2019

SOIL-BORNE DISEASE IN VEGETABLE CROPS

A practical guide to identification and control

ahr applied horticultural research

Hort Innovation

RMCG

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INTRODUCTION

Soil-borne diseases present an ongoing challenge to the Australian vegetable industry, with an estimated $120 million in losses annually.

Soil-borne diseases may be caused by fungi, bacteria, water moulds, nematodes and viruses living in the soil. These pathogens are able to survive for long periods on plant debris, organic matter or sometimes as free-living organisms, i.e. not requiring a plant host. The ability to survive for long periods in the soil, and often having a wide host range, makes control of soil-borne diseases difficult.

There are many factors that influence how often and how serious pathogens in the soil will impact on plant health. They include the plant genetics, environmental conditions, cultural practices and the types of other microbes present in the soil or root zone (see Figure 1.)

Figure 1. Factors contributing to plant health and resilience to soil borne diseases.

Some of these factors are more easily controlled than others and knowing how to best manage them to optimise plant health can be very powerful in the fight against soil-borne diseases.

HOW TO USE THIS GUIDE

The book is divided into chapters based on vegetable crop families.

EACH CHAPTER WILL COVER

1. *How to identify the most common soil-borne diseases affecting vegetable crops in Australia and conditions which favour disease*
2. *Summary of the methods available for control.*

Details on where you will find this information provided below

Chapters are divided by crop families and this will appear at the top and to the side of every page, along with the common, or everyday name of the disease.

CROP FAMILY

COMMON NAME

Scientific name

Sometimes there are different common names for the same disease. To avoid confusion the scientific name - which is the same the world over – is also provided.

WHAT SHOULD I LOOK FOR?

Here you will find images of typical symptoms of the disease to help with identification.

Discription of symtoms and additional onformation to help in disease indentification.

WHERE WILL I SEE SYMPTOMS?

STEM LEAVES

The parts of the plant where you will see symptoms are shown here

FAVOURABLE CONDITIONS

WET WARM WINDY

• 15-20°c

The environmental conditions which favour disease development are identified here

Look here for further info on what type of structure or mechanism the disease uses to survive in the soil, as well as typical survival time, which will vary depending on soil type, climate, etc.

CROP FAMILY | COMMON NAME

Here you will find images of typical symptoms of the disease to help with identification.

Some diseases are seen in large areas and others are more scattered in pockets across the field. This section gives a clue on what you should expect to see in the field:

Discription of symtoms and additional onformation to help in disease indentification.

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER WIND MOVEMENT OF CONTAMINATED SOIL CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS :

Soil-borne diseases can be spread by different mechanisms, which are summarized here

Here you will find options for disease control divided into sections based on when the strategies for control are best applied.

HOW DO I CONTROL IT?

FALLOW

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use chemical fumigants with care and as per label.

The fallow period refers to the time between crops when the field is typically bare. In vegetable production systems this period can be very short. Where possible, longer fallow periods can be useful in the fight against soil-borne disease and good management during this time is critical.

PLANTING PREPARATION

CROP ROTATION
Select non-host rotation or cover crops

DRAINAGE
Plant on raised beds or well-draining soil

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

Planting preparation is the period leading up to planting when you decide what crops are going to be planted and in which field. Considering paddock history, particularly in relation to plant disease, is very important in managing risk.

POST-PLANT

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread.

CONTROL PESTS
Control insect pests that spread spores

CHEMICAL TREATMENT
Treat plant with registered foliar fungicide

Control of soil-borne diseases post-planting can be a challenge. While control options are often limited, some are presented here, as well as recommendations on where to go for the most current information.

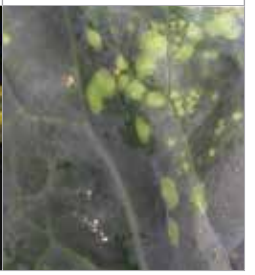
HOST RANGE

This sections outlines some of the other plants that host this disease. This is an important consideration when planning crop rotations.

BRASSICAS

Includes cabbages, cauliflower, broccoli, kale, mustards and Brussels sprouts

Black leg	Clubroot	Damping-off/ Wirestem	Fusarium wilt (yellows)
Page10	Page 14	Page 18	Page 22
			

Root knot nematode	Sclerotinia rot	Verticillium wilt	White blister rust
Page 26	Page 30	Page 34	Page 38
			

BLACK LEG (PHOMA LEAF SPOT)

Leptosphaeria maculans (Phoma lingam)

WHAT SHOULD I LOOK FOR?

Leaf lesions may appear as (a) grey ciruclar spots containing many small black dots (b) or white to brown spots with many tiny black dots in the centre *L. Tesoriero*

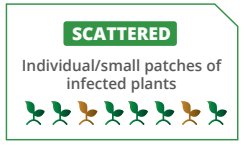
Stem and stalk develop sunken brown to purple lesions which eventually turn black and split. *L.Tesoriero*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 15-20°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Mycellium/pseudothecia

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

CROP ROTATION

Select non-host rotation or cover crops

CHEMICAL TREATMENT

Use registered soil drench fungicides at planting

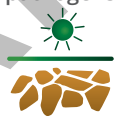
- Consult APVMA or InfoPest website for current registered products

DRAINAGE

Plant on raised beds or well-draining soil

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens



POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Other brassicas including cabbage, Chinese cabbage, kale, broccoli, cauliflower, mustards, radish, turnip, shepherds purse etc.

CLUBROOT

Plasmodiophora brassicae

WHAT SHOULD I LOOK FOR?

Digging up wilted plants reveals knot-like swelling (galls) on the root sytsem *S. Grigg*

Scattered areas of wilted plants may be seen across the field *S. Grigg*

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

FAVOURABLE CONDITIONS

WARM

WET

pH<7 ACIDIC SOIL

- 20-26°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Resting spores (zoospores)

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

CROP ROTATION

Select non-host rotation or cover crops

DRAINAGE

Plant on raised beds or well-draining soil

CROP SELECTION

Choose a less susceptible/resistant cultivar

SOIL PH

Use amendments to adjust soil pH

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

MAY BE CONFUSED WITH

Root-knot nematode

HOST RANGE

Other brassicas including cabbage, Chinese cabbage, kale, broccoli, cauliflower, mustards, radish, turnip, shepherds purse etc.

DAMPING-OFF / WIRESTEM

Pythium spp / Rhizoctonia solani

WHAT SHOULD I LOOK FOR?

Brassica seedlings showing symptoms of wilting and death caused by damping-off *B. Winter*

Stem dicolouration and rot can be seen at that base of stem, in this case caused by Rhizoctonia spp. Stem eventually collapses leading to wilt and plant death *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

STEM BASE

ROOTS

FAVOURABLE CONDITIONS

COOL

WATERLOGGED SOIL

- 13-15ºC

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Resting spores (oospores)

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

TRANSPLANTS

Use seedling transplants - not direct seeding

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

All brassicas, and a wide range of other vegetables

FUSARIUM WILT (YELLOWS)

Fusarium oxysporum f. sp. conglutinans

WHAT SHOULD I LOOK FOR?

Cutting open the stem reveals brown discolouration of the internal tissue *L. Tesoriero*

Lower leaves appear stunted, wilt and turn yellow often more on one side of the plant
L. Tesoriero

WHERE WILL I SEE SYMPTOMS?

LEAVES

STEM

FAVOURABLE CONDITIONS

WARM
- 13-15ºC

PLANT STRESS
- Especially potassium deficiency

AMMONIUM FERTILISERS
- Ammonium fertilisers can favour disease

DISTRIBUTION IN THE FIELD

SCATTERED
Individual/small patches of infected plants

HOW DOES IT SPREAD?

- INFECTED SEED/ SEEDLINGS
- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resis-tant cultivar

FERTILISER SELECTION

- Avoid acidifying NH4+ fertilizers

GOOD NUTRITION

Ensure plants nutritional needs are met

- Calciumsupplements may help suppress dieases

POST-PLANT

CONTROL PESTS

Control insect pests that spread spores

- Particularly important at the seedling stage

MAY BE CONFUSED WITH

Black rot (*Xanthomonas spp.*) Water or nutrient stress

HOST RANGE

Very wide including all brassica Vegetables

BRASSICAS

ROOT-KNOT NEMATODE

WARM-CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

COOL-CLIMATE SPECIES: *Meloidogyne hapla | Meloidogyne fallax*

WHAT SHOULD I LOOK FOR?

Aboveground, scattered areas of stunted, yellow and wilted plants may be visible. Belowground, infection with root-knot nematode results in swelling and galls on the root.
S. Nelson FLICKR

WHERE WILL I SEE SYMPTOMS?	WHOLE PLANT, ROOTS • Lower leaves
FAVOURABLE CONDITIONS	WARM, SANDY SOIL • Active 15°C + COOL, SANDY SOIL • Active 8.5°C +
HOW DOES IT SPREAD?	FREE WATER, MOVEMENT OF CONTAMINATED SOIL, CONTAMINATED PLANT DEBRIS
DISTRIBUTION IN THE FIELD	**LARGE AREAS** Large areas of infected plants clearly visible

SURVIVES IN SOIL AS : Adult or eggs

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

PLANT TRAP CROPS
Plant nematode resistant crops that prevent reproduction

ADJUST DATE
Adjust planting/harvest date to reduce infection risk

- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g.PREDICTA® B testing service.If numbers are high consider fallow or nonhost break crop

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resis-tant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

MAY BE CONFUSED WITH

Clubroot

HOST RANGE

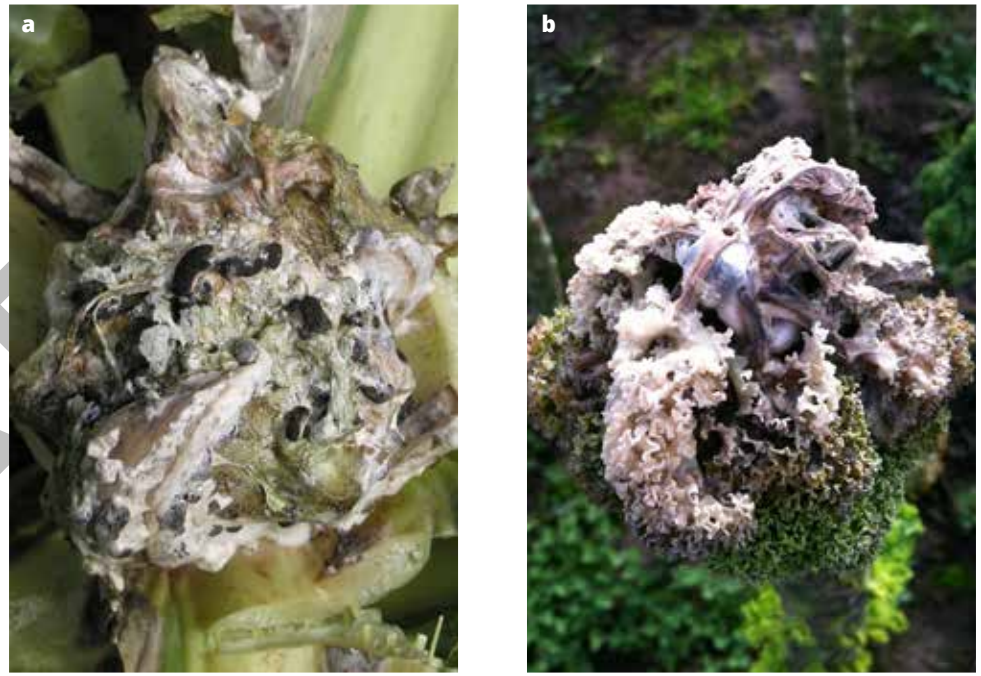
Very wide with over 2000 plant species acting as hosts to root-knot nematode

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

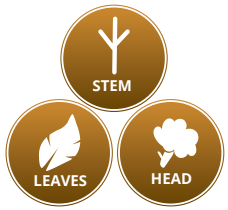
Symptoms begin as water-soaked lesions which eventually rot and collapse *R. Lancaster*



Characteristic white fluffy growth with black fruiting bodies (sclerotia) as seen on (a) a cauliflower head and (b) kale head. *S. sclerotiorum* can produce sclerotia up to 25mm long and *S.minor* produce much smaller sclerotia (up to 3mm long)

a: R.Lancaster , b: C. Ocamb, PNW Handbooks

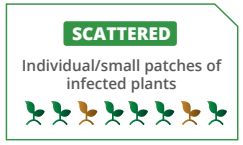
WHERE WILL I SEE SYMPTOMS?



FAVOURABLE CONDITIONS

• 13-18ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break from host crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most brassica vegetable crops and many weeds e.g. shepherd's purse, thistles, mustard, pigweed

VERTICILLIUM WILT

Verticillium dahliae | V. longisporum

WHAT SHOULD I LOOK FOR?

Pale green to yellow discolouration between veins. Eventually leaf will wilt and die, often only on one side of the plant. Dicoloured vascular tissue can also be seen at the base of the plant.
L. Tesoriero

Cutting open the stem reveals brown flecks of discoloured vascualr tissue, often in a V-shape
Ohio State University Extension

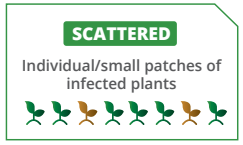
WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Air 23-25°C optimum for infection
- pH >7

Ammonium fertilisers can favour disease

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Microsclerotia

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

- Biofumigant brassica crops may help suppress disease

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

PLANTING PREPARATION

FERTILISER SELECTION

- Ammonium fertilisers help supress disease

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

MAY BE CONFUSED WITH

Fusarium wilt

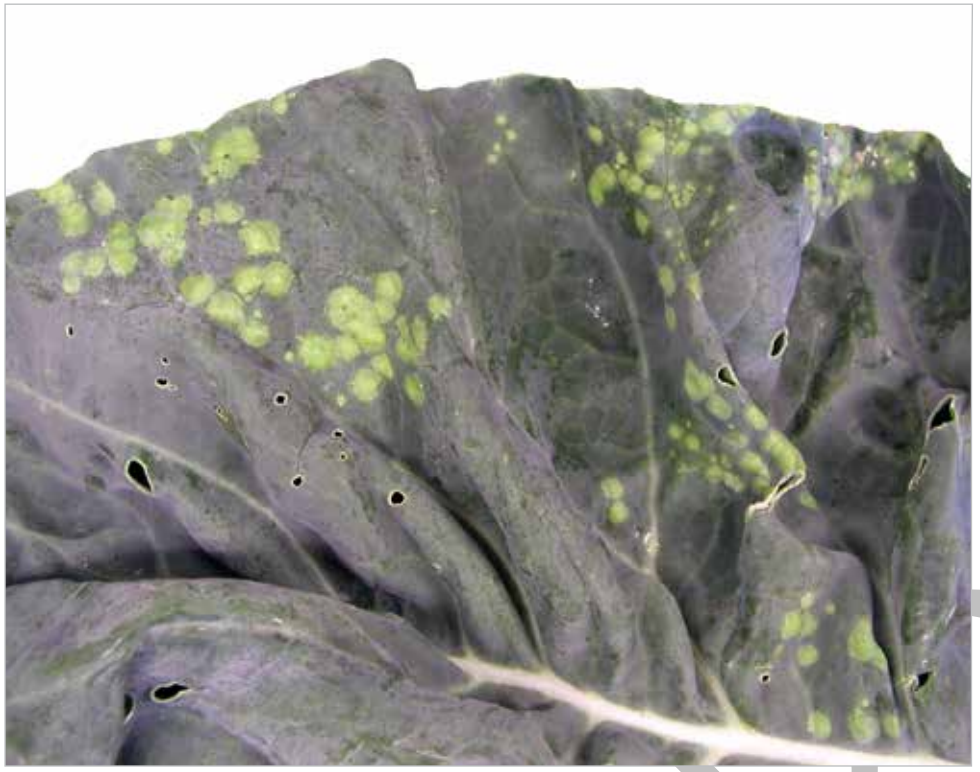
HOST RANGE

Brassica crops and weeds, tomatoes and olives

WHITE BLISTER RUST

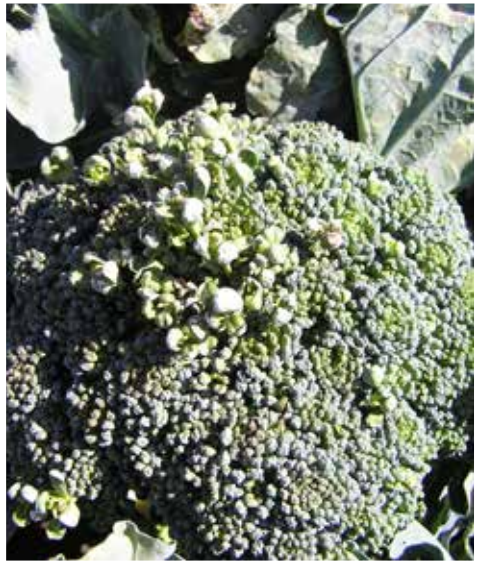
Albugo candida

WHAT SHOULD I LOOK FOR?



Light green to yellow spots can be seen on the top side of the leaf *R. Lancaster, DPIRD*

White blisters containing powdery spores form on the underside of the leaf
R. Lancaster, DPIRD



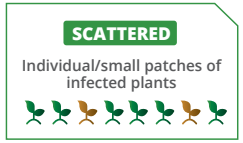
If the infection is inside the plant (systemic) abnormal growth such as tall leggy plants or distorted heads can be seen *R. Lancaster, DPIRD*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 13-25ºC
- >2-3 hrs

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Oospores in soil or plant debris

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break from host crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

DRAINAGE

Plant on raised beds or well-draining soil

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

AIR CIRCULATION

Increase row spacing to improve air circulation

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

GOOD NUTRITION

Ensure plants nutritional needs are met

- Ensure adequate. P and K Avoid excess N

HOST RANGE

Wide range of brassica vegetable including broccoli, cabbage, cauliflower, and weeds such as wild radish and wild turnip

CAPSICUM, CHILLI, EGGPLANT

Bacterial wilt	Damping-off	Phomopsis blight	Pythium root rot
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Root-knot nematode	Sclerotinia/white mould	Sclerotium rot	Verticillium wilt
Page 62	Page 66	Page 70	Page 74
			

CAPSICUM, CHILI, EGGPLANT

BACTERIAL WILT

Ralstonia solancearum

WHAT SHOULD I LOOK FOR?

Leaf yellowing, wilting and death in warm conditions within days of infection

M. Furlong, University of Queensland

Dissecting the lower stem reveals brown discolouration of internal tissue

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

To help identify bacterial wilt, cut the stem of an infected plant and place in a clear container with water. Look for a white milky liquid flowing from the stem

WHERE WILL I SEE SYMPTOMS?

LEAVES

STEM

FAVOURABLE CONDITIONS

HOT

• 25-35°C

HIGH HUMIDITY

WET

• Moist soil favours disease

DISTRIBUTION IN THE FIELD

HOW DOES IT SPREAD?

INFECTED SEED/ SEEDLINGS

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : A bacterial cell

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

GRAFTING

Use transplants grafted onto resistant rootstock

DRAINAGE

Plant on raised beds or well-draining soil

SOIL PH

Use amendments to adjust soil pH

- Adjust pH to 5.5-7

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Wide host range including most solanceae vegetable crops

DAMPING-OFF

Pythium spp. | *Phytophthora* spp. | *Rhizoctonia* spp.

WHAT SHOULD I LOOK FOR?

Infection may cause seed rot, resulting in large bare patches where the seed has failed to germinate

Penn State Department of Plant Pathology & Environmental Microbiology Archives, Penn State University, Bugwood.org

Seedlings that do emerge may have yellow to light brown discolouration around the stem at ground level. As the disease progresses stem eventually collapse leading to wilting and death

G. Holmes, California Polytechnic State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

ROOTS

STEM BASE

FAVOURABLE CONDITIONS

COOL

WATERLOGGED SOIL

DELAYED SEEDLING EMERGENCE

- 13-15°C

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Resting spores, sclerotia, or chlamydospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

DRAINAGE
Plant on raised beds or well-draining soil

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

TRANSPLANTS
Use seedling transplants - not direct seeding

POST-PLANT

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

HOST RANGE

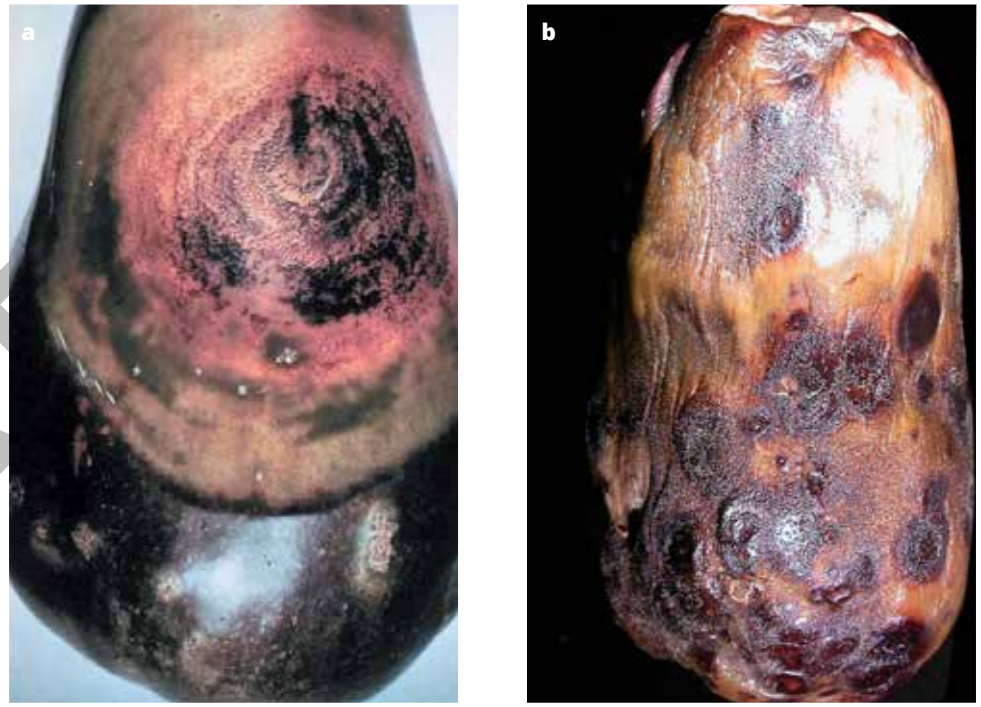
Wide - potatoes, eggplant, chilli, capsicum, brassica, carrots, cucurbits, lettuce etc.

PHOMOPSIS BLIGHT

Phomoposis vexans

WHAT SHOULD I LOOK FOR?

Small grey to light brown lesions with light coloured centres that expand covering large areas on leaf, stem or fruit. Leaves eventually wilt and drop. Stem develop large sunken cracked cankers *Yuan-Min Shen, Taichung District Agricultural Research and Extension Station, Bugwood.org*



Fruit lesions may be (a) sunken and soft with tiny black dots (fruiting bodies) around the margin or in rings and (b) in dry conditions fruit may shrivel

(a) D. Langston, University of Georgia, Bugwood.org (b) B.Olson, Oklahoma State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

LEAVES, STEM, FRUIT

FAVOURABLE CONDITIONS

COOL

- 13-15°C

WATERLOGGED SOIL

DELAYED SEEDLING EMERGENCE

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

INSECTS

SURVIVES IN SOIL AS : Pycnidia

SURVIVAL TIME WITHOUT HOST 3-10 years

WHAT SHOULD I LOOK FOR?

With age small black (pycnidia) can be seen within the lesion

B.Olson, Oklahoma State University, Bugwood.org

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 3 year break between eggplant crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

POST-PLANT

AIR CIRCULATION

Increase row spacing to improve air circulation

HOST RANGE

Eggplant

PYTHIUM ROOT ROT

Pythium aphanidermatum

WHAT SHOULD I LOOK FOR?

Aboveground, plants will appear wilted with yellowing of leaves that will eventually die

L.Tesoriero

Sunken dark lesions may occur on lower stems or a rot of the roots may develop

Penn State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

ROOTS

STEM BASE

FAVOURABLE CONDITIONS

HOT OR COOL

- 12-18°C

Can develop in hot or cold conditions

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Resting spores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 3 year break between eggplant crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CHEMICAL TREATMENT

Use registered soil drench fungicides at planting

- Consult APVMA or InfoPest website for current registered products

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Capsicums

CAPSICUM, CHILI, EGGPLANT

ROOT-KNOT NEMATODE

WARM CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

COOL-CLIMATE SPECIES: *Meloidogyne hapla | Meloidogyne fallax*

WHAT SHOULD I LOOK FOR?

Aboveground symptoms plants may appear chlorotic and stinted

G. Holmes, California Polytechnic State University

Belowground roots develop characteristic swelling and galls

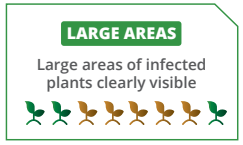
S. Nelson FLICKR

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Active 15°C +
- Active 8.5°C +

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Adult or eggs

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non host break crop

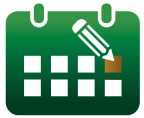
PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

ADJUST DATE
Adjust planting/harvest date to reduce infection risk



- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations

HOST RANGE

Very wide with over 2000 plant species acting as hosts to root-knot nematode

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | Sclerotinia minor

WHAT SHOULD I LOOK FOR?

Symptoms begin as water-soaked lesions on the stem or fruit, which eventually rot and collapse

C. Ocamb, PNW Handbooks

As the disease progresses characteristic white fluffy growth develops followed by black fruiting bodies (sclerotia) *S. sclerotiorum* can produce sclerotia up to 25mm long and *S.minor* produce much smaller sclerotia (up to 3mm long)

C. Ocamb, PNW Handbooks.

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

FAVOURABLE CONDITIONS

COOL

WET

•13-18ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

PLANTING PREPARATION

AIR CIRCULATION
Increase row spacing to improve air circulation

DRAINAGE
Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING
Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

CHEMICAL TREATMENT
Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species) including most vegetables and weeds in the pepper (nightshade) family

SCLEROTIUM ROT

Sclerotium rolfsii

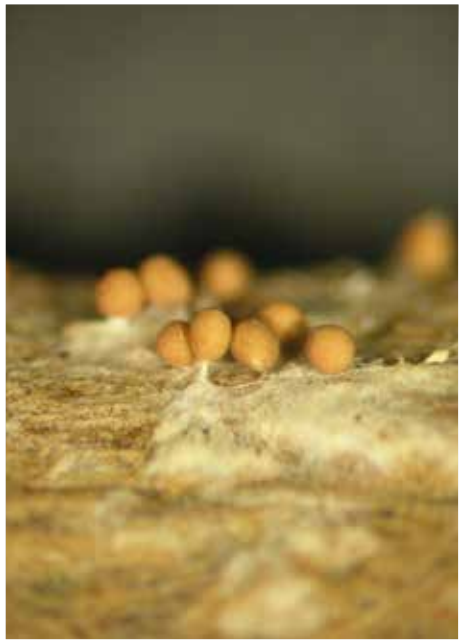
WHAT SHOULD I LOOK FOR?

Begins as a watery rot on stem or fruit that eventually leads to collapse of infected area. Infection of the lower stem can cause plant wilting and potential death

G. Holmes, California Polytechnic State University, Bugwood.org

Characteristic white "ropey" fungal growth develops along with light brown survival structures (sclerotia)

G. Holmes, California Polytechnic State University, Bugwood.org



Survival structures may develop on the infected tissue or soil surface and resemble mustard seeds

P.Bachi, University of Kentucky Research and Education Center, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

STEM

PODS

FAVOURABLE CONDITIONS

WARM

WET

pH<7 ACIDIC SOIL

• 25-35°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 500 different plant species) including capsicum and chilli

VERTICILLIUM WILT

Verticillium dahliae

WHAT SHOULD I LOOK FOR?

Begins as pale green blotches between veins and leaf margins. Eventually leaf will wilt, turn brown and die as the disease move up the plant. Often only on one side of the plant

Ontario Crop IPM, OMAFRA

Stunting of plants may also occur, as shown here with verticillium infected peppers on the right compared to healthy plants on the left

Ontario Crop IPM, OMAFRA

Cutting open the stem reveals brown flecks of discoloured vascular tissue, often in a V-shape

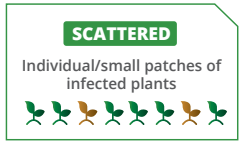
G. Holmes, California Polytechnic State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Air 23-25°C optimum for infection

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Microsclerotia

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

PLANTING PREPARATION

FERTILISER SELECTION

- Ammonium fertilisers help supress disease

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

MAY BE CONFUSED WITH

Fusarium wilt

HOST RANGE

Eggplants, tomatoes, olives, brassica crops and weeds

CARROT, CELERY, PARSNIP AND PARSLEY

BLACK CANKER

Itersonilia perplexans | Cylindrocarpon spp. | Mycocentrospora acerina

WHAT SHOULD I LOOK FOR?

Orange-brown lesions often with a pale green-yellow hallow form can be seen on the leaves. *M.Kowalik-Kepler, APS*

Red-brown to black cankers develop typically crown or shoulder of the root. Initially on the surface but. may decay further with secondary infection by other pathogens. *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

LEAVES

CARROT ROOT

FAVOURABLE CONDITIONS

COOL

- 18-22ºC

WET

- Periods of extended rain

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST < 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

- Minimum 12 months break between parsnip crops

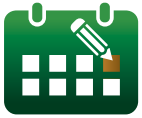
PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

ADJUST DATE

Adjust planting/harvest date to reduce infection risk



CROP SELECTION

Choose a less susceptible/resistant cultivar

- Avoid an autumn planting/spring harvest which can favour infection

HOST RANGE

Parsnip, carrot

BLACK ROOT ROT

Thielaviopsis basicola (Chalara elegans) or Chalaropsis thielavioides

WHAT SHOULD I LOOK FOR?

Dark grey to black fungal growth can develop around leaf base in the field. Blackened areas develop on roots, mostly post harvest when spores rapidly spread on wet carrots that are not stored below 5ºC

L DuToit, WSU

Blackened areas have a sooty appearance, do not have distinct margins and do not move beyond the skin of the carrot root

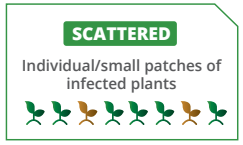
DPIRD

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 17-25ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-drawing soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Minimise irrigation splash

HARVEST

CLEAN WASH WATER

Ensure wash water is regularly sanitized and changed

AVOID PLANT INJURY

Avoid any physical damage to plant

POST-HARVEST STORAGE

- Rapid cooling and store at 0°C

HOST RANGE

Wide host range including beans, peas, cotton, lettuce, lucerne, lupin and soybean

CARROT SCAB

Streptomyces scabiei

WHAT SHOULD I LOOK FOR?

No visible symptoms on leaves. Dry corky lesions on root that may be raised or sunken
Usually develop where lateral roots emerge from tap toot

Bayer Crop Science, UK

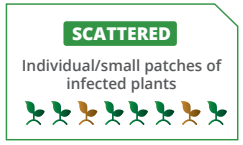
Multiple lesion may merge to form large scabby horizontal bands

Bayer Crop Science, UK

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Spores or mycellium

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 4-5 years break from carrot

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

- Preferably rotate with legumes. Avoid fields that have previously grown potatoes.

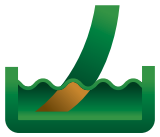
PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

SOIL PH

Use amendments to adjust soil pH



- Adjust soil pH to 5.5

FERTILISER SELECTION

- Use acidifying fertilisers e.g. ammonium sulphate to help lower pH

POST-PLANT

AVOID WATER STRESS

Ensure plants receive adequate water

HOST RANGE

Carrot, potato, peanut, beetroot, swede, parsnip, radish

CAVITY SPOT

Pythium sulcatum or P. violae

WHAT SHOULD I LOOK FOR?

Pin-head sized dots that progresses to small (10mm) sunken oval lesions often with a yellow halo anywhere along the root surface. *L DuToit, WSU*

Symptoms can begin one month before harvest and develop rapidly. Damage can make fresh carrots unmarketable. *L DuToit, WSU*

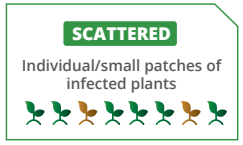
WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 20-28°C

Optimum *P. sulcatum* -28°C
P.violae -19°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Resting spores (oospores)

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 5 year break between host crops

HOST-FREE ZONE

Control volunteer host plants and weeds

- Rotate with non-hosts such as broccoli, lettuce or beans

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

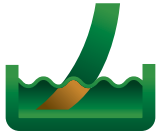
PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

SOIL PH

Use amendments to adjust soil pH



- On acidic soils adjust to pH 6.5-7.5

CROP SELECTION

Choose a less susceptible/resis-tant cultivar

POST-PLANT

CHEMICAL TREATMENT

Use registered soil drench fungicides at planting

- Consult APVMA or InfoPest website for current registered products

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Avoid summer or autumn harvest. Monitor 1 month prior to expected harvest date to avoid over maturity

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

P. sulcatum - Carrot, parsnips, celery, parsley

P.violae - Carrot, parsnips, celery, parsley, broccoli, wheat, lucerne

CRATER ROT

Rhizoctonia carotae

WHAT SHOULD I LOOK FOR?

Horizontal dark brown bands develop mostly on the crown and upper root *L. Tesoriero*

Rotted pits develop under the bands that that join to form craters as the disease progresses. White cottony growth may develop in high humidity

Plant Disease Clinic University of Minnesota

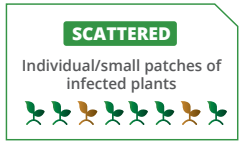
WHERE WILL I SEE SYMPTOMS?

- Crown and upper part of root

FAVOURABLE CONDITIONS

- 16-20ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia or mycelium

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 8 year rotation with non-host crop

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Harvest early in high risk situations to reduce chance of infection

HOST RANGE

Carrots

CROWN ROT

Fusarium spp. | *Rhizoctonia spp.*

WHAT SHOULD I LOOK FOR?

Crown rot in carrots caused by *Rhizoctonia* spp. causes black lesions at the soil line that spreads to the top of the root. This oftern causes breaking off of leaves at harvest *L. Tesoriero*

Crown rot symptms may also be caused by *Fusarium* spp. as shown in mature carrots *H. Pung, Peracto*

Crown rot in parsley caused by *Fusarium* spp. causes soft brown rot where the root meets the soil (a) and (b) dicolouration of the internal root tissue *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

LEAVES

CARROT ROOT

FAVOURABLE CONDITIONS

WARM

WET

pH<7 ACIDIC SOIL

NUTRITIONAL IMBALANCE

- 18-25ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Hyphae in plant residue, chlamydospores

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break between host crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

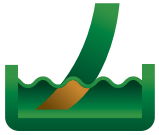
BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

SOIL PH

Use amendments to adjust soil pH



- Adjust soil pH to 6.5-7.5

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

GOOD NUTRITION

Ensure plants nutritional needs are met

- Stressed crops are more susceptible to infection

HOST RANGE

Carrot, parsnips, celery

DAMPING OFF

Rhizoctonia or Pythium spp.

WHAT SHOULD I LOOK FOR?

Seedling emergence may be poor leading to bare patches. Seedlings may emerge but have stunted growth, as shown in parsley *L. Tesoriero*

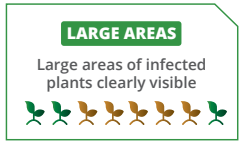
Seedlings may also develop red-brown lesions at the soil junction, resulting in wilt and eventual death as shown in carrots *B. Conde, NT DPIF*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 13-18ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia or resting spores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4 years between host crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

GOOD NUTRITION

Ensure plants nutritional needs are met

- Stressed crops are more susceptible to infection

HOST RANGE

Carrot, parsnips, celery, parsley

LEAF CURL/CELERY ANTHRACNOSE

Colletotrichum acutatum | C. orbiculare

WHAT SHOULD I LOOK FOR?

Stunting of plants with small cupped leaves. Older leaves may curl downwardand become distorted. Brown lesions may developon leaf margins, become brittle and crack. *L. Tesoriero*

Stalks may become twisted red to light-brown lesions, sometimes in stripes. *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

LEAVES

STALKS

FAVOURABLE CONDITIONS

WET

- Extended leaf wetness

WARM

- 23-27°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

- Continuous water splash

WIND

SURVIVES IN SOIL AS : Conidia, perithecia or mycellium

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

- 3 to 4-year break

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Consult APVMA or InfoPest for current registered products

HOST RANGE

Wide host range including celery

CARROT, CELERY, PARSNIP AND PARSLEY

ROOT-KNOT NEMATODE

WARM CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

COOL-CLIMATE SPECIES: *Meloidogyne hapla | Meloidogyne fallax*

WHAT SHOULD I LOOK FOR?

Aboveground scattered areas of stunted, yellow and wilted plants may be visible.
B. Hammeraas, NIBIO, Bugwood.org

Below ground infection by Meloidogyne spp. can result in swollen galls on carrot roots.
S. Nelson FLICKR

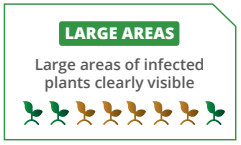
Infection by Melodogyne halpa can cause forking and severe distortion of carrot roots
W. Peraza-Padilla National Universtiy Cosa Rica, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Active 15°C +
- Active 8.5°C +

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Adult or eggs

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non host break crop

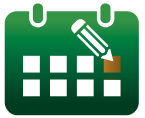
PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

ADJUST DATE
Adjust planting/harvest date to reduce infection risk



- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations

HOST RANGE

Very wide with over 2000 plant species acting as hosts to root-knot nematode

ROOT LESION NEMATODE

Pratylenchus penetrans

WHAT SHOULD I LOOK FOR?

Aboveground scattered areas of stunted, yellow and wilted plants may be visible

B. Hammeraas, NIBIO, Bugwood.org

Belowground infection by Pratylenchus penetrans can cause forking and distortion and prolific formation of lateral roots

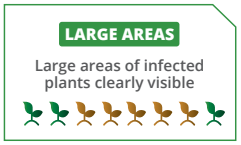
S. Collins DPIRD

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 20-25ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS :

Adults and can enter a “dehrydated “ state enabling long term survival

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non host break crop

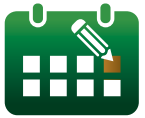
PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

ADJUST DATE
Adjust planting/harvest date to reduce infection risk



- Select planting date to maximise growth in cool conditions when nematode activity is reduced. Bring forward harvest to minimise damage in high risk situations

HOST RANGE

Wide infecting over 400 plant species inlcuding carrots, potatoes and fruit trees

ROOT ROT COMPLEX

Phytophthora/Pythium spp.

WHAT SHOULD I LOOK FOR?

Aboveground, yellowing andwilting of leaves followed by plant collapse and death, as shown in parsley *L. Tesoriero*

Belowground, reduction in side rootspredominantly by Pythiumspp,as shown in infected parsley (right) compared to healthy plant (left),caused.Infection with Phytophthora spp. leaves roots intact but often causes browning. *L. Tesoriero*

Roots may also develop a brown spongy rot as shown in carrots. *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

ABOVE GROUND

CARROT ROOT

FAVOURABLE CONDITIONS

- 8-15ºC

COOL

WET

- Especially waterlogged soils <10ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Resting spores or chlamydospores

SURVIVAL TIME WITHOUT HOST > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4 years between host crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Carrot, parsnips, celery, parsley

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

At base of stem fluffy white funagl growth is visible which can lead to stem rot and collapse

HF Schwartz. Bugwood.org

Survival structures (*sclerotia*) forms later on and can be up to 25mm long in *S. sclerotiorum* and much smaller (up to 3mm long) in *S.minor* *C.Balbalian, Mississippi State University, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

CARROT ROOT

FAVOURABLE CONDITIONS

COOL

WET

• 13-18ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops

SCLEROTIUM ROT

Sclerotium rolfsii

WHAT SHOULD I LOOK FOR?

Watery rot that eventually leads to stem collapse. Characteristic white ropey fungal growth seen at the soil line with light brown survival structures (sclerotia) resembling mustard seeds

D. Langston, Unive

WHERE WILL I SEE SYMPTOMS?	CARROT ROOT • Lower leaves
FAVOURABLE CONDITIONS	WARM, pH<7 ACIDIC SOIL, WET • 25-35°C
HOW DOES IT SPREAD?	FREE WATER, WIND, MOVEMENT OF CONTAMINATED SOIL • Mostly through splash
DISTRIBUTION IN THE FIELD	**SCATTERED** Individual/small patches of infected plants

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4 years between host crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops including legumes, brassicas and cucurbits

GREEN BEANS AND PEAS

APHANOMYCES ROOT ROT

Aphanomyces euteiches

WHAT SHOULD I LOOK FOR?

Initial honey-brown discolouration of root and area above the seed up to the soil line as shown in plants on right hand side, compared to healthy plants on the left. Nodulation on roots may also be poor. Roots become darker as disease progresses and eventually die

L. Porter, ARS USDA

Aboveground plants yellowing will occur starting at the bottom leaves followed by wilting and death

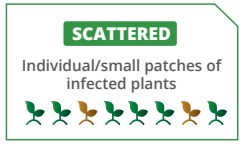
L. Porter, ARS USDA

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 17-23°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Oospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 6 to 10 year rotation

PLANTING PREPARATION

SOIL TEST

Conduct a pre-sowing soil test to help predict level of risk

CROP SELECTION

Choose a less susceptible/resistant cultivar

- Avoid late-maturing varieties especially in paddocks with history of Aphanomyces root rot

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Range of legume crops and weed species including peas, beans, clovers and medics

ASHY STEM BLIGHT (CHARCOAL ROT)

Macrophomina phaseolina

WHAT SHOULD I LOOK FOR?

Sunken lesions develop on the stem, as shown here in seedlings. Lesions have sharp margins and may contain concentric rings *H.Schwartz Charcoal Rot Colorado State University Bugwood.org*

As the disease progresses dry rot of the stem and pale, ash-coloured "dust" develop

H.Schwartz Charcoal Rot Colorado State University Bugwood.org

Small black survival structures (microsclerotia) develop in dead tissue

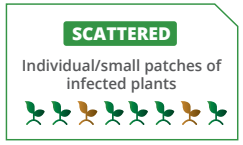
P. Bachi charcoal rot microsclerotia University of Kentucky Research and Education Center, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 24-27°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Microsclerotia

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 4 to 6 year break from susceptible crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

SOIL TEST

Conduct a pre-sowing soil test to help predict level of risk

POST-PLANT

AVOID WATER STRESS

Ensure plants receive adequate water

FERTILISER SELECTION

- Avoid excess N

HOST RANGE

Very wide host range infecting over 500 plant species including most cucurbits as well as legumes (e.g. peas, beans) , brassicas (e.g. cabbage) and solanaceae (e.g. peppers) vegetables

BLACK ROOT ROT

Thielaviopsis basicola(aka. Chalara elegans)

WHAT SHOULD I LOOK FOR?

Initially long red lesions appear on the on the root which eventually turn black

Virginia Tech Learning Resources Center

Tap root may become stunted, aboveground plant may also become stunted, wilt and possibly die

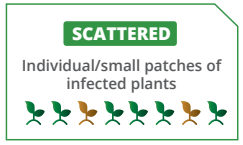
N. Cattlin, Alamy Stock Photo

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 17-25°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 5 to 6 year break from host crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Minimise irrigation splash

HOST RANGE

Wide host range including beans, peas, cotton, lettuce, lucerne, lupin and soybean

BLACK SPOT (ASCOCHYTA BLIGHT)

Didymella pinodes often in a disease complex with Phoma medicaginis var. pinodella, Phoma Koolunga and Didymella pisi.

WHAT SHOULD I LOOK FOR?

Irregular dark brown to black spots that develop into large purplish-black lesions on stems, leaves and pods.
M. Wunsch North Dakota State Universtiy

Concentric rings and black survival structures (pycnidia) can often be seen in the middle of the lesion.
M. Wunsch North Dakota State Universtiy

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

- In severe cases

FAVOURABLE CONDITIONS

WARM

WET

- 18-22°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

INFECTED SEED/ SEEDLINGS

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS : Perithecia

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break and 500m from previous host crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Avoid early planting at high seeding rates which increases exposure

AIR CIRCULATION

Increase row spacing to improve air circulation

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Most severe on peas but also infect lentils, alfalfa, faba beans, clover and vetch

FUSARIUM ROOT ROT)

Fusarium solani f. sp. phaseoli

WHAT SHOULD I LOOK FOR?

Aboveground plants may initially appear yellow, stunted and wilted and eventually may die

H. Schwartz, Colorado State University, Bugwood.org

Belowground lower root may die off and secondary roots may form above the diseased area

H. Schwartz, Colorado State University, Bugwood.org

Cutting the stem reveals drying out and reddening of the taproot

H. Schwartz, Colorado State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

ROOTS

FAVOURABLE CONDITIONS

COOL

COMPACTED SOIL

- Soil <13°C at planting

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

INFECTED SEED/ SEEDLINGS

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Microsclerotia

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CULTIVATION

Cultivate heavily compacted soil e.g. deep rip

- Consider cultivation in heavilycompacted soils

FERTILISER SELECTION

- Avoid acidifying NH4+ fertilizers

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

GOOD NUTRITION

Ensure plants nutritional needs are met

- Consider calcium supplements

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

HILL UP

Bury the base of the plant to encourage new growth

- May encourage new growth above diseased area

HOST RANGE

Green beans

PEA WILT

Fusarium oxysporum f.sp.pisi

WHAT SHOULD I LOOK FOR?

Aboveground yellowing of leaves, begins at the base of the plants and progresses upwards. Stunting of plants is also common. *L. Porter, ARS-USDA.*

Belowground brown to black lesions form around seed and root tissue that start small and then grow together to form large lesions. *L. Porter, ARS-USDA.*

Rot may only be confined to the outer layers of the root and cutting off the outer sheath reveals healthy inner tissue, as shown in the two outer plants. *L. Porter, ARS-USDA.*

WHERE WILL I SEE SYMPTOMS?

ROOTS LEAVES

- In severe cases

FAVOURABLE CONDITIONS

HOT

- 25-30°C

WET

- High soil moisture favours disease

COMPACTED SOIL

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

HOST RANGE

Peas

PYTHIUM STEM ROT

Pythium spp.

WHAT SHOULD I LOOK FOR?

Brown discolouration and soft rot of lower plant stem

H.Schwartz, Colorado State University, Bugwood.org

Watery rot and white fluffy growth may also develop on pods, sometime during transit. Unlike Sclerotinia no black fruiting with survival bodies (sclerotia) will form

B. Olson, Oklahoma State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

STEM BASE

ROOTS

FAVOURABLE CONDITIONS

HOT

WET

PHYSICAL DAMAGE

•Daytime 30-35°C
Night> 20°C

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Oospores

SURVIVAL TIME WITHOUT HOST > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

- Use registered seed treatment

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

AVOID PLANT INJURY

Avoid any physical damage to plant

MAY BE CONFUSED WITH

Sclerotinia (white mould)

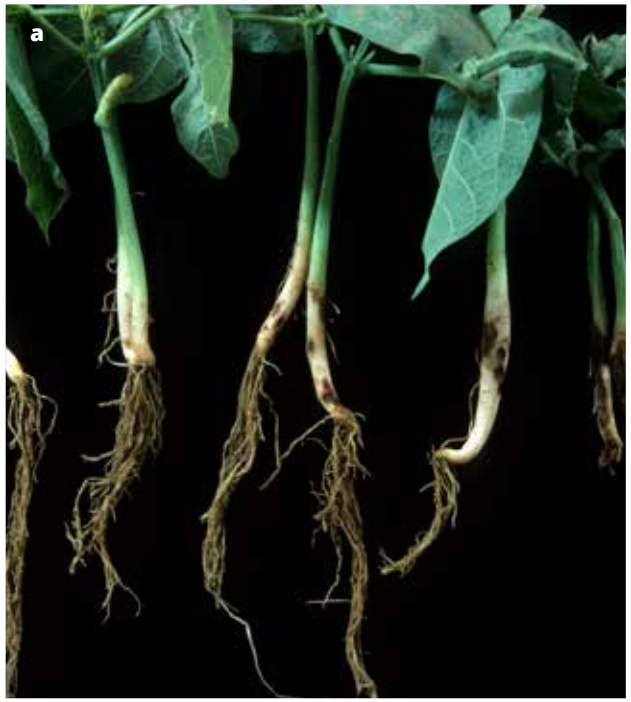
HOST RANGE

Very wide host range including all legumes and most vegetable crops

RHIZOCTONIA ROOT ROT

Rhizoctonia solani

WHAT SHOULD I LOOK FOR?



Infected seedlings may appear stunted and sunken, red lesions on root and lower stem are visible. In some cases new roots above the diseased area and the plant can continue to grow satisfactorily. Infection in older plants may occur

(a) E. Sikora, Auburn University, Bugwood.org. | (b) H.Schwartz, Colorado State University, Bugwood.org

Aboveground yellowing of leaves, begins at the base of the plants and progresses upwards. Stunting of plants is also common

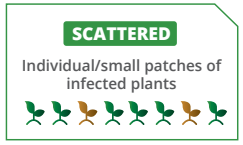
L. Porter, ARS-USDA.

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Soil temperature <20°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Mycelium or sclerotia

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 6 month breaks from potatoes, cabbages, cauliflowers or broccoli

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

HILL UP

Bury the base of the plant to encourage new growth

- May encourage new growth above diseased area

HOST RANGE

Very wide host range including all legumes and most vegetable crops

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

Symptoms begin as water-soaked lesions which eventually rot and collapse. As the disease progresses characteristic white fluffy growth develops followed by black fruiting bodies survival structures (sclerotia).

N. Cattlin, Alamy Stock Photo

Survival structures (sclerotia) can also develop on (a) stems and can (b) be up to 25mm long in *S. sclerotiorum* and much smaller (up to 3mm long) in *S.minor*

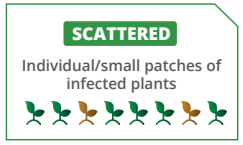
(a) NY State IPM Program, Bugwood.org | (b) C. Balbalian, Mississippi State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 15-20°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

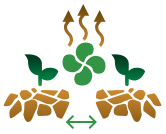
CHEMICAL FUMIGATION

Always use with care and as per label

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation



DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- May encourage new growth above diseased area

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species) including most vegetable crops species

SCLEROTIUM ROT

Sclerotium rolfsii

WHAT SHOULD I LOOK FOR?

Watery rot that eventually leads to collapse of infected area. Characteristic white "ropey" fungal growth develops along with light brown survival structures (sclerotia)

Bridget Lassiter, NCDA&CS, Bugwood.org

Survival structures may develop on the infected tissue or soil surface and resemble mustard seeds

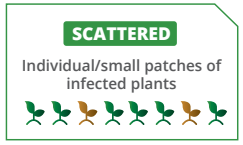
Clemson University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 25-35°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 500 different plant species) including most vegetable crops species

LETTUCE, ENDIVE, ARTICHOKE

Anthracnose (shot hole or ring spot)	Black root rot	Bottom rot	Corky rot
Page 176	Page 180	Page 184	Page 188
			

Damping off	Lettuce big vein disease/Miraflori lettuce virus complex	Lettuce drop	Root knot nematode
Page 192	Page 196	Page 200	Page 204
			

ANTHRACNOSE (SHOT HOLE/RING SPOT)

Microdochium panattonianum

WHAT SHOULD I LOOK FOR?

Begins as small water-soaked brown lesions *M. Titley, AHR*

Eventually centre of the lesion decays and falls out giving “shot hole” appearance
M. Titley, AHR

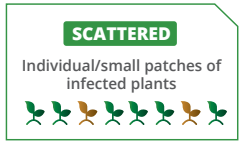
WHERE WILL I SEE SYMPTOMS?

• Lower leaves

FAVOURABLE CONDITIONS

• 15-22°C • Leaf wetness

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

• Mostly through splash

SURVIVES IN SOIL AS : Conidia, mycelium

SURVIVAL TIME WITHOUT HOST | > 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 4-year break

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Avoid excess periods of leaf wetness

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest for current registered products

HOST RANGE

Lettuce, prickly lettuce, endive

BLACK ROOT ROT

Thielaviopsis basicola

WHAT SHOULD I LOOK FOR?

Aboveground symptoms will appear in small scattered patches. Depending on the timing and severity of infection plant may appear small and stunted but otherwise healthy or in more severe cases lower leaves will turn yellow or brown *S. Koike, University of California*

Below ground the main tap root may be severely stunted (left) compared to the root system of a healthy lettuce plant (right). Disease roots also develop dark brown to black lesions, particularly on the fine feeder roots *S. Koike, University of California*

WHERE WILL I SEE SYMPTOMS?

ROOTS

FAVOURABLE CONDITIONS

WET

WARM

• 17-25ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS : Resting spores

SURVIVAL TIME WITHOUT HOST > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 5 to 6 year break from susceptible crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Minimise irrigation splash

HOST RANGE

Wide host range including beans, peas, cotton, lettuce, lucerne, lupin and soybean

BOTTOM ROT

Rhizoctonia spp.

WHAT SHOULD I LOOK FOR?

Starts as brown spots on underside of leaf midrib

Gerald Holmes, California Polytechnic State University,Bugwood.org

Develops to rot on midrib leaf blade. Heads can be slimy brown to dark brown/black as they collapse. Brown mycelium can grow over lesion with small brown sclerotia

G. Holmes, California Polytechnic State University,Bugwood.org

WHERE WILL I SEE SYMPTOMS?

LEAVES

HEAD

FAVOURABLE CONDITIONS

WET

WARM

•25-27ºC

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Sclerotia/mycelium

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3-year break

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

- Select cultivars with upright architecture to reduce soil contact

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

AIR CIRCULATION

Increase row spacing to improve air circulation

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Excess periods of leaf wetness encourage disease

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Lettuce, endive

CORKY ROT

Sphingomonas suberifaciens

WHAT SHOULD I LOOK FOR?

Aboveground plants appear stunted and wilted, as seen in infected lettuce on the left compared to a healthy lettuce on the right. Belowground symptoms begin as yellow banding on the root which turns brown. *B.Mou,ARS-USDA*

Eventually roots become swollen cracked and rough and stop functioning. Side roots are reduced and become brittle, as shown in infected root (right) compared to healthy roots from a corky root resistant variety (left) *C. Ochoa & R. Michelmore, University of California, Davis*

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

FAVOURABLE CONDITIONS

WARM

•20-25°C

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Unknown

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

- Minimum 18 months

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

FERTILISER SELECTION

- Do not over fertilise with nitrogen

TRANSPLANTS

Use seedling transplants - not direct seeding

HOST RANGE

Lettuce, prickly lettuce, sow thistle, endive

DAMPING-OFF

Pythium spp. | Rhizoctonia solani | Phytophthora spp.

WHAT SHOULD I LOOK FOR?

Seeds may not germinate or plants may rot soon after emergence leading to large bare patches. Plants that do emerge may be stunted. *N. Cattlin, Alamy Stock Photo*

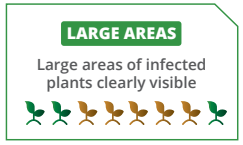
Seedlings may have yellow to light brown discolouration around on stem at ground level. As the disease progresses stem eventually collapse leading to wilting and death. *E. Tubb*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 15°C-18°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Resting spores, sclerotia/mycelium or chlamydospores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

TRANSPLANTS

Use seedling transplants - not direct seeding

CHEMICAL FUMIGATION

Always use with care and as per label

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

HOST RANGE

Lettuce, endive

LETTUCE BIG VEIN DISEASE /MIRAFLORI LETTUCE VIRUS COMPLEX

Mirafiori lettuce big-vein virus transmitted by fungal vector Olpidium virulentus (oomycete)

WHAT SHOULD I LOOK FOR?

Abnormally large clear veins

G. Homes Calif. Polytech State Uni Bugwood.org.jpg

Leaves are often puckered or mottled and may appear thickened

G. Homes Calif. Polytech State Uni Bugwood.org.jpg

Head size may be reduced or in some cases no head will develop

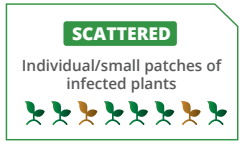
G. Homes Calif. Polytech State Uni Bugwood.org.jpg

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

•Less than 16°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

Transmitted by fungus Olpidium virulentus

SURVIVES IN SOIL AS : Resting spores

SURVIVAL TIME WITHOUT HOST | > 10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

- Minimum 18 months

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

- No fully resistant varieties available but some lettuce types more susceptible e.g. iceberg

DRAINAGE

Plant on raised beds or well-draining soil

HOST RANGE

Lettuce and weed species such as sowthistle and chickweed may act as hosts

LETTUCE DROP(WHITE MOULD)

Sclerotinia sclerotiorum | S minor

WHAT SHOULD I LOOK FOR?

Sclerotinia sclerotiorum – Begins as (a) watery, soft rot that develops to (b) white growth and formation of small (sclerotia 5-10mm). Typically Infects lower leaves and stems. Aerial spores can infect damaged or dead tissue.

L.Tesoriero

Sclerotinia minor only infects the stems and leaves in contact with the soil. Brown, soft decay that eventually destroys the tissue around crown. Near maturity the entire plant will wilt and collapse. White fluffy growth and sclerotia smaller than *S. sclerotiorum* (0.5 -3mm), form on the outside of the decayed crown.

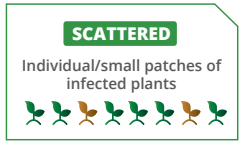
B. Shew, North Carolina State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 13-18ºC

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

DRAINAGE

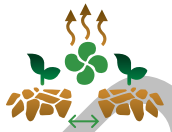
Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

AIR CIRCULATION

Increase row spacing to improve air circulation



POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops including lettuce, endive and chicory

ROOT-KNOT NEMATODE

WARM-CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

COOL-CLIMATE SPECIES: *Meloidogyne hapla | Meloidogyne fallax*

WHAT SHOULD I LOOK FOR?

Aboveground symptoms plants may appear chlorotic and stinted. Belowground roots develop characteristic swelling and galls. *G. Holmes, California Polytechnic State University.jpg*

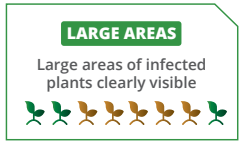
Belowground roots develop characteristic swelling and galls. *D. Blancard*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Active 15°C +
- Active 8.5°C +

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Adult or eggs

SURVIVAL TIME WITHOUT HOST | < 3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non host break crop

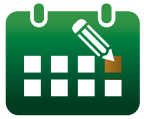
PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

ADJUST DATE
Adjust planting/harvest date to reduce infection risk



- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations

HOST RANGE

Very wide with over 2000 plant species acting as hosts to root-knot nematode

SPRING ONIONS AND LEEKS

Damping off	Fusarium basal rot	Leaf blight
Page 266	Page 270	Page 274
		

Pink root	Stem and bulb nematode	White rot
Page 278	Page 282	Page 286
		

DAMPING OFF

Pythium spp. | Rhizoctonia solani | Fusarium spp.

WHAT SHOULD I LOOK FOR?

Seeds may not germinate or plants may rot soon after emergence leading to large bare patches. Seedlings that do emerge may have yellow to light brown discolouration around base of the stem. As the disease progresses stem eventually collapse leading to wilting and death

H. Schwartz, Colorado State University, Bugwood.org

Significant stunting of root systems may also be evident, as shown here cause by *Rhizoctonia* spp.

Bill Dean, River Point Farms, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

STEM BASE

ROOTS

FAVOURABLE CONDITIONS

WARM

WET

COMPACTED SOIL

- 20-25°C

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Resting spores, sclerotia, or chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Onion most susceptible between flag leaf and first true leaf stage

HOST RANGE

Very wide host range including all legumes and most vegetable crops

FUSARIUM BASAL PLATE ROT, WILT AND CROWN ROT *Fusarium oxysporum f. sp. cepae*

WHAT SHOULD I LOOK FOR?

Leaf yellowing, curling, necrosis at tip leaf blades *H. Schwartz, Colorado State University, Bugwood.org*

Roots appear dark brown, flattened, transparent and hollow. Infected plants easily uprooted. Bulbs show external and internal watery brown discolouration

H. Schwartz, Colorado State University, Bugwood.org

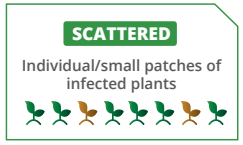
WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• Optimum above 25°C. Infection limited below 15°C

• Including mechanical, fertiliser or insect injury e.g. onion maggots

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 4 year break

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

CROP SELECTION

Choose a less susceptible/resis-tant cultivar

POST-PLANT

CONTROL PESTS

Control insect pests that spread spores

- e.g. onion maggots

AVOID PLANT INJURY

Avoid any physical damage to plant

- This may be mechanical or fertiliser injury

HOST RANGE

All members of the onion family

LEAF BLIGHT

Stemphylium vesicarium | S. botryosum

WHAT SHOULD I LOOK FOR?

Water-soaked lesions on the leaf or stalk that initially are light yellow to brown and develop to olive brown to black. Lesions join sometimes reaching leaf tip. Bulb size can be significantly reduced

G. Holmes, California Polytechnic State University, Bugwood.org

Older lesions develop distinct concentric rings

G. Holmes, California Polytechnic State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

LEAVES

• Initial symptoms on leaf and leaf sheaths

FAVOURABLE CONDITIONS

WARM

• 23- 28°C

HIGH HUMIDITY

• High humidity for more than 24hours

WET

• Especially extended periods of leaf wetness

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

• More prominent on side of prevailing wind

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

• Especially rain splash

SURVIVES IN SOIL AS : Pseudothecia

SURVIVAL TIME WITHOUT HOST | <3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 2 years break from host

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

- Especially extended periods of leaf wetness

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

GOOD NUTRITION

Ensure plants nutritional needs are met

MAY BE CONFUSED WITH

Downy mildew infection or often follows downy mildew infection

HOST RANGE

Members of the onion family and asparagus

PINK ROOT

Setophoma terrestris (Phoma terrestris)

WHAT SHOULD I LOOK FOR?

Basal plate grey to brown , white to pink fungal growth develops on roots. Bulb size may be reduced

H. Schwartz, Colorado State University, Bugwood.org

Wilt, white, yellow or brown dieback leaves starting from tips. Leaf number and size reduced. Death may occur over several weeks

Ed Kurtz, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

ROOTS

FAVOURABLE CONDITIONS

WARM

- Optimum 24-28C°

DISTRIBUTION IN THE FIELD

OR

SCATTERED
Individual/small patches of infected plants

SCATTERED
Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Chlamydospores/pycnidia

SURVIVAL TIME WITHOUT HOST <3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- 4 to 6 year break from host crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

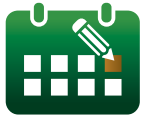
PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resis-tant cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk



- Ideally bulk of root growth before soil temperatures reach favourable conditions i.e. 24-28°C

HOST RANGE

Mostly members of the onion family but can be hosted by members of the pumpkin, bean carrot and pepper family

STEM AND BULB NEMATODE

Ditylenchus dipsaci

WHAT SHOULD I LOOK FOR?

Twisted and malformed leaves, slightly raised pimple like spots may be present. Severely infected plants eventually turn yellow and die *A. Brozova, Shutterstock*

The base of infected seedlings swollen Scales on older infected bulbs appear swollen or bloated and may split. Infected bulbs are also very susceptible to secondary infections by bacteria and fungi *Ed Kurtz, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

FAVOURABLE CONDITIONS

WARM

WET

- Optimum 20-22°C

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Fourth-stage juvenile (J4)

SURVIVAL TIME WITHOUT HOST <3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break. Consider pre-plant soil testing. Choose host or bare fallow based on numbers

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANT TRAP CROPS

Plant nematode resistant crops that prevent reproduction

- Consider planting a resistant trap crop i.e. nematodes can infect roots but unable to develop through to reproductive phase

SOIL TEST

Conduct a pre-sowing soil test to help predict level of risk

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

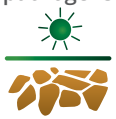
PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens



CROP SELECTION

Choose a less susceptible/resistant cultivar

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

HOST RANGE

Mostly devestating to the onion family but can be hosted by members apiaceae (e.g. carrot) and legume (e.g. bean) family

WHITE ROT

Sclerotium cepivorum

WHAT SHOULD I LOOK FOR?

Initially yellowing and dieback of leaf tip which eventual leads to wilting. *L. Tesoriero*

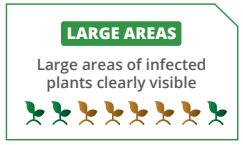
Soft rot of roots and base of stalk may also be seen. As the disease progresses white fluffy fungal and tiny survival structures (sclerotia) appear. *L. Tesoriero*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 14-18°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products.

PLANTING PREPARATION

CHEMICAL TREATMENT
Treat seed/sedlings with registered fungicide

CHEMICAL TREATMENT
Use registered soil drench fungicides at planting

DRAINAGE
Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING
Ensure no plant residues from host crops at planting

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

CHEMICAL TREATMENT
Treat plant with registered foliar fungicide

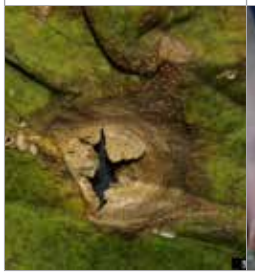
- Consult APVMA or InfoPest websitfor current registered products

HOST RANGE

Members of the onion family

PUMPKIN,SQUASH, ZUCCHINI AND CUCUMBERS

Charcoal rot	Damping-off	Fusarium foot rot	Fusarium wilt
Page 120	Page 124	Page 128	Page 132
			

Gummy stem blight	Root knot nematode	Sclerotinia rot	Sclerotium rot
Page 136	Page 140	Page 144	Page 148
			

CHARCOAL ROT

Macrophomina phaseolina

WHAT SHOULD I LOOK FOR?

Seedlings with early infection show water-soaked lesion at soil line that may choke and kill the plant *Schwartz, Colorado State University, Bugwood.org*

As the disease progresses ooze amber coloured ooze, similar to gummy stem blight, may be released. Lesions eventually dry out and many survival structures (microsclerotia) can be seen in the dead tissue *P. Bachi, University of Kentucky Research and Education Center, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

LEAVES

STEM

FAVOURABLE CONDITIONS

HOT

SOIL SALINITY

HEAVY FRUIT LOAD

- 27-30°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS : Microsclerotia

SURVIVAL TIME WITHOUT HOST | >10 years

WHAT SHOULD I LOOK FOR?

Infected fruit develop large soft grey to black sunken lesions, shown here in an infected cucumber *C.Averre North Carolina State University, Bugwood.org.jpg*

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

PLANTING PREPARATION

GRAFTING
Use transplants grafted onto resistant rootstock

NO RESIDUE AT PLANTING
Ensure no plant residues from host crops at planting

POST-PLANT

AVOID WATER STRESS
Ensure plants receive adequate water

HOST RANGE

Very wide host range infecting over 500 plant species including most members of the pumpkin, bean, brassica and pepper vegetable families.

DAMPING-OFF

Rhizoctonia spp. | Pythium spp. | Phytopthora spp. | Fusarium spp.

WHAT SHOULD I LOOK FOR?

Where direct seeding is used plants may not emerge resulting in bare patches. Infected seedlings that do emerge develop water soaked to dark brown discolouration at base of stem, shown here in cucurbit seedlings infected with *(a) Rhizoctonia spp. and (b) Pythium spp.*

G. Holmes, California Polytechnic State University, Bugwood.org

Plants experience stunting, wilting and eventual death

G. Holmes, California Polytechnic State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

ROOTS

STEM BASE

FAVOURABLE CONDITIONS

COOL

WATERLOGGED SOIL

DELAYED SEEDLING EMERGENCE

- 13-18°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Sclerotia, resting spores or chlamydospres

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

DRAINAGE
Plant on raised beds or well-draining soil

TRANSPLANTS
Use seedling transplants - not direct seeding

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

POST-PLANT

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

HOST RANGE

Very wide including all vegetables in the pumpkin (cucurbit) family.

FUSARIUM FOOT ROT

Fusarium solani f.sp. cucurbitae

WHAT SHOULD I LOOK FOR?

Light brown water-soaked rot on crown and upper root which eventually choke plant. Leaves wilt followed by plant death. Crown often breaks off and secondary pathogens invade decaying plant tissue sometimes producing a bad odour *L. Tesoriero*

Waiting for pic *waiting for pic*

WHERE WILL I SEE SYMPTOMS?

CROWN/ UPPER ROOT SYSTEM

ROOTS

FAVOURABLE CONDITIONS

WARM

- 25-30°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

INFECTED SEED/ SEEDLINGS

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 4 year break from host crop

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

PLANTING PREPARATION

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

- Plant when soil temperature are lower and nematodes are less active

HOST RANGE

Zucchini, pumpkin

FUSARIUM WILT

Fusarium oxysporum f. sp. cucumerinum (cucumber)

WHAT SHOULD I LOOK FOR?

Discolouration of stem, at ground level may be seen, in (a) younger seedlings and (b) more mature plants with pale pink fungal growth evident at the base

(a) C.F.Hong, University of Georgia, Bugwood,org, (b) L. Tesoriero

Lower leaves on young infected plants will be stunted, wilted and turn yellow (often more on one side). Cutting stem reveals brown discolouration of the internal tissue

Ontario Crop IPM, OMAFRA

WHERE WILL I SEE SYMPTOMS?

LEAVES

STEM

FAVOURABLE CONDITIONS

WARM

- 25-30°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

INFECTED SEED/ SEEDLINGS

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

FERTILISER SELECTION

- Consider calcium supplements

GRAFTING

Use transplants grafted onto resistant rootstock

POST-PLANT

CONTROL PESTS

Control insect pests that spread spores

- Especially at seedling stage

HOST RANGE

Cucumbers

GUMMY STEM BLIGHT

Stagonosporopsis cucurbitacearum

WHAT SHOULD I LOOK FOR?

Lesions begin as water soaked and with age can dry out, form rings and produce small black survival structures (pycnidia)

B. Watt, University of Maine

Small black survival structures (pycnidia) may be seen on older leaf or stem lesions

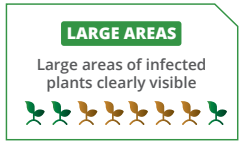
L. Tesoriero

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- 20-24°C

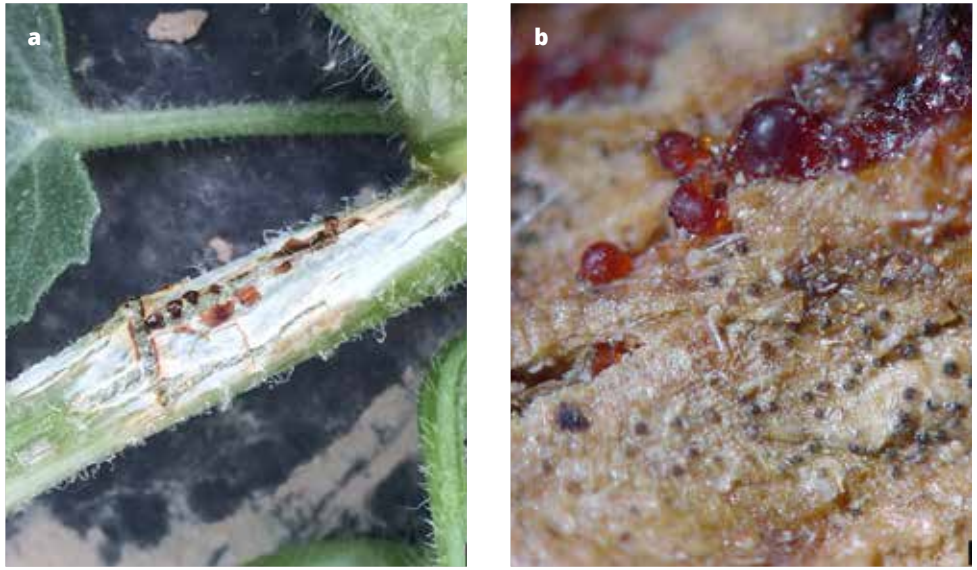
DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

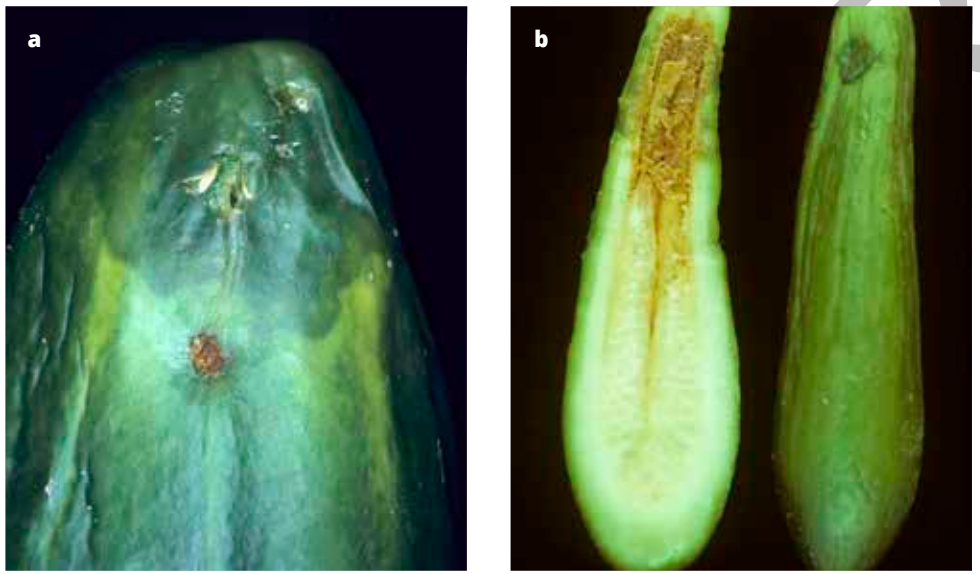
SURVIVES IN SOIL AS : -

WHAT SHOULD I LOOK FOR?



With age lesion may ooze a characteristic red-brown gummy substance

(a) Don Ferrin, Louisiana State University Agricultural Center, (b) Bugwood.org



In cucumbers, water soaked lesions with brown canker may appear (a) on the skin and (b) internally brown streaks extend from the flower end of the fruit. *L. Tesoriero*

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

- Minimum 2 years break from host

PLANTING PREPARATION

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

POST-PLANT

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Cucumber, gourd, pumpkin, squash, zucchini

ROOT-KNOT NEMATODE

WARM-CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne hapla | Meloidogyne javanica*

COOL-CLIMATE SPECIES: *Melodogyne fallax | Meloidogyne arenaria*

WHAT SHOULD I LOOK FOR?

Aboveground symptoms showing chlorotic stunted squash plants resulting from root-knot nematode infection *G. Holmes, California Polytechnic State University*

Belowground roots develop characteristic swelling and galls *R. Burns Texas A&M Agrilife FLICKR*

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

FAVOURABLE CONDITIONS

WARM

- Warm climate species: Active 15°C+

COOL

- Cold climate species: Active 8.5°C+

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

CONTAMINATED PLANT DEBRIS

SURVIVES IN SOIL AS : Adult or eggs

SURVIVAL TIME WITHOUT HOST <3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION
Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

SOIL TEST
Conduct a pre-sowing soil test to help predict level of risk

- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non host break crop

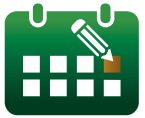
PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

SOIL SOLARISATION
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

ADJUST DATE
Adjust planting/harvest date to reduce infection risk



- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations

HOST RANGE

Very wide with over 2000 plant species acting as hosts to root-knot nematode

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | Sclerotinia minor

WHAT SHOULD I LOOK FOR?

Symptoms begin as water-soaked lesions which eventually rot and collapse. As the disease progresses characteristic white fluffy growth develops followed by black fruiting bodies (sclerotia). *N. Ward. FLICKR*

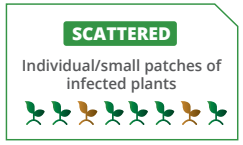
Survival structures (sclerotia) can be up to 25mm long in *S. sclerotiorum* and much smaller (up to 3mm long) in *S.minor* *C.Balbalian, Mississippi State University, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 13-18°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops including all brassicas and many broadleaf weeds e.g. shepherd's purse, thistles, mustard, pigweed

SCLEROTIUM ROT

Sclerotium rolfsii

WHAT SHOULD I LOOK FOR?

Watery rot that eventually leads to collapse of infected area. Characteristic white "ropey" fungal growth develops along with light brown survival structures (sclerotia). *L. Tesoriero*

Sclerotia may develop on the infected tissue or soil surface and resemble mustard seeds. *G. Homes Calif. Polytech State Uni Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

STEM

FRUIT

FAVOURABLE CONDITIONS

WARM

WET

pH<7 ACIDIC SOIL

- 25-35°C

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

AIR CIRCULATION

Increase row spacing to improve air circulation

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID OVER IRIGATION

Saturated soils favour disease development and spread

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops including from the beans, cabbage and pumpkin families.

SPINACH, SILVERBEET, BEETROOT

Aphanomyces root rot /damping off	Beet cyst nematode	Cercospora leaf spot
Page 244	Page 248	Page 252
		

Damping off, root rot or vascular wilt	Root knot nematode
Page 256	Page 260
	

APHANOMYCES ROOT ROT / DAMPING OFF

Aphanomyces cochlioides

WHAT SHOULD I LOOK FOR?

Patches of wilting or dead seedlings with blackened stems near ground level. Cotyledons rarely wilt before the seedling dies which helps distinguish it from symptoms caused by *Pythium* or *Rhizoctonia* spp.

Mariusz Sobieski, Bugwood.org

Lesions can appear on anywhere on roots that (a) begin as water-soaked and later become dark and dry If the disease progresses in (b) beets the lesion may penetrate further into the root

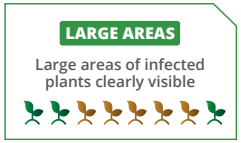
R. Harveson, University of Nebraska

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Infects >15ºC
  Optimum 20-30ºC

DISTRIBUTION IN THE FIELD



- Often areas with poor drainage

HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Oospores

SURVIVAL TIME WITHOUT HOST | <10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

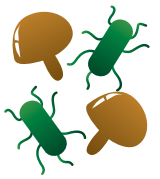
HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

POST-PLANT

BIOCONTROL PRODUCTS



- Beneficial bacteria and fungi may suppress disease

PLANTING PREPARATION

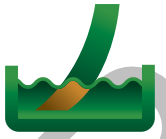
ADJUST DATE
Adjust planting/harvest date to reduce infection risk

- Disease losses are lower at soil temperatures below 15°C

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

- Quality compost (especially pine bark) addition to soils may help suppress disease

SOIL PH
Use amendments to adjust soil pH



- Acid soils favour disease so use amendments e.g.lime to raise soil pH to 7.5 or above

CROP SELECTION
Choose a less susceptible/resistant cultivar

- Beetroot and spinach are less sensitive than silverbeet

USE CLEAN SEED OR SEEDLINGS
Source seed/ seedlings from a certified reputable source

GOOD NUTRITION
Ensure plants nutritional needs are met

- Ensure crops are supplied with adequate potassium and calcium

AIR CIRCULATION
Increase row spacing to improve air circulation

NO RESIDUE AT PLANTING
Ensure no plant residues from host crops at planting

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

DRAINAGE
Plant on raised beds or well-draining soil

CHEMICAL FUMIGATION
Always use with care and as per label

HOST RANGE

Silverbeet, beetroot, spinach as well as related weeds such as fat hen & goose foot

BEET CYST NEMATODE

Heterodera schachtii

WHAT SHOULD I LOOK FOR?

Reduced plant stand, stunted growth, yellowing and wilting of aboveground plant

J. Eisenback, Virginia Polytechnic Institute and State University, Bugwood.org

Increase in finer "whisker-like" roots with small white spherical cysts. Root vegetables may also develop lumps or swellings

Mactode Publications, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

ROOTS

FAVOURABLE CONDITIONS

WARM

- 21-27°C Can have up to five generation in one growing season in warm conditions

PLANT STRESS

- Seedlings particularly susceptible

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVES IN SOIL AS : Cyst (hardened dead body of female nematode)

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Select fields that have not grown a host crop at least 5 years

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

SOIL TEST

Conduct a pre-sowing soil test to help predict level of risk

HOST-FREE ZONE

Control volunteer host plants and weeds

CHEMICAL FUMIGATION

Always use with care and as per label

- Not always effective as cysts can be difficult to penetrate. Check APVMA or Infopest website for registered products

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Plant when soil temperature are lower and nematodes are less active

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

SOIL SOLARISATION

Cover soil with a tarp to temperature and kill harmful pathogens

HOST RANGE

Silverbeet, beetroot, rhubarb and brassicas

CERCOSPORA LEAF SPOT

Cercospora beticola

WHAT SHOULD I LOOK FOR?

Numerous circular leaf spots (1-5mm diameter) with a pale brown centre and a red margin

Yonghao Li, The Connecticut Agricultural Experiment Station, Bugwood.org

Fungal growth and small black survival structures (conidia) may be seen at the centre of older spots

Bruce Watt, University of Maine, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

LEAVES

FAVOURABLE CONDITIONS

WARM

- 20-25°C

WET

- Especially leaf wetness for >8hrs, usually at night followed by daytime leaf drying

HIGH HUMIDITY

- Relative humidity 90-100%

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

WIND

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Sclerotia

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

- At least a 2 year break from susceptible crop

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

ADJUST DATE
Adjust planting/harvest date to reduce infection risk

- Disease losses are lower at soil temperatures below 15°C

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

- Quality compost addition to soils may help suppress disease

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

- Spores spread with water splash

CROP SELECTION
Choose a less susceptible/resistant cultivar

- Beetroot and spinach are less sensitive than silverbeet

AIR CIRCULATION
Increase row spacing to improve air circulation

- Dense plantings also encourage spread from plant to plant

USE CLEAN SEED OR SEEDLINGS
Source seed/ seedlings from a certified reputable source

NO RESIDUE AT PLANTING
Ensure no plant residues from host crops at planting

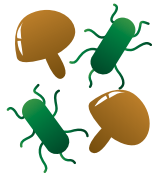
DRAINAGE
Plant on raised beds or well-draining soil

CHEMICAL FUMIGATION
Always use with care and as per label

POST-PLANT

CHEMICAL TREATMENT
Treat plant with registered foliar fungicide

BIOCONTROL PRODUCTS



- Beneficial bacteria and fungi may suppress disease

HOST RANGE

Silverbeet, beetroot and chard

DAMPING OFF, ROOT ROT OR VASCULAR WILT

Pythium aphanidermatum | Pythium ultimum | Pythium irregulare | Rhizoctonia solani | Fusarium oxysporum f.sp. spinaciae (Fos)

WHAT SHOULD I LOOK FOR?

Can cause seed rot in which case plants will not germinate and/or emerge leading to bare patches

D. Lucas, RMCG

Seedlings that do emerge may have yellow to light brown discolouration around on stem at ground level. As the disease progresses stem eventually collapse leading to wilting and death

S. Grigg, Ag-Hort Consulting

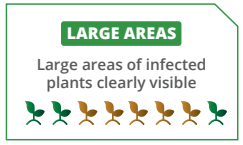
WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

•Optimum 15 to 20°C but can occur in warmer conditions

•Particularly wet soil

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

• Fungus gnats

SURVIVES IN SOIL AS : Oospores, sclerotia or chlamydospores

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

- At least a 2 year break from susceptible crop

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

BIO FUMIGATION
Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

IMPROVE SOIL HEALTH
Add organic matter or amendments to boost beneficial microbes

CROP SELECTION
Choose a less susceptible/resistant cultivar

- Some spinach varieties are resistant to Fusarium

USE CLEAN SEED OR SEEDLINGS
Source seed/seedlings from a certified reputable source

AVOID OVER IRRIGATION
Saturated soils favour disease development and spread

- Avoid periods of saturates soil

AIR CIRCULATION
Increase row spacing to improve air circulation

- Dense plantings also encourage spread from plant to plant.

DRAINAGE
Plant on raised beds or well-draining soil

CHEMICAL TREATMENT
Treat seed/sedlings with registered fungicide

CHEMICAL FUMIGATION
Always use with care and as per label

CHEMICAL TREATMENT
Use registered soil drench fungicides at planting

POST-PLANT

GOOD NUTRITION
Ensure plants nutritional needs are met

- Ensure crops are supplied with adequate potassium and calcium

HOST RANGE

Silverbeet, chard, beetroot and spinach. Pythium spp. and Rhizoctonia spp. have a wide host range while *Fusarium oxysporum f.sp. spinaciae* is specific to spinach

SPINACH, SILVERBEET, BEETROOT

ROOT-KNOT NEMATODE

WARM-CLIMATE SPECIES: *Meliodogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

COOL-CLIMATE SPECIES: *Meloidogyne hapla | Meloidogyne fallax*

WHAT SHOULD I LOOK FOR?

Aboveground symptoms plants may appear chlorotic and stinted. Belowground roots develop characteristic swelling and galls, as shown in spinach

S G. Holmes, California Polytechnic State University, Bugwood.org

New caption

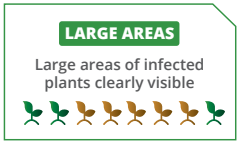
New caption

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

- Active 15°C+
- Active 8.5°C+

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Adults or eggs

SURVIVAL TIME WITHOUT HOST | <3 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Consider pre-plant soil testing. If numbers are high consider fallow or non-host break crop

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

CHEMICAL FUMIGATION

Always use with care and as per label

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

- Consider growth of biofumigant crops such as arugula (*Eruca sativa*) cv. Nemat

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

SOIL SOLARISATION

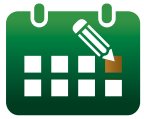
Cover soil with a tarp to temperature and kill harmful pathogens

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

ADJUST DATE

Adjust planting/harvest date to reduce infection risk



- Select planting date to maximise growth in cool conditions when nematode activity is reduced. Bring forward harvest to minimise damage in high risk situations

HOST RANGE

Very wide with over 2000 plant species acting as hosts to root-knot nematode

SWEET CORN

Boil smut	Damping off
Page 292	Page 296
	

Fusarium cob rot	Head smut
Page 300	Page 304
	

BOIL SMUT

Ustilago maydis

WHAT SHOULD I LOOK FOR?

Formation of (a) large pale green to silvery galls on cob up to150 mm

W. Upham Kansas State University Bugwood.org

Over time galls become dark and eventually burst releasing black spores

L. Tesoriero

WHERE WILL I SEE SYMPTOMS?

WHOLE PLANT

FAVOURABLE CONDITIONS

WARM

- 20-25°C

HIGH SOIL NUTRITION

DAMAGE TO COB

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

WIND

SURVIVES IN SOIL AS : Spores (teliospores)

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION
Select non-host rotation or cover crops

HOST-FREE ZONE
Control volunteer host plants and weeds

FARM HYGIENE
Stop movement of contaminated soil, water, plant and equipment

- Spores can survive 5 to 7 years out of corn

PLANTING PREPARATION

CROP SELECTION
Choose a less susceptible/resistant cultivar

CHEMICAL FUMIGATION
Always use with care and as per label

CHEMICAL TREATMENT
Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

GOOD NUTRITION
Ensure plants nutritional needs are met

AVOID WATER STRESS
Ensure plants receive adequate water

AVOID PLANT INJURY
Avoid any physical damage to plant

- Particularly important at the seedling stage

MAY BE CONFUSED WITH

Head smut

DAMPING-OFF

Pythium spp. | Fusarium spp., | Sclerotium rolfsii | Rhizoctonia solani

WHAT SHOULD I LOOK FOR?

Can cause seed rot in which case plants will not germinate and/or emerge leading to bare patches

A. Roberston, Iowa State University, Extension and Outreach.

Seedlings that do emerge may have yellow to light brown discolouration around on stem at ground level. As the disease progresses stem eventually collapse leading to wilting and death

W. Brown Jr., Bugwood.org

Symptoms appearing post emergence may also include severe stunting as shown in plants on the left compared to a healthy plant on the far right.

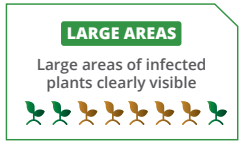
J, Thomsen, Iowa State University, Extension and Outreach.

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS

• 13-18°C

DISTRIBUTION IN THE FIELD



HOW DOES IT SPREAD?

SURVIVES IN SOIL AS : Resting spores chlamydospores sclerotia

SURVIVAL TIME WITHOUT HOST | >10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 years out of corn

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CHEMICAL FUMIGATION

Always use with care and as per label

CHEMICAL TREATMENT

Treat seed/sedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

SWEET CORN

FUSARIUM COB ROT

Fusarium verticillioides | F. proliferatum | F. subglutinans.

WHAT SHOULD I LOOK FOR?

White streaks start from tips of individual kernels then spreading out in a "starburst" pattern.

Ontario Ministry of Agriculture, Food and Rural Affairs

Advanced fungal growth may appear white pink or salmon coloured. Dangerous toxins are released from infected cobs and corn is not suitable for human consumption.

L. Osborne, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

COB

FAVOURABLE CONDITIONS

HOT

- 25-30ºC

PLANT STRESS

- Moisture or nutrition

PHYSICAL DAMAGE

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

INSECTS

- Spores enter via silks or wounds

SURVIVES IN SOIL AS : Chlamydospores

SURVIVAL TIME WITHOUT HOST | <10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 years out of corn

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

- Stop movement infected soil, remove infected plants/roots

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop e.g. mustard

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resistant cultivar

- Husks that prevent or delay insect entry

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Early plantings less prone to infection

FERTILISER SELECTION

- Avoid ammonium fertilisers. Nitrate fertilisers can help suppress disease

POST-PLANT

AVOID OVER IRRIGATION

Saturated soils favour disease development and spread

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Avoid delays in harvest that may result in split kernels and increasing risk of infection

HEAD SMUT

Sphacelotheca reiliana

WHAT SHOULD I LOOK FOR?

Infection occurs early symptoms occur at flowering/cob formation.Tassel symptoms include distortion and formation of masses of black spores *R. Croissant, Bugwood.org.*

Cobs may also replaced by a mass of black spores with a stringy appearance and often in a tear-drop shape *Agriculture and Agri-Food Canada , Agriculture and Agri-Food Canada, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

COB

TASSELS

FAVOURABLE CONDITIONS

WARM

PHYSICAL DAMAGE

- 20-30ºC

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

SURVIVES IN SOIL AS : Spores (teliospores)

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5 years out of corn

HOST-FREE ZONE

Control volunteer host plants and weeds

FARM HYGIENE

Stop movement of contaminated soil, water, plant and equipment

PLANTING PREPARATION

CROP SELECTION

Choose a less susceptible/resis-tant cultivar

- Select hyrbids with fast emergence

CHEMICAL FUMIGATION

Always use with care and as per label

POST-PLANT

GOOD NUTRITION

Ensure plants nutritional needs are met

- Ensure adequate nitrogen

MAY BE CONFUSED WITH

Boil smut