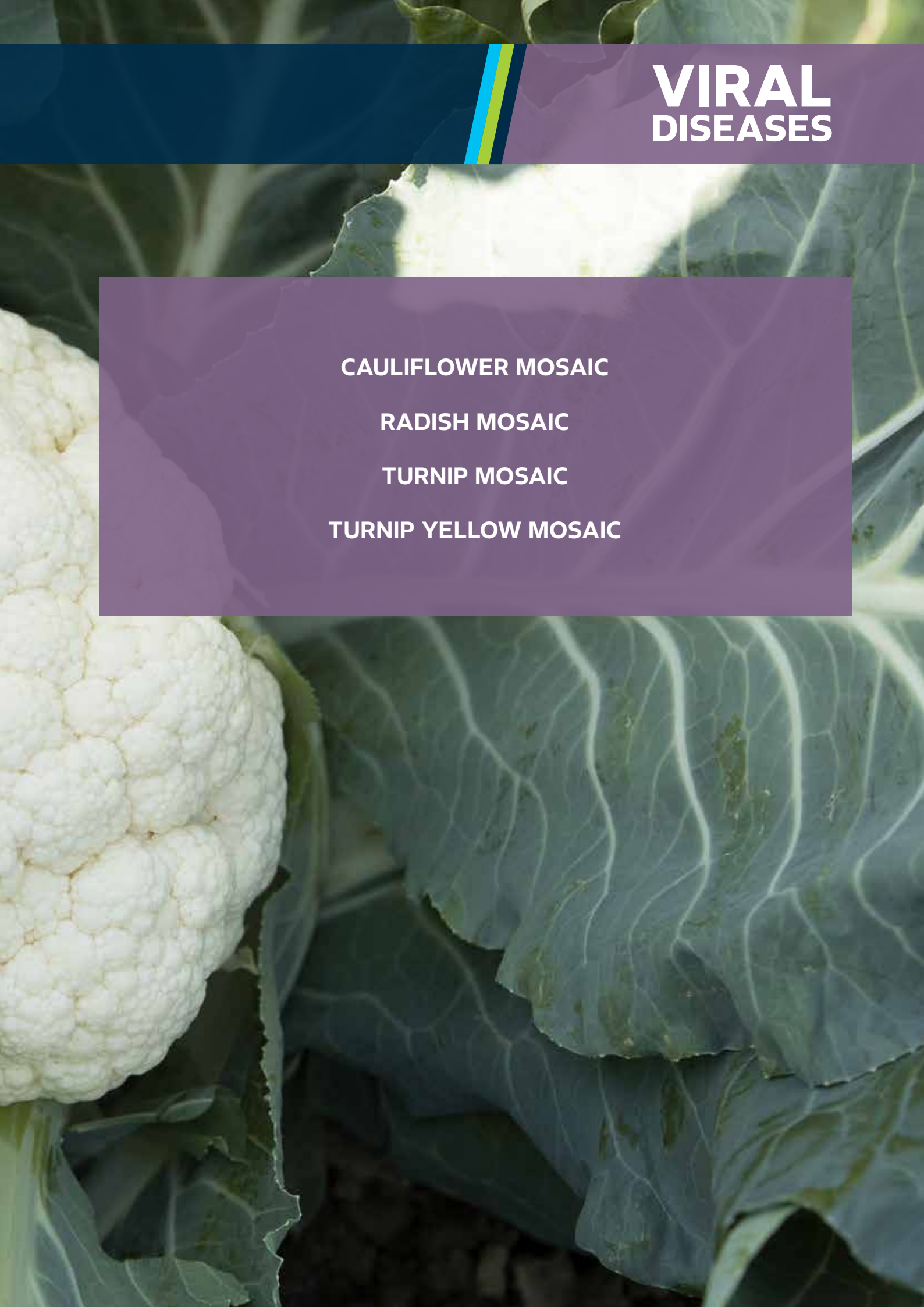
Cultivate to prevent compaction of soils and help promote good soil drainage. Avoid planting into a field with a history of Phytophthora root rot and implement three-year crop rotations to non-susceptible crops. Plant only on well-drained soil. Apply chemical soil treatments to help manage this disease.

Grey leaf spots as symptom of *Phytophthora megasperma*.

Severe wilting on Phythohthora infected fields.

Wilting of upper parts caused by Phytophthora root rot.

VIRAL DISEASES



CAULIFLOWER MOSAIC

RADISH MOSAIC

TURNIP MOSAIC

TURNIP YELLOW MOSAIC

Causal Agent

Cauliflower mosaic virus (CaMV)

Distribution

Worldwide

Symptoms

Only members of the brassica family are susceptible to CaMV. Systemic symptoms consist of a clearing or chlorosis along leaf veins (vein clearing). This is often seen first at the base of a leaf. Later, symptoms appear as dark green areas along veins (vein banding) and necrotic spotting of the leaf. Chinese cabbage is particularly susceptible to CaMV. In addition to vein clearing, a striking mosaic may develop with light and dark green areas on leaves leading to mosaic pattern. Plants can be stunted. Internal necrotic spotting in stored cabbage has been attributed to CaMV infection.

Conditions for Disease Development

The primary inoculum source of CaMV is infected brassica crops or cruciferous weeds. The virus is transmitted to the crop by many species of aphids, such as the cabbage aphid, the false cabbage aphid and the green peach aphid. Aphids can acquire and transmit the virus in a non-persistant, non-propogative manner within one minute of feeding on an infected plant. Temperatures between 16-20°C favour symptom expression in plants. CaMV is often found as a mixed infection with Turnip mosaic virus, resulting in more severe symptoms than when either virus is present alone.

Control

Use aphid control. Eradicate cruciferous weeds and volunteers, and incorporate (disk under) crop debris immediately after harvest. Isolate transplant beds from commercial brassica crops.

Cauliflower mosaic virus on a brassica leaf.

Cauliflower mosaic viruses causing distortion on a brassica plant.

Causal Agent

Radish mosaic virus (RaMV)

Distribution

Japan, Europe and the U.S. state of California

Symptoms

This virus infects almost all brassica vegetables. Symptoms include mosaic, ringspots, leaf distortion, veinal necrosis and systemic necrosis. Infected radish plants may show leaf enations. In cauliflower and cabbage, symptoms appear as chlorotic and necrotic lesions along with a mosaic.

Conditions for Disease Development

RaMV is transmitted by various beetles. The virus is present in both crop plants and weeds, which serve as reservoirs for spread of the disease.

Control

Control insect vectors to help manage this disease.

Radish mosaic virus on a brassica leaf.

Radish mosaic virus causing circular symptoms on a brassica leaf.

Distortion and mosaic caused by *Radish mosaic virus* on a brassica leaf.

Causal Agent

Turnip mosaic virus (TuMV)

Vectors

Worldwide, especially in temperate regions

Distribution

TICV: Asia, Europe, Middle East, North America, Tunisia
ToCV: Worldwide

Symptoms

Leaves of cabbage, cauliflower and broccoli infected by the cabbage black ringspot strain of TuMV have 2-5cm of circular, light green lesions, which can best be seen on the abaxial leaf surface. Later, these lesions turn necrotic and may coalesce, resulting in large necrotic areas, which lead to defoliation. In cabbage, the outer leaves may develop necrotic spots which can occur throughout the head. In Chinese cabbage, symptoms manifest as vein necrosis and necrotic spotting of head leaves, and are often on one side of the plant. In turnips, radishes and mustard, leaf distortion, blisters, mosaic and stunting are commonly seen symptoms with any strain of the virus.

Conditions for Disease Development

Turnip mosaic virus is generally transmitted mechanically and in a non-persistent manner by more than 80 species of aphid. Cruciferous weeds are hosts for both the virus and aphid vectors. Generally, virus symptoms are more severe at temperatures between 20-28°C. Simultaneous infections of TuMV and Cauliflower mosaic virus result in severe stunting and vein clearing in cool weather. During warm weather, mottling and stunting are more common.

Control

Implement an insecticide spray program to help control vectors. Eradicate cruciferous weeds and volunteers. Incorporate (disc under) plant residues immediately after harvest. Isolate transplant beds from brassica crop fields.

38 / TURNIP MOSAIC

Distortion caused by *Turnip mosaic virus* on a brassica plant.

Distortion and symptoms caused by *Turnip mosaic virus* on cabbage.

Turnip mosaic virus expressing symptoms on cabbage.

Causal Agent

Turnip yellow mosaic virus (TYMV)

Distribution

Western Europe

Symptoms

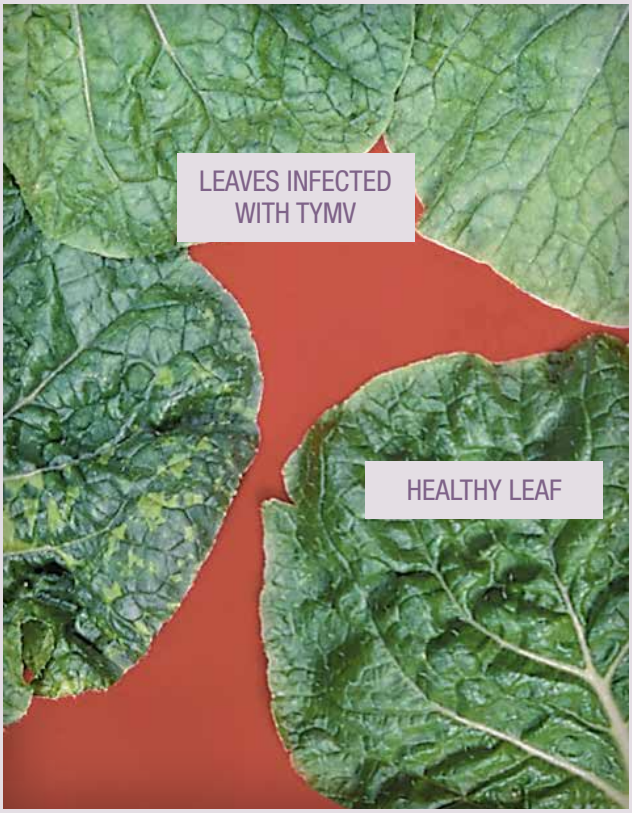
This virus only infects brassica vegetables. In cauliflower, symptoms begin as vein clearing, but subsequently develop into permanent yellow patches on older leaves. Symptoms on Chinese cabbage develop into bright yellow and dark green mosaic patterns. During cool weather, infected plants remain stunted. Symptoms are mild in other brassicas.

Conditions for Disease Development

This virus overwinters in cruciferous weeds.
Turnip yellow mosaic virus is generally transmitted by chewing insects such as flea beetles, mustard beetles, grasshoppers and earwigs. Temperatures near 25°C are optimal for symptom development.

Control

Use insecticides to help control insect populations. Eradicate cruciferous weeds and volunteers.



Leaves with and without *Turnip yellow mosaic virus*.

Plants infected with *Turnip yellow mosaic virus*.

An example of a leaf without *Turnip yellow mosaic virus*.

Comparison of brassica leaves with *Turnip yellow mosaic virus* and brassica leaves without the virus.

NEMATODE DISEASES

CABBAGE CYST

ROOT-KNOT

Casual Agents

Heterodera cruciferae (Cabbage Cyst Nematode), *H. schachtii* (Sugar Beet Cyst Nematode)

Distribution

Worldwide

Symptoms

Heterodera cruciferae only infects brassicas, while *H. schachtii* infects brassicas and sugar beets. Foliar symptoms are dependent on plant age, season and temperature. Generally, plants first appear small and nutrient deficient. As the disease progresses, leaves may wilt or curl, especially during hot weather. Invaded roots branch profusely, while the taproot remains small. Plants that survive produce loose, small heads and discoloured roots. Invasion of infected roots by fungi is common. A characteristic sign of this pathogen is the appearance of lemon-shaped cysts on the root surface, which are white, tan or reddish in colour. Plants often die prematurely.

Conditions for Disease Development

These nematodes overwinter as cysts and hatch soon after transplant, releasing juveniles that penetrate host root tissues. Loamy soils favour disease development, and irrigation water or rainfall allows these nematodes to swim or float to susceptible roots. The nematodes are also spread through contaminated soil, infected seedlings, tools and machinery.

Control

Sow resistant varieties and rotate to non-hosts for a period of three to five years in order to help reduce nematode populations. Fumigate soil, apply nematicides, incorporate crop residues immediately after harvest, and eradicate weeds and volunteers to help manage this disease.

Growth reduction due to nematode infection.

Nematode eggmasses (cysts).

Casual Agents

Meloidogyne spp.

Distribution

Worldwide

Symptoms

Root-knot nematodes on brassicas induce root branching and galling above the point of infection. When diseased plants are pulled-up, irregular swellings of the roots, referred to as galls or knots, are easily observed. Galls can act as a port of entry for fungal soil diseases.

Above ground symptoms include stunting, chlorosis and wilting. Though infected plants may survive a growing season, the resulting crop is generally small and may be unmarketable.

Symptoms looks similar to those of clubroot, but clubroot-affected plants produce larger, more continuous swellings on the older portion of their roots.

Conditions for Disease Development

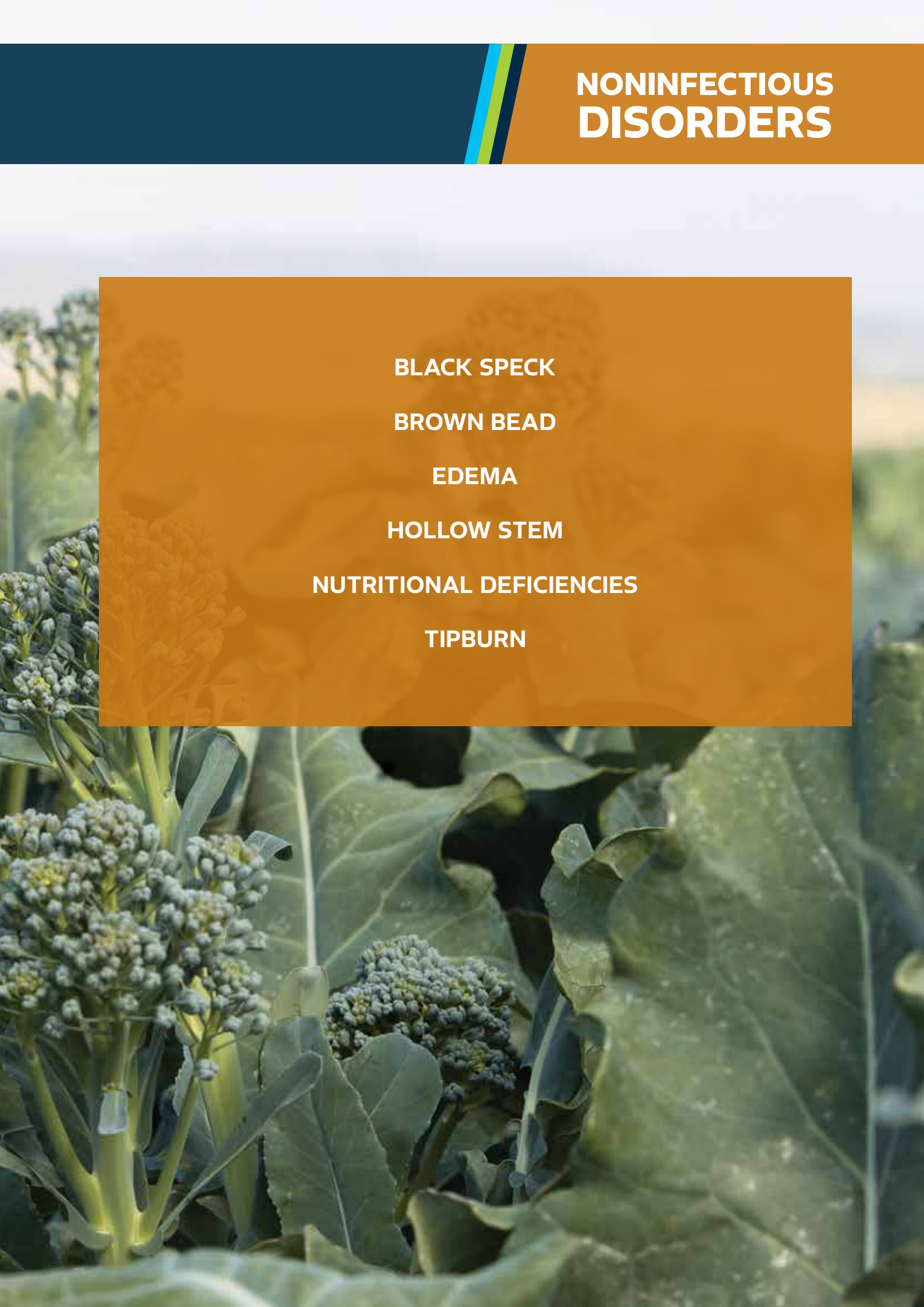
These nematodes survive in infected root debris. Juveniles are attracted to root exudates of host plants and feed on root tissue. The most severe damage can occur in sandy soil with moderate moisture, but these nematodes are not limited to these conditions. Infection can occur at temperatures ranging from 10-35°C. Freezing temperatures kill all life-cycle stages of Meloidogyne species.

Control

Soil fumigation, flooding or fallow farming to help manage populations of root knot nematodes.

Galling due to infection with root-knot nematodes.

NONINFECTIOUS DISORDERS



BLACK SPECK

BROWN BEAD

EDEMA

HOLLOW STEM

NUTRITIONAL DEFICIENCIES

TIPBURN

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

Black speck is a non-parasitic disorder of mature cabbage and Chinese cabbage. Lesions are discrete, dark brown or black, and up to 2mm in diameter. Lesion margins are short and often have a narrow, yellow halo. Larger lesions of up to 1cm in diameter may also occur. Lesions may coalesce, resulting in large, dead areas of leaf tissue. Minute specks occur on heart leaves. Symptoms may not occur until cabbage is stored at cool temperatures.

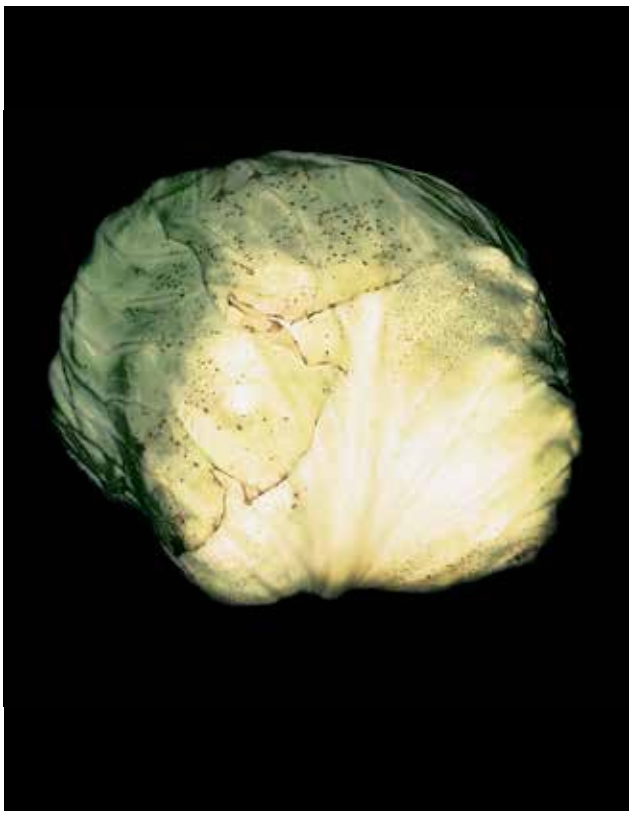
Conditions for Disease Development

This disorder appears to be more severe on tender, lush crops and on crops grown during warm weather. Cool conditions during storage favour development of this disorder. Alternating temperatures and conditions that promote vigorous growth increase sensitivity during storage.

Control

Not known.

Internal symptoms of Black speck.



Internal symptoms of Black speck.

Necrotic spots on internal tissue.

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

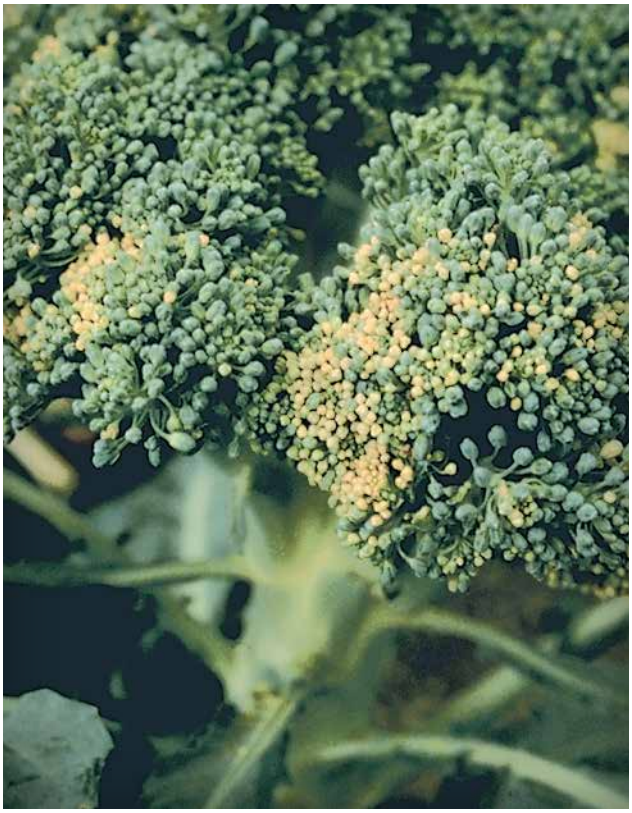
This disorder is most commonly seen when broccoli heads reach maturity. Sepals of individual buds turn from green to yellow to brown. As the necrotic buds die, they often dry up and senesce. This opens an avenue for soft rotting bacteria (Pectobacterium spp. and Pseudomonas spp.) to enter the host and cause further damage.

Conditions for Disease Development

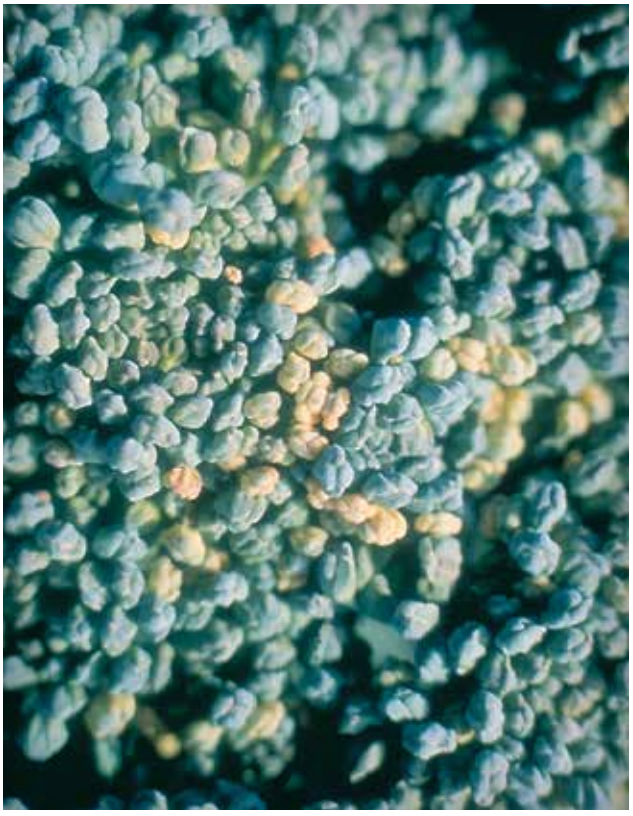
Brown bead is often seen when a period of high soil moisture is followed by a period of high temperatures and rapid plant growth, especially at the time of bud development. Widely varying relative humidities play a role in the expression of brown bead. Lack of boron may also be a contributing factor to this disorder.

Control

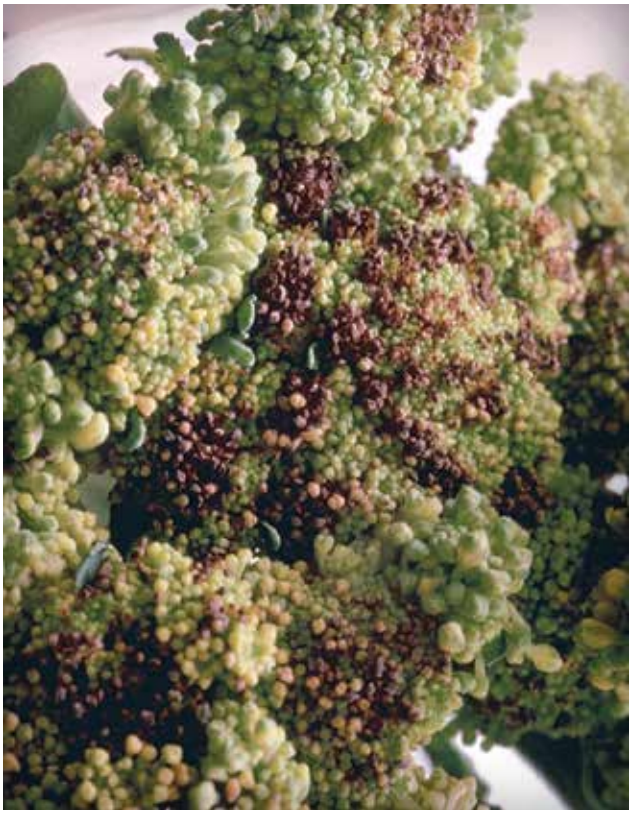
Not known.



Yellowing of sepals on individual buds.



Yellowing sepals.



Necrotic sepals.

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

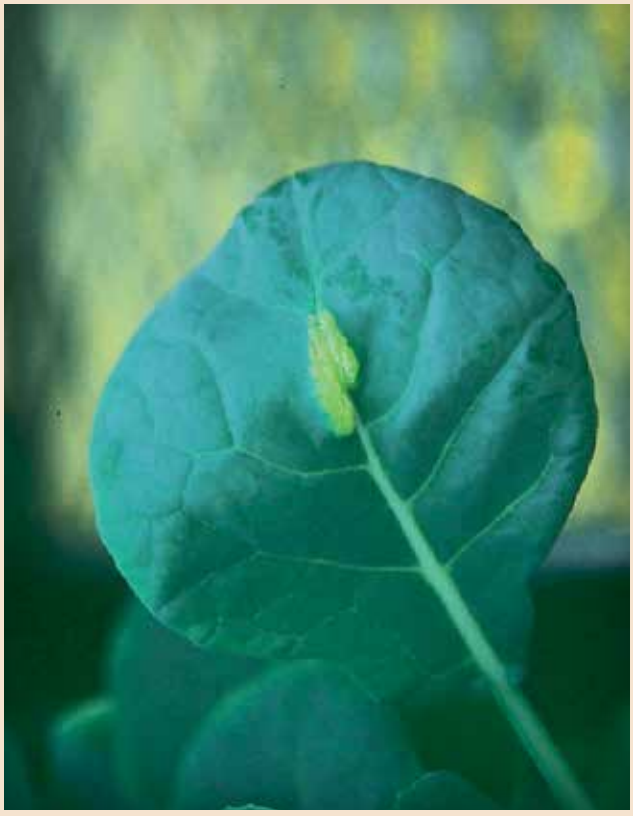
Symptoms may develop on any part of the plant, but are most common on the undersurface of leaves. Small, wart-like bumps form that may coalesce into ridges. Epidermal cells of the wart-like areas may rupture. Leaf blotching may also occur.

Conditions for Disease Development

The disorder generally occurs when the soil is warm and wet, and the air temperature is cool. For example, this may occur on a cool night after several warm, humid days. Prolonged periods of high humidity favour edema.

Control

For greenhouse crops, place heating pipes away from soil beds and close ventilators at night. Manage irrigation to help ensure proper soil moisture.



Leaf damage due to Edema.

Blotching of outer leaves.

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

Hollow stem occurs in cauliflower, broccoli and cabbage. The thick, fleshy centre of the stem core splits due to an uneven growth rate and an elongated cavity forms. The cavity may extend to either end of the plant to produce an opening to the outside environment. When this occurs, infections by fungi and bacteria are common.

Conditions for Disease Development

Irregular or sudden rapid growth, high temperatures, high nitrogen levels and low plant populations favour development of hollow stem. A boron-deficient growing condition may also encourage this disorder.

Control

Avoid excessive soil fertility. Increase planting density for broccoli to help decrease plant growth rates and reduce the incidence of hollow stem.

Hollow stem in broccoli.

Misshaped curds in cauliflower.

Hollow stem in broccoli.

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

The most common nutrient deficiencies in brassicas are:

Molybdenum: Causes whiptail and blindness (no apical growing point) of broccoli and cauliflower. Leaves are extremely malformed, being narrow with curled, ruffled edges. Curd development is poor.

Boron: Symptoms occur as cabbage and cauliflower approach maturity. The pith becomes cracked and brown. In cauliflower, the curd may become brown. Radish roots become distorted and an internal brown discolouration occurs. Scabby surface cankers may appear on radishes.

Magnesium: Chlorosis occurs on interveinal areas of lower leaves. Necrotic spots may occur in the chlorotic tissue. Growth is reduced.

Conditions for Disease Development

Acid or alkaline soils may lead to nutrient deficiencies due to the immobilisation of nutrients. Some soils are naturally low in specific nutrients. The excessive, or unbalanced, use of fertiliser may also cause some nutrients to become unavailable to the plants.

Control

Use a balanced fertiliser program appropriate to the soil and the crop. Alter soil pH or apply foliar fertilisers to help manage some deficiencies

Molybdenum deficiency.

Boron deficiency.

Magnesium deficiency.

Causal Agent

Physiological disorder

Distribution

Worldwide

Symptoms

Symptoms manifest as brown to black necrotic tissue at leaf tips. Leaves surrounding the growing point are particularly susceptible to this disorder. Tipburn is readily seen when exposed plant structures, such as leaves and curds, are affected. However, damage to the heads of Brussels sprouts, cabbage and Chinese cabbage may go undetected until they are cut open. In severe cases of tipburn, the head is soft and the plant is dwarfed.

Conditions for Disease Development

Tipburn is related to calcium deficiency in developing tissues. Fast growth and high relative humidity favour symptom development. Developing leaves, which are already low in calcium, are severely stressed for calcium during times of rapid growth. Transpiration and translocation are slowed when relative humidity is high, thus calcium transport is inhibited.

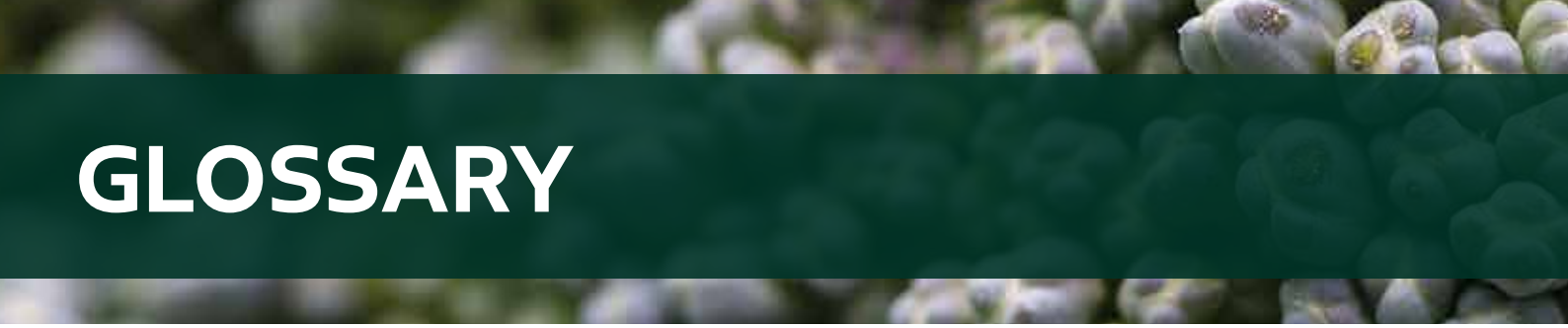
Control

Grow tolerant varieties. Avoid excessive fertilisation, and increase available calcium in the soil through soil amendments. Apply foliar nutrient solutions of calcium salts. Manage irrigation to help regulate plant growth.

Necrotic spot due to calcium deficiency.

Internal symptoms of calcium deficiency.

Tipburn in brassica leaves.



GLOSSARY

ABAXIAL Directed away from the axis or stem; the lower leaf surface.

ANAMORPH The asexual form in the life cycle of a fungus. Asexual spores (conidia) are usually produced.

ASCOSPORE Sexually derived fungal spore within a sack-like structure (ascus).

BACTERIUM (pl. bacteria) A microscopic, single-celled organism.

BLIGHT Sudden and severe necrosis of the above-ground portions of a plant.

CANKER Localised, necrotic areas on roots or stems. Tissue may be sunken and/or cracked.

CAUSAL AGENT The organism or agent (bacterium, fungus, nematode, virus, etc.) that incites a given disease.

CHLOROSIS (adj. chlorotic) The failure of chlorophyll development caused by disease or a nutritional disorder; the fading of green plant colour to light green, yellow or white.

COALESCE Merging of individual lesions.

CONCENTRIC More than one circle in a lesion with a common centre.

CONIDIUM (pl. conidia) An asexually-formed fungal spore.

COTYLEDON The first foliar structure to emerge from a seed.

CRUCIFER A member of the plant family brassicae that includes broccoli, Brussels sprouts, cabbage, cauliflower, kohlrabi, radishes, swedes and turnips.

CYST In fungi, the resting structure formed by a zoospore. In nematodes, the egg-containing carcass or oxidized cuticle of a dead adult female of the genera globodera and heterodera.

DAMPING-OFF A rotting of seedlings at or below soil level.

DEBRIS Remnant plant material.

DEFOLIATION The loss of leaves.

DISTAL Located far from the point of attachment.

EDEMA A watery swelling of plant organs or parts; often caused by overwatering in cloudy, humid weather when evaporation (transpiration) is reduced.

ENATION A tissue malformation often appearing as a ridge or a leaf-like growth and originating along leaf veins.

EPIDERMIS The outer layer of cells occurring on plants

FORMA SPECIALIS (f. sp.) Special form; a biotype (or group of biotypes) of a species of pathogen that differs from others in the ability to infect selected genera or species of infected plants.

FUMIGATION Sterilisation by chemical volaltilisation.

FUNGICIDE A chemical used to control fungi.

FUNGUS (PL. FUNGI) A microscopic organism with thread-like cells which grows on living and/or dead plants.

GALL Swelling of roots, stems or leaves caused by abnormal growth of tissue.

GIRDLE The encircling of a root or stem by a pathogen that results in disruption of the phloem.

HERBICIDE Chemical substance used to control weeds.

HIGH RESISTANCE (HR) The ability of a plant variety to restrict the growth and/or development of the specified pest, and/or the symptoms and/or damage it causes, to a high degree. HR varieties may still exhibit minor symptoms or damage under heavy pest pressure and should not be confused with immune plants that are defined as unable to support any pest growth and development.

HOST A plant from which a parasite obtains nutrition.

HYDATHODE A leaf structure that eliminates unused salts, sugars and water from a plant through a pore at the leaf margin.

HYPOCOTYL The lower stem of a plant between the cotyledons and the roots.

INFECTION The process in which an organism attacks a plant.

INFESTED Containing a great number of insects, mites, nematodes, etc., as applied to an area or field. Also applied to a plant surface or soil contaminated with bacteria, fungi, etc.

INOCULUM A pathogen or its parts that can cause disease.

INSECTICIDE A substance used to control insects.

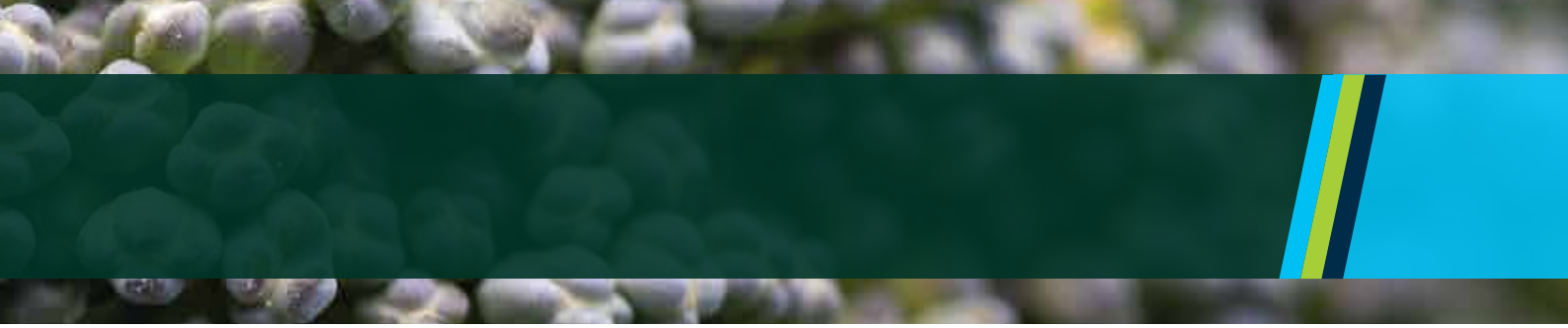
INTERMEDIATE RESISTANCE (IR) The ability of a plant variety to restrict the growth and/or development of the specified pest, and/or the symptoms and/or damage it causes, to a moderate degree. IR varieties may exhibit a greater range of symptoms or damage compared to HR varieties under similar environmental conditions and pest pressure. However, IR plant varieties will still show less severe symptoms or damage than susceptible plant varieties when grown under similar environmental conditions and/or pest pressure.

INTERVEINAL The area of leaf tissue bordered by veins.

JUVENILE An immature nematode.

LESION A well-defined, but localised, diseased area on a plant.

MOSAIC Variegated patterns of light and dark areas on a plant often caused by viruses.



MOTTLE Irregular light and dark areas on leaves or fruit surfaces symptomatic of viral diseases.

MYCELIUM (PL. MYCELIA) The mass of thin, microscopic, hair-like structures that forms the vegetative part of a fungus.

NECROSIS (ADJ. NECROTIC) The death of plant cells or tissues, usually accompanied by black or brown darkening.

NEMATODE Tiny worms that can live in plants, animals, soil or water

OOSPORE A sexual spore produced by the union of two morphologically different gametangia (oogonium and antheridium).

PATHOGEN An organism or agent that is capable of causing disease.

PATHOVAR (PV.) A type of subspecies; strain or group of strains of a bacterial species differentiated by pathogenicity on one or more hosts (species or cultivars).

PEDICEL The stalk of a flower or fruit.

PERSISTENT Referring to circulatory viruses that remain infectious within their insect vectors for long periods without inducing lysis and are transmitted via salivary fluids.

PETIOLE The stalk of a leaf.

PHLOEM The food conducting tissue of a plant.

PUSTULE A small blister-like elevation of the epidermis that forms as fungal spores develop and emerge.

PYCNIDIUM (PL. PYCNIDIA) A spherical or flask-shaped asexual fruiting structure of a fungus.

RACE A subspecific group of pests with distinct pathological or physiological properties.

RESERVOIR Infected plants that can serve as a source of inoculum for further infection of other plants.

SATURATION Being completely filled with liquid, generally water.

SCLEROTIUM (PL. SCLEROTIA) A compact mass of hyphae capable of surviving unfavourable environmental conditions.

SEEDBORNE PATHOGEN Infectious agent associated with seed and having the potential of causing a disease of a seedling or a plant.

SENESCE To decline or degenerate as with maturation or a physiological ageing process; often hastened by environmental stress, disease or insect attack; growing old.

SILIQUE The specialised seed pod of a crucifer.

SOILBORNE Denoting a soil source or origin of pathogens; the property of a microorganism living and surviving in the soil.

SPORANGIUM (PL. SPORANGIA) A spore case of fungi; commonly a sac-like or flask-like fungus structure of which the contents are converted by cleavage into an indefinite number of endogenous asexual spores.

SPORE A reproductive structure of fungi and some bacteria.

SPORULATE To form or produce spores.

STOMA (PL. STOMATA) A pore in a leaf surface.

STRAIN A general term referring to (a) an isolate; descendent of a pure culture pest, (b) a race; one of a group of similar isolates or (c) one of a group of virus isolates that have common antigens.

STUNTED Describing a plant reduced in size and vigor due to unfavourable conditions; may be due to a wide range of pathogens or abiotic agents.

SUSCEPTIBILITY The inability of a plant variety to restrict growth and/or development of a pest, causing symptoms and/or damage.

SYSTEMIC Spreading internally throughout a plant.

TELEOMORPH The sexual form of a fungus.

TOLERANCE The ability of a plant variety to endure abiotic stress without serious consequences for growth, appearance and yield.

TRANSLOCATION The transfer of nutrients or a virus through the plant.

TRANSPIRATION The loss of water vapor via stomata.

VASCULAR The conductive system of a plant combining the xylem and phloem.

VECTOR An agent able to transmit a pathogen.

VIRUS A sub-microscopic obligate disease causing agent.

VOLUNTEER A cultivated plant growing from self-sown or accidentally dropped seed or vegetative matter.

WATER-SOAKED Diseased plant tissue that appears wet and dark and may be depressed and translucent.

XYLEM The water-conducting tissue of a plant.

ZONATE Distinguished from adjacent parts by a distinctive feature (such as concentric rings).

ZOOSPORE An asexually produced fungal spore bearing flagella and capable of active movement in water.

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