Factsheet 18/04

Strawberry

Horticultural Development Council

Bradbourne House
East Malling
Kent ME19 6DZ
T: 01732 848383
F: 01732 848498
E: hdc@hdc.org.uk

Control of grey mould in strawberry crops

Angela Berrie, East Malling Research

This factsheet collates recent research and current knowledge to provide growers with practical information on the symptoms, spread and control of botrytis on strawberries. It includes a management calendar that gives a checklist of the tasks that need to be considered at the different growth stages in order to minimise the impact of this devastating disease.

Introduction

Botrytis, or grey mould, caused by the fungus *Botrytis cinerea*, is one of the most devastating diseases of strawberries in the UK.

The disease reduces yield and quality both pre- and post-harvest. A great deal of research has been conducted on strawberry botrytis. Yet despite this wealth of information, significant losses still occur in seasons favourable to the disease. This is particularly true for everbearer crops, where the long fruiting period makes control difficult and allows the build up of rotted fruit.

Control is dependent on fungicide sprays being applied often and near harvest time to maintain fruit quality and prolong shelf life.

Markets, however, are now requiring first quality fruit that is free, or almost free, of pesticide residues. Such requirements present growers with an increasing challenge to control fruit rotting diseases such as botrytis.

Fig 1 Botrytis is most commonly found on ripe fruit where it can attack any part though it is more usually found at the calyx end or on the sides

Botrytis symptoms

- The fungus attacks all parts of the strawberry plant that are above ground, though the disease is usually seen as fruit rot.

- Botrytis is most often seen on ripe fruit (Fig 1) but can occasionally occur on green fruit (Fig 2). In both cases it attacks any part of the fruit but is more usually seen at the calyx end or on the sides. The rot is generally light brown to brown in colour and fairly firm. Even completely rotted berries remaining firm and intact. Rotted berries become covered in a grey velvety growth (hence the name grey mould) consisting of a mass of dry, powdery spores which, in dry conditions, drift off in clouds if the fruit is touched.

- Eventually rotted berries dry and mummify and can become embedded with black resting bodies (sclerotia) the size of mouse droppings.

Fig 2 Though uncommon, it is not unheard of for botrytis to attack green fruit

- The disease may also be seen on flowers where one or several flowers in a cluster turn brown and eventually wither.

- Botrytis may occasionally cause crown rot in strawberries grown under protection or where vegetative growth is excessive, as in a runner bed. Mid-brown in colour, the rot usually progresses downwards from the top of the crown.

- Debris left in strawberry plantations over the winter months can also harbour the fungus, often in the form of sclerotia on dead stems, fruiting stalks and mummified berries. In moist spring conditions the sclerotia become covered in a grey sporing mass that is best seen with the help of a x10 magnifying hand lens. Similarly the fungus can be seen sporing on dead leaves in early spring.

Other diseases that cause similar symptoms

- Other fungi such as *Phytophthora cactorum* (crown or leather rot) or *Zythia fragariae* (leaf blotch) cause firm brown fruit rots. They can usually be distinguished from botrytis by the absence of the typical grey powdery spore masses.

- Berries infected with *Zythia* may also have small pinhead-sized black/brown fruiting bodies (pycnidia) which ooze pale orange slimy spore masses in damp weather.

- Blackspot (*Colletotrichum acutatum*) lesions on green fruit may be confused with those caused by botrytis. Blackspot lesions tend to be more spot-like than those of botrytis, but often the two can only be distinguished in a laboratory.

Disease cycle and spread

Botrytis cinerea is a ubiquitous fungus and can overwinter on the dead parts of many different plants in and around strawberry plantations, including weeds. Research shows, however, that most inoculum for infection of strawberry plants comes from within the plantation. During winter the fungus takes the form of sclerotia and dormant mycelium in plant debris within the plantation.

In moist spring conditions the fungus produces masses of grey spores that spread to flowers or fruits by wind or water splash (rainfall or irrigation). The spores require free water to germinate (rain, dew, fog or irrigation) and, under ideal conditions, infection can occur in hours. Botrytis generally favours cool/moderate temperatures (15-25°C), prolonged surface wetness and high humidity, the last being the most important factor regulating its development. Spores may also germinate on the wet surface of the flower's stigma. During flowering the fungus colonises healthy or senescing flower parts, such as petals, sepals, stamens or receptacles, often turning the flowers brown (Fig 3). Stamens are considered the main route of infection leading to botrytis fruit rot.

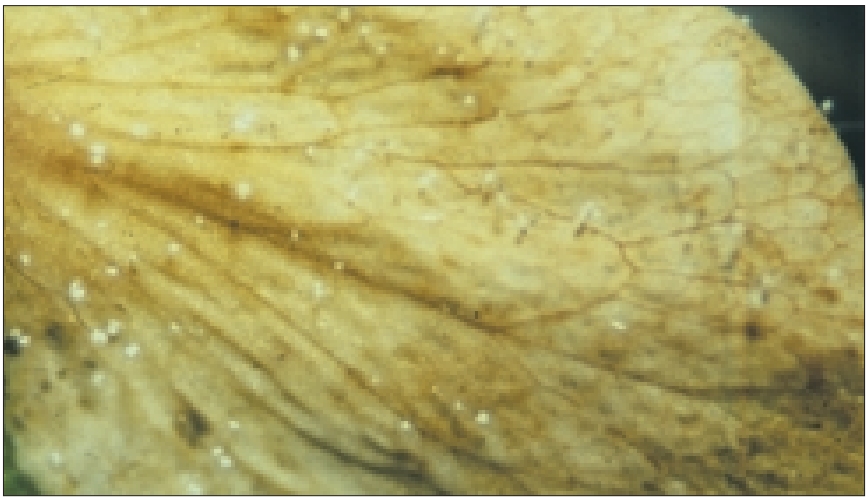

Fig 3 Healthy or senescing flower parts such as this petal often turn brown when attacked

Once established, the fungus attacks the developing fruit. However, it will more usually remain latent or quiescent until the fruit starts to ripen. The fungus then becomes active and the rot sets in. Adhering petals and direct contact with other diseased fruit are seen as other ways in which infection can be transmitted. Once established as a fruit rot, spore production starts within days generating more inoculum to infect other flowers and fruits. Botrytis rotted fruit is a major source of inoculum for flower infection in everbearer crops where the flowering and fruiting periods are prolonged and the build-up of rotted fruit significant.

Botrytis can also colonise green leaves as a symptomless infection until the leaves senesce and die. The flowers, fruits and leaves of any weeds present in the plantation can also similarly be infected.

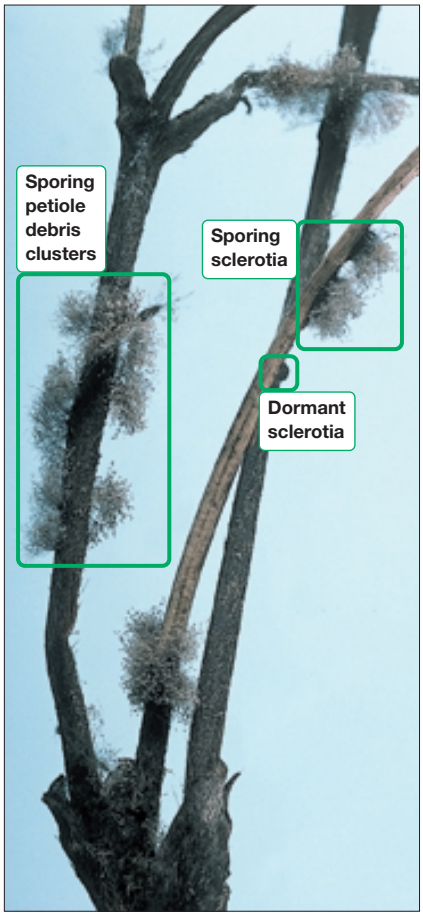

Fig 4 Crop debris is an important source of inoculum for infection for the following crop

Growing systems and botrytis risk

The choice of production system can have a significant effect on the botrytis risk and this should be taken into account when deciding on a control strategy.

- The risk of botrytis in everbearer crops is much higher compared with June bearers because of the extended period of flowering and fruiting which, because of numerous harvests and their subsequent fruit drop, allows the build up of over-ripe rotted fruit. This limits the choice of fungicides to those with short harvest intervals.

- The risk of botrytis in annual cropping systems is much lower since crop debris (Fig 4), which is an important source of botrytis inoculum, is considerably reduced.

- The higher temperatures and lower moisture levels found in protected cropping systems reduce (but does not eliminate) the risk of botrytis, while open field systems are more vulnerable.

Control strategy

Control of botrytis in strawberries has been researched over many years and currently there is a wide range of fungicides available that are effective in controlling the disease. Yet despite this, when conditions favour the disease, losses due to fruit rot can still be high. Effective control of botrytis fruit rot requires an integrated approach based on:

- knowledge of the ways in which the fungus spreads

- an awareness of critical times for control

- sources of inoculum and when to deal with them

- cultural control strategies

- fungicides and their mode of action

- fungicide resistance management

- market requirements for fruit quality and minimal use of fungicides.

Treatment timing

The most critical period for controlling botrytis on strawberries is during the flowering period. Newly opened flowers are most susceptible to the disease, so fungicides applied as protectants should start at first flower and continue until the end of flowering.

Similarly, cultural operations to minimise the inoculum level should be completed in good time before flowering. Green fruit is fairly resistant to botrytis but fruit increases in susceptibility as it matures.

Additional protectant fungicide treatments may be required during the period between fruiting and harvest depending on inoculum level, the weather and whether the crop is open field or protected.

Sources of inoculum and cultural control

Since most of the inoculum for flower and fruit infection arises from within the plantation, crop hygiene is an essential part of the integrated programme.

- Mow off June bearer strawberry crops soon after harvest at the end of the summer and again the following spring.

- Hand thin crowns in spring to improve fruit size and quality. This will also lower botrytis levels by improving air circulation around the plant.

- Ideally crop debris from mowing off and crown thinning should be removed from the plantation. If left in the alleyway it will remain as a source of inoculum. However, where it is impractical to completely remove debris from the plantation, it has been observed that removing debris from around the plants and dumping it in the alleyway is better than taking no action at all.

- Where crop debris is excessive a drenching spray of tolylfluanid (Elvaron Multi) in late March or early April will help suppress botrytis sporulation.

Cultural control and environment manipulation

- High humidity and surface moisture are important conditions for sporulation and infection by botrytis. Growing strawberries under protection reduces but does not eliminate the risk of botrytis fruit rot.

- In polytunnels, however, the humidity can be high, which increases the risk of botrytis. Therefore, it is important to ensure tunnels are effectively ventilated to reduce the humidity at critical times, especially in the late summer and autumn when the humidity outside is generally higher.

- Certain types of polythene cover – ‘smart films’ – are reported to reduce the risk of botrytis by blocking the specific light wavelengths required for sporulation. Results from trials have been inconsistent, but the use of these covers may hold future potential.

Other cultural control measures

- Choose a planting site with good soil drainage and air circulation to promote faster drying of foliage and fruit.

- Lay straw mulches to minimise fruit contact with soil.

- Correctly space plants to allow air to circulate.

Table 1 Fungicides registered for use on strawberry in the UK for botrytis control

Active ingredient	Product name	Open field	Protected	Harvest interval (days)	Mode of action			Other diseases controlled or partially controlled			
					Protectant	Curative	Sporulation suppressant	Black spot	Powdery mildew	Leaf spots	Phytophagus mites
azoxystrobin*	Amistar	✓	✓	3	✓	✓		✓	✓	✓	
boscalid & pyraclostrobin	Signum	✓		3	✓			✓	✓		
captan	Alpha Captan 80	✓	✓	7	✓			✓			
chlorothalonil	Bravo 500 Clortosip 500 Jupital DG Repulse Rover Sipcam Echo 75 Ultrafaber	✓	✓***	14	✓	✓	✓	✓	✓	✓	
chlorothalonil**	Bravo 500 Clortosip 500 Rover	✓		3	✓	✓	✓	✓	✓	✓	
fenhexamid	Teldor	✓	✓	1	✓		✓				
fenhexamid & tolylfluanid	Talat	✓		14	✓		✓	✓	✓(reduction)	✓	✓
iprodione	IT Iprodione Rovral Flo Rovral WP Standon Iprodione 50	 ✓ ✓	 ✓ ✓	1	✓	✓					
mepanipyrim	Frupica	✓	✓	3	✓			✓			
pyrimethanil	Scala Standon Scala	✓	✓	1	✓						
thiram	Unicrop Thianosan	✓	✓	7	✓			✓			
tolylfluanid	Elvaron Multi	✓		14	✓		✓	✓	✓(reduction)	✓	✓

*** Specific off-label approval for use on strawberry. Growers wishing to use these products must be in possession of a copy of the SOLA.**
**** Specific off-label approval for use on strawberry at reduced dose (maximum individual dose 3.0 litres product per hectare) with shorter harvest interval.**
***** Some scorching of the calyx may occur on crops grown under glass or polythene tunnels.**

Note Growers wishing to use products approved under the SOLA scheme must be in possession of a copy of the relevant SOLA.

Fig 5 Fungicides still form the basis of control as it is impossible to eliminate inoculum

- Choose correct timing and rate of fertiliser applications, particularly on everbearers. Excessive applications of nitrogen fertilisers can produce dense foliage which provides too much shade. This prevents leaves and fruit from drying quickly enough and increases the risk of botrytis.
- Keep weeds under control. Dense weed populations prevent air from circulating around plants and increase the risk of botrytis infection. Weeds may also be an inoculum source for botrytis.
- Harvest fruit frequently and early in the day to prevent the build up of over-ripe fruit and rotted berries. Remove rotted berries from the field and dump well away from other strawberry crops, preferably in a pit covered with soil. This is especially important for everbearers where rotted fruit is an important source of inoculum for flower infection.
- Handle fruit carefully to avoid damage that can readily be colonised by botrytis.
- Rapidly cool fruit after harvest to maintain quality and reduce rot

Table 2 Fungicides approved for use in the UK and the risk of them becoming resistant to botrytis

Active ingredient	Fungicide group	Resistance risk
azoxystrobin	strobilurin	high
boscalid & pyraclostrobin	anilide/carboximide & strobilurin	moderate
captan	phthalimide	low
chlorothalonil	chlorophenyl	low
fenhexamid	hydroxyanilides	high
iprodione	dicarboximide	high
mepanipyrim	anilinopyrimidine	high
pyrimethanil	anilinopyrimidine	high
thiram	dithiocarbamate	low
tolylfluanid	sulfamide	low

Table 3 Action calendar for control of botrytis

Growth stage	Checklist of tasks
Onset of growth	Examine crop for amount of debris, straw, weeds and mummified fruit, all of which are sources of botrytis inoculum. Mark those for topping or hand removal during crown thinning. Place debris in alley or preferably remove from field. If trash is excessive, apply a drenching spray of tolylfluanid (Elvaron Multi) to suppress inoculum. Botrytis inoculum sources must be minimised before flowering.
First open flower	Check crop for signs of flowering. Newly opened flowers are most susceptible to botrytis. Apply first spray promptly regardless of visual symptoms of disease.
Flowering	Apply protectant sprays at 7-14 day intervals depending on weather conditions and whether the crop is open field or protected. Choose a protectant fungicide such as tolylfluanid (Table 1). Should rain delay spraying, then a product such as iprodione (Rovral) with curative action could be used to eradicate infections. The fungicide programme should take into account the risk of fungicide resistance (Table 2).
Fruiting	Further fungicide treatments may be needed depending on the weather conditions and whether production system is open field or protected. Choose products with short harvest interval and those least likely to leave a fungicide residue at harvest.
Harvest	Pick crop frequently to prevent the build up of over mature rotting fruit. Remove all rotted berries from the crop and dump well away from plantation. (This is very important for everbearer crops). Handle fruit carefully to avoid damage and chill soon after picking to maintain fruit quality and minimise rot development.
Post harvest	Mow off June bearers after harvest in July / August. Remove debris from field if possible.

Fungicide control

As it is impossible to eliminate all sources of botrytis inoculum (Fig 5) and because protection of flowers is critical to rot control, fungicides still form the basis of the control strategy.

However, their efficacy is much enhanced if their use is combined with the above cultural control measures. A list of products registered for use on strawberries for botrytis control in the UK is given in Table 1.

Fungicide protection is usually applied from first open flower until the end of flowering, with additional treatments during fruiting, depending on the weather.

Since flowers open daily, short interval spraying (every seven days) will ensure protection and improve botrytis fruit rot control.

Factors affecting fungicide choice

- Efficacy
- Mode of action – protectant, curative or sporulation suppressant
- Outdoor or protected
- Harvest interval
- Other diseases or pests, controlled or part controlled
- Cost
- Fungicide resistance risk

Fungicide resistance

Table 2 lists the fungicides recommended for strawberries, along with their chemical groups and resistance risk.

Fungicides such as tolylfluanid, captan, chlorothalonil, and thiram have a number of ways of working against botrytis and as strains of the disease are unlikely to develop a resistance to these products they can be used many times over.

Other products, such as fenhexamide, iprodione, mepanipyrim and pyrimethanil, have a single mode of action and so the risk of resistant strains of botrytis occurring is high if a spray is used frequently.

To minimise this, fungicides with a high resistance risk should be restricted to a maximum of two consecutive sprays and alternated with other products from a different chemical group which work in a different way.

The information printed on the product labels regarding fungicide resistance management should be studied carefully before use.

Market requirements for fruit quality with zero or minimal pesticide residues

Demand for quality fruit free from pesticide residues is growing. Satisfying this demand presents strawberry growers with a significant challenge, given the nature of botrytis.

Adopting integrated approaches to disease control will make the best use of the available fungicides, but they will not eliminate the need for fungicides for botrytis control.

Fungicide residues can be avoided by extending harvest intervals and avoiding the use of products likely to leave residues – though in these cases, crops may run a higher risk of botrytis infection.

Fruit co-operatives have specific information available for their suppliers and growers should contact their co-operative or technical consultant for advice.

Action

As botrytis is one of the most devastating diseases that attack strawberries in the UK it is essential to employ a strategy that takes account all possible control measures.

An action calendar which highlights the tasks to be considered at specific times of the season is given in Table 3.

Future developments

Botrytis warning systems

Disease warning systems that take the weather into account can rationalise fungicide use and save money by targeting treatments at times of high risk.

BOTEM (Botrytis East Malling), which has been developed with the help of funding from Defra, identifies days during which there is a risk of infection by calculating the daytime temperature and night-time vapour pressure deficit (VPD).

The BOTEM model has been validated following extensive evaluation on commercial farms and should be available to strawberry growers soon.

Disease resistant varieties

Strawberry varieties vary in their susceptibility to botrytis, mostly through differences in leaf canopy structure. Some are more dense than others and affect air circulation around the plant.

Varieties that are resistant to disease are unlikely to be bred in the near future by conventional means – genetic manipulation (GM) may provide an answer, if it is publicly acceptable.

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