Horticultural Development Company

Field Vegetables

Brassica disease factsheets

Black rot on vegetable Brassicas

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Black rot (*Xanthomonas campestris* pv. *campestris*) is one of the most important diseases of Brassicas worldwide. It is less severe under UK conditions than in the warmer tropical and subtropical environments. Outbreaks are often associated with seed-borne infection and restricted to individual varieties. Spread can occur during propagation. In recent years, recurring problems in cauliflower have attributed to spread from infected crop residues. Crops with severe leaf symptoms may be unmarketable. The disease is prevalent over the entire UK but is particularly common in Cornwall where very wet conditions are optimal for spread.

Action points

- Use seed that has been tested and shown to be free from black rot.
- Good hygiene is required during propagation and on affected farms where outbreaks have occurred.
- Use a non-Brassica break for two years after field outbreaks of black rot.

Symptoms

The most characteristic symptoms are yellow 'V-shaped' lesions at the leaf margin (Figure 1). These soon develop a pale brown centre and veins within the lesions are distinctly dark brown or black in colour. Early symptoms include water soaked spots and fine brown spots with a chlorotic halo but these are similar to symptoms caused by other bacteria pathogens. Numerous lesions can occur at the margins of individual leaves and many leaves are affected on each plant. Where there is systemic infection, plants may show yellow blotches and darkening of the veins within the leaf lamina. Marginal lesions occur at 16°C, whilst those within the leaf tend to occur at temperatures above 20°C. Symptoms can appear in 10-14 days at 25°C. Symptoms can also develop where infection occurs as a result of leaf damage from pests, hail or chemical scorch. Severely affected plants show considerable leaf loss and stunted growth. On Brussels sprouts, both leaves and buttons are affected. Some strains can cause plant death whilst others only cause leaf spotting.

Spread within the crops often produces small patches of infected plants but whole crops can be affected if initial incidence and spread are high (Figure 2).

1. Yellow V-shaped lesions on the leaf margin are typical of black rot

2. Severely affected crops can result in considerable leaf loss and stunted growth

Life Cycle

The disease is caused by the bacteria *Xanthomonas campestris* pv. *campestris* that occurs in a variety of races and strains. All cultivated Brassicas, radish and related weeds and ornamental species are affected. Most problems are associated with seed-borne infection but it can survive in crop residues, volunteers and some weeds. Spread by water splash from infected seedlings occurs from the propagation stage onwards. Some spread can occur via insects and on clothing and machinery that are used in infected crops.

In seed crops, the pathogen may develop systemically without showing symptoms and infect the developing seeds.

Epidemiology

Infected seeds produce infected seedlings which are the primary source for splash dispersal to adjacent plants. The pathogen survives on the leaf surface. Suitable environmental conditions are required for the bacterial inoculum to increase and for symptoms to show up.

The bacteria invade the plant at the leaf margin entering through the ends of the leaf veins. Temperatures at the seedling stage are often too low for symptoms to show. Thus infected but symptomless plants are planted out and only show symptoms several weeks later. Secondary spread occurs from infected plants by means of rain splash, irrigation and farm machinery that are used in the crop. The bacteria are also carried in surface run-off water so low-lying areas are often badly affected. The disease often appears as patches in the crop. Control measures are only generally successful when applied at this stage before it becomes widespread in the crop.

A seed infection threshold of nil in 30,000 seeds is recommended, with eradicant seed treatment if seed stocks exceed this level. As the threshold is low, seed tests will not guarantee that seed lots are free from the pathogen.

Control

- Use healthy seed. Hot water treatment should be considered if valuable seed stocks are known to be infected.
- Control using copper sprays is generally not very effective and if applied should be used early before infection becomes established.
- After black rot outbreaks, there should be a 2-3 year break from Brassicas to allow crop residues to decay.
- Hygiene measures are required to prevent spread from affected crops to healthy crops nearby. This includes washing down and disinfection of machinery and waterproof clothing and footwear after visiting infected crops.
- Field observations indicate that where Amistar (azoxystrobin) is used the severity of black rot symptoms may be reduced. The mode of action of this treatment is not understood.

Varietal resistance

Progress is being made to develop resistance varieties but these may not be a priority for the UK.

Products

See separate insert `Chemical control of Brassica diseases'.

Agronomy issues

The priority is to use high quality seed as little can be done to control the disease once it is present in the crop.

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Factsheet 13/12 (Project FV 347)

Field Vegetables

Clubroot on vegetable Brassicas

Roy Kennedy, University of Worcester and Peter Gladders, ADAS

Clubroot caused by the pathogen *Plasmodiophora brassicae* is one of the most difficult diseases to control in cruciferous crops worldwide. Symptoms are characteristically galls or clubs formed on the roots which reduce plant vigour and yield (Figure 1). Infection leads to wilting, death and total crop loss especially when young plants are invaded. Older plants may have lower yields but the main problem is that plant maturity will be erratic and harvesting schedules disrupted. Swedes can be severely affected and problems in oilseed rape are increasing.

Action points

- Test the soil for clubroot contamination.
- Choose appropriate control measure depending on the contamination level.
- Do not crop fields where clubroot levels are very high.
- Ensure soil pH is maintained above 7.2 in fields used for Brassica production.
- Apply Limex between 7.5–10 tonnes per hectare to control clubroot even in the presence of high contamination.
- Resistant varieties can be used successfully where moderate levels of clubroot in the soil are present.

Symptoms

The only visible symptom of clubroot is the galls on infected roots (Figure 1) but severely infected plants usually wilt due to the sheer amount of clubroot infection. This is because the galls affect the plant's ability to take up water and this in turn disrupts the growth of the plant.

1. The only visible symptom of clubroot is the characteristic galls which form on the roots

Epidemiology

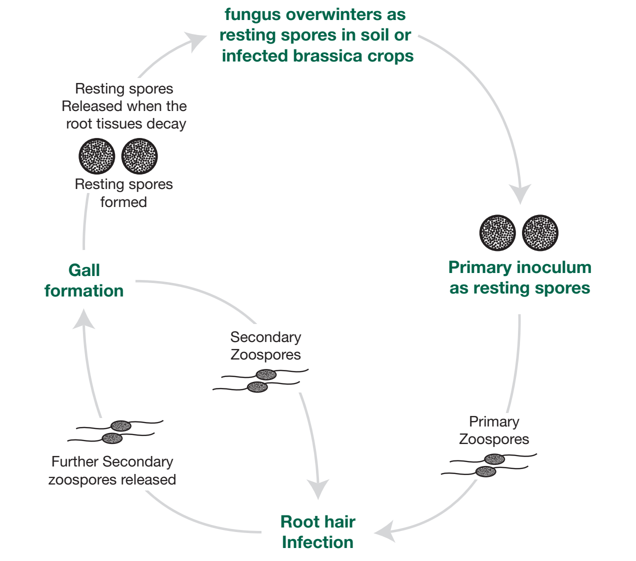
Once land is infested with the clubroot, it is very difficult to get rid of it because the thick-walled resting spores can live in the soil for up to 18 years. The resting spores release mobile swimming spores (zoospores) which are the primary source of transmission and infection of vegetable Brassica roots. The process of infection, subsequent growth and development of the pathogen within host tissues is still not completely understood, however resting spores are formed within the infected roots.

When the root decays these resting spores are released into the soil where they may germinate immediately, or in the absence of a host remain viable for many years. Disease spread is caused by several factors. Movement of surface water and transfer of contaminated soil are major sources of potential disease transfer. Spreading manure from livestock that have been fed on clubroot infected Brassicas is also widely known to spread the disease to new areas. Additionally, the use of transplants in vegetable Brassica production can also be an important source of disease. Infected plants and soil are transported widely within modern vegetable production and this could contribute to spread of disease to new areas of production.

Inoculum concentration plays an important part in the incidence and severity of clubroot development within crops. Studies have indicated that symptom expression is primarily dependent on the presence of a threshold level of infection (approximately

1000–10000 clubroot spores per gram of soil). Above this threshold, increasing spore concentration may generate greater root hair infection and yield loss. In order for the disease to cause significant economical yield losses, a higher level of inoculum than the normal threshold level is usually required but this varies depending on the weather and soil type. It has also been reported that calcium and soil pH can affect infection, colonisation and symptom formation.

The environmental conditions which favour clubroot development are poorly understood. Infection occurs in moist soils when temperatures are above 15°C. Summer Brassicas can be severely infected particularly where high soil moisture occurs soon after planting. However, overwintered Brassica crops may not show any visible symptoms of clubroot even when planted in clubroot infected soil. In general, there are few reliable methods which can be used for forecasting soil-borne pathogens based on environmental criteria. For this reason, many studies have attempted to develop methods to detect and quantify clubroot resting spores in the soil as a means of determining risk of clubroot infection and development.



2. The clubroot life cycle

Control

- Improve drainage
- Raise soil pH
- Rotate with non-cruciferous crops
- Use lime before cropping to increase calcium and soil pH
- Test soil before cropping and do not use if levels too high

Thresholds for infection are affected by the environmental conditions in the crop. Minimal spore concentrations and pH 7.2 would inhibit root hair infection but infection can occur if the pH is the same but the inoculum level higher. Clubroot can be controlled by maintaining pH levels in the soil above the 7.2 level. However, this can cause problems within crop rotations where high soil pH levels could cause problems for subsequent crops.

Varietal resistance

There is some tolerance of clubroot between Brassica types but, until recently, no commercially available varieties were resistant. A clubroot differential set has been used in the past to determine difference between Brassica types in clubroot susceptibility but little of this information has been used in breeding clubroot resistant varieties. Clubroot resistant varieties of Brussels sprouts (cv. Crispus), broccoli, cauliflower (cv. Clapton) and white cabbage (cv. Kilazol) are now available, however, clubroot infection on these resistant varieties still occurs. Resistance is also available in some varieties of swede (cv. Marian). Little or no secondary clubroot development appears when these varieties are used. Unless varietal resistance is managed correctly it may breakdown.

Products

See separate insert ‘Chemical control of Brassica diseases’.

Agronomy

Clubroot can be managed by raising soil calcium and maintaining pH levels above 7.2. This can be achieved by lime and calcium products eg Limex or Perlka. However increasing pH above these levels could be problematic if the land is in rotation with potatoes. Resistant varieties could be a potentially useful option in controlling clubroot if used where soil contamination levels were moderate.

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Factsheet 14/12

Field Vegetables

Downy mildew on vegetable Brassicas

Roy Kennedy, University of Worcester and Peter Gladders, ADAS

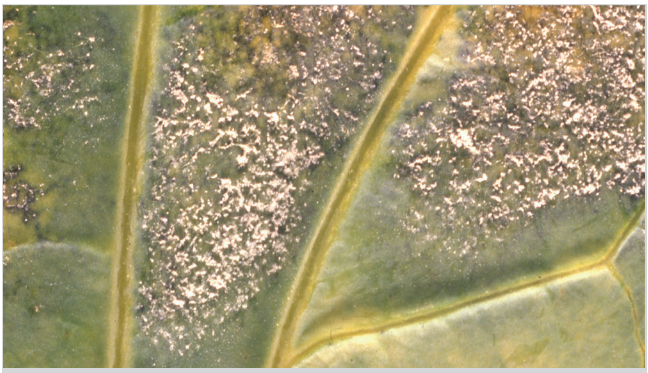
Downy mildew (*Hyaloperonospora parasitica*) is a widespread disease that affects many vegetable and ornamental crops in the UK. It is particularly a problem in vegetable Brassica crops where the seedlings are raised in glasshouses. Downy mildew can inhibit seedling growth and cause stunting of seedlings, rendering the seedlings unsuitable for transplanting into the field. Furthermore, latent downy mildew infections (no observable disease) at a low incidence in glasshouse-raised transplants are often not noticed by transplant producers and may provide inoculum leading to epidemics in the field. Although the disease is primarily a seedling disease it can be economically important on cauliflowers in the field.

Action points

- Fungicide treatments should be used as preventatives as cotyledons and the first true leaves are the most susceptible to downy mildew.
- As downy mildew can infect plants in a few hours, irrigation should be done in the morning so that plant surfaces can dry as quickly as possible.
- For propagators, ventilate glasshouses to avoid a warm humid atmosphere
- Keep leaves as dry as possible
- Sterilise greenhouses between crops and sterilise trays
- Do not grow new crops with old in the same area

Symptoms

Lesions are first seen on cotyledons and leaves of Brassica seedlings as pale green yellowish spots, which are angular in shape and usually bounded by leaf veins. The pathogen readily sporulates on the underside of the infected leaves and the downy appearance of these structures gives rise to the common name for the pathogen. In transplants, the pathogen sporulates profusely on infected cotyledons seven days after infection when temperatures are optimal (Figure 1) and infected cotyledons usually drop off after sporulation.



1. In optimal conditions downy mildew rapidly sporulates on the cotyledons

Infected seedlings are not usually killed by downy mildew infection and fresh growth is produced as normal provided the apical meristem is unaffected by the disease. Most Brassicas show some leaf infection during the growing season, but its severity is usually low. However, cauliflowers occasionally show symptoms of systemic infection by the downy mildew pathogen in the form of discolouration of the interior of the cauliflower curd (Figure 2). Yellow or black specking symptoms occur on the buttons of Brussels sprouts and these can extend through several leaf layers into the button. Similar penetrating lesions may also develop on stored cabbage.

2. Downy mildew infection on cauliflower

Epidemiology

Spore dispersal within the crop can occur after only 30 minutes of leaf wetness at temperatures ranging from 8 to 22°C. Spores dispersed through the air require 4h of leaf wetness to infect Brassica seedlings at the same temperatures. Some batches of seedlings particularly overwintered cauliflowers can be severely affected. Sequential sowing of culitivars and the production of spring transplants enables downy mildew to occur throughout the year within glasshouses (Figure 3).

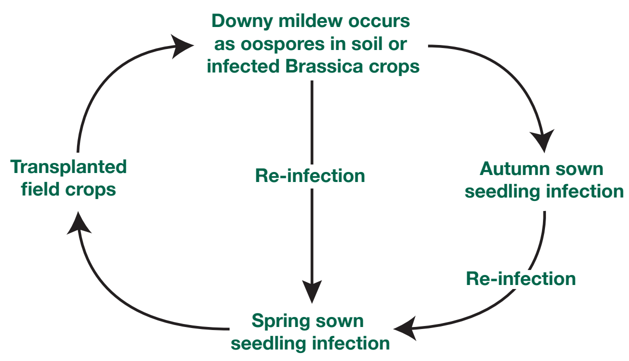
Epidemics can become severe in the spring when average temperatures within the glasshouse increase. Transplants are irrigated creating very conducive environments for downy mildew infection. The field environment is less optimal for downy mildew and generally adult plant resistance is observed with this disease. Lesions of Brassica downy mildew can often be observed under field conditions but they are usually of little economic importance.

However, field infection may play a role in the re-infection of glasshouse crops grown in proximity to field crops.

Life Cycle

A simplified version of the Brassica downy mildew life cycle is shown in Figure 4. Soil-borne spores can initiate infection of direct sown seedlings and there are many periods where established seedlings with symptoms can give rise to new infections on freshly sown crops. Seedlings are sown in sequence in the autumn for spring planting and in the spring for autumn planting. Mature crops may also have sporulating lesions which give rise to glasshouse seedling infection.

3. Downy mildew infection occurs throughout the year in glasshouse production



4. Life cycle of downy mildew on vegetable brassicas

Control

Varietal resistance

Flowerhead Brassicas, particularly cauliflowers, appear to be more susceptible than other types of Brassicas. There is little known varietal resistance. Current commercial cauliflowers are susceptible at the seedling stage but do not commonly show symptoms of systemic infection of the heads.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

Downy mildew is difficult to manage in glasshouse production of modules, particularly in over-wintered cauliflowers for which there are insufficient fungicide treatments. Propagators should take care to ensure glasshouses and trays are sterilised between crops and to avoid cross contamination of crops by not growing old crops in the same area as new crops. Glasshouses should be properly ventilated to avoid a warm humid atmosphere. Resistance to metalaxyl in Brassica downy mildew was confirmed soon after the fungicide was introduced about 30 years ago. Diversify fungicide regimes to reduce the risk of selecting fungicide resistant strains.

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Factsheet 15/12

Field Vegetables

Dark leaf spot on vegetable Brassicas

Roy Kennedy, University of Worcester and Peter Gladders, ADAS

Dark leaf spot on vegetable Brassicas is caused by two fungi: *Alternaria brassicae* and *Alternaria brassicicola*. Both species can infect all types of commercial Brassica crops. Both diseases, until relatively recently, were commercially important on Brussels sprouts. They form necrotic lesions on leaves, petioles, stems and buttons of all sprout cultivars.

Action points

- Use healthy seed.
- Plough in crop residues as soon as possible after harvesting the crop.
- Monitor crops at least weekly and use fungicides when the first leaf symptoms start to appear.

Background

The disease has become less problematic in vegetable Brassica crops over the last 5–10 years. It is unclear why this has occurred but one explanation may be related to the increased use of fungicides in winter oilseed rape and low disease levels in that crop. Alternatively fungicidal sprays have been used more effectively in vegetable Brassicas in comparison to the protective routine spray programmes used previously. In the past yield losses of 70% resulting from infection by *A. brassicicola* have been reported in vegetable Brassicas. Yield losses greater than 50% have been reported in oilseed rape crops infected with *A. brassicae*. Yield losses in vegetable Brassicas results from cosmetic damage to the crop. In arable Brassicas the yield loss is related to the severity of pod symptoms.

1. Dark leaf spot causes necrotic lesions on the leaves of Brassicas

Symptoms

Both fungi can produce pale to dark brown circular and zonate leaf spots on all types of Brassicas and related weeds with most severe symptoms usually occuring on Chinese cabbage, turnip and cabbage. Spots initially start as small black spots (Figure 2) but become dark brown when mature. Lesion size varies from 1–2mm to 20mm. Larger lesions are often associated with a chlorotic yellow halo with well defined margins. When mature the centre of the lesion is often raised and can cross major leaf veins. Immature lesions do not sporulate easily. Symptoms appear within 2–5 days after infection regardless of temperature.

2. Spotting symptoms on a Brussels sprout buttons

Epidemiology

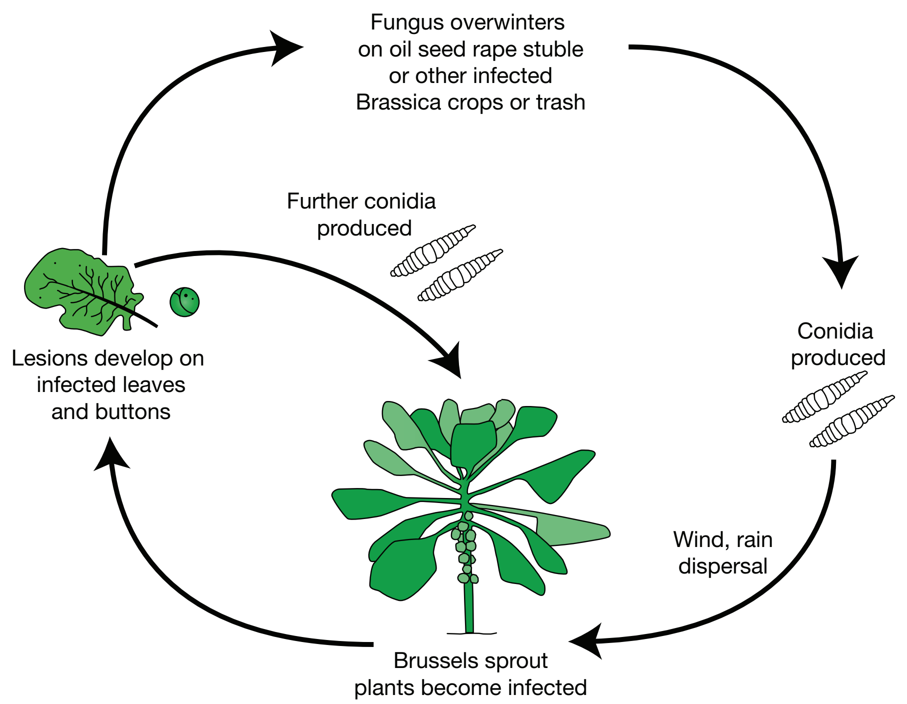
Both pathogens can infect oilseed rape and vegetable Brassica seeds however modern seed treatments used in vegetable Brassica production has reduced the importance of this source of infection. Both pathogens are much more prevalent on arable Brassicas and there is a high likelihood of an interaction between vegetable and arable Brassicas in overwintering and epidemic development in the spring.

Alternaria brassicae is the more prevalent of the two fungal species causing dark leaf spot in horticultural and arable crops while *A. brassicicola* may predominate in some crops it usually occurs along with *A. brassicae*. Both pathogens can result in considerable yield losses in arable Brassicas because they occur on the pods of oilseed rape plants. Much of the transmission between crop types may relate to the timing of arable Brassica harvesting activities. During harvesting a great deal of material is ejected into the atmosphere where it is readily dispersed over considerable distances. Material including spores can be deposited within rain drops leading to germination and infection of other vegetable Brassicas.

There is a great deal of evidence to show that one peak of *Alternaria* spore production occurs in the air during June or July in most years in the UK. In the Mediterranean more than two peaks are often observed but this may be related to variations in cropping/harvesting between temperate and Mediterranean areas. There are other *Alternaria* species present in vegetable Brassica crops which may also cause dark leaf spot like lesions. However the importance of these is not clear. It is possible that their presence results in spotting on the crop but they do not give rise dark leaf spot epidemics. Isolations taken from sporulating lesions in horticultural Brassicas show only the presence of *A. brassicae* and *A. brassicicola*.

Life cycle

Dark leaf spot requires free water for spore germination and infection. At optimal temperatures of 20°C, infection by *A. brassicae* may occur within 6h but for substantial disease development at least 10h of wetness is required. Both dark leaf spot species require at least 12–14h with a relative humidity of greater than 90% for sporulation to occur. Spore production on the lesions of many fungal species is known to require high humidity and similarly the infection process needs the presence of free water on the host surface. Where infection and sporulation occur frequently, and the pathogen completes its life cycle relatively rapidly, prediction of complete cycles of sporulation and infection can be made from microclimate measurements which can be used as an aid in determining the necessity of control measures. The sporulation rate by *A. brassicae* is optimal between 18°C and 24°C. Sporulation is inconsistent at 26°C and spores formed at this temperature are often unviable. Sporulation by *A. brassicicola* is observed over a greater temperature range. However, time to 50% spore production is greater over the lower temperature ranges indicating higher temperature optima for this species. No sporulation by either pathogen is observed below 5°C. Both pathogens are disseminated from infected host tissue by means of spores produced on mature fungal lesions. Spore dispersal can occur by a number of mechanisms including air currents, rain splash or dew droplets. Potentially dispersal in air is over much greater distances than by rain splash. Spores of dark leaf spot have been shown to travel at least 1.8km from source. Viable spores landing on healthy plant tissue germinate on and penetrate the host surface. Infection and spore production are important parts of the fungal life cycle and depend on environmental conditions at the host surface.



2. Life cycle of dark leaf spot on vegetable Brassicas

Control

Varietal resistance

Dark leaf spot is problematical on Chinese cabbage where there appears to be little known resistance. Turnips are more susceptible than Swedes. Other vegetable Brassica types appear uniformly susceptible.

Products

See separate insert ‘Chemical control of Brassica diseases’.

Agronomy issues

Dark leaf spot shows considerable varaiation from year to year and between crops so regular crop monitoring is required. Take note of the disease situation in oilseed rape and be prepared for movement of spores into vegetable Brassicas when oilseed rape is harvested.

Notes

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Factsheet 16/12

Field Vegetables

Light leaf spot on vegetable Brassicas

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In Scotland and parts of Northern England, light leaf spot (*Pyrenopeziza brassicae, anamorph, Cylindrosporium concentricum*) is the predominant air-borne pathogen affecting vegetable Brassica crops. Light leaf spot is also an important disease of winter oilseed rape in Germany, France, Poland and the UK. Light leaf spot is a polycyclic disease, which infects oilseed rape leaves, stems, flowers and pods during the course of the season between sowing in autumn and harvest in summer. Brussels sprouts are the vegetable Brassica crop most likely to suffer economic losses but other Brassicas may require extra trimming and rejection of heavily infected plants.

Action points

- Do not grow vegetable Brassicas close to oilseed rape.
- Inspect Brassica crops regularly for signs of light leaf spot.
- Protect Brussels sprout buttons with fungicide as they develop.
- On other Brassicas, fungicides may be required 4-12 weeks before harvest.

1. Light leaf spot lesions look like thumb prints on the undersides of leaves

Symptoms

A light leaf spot lesion can be recognised as groups of small black spots on the underside of the leaf clustered into a ‘thumb print’ (Figure 1). These occur on Brussels sprouts, cabbage (particularly spring greens), cauliflower and various other Brassicas. Small white spore droplets are produced on and around these lesions (Figure 2). On very susceptible varieties, large areas of individual leaves may be affected and large pale blotches develop. Cauliflowers may show pinkish black lesions at the base of the leaves and petioles, which spoil the appearance of trimmed heads. Lesions on the older yellowing leaves often have a ‘watermark’ appearance, confined to one side of the leaf and developing a pinkish or red colour. Leaf lesions are not very numerous in summer, but become easier to find on the upper leaves in autumn and winter. The symptoms on sprout buttons are also ‘thumb print’ lesions and these develop on the outer leaves and underneath the wing leaves (Figure 3). The white spore droplets are usually found around the edges of the lesions, but are less likely to be found when buttons have been wetted by rain. Lesions on buttons induce considerable yellowing of the outer leaves and advanced symptoms may be confused with over-maturity and soft rots.

Symptoms of light leaf spot can appear as early as July, but disease symptoms become most prevalent during autumn and winter. A feature of the disease is its rapid development on buttons in autumn, despite little evidence of earlier leaf infection. This is probably due to spread of air-borne spores from debris in nearby fields, rather than secondary spread within the crop itself. Because light leaf spot is one of several diseases which cause black spots in Brassicas, reliable identification may require laboratory diagnosis.

2. Small white spore droplets are produced around the edges of the lesions

3. Symptoms on Brussels sprout buttons are dark ‘thumb print’ lesions

Epidemiology

Light leaf spot was more common in Brussels sprout crops adjacent to oilseed rape crops than in more distant crops. The Brussels sprout crop is at risk over considerable periods of time which is an additional problem if light leaf spot is to be controlled. Brussels sprouts crops in Scotland are planted in May and can remain until harvest in mid-April of the following year. The wind-dispersed ascospores of light leaf spot are likely to be responsible for transmitting the disease to Brussels sprout and other vegetable Brassica crops. These ascospores are produced on leaf debris underneath oilseed rape crops in spring/early summer when sprout crops are transplanted to the field and on stem and pod debris after oilseed rape harvest during late summer/autumn when sprout crops have been fully established. Volunteer oilseed rape plants may play an important part in the epidemiology of light leaf spot on Brussels sprout crops in Scotland.

The infection of oilseed rape plants by light leaf spot spores is influenced by environmental factors such as temperature and leaf wetness duration. Infection in oilseed rape experiments occurred most quickly at 16ºC when the leaves were wet. Infection was delayed when temperatures reached as high as 20ºC or as low as 4ºC. When plants were moved immediately after being infected with light leaf spot to field conditions at weekly intervals from September to February (under different sets of fluctuating conditions), the period of infection ranged from 15 to 40 days.

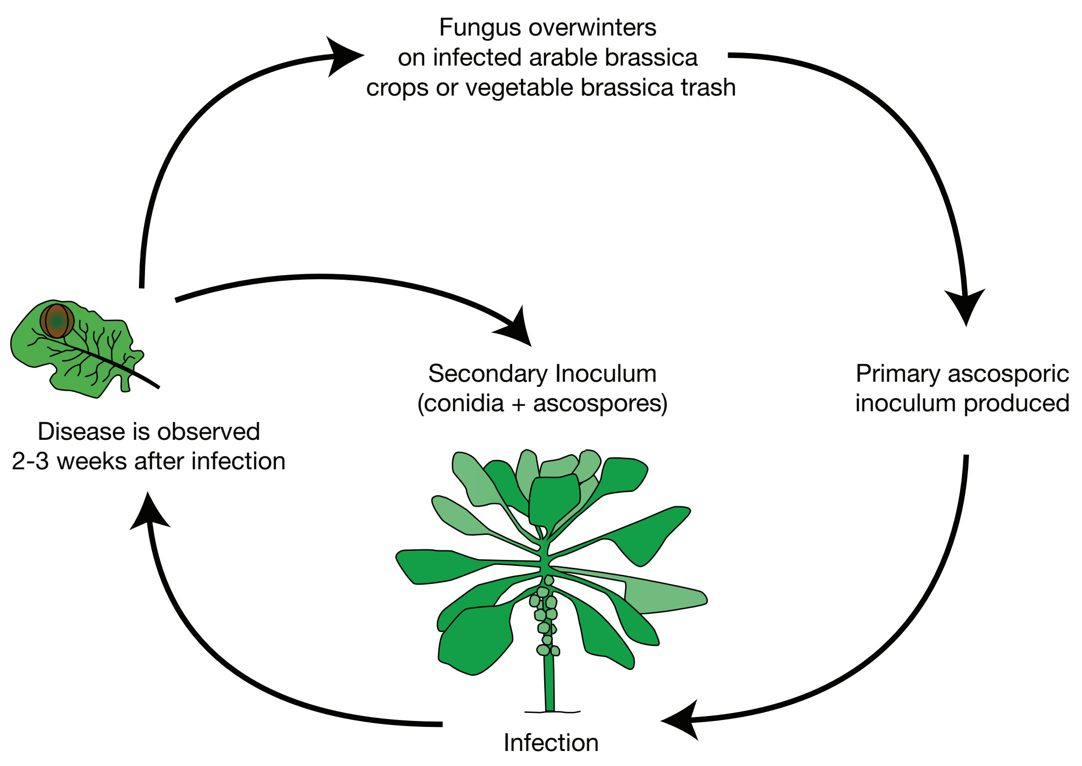
Little is known about the relative effectiveness of the two types of light leaf spot spores (ascospores and conidia) in causing a successful infection. Recent controlled environment work on the infectivity of ascospores and conidia on oilseed rape and Brussels sprouts leaves suggests that ascospores may be more infective than conidia.

Life Cycle

The fungus produces ascospores on dead tissue and conidia formed in acervuli on living tissue. Ascospores and conidia are morphologically similar, when observed under a light microscope. Ascospores are hyaline, cylindrical, 0-1 septate, 15.5-15.5 x 2.5-3µm and conidia are hyaline, cylindrical, aseptate, 10-16 x 3-4µm.

Ascospores play an important role in initiating epidemics in the autumn, when they are released from infected oilseed rape debris as it dries after overnight dew or rainfall and are dispersed by wind. Conidia travel only short distances by splash dispersal and are responsible for secondary spread of the disease during autumn and winter.

A simplified version of the light leaf spot life cycle is shown in Figure 4.



4. Life cycle of light leaf spot on vegetable Brassicas

Control

- Do not grow vegetable Brassicas close to oilseed rape.
- Inspect Brassica crops regularly for signs of light leaf spot.
- Protect Brussels sprout buttons with fungicide as they develop.
- On other Brassicas, fungicides may be required 4-12 weeks before harvest.

Varietal resistance

There appear to be useful differences in the resistance of Brussels sprout varieties but no recent independent data is available.

Products

See separate insert `Chemical control of Brassica diseases'.

Agronomy issues

Crop walking to find early signs of light leaf spot may not always be a reliable guide to disease risk. Symptoms of light leaf spot can appear suddenly in large numbers where there is infection from air-borne spores. Crops close to winter oilseed rape should be considered at risk from late summer onwards as light leaf spot levels are currently high in oilseed rape in all regions.

Poor disease control with fungicides is often due to poor spray timing, but there are also concerns about decreased sensitivity to azole fungicides.

Notes

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Factsheet 17/12

Field Vegetables

Phoma on vegetable Brassicas

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Phoma diseases (*Leptosphaeria maculans* and *Leptosphaeria biglobosa*; asexual stage *Phoma lingam*), also known as blackleg, are important worldwide in Brassica crops including the leafy and flowerhead types, turnip, Chinese cabbage and pak choi, oilseed rape and swedes and mustard. In the UK, Phoma stem canker of oilseed rape is the most economically important disease in southern, eastern and central England. Severe losses can occur in cauliflower and swede, but it is mainly a leaf blemish on other vegetable Brassicas. Once leaf spots appear, the fungus can grow in the plant without causing any symptoms before causing severe stem symptoms.

Action points

- Use healthy seed.
- Monitor crops regularly and use fungicides at the propagation stage when Phoma leaf spots are first found.
- Bury crop residues and use non-Brassica crops in the rotation where Phoma problems are identified.
- Do not grow leafy salad Brassicas close to oilseed rape.

Symptoms

Leaf symptoms can occur from the cotyledon stage onwards. Very young seedlings can be killed very rapidly. Typical leaf spots are variable in shape and pale brown or white with numerous dark brown dots within the lesion, these are the fruiting bodies called pycnidia which produce the spores (Figure 1). This contrasts with ringspot symptoms which have more numerous tiny black fruiting bodies (psuedothecia) within the lesions. The Phoma pycnidia produce a deep pink spore exudate that is diagnostic for *Phoma lingam*. The lesions are usually greenish on the underside of the leaf and this enables them to be distinguished from downy mildew lesions that are often yellow or pale brown on the underside. As leaf spots enlarge (1-2 cm diameter) they may develop a darker margin and show yellowing around the lesion. There is darkening of the leaf veins within the leaf spots and around the lesions, indicative of Phoma spreading through the leaf towards the stem.

1. Typical symptoms are light lesions with numerous dark spots on them

The leaf symptoms caused by *Leptosphaeria biglobosa* are smaller and darker than those caused by *L. maculans* and also contain fewer pycnidia. Vegetable Brassicas with more delicate leaves such as pak choi and Chinese cabbage are very susceptible to leaf spotting. On mature leafy Brassicas there may be few signs of leaf spotting and only low levels are usually found on buttons of Brussels sprouts. There may be some difficulties distinguishing between ringspot and Phoma lesions however one difference is that fruiting bodies within lesions of ringspot tend to form in concentric circles.

The spread of Phoma through the leaf and petiole is largely symptomless. It invades the stem via the vascular system of the infected leaf and after a period of several weeks stem cankers form. These cankers are sunken areas on the lower stem and roots and have a distinct black margin. Sectioning the root shows internal blackening of the woody tissues and a dry rot that can weaken the stem or kill the plant (Figure 2).

2. Phoma travels from the lesions in the leaf down to the lower stem and roots causing a canker which can weaken the stem or kill the plants

3. In swede roots, the disease causes a dry rot in the neck and shoulders of the root which progresses through the root even when temperatures are low

4. A sunken phoma lesion on swede

Problems in cauliflower may only become apparent when plants start to wilt and die close to maturity. In swede roots, the disease causes a dry rot in the neck and shoulders of the root which progresses through the root even when temperatures are low (Figures 3 & 4).

In seed crops and oilseed rape, Phoma affects the leaves, stem base (canker lesions), the upper stem and branches, flower buds and pods.

Epidemiology

There are different types of epidemics because the initial source of disease may be infected seeds or air-borne spores. Air-borne ascospores are dispersed after periods of rainfall or high humidity and can germinate after as little as 4 hours of leaf surface wetness. The proportion of spores producing lesions increases as the duration of surface wetness increases to 24-48 hours. Symptoms appear in 5-6 days when temperatures are near the optimum of 20°C. Secondary spread by pycnidiospores is also favoured by long periods of leaf wetness and warm temperatures. It is also able to invade the plant where there is physical damage or pest injury.

Growth through the leaf to the stem is thought to occur at a rate of several millimetres/day under optimum temperature conditions. Thus stem infection and hence survival on woody crop residues does not occur in short term Brassica crops because the fungus does not reach the stem. In oilseed rape, for example, stem canker lesions develop in spring, about 6 months after leaf infection in the autumn. Stem symptoms appear more rapidly in spring-sown crops because temperatures are more favourable for fungal growth.

Where there is seed-borne infection, Phoma can spread in seed-beds and in module production under glass. When bare root transplants were used, spread was facilitated by washing plants particularly as plants also had damaged roots.

Life Cycle

Epidemics can be initiated by air-borne spores (ascospores) produced on crop residues and dispersed by wind. Ascospores are produced mainly on stubble in minute structures called pseudothecia. Ascospores form on infected woody stems and roots after cropping. Survival of the pathogen and spore production can continue for several years until the woody remains decay.

Winter oilseed rape stubbles are an important source of inoculum when located near to areas of Brassica production. The main period of ascospore production is during the autumn and winter so crops planted in the spring and summer are only lightly infected or escape.The leaf spots produce pycnidiospores that are splash-dispersed within the crop. The significance of this secondary phase in vegetable Brassicas is not well understood.

Phoma can be seed-borne and this can result in problems in individual varieties if there is a high level of seed-borne infection and/or spread during plant propagation. Ascospores can enter propagation glasshouses through the open vents and also introduce the disease onto seedlings.

The development of ascospores on stubbles after harvest is dependent upon rainfall and these spores are the most important for crop to crop spread. Above average rainfall in August and September encourages early ascospore production. The spores are produced over several months. If weather in the autumn is dry then spore production is delayed but continues longer into the spring.

There are different races of *L. maculans* that are characterised by their ability to overcome different resistance genes in Brassicas. This has been investigated in oilseed rape where several resistance genes have been overcome by the pathogen. The situation in vegetable Brassicas is not well understood. As leaf symptoms are much less prevalent on cabbage, cauliflower and Brussels sprouts than nearby oilseed rape, there appears to be useful 'resistance' in some vegetable Brassicas.

L. biglobosa often occurs along with *L. maculans* on leaves, but is considered less damaging and causes more superficial stem lesions and some blackening of the pith within the stem.

Control

Cultural control to dispose of crop residues, unharvested crops and volunteers are important to reduce the carry-over of inoculum, particularly where crops are planted in quick succession. Chopping and burial of stems and roots will encourage more rapid breakdown of crop residues that might otherwise persist for several years. Use a rotation with non-Brassica crops for at least two years where severe Phoma problems have occurred to allow crop residues to decay.

Avoid planting vegetable Brassicas close to oilseed rape.

Use healthy seed. Where seed is known to have a low level of Phoma infection, use a fungicide seed treatment or hot water treatment.

Monitor seedlings regularly during propagation and be prepared to apply fungicide treatment if Phoma leaf spots are found. Foliar fungicides may be beneficial during the growing season when used as Phoma leaf spots start to appear. Note fungicides used against other foliar diseases may have some effect on Phoma development.

Varietal resistance

Little is known about varietal differences in the susceptibility of many Brassicas to Phoma diseases. The *Brassica rapa* group that includes Chinese cabbage, pak choi and turnip appear to be more susceptible to leaf spotting, whilst cauliflower and swedes can suffer severe stem and root damage.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

The disease is only occasionally economically important on cauliflower, Brussels sprouts, and cabbage and prevention relies heavily on using healthy seed and transplants. Local knowledge of recent problems is important to guide decisions about using fungicides on swedes as treatment timings have not been investigated. Be aware that most foliar fungicides have broad-spectrum activity and may give some control of Phoma diseases.

Notes

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Factsheet 18/12

Field Vegetables

Powdery mildew on vegetable Brassicas

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Powdery mildew caused by the fungus *Erysiphe cruciferarum*, is one of the most common foliar diseases of vegetable Brassicas in the UK. It is an important cause of blemish on Brussels sprout buttons and on cabbage. When swedes and turnips are severely affected it causes loss of yield and quality, however, sprout quality is affected by the appearance of blemishes on the buttons. Many Brassicas show only slight infection that does not impair quality. It can also occur on Brassicas grown under protection. There is some variation in the severity of epidemics from year to year but the main risk period is usually from late July to October.

Action points

- Use resistant varieties, particularly for swedes and Brussels sprouts.
- Monitor crops regularly and be prepared to use fungicides from disease onset.

Symptoms

The first signs of powdery mildew are small scattered colonies of white fungal growth (Figure 1). Colonies develop on upper and lower leaf surfaces and petioles. These are almost translucent and difficult to detect in the early stages. The powdery mildew pustules become larger and develop the characteristic white powdery appearance that can cover most of the aerial plant surfaces in susceptible varieties (Figure 2). This leads to yellowing and premature loss of leaves. On more resistant varieties the colonies are more restricted in size and greyish in colour, though some may show only fine black speckling with little fungal growth.

There may be purpling of the underlying plant tissues associated with lesions. On Brussels sprout, powdery mildew produces colonies in the stem between the buttons and often black speckling on the outer leaves on the buttons. This is easily confused with various other conditions such as oedema and over-maturity that also cause fine black speckling on buttons. There may be more pronounced button symptoms if infected buttons are subject to frost. In seed crops, the stems and pods may become heavily infected.

1. The first signs of powdery mildew are scattered colonies of white fungal growth

2. In susceptible varieties, the powdery mildew develops a characteristic white powdery appearance

Epidemiology

The spores can germinate at low relative humidity and free water or rain can be inhibitory. New colonies are produced within 7-10 days in summer. Severe disease outbreaks are associated with warm dry summers with limited rainfall. Disease development is often evident towards the end of July and continues into the autumn until curtailed by frost. On Brussels sprouts the disease develops from late August onwards initially infecting all types of foliage but becoming more prevalent on sprout buttons (Figure 3).

The presence of the disease on the sprout buttons can downgrade their value especially if cold weather occurs which gives rise to melanisation of the fungal mycelium giving a speckled appearance to the button. Infection with *Erysiphe cruceriferium* can encourage the entry of secondary organisms on infected tissues such as grey mould (*Botrytis cinerea*). Periods of moisture stress may also render plants more susceptible to powdery mildew infection.

3. Powdery mildew causes black speckling on Brussels sprout buttons

Life Cycle

Epidemics are initiated by air-borne spores (conidia) produced in overwintered crops and volunteers and dispersed by wind. Mild winters are conducive to the survival of inoculum. The conidia can spread over considerable distances and once new crops are affected there can be rapid development and spread within and between in close vicinity. The pathogen sometimes forms a sexual stage, producing minute pinkish brown to dark brown fruiting bodies (cleistotheca) on diseased foliage, though its importance is not known.

There are different strains of powdery mildew that show varying degrees of specialisation to different Brassica species. Turnip isolates are reported not to affect Brussels sprouts for example. There may be some cross-infection between oilseed rape and other Brassicas.

Control

Cultural control to dispose of crop residues, unharvested crops and volunteers are important to reduce the carry over of inoculum, particularly for overwintered crops.

Careful management of nutrition is beneficial as powdery mildew is aggravated by excessive nitrogen applications and where plants are under stress from nutrient deficiencies.

Varietal resistance

There are significant varietal differences in the susceptibility of many Brassicas to powdery mildew. Guidance should be sought from plant breeders particularly for Brussels sprouts and swedes as there is no recent independent data available.

Products

See separate insert ‘Chemical control of Brassica diseases’.

Agronomy issues

The disease is economically important on Brussels sprouts, swedes, turnip and some cabbage crops. Other Brassicas may have problems from time to time. Regular crop inspection is required to the onset of the epidemic and to help identify situations where the seasonal risk is higher than usual. Some infection of cauliflowers or broccoli can be tolerated but early powdery mildew activity may require an intervention in epidemic years. A programme of fungicides may be required to protect crops during the August to October period. Local data on the resistance of varieties should be collected to guide future decisions.

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Rhizoctonia diseases on vegetable Brassicas

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Rhizoctonia disease, caused by the fungal pathogen *Rhizoctonia solani*, can occur from sowing onwards though it does not usually cause severe problems. It is one of a number of pathogens (along with *Pythium* spp.) that cause damping-off of seedlings. On young plants, the disease is known as wirestem (Figure 1). In swedes and turnips the quality of roots can be affected when the infection causes black spot which disfigures the roots. Root symptoms are also an important problem on radish. There are occasional reports of foliar symptoms including leaf spots and bottom rots on cauliflower, cabbage and other Brassicas. Growers also report that calabrese can be more severely affected than cabbage.

Action points

- Strict hygiene is required during propagation and trays that are re-used should be thoroughly cleaned and disinfected.
- Fungicides may be required to control black spot in swedes and turnip.

Symptoms

Poor emergence and collapsed seedlings soon after emergence are the first signs of Rhizoctonia infection. Other pathogens, notably *Pythium* spp. can cause similar symptoms and laboratory diagnosis may be required to identify the cause. It attacks the roots and lower stem of young seedlings and plants become less susceptible as they get older. Affected plants show browning and cracking of the outer tissues of the stem around soil level and develop 'wirestem' symptoms where only the core of vascular tissue remains. Where direct sown or transplanted crops are affected, plant growth is uneven and there are numerous gaps where plants have died (Figure 2).

Badly affected plants die subsequently or may snap off in windy weather. Cauliflowers are usually the most susceptible Brassica crop. On root Brassicas small black or brown spots up to 1cm in diameter develop on the roots of swedes and turnips (Figure 3). These lesions become sunken as the rot progresses. Rather larger lesions with concentric light and dark zones also develop on the roots. Dark slightly sunken lesions develop on radish roots. Webs of fungal mycelium of Rhizoctonia can spread over the underside of leaves and cause grey leaf lesions or bottom rots on cabbage, particularly where these are in contact with soil.

1. Rhizoctonia attacks the roots and lower stem of young seedlings

2. The plant growth is uneven with numerous gaps where plants have died in affected crops

3. In swedes and turnips, Rhizoctonia causes small black or brown spots up to 1cm in diameter

Life Cycle

Rhizoctonia solani occurs commonly in soil and composts where it survives saprophytically. It has brown pigmented fungal filaments called hyphae and many strains produce resting bodies called sclerotia that aid their survival. Its hyphae grow through soil but *Rhizoctonia solani* is able to grow more rapidly over the soil surface under humid conditions. There is a sexual stage (*Thanatephorus cucumeris*) that produces air-borne spores, typically forming a white collar of fungal growth just above soil level on a variety of plants.

Strains of *R. solani* are separated into groups and the strain AG 2-1 is specific to Brassicas and closely related species such as radish. AG 4 strains also affect Brassicas but have a wider host range and tend to be less virulent than AG 2-1 isolates. Other strains and species of *Rhizoctonia* may sometimes occur on Brassicas in the UK.

Epidemiology

The occurrence of Rhizoctonia diseases is influenced by the weather or glasshouse environment and the level of fungal inoculum present. Cool (7-8°C), wet conditions at sowing favour damping-off by AG 2-1 strains whilst AG4 stains cause little damage at these low temperatures. Conversely, AG 4 strains cause most damage when temperatures are above 25°C and can attack more mature plants. The disease often occurs in patches and spread from plant to plant may occur whilst seedlings are still at a susceptible stage. Recent studies have shown that *R. solani* cannot always be detected within glasshouse production systems however it is more consistently present in the stem bases of field crops. Seed-borne infection has been reported but is uncommon and may be associated with poor quality seed lots contaminated with soil and plant residues.

Control

Good hygiene measures are required on propagation nurseries as Rhizoctonia problems are often associated with re-used trays that have not been thoroughly cleaned and disinfected. The general nursery area should be kept clean as wind-blown soil and dust can introduce the pathogen. Composts should be kept covered prior to use so that they do not get contaminated. *R. solani* often occurs in association with plant material although the basis of this association is not clear.

Propagation conditions for sowing depth, temperature, nutrition, compost quality and moisture should be adjusted to ensure that seedlings emerge quickly. Plants should be hardened off before transplanting as this reduces their susceptibility to attack. If part of a tray has Rhizoctonia symptoms, the whole tray should be discarded. Avoid planting modules too deep and before plants are hardened off.

In the field, crop rotation with non-Brassica crops should be beneficial particularly where AG 2-1 strains are involved or severe attacks have occurred.

Varietal resistance

There are no resistant varieties though cabbage and Brussels sprouts are generally less susceptible than cauliflowers. Growers also report that calabrese (broccoli) is susceptible.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

This disease is often a minor problem and careful crop management can minimise problems. Where Brassicas are grown intensively, avoid using soft plants and treatments that might stress the plant and affect its ability to grow away quickly.

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Factsheet 20/12 (Project FV 233 & FV 313)

Field Vegetables

Ringspot on vegetable Brassicas

Roy Kennedy, University of Worcester and Peter Gladders, ADAS

Ringspot, caused by *Mycosphaerella brassicicola*, is a major foliar disease of vegetable Brassicas in the UK. In areas of intensive vegetable Brassica cultivation, the ability to control the disease is problematic because of the air-borne nature of the inoculum and the prevalence of favourable environmental conditions required for infection to occur. The ability of the pathogen to spread from heavily infected overwintered crops onto sequentially transplanted crops in the same area has a major impact on control of the disease during the season. Long season brussels sprouts are particularly badly affected by ringspot. Extra trimming may be required to remove affected leaves in cabbage and kale. To maintain the high quality of produce demanded by the market there is heavy reliance on regular fungicide applications.

Action points

- Monitor crops regularly
- Use prediction systems to identify risk periods
- Use rotations with non-Brassica crops
- Plough in or incorporate residues immediately after harvest
- Do not plant new crops next to mature crops with ringspot

1. Ringspot is a major foliar disease of vegetable Brassicas in the UK

Symptoms

The lesions are commonly grey or light brown when mature but can be black in appearance when developing. Mature lesions develop black pin head size fruiting bodies (pseudothecia) within the brown areas of the lesion. These are formed when free water (as droplets) is present on the lesions giving rise to rings of black fruiting structures (from which the name of the disease arises). These fruiting bodies are smaller and more numerous than those found in phoma leaf spots. Ringspot lesions characteristically have a distinct margin when they are developing on leaves. This is often best seen on the underside of the leaf. This characteristic is not normally associated with other leaf spots on vegetable Brassicas. Severe infection causes premature loss of leaves and can reduce both yield and quality.

Epidemiology

Fruiting structures (pseudothecia) release ascospores (the main infective spore type) from mature leaf lesions. A second stage forms on young lesions but these spores are unable to infect the Brassica plant. Ascospores are wind-borne over considerable distances. After leaf infection the pathogen requires relatively long periods (4 consecutive days) of leaf surface wetness for the development of pseudothecia and production of ascospores. Optimum temperatures for infection are 16-20°C and new lesions appear in 10-28 days.

Mathematical models have been developed which accurately describe the effect of temperature on infection by ascospores and development of pseudothecia and production of ascospores on lesions within the crop. Ascospores can germinate at high relative humidity and infect seedlings in the absence of free water. By measuring environmental variables (temperature, precipitation and relative humidity) in the field, predictions of the likely ascospore inoculum availability from lesions within the crop can be ascertained using mathematical models available within the BrassicaSpot system. However, infection resulting from long distance dispersal of ascospores cannot be predicted. Detecting the ascosporic source of inoculum is potentially important if more accurate timing of fungicide application to the crop is to be achieved to improve efficient use of fungicides. The temperature and wetness optima for development of this disease, means it can be limited by low temperatures and dry conditions. For this reason ringspot is not often present in colder production areas of the country such as Scotland.

Life Cycle

Infected crop residues and nearby crops are the main source of the disease. It thrives where there is year-round production of Brassicas. Once ringspot is established within the crop, secondary spread occurs by means of ascospores produced on mature leaf lesions.

There are different strains of ringspot and some appear to only infect cabbage. It is a minor disease of oilseed rape in the UK and also affects forage Brassicas such as kale.

Control

Crop rotation with non-Brassica crops and hygiene measures to dispose of crop residues are important for control of ringspot. Plough in or incorporate crop residues immediately after harvest. Avoid planting new crops adjacent to mature crops with ringspot. Break the year-round cycle of Brassica cropping for several months to allow crop residues to decay. Lateral flow devices have been developed in HDC projects FV 233 & FV 313 to help growers with forecasting of the disease. These devices will be made available commercially by Syngenta Crop Protection UK Ltd. in 2013. Specific details for ordering will be sent out to industry in Spring 2013.

Varietal resistance

There are no resistant varieties to ringspot although varieties do differ in their susceptibility.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

Ringspot affects all varieties of vegetable Brassica however it is a major problem on the buttons of Brussels sprouts where small amounts of disease can lower yield levels in the crop disproportionately. The occurrence of one lesion on the Brussels sprout button can render it unmarketable. A preventative approach with fungicides is required in high risk areas so that ringspot does not become established within the crop.

The disease is less economically important on other vegetable Brassicas where only infection of the packing leaves of cauliflowers or Broccoli could render the heads unsaleable. However this can only occur where high levels of disease occur in the crop. When there is a short cropping interval between planting and harvest the disease impact is limited if disease development comes from spores produced within the crop. Under optimal conditions it can take 4-6 weeks between infection and inoculum production.

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Factsheet 21/12

Field Vegetables

Sclerotinia on vegetable Brassicas

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Sclerotinia can affect vegetable Brassicas at all stages of growth from seedlings to flowering seed crops and stored crops. The various names of Sclerotinia disease reflect the symptoms it causes at the different plant growth stages. These include watery soft rot, white mould, stem rot and cabbage drop. In the UK, the levels of these diseases are very low except in some Brassica seed crops or where a crop has been predisposed to infection by damage or poor management. Epidemics do occur in oilseed rape in certain years, most recently in 2007 and 2008, when weather conditions favoured infection during flowering.

Action points

- Review rotations to ensure different susceptible crops are not grown too close in the rotation. Brassicas should not be grown immediately after another crop that has had Sclerotinia.
- Careful handling is essential for crops going into storage.
- Protect seed crops with fungicides at flowering and ensure harvested seed is not contaminated by sclerotia.

Symptoms

Sclerotinia is an aggressive pathogen that grows rapidly under cool moist conditions. When its sclerotia are seed-borne it can cause damping off and patches of collapsed seedlings can be found in small containers of 'cress' for example. Leaf infection can occur on module raised transplants where there are senescent leaves or scorch (Figure 1). Fluffy white fungal growth develops on the foliage under humid conditions followed by the production of small black sclerotia. If conditions remain favourable for its development, there is progression to stem rotting and collapse of young plant. The fungus can keep spreading by direct contact from plant to plant.

On young cabbage a watery soft rot symptom can develop on the leaves and head from infection taking place at or near soil level. Similar symptoms can occur on the developing heads of flowerhead Brassicas and on other types of Brassica where there is scorch or physical damage (Figure 2). On winter white cabbage a few heads may show white mould in the field and these have numerous black sclerotia on the surface of the head. Often the affected plants are just a few scattered heads near the edge of the crop where machinery has damaged the plant during field operations. Similar symptoms occur on stored heads under both ambient and cold storage conditions.

1. Cauliflower stems affected by Sclerotinia in modules

2. Infection of Sclerotinia in Brussels sprout

Flowering Brassicas are particularly prone to Sclerotinia attack as the petals provide a nutrient source that enables Sclerotinia spores to infect the plant. Pale brown or white lesions develop on leaves or directly on the stems and gradually enlarge to produce large girdling stem lesions. They kill the upper part of the plant and can weaken the stems so that the plant falls over. Black sclerotia are produced within the stem cavity and occasionally on the outside of the stem. Stem lesions continue to enlarge given humid conditions and can spread into the root system.

Epidemiology

Whilst *S. sclerotiorum* occurs very widely in broad-leaved crops and weeds, the localities where severe attacks occur usually have a history of problems in one or more susceptible crops. The sclerotia require a period of dormancy and cold conditioning before they produce saucer-shaped fruiting bodies (apothecia) at the soil surface. This conditioning usually occurs during the autumn and winter so that sclerotia germinate and produce apothecia in spring when soils are moist and soil temperatures are above 10°C. Spores are produced a few days after apothecia first appear and are dispersed mainly within the field and adjacent areas. The spores may be able to survive for several weeks on leaves and require long periods of high humidity (minimum 23h) with temperatures of at least 7°C for plant infection to occur. Once plant infection has occurred, further fungal growth can occur over a range of temperatures 0-25°C, but can be inhibited by hot dry conditions.

At the end of cropping, the sclerotia produced in the crop fall to the soil where they are usually buried by cultivations. Some sclerotia may be harvested with the seed crop and small ones may contaminate seed if they cannot be removed during seed cleaning.

Life cycle

The disease cycle has two main components, soil-borne fungal resting bodies (sclerotia) capable of long-term survival when buried deeply and air-borne ascospores produced when sclerotia near the soil surface germinate and form fruiting bodies (apothecia). Spores can be produced from late winter until the autumn and can initiate infection in a very wide range of broad-leaved crops and weeds. They have limited ability to infect healthy plants and most attacks occur when there are additional nutrients available from fallen petals or damaged or senescent foliage. Once initial infection has occurred, the disease spreads through the plant and between plants by plant to plant contact. Sometimes Sclerotinia infects the weeds in the crop and then spreads from weeds to crop plants.

If plant stems or leaves are in almost direct contact with sclerotia, there may be direct infection. Similarly, if there are infected plant residues in the field when the new crop is planted, Sclerotinia can infect by direct mycelial growth. Sclerotinia may also be seed-borne and this is difficult to detect even in untreated seed as some sclerotia are the same size and colour as Brassica seeds.

The whole rotation should be considered when assessing the risks of Sclerotinia diseases. Oilseed rape, potatoes, legumes (apart from winter field beans), carrots and many other vegetables are susceptible and contribute to maintaining soil-borne populations.

Control

Crop rotation is an important part of controlling this disease. An interval of 3-4 years between susceptible crops should allow some decline in sclerotial numbers. Risks will be increased by growing susceptible crops close together in the rotation. Deep ploughing to bury Sclerotinia may be worthwhile though sclerotia should not be brought back to the surface by subsequent cultivations when susceptible crops are grown.

Varietal resistance

There are no resistant varieties.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

As Sclerotinia problems occur infrequently, rotational planning and local knowledge of Sclerotinia problems are the most important aspects to consider. There is potential for attacks where there is fertiliser or spray scorch and physical damage.

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Factsheet 22/12 (Project FV 378)

Field Vegetables

Spear rot on calabrese

Peter Gladders, ADAS and Roy Kennedy, University of Worcester

Spear rot (also known as headrot) of calabrese (broccoli) is a major cause of crop losses in the UK, estimated to be over £15 million per year (Project FV 378). The disease is caused by several different bacteria (*Pseudomonas fluorescens, Pseudomonas marginalis* and *Pectobacterium carotovorum* subsp. *carotovorum*) that commonly occur in soil and growing crops. They cause disease problems on developing heads when there are prolonged wet and humid conditions and are difficult to predict.

Action points

- Assess field risks before deciding the planting schedule.
- Optimise crop management particularly nitrogen use.
- Use weather forecast to help time use of copper sprays.
- Use copper sprays at repeated low dose applications from the mid-vegetative stage but bear in mind that copper sprays can have a phytotoxic effect.

Symptoms

Small black or water-soaked buds can be found on developing heads where these have remained wet for several days. The affected areas lose their waxy bloom as the bacteria produce surfactants. The affected areas gradually increase in size and become blackened patches as the bacteria cause a progressive soft rot. Symptoms can develop after cutting, though this may well relate to low levels of bud infection that were not detected in the field. Sometimes the primary problem is caused by downy mildew affecting the developing buds and this allows opportunistic soft rot bacteria to cause more extensive damage.

Pseudomonas fluorescens is usually the most important pathogen on calabrese. These bacterial pathogens also cause soft rots of other Brassicas in the field and during shipment and storage. They can be associated with physical damage, other pest and diseases, growth cracks and overmaturity.

1. A broccoli head affected by spear rot bacteria

Epidemiology

Serious outbreaks of spear rot are strongly linked to weather conditions at heading. Spear rot symptoms can appear within three days if there is continuous wetness. Infection can also develop if there are long periods when dew is present. The autumn period is particularly prone to problems when there are warm days and cool nights that allow dew to form (Project FV 104). Sheltered fields and coastal locations prone to fog are other factors that influence risks of spear rot.

Life Cycle

The bacteria responsible for spear rot are soil-borne and become established on plant foliage by rain splash from an early stage. They also survive in plant residues. They usually remain symptomless whilst the crop is growing, though they can cause rots where plants suffer scorch or other forms of damage.

Control

As the bacteria involved are common, there is little prospect of preventing them becoming established in the crop. The priority is to manage the crop well and optimise nitrogen use as excessive nitrogen applications increase susceptibility to spear rot. Locate crops to avoid higher risk sites in the autumn such as sheltered fields and coastal areas prone to fog. Ground cover mulches that restrict movement of soil bacteria to the crop may be beneficial, though the economics of such treatments are uncertain. HDC recently funded project FV 378 to investigate the potential for using plant growth elicitors as an alternative method for control. More information about this project can be found on the HDC website www.hdc.org.uk.

Varietal resistance

There appear to be varietal differences that are associated with waxiness and more cone-shaped heads in calabrese however there is no independent data available to guide growers.

Products

See separate insert 'Chemical control of Brassica diseases'.

Agronomy issues

The disease is difficult to manage as it is so weather dependent. Risks can be spread by growing different varieties and avoiding high risk sites in autumn. Copper sprays should be used preventatively when wet weather is imminent. Repeated low dose applications from the mid-vegetative stage are considered most effective (Project FV 104b). However, commercially, copper applications can cause phytotoxicity, particularly if high doses are applied directly to the broccoli head and occasionally applications have been found to actually exacerbate spear rot.

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Figure 1 © James Hutton Institute

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Factsheet 23/12

Field Vegetables

White blister on vegetable Brassicas

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White blister (*Albugo candida*) occurs frequently in vegetable Brassica crops and has a widespread distribution covering most vegetable Brassica production areas in the UK. It is also referred to as white rust. The disease was common in UK production during the 1950s but largely disappeared until the 1980s in the UK. White blister like many leaf spot pathogens has specific requirements for its development in vegetable Brassica crops. White blister has a long incubation period between infection and appearance of the disease. This means that success or failure of control is only apparent in some cases weeks after fungicide applications. Often this leads to diseases becoming well established in crops before the disease is really visible.

Action points

- Use healthy transplants.
- Monitor crops regularly and be aware of potential for spread of white blister from infected crops to nearby fields.
- Use fungicides when first symptoms are found, particularly to protect the buttons of Brussels sprouts and heads of green cabbage. Several treatments may be required to maintain protection whilst temperatures are favourable for disease development.

Background

White blister is caused by the oomycete pathogen *Albugo candida* and is a common disease of many economically important vegetable Brassica and oilseed crops worldwide. Significant yield losses from this disease have been reported on the oilseed crops of *Brassica rapa* (turnip rape) and *Brassica juncea* (mustard). Whilst it can affect susceptible lines of *B. napus* (the predominant oilseed type in the UK), it has not been recorded in commercial oilseed rape crops apart from spring turnip rape in Scotland. Affected vegetables include broccoli, Brussels sprouts, cauliflower, radish, mustard, Chinese cabbage and turnip. The impact of disease in these crops is of a cosmetic nature and can render crops unmarketable. In Australia the disease has been commercially important in vegetable production since 2002.

1. White blister lesions on cabbage

2. White blister infection on Brussels sprout buttons can cause significant yield losses

To date, more than 10 distinct biological races of *A. candida* have been identified and classified based on the host plants they attack. Race 9 infects vegetable Brassicas and is considered to have caused the recent outbreaks of white blister on broccoli in Australia. Strains affecting radish are unlikely to affect leafy Brassicas. White blister is common on various cruciferous ornamental species and weeds such as Shepherd's purse weeds (*Capsella bursa-pastoris*) and plants but the latter strain does not infect vegetables. Disease management strategies to control the disease are largely based on routine spray programmes in the UK. Improved management of the disease can be achieved by utilising information from a white blister disease risk computer forecast program called BrassicaSpot. This program has also been used in all parts of Australia where it can be used to schedule irrigation periods which limit disease development.

Symptoms

White blister symptoms first appear as yellow spots on leaves and these eventually become white in colour (Figure 1). However, often the yellow spots on leaves do not develop further (especially on older leaves) and white lesions are not formed. Often infected tissues become distorted especially when immature. This facilitates spore dispersal as infected tissues are more exposed to air streams within the crop. Hollows in leaves also aid in dispersal by creating funnelling which is important because the airborne spores of white blister are relatively large and need assistance to become airborne over wider areas. White blister infects only young immature tissue and this is the reason that on some older leaves the white lesions are not readily formed. The maturity of the tissue is also affected by the time between infection and symptom appearance. Once tissues are mature they cannot show symptoms. If symptoms occur on inflorescences they can result in distortion of tissues, a symptom which is often referred to as stagshead. Stagshead can result in significant yield loss in seed crops and on Brussels sprout buttons (Figure 2). The distortion makes the Brussels sprout button unsaleable but the occurrence on leaf tissues also affects marketability. Oospore (the sexual spore form) formation may occur on inflorescences or on tissues showing stagshead symptoms. Oospores can germinate directly on the plant by germ tube formation or by zoospore release. It is common for white blister to form systemic asymptomatic infections that are not visible for long periods of time. Downy mildew (*Hyaloperonospora parasitica*) sometimes grows on white blister lesions and can confuse diagnosis. Small root galls may develop on radish.

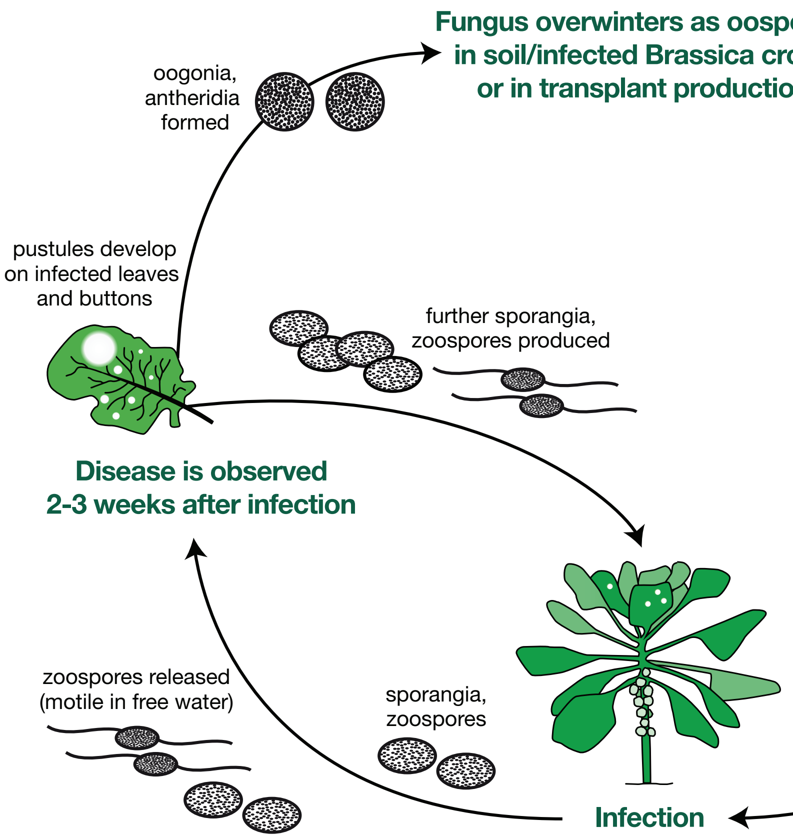
Epidemiology

Disease outbreaks are initiated from oospores in soil or plant debris, though during the growing season air-borne spores are likely to be more important in the spread between nearby crops. White blister like other pathogens of vegetable Brassicas requires free water for infection by the zoospore (the main infective propagule). Once the disease is established, relatively short dewfall periods can be very favourable for white blister development. High temperatures result in relatively short periods of time elapsing between infection and symptom appearance on the plant. This is dependent on the temperature under which the plants are grown. White blister symptoms do not develop at temperatures below 8˚C. However the optimal temperature for symptom development is at temperatures of 20˚C and above. This explains why white blister is not prevalent in Scotland and many northerly areas of vegetable Brassica production. The results indicate that epidemics will not develop in areas with cool daily average temperatures because there is not sufficient time for white blister symptoms to occur.

Life Cycle

The life cycle of white blister is quite complex (Figure 3) with both a sexual and asexual stage. In the UK the sexual stage is not often observed but may be present within lesions associated with specific environmental conditions. In Australia, white blister (Race 9) sexual stages are sometimes observed as galls on the stems of seedlings. The asexual stages are commonly called zoosporangia and are the white spores most commonly associated with white blister lesions. Zoosporangia germinate in the presence of free water to release zoospores however zoospore release is not associated with high temperatures and occurs more frequently if the water is at approximately 4˚C . Released zoospores quickly stop moving if the temperature of the water rises above 10˚C. For these reasons white blister infection is frequently associated with dew on the crop. Infection of immature tissues occurs within 4 hours at temperatures of 10-24˚C. Infection rarely occurs below 6˚C or above 26˚C. No symptom expression occurs at 8˚C or below. The time between infection and symptom appearance is approximately 2-3 days at a constant temperature of 20˚C, but can be up to 14 days at a constant temperature of 10˚C .

BrassicaSpot models predicting the length of incubation period can be used to determine spray intervals for white blister in the field. Infection models can be used to determine when infection periods are first observed and when infection is no longer possible during the growing season.



2. Life cycle of white blister on vegetable Brassicas

Control

Varietal resistance

Tests in the UK with Brussels sprouts (cv. Adonis), broccoli (cv. Shogun), cauliflower (cv. Belot), red cabbage (cv. Rodon) and savoy cabbage (cv. Tarvoy) showed little variation in infection and in time to symptom development. This suggests that races found on vegetables in the UK may be able to infect all Brassica types. There is little information on differences between current varieties. Other races of white blister in other areas of the world may have specific host ranges. Given that only immature tissues can become infected it is likely that varieties differing in growth habit might vary in their susceptibility to white blister infection. For this reason early season cultivars of Brussels sprouts might have a higher chance of becoming infected with white blister. Additionally early season cultivars usually grow at times of the year when environmental conditions are more favourable for white blister infection.

Products

See separate insert ‘Chemical control of Brassica diseases’.

Agronomy issues

Regular crop monitoring is required to detect the early stages of the disease. It is occasionally found on transplants. Several fungicide treatments are likely to be required to maintain protection. Brussels sprouts and cabbage are most at risk. Control is difficult to achieve if the disease becomes well established in the crop.

Notes

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Chemical control of Brassica diseases

Example approved products (both on-label and EAMUs) for the control of Brassica diseases on outdoor crops (December 2013)

	Active Ingredient(s)	Product Example	Target Disease	Broccoli	Brussels sprouts	Cabbage	Cauliflower	Chinese cabbage	Kale and collards	Swede and turnips
Field treatments	Azoxystrobin	Amistar	Dark leaf spot, ringspot, powdery mildew, white blister	✔	✔	✔	✔		✔	✔
Field treatments	Azoxystrobin + difenconazole	Amistar Top	Dark leaf spot, ringspot, white blister	✔	✔	✔	✔		✔	
Field treatments	Boscalid + pyraclostrobin	Signum	Dark leaf spot, ringspot, white blister	✔	✔	✔	✔	✔	✔	
Field treatments	Chlorothalonil + metalaxyl M	Folio Gold	Dark leaf spot, downy mildew, ringspot, white blister		✔		✔			
Field treatments	*Coniothyrium minitans* (soil treatment)	Contans WG	Sclerotinia	✔	✔	✔	✔	✔	✔	✔
Field treatments	Copper oxychloride	Cuprokylt	Xanthomonas, spear rot	✔	✔	✔	✔	✔	✔	
Field treatments	Difenconazole	Plover	Dark leaf spot, ringspot	✔	✔	✔	✔	✔	✔	
Field treatments	Fluopicolide + propamocarb hydrochloride	Infinito	Downy mildew			✔	✔			
Field treatments	Flusilazole	Nustar 25	Phoma		✔					✔
Field treatments	*Gliocladium catenulatum* strain J1446	Prestop	Rhizoctonia	✔	✔	✔	✔	✔	✔	✔
Field treatments	Mancozeb + metalaxyl-M	Fubol Gold WG	White blister			✔				
Field treatments	Metalaxyl-M	SL567A	White blister	✔					✔	
Field treatments	Prothioconazole	Rudis	Dark leaf spot, light leaf spot, phoma, powdery mildew, ringspot	✔	✔	✔	✔			✔
Field treatments	Tebuconazole	Folicur	Dark leaf spot, light leaf spot, powdery mildew, ringspot	✔		✔	✔	✔		✔
Field treatments	Tebuconazole + Trifloxystrobin	Nativo 75WG	Dark leaf spot, light leaf spot, phoma, powdery mildew, ringspot	✔	✔	✔	✔			
Seed and propagation treatments	Fosetyl aluminium + propamocarb hydrochloride	Previcur Energy	Downy mildew	✔	✔	✔	✔	✔	✔	
Seed and propagation treatments	Thiram (seed treatment)	Agrichem	Rhizoctonia, damping off			✔	✔			✔
Seed and propagation treatments	Metalaxyl-M (seed treatment)	Apron XL	Damping off (*pythium spp.*)	✔	✔	✔	✔	✔		
Seed and propagation treatments	Tolclofos methyl	Basilex	Rhizoctonia	✔	✔	✔	✔	✔		✔
Seed and propagation treatments	Dimethomorph	Paraat	Downy mildew	✔	✔	✔	✔	✔	✔	

✔ = Full approval or EAMU   ■ (green) = No approval

These factsheets are intended to provide growers with information on results and practical applications from HDC and non-HDC-funded research and development. They are not intended to endorse or recommend the use of any products or active ingredients mentioned. Only products officially approved as plant protection products should be applied to control pest, disease and weed problems or used as plant growth regulators. Before using any such substance, growers should refer to product approval and label documents, seek guidance from a BASIS qualified consultant and consult their customer's plant protection product list.

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