

Spinach

Project No. FV 268

Spinach leaf spots and their management

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Leaf spot diseases are becoming an increasing constraint to the production of baby- and mid-leaf spinach crops. This factsheet describes common leaf spot diseases of spinach crops in the UK and summarises currently available information on disease biology and management options. Other major diseases on spinach, such as downy mildew and white rust are largely managed through the use of resistant varieties and fungicides, and are not included in this factsheet.

Action points

- Key leaf spot pathogens of spinach can be seed-borne and routine seed-health testing methods are available. Check the health status of seed before use.
- Aim for a field rotation of at least three years.
- Ensure fields are free of volunteers.
- Manage irrigation (if used) to avoid prolonged leaf wetness durations.
- Closely monitor crops for disease development, particularly after periods of warm, wet weather.
- Ensure correct diagnosis of leaf spot pathogens. Correct diagnoses are important because they can aid correct fungicide selection, improve the timing of fungicide applications, assist with the selection of higher levels of resistance and determine appropriate cultural practices for more effective management.
- Bury, burn or dispose of any crop debris carefully (particularly infected crop material) that could potentially be a source of inoculum for leaf spot diseases. This is very important where sequential or repeated cropping is done.

Background

Although leaf spots can develop on spinach at any time during the growing season, they tend to be more prevalent on late summer and autumn crops, as these have a longer growing period and a higher risk of wet conditions favourable for pathogen development. Foliar damage due to spinach downy mildew infection may create sites for leaf spot infection. During HDC project FV 268, the diseases most commonly encountered on UK baby – and mid-leaf spinach crops were anthracnose, cladosporium leaf spot and stem-phyllium leaf spot. Key features of these three diseases are summarised in Table 1. The host range of common leaf spot pathogens on crops of the *Chenopodiaceae* (beet family), is summarised in Table 2.

In baby and mid-leaf spinach crops, symptom development does not always follow typical descriptions of the same diseases on spinach seed

and processing crops from published literature (mainly from the USA). This is because the soft and succulent young spinach leaf tissue leads to the

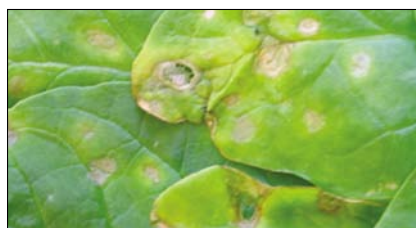
development of individual lesions which are rapidly followed by general disintegration, yellowing and rotting of leaf tissue.



1 Young lesions of spinach anthracnose

Table 1 Key features of three fungal leaf spot diseases of spinach

Disease	Anthrachnose	Cladosporium leaf spot	Stemphylium leaf spot
Pathogen Name	<i>Colletotrichum dematium</i>	<i>Cladosporium variabile</i>	<i>Stemphylium botryosum</i>
Symptoms	Initially, pale green/brown irregular lesions, then light-brown and shot-holed (see Figure 2 below)	Pale lesions (see Figure 3 below)	Tan lesions with green watersoaked margin (see Figure 4 below)
Fungal structures in leaf spots (under low-power magnification)	Black structures with 'spines'	Olive-green sporulation on older lesions	Occasionally (dark brown sporulation on older lesions)
Seed-borne	Yes (occasional)	Yes	Yes
Dispersal	Water splash, seed	Wind, seed	Wind, seed
Over-wintering	Volunteers, seed	Volunteers, seed	Woody spinach debris, seed
Favourable conditions	Wet, cool	Moist, cool	Moist, warm
Host range	Chenopod species	Chenopod species	Spinach only



2 Anthracnose symptoms



3 Cladosporium leaf spot symptoms



4 Stemphylium leaf spot symptoms

Table 2 Host range of common fungal leaf spot pathogens on crops of the *Chenopodiaceae* family

Pathogen	Disease	Crop host			
		Spinach (<i>Spinacea oleracea</i>)	Red chard (<i>Beta vulgaris</i>)	Spinach beet (<i>Beta vulgaris</i>)	Sugar beet (<i>Beta vulgaris</i>)
<i>Colletotrichum dematium</i>	Anthrachnose	✓	?	?*	?
<i>Cladosporium variabile</i>	Cladosporium leaf spot	✓	?	?	?
<i>Stemphylium botryosum</i>	Stemphylium leaf spot	✓	x	x	x **
<i>Cercospora beticola</i>	Cercospora leaf spot	✓	✓	✓	✓
<i>Ramularia beticola</i>	Ramularia leaf spot	✓	✓	✓	✓
<i>Phoma betae</i>	Phoma leaf spot	✓	✓	✓	✓

* observed in a UK organic spinach beet crop ** can be a common saprophyte on dead or damaged plant material

Anthracnose

Spinach anthracnose is caused by the fungus *Colletotrichum dematium*. It has been previously reported and is occasionally observed in the UK, with at least two confirmed outbreaks in October 2005. The disease has been reported from spinach production areas in the USA, mainland Europe and Australia.

Symptoms

Lesions are initially green/pale brown, watersoaked and irregular in appearance (Figure 1). Later, the lesions become light brown (approximately 5 mm in diameter), sometimes with yellow haloes (Figure 5). The centres of the lesions become thin and 'papery' in texture and often fall out giving a 'shot-hole' appearance (Figure 5). Lesions may merge so that the whole leaf becomes affected. A useful diagnostic feature of the disease is that structures characteristic of the fungus can be seen under low power magnification. Clusters of minute black spines are often visible (Figure 6) and grey or salmon-pink spore-containing droplets may also be seen. These features can be used to distinguish anthracnose from cladosporium or stemphylium leaf spots that are similar in appearance.

Sources of the disease

The fungus survives as dormant mycelium (fungal strands) in infected plant debris and this is probably the primary source of inoculum for spinach anthracnose between growing seasons. The fungus is occasionally seed-borne on spinach; however, the relative importance of seed-borne inoculum in outbreaks of anthracnose on UK spinach has not been documented.

Colletotrichum isolated from spinach is generally thought to be pathogenic only to spinach, so risk of infection from alternative host crops is low. However, laboratory studies show that some beet cultivars are slightly susceptible and the disease has been observed on organic spinach beet in the UK.

Conditions for infection and spread

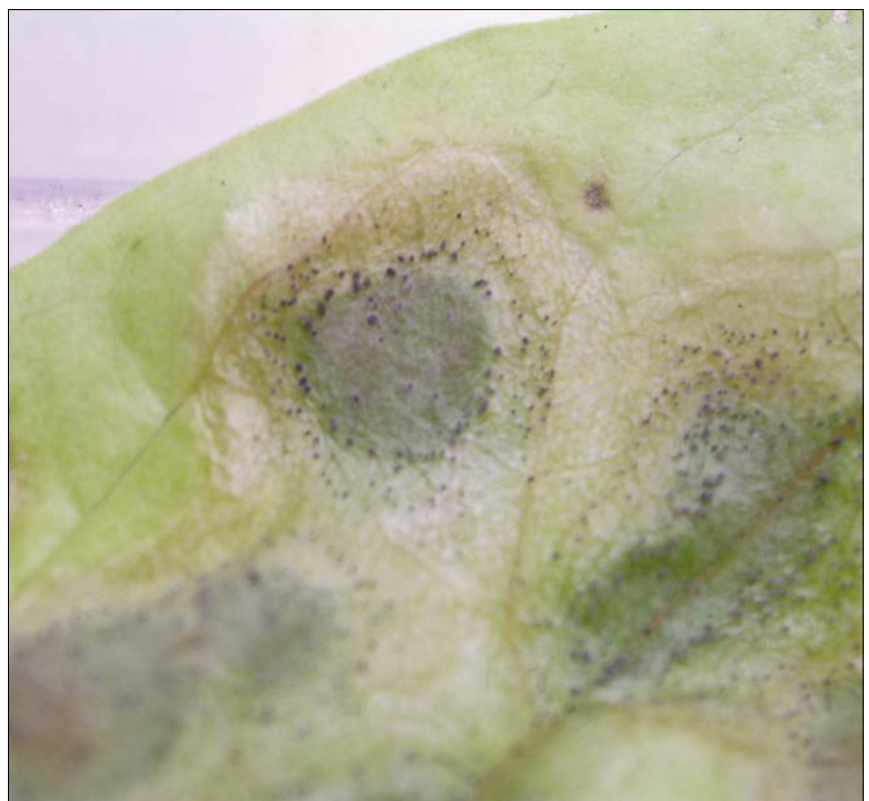
Conditions favouring infection by *Colletotrichum* species include high relative humidity and prolonged leaf wetness. Once infection has taken place, spores develop in structures on the leaf surface and are readily spread to neighbouring plants or beds by overhead

irrigation, rain-splash or wind-driven rain, resulting in rapid disease spread. Anthracnose epidemics are sporadic but factors such as dense plantings, poor air circulation and low plant fertility can increase the risk of infection.

Colletotrichum dematium is a primary pathogen causing anthracnose on spinach, but it is also a common secondary pathogen, readily colonising lesions caused by other diseases such as white rust.



5 Older lesions of spinach anthracnose with yellow haloes and 'shot-holes'



6 Black fungal structures (setae) visible in anthracnose lesions

Cladosporium leaf spot

Cladosporium leaf spot is caused by the fungus *Cladosporium variable*. This disease is frequently observed on spinach and has been reported from USA, Europe (including the UK) and Asia. In the UK, it is reported to be more severe in cool, wet autumn conditions. Another *Cladosporium* species, *C. macrocarpum*, which is a common saprophyte, may also be found on deteriorating spinach leaves and on spinach seed but is not a pathogen of spinach.

Symptoms

Leaf lesions are initially white, circular and up to 0.5 cm diameter (Figure 7). Older lesions are usually round, white/yellow with a dark margin and up to 1 cm in diameter, becoming irregular in shape when they merge with other lesions (Figure 8). Dark green fungal growth (spore clusters) may be visible in lesion centres, and this helps to distinguish cladosporium leaf spot from symptoms of anthracnose and stemphylium leaf spot. In the USA, the disease is particularly severe on seed crops, in which ripening seed may also develop lesions and become shrivelled.

Sources of the disease

The disease is commonly seed-borne. Seed transmission of the fungus has been demonstrated in greenhouse trials but this has not been proven under field conditions. The incidence of *C. variable* on spinach seed lots used for UK production has not been determined.

Volunteer spinach can also serve as a 'reservoir' for this disease.

C. variable is reported to be pathogenic to sugar beet and *Chenopodium amaranticolor* as well as spinach, but it is not clear whether cross-infection occurs under field conditions.

Conditions for infection and spread

The fungus can grow and infect spinach under a wide range of temperatures, but a temperature range of 15–20°C with relative humidity above 80% is most conducive to disease development. Spores of *C. variable* on the leaf surface can germinate and penetrate leaf stomata within 48 hours in the presence of free moisture. Symptoms of the disease generally develop 4–10 days later. Once infection is established, the fungus grows in the leaf tissue and

spores produced within leaf lesions start new infection cycles. Spores of

C. variable can be spread by wind, rain splash or carried on equipment.



7 Early symptoms of cladosporium leaf spot on spinach



8 Older lesions of cladosporium leaf spot

Stemphylium leaf spot

Stemphylium leaf spot is caused by the fungus *Stemphylium botryosum*. The disease has been reported on baby-leaf spinach in the UK and Spain and also across the USA on seed and processing crops.

Symptoms

Lesions are initially brown (round or oval) with a green water-soaked margin (5–7.5 mm diameter) (Figure 9). Lesions enlarge, coalesce and become paler and papery in texture. Older lesions may have a dark brown border and there is often general yellowing of surrounding leaf tissue and water-soaked leaf decay (Figure 10). Fungal structures on lesions are often absent but dark brown spore clusters are occasionally visible in lesion centres (Figure 11). Older lesions can closely resemble the pale, circular spots caused by pesticide or fertiliser damage and for this reason the disease may commonly be incorrectly diagnosed.

Sources of the disease

S. botryosum is commonly seed-borne. The percentage of seed infected with *S. botryosum* declines with time but the fungus can remain viable on spinach seed (stored at 4.4°C and 60% relative humidity) for up to 11 years. As well as being present in the seed coat, internal infection by *S. botryosum* in seed embryos has also been detected with transmission of the fungus from infected seeds to seedlings being demonstrated in glasshouse experiments. This internal seed infection by the pathogen suggests there could be difficulties in eradicating *S. botryosum* from infected spinach seed using seed treatment. The prevalence of *S. botryosum* in spinach seed lots, combined with routine international movement of spinach seed, may explain widespread first outbreaks of stemphylium leaf spot in the USA, plus observations of the disease on crops in Spain and the UK. The incidence of *S. botryosum* on spinach seed lots used for UK production has not, as yet, been ascertained.

Stemphylium botryosum can infect a wide range of hosts including lettuce, pea and onion, and also survives as a saprophyte on crops such as sugar beet. However, the pathogen 'type' that infects spinach appears to be



9 Early symptoms of stemphylium leaf spot on spinach



10 Older lesions of stemphylium leaf spot



11 Dark brown spores visible in stemphylium lesion centre

specialised and does not infect other plant species.

The fungus can survive on spinach crop debris as fruiting bodies, which can discharge airborne spores that could be a source of inoculum in spring for infection of newly-planted spinach crops. Burial of crop debris will reduce pathogen survival by several weeks compared with leaving residues on the soil surface.

Conditions for infection and spread

Infection may take place over a wide range of conditions but is favoured by temperatures in the range 18–24°C and prolonged periods of leaf wetness. Spores may be spread by wind, rain splash, irrigation and farm implements or workers.

Other leaf spot diseases

Leaf spot diseases that commonly affect beet crops (eg sugar beet and spinach beet) can also occur on spinach, namely cercospora, ramularia (Figure 12) and phoma leaf spots. The key features of these diseases are described in Table 3.

Alternaria species have occasionally been reported as causing leaf spots of

spinach in other countries. A bacterial leaf spot of spinach (*Pseudomonas syringae* pv. *spinaciae*) has also been

described as a minor problem in Europe and the USA.



12 Ramularia leaf spot on spinach beet

Table 3 Key features of three fungal leaf spot diseases of beet that can also affect spinach

Disease	Cercospora leaf spot	Ramularia leaf spot	Phoma leaf spot
Pathogen Name	<i>Cercospora beticola</i>	<i>Ramularia beticola</i>	<i>Phoma betae</i>
Symptoms	Circular leaf spots, red-brown margin, on older leaves	Light brown leaf spots, angular and larger on older leaves	Round leaf spots, concentric rings on perimeter, dark margin
Fungal structures in leaf spots (seen under low-power magnification)	Minute black dots (stromata)	Silvery grey to white spore masses	Black fruiting bodies (pycnidia)
Seed-borne	Yes (external)	Yes (?)	Yes
Dispersal	Splashing water, wind, insects, seed	Wind, seed	Splashing water, insects, seed
Over-wintering	Weeds, debris, seed	Debris, seed	Soil, roots, debris, weeds, seed
Favourable conditions	Warm, moist	Cool, moist	Cool to warm, moist
Host range	Beet, chard, spinach, chenopod weeds	Beet, chard, spinach	Beet, spinach

Disease management

Seed health

Key leaf spot pathogens of spinach can be seed-borne and routine seed-health testing methods are available. Check the health status of seed before use.

Reports on the efficacy of sodium hypochlorite and hot water for eradication of fungal pathogens on spinach seed showed that sodium hypochlorite (1.2% for at least 20 minutes) or hot water seed treatments (50°C water for 20 min) were used to eradicate *C. variable* without damaging seed germination. These treatments were only partially effective against *S. botryosum*, even for a lightly infected seed lot. The difficulty in eradicating *S. botryosum* from seed by disinfection or hot water treatment may be due to the deep-seated nature of the infection.

Host resistance

Host resistance to spinach anthracnose has been reported but is not available as a trait in commercial cultivars.

In the USA, some semi-savoy types like 'Ozarka II' and 'Fall Green' have been shown highly susceptible to

cladosporium leaf spot in greenhouse tests and field observations. The savoy cultivar 'Winter Bloomsdale' tended to be more resistant. No commercially acceptable level of resistance has been identified.

Little is known about the variation in resistance of commercial spinach cultivars to stemphylium leaf spot. Research in California showed only slightly less lesion development on the savoy spinach cultivar 'Vienna' than on other varieties tested including flat leaf and semi-savoy types.

Cultural practices

Cultural practices to reduce the risk of leaf spots on spinach include:

- Rotation of at least three years
- Ensure fields are free of volunteers
- Manage irrigation (if used) to avoid prolonged leaf wetness durations
- Ensure adequate plant nutrition
- Closely monitor crops for disease development, particularly after periods of warm, wet weather
- Bury, burn or dispose of crop debris carefully (particularly infected

crop material) that could potentially be a source of inoculum for leaf spot diseases.

Fungicides

The efficacy of fungicides for the control of leaf spot pathogens on UK spinach crops is being evaluated in FV 268a and will be reported in a future update of this factsheet.

The activity of approved fungicides for the control of spinach anthracnose is not well-documented. Once symptom development has occurred, the disease can spread rapidly under wet conditions.

Additional information:

Further information: A full copy of the annual report for HDC project FV 268 is available from the HDC office (01732 848383).

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