/// Vegetables
by Bayer

BAYER | Seminis De Ruiter

ONION DISEASE FIELD GUIDE

ONION DISEASE FIELD GUIDE

/// Vegetables by Bayer

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 onion and leek diseases and disorders as well as their control.

We developed the onion and leek disease field guide for use by a wide range of professionals involved in the onion industry including growers, agricultural advisors, farm managers, agronomists, food processors, and members of the chemical and vegetable seed industries. It does not include every onion and leek 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 onion and leek 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 onion and leek 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 onions. 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 onion and leek 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.

SPECIAL THANKS

Special thanks to the following people who have reviewed or contributed photographs for this publication:

Contributors

Ton Allersma *Bergschenhoek, The Netherlands*
Sridhara Gupta Kunjeti, *Bangalore, India*
Kacie Quello, *Woodland, CA, USA*
Evan Pellerin, *Woodland, CA, USA*
Susan Van Tuyl, *Woodland, CA, USA*
Stephanie Gimenez, *Saint Andiol, France*
Nutchanart Koomankas, *Chiang Rai, Thailand*
Elisa Ruiz, *El Ejido, Spain*
Staci Rosenberger, *Woodland, CA, USA*
Lowell Black, *DeForest, WI, USA*
John Kao, *Woodland, CA, USA*
Nancy Koval, *DeForest, WI, USA*
Brad Gabor, *Woodland, CA, USA*
Kevin Conn, *Woodland, CA, USA*
Jeffrey Lutton, *Woodland, CA, USA*

CONTENTS

I. BACTERIAL DISEASES

II. FUNGAL DISEASES

III. NEMATODE DISEASES

IV. OOMYCETE DISEASES

V. PARASITIC DISEASES

VI. PHYTOPLASMA DISORDERS

VII. VIRAL DISEASES

VIII. NON-INFECTIOUS DISORDERS

BACTERIAL DISEASES

BACTERIAL BLIGHT OF LEEK

BACTERIAL LEAF STREAK AND BULB ROT

BACTERIAL SOFT ROT

CENTRE ROT

ENTEROBACTER BULB DECAY

POST-HARVEST ROT

SLIPPERY SKIN

SOUR SKIN

XANTHOMONAS LEAF BLIGHT

Causal Agent

Pseudomonas syringae pv. *porri*

Distribution

Asia, Canada, Europe, New Zealand and USA

Symptoms

The disease first appears as dark-green, longitudinal, water-soaked lesions that form at leaf tips and edges. As they elongate, lesions turn orange to brown with surrounding chlorosis and may extend as a narrow strip from leaf tip to the sheath. When a lesion extends into the sheath, the affected leaf turns light-green, curls, splits and eventually wilts and dies. Severely affected plants are misshapen, undersized and cannot be harvested.

Conditions for Disease Development

Infested seed and infected leek debris from a previous crop are both sources of primary inoculum. The bacterium may infect but remain latent in the plant until environmental conditions favour development of disease. Generally, warm temperatures and high humidity encourage symptom expression and disease spread.

Control

Sow only clean seed. During the growing season, limit overhead irrigation and avoid mowing the crop when plants are wet with dew or rain. Removing infected plants and plant debris throughout the season and rotating to a non-host help mitigate the risk of disease. Apply soil amendments as needed to increase soil pH to at least 5.5 to reduce the chance of infection.

6 / BACTERIAL BLIGHT OF LEEK

Elongate orange to brown lesions with surrounding chlorosis.

Causal Agent

Pseudomonas viridiflava

Distribution

Africa, Asia, North America and Venezuela

Symptoms

The first symptoms observed are oval, water-soaked leaf lesions, tip-burn and leaf streaking of varying lengths. Initially, leaf streaks are green but eventually darken to black. As infections become more severe and spread down the leaf, entire leaves collapse and dry. Leaf distortion and twisting may also occur.
Bulb infection is characterised by dark spots on outer scales and reddish brown discolouration of inner scales. Symptoms often develop in a ring-like pattern due to restriction of the rot by the scales.

Conditions for Disease Development

This disease occurs particularly in winter and spring when temperatures are cool. Epidemics are associated with prolonged periods of rain, which favour progression of the disease. Excess fertiliser stimulates disease development. It is thought that frost damage may predispose onion plants to infection.

Control

Applications of fixed copper compounds or streptomycin inhibit spread of this disease although bacterial strains resistant to copper may occur. Excessive fertiliser applications may increase foliar symptoms and should be avoided. Reduce postharvest rot by harvesting onions at the proper maturity stage, by reducing wounding and bruising during harvest and by proper curing of bulbs with forced hot air.

Darkening and collapse of the entire leaf.

Early disease symptoms showing leaf streaking caused by *Pseudomonas viridiflava*.

Bulb cross-section showing reddish-brown discolouration of infected inner scales.

Disease progression from leaf streaking (right) to plant death (left).

Causal Agent

Dickeya dadantii

Pectobacterium carotovorum subsp. *carotovorum* (syn. *E. carotovora subsp. carotovora)*

Distribution

Mexico and USA *(D. dadantii)*, worldwide *(P. carotovorum* subsp. *carotovorum)*

Symptoms

Bacterial soft rot is mainly a problem on mature bulbs. Affected scales first appear water-soaked and pale yellow to light brown when infected by *Dickeya dadantii* or bleached grey to white when infected with *Pectobacterium carotovorum* subsp. *carotovorum*. As the soft rot progresses, invaded fleshy scales become soft and sticky with the interior of the bulb breaking-down. A watery, foul-smelling thick liquid can be squeezed from the neck of diseased bulbs.

Conditions for Disease Development

Bacterial soft rot is most common on onions in storage or transit; however, this disease can develop on onions in the field before harvest, after heavy rains and when leaves are drying. The main sources of inoculum are contaminated soil and crop residues. The bacteria are spread by splashing rain, irrigation water and insects. Entry into bulbs is only through wounds such as those caused by transplanting, mechanical injuries or sunscald. Also, onion maggots can carry soft rot bacteria and introduce them while feeding. This disease is favoured by warm, humid conditions with an optimum temperature range of 20-30°C. However, during storage or transit soft rot can develop when temperatures are above 3°C.

Control

Avoid overhead irrigation where possible, and control insect pests such as the onion maggot. Disease spread and infection may be reduced by copper-based bactericides. Allow onion tops to mature before harvesting and avoid damaging bulbs during harvest. Store onion bulbs only after they have been properly dried, and provide the appropriate temperature and humidity with good ventilation to prevent moisture condensation from forming on the bulbs.

Foliar collapse of an infected plant.

Early season soft rotting of a bulb.

Soft rot developing late in the season in two bulbs.

Causal Agent

Pantoea ananatis, P. agglomerans, and *P. allii*

Distribution

Peru, Poland, South Africa and USA (Colourado, Georgia, Michigan, Texas and New York)

Symptoms

Symptoms first appear as whitish to tan lesions with water-soaked margins, often on interior leaves. Foliar lesions can rapidly coalesce, progressing to wilt and dieback of affected leaves. The pathogen moves from the leaves into the neck and bulb causing yellowish to light-brown discolouration. With severe infections, all leaves can be affected giving a bleached appearance to plants. Secondary bacterial infections rot interior bulb tissue and produce a foul odour. Under conditions favourable to the disease, yield losses may approach 100 percent.

Conditions for Disease Development

Both pathogens are seedborne and can survive on a few reported alternate hosts (corn, cotton, melon, pineapple, rice and sugar cane). They may also survive epiphytically on weeds and crop debris. Spread can occur by wind, splashing water and thrips. Infection is favoured by moderate to warm temperatures and rainfall during bulb initiation.

Control

Seed produced in high risk areas should be tested for Pantoea ananatis and Pantoea agglomerans before sowing. Some onion varieties are known to be more susceptible to this disease than others. Avoid planting these varieties where disease pressure is high. Control weeds, volunteer onions and thrips. Consider drip rather than sprinkler irrigation if possible, and avoid working in fields when foliage is wet. Avoid excessive nitrogen fertilisation. If applied preventively, copper-based bactericides may provide control under low to moderate disease pressure. Initiate sprays two weeks before bulbing and continue every 5-7 days thereafter. Deep cultivate after harvest to promote decomposition of crop debris. Where this disease occurs, a minimum three-year rotation to non-hosts is recommended.

Wilt and dieback of onion leaves infected with *Pantoea ananatis*.

Bacterial decay of interior bulb tissue associated with centre rot.

Causal Agent

Enterobacter cloacae

Distribution

Poland and USA (California, Colourado, New York, Utah and Washington)

Symptoms

The exterior of the bulb remains asymptomatic while the inner scales show a brown to black discolouration and decay.

Conditions for Disease Development

This disease was observed in mature bulbs in the field after a period where air temperatures had reached 40-45°C. The bacterium is common in many environments and is considered to be an opportunistic pathogen on onions.

Control

No control measures have been reported.

Bulb longitudinal-section showing infected internal scales.

Bulb cross-section showing infected internal scales.

Post-Harvest Rot

Causal Agent

Bacterial agents may be single agents or a combination of multiple agents.

Primary: *Burkholderia allilicola* and *B. cepacian, Pantoea agglomerans, P. ananatis, Pseudomonas viridiflava*

Secondary: *Enterobacter cloacae, Pseudomonas fluorescens* and *Pseudomonas aeruginosa*

Distribution

North America, Spain

Symptoms

Symptoms begin as water-soaked lesions on the leaves or neck of the bulb. The bacteria quickly cause the scales of the bulb and, depending on the causal agent, may remain confined to a layer or spread throughout the tissue. Symptoms may not be noticed until post-harvest grading.

Conditions for Disease Development

Burkholderia, Enterobacter and *Pantoea* spp. proliferate in moderate to high temperature (above 30 °C), moist conditions. *Pseudomonas* species prefer cooler temperatures and ample moisture. Damage from insects, hail or farm equipment can become an entry point for bacteria to infect.

Control

Use only disease-free transplants and/or seed. Damage from biotic and abiotic causes (including rain, hail and frost as well as mechanical wounds and insects, especially thrips) provides an entryway for the bacteria. Reduce excess irrigation/runoff and avoid overhead irrigation when possible. Avoid excessive fertility especially post bulb initiation. Avoid planting in dense stands. Keep fields free of weeds as a number can be symptomatic or asymptomatic hosts of the bacteria. Ensure onions are properly cured. When drying onions down, use wind or forced air versus heat.

Slippery Skin

Causal Agent

Burkholderia gladioli pv. *alliicola*
(syn. *Pseudomonas gladioli* pv. *alliicola)*

Distribution

Worldwide

Symptoms

Field symptoms often appear as one or two wilted leaves in the centre of the leaf cluster. These leaves eventually turn pale yellow and dieback from the tip while older and younger leaves maintain a healthy green appearance. During the early stages of this disease, the bulbs may appear healthy except for a softening of the neck tissue. In a longitudinal section, one or more inner scales will look watery or cooked. The disease progresses from the top of the infected scale to the base where it can then spread to other scales, rather than by spreading crosswise from scale to scale. Eventually, all the internal tissue will rot. Finally, the internal scales dry and the bulb shrivels. Squeezing the base of infected plants causes the rotted inner portion of the bulbs to slide out through the neck, hence the name slippery skin.

Conditions for Disease Development

This bacterium requires moisture for infection and grows in the temperature range of 5-41°C. Severe disease can occur during periods of high rainfall combined with strong winds or hail. Heavy irrigation and persistent dews are also conducive to this disease. This bacterium is soil-borne and can be readily water-splashed to the foliage and necks where it can enter through wounds.
As the plant matures it increases in susceptibility with the mature plant being highly susceptible. In warm weather, approximately 30°C, infected bulbs can decay within 10 days. However, in storage decay moves slowly, often requiring 1-3 months for a bulb to decay completely.

Control

Harvest onions when bulbs have reached full maturity. Do not store bulbs until they have been properly dried. Minimising stem and bulb injury and avoiding overhead irrigation when the crop is approaching maturity can reduce losses from this disease. Bulbs should be stored at 0-2°C with adequate ventilation to prevent condensation from forming on the bulbs.

Bulb cross-section showing collapse and shriveling of internal scales.

Causal Agent

Burkholderia cepacia, Burkholderia semiarida sp. nov. and *Burkholderia sola* sp. nov.

Distribution

Worldwide

Symptoms

Field symptoms often appear as one or two leaves that have turned a light brown colour. A watery rot develops at the base of the leaves and proceeds into the neck, allowing the leaves to be easily pulled from the bulb. As the disease progresses the outer bulb scales are infected. However, the outer most bulb scales and inner bulb scales may not become infected, which distinguishes sour skin from slippery skin where inner bulb scales are infected first. Infected scales develop a slimy pale yellow to light brown decay and may separate from adjacent scales allowing the firm centre scales to slide out when the bulb is squeezed. Infected bulbs often have an acrid, vinegar-like odour due to secondary invaders, especially yeasts, colonising decaying bulbs.

Conditions for Disease Development

Burkholderia cepacia complex is commonly spread by heavy rains, overhead irrigation and flooding which splash the bacteria onto young or wounded foliage. Infection typically occurs through wounds including those made when onions are cut at harvest. Infection can also occur when water lands on upright leaves and flows into leaf blade axils carrying the bacterium with it. Sour skin is favoured by rainstorms and warm weather, and develops rapidly at temperatures above 30°C.

Control

The use of furrow irrigation, instead of overhead and recycled irrigation water, will reduce losses from this disease. Do not damage foliage prior to harvest or bulbs during harvest since *B. cepacia* enters the plant primarily through wounds. Onion crops should be harvested at maturity and the bulbs dried quickly. Storing onions at cool temperatures 0°C with adequate ventilation to prevent condensation on the bulbs will reduce storage losses resulting from this disease.

Light brown discolouration of infected inner leaves.

Cross-section through bulb showing separation of scales.

Yellowing of infected inner leaves.

Cross-section through bulb showing water-soaking of infected scales.

Longitudinal-section through bulb showing yellow brown discolouration of infected outer scales.

Causal Agent

Xanthomonas axonopodis pv. *allii*

Distribution

Brazil, the Caribbean, Japan, Reunion Island (France), South Africa, USA, Venezuela and Vietnam

Symptoms

Symptoms first appear as white to tan flecks, light-coloured spots and/or lenticular lesions surrounded by water-soaking. Lesions rapidly enlarge, turning tan to brown with extensive water-soaking. As the disease progresses, lesions coalesce into dry necrotic areas of tip dieback. Typically, blighting of outer, older leaves leads to plant stunting and undersized bulbs. When conditions are favourable for disease, all leaves may become completely blighted and plant death may follow. Symptoms in leek, shallot, chives, and garlic are similar to those in onion but are less severe. Short-day onion varieties may develop symptoms at any stage of crop development, and long-day onion varieties usually develop symptoms during or after bulb-initiation.

Conditions for Disease Development

Disease is favoured by temperatures above 26°C. Frequent rains and high humidity promote disease development. Severe outbreaks are often associated with heavy rain, hail and wind-blown sand that damages foliage. Symptoms usually appear 7-10 days later. Spread of the pathogen within and between fields occurs with both overhead and furrow irrigation and movement of residual onion debris by field equipment. *Xanthomonas axonopodis* pv. *allii* is also seed-transmitted. Frequent rains and overhead irrigation can initiate an epidemic from contaminated seed in semi-arid environments. The bacterium survives on contaminated seed, in infested crop debris and as an epiphyte or pathogen on volunteer onions, legumes and weeds.

Control

Use only clean seed or transplants. Rotate to non-hosts for at least two years. Do not plant onion or garlic after dry beans, soybeans or alfalfa which may harbor this pathogen. Control volunteer onions and weeds in and around fields. During the growing season avoid overhead irrigation and excessive nitrogen fertilisation. Copper bactericides alone or in combination with recommended fungicides can be effective in semi-arid regions when applied prior to the onset of symptoms. Incorporate crop debris into soil promptly after harvest.

Tip dieback in an infected onion field.

Lenticular lesions on an onion leaf.

FUNGAL DISEASES

- BLACK MOULD
- BLACK STALK ROT
- BLUE MOULD ROT
- BOTRYTIS BROWN STAIN
- BOTRYTIS LEAF BLIGHT
- FUSARIUM BASAL ROT
- LEAF BLOTCH
- NECK ROT
- PINK ROOT
- POWDERY MILDEW
- PURPLE BLOTCH
- RUST
- SMUDGE
- SMUT
- SOUTHERN BLIGHT
- STEMPHYLIUM LEAF BLIGHT
- TWISTER
- WHITE ROT
- WHITE TIP
- YEAST SOFT ROT

Causal Agent

Aspergillus niger

Distribution

Worldwide

Symptoms

Black mould generally develops at the neck of the bulbs on injured or necrotic leaf tissue. However, it can develop on injured or diseased roots, or on bruised or split outer scales along the side of bulbs. Infected bulbs may develop a black discolouration at the neck. Clusters of black spores generally form along veins and on or between the outer papery scales of bulbs. Infected tissue first has a water-soaked appearance and over time will dry and shrivel. No external symptoms may be visible on some infected bulbs. Soft rot bacteria can follow infection by this fungus.

Conditions for Disease Development

Spores of this fungus are very common in the air and soil. Black mould is most common when temperatures are higher than 30°C in the field or 24°C in storage. Free moisture for six hours or longer on the onion surface is necessary for infection to occur.

Control

Fungicide applications to seeds, seedlings and bulbs may be helpful. Storage conditions should be cool and dry, and bruising of bulbs should be avoided.

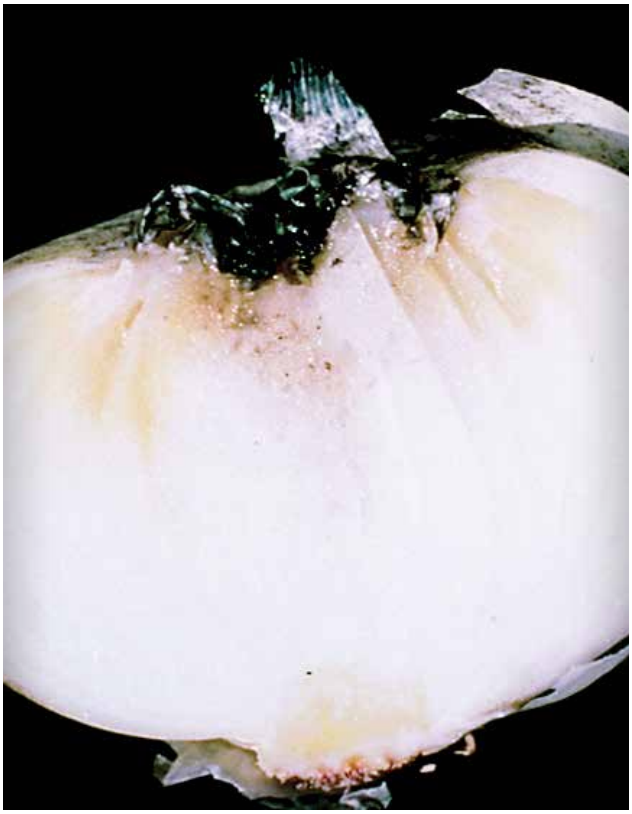
Black fungal spores are visible under the outer papery scales of the bulb.

Exposed black fungal spores under the outer papery scales.

Bulb showing extensive black fungal spores.
(Courtesy S. K. Mohan—© APS. Reproduced, by permission, from Schwartz, H. F., and Mohan, S. K., eds. 2008. Compendium of Onion and Garlic Diseases and Pests, 2nd ed. American Phytopathological Society, St. Paul, MN.)

Exposed black fungal spores under the outer papery scales.
(Courtesy S. K. Mohan—© APS. Reproduced, by permission, from Schwartz, H. F., and Mohan, S. K., eds. 2008. Compendium of Onion and Garlic Diseases and Pests, 2nd ed. American Phytopathological Society, St. Paul, MN.)

Bulb longitudinal-section showing extensive infection of the scales (right).



Bulb longitudinal-section showing initial infection of scales at the bulb neck.

Causal Agent

Stemphylium botryosum (teleomorph: *Pleospora tarda)*

Distribution

Worldwide

Symptoms

Early symptoms of black stalk rot and purple blotch may be confused because they are similar in appearance. However, black stalk rot will eventually cover the infection site with a dense carpet of black spores. The affected areas generally progress along the length of leaves and flower stalks. Initially yellow then tan, these lesions later darken when spore production is at its highest. Seed stalks may become girdled and break before the seed matures. Surface infection of bulbs results in a black sooty appearance.

Conditions for Disease Development

This fungus can infect and survive over a wide range of environmental conditions, causing the most severe damage in warm, humid climates. It generally attacks old, diseased, weakened host tissue and will often follow downy mildew.

Control

The crop should be kept free from downy mildew, leaf blight and other diseases. Although chemical sprays can be effective, cultural control may also be achieved with proper plant spacing, fertiliser applications and irrigation to ensure the healthiest plant possible. Controlling insects such as thrips, which may injure the plant and provide access for the fungus, can be beneficial. Also, bulbs should not be bruised when harvested and should be properly dried before storage.

Black spore production on a scape.

Causal Agent

Penicillium spp.

Distribution

Worldwide

Symptoms

First symptoms include pale yellowish lesions and watery soft spots. These affected areas are soon covered with characteristic blue-green spores. Fleshy scales may show water-soaking and a light tan or grey colour when affected bulbs are cut open. As decay continues, bulbs may become soft and tough or may develop a watery rot. A musty odour is usually present.

Conditions for Disease Development

Penicillium spp. can be found in soil, on plant and animal debris or on senescing tissues. Infection of bulbs is usually through tissues damaged by bruising, freezing injury or sunscald. The pathogen grows well at 21-25°C and under moist conditions.

Control

A minimum of bruising and wounding of bulbs during harvest and prompt drying of harvested bulbs is recommended. Low temperature, approximately 5°C, and relative humidity are recommended for storage. Fungicide treatment of bulbs can be effective in controlling this disease.

Lesion development on the side of a bulb.

Blue-green fungal sporulation develops within a lesion.

Causal Agent

Botrytis cinerea

Distribution

North America and Europe

Symptoms

This fungus generally is not capable of infecting healthy leaf tissue, but it can infect the outer scales of storage onions. Spores of the fungus germinate on onion leaves and produce enzymes that result in superficial flecking. When the fungus grows into the bulb scales, it causes a brown stain on the neck and outer scales. The leaf fleck and bulb stain are usually not regarded as economic problems.

Conditions for Disease Development

Leaf fleck may occur during periods of moist weather with moderate temperatures, 21°C. Brown stain may decrease during storage because of environmental conditions that do not favour disease development.

Control

The fungus can survive as sclerotia in cull piles, therefore destroying cull piles will reduce this inoculum source. A fungicide spray program to control leaf blight and downy mildew should provide adequate control of brown stain. However, control measures are generally not required for the leaf flecking. Bulb scales that are discoloured normally dry out during storage and fall off during handling, leaving the remainder of the bulb salable.

Brown stain on the neck and outer bulb scales.

Superficial leaf flecking.

Causal Agent

Botrytis squamosa (now *Botryotinia squamosa)*

Distribution

North America and Europe

Symptoms

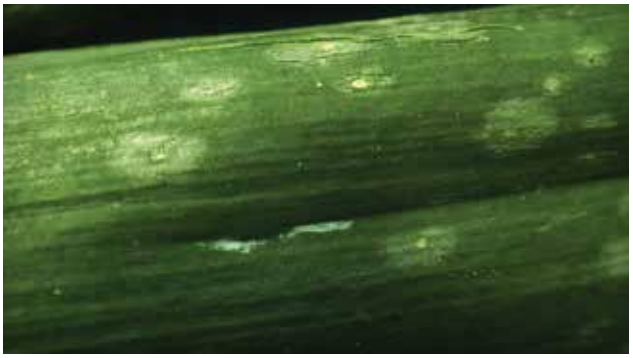
The fungus primarily attacks the leaves. The first symptoms begin as small white spots that are surrounded by a greenish halo. Centres of spots often are tan, making it difficult to distinguish between leaf blight and damage from insect feeding, mechanical damage or herbicide injury. Lesions expand with age and when numerous, may cause leaf tips to dieback. Eventually, leaf death results and severely affected onion fields develop a blighted appearance. Bulbs from infected plants may be small because growth is reduced by leaf loss.

Conditions for Disease Development

The fungus may over-winter in infected plant material or may survive in the soil as small, dark brown sclerotia. During moist periods with moderate temperatures, fungal spores are dispersed from sclerotia, infected leaves and debris to initiate infection. This disease can spread rapidly when environmental conditions are favourable for development.

Control

A good preventive fungicide spray program is important. Disease forecasting systems have been developed for some areas and these are very useful for determining the optimum timing for sprays. Destroying onion or debris cull piles will help reduce sources of inoculum. Orienting plant rows and spacing to maximise air movement helps reduce the time that leaves are wet and results in less disease incidence and severity. Cultural practices such as deep plowing and crop rotation will help reduce numbers of sclerotia in the soil.



White spots surrounded by a greenish halo.

White spots surrounded by a greenish halo.

Tan coloured leaf spots.

Black sclerotia develop on an infected bulb.

Casual Agent

Fusarium oxysporum f. sp. *cepae*

Distribution

Worldwide

Symptoms

The first above ground symptoms are yellowing, curling and necrosis at the tip of leaf blades. With time, whole leaf blades show symptoms and eventually wither and decay. Infected roots are dark brown, flattened, transparent and sometimes hollow. When affected bulbs are cut vertically, they show a watery, brown discolouration of the outermost layer of the stem plate, which may progress up through the storage leaves. White mycelium of the fungus may colonise the stem plate and, eventually, roots may rot completely. Infected plants can be pulled easily because of their stunted, decayed root system. Infected bulbs may show no decay at harvest but may rot in storage.

Conditions for Disease Development

Optimum temperature for disease development is 27°C and infection is limited when temperatures are below 15°C. Onion plants can be infected directly by the pathogen at any stage, but injury to the roots, the basal plate or bulbs by onion maggots or other insects appears to increase the incidence of this disease. The fungus can persist in soil as resting spores called chlamydospores for several years. Spread of this fungus often occurs by movement of infested soil on equipment, in irrigation water or on infected onion sets.

Control

Growing varieties with Intermediate Resistance to Fusarium basal rot can reduce losses from this disease. Long term rotation with non-host crops for four years or longer may also help to reduce losses. Dipping seedlings in fungicide before transplanting can also reduce disease severity. Additionally, control of soil insects and foliage diseases, the use of healthy onion sets and avoidance of fertiliser injury all help to reduce Fusarium basal rot losses.

Foliar symptoms and extensive root loss on infected seedlings.

White mycelial growth on the basal plate.

Foliar symptoms showing withering and necrosis of leaves.

Bulb and basal plate rot.

Basal plate rot.

Causal Agent

Cladosporium allii-cepa

Distribution

British Isles and Canada

Symptoms

Leaf infection results in elongated lesions that develop parallel to leaf veins. At first, lesions appear as chlorotic areas but later turn brown. Weak, senescent tissue is more likely to be colonised by this fungus than healthy foliage and stalks. *Cladosporium allii-cepa* produces an abundance of brown to olive-brown spores giving affected tissues a dark, velvety appearance. As the disease progresses onion plants begin to die.

Conditions for Disease Development

Usually, this fungus is considered a weak pathogen infecting plants already weakened by wounds, adverse growing conditions or disease. The disease is spread by air-borne spores that land on the foliage and scales. Infection occurs over a wide range of temperatures and when humidity is high. However, free water can reduce conidial germination.

Control

A healthy, vigorously growing plant rarely is infected by this fungus so proper fertilisation, plant spacing and irrigation can prevent high disease incidence. In addition, disposing of onion debris by removal or plowing reduces fungal inoculum and disease incidence. Chemical sprays applied at regular intervals can effectively control leaf blotch.

Elongated leaf lesion.

Olive-brown fungal sporulation on a leaf.

Causal Agent

Botrytis allii (teleomorph: *Botryotinia allii)*

Distribution

Worldwide

Symptoms

The growing crop seldom shows symptoms until harvest. However, this disease can be very destructive on stored onions. The fungus can invade the young healthy leaf tissue, but it usually infects the neck directly or through wounded tissue. This tissue becomes soft and spongy as the fungus continues to grow into the bulb. Affected parts of the bulb are brown and water-soaked, and the diseased tissue eventually collapses and becomes spongy. A white to grey mycelial growth eventually develops between the bulb scales and masses of small black sclerotia may develop on the outer scales around the neck. In addition to neck rot, *Botrytis allii* has been implicated in causing a soil-line rot. Other *Botrytis* species can also cause this disease. The fungus penetrates the outer scales of the bulb initiating a rot that is exacerbated by secondary invaders.

Conditions for Disease Development

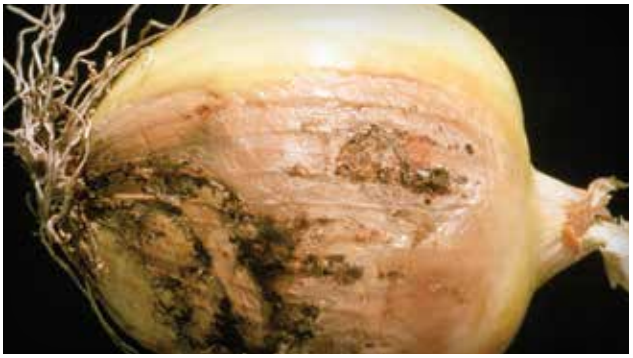
Under prolonged wet conditions the fungus can sporulate on dead and decaying tissue in the field as well as from sclerotia. Wind readily disseminates these conidia to other plants where they can infect the neck of the plant through wounds or cuts. Disease spread is most rapid during moderate temperatures with high humidity, rainfall or overhead irrigation. The condition of plants at harvest is important since infection can be more severe if necks are still succulent. Also, storing uncured onions at temperatures and humidity that are too high can promote disease development and spread. Soil-line rot is often more severe when onions are transplanted and during cool, moist weather.

Control

Use varieties that are adapted to the growing area to ensure that the plants mature by harvest. Avoid excessive late season fertilising, which may delay maturity. Adjust plant spacing and row orientation to obtain the best air movement through the plants. Avoid injury to the onion neck and damage to the bulbs, especially at harvest. Field applications of fungicides prior to harvest may reduce disease severity. Destroy onion cull and debris piles that may serve as a source of inoculum. Deep plow fields with a history of the disease to bury the sclerotia and rotate out of onions in these fields for several years. Be sure bulbs are cured and remove damaged bulbs before storage. Do not allow moisture condensation to form on the bulbs and use cool temperatures and moderate humidity for bulb storage.

Bulb longitudinal-section showing early symptoms of neck rot.

Bulb longitudinal-section showing advanced symptoms of neck rot.



Soil-line neck rot development on a bulb.

Botrytis allii mycelia and sclerotia on a bulb.

Casual Agent

Pyrenochaeta terrestris (now *Setophoma terrestris)*

Distribution

Worldwide

Symptoms

The term “pink root” reflects the most obvious symptom of this disease. Infected roots show a light pink colour that become deeper pink or red with time and finally purple-brown as the roots shrivel and disintegrate. New roots may continue to form and then be killed by the fungus. Plants with severe infections appear to suffer from nutrient deficiencies or drought, and the leaves turn white, yellow or brown starting at the tips and eventually die. Leaf number and size are reduced and the plants are easily uprooted. Plants infected early in the season start bulbing prematurely and show more damage than those infected later. Note that the older roots of resistant cultivars will also display the pink colour due to fungal infection as the roots senesce. However, resistant cultivars suffer very little loss of yield in the presence of the pathogen. Bulbs from infected plants are usually undersized and of reduced market value.

Conditions for Disease Development

The fungus is generally considered ubiquitous and can survive in the soil, in diseased roots and the debris of susceptible crops for several years. The fungus can be spread through soil movement and in surface water. This disease can develop at all soil moisture levels that allow onion growth. This pathogen will attack healthy crops in warm onion growing regions. Optimum temperatures for growth of the pathogen and disease development are 24-28°C. Little disease will develop when temperatures drop below 16°C.

Control

Resistance to the pathogen varies among cultivars, thus resistant cultivars should be planted when possible. Resistance may be overcome if soil temperatures of 28°C or higher occur. Planting so the bulk of the root growth occurs prior to reaching soil temperatures that favour disease development can minimise severe losses from this disease. Long term rotation (4-6 years) with non-host crops, such as cereals, helps reduce losses. Also, soil solarisation or fumigation can help to reduce pink root and increase marketable bulbs.

Leaf tip dieback is apparent on the infected plants in the foreground.

Infected roots turn reddish-purple in colour.

Pink root-resistant bulb (left) and susceptible bulb (right).

Seedlings with severe root infection.

Casual Agent

Leveillula taurica (anamorph: *Oidiopsis sicula)*

Distribution

Worldwide

Symptoms

Circular to oblong chlorotic lesions 5-20 mm (0.2-0.8 in.) in diameter develop on older leaves and rarely on younger leaves prior to bulb initiation. Sporulation gives lesions a grey to white powdery appearance. Chlorosis and eventually necrosis may develop around areas of sporulation. Lesions may coalesce to cover large areas of the leaf surface. This disease appears to be most common on varieties with glossy leaves, which are associated with thin cuticular waxes.

Conditions for Disease Development

Leveillula taurica overwinters in crop residue and many alternate hosts. Conidia are spread primarily by wind. Environmental conditions that favour infection include relatively warm temperatures and alternating humidity.

Control

Following harvest, removal of crop residue, deep tillage and rotation to a non-host crop for at least one year will help eliminate the pathogen. Fungicide sprays to control this disease are available. Avoid excessive nitrogen fertilisation and moisture stress.

White fungal sporulation on several leaves.

Casual Agent

Alternaria porri

Distribution

Worldwide

Symptoms

Older leaves tend to be more susceptible than younger leaves. Symptoms begin as water-soaked lesions that usually have a white centre. Edges of lesions become brown to purple and the leaf turns yellow above and below the lesions. With time, dark brown to black concentric rings form throughout the lesions. These are areas of sporulation of the fungus. As the disease progresses, lesions may girdle the leaf causing it to collapse and die. Similar symptoms occur on seed stalks and infected stalks can collapse resulting in shriveled seed development. When bulb infection occurs, it is normally through the neck. If the fungus invades the bulb, the infected area is initially bright yellow, semi watery rot, shrinkage of the fleshy bulb, but eventually turns a characteristic red wine colour.

Conditions for Disease Development

The fungus over-winters as mycelium in leaf debris and cull piles. Spores are formed during humid nights and leaf wetness periods greater than 12 hours. As the morning dew dries, spores become air-borne and are disseminated to susceptible onion tissue. 1-4 days are needed for symptoms to develop after infection. Disease development is greatest during prolonged periods of leaf wetness.

Control

A fungicide spray program with broad spectrum protective fungicides applied prior to infection can provide good protection. Minimising leaf wetness by using surface rather than sprinkler irrigation, good field drainage and correct plant spacing can reduce disease development. A rotation out of *Allium* to unrelated crops for several years can reduce disease as well.

Brownish-purple foliar lesions.

Brownish-purple leaf lesion.

Expanding brownish-purple lesion showing concentric rings of sporulation.

Casual Agent

Puccinia allii (synonym: *P. porri)*

Distribution

Disease occurs worldwide in temperate and cool growing regions.

Symptoms

The disease first appears as small, circular, white to tan lesions along leaf veins. Lesions typically form first on older leaves, and then spread to younger leaves. Lesions develop into orange to red circular or elongate uredial pustules that are often surrounded by chlorosis. Chlorotic leaf spots may also occur without further symptom development. When disease pressure is severe, leaves turn yellow and die prematurely. Dark brown teliospores may form in the pustules later in the season.

Conditions for Disease Development

The fungus can survive as urediospores or teliospores. Wild *Allium* species serve as a source of inoculum from which urediospores are disseminated by wind over long distances. Infection is favoured by cool to mild temperatures and high relative humidity (97 percent). Stressed plants are more severely affected by this disease than are healthy plants.

Control

Routine application of fungicides adequately controls this pathogen when disease pressure is low. Disease incidence is reduced by cultural practices such as crop rotation, low planting densities, destruction of wild *Allium* species and cultivation for good soil drainage. Where appropriate, isolation of leek from onion crops may also reduce disease.

Early infection in leek showing small white to tan lesions.

Uredial pustules with surrounding chlorosis on leek.

Rust lesions with orange pustules.

Black granular pustules develop late in the growing season.

Foliar chlorosis and dieback in leek with severe *Puccinia allii* infection.

Casual Agent

Colletotrichum circinans

Distribution

Worldwide

Symptoms

The disease occurs late in the season as the crop matures and continues to develop on bulbs in storage. The fruiting bodies of the fungus turn from dark green to black as they mature, and form concentric rings around the neck and on the surface of dry outer bulb scales. If the humidity is high, the disease may spread to the inner scales, causing small, yellow lesions. If the disease continues to develop, the bulb may shrivel and sprout prematurely. Under warm, wet conditions this fungus can cause damping-off and leaf spotting.

Conditions for Disease Development

The fungus can over-winter in the soil and can be introduced on infected bulbs. Warm moist conditions favour conidial production and wind and rain splash spread the conidia. These conidia infect mature bulb scales and cause disease when free moisture and optimum temperatures 20-26°C for infection occur.

Control

Yellow and red skinned varieties can be used in areas where disease pressure is high. The use of healthy transplants as well as crop rotation for several years out of white onions can reduce disease severity. Harvesting onions during dry weather and curing them quickly at the proper temperature and moisture can reduce disease incidence. Fungicide programs similar to those used to control neck rot and downy mildew can be effective against smudge.

Concentric rings of fungal fruiting bodies form on the surface of bulb scales.

Casual Agent

Urocystis colchici, U. cepulae (syn. *U. magica)*

Distribution

Worldwide

Symptoms

Infected seedlings often die within six weeks of emergence. Dark areas can be seen first on cotyledons soon after their emergence from soil. On older plants raised, blister-like lesions can occur near the base of the scales, and large lesions cause leaves to curve downward. Streaks may develop within the leaves, leaf sheaths and bulbs. Mature lesions contain a black, powdery mass of spores. Infected plants are stunted as infection progresses inward from leaf to leaf.

Conditions for Disease Development

The fungus can over-winter as resting spores in the soil for several years. Spread of the fungus occurs through infected onion sets, transplants and when spores are transported by wind, equipment and water. Onion seedlings are susceptible to infection from just after germination until they reach the first true leaf stage. As each new leaf emerges it goes through a growth phase where it is susceptible to infection. After that growth phase, infection does not occur. Optimum temperatures for spore germination and growth are 13-22°C while both are decreased above 25°C.

Control

Chemical seed treatments can protect seedlings through the susceptible stage. In addition, any cultural practice that is favourable for rapid growth can shorten the susceptible stage of the onions. Healthy onion sets and transplants that are planted into infested soil may escape infection. A crop rotation out of onions for three or more years also reduces disease.

Early symptoms of smut infection manifest as black streaks on leaves.

Infected seedlings showing dark streaks that contain masses of fungal spores.

Infected seedlings are stunted (one healthy seedling on the left and three infected seedlings on the right).

Casual Agent

Sclerotium rolfsii (teleomorph *Athelia rolfsii)*

Distribution

Worldwide

Symptoms

At the initial stage of the disease, outer leaves turn yellow and wilt. The fungus infects the outer scales of bulbs resulting in the development of white spot-like lesions. The infected bulb and neck tissues become soft and a watery rot develops. A white fungal growth often develops over the surface of the bulb scales, and mustard seed-sized light brown sclerotia form on the infected tissue, as well as in nearby soil and debris.

Conditions for Disease Development

The pathogen has a wide host range and infects as many as 500 plant species besides onion. The fungus can survive for many years as sclerotia in the soil or for shorter periods in infected plant debris. It may spread from plant to plant in the root zone or through the movement of soil and water. Disease is most severe in warm 25-30°C, moist soils that are high in organic matter. Fungal growth rapidly decreases below 15°C, resulting in little disease development.

Control

Deep plowing of crop residue to bury sclerotia, soil fumigation or soil solarisation may all help to reduce disease on subsequent crops. Crop rotation to cereals and grasses may help to reduce inoculum levels in soil. Post-harvest fungicide treatment of bulbs, as well as, storing bulbs at 10°C or lower may help to limit storage losses.

Leaf dieback on infected plants in the field.

Mustard seed-sized light brown sclerotia on infected seedlings.

Casual Agent

Stemphylium vesicarium

Distribution

India and USA, however, the pathogen may occur in other onion growing regions of the world.

Symptoms

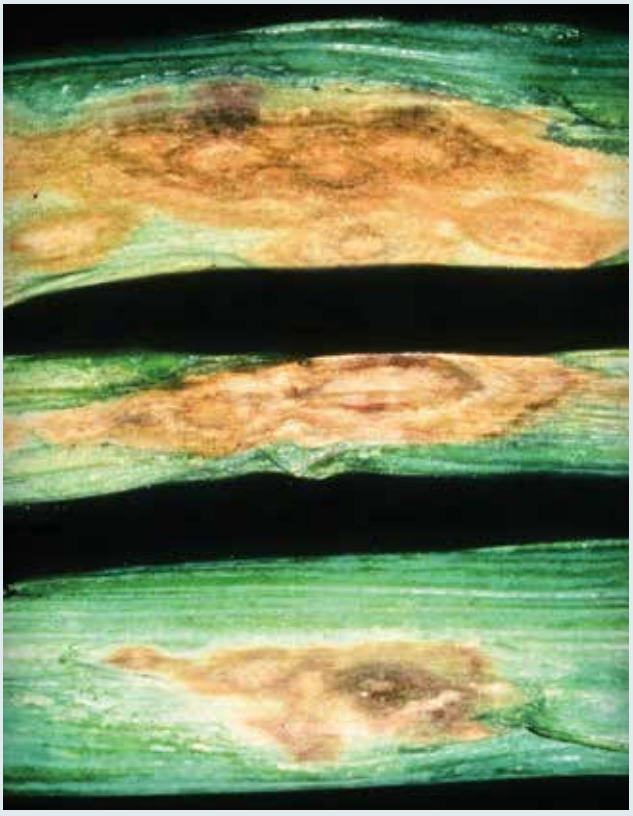
Initial infections on the leaves and leaf sheaths are small, light yellow to brown, and water-soaked. As the lesions expand they coalesce causing extensive blighting of the leaves. Typically, lesions are found in higher numbers on the side of leaves facing the prevailing wind. The centres of lesions turn brown to tan, then dark olive brown and finally black as the fungus sporulates. Sometimes fruiting bodies called perithecia may appear in infected tissue as small, black, pinhead-like raised bodies. Symptoms of stemphylium leaf blight are very similar to those of purple blotch, which often results in misidentification.

Conditions for Disease Development

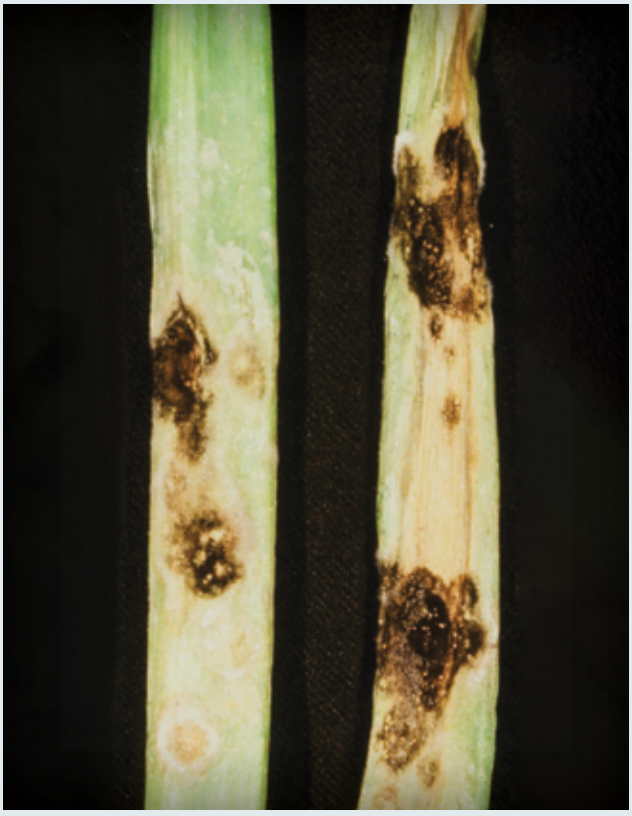
Extended periods of leaf wetness from dew formation, rainfall or overhead irrigation during bulb formation and development can result in severe leaf blighting. Bulb size can be greatly reduced due to loss of foliage. Infection is usually limited to leaves and does not extend down to the scales of the bulb.

Control

Chemical control with fungicides is effective in reducing disease development. Long term rotation with unrelated crops may reduce losses. Also, good field drainage and reduced plant density may lessen disease severity.



Dark brown to black sporulation on leaves.



Dark brown to black sporulation on senescing leaves.

Casual Agent

Colletotrichum gloeosporioides

Distribution

Worldwide, although only of significance in tropical and sub-tropical regions.

Symptoms

Typically under field conditions leaves turn chlorotic, curl and twist resulting in an elongated neck and slender bulbs. The affected leaves shrivel and droop down. Roots tend to be stunted and the plants may die. Small, white sunken lesions with dark, conidia-bearing structures may be present on leaves. When lesions are present, masses of pinkish orange conidia may develop. Up to 100 percent crop loss can occur when environmental conditions favour this disease.

Conditions for Disease Development

This soilborne fungus has a wide host range and survives in infected debris and on alternate hosts. Propagules are spread by rain, wind, irrigation water and insects. High humidity and temperatures between 23-30°C favour leaf infection.

Control

Hybrids with resistance are available. Cultivation practices reduce soilborne inoculum and fungicide applications also provide effective control.

Young onion plant showing typical symptoms of twister caused by *Colletotrichum gloeosporioides.*

White sunken lesions with dark, conidia-bearing structures.

Casual Agent

Sclerotium cepivorum (now *Stromatinia cepivora)*

Distribution

Worldwide

Symptoms

This disease can be one of the most damaging on onions with the first symptoms including yellowing, wilting and dropping of the older leaves. As the fungus invades the root system and basal plate it causes a rot, which eventually results in the collapse of the foliage. A soft rot gradually develops in the bulb and a thick white mycelial growth develops on the base of the bulb. Numerous sclerotia form on the diseased tissues. This disease usually appears on groups of plants in the field that are often widely spaced. However, large groups of plants may die suddenly when the fungus is abundant in the soil and conditions are favourable for disease.

Conditions for Disease Development

This disease is most severe in cool soils when soil moisture is favourable for root growth. The fungus can survive as sclerotia in the soil for many years and it can over-winter in infected onion debris and in diseased onion sets. Within rows this disease can spread laterally from root system to root system. The fungus is spread by movement of infested soil, infected onion sets and transplants.

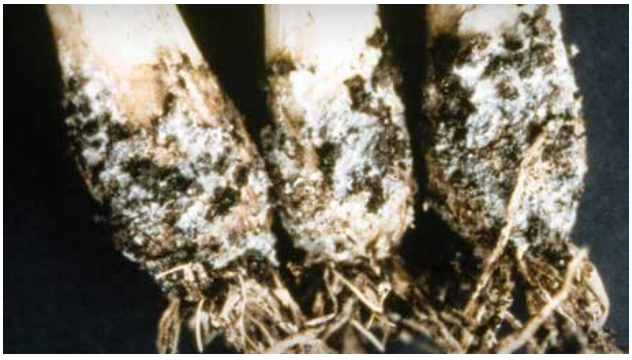
Control

White rot is difficult to control. Use healthy sets of plants and avoid introducing infested soil and water into the field. If the disease is just beginning in the field, removing and disposing of infected plants will help reduce the amount of the fungus in the soil. Spot treatments of soil with fumigants or fungicides may provide some control when the disease is limited in the field. Flooding, soil solarisation and the use of natural and synthetic sclerotia germination stimulants have been shown to reduce sclerotia populations in the soil, and therefore may reduce losses from this disease.

Localised plant death in the field.

Many small black sclerotia on an infected bulb.

White mycelia and small black sclerotia on mature bulbs.



White mycelia and small black sclerotia on bunching onions.

Casual Agent

Phytophthora porri

Distribution

Worldwide

Symptoms

Initial infection mainly occurs at the leaf tip and less frequently between the leaf tip and mid-leaf. Disease first appears as water-soaked spots that expand into lesions. Lesion margins remain water-soaked as affected tissue wilts and dries to the bleached white appearance for which this disease is named. When environmental conditions favour disease development, secondary lesions elongate to the base of the leaf. Crop losses are generally due to reduced plant weight in leek and storage rot of onion bulbs. Total crop loss may occur under severe disease pressure.

Conditions for Disease Development

Phytophthora porri oospores can survive for years in soil. High humidity and rainfall combined with low temperatures 15°C favour disease development. This disease tends to be more severe in fields with poor drainage. Once the disease is established, wind-borne and water-splashed sporangia and zoospores are easily spread.

Control

Avoid sprinkler irrigation. Rotation to nonhost crops helps to reduce soil inoculum levels and losses from this disease. Some fungicides may be efficacious during early stages of infection.

Severe disease development in the field.

Advanced leaf tip dieback.

Advanced leaf tip dieback.

Leaf lesions showing tissue collapse.

Casual Agent

Kluyveromyces marxianus var. *marxianus*

Distribution

USA (Oregon and Washington)

Symptoms

Symptoms are similar to those caused by soft rot bacteria. Diseased bulbs develop a soft, watery rot that tends to be confined to either the inner or outer fleshy scales and does not readily spread from scale to scale. When squeezed, fluid may exude from the neck of bulbs. Often, a large part of a bulb shows water-soaking and soft rotting.

Conditions for Disease Development

This fungus can survive in infected bulbs in cull piles or in onion field debris. It may be spread by fruit flies and other insects, and infection is thought to occur through wounds or natural openings in neck tissues. Temperatures between 20-30°C favour development of this disease.

Control

Bulbs should be harvested and handled carefully to reduce bruising and should be transported and stored at cool temperatures.

Water-soaking of the inner bulb scales.

Extensive collapse and soft rotting of the inner bulb scales.

NEMATODE DISEASES

LESION NEMATODE

ROOT-KNOT NEMATODE

STEM AND BULB NEMATODE

STUBBY-ROOT NEMATODE

Casual Agents

Pratylenchus penetrans, Meloidogyne hapla

Distribution

Worldwide

Symptoms

Infected plants are stunted and develop very few fine roots. Small, round to elongated lesions develop on roots. These lesions may be a cloudy yellow colour initially, turning darker brown as the disease develops. Depending on disease severity, infected plants will grow poorly, produce low yields and show symptoms of water and nutrient deficiencies.

Conditions for Disease Development

Moderate soil moisture and temperatures from 20-30°C favour growth and development of the lesion nematode. In certain areas a soil pH of 5.5-5.8 favours nematode development. Other factors such as soil type and organic amendments also affect development of the lesion nematode. Nematode infection makes the plant more sensitive to other soil-borne pathogens entering through wounds.

Control

Soil fumigation and nematicide treatments offer the best control of the lesion nematode. Rotation with resistant crops such as oats or a summer fallow in hot, dry growing areas may reduce nematode populations.

Root lesions caused by *Pratylenchus penetrans*.

Nematodes feeding on root tip.

Casual Agents

Meloidogyne spp *(M. arenaria, M. incognita, N, javanica, M. chitwoodi, M. fallax, M. hapla)*

Distribution

Worldwide

Symptoms

Small, swollen galls 1-2 mm (0.06 in.) in diameter can be found on the roots when infected plants are carefully lifted from the ground and freed from soil particles without damaging the roots. Depending on the species causing infection, the shape of the galls can be round or spindly, and with or without short root branches that rise from the upper part of galls. It is often possible to see white to dark brown egg masses on the surface of the roots. Above ground symptoms may include stunting and yellowing that resembles water and nutrient deficiency and poor or irregular plant stands.

Conditions for Disease Development

Damage is more severe in sandy and muck soils than in clay soils. Temperatures for infection range from 10-35°C. However, *Meloidogyne* spp. are inactive above 40°C or below 5°C. The nematodes are moved within and between fields by irrigation water or cultivation equipment, and can be introduced into fields in vegetative material such as bulbs and transplants.

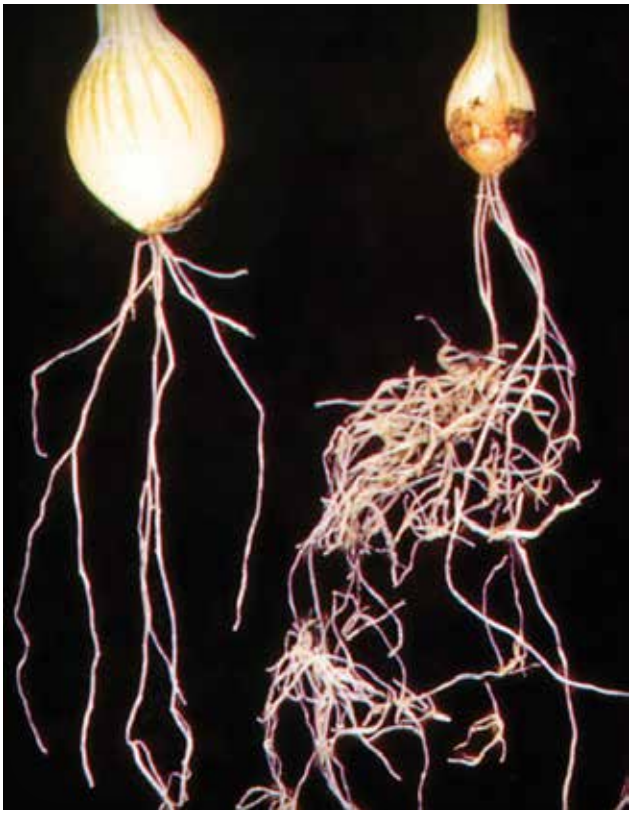
Control

Soil fumigation, crop rotation to a non-host or a long fallow period helps to reduce populations of root-knot nematodes.

Root galls caused by *Meloidogyne hapla*.

Stunting of infected plants in the field caused by *Meloidogyne hapla*.

Seedling root symptoms caused by *Meloidogyne chitwoodi*.



Extensive branching of an infected root system. Healthy plant (left) and infected plant (right).

Casual Agents

Ditylenchus dipsaci

Distribution

Worldwide

Symptoms

Infected young seedlings are stunted, pale and have swollen areas along the cotyledons. Leaves can develop yellowish-brown spots, can be short and thickened and stem swelling (bloating) can occur. As the disease progresses, the foliage collapses and the stems and necks of bulbs soften. The bulb scales become soft and light grey. Infected bulbs are light in weight, may be malformed or produce sprouts and double bulbs. Fungal and bacterial secondary infections are common and often give off a foul odour.

Conditions for Disease Development

New infections often come from nematode infested onion sets. Once the nematodes enter the seedlings they reproduce and migrate within or on the surface of plants. They can be spread by moving infested soil and debris, by rain and irrigation water and by farming equipment. Infected weeds and discarded onions often become the source of nematodes for the next crop. A soil temperature of 21°C is optimum for nematode movement and symptom development, while free moisture favours nematode longevity and activity.

Control

To avoid introducing the nematode, check onion sets to verify they are disease free prior to planting. If the nematode is present in the soil, fumigation can give good control. Complete removal and destruction of cull piles, volunteer onions and host weeds are important for reducing this disease. Also, a four year crop rotation to non-hosts such as spinach, carrots, beets, crucifers, lettuce or grains has proven effective.

Field symptoms, infected (left) and healthy (right).

Longitudinal section of a bulb showing infected basal plate.

Stem and bulb bloating.

Young plants infected by *Ditylenchus dipsaci*.

Casual Agents

Paratrichodourus allius, P. minor

Distribution

Worldwide

Symptoms

Plants are stunted, turn yellow or may be killed when infection occurs at the seedling stage. Infected root systems develop numerous stubby branches, often in clusters, as a result of nematodes feeding on root tips. Distinctive lesions are not visible; however, discolouration and necrosis will occur on infected roots due to secondary infections by other organisms. The stubby-root nematode is a strictly external feeder and therefore will not be embedded in root tissue like the rootknot nematode.

Conditions for Disease Development

The stubby-root nematode is active at soil temperatures between 20°C and 35°C. Sandy and sandy loam soils favour its reproduction.

Control

Treatment of infested soil with fumigants and nematicides reduces nematode populations. Flooding followed by soil drying can also decrease the population density. Long term rotation to resistant crops may give some control.

Field symptoms.

Stubby-root symptoms, infected (left) and healthy (right).

OOMYCETE DISEASES

DAMPING-OFF

DOWNY MILDEW

PHYTOPHTHORA NECK AND BULB ROT

Casual Agent

Fusarium spp. *(Fungus), Pythium* spp. (oomycete), *Rhizoctonia solani* (Fungus) (teleomorph: *Thanatephorus cucumeris)*

Distribution

Worldwide

Symptoms

***Fusarium* species:** The fungus may cause both pre- and post-emergence damping-off. Roots are invaded and eventually turn dark red or black as they decay. Seedlings are unthrifty and stunted, eventually turn yellow, wilt and die.

***Pythium* species:** Symptoms on young seedlings are similar to those caused by Rhizoctonia. A water-soaked lesion develops on lower stems and a watery rot occurs on the roots. The roots may turn black as they decay. The fungus can also attack seeds and cause a watery decay. Older plants that are infected are stunted and yellowing and wilting of leaves may occur during severe infections.

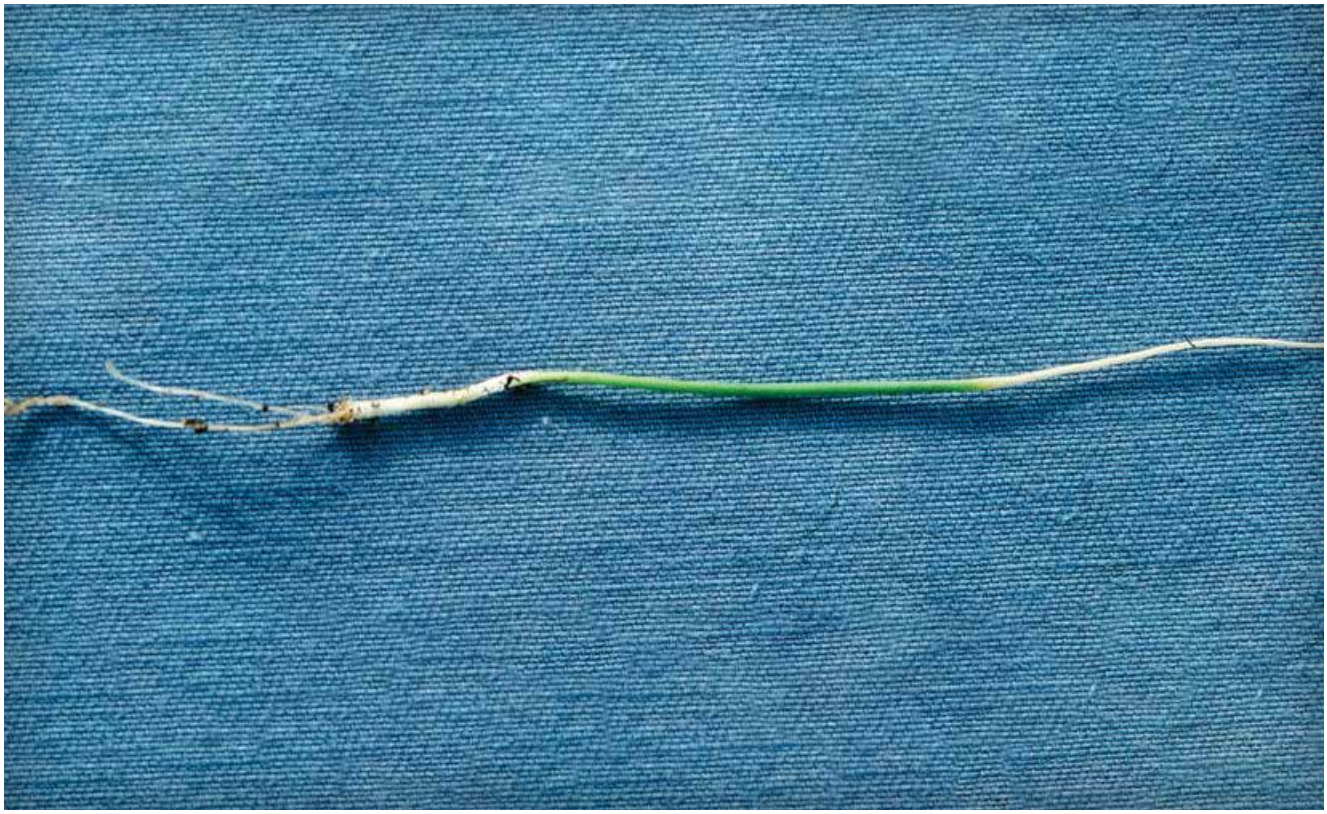
***Rhizoctonia* solani:** Seeds may rot before germinating and seedlings may decay before emergence. A brown rot develops on roots and lower stems at or below the soil line, and infected seedlings quickly wilt and collapse. Environmental conditions favour this disease.

Conditions for Disease Development

The fungi that cause damping-off are usually common in an onion production field. These fungi generally survive for long periods in soil and may persist in plant debris or on roots of weeds. Damping-off tends to be most severe under conditions of high soil moisture and compaction. Moderate temperatures, especially when onion crops are grown in succession, favour this disease. In greenhouses, damping-off can be more common when improperly pasteurised soil or previously used seedling trays are used for planting. Water splash can move infested soil from diseased to healthy plants and spread this disease.

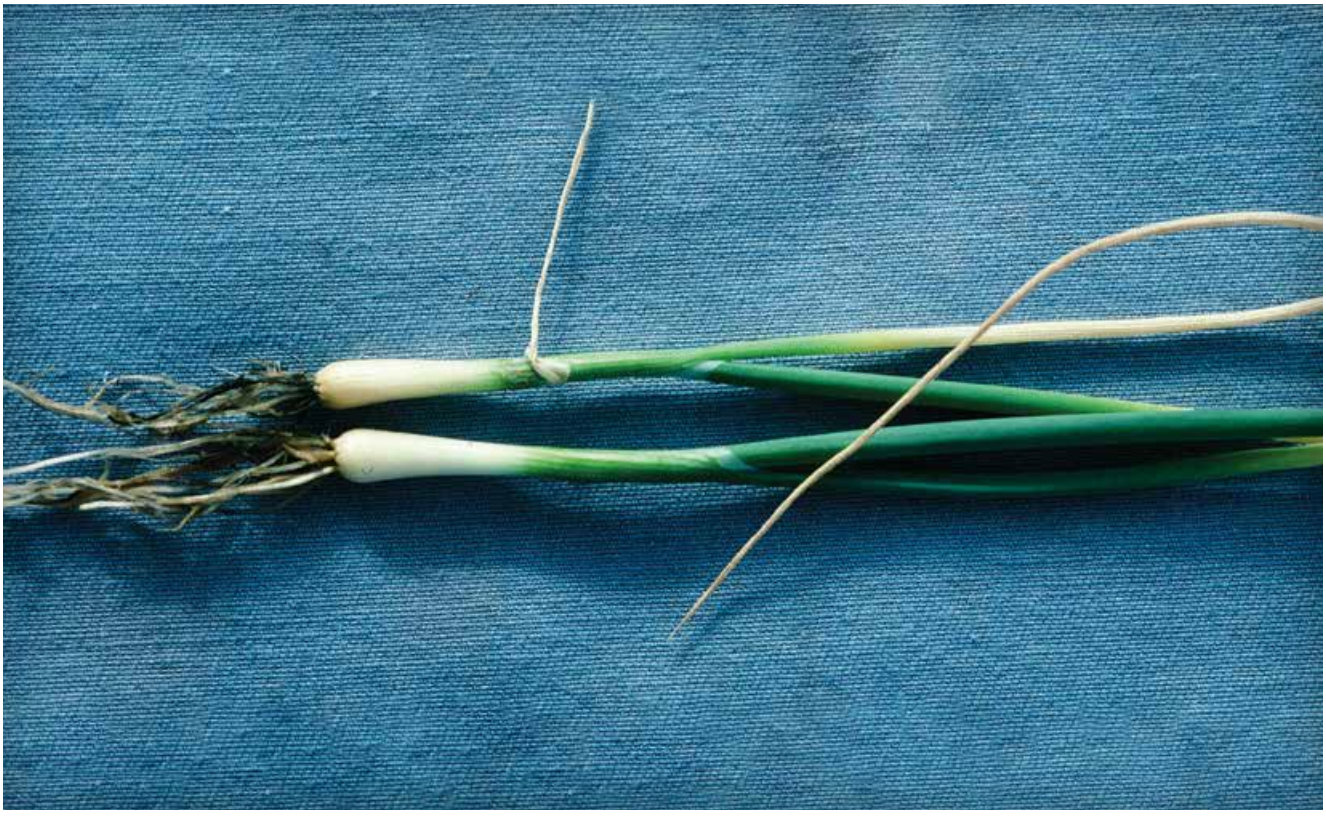
Control

Crop rotation with cereal crops and soil fumigation or solarisation may help reduce damping-off in fields. Improving soil drainage by using raised beds, and regulating soil moisture by avoiding excessive irrigation help to reduce disease. Good sanitation in greenhouses, including using sterilised planting trays and proper soil pasteurisation, reduces damping-off. Onions are most susceptible between the flag leaf and first true leaf stage, especially under low light intensity. Therefore, reduced watering can lessen disease losses during this stage. Some fungicide seed treatments or soil drenches can help prevent serious damping-off.



Damping-off caused by *Fusarium* species.

Damping-off caused by *Fusarium* species.



Root rot caused by *Pythium* species.

Casual Agent

Peronospora destructor

Distribution

Worldwide

Symptoms

Typically the first symptom observed is the brownish-purple velvet-like sporulation of the pathogen on healthy green leaves. As the disease progresses lesions which are slightly paler than the normal leaf colour, enlarge and may girdle the leaf. These lesions progress to a pale yellow followed by brown necrosis resulting in collapse of the leaf tissue. Infected seed stalks tend to remain pale yellow and, as with the foliage, are often invaded by other fungi, typically *Stemphylium* or *Alternaria* species. Field infections usually begin in small patches and progress rapidly throughout the field. Bulbs can be infected and may either rot in storage, or if planted, give rise to pale green foliage.

Conditions for Disease Development

The fungus survives in volunteer onion plants, onion sets, plant debris or in the soil. The fungal spores are disseminated onto plants by winds and splashing rain during cool wet weather, which is essential for disease development. Rain, dew or high humidity (>95 percent) is required for fungal spore germination and infection. The fungus grows internally and continues to produce spores as long as the weather remains cool and wet.

Control

A regular fungicide spray program based on climatic conditions can reduce crop losses. Avoid planting onion sets that are contaminated with the fungus. Eliminate plant debris and cull piles. Plant rows in the direction of the prevailing winds and use furrow irrigation rather than sprinkler irrigation. A 3-4 year rotation out of onions in areas where the disease is present can help reduce losses.

Sporulation on an infected leaf.

Pale yellow lesions on scapes.

Symptom development on an affected scape.

Extensive foliar damage in the field.

Peronospora destructor infection may be followed by invading secondary organisms, often leading to plant collapse.

Peronospora destructor sporulation on leaves.

Brownish-purple sporulation on healthy green leaves.

Casual Agent

Phytophthora nicotianae
(syn. P. nicotianae var. *parasitica and P. parasitica)*

Distribution

Brazil and Taiwan

Symptoms

Onion plants from small seedlings to the mature bulb stage may be affected. Initial above-ground symptoms include pale green leaves followed by yellowing and drying from the tips. Soon thereafter, the necks become soft and tops fall over, especially in younger plants. Internal symptoms include a watery soft rot of the neck interior that progresses into grey water-soaked tissue with a leathery texture below ground in young plants and into bulbs of more mature plants. Sunken white to grey leaf lesions occur, but are rare and generally do not extend into the neck region. Roots become necrotic only during later stages of disease development.

Conditions for Disease Development

Warm, wet conditions are conducive to disease development. Disease incidence is much greater in low spots in the field or areas near centre irrigation pivots that remain wet for prolonged periods. Use of irrigation water from ponds receiving agricultural run-off water is a potential source of inoculum.

Control

Resistant varieties are available. Avoid wet areas in the field and recirculation of field run-off water for irrigation. Fungicide applications in-furrow at time of transplant or as a plant drench after transplanting may reduce losses from this disease.

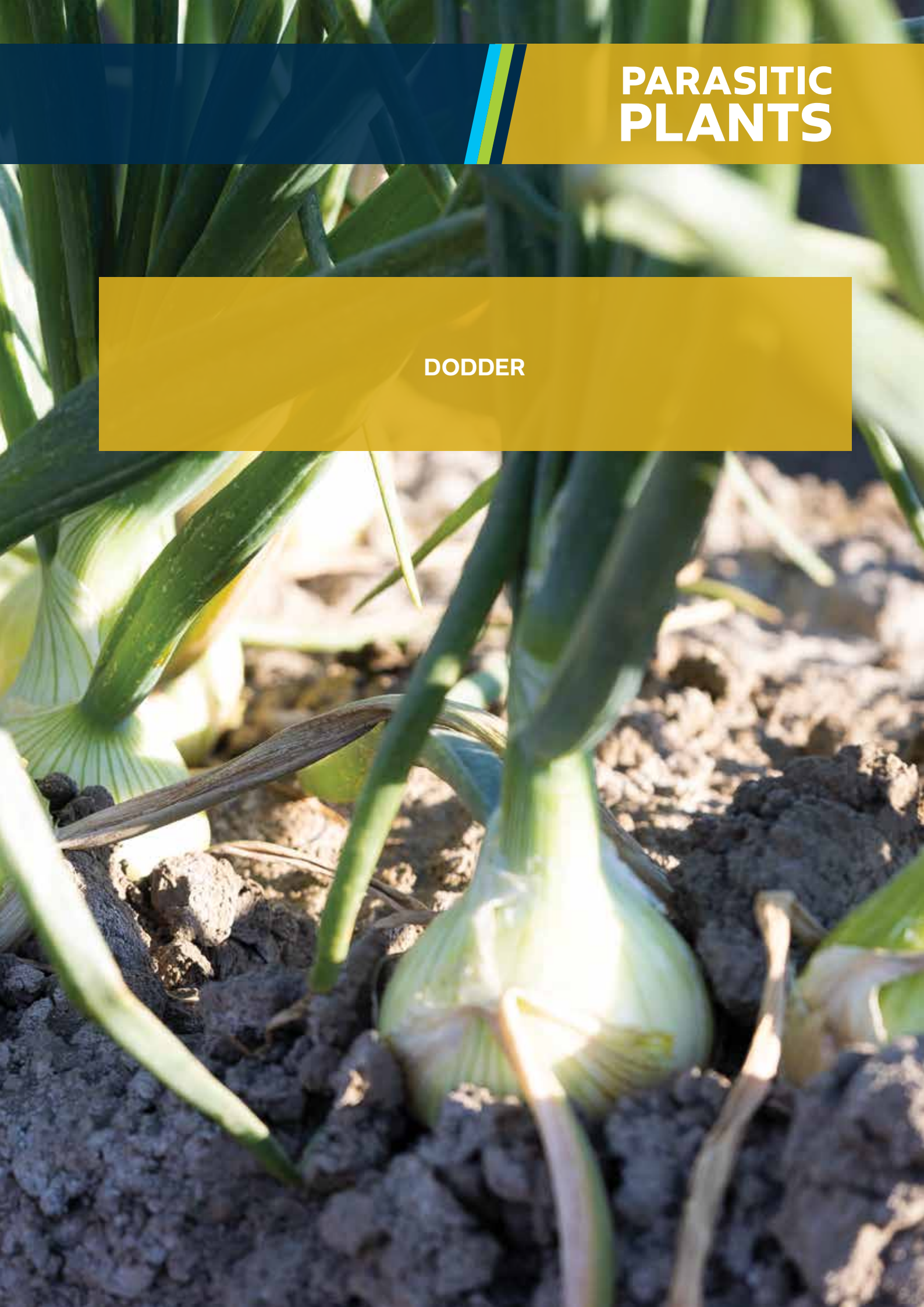
Pale green to yellow leaves drying from the tips.

Tip dieback, watery soft rot of the neck interior and grey water-soaked leathery interior bulb scales.

Watery soft rot of neck interior and grey water-soaked leathery interior bulb scales.

PARASITIC PLANTS

DODDER



Causal Agent

Cuscuta spp.

Distribution

Worldwide

Symptoms

More than one hundred species of *Cuscuta* occur worldwide. Dodder is an annual parasitic plant that can be identified by slender, white, yellow or red, leafless strands that twine around the host plant. Dodder has no chlorophyll and depends solely on the host plant for its nutrition. These shoots produce pegs that penetrate into the plant to absorb nutrients. The vine spreads to adjacent plants as it continues to grow.

Conditions for Symptom Development

Generally, dodder has a very wide host range and is adapted to a wide range of environments. After germination, the seedling depends on nutrients stored for its survival. If a suitable host is not found within a few days, it will die. Once a seedling contacts a host it forms sucker-like projections (haustoria) that penetrate plant tissues. It produces tiny flowers in clusters that contain thousands of small seeds. A few seeds will germinate the first year, but the remaining seeds lie dormant for many years before germinating. In the field, dodder emerges and twines around onion seedlings.

Control

Dodder may survive as debris or seeds on or in the ground. It can also be introduced into fields via equipment and in irrigation water. Therefore, early removal of dodder along with infected plants is the best method of control. Immediately remove or burn dodder, along with infested plants upon detection. Apply contact herbicides to control localised infestations. If an infestation is widespread, apply pre-emergence herbicides, deep-plow crop debris, and rotate to grasses. Herbicides and rotation to cereal crops may also provide control.

Flowering dodder.

Dodder plants parasitising onion plants in the field.

Dodder wrapped around onion leaves and scapes.

PHYTOPLASMA DISEASES

ASTER YELLOWS

Causal Agent

The Aster Yellows Phytoplasma
(syn. The Onion Yellows Phytoplasma)

Vector

The aster leafhopper *(Macrosteles quadrilineatus)*, many other species of leafhoppers

Distribution

Europe, Japan and North America

Symptoms

In bulb crops foliar symptoms begin as yellow and green streaks at the base of young leaves. Affected leaves will flatten and occasionally twist and intertwine. Eventually, entire leaves become yellow. In seed crops the umbel will have a star-burst appearance with elongated pedicels and distorted flowers. Occasionally, small bulbs will form in the flowers instead of seed.

Conditions for Disease Development

The aster yellows phytoplasma is transmitted during feeding by the aster leafhopper, *Macrosteles quadrilineatus*. Conditions that favour succulent plant growth may result in more leafhoppers being attracted to these plants and increase the incidence of this disease.

Control

This phytoplasma can over-winter in adult leafhoppers, grains, weeds and ornamentals and therefore, crop rotation and a good weed and leafhopper control program can be effective in reducing the incidence of this disease. Isolating onion seed crops from other host crops and weed sources may also be effective.

Affected umbel showing elongated pedicels.

Severely affected umbel showing “star-burst” appearance.

Foliar symptoms showing yellow and green streaks.

Aster yellows affected seed crop showing umbel distortion.

VIRAL DISEASES

IRIS YELLOW SPOT

LEEK YELLOW STRIPE

ONION YELLOW DWARF

Causal Agent

Iris yellow spot virus (IYSV)

Vectors

Onion thrips *(Thrips tabaci)*

Distribution

Worldwide

Symptoms

Infections remain localised and occur where thrips feed, resulting in an uneven distribution of the disease within the plant. Iris yellow spot virus (IYSV) can only be detected in or adjacent to lesions. Infected leaves are generally dull in appearance. Initially, lesions can be irregular to diamond-shaped and chlorotic to bleached white in colour. Distinctive, defined borders may or may not develop as lesions elongate. Leaves dieback as lesions enlarge and coalesce. Lesions may completely girdle the scape and cause lodging before seeds mature. Infected onion plants usually produce undersized, asymptomatic bulbs. Infected leek plants are stunted.

Conditions for Disease Development

Onion thrips *(Thrips tabaci)* transmit IYSV in a persistent manner. Disease severity is positively correlated with thrips populations in the field. This virus is not seed transmitted. Over-wintering onions, volunteers from prior productions, infected transplants and alternate hosts can all serve as sources of both vector and virus. Bulb to plant transmission of IYSV has not been demonstrated in bulbs collected from infected plants.

Control

All onion and leek varieties are susceptible to IYSV; however some varieties appear less susceptible than others. Many pesticides are available to help manage and control weeds, alternate hosts and the thrips vector. In addition, culled onions from packing operations should immediately be removed from the vicinity of all onion productions to provide further control of the thrips vector.

Developing IYSV lesion.

Irregular to diamond-shaped lesions on leaves.

Numerous IYSV lesions resulting from intense thrips feeding activity.

Uneven distribution of IYSV lesions on scapes.

Causal Agent

Leek yellow stripe virus (LYSV)

Vectors

Many species of aphids

Distribution

Worldwide

Symptoms

Symptom expression can vary by type. In green leeks, leaves of infected plants develop longitudinal yellow stripes and plants appear yellow. In grey leeks, symptoms appear milder and stripes are grey-green. Generally, stripes are more prominent in older leaves. Leaf cuticles of infected plants are thinner than those of healthy plants, and the leaf surface is often rippled in appearance. Infected plants are stunted, lack vigor and may be more prone to frost injury than healthy plants.

Conditions for Disease Development

While principally a pathogen of leek, onion and garlic are also hosts of this virus. Because leeks are vegetatively propagated, leek yellow stripe may be spread through pruning and handling infected plants and bulbils. The virus is transmitted by many aphid species in a non-persistent manner. Cool temperatures and low light favour disease development. Early infections affect plants more severely than those that occur late in the growing season. Infected plants may recover under higher temperatures that favour growth of the host.

Control

Cultural practices that promote vigorous plant growth can help to reduce losses from this disease. Mechanical transmission is best managed by following proper sanitation practices during vegetative propagation. Rogue infected plants and control aphids to reduce incidence of LYSV. This virus is not seed transmitted.

Longitudinal streaking in mature plants.

Longitudinal streaking in mature plants.

Rippled areas of infected leaves.

Causal Agent

Onion yellow dwarf virus

Vectors

Many species of aphids

Distribution

Worldwide

Symptoms

Infected leaves have symptoms ranging from yellow streaks to complete yellowing. Leaves tend to flatten, crinkle, twist and bend over. Plants may be wilted and dwarfed and bulbs usually remain solid but do not reach their full size. In seed crops, plants produce smaller flower clusters and fewer florets.

Conditions for Disease Development

The virus is carried by infected seed bulbs, onion sets and volunteer onions. Many aphid species can transmit this virus from infected to healthy plants. Plants that are infected at a young stage may form small bulbs or fail to form bulbs, whereas plants infected during mid-season may produce slightly undersized bulbs.

Control

Some onion varieties have Intermediate Resistance that can help reduce losses from this disease. The use of true seed for onion production results in virus-free plants since the virus is not seed-borne. The use of virus-free bulbs and sets, and producing crops in an area where the virus is absent are also effective. Roguing out infected plants helps to reduce the incidence of this virus.

Foliar symptoms showing leaf streaking.

Foliar symptoms showing flattening and twisting of the leaves.

Foliar symptoms showing yellow streaking of the leaves.

NONINFECTIOUS DISEASES

BULB SPLITTING

FREEZE DAMAGE

GREENING

HERBICIDE INJURY

LEAF VARIEGATION

NUTRIENT DISORDERS

STORM DAMAGE

SUNSCALD

THRIPS DAMAGE

TRANSLUCENT SCALE

Causal Agent

Physiological

Distribution

Worldwide

Symptoms

The first symptom observed is the splitting of the basal plate. Secondary growth of the affected bulb often occurs as one to several small bulbs protruding from the split basal plate.

Conditions for Disease Development

Uneven irrigation of onion fields increases the incidence of this disorder. Fields that are over-irrigated, allowed to dry completely and then over-irrigated again often have many split bulbs. This condition is more prevalent in areas of the field were stands are thin or uneven. These openings can provide an entrance for secondary microorganisms, which cause bulb decay. Bulb mites (*Rhizoglyphus* species) are frequently associated with bulb splitting. However, they have yet to be implicated as the causal agent.

Control

Attention to seedbed prep, planting and the use of high quality seed will result in uniform stands, which will reduce this disorder. The maintenance of uniform irrigation and fertilisation practices to prevent phases of rapid and slow growth of onion bulbs can reduce the incidence of this disease.

Small bulbs protruding from a split basal plate.

Small bulbs protruding from split basal plates.

Causal Agent

Environmental

Distribution

Worldwide

Symptoms

Affected seedlings become yellow at or near the soil line when temperatures are below freezing for prolonged periods. Upon freezing and thawing the soft tissues lose their integrity and become translucent and watery in appearance and texture. Freeze damaged scales become a greyish yellow colour. Often, individual scales are injured entirely but adjacent inner and outer scales may or may not show freeze damage. The innermost sections of an onion may escape damage. However, the bulb may still be unmarketable.

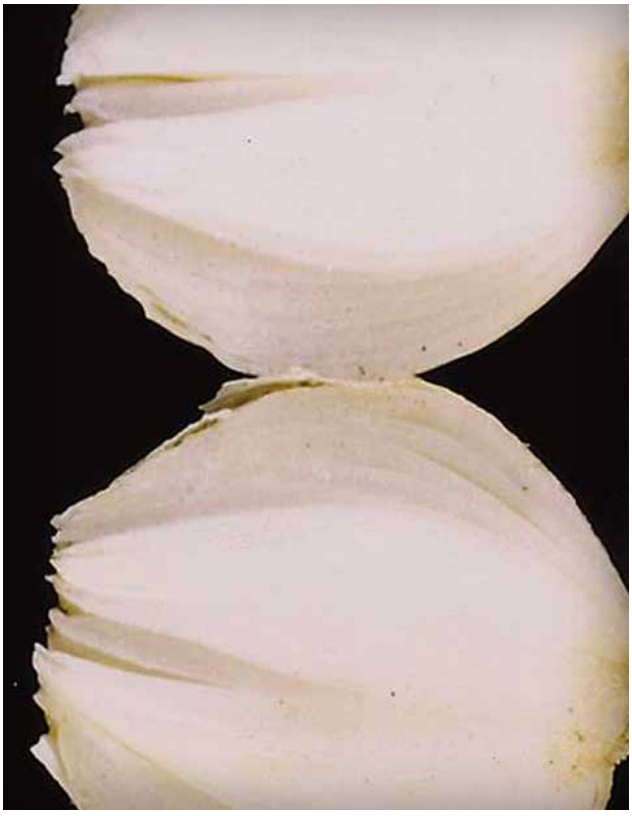
Conditions for Disease Development

Freezing of onions becomes a problem at temperatures below -2°C. When soil is repeatedly frozen and thawed the plants can be heaved to the surface of the soil where they die from root damage and desiccation. Bulbs in the ground are less likely to be freeze damaged than those on the soil surface.

Control

Onion bulbs vary greatly in their ability to tolerate freezing temperature. Onions least tolerant to freezing are usually those lowest in solids such as the Grano types.

Cross-section of a bulb showing water-soaking of freeze-damaged tissue.



Longitudinal-section of a bulb showing water-soaking of freeze-damaged tissue.

Causal Agent
Environmental

Distribution
Worldwide

Symptoms
Sunlight causes the formation of chlorophyll in the outer scales, which results in the scales turning green.

Conditions for Disease Development
Excessive or late season nitrogen applications can delay maturity and enhance the greening of onion bulbs. Greening can occur if onion bulbs are exposed to sunlight during the growing season or the bulbs are allowed to cure for extended periods under moderate light.

Control
An early fertilisation program that promotes foliar development can reduce losses from greening at bulb maturity. Avoid excessive and late season nitrogen application. Do not cure bulbs for extended periods in the field.

Green outer bulb scales.

Green outer bulb scales.

Causal Agent

Herbicides

Distribution

Worldwide

Symptoms

Contact herbicides typically will cause chlorotic or necrotic spots. Multiple spots can result in deformed leaves as well as leaf curling. Systemic herbicides, those that are translocated in the plant, tend to cause a yellowing of the foliage. They may also cause necrotic spots and leaf curling.

Conditions for Disease Development

Generally, foliar damage occurs when herbicides are applied at excessive rates, at the wrong stage of plant growth or during unfavourable weather conditions. Injury often occurs from herbicide drift when crops or weeds adjacent to onions are sprayed. Damage from drift is usually most severe at the edge of a field closest to where a herbicide was applied, with injury decreasing with increasing distance from the source.

Control

Use herbicides as directed and apply during appropriate weather conditions. Plants will frequently recover from foliar damage if it is not too extensive.

Leaf tissue yellowing caused by glyphosate.

Leaf lesions caused by paraquat.

Leaf lesions and leaf curling caused by bromoxynil and oxyfluorfen.

Leaf lesions caused by oxyfluorfen.

Causal Agent

Genetic mutation

Distribution

Worldwide

Symptoms

Leaf tissue is variegated resulting in tissues that have a normal green colour being directly adjacent to tissues that are varying shades of yellow to white in colour. Variegated tissue patterns may be mosaic or linear. The yellow to white tissue is deficient in chlorophyll and can result in abnormal or stunted plant growth when severe.

Conditions for Disease Development

This is a genetic abnormality and its expression and occurrence is unaffected by environmental conditions. This condition generally occurs on only a small percentage of the plants in a field.

Control

Plant seed that is known to be free of genetic abnormalities.

Foliar symptoms showing yellow leaf streaking.

Chimera seen in *Allium cepa*.
(Courtesy H. F. Schwartz—© APS. Reproduced, by permission, from Schwartz, H. F., and Mohan, S. K., eds. 2008. Compendium of Onion and Garlic Diseases and Pests, 2nd ed. American Phytopathological Society, St. Paul, MN.)

Causal Agent

Insufficient nutrients

Distribution

Worldwide

Symptoms

The following symptoms are indicative of nutritional deficiencies, however, soil and foliar fertiliser analyses should be conducted to verify nutritional needs:

Nitrogen: Deficiencies result in stunted plants with pale green to yellow leaves that dieback from the tips. Also, the foliage tends to be erect and the bulbs are smaller than normal and mature earlier. Excess nitrogen causes rapid plant growth and delays maturity. The bulbs tend to be softer and more susceptible to storage rots.

Phosphorus: Deficiencies result in slow growth, delayed maturity and a high percentage of thick necked bulbs at harvest. Leaves become a dull green colour and dieback from the tips without the yellowing associated with nitrogen and potassium deficiencies.

Potassium: Deficiencies result in the foliage initially becoming darker green and the tips of the older leaves begin to wilt, especially on the upper surface. Eventually the leaves droop and take on a satiny progressing to paper-like appearance and develop chlorosis similar to that caused by nitrogen deficiencies.

Magnesium: Deficiencies result in slow plant growth with the older leaves becoming uniformly yellow along their entire length.

Zinc: Deficiencies result in stunted plant growth with noticeable twisting and faint interveinal chlorosis of the leaves. Onions are very sensitive to zinc deficiencies.

Molybdenum: Deficiencies result in poor emergence and seedling death. As the plant grows, leaves will dieback from the tip with a noticeable soft transition zone between the healthy and necrotic tissue. Onions are very sensitive to molybdenum deficiencies.

Manganese: Deficiencies result in slow growth, delayed maturity and a high percentage of thick necked bulbs at harvest. The older leaves develop interveinal chlorosis, which progresses to a tip-burn, and they may curl and eventually become necrotic. Onions are very sensitive to manganese deficiencies.

Boron: Deficiencies result in distorted and stunted plant growth. Leaves become brittle and may turn a grey-green to a blue-green colour. Young foliage may be a mottled yellow green while older leaves become chlorotic with tip dieback and sunken areas. Transverse yellow lines that develop into cracking can occur near the base of the leaves.

Nitrogen deficient (left) and healthy (right).

Conditions for Disease Development

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

Control

Use a balanced fertiliser program. Soil and foliar nutrient analysis can give valuable information on nutritional deficiencies and excesses. Altering the soil pH and using foliar nutrient sprays can correct some deficiencies.

Foliar response to increasing boron concentrations.

Causal Agent

Environmental

Distribution

Worldwide

Symptoms

Injury from wind, pelting rain or hail is usually visible only on the side of leaves that were facing prevailing winds during a storm. Spots develop that are typically 1-5 mm (0.06–0.2 in.) in diameter, white to yellow in colour and round or irregular in shape. Although rain damage is rarely serious, hail damage may defoliate a crop. Storm damage may be confused with *Botrytis* leaf blight or herbicide injury and can also make plants more susceptible to fungal and bacterial pathogens.

Conditions for Disease Development

Raindrops, hailstones and soil particles blown by strong winds wound leaf, neck and flower stalk tissues.

Control

In areas that are subject to storms, seed cereal crops with onions to act as a wind break. Once the onion seedlings are established use selective herbicides to kill the cereal crop. Spray broad spectrum fungicides on storm damaged plants to reduce the risk of secondary infections.

Foliar lesions caused by hail.

Foliar lesions caused by pelting rain.

Causal Agent

Environmental

Distribution

Worldwide

Symptoms

Sunscald is primarily a problem on young seedlings and mature bulbs. High soil temperatures damage seedling tissue at the soil line, resulting in shriveling and collapse of plants. On onion bulbs, affected tissue collapses and becomes bleached, soft and slippery. Affected areas dry and shrivel rapidly, and scales eventually become brown and necrotic. Soft rot organisms can invade and decay the bulbs if sun-scalded onions are not dried and cured rapidly.

Conditions for Disease Development

Direct sun can heat dark soils to temperatures as high as 65°C resulting in tissue death at the soil line. Harvesting and curing onions in direct sunlight can result in sunscald on the bulbs.

Control

Sow onion seed to avoid high soil temperatures when seedlings are succulent and most susceptible to sunscald. Onions can be cured in the field only after day-time high temperatures are below 29°C. If curing is done in the windrows, the tops of one set can be used to cover the bulbs of the previous set.

Affected tissue collapses and becomes bleached in appearance.

At the soil line affected tissue shrivels and collapses.

Causal Agent

Thrips tabaci (the onion thrips), *Frankliniella occidentialis* (the western flower thrips) and numerous other species

Distribution

Worldwide

Symptoms

Thrips damage results from the piercing and rasping action of the cone-shaped mouth parts of the insect. At first, tiny, dark green spots appear on the leaf. These spots become white or silver with time and if widespread, can impart a silvery streaked appearance to the leaves, which will appear as a bright sheen in direct sunlight. Severely affected leaf tissues wither and collapse when plants are water stressed. Thrips are most commonly found between the newest growing leaves or in seed heads.

Conditions for Disease Development

Thrips over-winter in bulbs, as larvae or pupae in leaf litter or in the soil and on alternate hosts. The life cycle of these insects from egg to adult can be completed within two weeks. Thrips damage is greatest after periods of hot, dry weather. Cool, rainy weather reduces thrips populations and thrips damage.

Control

Good crop management and sanitation generally keep thrips damage to a minimum. Healthy leaf tissue will endure thrips feeding better than stressed tissue. *Thrips tabaci* has a wide host range including numerous weed species; thus, weed control in and around an onion crop may reduce thrips levels. Also, cultivation and plowing to eliminate debris near the soil surface will reduce thrips populations. Insecticide control is feasible, however, several applications are usually required and resistance to insecticides has been reported.

Thrips feeding on the leaf surface.

A high population of thrips feeding results in white-silvery spots and streaks on the foliage.

Synonym

Physiological breakdown

Causal Agent

Environmental

Distribution

Worldwide

Symptoms

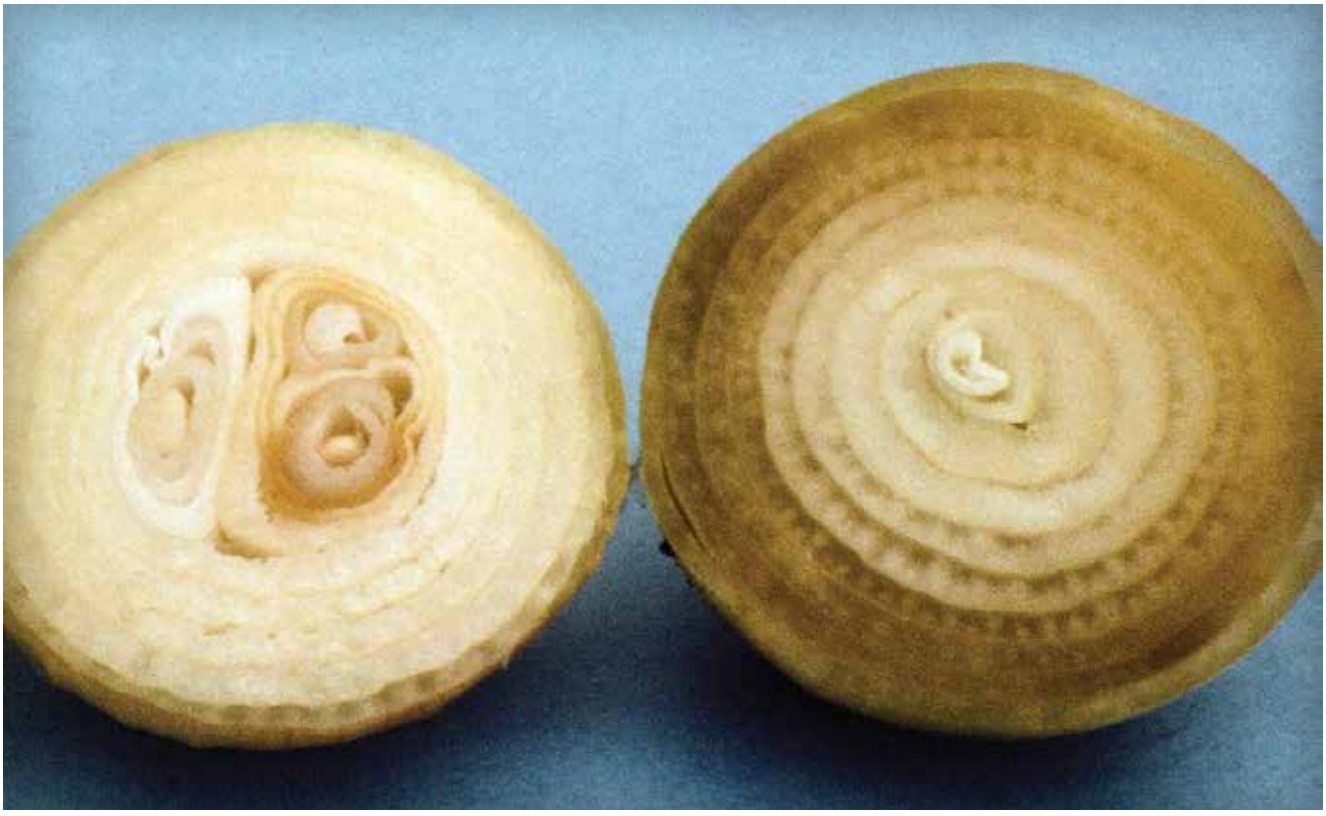
Translucent scale typically appears after harvest and worsens after 3-4 months of bulb storage. The onion scales take on a greyish watery texture making them appear translucent. All scales can be affected, however, typically only the second and third fleshy scales exhibit symptoms. These symptoms are similar to freezing injury and can be distinguished from it only when it is known the bulbs were not subjected to cold temperatures. Also, frost damage occurs from the outside in, and opaque white tissues are often produced within frost damaged scales.

Conditions for Disease Development

Exposure to high relative humidity and high temperatures 32°C during the last several days of field curing onions can cause an increase in the incidence of this disorder. In addition, a delay of 2-4 weeks between field curing and cold storage of onions at 0°C may also increase the incidence of this disorder.

Control

Onion bulbs should be cured properly and stored at the appropriate temperature 0°C and relative humidity.



Bulb cross-section showing the greyish watery texture of the scales.

GLOSSARY

ABIOTIC Of or pertaining to the absence of life, as in a disease not caused by living organisms.

ALTERNATE HOST One of two species of host on which some pathogens, such as certain rust fungi, must develop to complete their life cycles; or, a species of host other than the principal host on which a parasite can survive.

AXIL The upper angle between a lateral organ, such as a leafstalk, and the stem that bears it.

BACTERICIDE A substance that kills bacteria.

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

BASAL PLATE The base of the stem where root growth is initiated.

BLIGHT A sudden and severe necrosis of the above ground portions of a plant.

BULBIL A small secondary bulb that forms in the angle between a leaf and stem or in place of flowers on certain plants.

CANKER A localised, diseased area on roots or stems where tissue shrinks and cracks open.

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

CHLAMYDOSPORE A thick-walled, asexual resting spore produced by some fungi.

CHLOROPHYLL The green pigment used by plants in their food production process.

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

COALESCE To come together.

CONCENTRIC Different size circles having a common centre.

CONIDIUM (pl. conidia) A fungal spore formed asexually.

COTYLEDON The first foliar structure to emerge from a seed.

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

DEBRIS Remnant plant material.

DEFOLIATION The loss of leaves.

DIEBACK Progressive death of shoots, branches or roots, usually starting from the tip, as the result of biotic or abiotic factors.

DISTAL Located far from the point of attachment.

DIURNAL Occurring or active during the daytime.

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

ENDOGENOUS Produced, living or undergoing development inside.

EPIDERMIS The superficial layer of cells occurring on all plant parts.

EPIPHYTE An organism (e.g. bacterium) growing on the surface of a plant, from which it gains physical and nutritional support, without causing disease.

FALLOW Pertains to cropland not cultivated or not planted for one or more seasons.

FLORET Small flower, usually part of a dense cluster.

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 or infected plants.

FUMIGATION Sterilising by fuming action.

FUNGICIDE A substance that kills or inhibits the growth of fungi.

FUNGUS (pl. fungi) A microscopic organism with thread-like cells which lives on dead or living plants.

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

GIRDLE To encircle with dead tissue around a root or stem.

HERBICIDE A substance used to control weeds.

HIGH RESISTANCE The ability of a plant variety to highly restrict the activities of a specific pathogen or insect pest and/or to restrict the symptoms and signs of a disease, when compared to susceptible varieties. Varieties with high resistance may exhibit some symptoms when specified pathogen or pest pressure is severe. New and/or atypical strains of the specific pathogen or pest may overcome the resistance, sometimes completely.

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

INFECTION The process by which an organism attacks a plant.

INFESTED Containing great numbers 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 potentially infective agent available in soil, air or liquid that could be applied to a host either naturally or artificially to elicit a response.

INTERMEDIATE RESISTANCE The ability of a plant variety to restrict the growth and development of the specified pest or pathogen, but may exhibit a greater range of symptoms compared to varieties with high resistance. Plants that have Intermediate Resistance will still show less severe symptoms or damage than susceptible plant varieties when grown under similar environmental conditions and/or pest or pathogen pressure.

INTERVEINAL The area of tissue bordered by veins.

LENTICULAR Shaped like a biconvex lens.

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

MOSAIC The pattern of light and dark areas often caused by viruses.

MOTTLE Irregular blotches of light and dark areas.

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

NECK The part of an onion or leek plant just above the bulb. Consists of the lower portions of leaves and/or scape(s).

NECROSIS (adj. necrotic) The death of plant cells or tissue, usually accompanied by black or brown darkening.

NEMATICIDE A substance that kills or inhibits nematodes.

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).

OPPORTUNISTIC A pathogen that is naturally saprobic and often common, but on occasion able to cause disease in a host plant rendered susceptible by one or more predisposing factors.

PATHOGEN An agent that incites disease.

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

PEDICEL Small slender stalk; stalk bearing an individual flower, inflorescence or spore.

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

PHYSIOLOGICAL DISEASE A disease (or disorder) produced by some unfavourable genetic, physical or environmental factor.

PHYTOPLASMA An obligate, pleomorphic, single-celled organism lacking a cell wall.

PROPAGULE Any part of an organism capable of initiating independent growth when separated from the parent body (e.g. fungal spore).

PUSTULE The small blister-like elevation of epidermis formed as fungal spores develop and emerge.

RACE A group of pathogens with distinct pathological or physiological properties.

RESERVOIR Plants which are infected with a disease-causing organism and can serve as a source for further infection of other plants.

ROGUE To remove and destroy undesired individual plants from a population.

SATURATION Being completely filled with liquid, generally water.

SCALE Fleshy basal leaf tissue that forms the layers of a bulb.

SCAPE A peduncle, rising from the ground, naked or without leaves; a leafless flower stalk.

SCLEROTIUM (pl. sclerotia) A hardened resting body produced by certain fungi.

SEEDBORNE PATHOGEN An 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 aging process; often hastened by environmental stress, disease or insect attack; growing old.

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 whose 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.

STRAIN A general term referring to (a) an isolate; descendent of a pure culture of a pathogen, (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 plants to restrict the activities of a specified pest or pathogen.

SYSTEMIC Spreading internally throughout the plant

GLOSSARY

TELEOMORPH The sexual form of a fungus. Sexual spores are produced after meiosis occurs.

TELIOSPORE Thick-walled resting or over-wintering spore produced by the rusts (Uredinales) and smuts (Ustilaginales) in which karyogamy occurs; it germinates to form a promycelium (basidium) in which meiosis occurs.

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

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

TRANSLUCENT Transmitting light but diffusing it enough to cause images to be blurred.

TRANSPIRATION The loss of water vapor from the surface of leaves.

UMBEL A type of inflorescence in which flowers are borne at the end of a common stalk forming a more or less flattened or rounded cluster; can be composed with subsets of umbels.

UREDINIOSPORE Binucleate, dikaryotic (n+n), asexual, one-celled repeating or summer spore of rust fungi; borne in a uredinium.

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

VASCULAR Referring to the conductive system of a plant composed of the xylem and phloem.

VECTOR An organism able to transmit a pathogen.

VIRUS Very small sub-microscopic disease-causing agent.

WATER-SOAKED Tissue having the appearance of being soaked in water.

WINDROW Leaves or other plant material swept or raked into rows to dry.

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

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

REFERENCES

Allium Crop Science: Recent Advances. *2002. H. D. Rabinowitch and L. Currah, eds., CAB International, Wallingford, Oxon, United Kingdom.*

Burkholderia semiarida sp. nov. and Burkholderia sola sp. nov., two novel B. cepacia complex species causing onion sour skin. *2023. L.S. Velez, F.F. Aburjaile, A.R.G. Farias, A.D.B. Baia, W.J. Oliveira, A.M.F. Silva, A.M. Benko-Iseppon, V. Azevedo, B. Brenig, J.H. Ham, E.B. Souza, M.A.S. Gama. Systematic and Applied Microbiology. 46(3):126415.*

Colour Atlas of Post-Harvest Diseases and Disorders of Fruits and Vegetables, volume 2: Vegetables. *1992. A. L. Snowdon. CRC Press Inc., Boca Raton, Florida.*

Colourado Onion Production and Integrated Pest Management. *1995. H. F. Schwartz and M. E. Bartolo. Colourado State University Cooperative Extension, Fort Collins, Colourado.*

Compendium of Onion and Garlic Diseases and Pests, 2nd Ed. *2008. H. F. Schwartz and S. K. Mohan. APS Press. The American Phytopathological Society, St. Paul, Minnesota.*

Diagnosis of Mineral Disorders in Plants, volume 2. *1983. A. Scaife and M. Turner. Her Majesty's Stationary Office, London, United Kingdom.*

Diseases and Pests of Vegetable Crops in Canada. *1994. R. J. Howard, J. A. Garland and W.L. Seaman. The Canadian Phytopathological Society and the Entomological Society of Canada, Ottawa, Ontario, Canada.*

Diseases of Onions in Canada. *1981. R. Crete, L. Tartier and A. Devaux. Publication #1716E. Minister of Supply and Services Canada. Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada.*

Nutritional Deficiencies and Toxicities in Crop Plants. *1993. W. F. Bennett. APS Press. The American Phytopathological Society, St. Paul, Minnesota.*

Onion Diseases and Their Control. *1961. J. C. Walker and R. H. Larson. Agricultural Handbook No. 208, Agricultural Research Service, United States Department of Agriculture, Washington, D.C.*

Onions and Other Vegetable Alliums. *1994. J. L. Brewster. CAB International, Wallingford, Oxon, United Kingdom.*

Pantoea allii sp. nov., isolated from onion plants and seed. *2011. C.L Brady, T. Goszczynska, S.N. Venter, I. Cleenwerck, P. Vos, R.D. Gitaitis, T.A. Coutinho and P. de Vos. International Journal of Systematic and Evolutionary Microbiology. 61:932–937.*

Vegetable Diseases and Their Control, 2nd Ed. *1986. A. F. Sherf and A. A. MacNab. John Wiley and Sons. New York, New York.*

Publication date: July 2025

Vegetables by Bayer Australia
Level 4, 109 Burwood Rd
Hawthorn VIC 3122

Customer Service
1800 364 846
vegetables.australia@bayer.com

Vegetables by Bayer New Zealand
704 Harrisville Rd
Pukekohe RD2 2677

Customer Service
(09) 239 0666
vegetablesales.nz@bayer.com

vegetables.bayer.com

BAYER | Seminis | De Ruiter