2019

SOIL-BORNE DISEASES IN VEGETABLE CROPS

A practical guide to identification and control

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2019

SOIL-BORNE DISEASES IN VEGETABLE CROPS

A practical guide to identification and control

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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 seriously 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).

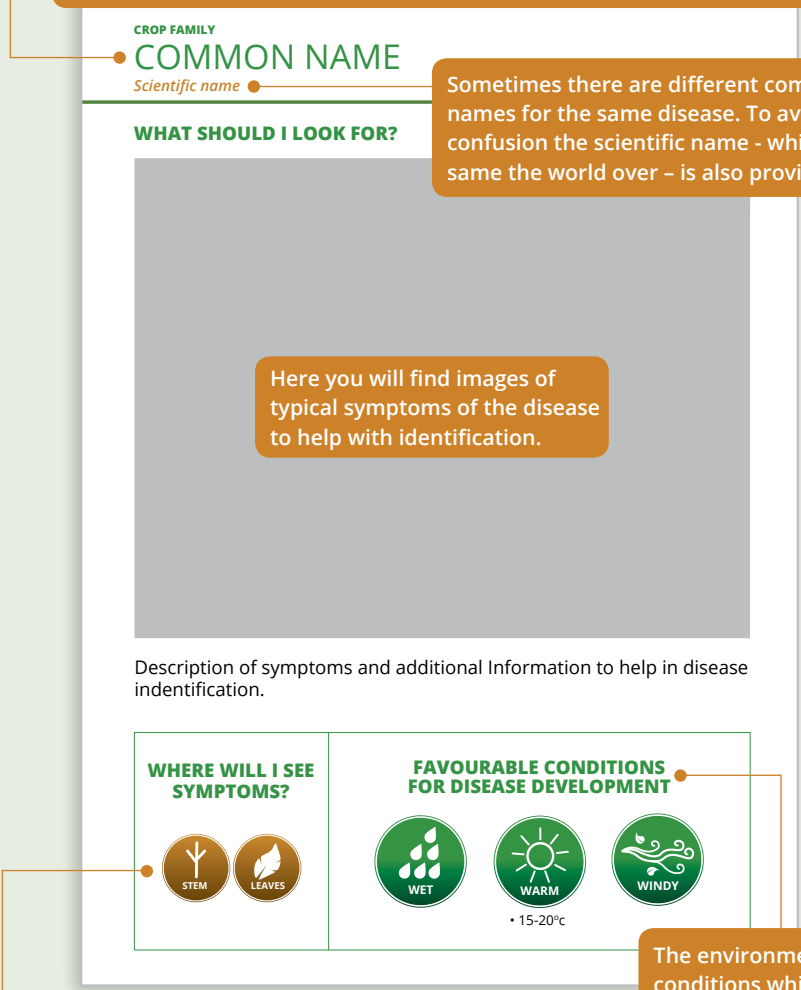
Figure 1. Factors contributing to plant health and resilience to soil-borne diseases.

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.

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.



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.

The environmental conditions which favour disease development are identified here.

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

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 are provided below

Look here for further information on typical survival time, which varies 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 scattered in pockets across the field. This section gives a clue on what you should expect to see in the field.

Description of symptoms and additional information to help in disease identification

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

SURVIVAL TIME WITHOUT HOST | More than 10 years

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/COVER CROP

HOST-FREE ZONE
Control volunteer host plants and weeds

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

CHEMICAL FUMIGATION
Always use with care and as per label

PLANTING PREPARATION

CROP SELECTION
Choose a resistant/less susceptible cultivar

DRAINAGE
Plant on raised beds or well-draining soil

SOIL SOLARISATION
Cover soil with a tarp and kill harmful pathogens

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

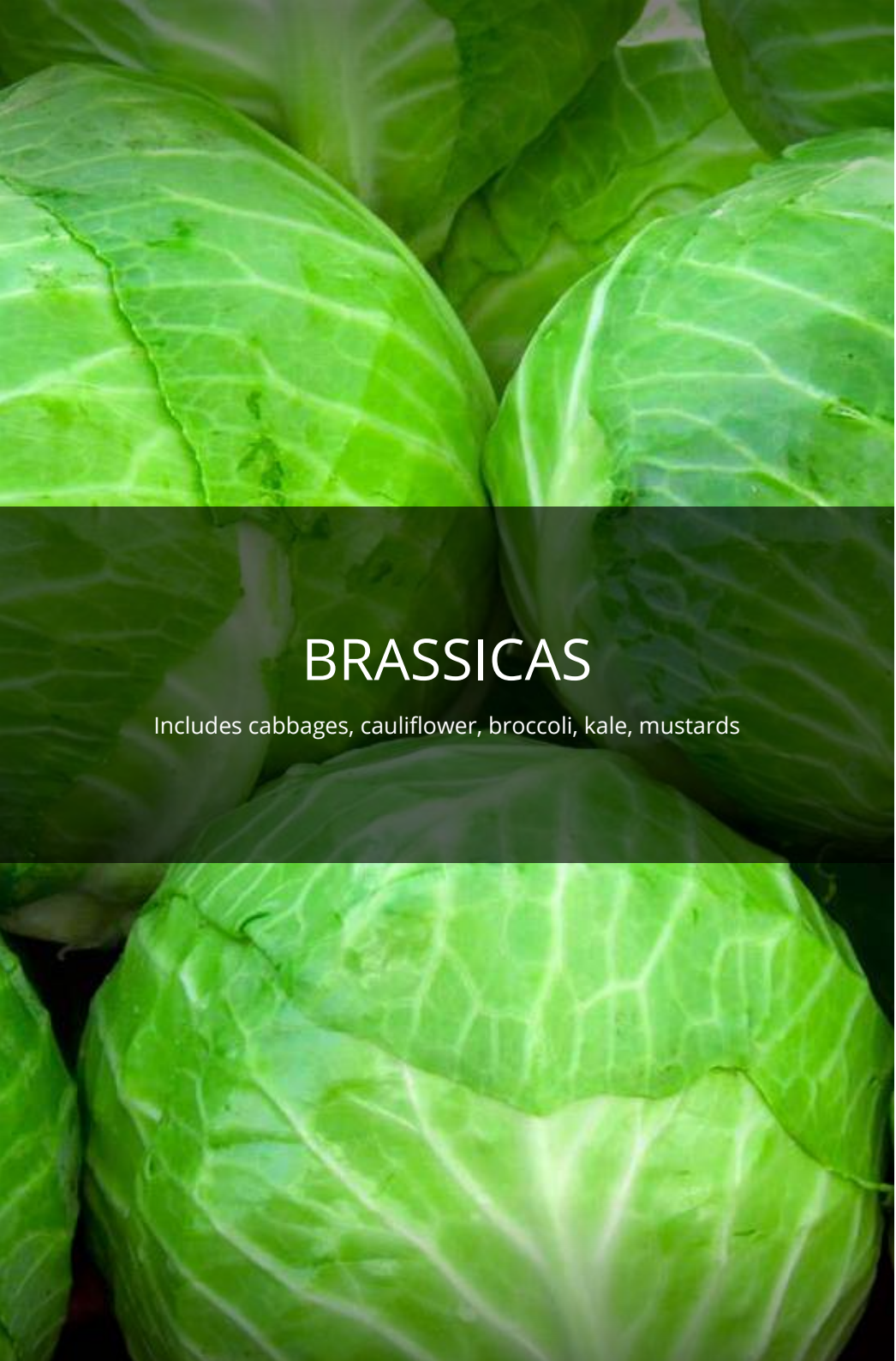
HOST RANGE

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

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. Alternatively a cover crop or break crop (non-vegetable crop) may be grown to provide ground cover and improve soil health. If it does not act as a host to the disease, a cover crop can also be valuable in providing a break in the disease cycle and can help control soil-borne disease.

Planting preparation is the period immediately leading up to planting. Typically this is referring to the 4 to 6 week period pre-planting but this will vary depending on the crop rotation system.

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.



BRASSICAS

Includes cabbages, cauliflower, broccoli, kale, mustards

Beet cyst nematode	Black leg (Phoma leaf spot)	Clubroot	Damping off/ Wirestem
Page 12	Page 16	Page 20	Page 24
			

Fusarium wilt (yellows)	Root-knot nematode	Sclerotinia rot	Verticillium wilt
Page 28	Page 32	Page 36	Page 40
			

BEET CYST NEMATODE

Heterodera schachtii

WHAT SHOULD I LOOK FOR?

Stunted growth and yellowing of aboveground plant

DAFF Archive, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 21-27°C In warm conditions can have up to five generations in one growing season.

• Seedlings particularly susceptible

Increase in fine “whisker-like” roots with small white spherical cysts
L. Tesoriero, Crop Doc Consulting

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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

SOIL TEST

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

PLANT TRAP CROPS

Plant nematode resistant crops that prevent reproduction

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

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

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

HOST RANGE

Brassica crops and weeds, silverbeet, beetroot and rhubarb

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

BIO FUMIGATION

Grow a biofumigant crop

- Use non-brassica crops e.g. biofumigant sorghum varieties

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BLACK LEG (PHOMA LEAF SPOT)

Leptosphaeria maculans (Phoma lingam)

WHAT SHOULD I LOOK FOR?

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 10-15°C for spread

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

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 | INFECTED SEED/ SEEDLINGS

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

- Solarise for 4-6 weeks preplanting with soil temperature ideally reaching 30°C +

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

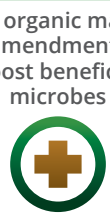
Ensure plants' nutritional needs are met

HOST RANGE

Crop and weed brassicas including cabbage, Chinese cabbage, kale, broccoli, cauliflower, canola mustards, radish, turnip and shepherd's purse

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes



USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

CLUBROOT

Plasmodiophora brassicae

WHAT SHOULD I LOOK FOR?

Digging up wilted plants reveals knot-like swelling (galls) on the root system
S. Grigg, Ag-Hort Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-26°C

Scattered areas of wilted plants may be seen across the field *S. Grigg, Ag-Hort Consulting*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- WIND
- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

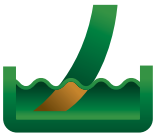
CROP SELECTION

Choose a resistant/less susceptible cultivar

- Chinese cabbage is highlu suscpetible

SOIL PH

Use amendments to adjust soil pH



- Adjust pH to 7.0-7.5

POST-PLANT

CHEMICAL TREATMENT

Use registered soil drench at planting

- Consult APVMA or InfoPest website for current registered products

AVOID PLANT INJURY

Avoid any physical damage to plant

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Use non-brassicas e.g. biofumigant sorghum varieties

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

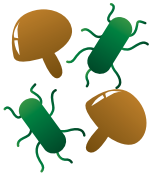
SOIL TEST

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

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

BIOCONTROL PRODUCTS



GOOD NUTRITION

Ensure plants' nutritional needs are met

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

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, Stuart Grigg Ag-Hort Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-15ºC

Stem discolouration and rot evident at stem base, in this case caused by *Rhizoctonia* spp. Stem eventually collapses leading to wilt and plant death *L. Tesoriero, Crop Doc Consulting*

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

- Small areas (3-4 infected plants) may also be visible

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL | INSECTS

SURVIVAL TIME WITHOUT HOST More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- Oats are a good rotation option to reduce *Rhizoctonia* spp.

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

TRANSPLANTS

Use seedling transplants - not direct seeding

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Crop and weed brassicas including cabbage, Chinese cabbage, kale, broccoli, cauliflower, canola mustards, radish, turnip, shepherd's purse

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

BIO FUMIGATION

Grow a biofumigant crop

- Use non-brassicas e.g. biofumigant sorghum varieties

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

SOIL TEST

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

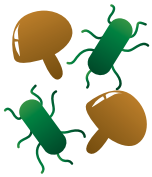
CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



CONTROL PESTS

Control insect pests that spread spores

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, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• >22°C Varies between types of Fusarium

• Especially potassium deficiency

• Ammonium fertilisers can favour disease

Often lower leaves appear stunted, wilt and turn yellow more on one side of the plant. May be confused with water stress or nutrient deficiency *L. Tesoriero, Crop Doc Consulting*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Calcium supplements may help suppress diseases

POST-PLANT

CONTROL PESTS

Control insect pests that spread spores

- Particularly important at the seedling stage

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Crop and weed brassicas including cabbage, Chinese cabbage, kale, broccoli, cauliflower, canola mustards, radish, turnip, shepherd's purse

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

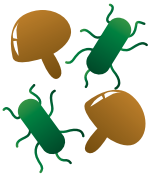
- Consult APVMA or InfoPest website for current registered products
- Use non-brassicas e.g. biofumigant sorghum varieties

FERTILISER SELECTION

CHEMICAL TREATMENT

Use registered soil drench at planting

BIOCONTROL PRODUCTS

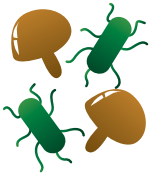


- Avoid acidifying ammonium fertilisers

GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



ROOT-KNOT NEMATODE

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

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

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

WHERE WILL I SEE SYMPTOMS?

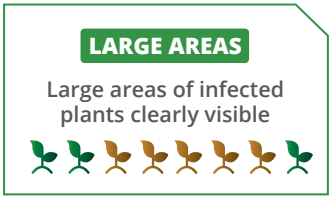
- Lower leaves

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Active 15°C +
- Active 8.5°C +

HOW DOES IT SPREAD?

DISTRIBUTION IN THE FIELD



SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANT TRAP CROPS

Plant nematode resistant crops that prevent reproduction

CROP ROTATION

Select non-host rotation or cover crops

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 resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

HOST RANGE

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

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

- If numbers are high consider fallow or non-host break crop

BIO FUMIGATION

Grow a biofumigant crop

- Use non-brassicas e.g. biofumigant sorghum varieties

SOIL TEST

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

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

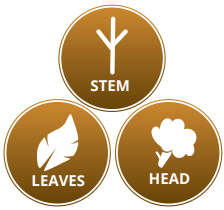
SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

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

WHERE WILL I SEE SYMPTOMS?



FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18ºC

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

a: R. Lancaster, DPIRD; b: G. Holmes, California Polytechnic State University, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

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

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

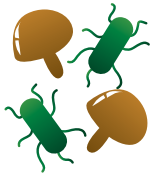
CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

BIOCONTROL PRODUCTS



- 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 and pigweed

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

BIO FUMIGATION

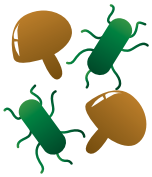
Grow a biofumigant crop

- Use non-brassicas e.g. biofumigant sorghum varieties

GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



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. Discoloured vascular tissue can also be seen at the base of the plant.

L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• Air 23-25°C optimum for infection

• pH >7

Ammonium fertilisers can favour disease

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

Ohio State University Extension

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

PLANTING PREPARATION

FERTILISER SELECTION

- Ammonium fertilisers help suppress disease

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

SOIL TEST

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

POST-PLANT

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

AVOID PLANT INJURY

Avoid any physical damage to plant

AVOID WATER STRESS

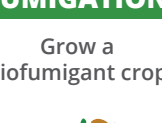
Ensure plants receive adequate water

HOST RANGE

Brassica crops and weeds, tomatoes and olives

BIO FUMIGATION

Grow a biofumigant crop



- Use non-brassicas e.g. biofumigant sorghum varieties

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

GOOD NUTRITION

Ensure plants' nutritional needs are met

CAPSICUM, CHILLI AND EGGPLANT

Bacterial wilt	Damping off	Phomopsis blight /Fruit rot	Pythium root rot
Page 46	Page 50	Page 54	Page 58
			

Root-knot nematode	Sclerotinia (white mould)	Sclerotium rot	Verticillium wilt
Page 62	Page 66	Page 70	Page 74
			

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

WHERE WILL I SEE SYMPTOMS?

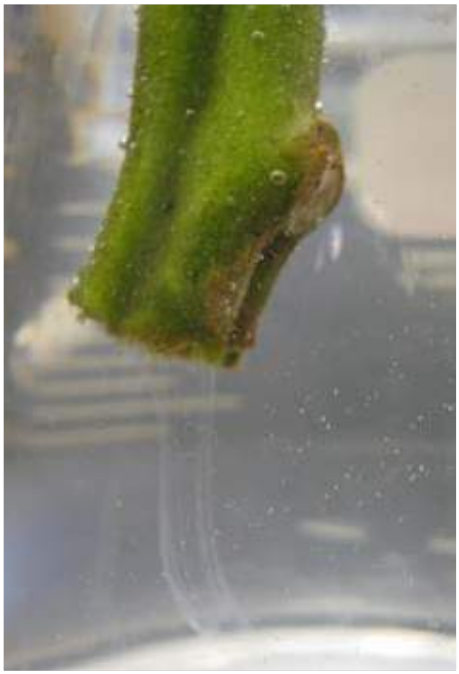
FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 25-35°C

- Moist soil favours disease

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

GRAFTING

Use transplants grafted onto resistant rootstock

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Avoid excess nitrogen

HOST RANGE

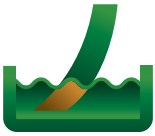
Wide host range including most solanceae vegetable crops

BIO FUMIGATION

Grow a biofumigant crop

SOIL PH

Use amendments to adjust soil pH



- Adjust pH to 5.5-7

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Avoid planting during high temperatures

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-15°C Some *Pythium* spp. prefer warmer temperatures

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

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

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND | MOVEMENT OF CONTAMINATED SOIL | FREE WATER | INSECTS | CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

SOIL TEST

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

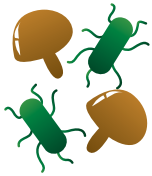
NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

BIOCONTROL PRODUCTS



CONTROL PESTS

Control insect pests that spread spores

PHOMOPSIS BLIGHT/FRUIT ROT

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. Stems develop large sunken cracked cankers *Yuan-Min Shen, Taichung District Agricultural Research and Extension Station, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- > 28°C

Fruit rot occurs >29°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER | MOVEMENT OF CONTAMINATED SOIL | INSECTS | INFECTED SEED/ SEEDLINGS | WIND | RAIN SPLASH

SURVIVAL TIME WITHOUT HOST 3-10 years

WHAT SHOULD I LOOK FOR?

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

B.Olson, Oklahoma State University, Bugwood.org

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Eggplants

CROP ROTATION

Select non-host rotation or cover crops

- 3 year break between eggplant crops

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

- Consider plastic mulch to avoid soil contact

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

CONTROL PESTS

Control insect pests that spread spores

AVOID CONTACT WITH SOIL

Use plastic mulch to avoid plant-soil contact

- Plastic mulch

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, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 12-18°C

Can develop in hot or cold conditions

Sunken dark lesions may occur on lower stems or a rot of the roots may develop
Penn State University, Bugwood.org

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND | MOVEMENT OF CONTAMINATED SOIL | FREE WATER | INSECTS | CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- 3 year break between eggplant crops

PLANTING PREPARATION

CHEMICAL TREATMENT

Use registered soil drench at planting

DRAINAGE

Plant on raised beds or well-draining soil

SOIL TEST

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

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

Capsicum

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

NO RESIDUE AT PLANTING

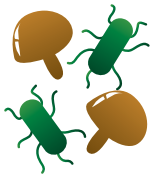
Ensure no plant residues from host crops at planting

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



CONTROL PESTS

Control insect pests that spread spores

ROOT-KNOT NEMATODE

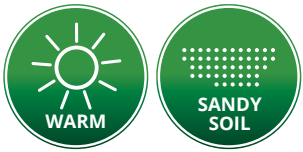
WARM CLIMATE SPECIES: *Meloidogyne incognita | Meloidogyne javanica | Meloidogyne arenaria*

WHAT SHOULD I LOOK FOR?

Aboveground plants may appear chlorotic and stunted
G. Holmes, California Polytechnic State University

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT



• Active 15°C +

• Active 8.5°C +

Belowground roots develop characteristic swelling and galls *S. Nelson FLICKR*

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

- CONTAMINATED PLANT DEBRIS
- MOVEMENT OF CONTAMINATED SOIL
- FREE WATER

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

CHEMICAL TREATMENT

Use registered soil drench at planting

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

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

CHEMICAL FUMIGATION

Always use with care and as per label

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- Consult APVMA or InfoPest website for current registered products

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

SOIL TEST

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

- Maximise growth in cool conditions when nematode activity is low. Harvest early in high risk situations
- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non-host break crop

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

•13-18ºC

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*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- WIND
- MOVEMENT OF CONTAMINATED SOIL
- FREE WATER
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

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

GOOD NUTRITION

Ensure plants' nutritional needs are met

- 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 family

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

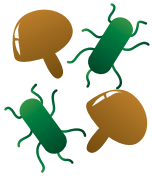
Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 25-35°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- WIND
- MOVEMENT OF CONTAMINATED SOIL
- FREE WATER
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

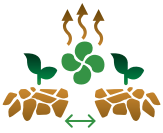
CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow



DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

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

HOST RANGE

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

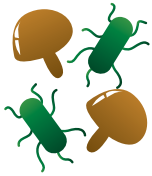
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIOCONTROL PRODUCTS



VERTICILLIUM WILT

Verticillium dahliae

WHAT SHOULD I LOOK FOR?

Symptoms begin as pale green blotches between veins and leaf margins. Eventually leaf will wilt, turn brown and die as the disease moves up the plant; often only on one side of the plant

A. Vieira, Ontario Crop IPM, OMAFRA

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• Air 23-25°C
Optimum for infection

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

A. Vieira, Ontario Crop IPM, OMAFRA

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

A. Vieira, Ontario Crop IPM, OMAFRA

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- MOVEMENT OF CONTAMINATED SOIL
- FREE WATER
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

BIO FUMIGATION

Grow a biofumigant crop

PLANTING PREPARATION

FERTILISER SELECTION

- Ammonium fertilisers help suppress disease

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

SOIL TEST

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

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

AVOID WATER STRESS

Ensure plants receive adequate water

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

Eggplant, tomato, olive trees, brassica crops and weeds

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

CHEMICAL FUMIGATION

Always use with care and as per label

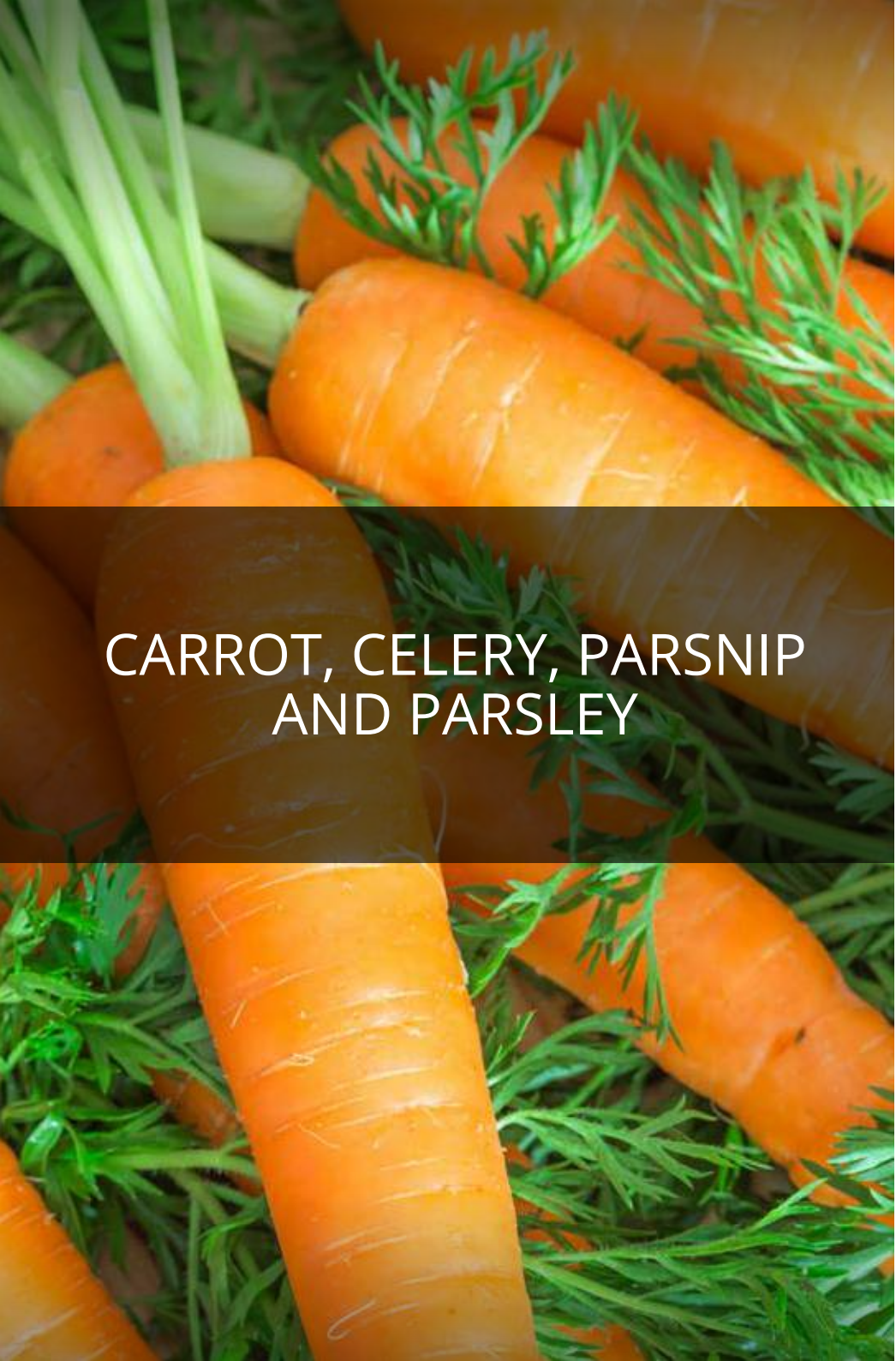
- Consult APVMA or InfoPest website for current registered products

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting



CARROT, CELERY, PARSNIP AND PARSLEY

Black canker	Black root rot/black mould	Carrot scab	Cavity spot	Crater rot
Page 80	Page 84	Page 88	Page 92	Page 96
				

Crown rot	Damping off	Leaf curl/ celery anthracnose	Root-knot nematode
Page 100	Page 104	Page 108	Page 112
			

Root-lesion nematode	Root rot complex	Sclerotinia rot (white mould)	Sclerotium rot
Page 116	Page 120	Page 124	Page 128
			

BLACK CANKER

Itersonilia perplexans | *Cylindrocarpon* spp. | *Mycocentrospora acerina*

WHAT SHOULD I LOOK FOR?

Orange-brown lesions often with a pale green-yellow halo form are seen on the leaves.
M. Kowalik-Kepler, APS

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 18-22ºC
- Periods of extended rain

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | Less than 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 12 month break between parsnip crops

BIO FUMIGATION

Grow a biofumigant crop

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

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

CROP SELECTION

Choose a resistant/less susceptible cultivar

HOST RANGE

Parsnip, carrot

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

BLACK ROOT ROT/BLACK MOULD

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 5°C

L. du Toit, WSU

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 17-25°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

CONTAMINATED PLANT DEBRIS

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

BIO FUMIGATION

Grow a biofumigant crop

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

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- Minimise irrigation splash

HOST RANGE

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

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

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*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

Multiple lesions may merge to form large scabby horizontal bands *Bayer Crop Science, UK*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- FREE WATER
- CONTAMINATED PLANT DEBRIS
- MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- 4-5 year break from carrot crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

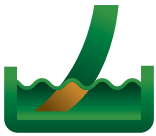
PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL PH

Use amendments to adjust soil pH



- Adjust soil pH to 5.5

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID WATER STRESS

Ensure plants receive adequate water

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

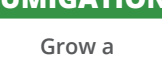
Ensure plants' nutritional needs are met

HOST RANGE

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

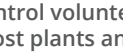
BIO FUMIGATION

Grow a biofumigant crop



HOST-FREE ZONE

Control volunteer host plants and weeds



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

FERTILISER SELECTION

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

CAVITY SPOT

Pythium sulcatum or P. violae

WHAT SHOULD I LOOK FOR?

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 20-28°C
Optimum *P. sulcatum* -28°C
P. violae -19°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

CONTAMINATED PLANT DEBRIS

INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

BIO FUMIGATION

Grow a biofumigant crop

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

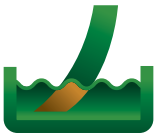
PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

SOIL PH

Use amendments to adjust soil pH



CROP SELECTION

Choose a resistant/less susceptible cultivar

- On acidic soils adjust to pH 6.5-7.5

POST-PLANT

CHEMICAL TREATMENT

Use registered soil drench at planting

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

P. sulcatum - Carrot, parsnips, celery, parsley

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

CROP ROTATION

Select non-host rotation or cover crops

- 5 year break between host crops

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

SOIL TEST

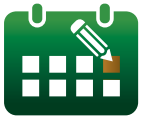
Conduct a pre-sowing soil test to help predict level of risk

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

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

CRATER ROT

Rhizoctonia carotae

WHAT SHOULD I LOOK FOR?

Horizontal dark brown bands develop mostly on the crown and upper root
L. Tesoriero, NSW DPI

WHERE WILL I SEE SYMPTOMS?

• Crown and upper part of root

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 16-20ºC

Rotted pits develop under the bands, joining to form craters as the disease progresses. White cottony growth may develop in high humidity *Plant Disease Clinic, University of Minnesota*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

- 8 year rotation with non-host crop

PLANTING PREPARATION

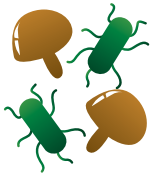
DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

BIOCONTROL PRODUCTS



POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

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

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Carrot

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL TREATMENT

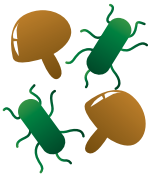
Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



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 often causes breaking off of leaves at harvest *L. Tesoriero, Crop Doc Consulting*

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 18-25ºC

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

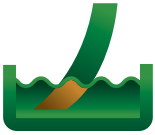
Select non-host rotation or cover crops

- Minimum 3 year break between host crops

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

IRRIGATION MANAGEMENT

Monter crop and soil to optimize amount and timing

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Stressed crops are more susceptible to infection

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Carrot, parsnips, celery

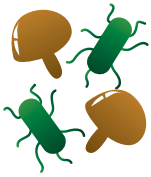
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIOCONTROL PRODUCTS

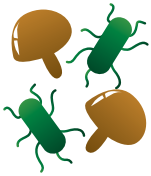


CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



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, Crop Doc Consulting*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18°C

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*

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

FREE WATER

WIND

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

- 3 to 4 years between host crops

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

GOOD NUTRITION

Ensure plants' nutritional needs are met

AVOID PLANT INJURY

Avoid any physical damage to plant

- Stressed crops are more susceptible to infection

HOST RANGE

Carrot, parsnips, celery, parsley

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

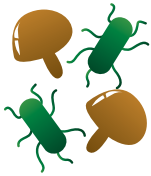
Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



CONTROL PESTS

Control insect pests that spread spores

- Sciarid flies can spread disease

LEAF CURL/CELERY ANTHRACNOSE

Colletotrichum acutatum | C. orbiculare

WHAT SHOULD I LOOK FOR?

Stunting of plants resulting in small cupped leaves. Older leaves may curl downward and become distorted. Brown lesions may develop on leaf margins. Lesions may become brittle and crack.

L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Extended leaf wetness
- 23-27°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

WIND

- Continuous water splash

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4-year break

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible 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

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest for current registered products

HOST RANGE

Wide host range including celery

ROOT-KNOT NEMATODE

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

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 *Meloidogyne* spp. can result in swollen galls on carrot roots. *S. Nelson FLICKR*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Active 15°C +
- Active 8.5°C +

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

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

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

HOST RANGE

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

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

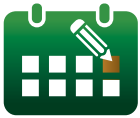
SOIL TEST

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

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

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

CHEMICAL TREATMENT

Use registered soil drench nematicide at planting

- Consult APVMA or InfoPest website for current registered products

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-25ºC

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

S. Collins, DPIRD

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

HOST RANGE

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

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

SOIL TEST

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

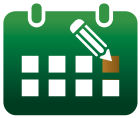
- e.g. PREDICTA® B testing service. If numbers are high consider fallow or non-host break crop

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

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

ROOT ROT COMPLEX

Phytophthora/Pythium spp.

WHAT SHOULD I LOOK FOR?

Aboveground, yellowing and wilting of leaves followed by plant collapse and death, as shown in parsley

L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

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

L. Tesoriero, Crop Doc Consulting

Roots may also develop a brown spongy rot as shown in carrots

L. Tesoriero, Crop Doc Consulting

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4 years between host crops

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

HOST RANGE

Carrot, parsnip, celery, parsley

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

At base of stem fluffy white fungal growth is visible, leading to stem rot and collapse
H.F. Schwartz. Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18ºC

Survival structures (*sclerotia*) form 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*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

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

AVOID PLANT INJURY

Avoid any physical damage to plant

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

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

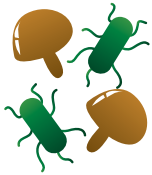
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

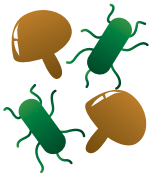
BIOCONTROL PRODUCTS



GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



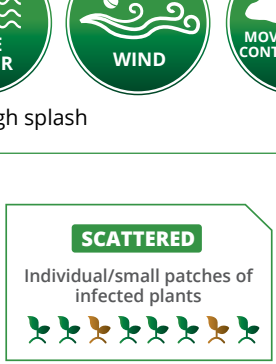
SCLEROTIUM ROT

Sclerotium rolfsii

WHAT SHOULD I LOOK FOR?

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

D. Langston, University of Georgia, Bugwood.org

WHERE WILL I SEE SYMPTOMS?	
FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT	 • 25-35ºC
HOW DOES IT SPREAD?	 • Mostly through splash
DISTRIBUTION IN THE FIELD	

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- 3 to 4 years between host crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

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

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Very wide (more than 400 different plant species). Infects most vegetable crops including members of the bean, brassica and pumpkin families.

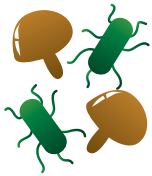
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

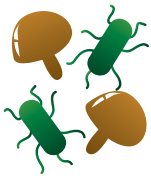
BIOCONTROL PRODUCTS



GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS




GREEN BEANS AND PEAS

Aphanomyces root rot	Ashy stem blight (charcoal rot)	Black root rot	Black spot
Page 134	Page 138	Page 142	Page 146
			

Fusarium root rot	Pea wilt	Pythium stem rot
Page 150	Page 154	Page 158
		

Rhizoctonia root rot	Sclerotinia rot (white mould)	Sclerotium rot
Page 162	Page 166	Page 170
		

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 22-28°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- 6 to 10 year rotation

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

SOIL TEST

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

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

CONTROL PESTS

Control insect pests that spread spores

- Sciarid flies can spread spores and larvae damage roots

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

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

CROP SELECTION

Choose a resistant/less susceptible cultivar

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

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, Colorado State University, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 24-27°C

As the disease progresses, dry rot of the stem and pale, ash-coloured "dust" develop
H. Schwartz, Colorado State University, Bugwood.org

Small black survival structures (*microsclerotia*) develop in dead tissue
P. Bachi, University of Kentucky Research and Education Center, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED
Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- 4 to 6 year break from susceptible crop

PLANTING PREPREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

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

POST-PLANT

AVOID WATER STRESS

Ensure plants receive adequate water

GOOD NUTRITION

Ensure plants' nutritional needs are met

AVOID PLANT INJURY

Avoid any physical damage to plant

- Avoid excess Nitrogen

HOST RANGE

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

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

BIO FUMIGATION

Grow a biofumigant crop

SOIL TEST

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

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

BLACK ROOT ROT

Thielaviopsis basicola (aka. Chalara elegans)

WHAT SHOULD I LOOK FOR?

Initially long red lesions appear on the root which eventually turn black
Virginia Tech Learning Resources Center

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 17-25°C

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

N. Cattlin, Alamy Stock Photo

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- 5 to 6 year break from host crops

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

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

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- Minimise irrigation splash

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

BLACK SPOT (ASCOCHYTA BLIGHT)

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

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 University

WHERE WILL I SEE SYMPTOMS?

- In severe cases

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 18-22°C

Phoma Koolunga and Didymella pisi.

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

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

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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

PLANTING PREPARATION

NO RESIDUE AT PLANTING

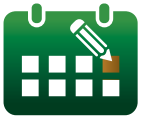
Ensure no plant residues from host crops at planting

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

HOST RANGE

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

AIR CIRCULATION

Increase row/plant spacing to improve air flow

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Soil <13°C at planting

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- CONTAMINATED PLANT DEBRIS
- INFECTED SEED/ SEEDLINGS
- MOVEMENT OF CONTAMINATED SOIL
- INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

PLANTING PREPARATION

CULTIVATION

Cultivate heavily compacted soil e.g. deep rip

- Consider cultivation in heavily compacted soils

FERTILISER SELECTION

- Avoid acidifying NH4+ fertilizers

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

POST-PLANT

HILL UP

Bury the base of the plant to encourage new growth

- May encourage new growth above diseased area

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Consider calcium supplements

HOST RANGE

Green beans

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

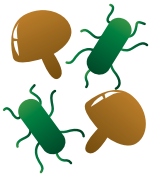
NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

CONTROL PESTS

Control insect pests that spread spores

BIOCONTROL PRODUCTS



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*

WHERE WILL I SEE SYMPTOMS?

ROOTS LEAVES

- In severe cases

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

HOT

- 25-30°C

WET

- High soil moisture favours disease

COMPACTED SOIL

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.*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- CONTAMINATED PLANT DEBRIS
- INFECTED SEED/ SEEDLINGS
- MOVEMENT OF CONTAMINATED SOIL
- INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

CONTROL PESTS

Control insect pests that spread spores

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

Peas

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

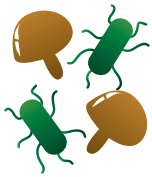
CROP SELECTION

Choose a resistant/less susceptible cultivar

FERTILISER SELECTION

- Use low ammonium fertilisers

BIOCONTROL PRODUCTS



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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Daytime 30-35°C
  Night >20°C

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

B. Olson, Oklahoma State University, Bugwood.org

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL | INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5-6 year break from host crop

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

- Use registered seed treatment

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

CONTROL PESTS

Control insect pests that spread spores

HOST RANGE

Very wide host range, including all legumes and most vegetable crops

CHEMICAL FUMIGATION

Always use with care and as per label

BIO FUMIGATION

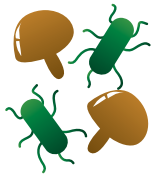
Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- Consult APVMA or InfoPest website for current registered products

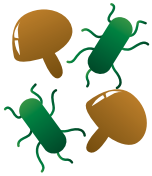
BIOCONTROL PRODUCTS



GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



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 form 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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Soil temperature <20°C

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

L. Porter, ARS-USDA

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-draining soil

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

POST-PLANT

HILL UP

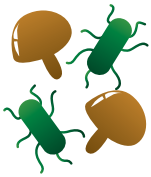
Bury the base of the plant to encourage new growth

- May encourage new growth above diseased area

AVOID PLANT INJURY

Avoid any physical damage to plant

BIOCONTROL PRODUCTS



HOST RANGE

Very wide host range, including all legumes and most vegetable crops

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

BIO FUMIGATION

Grow a biofumigant crop

- Consult APVMA or InfoPest website for current registered products

GOOD NUTRITION

Ensure plants' nutritional needs are met

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

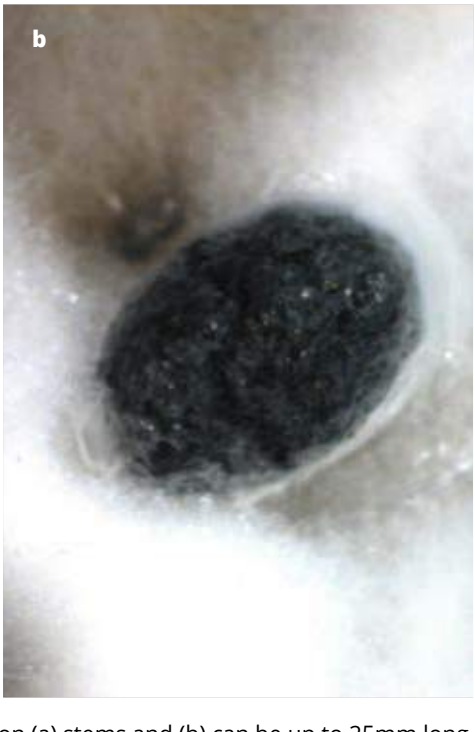
Symptoms begin as water-soaked lesions which eventually rot and collapse. As the disease progresses, characteristic white fluffy growth develops followed by black survival structures (sclerotia).

N. Cattlin, Alamy Stock Photo

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 15-20°C



Survival structures (sclerotia) can also develop on (a) stems and (b) can 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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL | CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

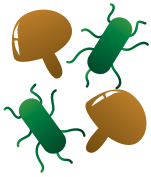
- Consult APVMA or InfoPest website for current registered products

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

BIOCONTROL PRODUCTS



CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

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

- Consult APVMA or InfoPest website for current registered products

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 25-35°C

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

Clemson University, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

- WIND
- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

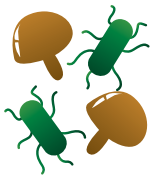
Monitor crop and soil to optimize amount and timing

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



HOST RANGE

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

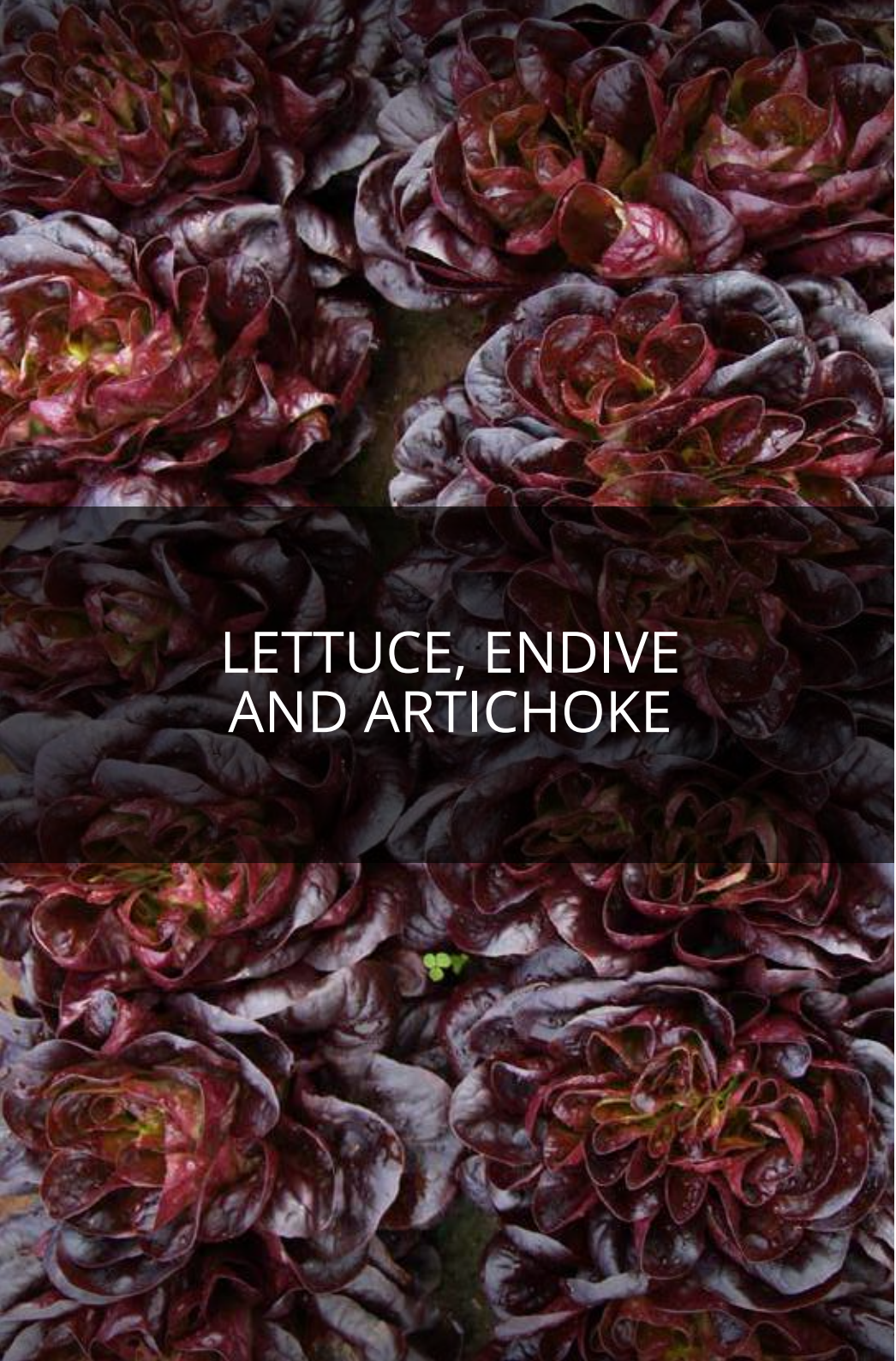
CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source



LETTUCE, ENDIVE AND ARTICHOKE

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

Damping off	Lettuce big-vein disease	Sclerotinia rot (white mould)	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

WHERE WILL I SEE SYMPTOMS?

• Lower leaves

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 15-22ºC

• Leaf wetness of 8 hours or more increases infection risk

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER | WIND | MOVEMENT OF CONTAMINATED SOIL

- Mostly through splash

SURVIVAL TIME WITHOUT HOST | More than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 4 year break

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- 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 and 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. In more severe cases lower leaves will turn yellow or brown *S. Koike, TriCal Diagnostics*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 17-25ºC

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- 5 to 6 year break from susceptible crops

BIO FUMIGATION

Grow a biofumigant crop

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

DRAINAGE

Plant on raised beds or well-draining soil

CROP SELECTION

Choose a resistant/less susceptible cultivar

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- Minimise irrigation splash

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BOTTOM ROT

Rhizoctonia spp.

WHAT SHOULD I LOOK FOR?

Starts as brown spots on underside of leaf midrib and develops to rot on midrib leaf blade
Gerald Holmes, California Polytechnic State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

•25-27°C

Heads can be slimy brown to dark brown/black as they collapse. Brown mycelium can grow over lesion with small brown sclerotia. Brown rot of root may also be seen
G. Holmes, California Polytechnic State University, Bugwood.org

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

- WIND
- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 year break

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible 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

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

AVOID PLANT INJURY

Avoid any physical damage to plant

HOST RANGE

Lettuce, endive

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

AIR CIRCULATION

Increase row/plant spacing to improve air flow

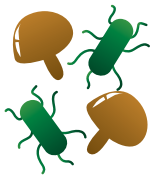
SOIL TEST

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

GOOD NUTRITION

Ensure plants' nutritional needs are met

BIOCONTROL PRODUCTS



CORKY ROOT ROT

Sphingomonas suberifaciens

WHAT SHOULD I LOOK FOR?

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 20-25°C

Eventually roots become swollen, cracked, 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*

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 18 months

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

FERTILISER SELECTION

- Nitrate form of fertiliser may increase severity

TRANSPLANTS

Use seedling transplants - not direct seeding

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Avoid excess nitrogen

HOST RANGE

Lettuce, prickly lettuce, sow thistle, endive

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

DAMPING OFF

Pythium spp. | *Rhizoctonia solani* | *Phytophthora* spp. | *Fusarium* 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*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 15°C-18°C

Some *Pythium* spp. prefer warm weather i.e. >24°C

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

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL | CONTAMINATED PLANT DEBRIS | INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

TRANSPLANTS

Use seedling transplants - not direct seeding

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

CONTROL PESTS

Control insect pests that spread spores

HOST RANGE

Lettuce, endive

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CHEMICAL FUMIGATION

Always use with care and as per label

CHEMICAL TREATMENT

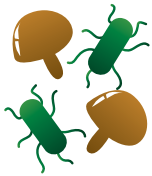
Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

SOIL TEST

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

BIOCONTROL PRODUCTS



GOOD NUTRITION

Ensure plants' nutritional needs are met

LETTUCE BIG-VEIN DISEASE

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

WHAT SHOULD I LOOK FOR?

Abnormally large clear veins

S. Grigg, Ag-Hort Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- <16°C

Leaves are often puckered or mottled and may appear thickened
S. Grigg, Ag-Hort Consulting

Head size may be reduced or in some cases no head will develop
S. Grigg, Ag-Hort Consulting

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

Transmitted by fungus *Olpidium virulentus*

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 18 months

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

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

AVOID PLANT INJURY

Avoid any physical damage to plant

REMOVE INFECTED PLANTS

Contain and dispose of infected plant material away from field

HOST RANGE

Lettuce and weed species such as sow thistle and chickweed may act as hosts

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Avoid planting in cool temperatures which increase disease expression

CROP SELECTION

Choose a resistant/less susceptible cultivar

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

SCLEROTINIA ROT (WHITE MOULD)

Sclerotinia sclerotiorum | S. minor

WHAT SHOULD I LOOK FOR?

Symptoms begin as (a) watery soft lesions that (b) develops into fluffy white growth sometimes containing black survival structures (sclerotia). Lower leaves and stems are most affected.

L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18ºC

Brown, soft decay eventually destroys the tissue around crown. Near maturity the entire plant will wilt and collapse. *B. Shew, North Carolina State University, Bugwood.org*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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/plant spacing to improve air flow

POST-PLANT

IRRIGATION MANAGEMENT

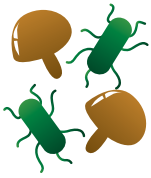
Monitor crop and soil to optimize amount and timing

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

ROOT-KNOT NEMATODE

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

WHAT SHOULD I LOOK FOR?

Aboveground plant may appear chlorotic and stunted (left) compared to a healthy lettuce (right)

Ontario Ministry of Agriculture and Food (OMAFRA)

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Active 15°C +
- Active 8.5°C +

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

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

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

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

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- Consult APVMA or InfoPest website for current registered products

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

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

PUMPKIN, SQUASH, ZUCCHINI AND CUCUMBER

Charcoal rot	Damping off	Fusarium foot rot	Fusarium wilt
Page 210	Page 214	Page 218	Page 222
			

Gummy stem blight	Root-knot nematode	Sclerotinia rot	Sclerotium rot
Page 226	Page 230	Page 234	Page 238
			

CHARCOAL ROT

Macrophomina phaseolina

WHAT SHOULD I LOOK FOR?

Seedlings with early infection show water-soaked lesions at soil line that may choke and kill the plant

H. Schwartz, Colorado State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 27-30°C

As the disease progresses amber coloured ooze, similar to gummy stem blight, may be released. Lesions eventually dry out and many survival structures (microsclerotia) may be seen in the dead tissue

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

Infected fruit develop large soft grey to black sunken lesions, shown here in an infected cucumber

C. Averre North Carolina State University, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

BIO FUMIGATION

Grow a biofumigant crop

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

GRAFTING

Use transplants grafted onto resistant rootstock

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

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

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

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 dark brown lesions 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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18°C

Plants experience stunting, wilting and eventual death
G. Holmes, California Polytechnic State University, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED
Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP SELECTION

Choose a resistant/less susceptible cultivar

PLANTING PREPARATION

DRAINAGE

Plant on raised beds or well-draining soil

TRANSPLANTS

Use seedling transplants - not direct seeding

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

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

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

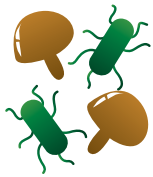
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIOCONTROL PRODUCTS



CHEMICAL TREATMENT

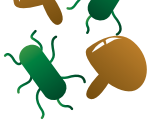
Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

CONTROL PESTS

Control insect pests that spread spores

BIOCONTROL PRODUCTS



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 chokes plant. Leaves wilt followed by plant death. Crown often breaks off and secondary pathogens invade decaying plant tissue sometimes producing a bad odour.

M. Lloyd, University of California, Co-operative Extension

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 25-30°C

Pink to white fungal mycelium is often found on the soil surface beside the lesion and darkened soil may also be evident *M. Lloyd, University of California, Co-operative Extension*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

SURVIVAL TIME WITHOUT HOST More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

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

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

CONTROL PESTS

Control insect pests that spread spores

HOST RANGE

Zucchini, pumpkin

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

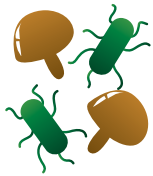
BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIOCONTROL PRODUCTS



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, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 25-30°C

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

FERTILISER SELECTION

GRAFTING

Use transplants grafted onto resistant rootstock

- Consider calcium supplements

POST-PLANT

CONTROL PESTS

Control insect pests that spread spores

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Especially at seedling stage

HOST RANGE

Cucumber

CHEMICAL FUMIGATION

Always use with care and as per label

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- Consult APVMA or InfoPest website for current registered products

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

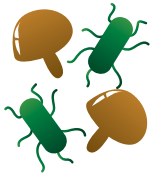
USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

DRAINAGE

Plant on raised beds or well-draining soil

BIOCONTROL PRODUCTS



GUMMY STEM BLIGHT

Stagonosporopsis cucurbitacearum

WHAT SHOULD I LOOK FOR?

Symptoms begin as water-soaked lesions and with age can dry out, form rings and produce small black survival structures (pycnidia) *B. Watt, University of Maine*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-24°C

Small black survival structures (pycnidia) may be seen on older leaf or stem lesions
L. Tesoriero, Crop Doc Consulting

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

SURVIVAL TIME WITHOUT HOST | Less than 3 years

WHAT SHOULD I LOOK FOR?

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 2 years break from host

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

a) R.Melanson, Mississippi State University Extension, Bugwood.org

b) G.Holmes, California Polytechnic State University, 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, NSW DPI*

HOW DO I CONTROL IT?

FALLOW/COVER CROP

BIO FUMIGATION

Grow a biofumigant crop

CHEMICAL FUMIGATION

Always use with care and as per label

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

- Consult APVMA or InfoPest website for current registered products

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

POST-PLANT

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Consult APVMA or InfoPest website for current registered products

HOST RANGE

Cucumber, gourd, pumpkin, squash, zucchini

ROOT-KNOT NEMATODE

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

WHAT SHOULD I LOOK FOR?

Aboveground symptoms showing chlorotic stunted squash plants resulting from root-knot nematode infection

G. Holmes, California Polytechnic State University

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Warm climate species: Active 15°C+
- Cold climate species: Active 8.5°C+

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

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

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

HOST RANGE

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

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

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

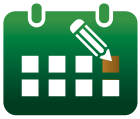
CHEMICAL TREATMENT

Use registered soil drench nematicide at planting

- Consult APVMA or InfoPest website for current registered products

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

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)

M. Gammelgaard, Plantesygdomme

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 13-18°C

Survival structures (sclerotia) can be up to 25mm long in *S. sclerotiorum* and much smaller (up to 3mm long) in *S. minor*

M. Gammelgaard, Plantesygdomme

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

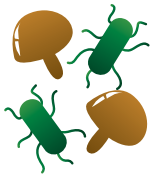
IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

BIOCONTROL PRODUCTS



- 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

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Consult APVMA or InfoPest website for current registered products

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, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 25-35°C

Sclerotia may develop on the infected tissue or soil surface and resemble mustard seeds
G.Holmes, California Polytechnic State University, Bugwood.org

DISTRIBUTION IN THE FIELD

SCATTERED
Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND | FREE WATER | MOVEMENT OF CONTAMINATED SOIL

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest website for current registered products

AVOID PLANT INJURY

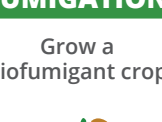
Avoid any physical damage to plant

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop



IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

GOOD NUTRITION

Ensure plants' nutritional needs are met

SPINACH, SILVERBEET AND 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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Infects >15°C
Optimum 20-30°C

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

R. Harveson, University of Nebraska

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

- Often areas with poor drainage

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVAL TIME WITHOUT HOST | Less than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

AIR CIRCULATION

Increase row/plant spacing to improve air flow

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

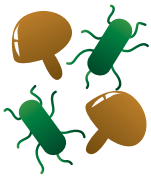
- Disease losses are lower at soil temperatures below 15°C

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

BIOCONTROL PRODUCTS



- Beneficial bacteria and fungi may suppress disease

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

HOST RANGE

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

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

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

DRAINAGE

Plant on raised beds or well-draining soil

CROP SELECTION

Choose a resistant/less susceptible cultivar

- Beetroot and spinach are less sensitive than silverbeet

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Ensure crops are supplied with adequate potassium and calcium

- Check APVMA or InfoPest website for current registered products

CHEMICAL FUMIGATION

Always use with care and as per label

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

BEET CYST NEMATODE

Heterodera schachtii

WHAT SHOULD I LOOK FOR?

Reduced plant stand, stunted growth, yellowing and wilting of aboveground plant, as shown in silverbeet

L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 21-27ºC Up to 5 generations in one growing season is possible in warm conditions

• Seedlings particularly susceptible

Increase in finer "whisker-like" roots with small white spherical cysts. Root vegetables may also develop lumps or swellings *Mactode Publications, Bugwood.org*

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

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

SOIL TEST

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

PLANTING PREPREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

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

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

HOST RANGE

Silverbeet, beetroot, rhubarb and brassicas

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Use non-brassica crops e.g. biofumigant sorghum varieties

PLANT TRAP CROPS

Plant nematode resistant crops that prevent reproduction

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-25°C

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

- Relative humidity 90-100%

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

Bruce Watt, University of Maine, Bugwood.org

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

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

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

PLANTING PREPARATION

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

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

AIR CIRCULATION

Increase row/plant spacing to improve air flow

- Dense plantings encourage spread from plant to plant

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- Spores spread with water splash

HOST RANGE

Silverbeet, beetroot and chard

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

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

DRAINAGE

Plant on raised beds or well-draining soil

CROP SELECTION

Choose a resistant/less susceptible cultivar

- Silverbeet is more sensitive than beetroot and spinach

CHEMICAL FUMIGATION

Always use with care and as per label

- Check APVMA or InfoPest website for current registered products

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Check APVMA or InfoPest website for current registered products

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

DAMPING OFF, ROOT ROT OR VASCULAR WILT

Pythium aphanidermatum | Pythium ultimum | Pythium irregulare | Rhizoctonia solani

WHAT SHOULD I LOOK FOR?

Plants will not germinate or will emerge with poor growth, leading to bare patches
D. Lucas, RMCG

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 15-20°C optimum but can occur in warmer conditions

Seedlings that do emerge may have yellow to light brown discolouration on stem at ground level. As the disease progresses stem eventually collapses leading to wilting and death *S. Grigg, Ag-Hort Consulting*

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

FREE WATER | MOVEMENT OF CONTAMINATED SOIL | INSECTS | INFECTED SEED/ SEEDLINGS | CONTAMINATED PLANT DEBRIS

- Fungus gnats

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

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

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

- Some spinach varieties are resistant to Fusarium

AIR CIRCULATION

Increase row/plant spacing to improve air flow

- Dense plantings encourage spread from plant to plant

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

CONTROL PESTS

Control insect pests that spread spores

- Ensure crops are supplied with adequate potassium and calcium

HOST RANGE

Silverbeet, chard, beetroot and spinach. *Pythium* spp. and *Rhizoctonia* spp. have a wide

BIO FUMIGATION

Grow a biofumigant crop

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

CHEMICAL TREATMENT

Use registered soil drench at planting

CHEMICAL TREATMENT

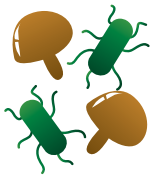
Treat seed/ seedlings with registered fungicide

DRAINAGE

Plant on raised beds or well-draining soil

- Check APVMA or InfoPest website for current registered products

BIOCONTROL PRODUCTS



IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- Avoid periods of saturated soil

CHEMICAL FUMIGATION

Always use with care and as per label

- Check APVMA or InfoPest website for current registered products

host range, while *Fusarium oxysporum f. sp. spinaciae* is specific to spinach

ROOT-KNOT NEMATODE

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

WHAT SHOULD I LOOK FOR?

Aboveground plants may appear chlorotic and stunted. Belowground, roots develop characteristic swelling and galls. *G. Holmes, California Polytechnic State University, Bugwood.org*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Active 15°C+
- Active 8.5°C+

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

Swelling and galls on roots of beetroot caused by root-knot nematodes.
G. Holmes, California Polytechnic State University, Bugwood.org

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

- FREE WATER
- MOVEMENT OF CONTAMINATED SOIL
- CONTAMINATED PLANT DEBRIS

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

HOST RANGE

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

CHEMICAL FUMIGATION

Always use with care and as per label

- Check APVMA or InfoPest website for current registered products

BIO FUMIGATION

Grow a biofumigant crop

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

SOIL TEST

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

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

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


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 collapses leading to wilting and death

H. Schwartz, Colorado State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 5-15°C

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

Bill Dean, River Point Farms, Bugwood.org

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

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

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

PLANTING PREPARATION

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

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 PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

HOST RANGE

Very wide host range including all legumes and most vegetable crops

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Consult APVMA or InfoPest website for current registered products

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

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*

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Optimum above 25°C. Infection limited below 15°C
- Including mechanical, fertiliser or insect injury e.g. onion maggots

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

INFECTED SEED/ SEEDLINGS

CONTAMINATED PLANT DEBRIS

INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 4 year break

BIO FUMIGATION

Grow a biofumigant crop

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

CROP SELECTION

Choose a resistant/less susceptible 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

FERTILISER SELECTION

- Avoid acidifying ammonium fertilisers

HOST RANGE

All members of the onion family

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Calcium supplements may help suppress disease

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 into olive brown to black. Lesions join sometimes reaching leaf tip. Bulb size can be significantly reduced

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

WHERE WILL I SEE SYMPTOMS?

• Initial symptoms on leaf and leaf sheaths

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 23- 28°C

• High humidity for more than 24 hours

• Especially extended periods of leaf wetness

Older lesions develop distinct concentric rings
G. Holmes, California Polytechnic State University, Bugwood.org

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

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 2 year break from host

PLANTING PREPARATION

AIR CIRCULATION

Increase row/plant spacing to improve air flow

DRAINAGE

Plant on raised beds or well-draining soil

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

- 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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Optimum 24-28ºC

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*

DISTRIBUTION IN THE FIELD

OR

SCATTERED
Individual/small patches of infected plants

LARGE AREAS
Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

FREE WATER

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

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

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

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

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

AVOID WATER STRESS

Ensure plants receive adequate water

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

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

CHEMICAL FUMIGATION

Always use with care and as per label

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

- Consult APVMA or InfoPest website for current registered products

BIO FUMIGATION

Grow a biofumigant crop

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

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- Optimum 20-22°C

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

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

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

SURVIVAL TIME WITHOUT HOST | Less than 3 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

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

PLANTING PREPARATION

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

SOIL SOLARISATION

Cover soil with a tarp and kill harmful pathogens

CROP SELECTION

Choose a resistant/less susceptible cultivar

POST-PLANT

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

Mostly devastating to the onion family but can be hosted by members of the carrot and bean families

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

USE CLEAN SEED OR SEEDLINGS

Source seed/ seedlings from a certified reputable source

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

WHITE ROT

Sclerotium cepivorum

WHAT SHOULD I LOOK FOR?

Initially yellowing and dieback of leaf tip which eventually leads to wilting.
L. Tesoriero, Crop Doc Consulting

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 14-18°C

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

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

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

CROP ROTATION

Select non-host rotation or cover crops

HOST-FREE ZONE

Control volunteer host plants and weeds

PLANTING PREPARATION

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

CHEMICAL TREATMENT

Use registered soil drench at planting

DRAINAGE

Plant on raised beds or well-draining soil

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

HOST RANGE

Members of the onion family

CHEMICAL FUMIGATION

Always use with care and as per label

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

- Consult APVMA or InfoPest website for current registered products

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

AIR CIRCULATION

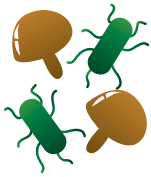
Increase row/plant spacing to improve air flow

CHEMICAL TREATMENT

Treat plant with registered foliar fungicide

- Consult APVMA or InfoPest web site for current registered products

BIOCONTROL PRODUCTS



POST-HARVEST STORAGE

- Store at 4°C to minimise losses


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 large pale green to silvery galls on cob up to 150mm

W. Upham, Kansas State University, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-25°C

Over time galls become dark and eventually burst releasing black spores

L. Tesoriero, NSW DPI

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

FREE WATER

MOVEMENT OF CONTAMINATED SOIL

WIND

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Spores can survive 5 to 7 years out of corn

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

CHEMICAL FUMIGATION

Always use with care and as per label

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Particularly important at the seedling stage

AVOID WATER STRESS

Ensure plants receive adequate water

AVOID PLANT INJURY

Avoid any physical damage to plant

SWEET CORN

DAMPING OFF

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

WHAT SHOULD I LOOK FOR?

Can cause seed rot, in which case seedling will fail to germinate leading to bare patches.
A. Roberston, Iowa State University, Extension and Outreach

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

• 13-18°C
Some pathogens prefer warmer conditions i.e. >25°C

Seedlings that do emerge may have yellow to light brown discolouration around stem at ground level. As the disease progresses, stem eventually collapses 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

DISTRIBUTION IN THE FIELD

LARGE AREAS

Large areas of infected plants clearly visible

HOW DOES IT SPREAD?

FREE WATER | MOVEMENT OF CONTAMINATED SOIL | WIND | CONTAMINATED PLANT DEBRIS | INSECTS

SURVIVAL TIME WITHOUT HOST | More than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 3 years out of corn

PLANTING PREPARATION

CHEMICAL FUMIGATION

Always use with care and as per label

CHEMICAL TREATMENT

Treat seed/ seedlings with registered fungicide

SOIL TEST

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

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

AVOID PLANT INJURY

Avoid any physical damage to plant

GOOD NUTRITION

Ensure plants' nutritional needs are met

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

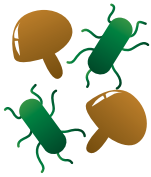
DRAINAGE

Plant on raised beds or well-draining soil

CONTROL PESTS

Control insect pests that spread spores

BIOCONTROL PRODUCTS



FUSARIUM COB ROT

Fusarium verticillioides | F. proliferatum | F. subglutinans.

WHAT SHOULD I LOOK FOR?

White streaks start from tips of individual kernels then spread out in a “starburst” pattern.
Ontario Ministry of Agriculture, Food and Rural Affairs

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 25-30°C
- Moisture or nutrition

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

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

WIND

INSECTS

- Spores enter via silks or wounds

SURVIVAL TIME WITHOUT HOST | Less than 10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Stop movement of infected soil, remove infected plants/roots
- Minimum 3 years out of corn

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

NO RESIDUE AT PLANTING

Ensure no plant residues from host crops at planting

ADJUST DATE

Adjust planting/harvest date to reduce infection risk

- Husks that prevent or delay insect entry
- Early plantings less prone to infection

POST-PLANT

IRRIGATION MANAGEMENT

Monitor crop and soil to optimize amount and timing

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

IMPROVE SOIL HEALTH

Add organic matter or amendments to boost beneficial microbes

BIO FUMIGATION

Grow a biofumigant crop

FERTILISER SELECTION

- Avoid ammonium fertilisers. Nitrate fertilisers can help suppress disease

AVOID PLANT INJURY

Avoid any physical damage to plant

HEAD SMUT

Sphacelotheca reiliana

WHAT SHOULD I LOOK FOR?

Infection occurs during early vegetative stage. Symptoms appear at flowering/cob formation. Tassel symptoms include distortion and formation of masses of black spores

R. Croissant, Bugwood.org

WHERE WILL I SEE SYMPTOMS?

FAVOURABLE CONDITIONS FOR DISEASE DEVELOPMENT

- 20-30°C

Cobs may also be 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*

DISTRIBUTION IN THE FIELD

SCATTERED

Individual/small patches of infected plants

HOW DOES IT SPREAD?

MOVEMENT OF CONTAMINATED SOIL

WIND

SURVIVAL TIME WITHOUT HOST | 3-10 years

HOW DO I CONTROL IT?

FALLOW/COVER CROP

FARM HYGIENE

Stop movement of contaminated soil, water, plants and equipment

HOST-FREE ZONE

Control volunteer host plants and weeds

CROP ROTATION

Select non-host rotation or cover crops

- Minimum 5 years out of corn

PLANTING PREPARATION

CROP SELECTION

Choose a resistant/less susceptible cultivar

- Select hybrids with fast emergence

CHEMICAL FUMIGATION

Always use with care and as per label

- Consult APVMA or InfoPest website for current registered products

POST-PLANT

GOOD NUTRITION

Ensure plants' nutritional needs are met

- Ensure adequate nitrogen

BIO FUMIGATION

Grow a biofumigant crop