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AHDB Horticulture Projects FV 237 and FV 237a

# Management of celery leaf spot

Leaf spot caused by the fungus *Septoria apiicola* is the most destructive disease of field-grown celery. Based on the findings of two past AHDB Horticulture projects FV 237 and FV 237a and information arising from AHDB Horticulture-funded mesh-cover disinfection experiments carried out at ADAS in 2014, this factsheet summarises knowledge of the disease and describes current best-practice guidelines for its management, considering all aspects of production from seed health through to harvest.



Figure 1. Typical symptoms of leaf spot (*Septoria apiicola*) on celery

## Action points

- It is of utmost importance that only chemical or heat treated seed or seed from batches that have been tested and found to be free from *Septoria* is sown.
- Discard infected transplants and inspect crops regularly for disease symptoms.
- Take care not to move crop debris or soil from fields that were infected with *Septoria* in the previous year, or that have been infected in the current year. Unless buried, the pathogen can survive in diseased debris for at least a year.
- Equipment such as crop nets, irrigation pipes and farm machinery can move *Septoria* spores from infected fields to *Septoria*-free celery crops. The pathogen can survive for at least a year in infected plant debris. Clean and disinfect machinery and equipment that comes into contact with infected plants. It is also advised to clean and disinfect the protective clothing and boots of staff.
- Leaf spot development is highly dependent on the duration of leaf wetness and temperature. Table 1 and figure 8 in this factsheet provide a useful decision tool to help predict disease risk during particular weather periods and aid spray timing.
- Extra vigilance is required when temperatures are 20°C or more as symptoms can spread rapidly when this coincides with periods where leaves remain wet for more than six hours.
- In 2014 laboratory experiments at ADAS, the immersion of crop mesh in water at 70°C for an hour killed spores in *Septoria* fruiting bodies; immersion in water containing Jet 5 disinfectant reduced the time needed to kill spores to two minutes.
- Consider spot fungicide treatment or localised plant destruction if infection foci develop in a crop, in order to reduce the risk of spore splash to other plants.
- Options for fungicide control in the crop are limited by the number of permitted applications per product and the need for product alternation to aid resistance management.
- Fungicide application should not be needed in hot dry conditions; regional weather forecasts can be used to help guide decisions on the risk of infection development.
- Copper oxychloride is a suitable protectant fungicide where disease risk is high. Products containing azoxystrobin, which has translaminar activity, are also suitable when conditions conducive to disease development and spread have recently occurred.
- Cyprodinil + fludioxonil or difenoconazole can be used on outdoor crops only.

## Background

### Symptoms

The disease is characterised by the development of small yellow leaf spots that later turn brown or grey (figure 1). Spores germinate in moisture on the leaf surface, producing mycelium, which can invade directly through the leaf cuticle or via stomata on either leaf surface. Initially, small, circular water-soaked spots develop on the leaves. After 10 to 20 days small black spore cases (pycnidia) become visible, partially embedded in leaf tissue in the lesions. Where the lesions remain small (less than 3mm across), pycnidia are numerous and scattered throughout the lesions, but in larger lesions (up to 10mm) pycnidia are concentrated near the lesion centre and are fewer in number. Lesions may coalesce together. The reddish-brown necrotic areas can rapidly enlarge to cover leaves and petioles.



Figure 2. Septoria pycnidia – one pycnidia can contain over 3,000 spores



Figure 3a. Under favourable conditions Septoria develops rapidly in a celery crop



Figure 3b. Severe Septoria blight close up

When pycnidia take up water they exude gelatinous tendrils of spores that require water splash or contact to be spread. One pycnidia can contain over 3,000 spores and there may be over 50 pycnidia in a lesion (figure 2). Under wet conditions, usually late in the growing season, the disease can progress rapidly, causing severe damage to both the leaves and petioles earning the disease the term 'late blight', which renders the whole crop unmarketable if left unchecked (figures 3a, 3b and 4).



Figure 4. Celery petioles affected by Septoria are unmarketable

### Sources of the disease

The major means of transmission of *S. apicola* is via infected seed, as the causal fungus survives either as an external contaminant or within the seed. Pycnidia, mycelium and spores are found on infected seed; the pathogen is absent from seed embryos and endosperms but mycelium penetrates the outer seed coat. Infected seed can carry viable spores for at least 15 months (figure 5). The seed coat attached to the cotyledon (the embryonic leaf within the seed that emerges as the first leaf during germination) can act as a source of infection for seedling leaves during propagation.

It has been shown that the fungus can overwinter on volunteer plants and crop debris, surviving for seven to nine months in buried debris or for longer if in surface debris, with spore germination success shown to only fall to 62% in surface debris between November and June. Past research work has shown that spores survive for up to 10 months on celery leaves under laboratory conditions. Diseased debris is an important avenue of survival and localised spread, for example, a June transplanted crop can be infected by debris that was buried in soil nine months earlier.

There is also a risk of cross-infection from neighbouring celery crops either by wind-driven rain or by anything that can carry spores (people, wildlife or machinery). The risk is greatest when crops are wet, as this encourages spores to ooze from the spore bodies on infected celery and aids the infection process on clean tissue. Other plants that act as hosts for the disease are celeriac and wild celery. The fungus that causes leaf spot on parsley (*Septoria petroselinii*) does not infect celery.

The various means of spreading *Septoria* are shown in the life cycle diagram (figure 6).



Figure 5. Pycnidia of *Septoria apiicola* on celery seeds

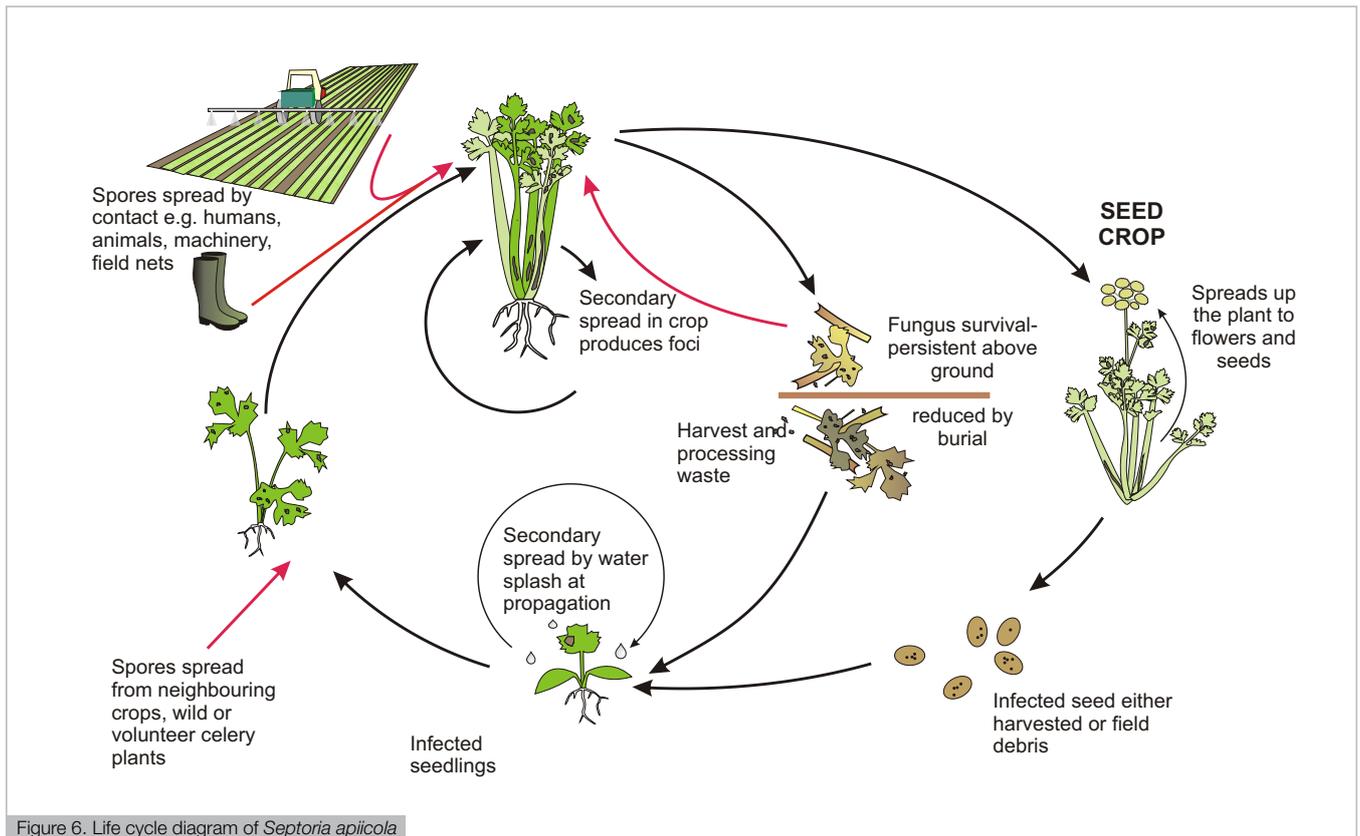


Figure 6. Life cycle diagram of *Septoria apiicola*

### Weather conditions favourable for leaf spot development

Disease development is highly dependent on the presence of water for the spore cases to swell and release spores, for splash dispersal of spores between plants and for leaf infection to occur. Crops are therefore particularly at risk after long periods of leaf wetness, for example, during persistent rain or dewy, misty nights and dull days.

Experiments were carried out over three years on celery plants in controlled environment cabinets to determine the effects of temperature and leaf wetness duration on the development of celery *Septoria*. Key findings were as follows:

- There was a trend for disease severity (number and size of leaf spots) to increase with both temperature (5–25°C) and leaf wetness duration (1–96 hours). A simple disease risk assessment scheme based on leaf wetness durations and temperatures is shown in table 1. This may provide a useful decision tool to determine whether or not to spray during a particular weather period.
- Optimum conditions for disease development were at temperatures of 20°C or more and leaf wetness durations of 24 hours or more. Under these conditions, symptom development was generally rapid, with leaf lesions evident in as few as 10 days after inoculation and present on all plants after 15 days.
- Although infection occurred at most other combinations tested (in the range 5–30°C and 1–96 hours leaf wetness), disease development was slower compared with the optimum conditions described above.
- At lower temperatures (less than 10°C), considerable periods of leaf wetness duration (over 72 hours) were required before disease severity exceeded 5%. It should be noted that although disease development was slight, infection still occurred at temperatures as low as 5°C after just one hour of leaf wetness.
- Under fluctuating temperature conditions relevant to an early or late season celery crop, there is the potential for high levels of disease severity (over 5%) to develop, following leaf wetness periods of 24 hours or more.

**Table 1. Effect of incubation at different leaf wetness durations and temperatures on the severity of Septoria leaf spot, 28 days after inoculation**

Temperature (°C)	Leaf wetness duration (hours)					
	Less than 1	1–6	6.1–24	24.1–48	48.1–72	72.1–96
5	Low	Moderate	Moderate	Moderate	Moderate	High
10	Low	Low	Low	Moderate	Very high	Very high
15	Low	Low	Low	High	Very high	Very high
20	Low	Moderate	High	Very high	Very high	Very high
25	Low	Low	Very high	Very high	Very high	Very high
30	Low	Low	Low	High	Very high	Very high

Disease severity: **Low:** less than 1%    **Moderate:** 1–5%    **High:** 5–20%    **Very high:** over 20%

## Integrated disease management strategy

### Varietal resistance

Resistant varieties are currently not available and are unlikely to be available in the near future, however, grower experience indicates that varieties do differ in susceptibility.

### Seed production and treatment

As the fungus can survive on seed for two years under normal conditions, strict monitoring of seed crops and a prophylactic fungicide spray regime is necessary to ensure that disease development is kept to a minimum. Production of the seed crop under protected conditions can also reduce risk of the disease.

Under favourable environmental conditions, a very low seed infection rate can give rise to a Septoria epidemic. Seed companies routinely use a thiram seed treatment to reduce Septoria infection to acceptable levels. An effective treatment involves a seed soak in a warm thiram solution for 24 hours at 30°C (see table 2). The UK standard product is a primed seed to improve germination speed and uniformity and is supplied as a pill to allow the celery seed to be sown accurately. In the UK, celery seed is commonly requested to be given a thiram seed soak plus inclusion of thiram in the pill. Celery seed treatment tends to be carried out in the Netherlands. Ideally, treated seed should not be kept from one season to the next and should be treated as near to the planting date as possible.

AHDB Horticulture project FV 237a results showed that there is potential for controlling seed-borne *S. apicola* using hot water treatment, or by soaking seed in Jet 5 (peroxyacetic acid). However, thiram was the most effective and is currently the only legal chemical seed treatment. Hot water treatment of celery seed at 48°C for 30 minutes is recommended in Australia, although it is not offered by major seed suppliers to the UK. Some companies are working on or are beginning to use hot, humidified air to treat vegetable seed. At present, there are no commercial celery seed treatments using biopesticides or additives such as plant stimulants, elicitors, micronutrients and stress protectors to the celery seed pill but work in this area is progressing.

There are methods available to detect Septoria in celery seed. The health of seed samples can be confirmed by testing at laboratories offering seed testing services. Pycnidia in the seed coat of diseased seed swell when soaked in water, which helps in distinguishing diseased seed.

Under good seed storage conditions the viability of Septoria on the seed may decline slightly over 2–3 years but not to the extent that it could be used as a reliable control method. Pathogen viability can be reduced considerably over a 2–3 year period by seed storage at higher humidities and higher temperatures but these conditions adversely affect seed germination.

### During propagation

As Septoria can survive in plant debris, plant trays should preferably be new. When it is necessary to reuse trays, soil should be removed by washing with water, followed by treatment with a suitable disinfectant such as Jet 5 (refer to AHDB Horticulture Factsheets 03/14 and 19/14).

Irrigation and ventilation should be carefully regulated, since excessive overhead watering can result in splash dispersal of the fungus between plants, while poor air movement can lead to extended periods of leaf wetness that are conducive for disease development.

Plants should be inspected regularly for the development of Septoria leaf spot and any infected plants rogued out. Trays of seedlings with any leaf spots (with or without pycnidia) should be rejected.

Only Cuprokylt and Amistar can be used on celery under protection (Cuprokylt has an on-label approval, see table 2). A strategy of alternating fungicide groupings should be used to minimise the risk of developing fungicide resistance.

### Minimising the risk of disease development in the field

Volunteer celery plants or wild celery (*Apium graveolens*) in or bordering the field should be controlled, since these can harbour the disease.

Check transplants on arrival. Do not use seedlings with any disease symptoms. If possible, isolate new plantings to avoid splash dispersal from currently or recently affected crops.

To minimise the risk of disease spread, bury crop debris rather than leaving it on the surface and leave one clear year before re-planting with celery.

Regular crop monitoring is important to detect the early symptoms of disease. Small foci of infected plants should be promptly removed and destroyed to prevent epidemic development through the crop.

Use a low level irrigation system such as drip, tape or sub-surface water as an alternative to overhead irrigation or, where possible, raise the water table level in order to reduce disease risk. Wider plant spacing may also help to improve air circulation in the canopy, thus reducing leaf wetness duration and associated disease risk.

### Minimising disease spread in infected fields

The following sanitation measures should be implemented to minimise spread of the disease by people, equipment and machinery:

- Inform staff of how the disease is spread and the measures to reduce the risk
- If possible, restrict entry into the crop when it is wet and spore spread is most likely
- When working in the crop, try to avoid moving through infection foci
- Always clean boots and waterproofs of mud on exit from crops, regardless of whether or not leaf spot has been seen (figure 7)
- Thoroughly wet cleaned-down surfaces with a clean or freshly changed disinfectant product at the correct dilution and allow to dry
- Clean planting and harvesting equipment, ideally before moving to another field
- Do not reuse fleece or crop mesh from an infected crop without disinfection
- Avoid disposal of celery trimmings or other debris in or near to irrigation reservoirs
- Remove any reject transplants from the cropping field using black bags and place in a skip.



Figure 7. Field disinfection station for staff to reduce soil movement between fields

In the 2014 AHDB Horticulture-funded ADAS laboratory tests on artificially inoculated pieces of Enviromesh, results showed that *S. apiicola* spores on the surface of this reusable insect protection crop cover remained viable after seven days in dry storage. Mycelia (fungal threads) were produced in eight out of the nine test Enviromesh squares after this period. All mesh squares had viable spores if they remained wet for a week at 20°C.

Further tests that finished in November 2015 on celery leaf and petiole debris bearing *Septoria pycnidia* held in nets, showed spore survival after a year's storage indoors; whether kept dry or moist. Viable spores were also retrieved from netted crop debris from the same source left outdoors and subject to periods of rainfall and drying-out.

It is possible to kill *S. apiicola* spores by immersion of the contaminated surface in hot water; immersion in 50°C water for an hour gives complete kill. However, if there are pycnidia present then spores inside the pycnidia are able to survive unless the temperature is raised to 70°C for an hour or the period of immersion at 50°C is increased for five hours. Results also showed that spores in pycnidia survived for at least 10 hours in 20°C water.

Jet 5 diluted to the standard of 1:125 was shown to be effective at killing *S. apiicola* spores. Spores in pycnidia were killed after only two minutes immersion in the solution, whether or not the disinfectant was rinsed off after this period or left to dry on the pycnidia.

### Fungicide activity

Fungicide use is an important component of integrated control of *Septoria* on conventionally produced celery. Table 2 lists fungicides currently approved for control of celery leaf spot and table 3 illustrates the relative protectant and curative activity of these fungicides against *S. apiicola*, based on results from inoculated pot experiments (ADAS Arthur Rickwood, 2001). Fungicides that are effective when applied prior to infection have a 'protectant' mode of action. 'Curative' fungicides are effective when applied after infection has taken place but before symptom development. Sprays need to be reapplied to protect new growth.

Amistar (azoxystrobin) has an Extension of Authorisation for Minor Use (EAMU) for use on celery. It provides excellent protection against *S. apiicola* when applied up to 10 days prior to infection. An application of Amistar early in the season may also provide useful protection against *Sclerotinia* and *Rhizoctonia*. This product has limited ability to control *Septoria* in celery if applied after infection has occurred.

Cuprokylt (copper oxychloride) replaces the products Cuprokylt FL and Bordeaux mixture, which have approval expiry dates of 30 November 2015, as does Headland Inorganic Liquid Copper. Cuprokylt is for use as a protectant against celery leaf spot. Copper was less effective than Amistar in pot and field trials, but it may be of use under conditions of low disease risk, to ensure that the maximum number of sprays of other protectant products are not exceeded. Copper can leave an unsightly deposit on the leaves so care should be taken over the number of applications close to harvest.

Plover (difenoconazole) has an EAMU for use on outdoor celery against *Septoria*. It has excellent curative activity against *S. apiicola* when applied up to three days after infection and good control when applied up to seven days after infection. Plover also showed excellent protectant activity in pot trials. As only two applications of Plover are permitted, it is advisable to use this product only in situations that are high risk for disease development, eg following a period of prolonged rainfall when it has not been possible to spray at the planned time.

Amistar Top (azoxystrobin + difenoconazole) has an EAMU for use on outdoor celery leaves ie 'baby-leaf' celery not main-crop, against Septoria. It combines the systemic translaminar and protectant benefits of azoxystrobin with the protectant and curative benefits of difenoconazole. Only two applications are permitted per crop and there is a 21 day harvest interval.

Switch (cyprodonil + fludioxonil) has an EAMU for use on outdoor celery against leaf spot (Septoria) and Sclerotinia. It combines protectant and systemic activity with two distinctly different modes of action. Best results are achieved from an application in the earliest stage of disease development or as a protective treatment. Only two applications are permitted per crop and there is a 14 day harvest interval.

Serenade ASO (*Bacillus subtilis* strain QST 713) has an EAMU 0709/2013 (expiry 31/03/2017) and EAMUs 0706/2013 and 0306/2013 (expiry 31/12/2020) all authorising use on outdoor celery at a maximum individual dose of 10L/ha with one application permitted per crop. However, these are for application of the product as a root drench against damping off. Many other pathogens are suppressed by Serenade ASO but Septoria species are not commonly cited, *S. glycines* on soybean only being listed in the literature. Limited trials by the suppliers of Serenade ASO have shown a reduction of Septoria on celery leaves and stems compared to untreated plots, suggesting potential as a protectant, particularly under low disease pressure conditions. Bio-stimulants are being tested for horticultural crops in the UK and these might be of use as protectants or in the early stages of Septoria infection in celery.

## Fungicide programmes

### Routine spray programme

Field trials in AHDB Horticulture projects FV 237 and FV 237a showed that effective control of celery Septoria is achievable, even under high disease pressure, using timely fungicide sprays, for example, using an alternating sequence of Amistar, Plover and Bravo 500 (14 day spray interval, six sprays in total). Growers should note that Bravo 500 can no longer be used on celery but Switch has received an EAMU and could be a suitable substitute. Switch has different modes of action to Amistar and Plover. Consider following a programme with these products if you are not using leaf wetness duration to assess infection risk. Note that disease control may be reduced if Septoria is evident in the crop before the first spray is applied.

### Selecting the best fungicide according to rainfall

The efficacy of a prophylactic spray regime (eg having a 14 day spray) may be enhanced by selecting the appropriate fungicide product in relation to recent and forecasted rainfall and irrigation.

A simple scheme for product selection, based on the relative protectant and curative ability of approved fungicides for celery, was found to be effective in the 2003 field trial. The information in table 3 may provide a useful scheme for selecting the most appropriate fungicide to use when a spray application is due.

## Using leaf wetness data to aid spray timing

The Septoria Predictor was developed for use in celery in Michigan in the 1990s. In this, before the celery canopy is large enough to close over the rows, fungicide is applied when leaves have been wet for more than 12 hours. Once the canopy closes, regular fungicide applications at 7 to 10 day intervals are recommended. Tomcast was developed to manage leaf blights on tomato and used successfully in experiments in California to reduce Septoria blight in celery. When these programmes were compared in trials in Ontario in 2006, the severity of Septoria from both was comparable to a 6–8 calendar spray programme, but with only 5–7 with the Septoria Predictor and 4–6 sprays with the Tomcast. The Tomcast model utilises both leaf wetness duration and the mean temperature, taking into account that disease severity will be lower when conditions are less than optimum for these two measures. A similar table was drawn up for use in FV 237 (table 1).

Leaf wetness duration recorded on in-crop loggers provides a useful indication of risk of Septoria development. Spraying only when conditions are conducive for disease development may also provide the opportunity to reduce spray applications and is a useful component of an Integrated Pest Management (IPM) strategy.

For example, effective control of celery Septoria was achieved in field trials over two growing seasons (2002 and 2003) when fungicide sprays were applied only when a leaf wetness duration of 12 hours or more had been recorded on an in-crop logger in the previous seven days. Control was equivalent to, or better than, the routine spray programme and used one less spray application (table 4). Spray timing based on longer leaf wetness durations (more than 24 hours) was not so effective. In 2002, a fixed sequence of fungicides was used, while in 2003, product choice was made based on recent and forecasted precipitation (table 4). A possible scheme on how to use logger data to aid spray timing is shown in table 3.

**Table 2. Plant protection products approved for control of celery Septoria (May 2015)**

Product/approval	Active ingredient	FRAC code	Diseases controlled (or partially controlled)	Label details
<b>Seed</b>				
Agrichem Flowable Thiram [Full approval Expiry 31/12/2021]	Thiram	M3	Septoria	1L in 300L water, 24 hour seed soak at 30°C, then dried Treated seed should not be stored for the next season
<b>Protected and outdoor crops</b>				
Cuprolyt MAPP 16944	Copper oxychloride	M1	Septoria, (Erwinia)	Maximum dose of 5kg/1,000L Spray at 10–14 day intervals
Amistar [EAMU 1041/2001 Expiry 30/06/2024]	Azoxystrobin	11	Botrytis, Rhizoctonia, Sclerotinia	Maximum individual dose of 1L/ha Maximum dose of 4L product/ha/crop 14 day harvest interval Recommended use in an alternating programme where only one application in three is a strobilurin based fungicide LERAP assessment required LERAP category B
<b>Outdoor crops</b>				
Plover [EAMU 2786/2015 Expiry 31/12/2017]	Difenoconazole	3	Septoria	1 application of 0.5L/ha 14 day harvest interval
Switch [EAMU 0865/2015 Expiry 31/10/2020]	Cyprodinil + fludioxonil	9 + 12	Leaf spot, Sclerotinia	Maximum individual dose 1kg product/ha Maximum two applications per crop Minimum 10 days between applications 14 day harvest interval LERAP assessment required LERAP category B
<b>Celery leaves</b>				
Amistar Top [EAMU 1838/2012 Expiry 31/12/2021]	Azoxystrobin + difenoconazole	11 + 3	Septoria, Rust	Maximum individual dose 1L/ha Maximum two applications per crop 21 day harvest interval Do not apply more than two applications of strobilurin based fungicides

**Table 3. Relative protectant and curative activity of fungicides approved for control of celery leaf spot (*S. apiicola*)**

Fungicides	No. of days before/after inoculation				
	10	4	0	3	7
Amistar	***	***			
Cuprolyt	*	**			
Plover	***	***		***	**
	PROTECTANT			CURATIVE	

Results based on inoculated celery plants; see FV 237 annual report (2001) for full details.

- \*\*\* Excellent disease control.
- \*\* Good disease control.
- \* Some disease reduction.

**Table 4. Criteria for fungicide product choice**

Rainfall for last seven days	Five-day forecast	Product choice
Dry	Dry	Amistar
Wet*	Dry	Plover
Dry	Wet	(was Bravo), consider Switch
Wet*	Wet	Plover

\*At least one significant rain event in last seven days (eg more than three hours of heavy rain or more than 12 hours of light rain).

**Table 5. Effect of selected fungicide programmes on Septoria leaf spot in inoculated field trials at ADAS Arthur Rickwood, 2002–2003**

Fungicide regime	2002 (two months after inoculation)			2003 (three months after inoculation)		
	No. of sprays	% plants affected	% leaf area affected	No. of sprays	% plants affected	% leaf area affected
Untreated control	0	100	28	0	97	22
Routine spray programme (14 day interval)*	6	100	10	6	0	0
Timing according to 12 hours leaf wetness or more**	5	99	2	5	1	0

\*Amistar, Plover and Bravo 500 were used in a fixed sequence.

\*\*In 2002, Amistar, Plover and Bravo 500 were used in a fixed sequence; in 2003, fungicide products to be applied were chosen on the basis of recent and forecasted rainfall.

This factsheet includes information available on the Health and Safety Executive (HSE) website (pesticides.gov.uk), on product labels and in supplier technical leaflets. Please check the HSE website or with an appropriate adviser before using the information as regulations may have changed.

**EAMU – Extension of Authorisation for Minor Use.**

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Anyone using a plant protection product with an EAMU should follow EAMU (or label) recommendations. Use is carried out at the grower's own risk. If specific crop safety information is not available, consider undertaking small-scale tests and/or obtain professional advice before widespread commercial use.

If in doubt about which products are permissible, or how to use them correctly, seek advice from a BASIS-qualified consultant.

Details of compatibility of plant protection products with biological control agents are available from biological control suppliers or IPM consultants.

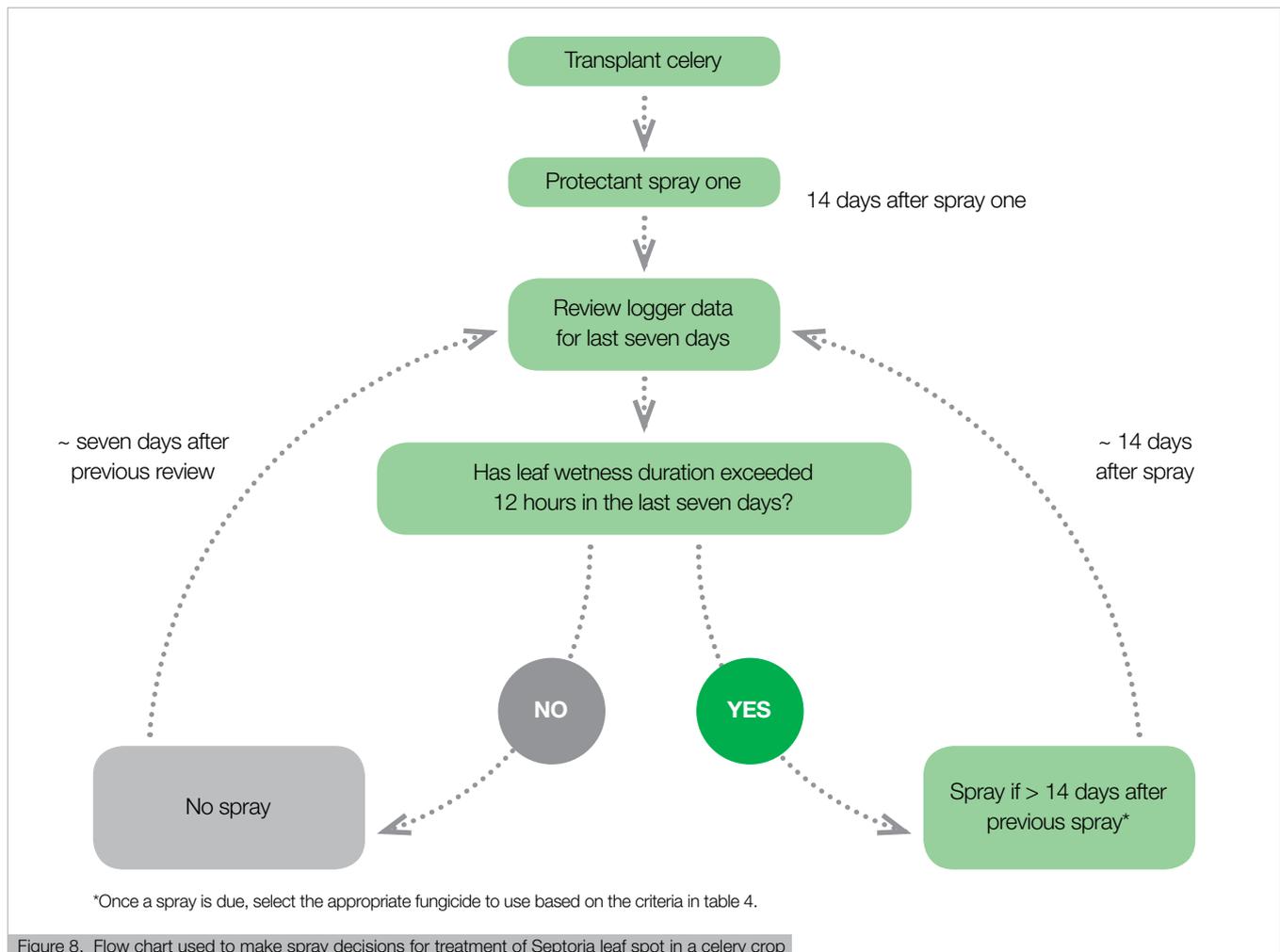


Figure 8. Flow chart used to make spray decisions for treatment of Septoria leaf spot in a celery crop

## Fungicide resistance

It is recommended that growers use the range of fungicide products that are available against Septoria in celery. Alternating between products with different modes of action can help to reduce the risk of pathogen resistance to an individual product. This is particularly important in the case of Amistar, since resistance to strobilurin fungicides has been detected in populations of *Mycosphaerella graminicola* (*Septoria tritici*) on wheat. The sensitivity of cereal Septoria to azole fungicides has also declined since the 1990s.

The following procedures are recommended in order to preserve the effectiveness of strobilurin fungicides such as Amistar and azoles such as Plover:

- Use no more than two sprays of the same fungicide in sequence, then use a completely different fungicide group
- For strobilurin fungicides, use no more than 50% of the total sprays of this type of fungicide per crop
- Follow the label recommendations carefully and keep to the manufacturer's recommended dose rate
- Do not rely on fungicides alone for disease control; follow the cultural control measures detailed in this factsheet
- For further guidance on managing Septoria resistance [hse.gov.uk/pesticides](http://hse.gov.uk/pesticides).

## Organic celery production

The use of conventionally produced celery seed for organic production is currently permitted under a derogation of EU regulations, in situations where appropriate varieties of organic seed are not available. This may not be chemically treated, but can be heat-treated. Further guidance on sourcing organic seed can be found on the website of OrganicXseeds UK, the official UK database of organic seed availability funded by Defra and managed by the Soil Association ([organicxseeds.co.uk](http://organicxseeds.co.uk)).

Under laboratory conditions, hot water treatment (eg 48°C for 30 minutes) was shown to significantly reduce viable Septoria in celery seed without affecting seed germination. The seed industry is aware of this treatment but celery seed sold by some companies is obtained already thiram treated direct from the Netherlands. However, batches of celery seed are tested for Septoria in the Netherlands so that the seed sent to growers is as clean as possible.

Since options for seed treatment are currently limited, cultural control measures and crop sanitation (as described for conventionally produced crops) are vital in reducing the risk of infection and disease development. Copper products (see for example, table 2) are restricted under Soil Association standards and for a grower to use copper in situations of high disease risk, they would need to submit a written derogation request to obtain approval prior to field application. Advice on maximum application rates should be sought from the Soil Association.

**Always read and follow the product label.**

### Note:

Regular changes occur in the approval status of pesticides arising from changes in pesticide legislation or for other reasons.

For the most up to date information, please check with your professional supplier, BASIS registered adviser or search the plant protection product databases available from the Chemical Regulations Directorate [hse.gov.uk/pesticides](http://hse.gov.uk/pesticides)

Enquiries about pesticides that cannot be answered via the website should be made to the Defra Helpline 03459 335 577 or via [pesticides&detergents@defra.gsi.gov.uk](mailto:pesticides&detergents@defra.gsi.gov.uk)

## Acknowledgements

All images, figures and diagrams are courtesy and copyright of ADAS, apart from figure 3a (celery blight in a field) and figure 7, which are both courtesy of an AHDB member.

## Further information

AHDB Horticulture Project 237: 'Outdoor celery: development of integrated strategies for the management of Septoria leaf spot and other diseases'.

AHDB Horticulture Project 237a: 'Celery: evaluation of alternative seed treatments for the control of *Septoria apiicola* (celery leaf spot)'.

AHDB Horticulture Factsheet 03/14 'Chemical disinfectants in protected ornamental plant production'.

AHDB Horticulture Factsheet 19/14 'Disinfection for the control of clubroot during propagation'.

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