

Fungicide Resistance Management in Soft Fruit

FRAG UK



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Fungicide Resistance Management in Soft Fruit



Introduction

Fungicides, in combination with exploitation of resistant varieties and other agronomic and cultural techniques, will be the mainstay of disease control in soft fruit for the foreseeable future and so must be protected from the threat of resistance.

Applying appropriate and effective products at the right time and at the right dose, is critical for good disease control and reducing the risk of resistance. Poor field performance can often be attributed to low application rates of use, or to poor or mistimed application, rather than resistance.

The risk of development of resistance is linked to a number of factors, including the specific mode of action (MOA) of the fungicide, the biology of the target pathogen and the level of exposure of the pathogen to the fungicide. Soft fruit grown as a perennial crop or when grown as an annual and discarded after one season, but with permanent or semi-permanent production sites, may be particularly vulnerable to the selection of resistant fungal strains as resistant strains can overwinter in soils or in/on structures such as polytunnel frames and be present as soon as treatment begins in the next season. Fungicide programmes for most soft fruit crops entail multiple sprays per season, while some major diseases of soft fruit including Botrytis, are considered high risk for the development of resistance. The adoption of robust anti-resistance strategies which aim to minimise the unnecessary use of pesticides (i.e. fully integrated control approaches) thereby reducing the risk of resistance, are vital to maintain effective control. Where the performance of a plant protection product results in poor disease control, specialist advice should be sought to establish whether the strains of disease present are insensitive to the active substance(s) being used. Details should also be reported to the appropriate plant protection product authorisation holders.

Resistance terminology

Resistance occurs when a pathogen becomes so insensitive to a fungicide that the fungicide's field performance is impaired. Resistance can arise rapidly and completely so that disease control is lost in a single step. More commonly, resistance develops gradually so that the pathogen becomes progressively less sensitive. When this happens there is usually no initial detectable loss of control. Once resistance arises, resistant strains may come to dominate the population leading to complete loss of disease control or they may stabilise at a lower frequency or fluctuate in frequency, leading to partial but unpredictable levels of disease control.

Laboratory testing can reveal a number of things about potentially resistant fungal strains isolated from the field. They can tell us about the genetic make-up of the isolate and how it has changed (mutated) by comparison with sensitive "wild-type" isolates from many years ago. Growth tests on laboratory media with different doses of fungicide can show how sensitive that isolate is compared with the wild type. Where selection has taken place, it is often very difficult to find any 'wild type' isolates because such isolates are very sensitive to fungicides and have been removed from the population by frequent fungicide use. The isolates that remain are less sensitive than the wild type – often by a large factor. These isolates may not be 'resistant' in practical terms as they are still well-controlled in the field by using recommended label doses. However, they may represent a step towards more resistant isolates that cannot be adequately controlled at recommended label doses or may require higher doses than the commercial norm, thereby increasing costs.

FRAG-UK

The Fungicide Resistance Action Group - UK (FRAG-UK) is a forum set up to look at fungicide resistance issues and to publish information and advice relevant to the UK. The group combines the expertise of industry with the independent sector to produce up-to-date information on the resistance status of important diseases in UK agriculture and to suggest ways of combating resistance.

Integrated disease control and general resistance management

Adopt an integrated approach to disease and crop management to avoid an over-reliance on fungicides, which increases the risk of selecting resistant pathogen strains.

Cultivar choice: growing cultivars with high disease resistance is one of the most effective ways of reducing the risk from disease. However, it is difficult if customers demand a specific, highly susceptible cultivar.

In particular, avoid growing large areas of highly susceptible cultivars or highly susceptible cultivars in regions or on sites where the local micro-climate can result in high disease pressure. These risk becoming infected early in the season, requiring more fungicide sprays, increasing the chance of selecting resistant isolates.

Propagation material: source good quality material as propagation material is often a source of some diseases such as crown rot in strawberries.

Crop hygiene: practice good crop hygiene including disposal of primary inoculum sources such as plant debris, soil and water disinfection and general hygiene, such as tool disinfection. Ensure all fruit, including rots, is removed at each harvest to prevent the build up of inoculum.

Good ventilation: improve ventilation in protected crops to reduce humidity and the incidence of conditions conducive to disease spread.

Start spray programmes promptly: powdery mildew and Botrytis risk models are available and can help to time spray applications. In the absence of risk models, the timing of the first fungicide application should take account of crop-specific and local factors and the guidance on specific product labels. Learn to spot the early signs of foliar diseases. Early action can often prevent a more serious epidemic later in the season.

Optimise application: aim to maximise coverage of the canopy through correct selection of nozzles and air speed and use of water volumes appropriate for the growth stage and product. Good spray cover to the leaf underside and to the young leaves in the crown is essential for control of powdery mildew on strawberries.

Use appropriate spray intervals: once spraying is underway, and where practical, adjust intervals according to risk (weather-based risk/crop growth rate/known local inoculum sources); do not over-extend intervals. Weather-based risk assessment systems are available for strawberry powdery mildew and strawberry Botrytis.

Avoid eradicant treatments: avoid applying fungicides when disease is well established in the crop, i.e. do not 'chase' the epidemic with fungicide.

Integrated disease control and general resistance management

Make full use of fungicides with different modes of action: avoid over-reliance on a single fungicide group, use co-formulations or tank mixes of different active ingredients and include multi-site fungicides where authorised. Check product labels for manufacturers' recommendations on dose, timing and spray interval and restrictions on total and sequential numbers of applications.

Biofungicides: as an alternative to conventional fungicides, biofungicides (sometimes known as biologicals) are an increasingly viable option for control of some diseases and can be used to take the pressure off fungicides in part or all of the season, with conventional fungicides employed to control high disease pressure 'hot spots'.

Avoid compromised fungicides: where the target disease is known or suspected to have resistance to a mode of action avoid or severely limit using that mode of action to prevent further selection for resistance.

Introduction

Grey mould caused by *Botrytis cinerea* is ubiquitous in the environment and infects a wide range of crops, including strawberries and raspberries. It is impossible to eliminate all sources of *Botrytis* inoculum and it is a critical rot to control in soft fruit production.

Cultural control can deliver some benefits, but fungicides still form the basis of the control strategy. Frequent applications and a long growing season, exacerbated by a choice of fungicides limited to those with short harvest intervals, particularly in everbearer strawberry crops, results in a high risk scenario for the development of fungicide resistance.



Resistance status

Monitoring of *Botrytis cinerea* in soft fruit has revealed resistance to the following fungicide groups. **R** shows where resistance has been recorded in the UK, **r** where resistance has been found outside the UK, - no resistance detected.

Fungicide Group	FRAC Code	Resistance found in	
		Strawberry	Raspberry
QoI (strobilurins)	11	R	-
SDHI (succinate dehydrogenase inhibitors)	7	R	r
AP (Anilino-pyrimidines)	9	R	r
KRI (KetoReductase Inhibitors, SBI class III)	17	R	r
PP (Phenylpyrroles)	12	r	r

To minimise the development of further resistance follow resistance management guidelines on product labels. There are strict instructions on most fungicides recommended for *Botrytis* control for the maximum number of sprays and recommendations for use of fungicides with different modes of action. In the absence of specific guidance, fungicides with a high resistance risk should be restricted to a maximum of two consecutive sprays and alternated with other products from a different mode of action (FRAC group) or with biofungicides.

Resistance Management Guidelines

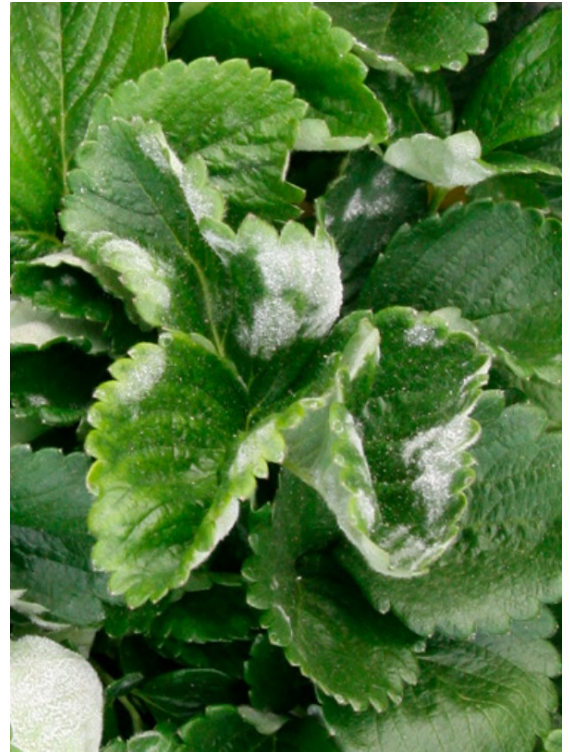
Strawberries – General

Modern strawberry production in the UK is predominantly under protection. Cultivars are either June-bearer types, which depending on planting time can be early, main crop or late season or everbearers. June bearer types have one period of flowering and fruiting, with fungicide use of around four-six sprays targeted around flowering and fruiting for control of foliar, flower and fruit pathogens. Everbearer types are mainly grown as annual crops and can be planted in February/March and crop from May/June to November. Flowering, fruiting and harvest are continuous through this period so control of foliar and fruit diseases is much more challenging, with fungicide use of around 20-30 sprays per season. Managing disease control programmes is critical to the success of disease control and avoiding fungicide resistance issues.



Introduction

There are many different fungal species that cause powdery mildew disease, each with specificity to a particular crop. The strawberry powdery mildew pathogen (*P. aphanis*) is closely related to the raspberry powdery mildew pathogen (*P. macularis*), but cross infection does not occur. Strawberry powdery mildew affects leaves, flowers and fruit; symptoms include patches of fungal mycelium, leaf cupping (roll) and dark red leaf patches. Significant crop losses can occur if infection spreads through the crop. Its importance as a disease has increased and it can be a particular problem in tunnel and glasshouse grown crops. The disease can be introduced on infected planting material, especially on tray or module plants particularly on annual crops. In crops grown for more than one season infection primarily arises from within the crop, from infections overwintered on leaves or in leaf debris and so autumn and early pre-season fungicide applications can reduce risk and delay onset of an epidemic.



A weather-based risk assessment system is available for strawberry powdery mildew which can be used to assist in decisions on fungicide use. Otherwise frequent monitoring of crops to assist disease incidence can also be used to decide on sprays.

Resistance status

Powdery mildews are considered medium risk of developing resistance, with many instances of partial or full resistance in powdery mildew pathogens recorded. Resistance in *P. aphanis* to QoI fungicides has been recorded in Japan.

Fungicide Groups for chemical control (some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) – FRAC Code 3

There are reports of moderate frequency of resistant strains occurring in *P. aphanis* in 2020 monitoring.

Uses

- Medium resistance risk
- Never use DMIs alone or repeatedly for powdery mildew control
- Alternate or mix fungicides with different modes of action in repeat spray programmes
- Include another mode of action with eradicant activity if powdery mildew is already active

Quinone-outside inhibitors, Strobilurins (Qols) – FRAC code 11

Resistance in powdery mildews to Qol fungicides is widespread and has been reported in *P. aphanis* in Japan. This group should not be relied upon for control of this disease.

Uses

- High resistance risk
- Qol fungicides are very effective at preventing spore germination and should therefore be used at the early stages of disease development (preventive treatment)
- See Table 1 for guidelines on use of Qols where multiple sprays are applied

Fungicide Groups

(some actives and groups may be authorised under an EAMU)

Azanaphthalenes - FRAC code 13

Azanaphthalene (AZN) fungicides have a spectrum of activity limited to powdery mildews. Resistance has been reported in some powdery mildew pathogens e.g. grape powdery mildew, (*Erysiphe necator*), but not in *P. aphanis*. Resistance management is required.

Uses

- Resistance risk is medium
- Apply preventatively, in mixture with fungicides from other groups with a different mode of action before mildew is established. Will not control latent or established infections
- Use with a suitable eradicant partner for established infections
- AZN fungicides should not exceed 50% of the total number of powdery mildew applications per season, whether applied alone or with an effective mixture partner from a different cross-resistance group
- Do not exceed two consecutive applications of AZN fungicides per season

Amidoximes - FRAC code U06

Resistance reported in cucurbit powdery mildew (*Podosphaera xanthii*). Resistance management required.

Uses

- Use early in the spray programme to make the best use of the protectant activity
- Use with a suitable eradicant partner for established infections
- Maximum of two treatments per crop

Fungicide Groups

(some actives and groups may be authorised under an EAMU)

Succinate-dehydrogenase inhibitors, (SDHIs) - FRAC code 7

Resistance has been confirmed in other powdery mildew pathogens such as cucurbit powdery mildew (*Podosphaera xanthii*).

Uses

- Resistance risk is thought to be medium to high
- Currently only available in mixtures
- See Table 2 for guidelines on use of SDHIs where multiple sprays are applied

Hydroxy (2-amino-) pyrimidines, Adenosine-Deaminase - FRAC code 8

Resistance has been detected in powdery mildew pathogens of barley and cucurbits.

Uses

- Resistance risk is thought to be medium to high
- Curative and protectant
- Maximum of three applications per year

Multi-site activity – sulphur, dithiocarbamates and potassium salts

There is no evidence of resistance developing and resistance risk is low. They are protectants offering alternative modes of action.

Uses

- Regular applications of potassium hydrogen carbonate can significantly reduce the incidence of powdery mildew and can be used to reduce the selection pressure on fungicides
- Potassium hydrogen carbonate can be used near to harvest to reduce the incidence of residues

Introduction

Botrytis or grey mould is the most important fruit rot disease affecting strawberries. Typical symptoms include a spreading brown rot and fuzzy grey mould on ripening berries. As grey mould develops on infected berries, these become sources of inoculum for secondary infections of adjacent berries. The grey mould fungus overwinters on old leaves and can sporulate profusely on dead and decaying plant material. The spores are airborne and are usually plentiful in strawberry fields.

A weather-based risk assessment system is available for strawberry *Botrytis* which can be used to assist in decisions on fungicide use. Frequent monitoring of crops to assess the incidence of *Botrytis* is also important and can be used with the forecast risk to decide on sprays. Cool chain management of the fruit at harvest is essential in reducing fruit rot post-harvest.



Resistance status

Resistance to different fungicide modes of action has developed widely in strawberry *B. cinerea* strains, as well as those affecting raspberries and grapes, with multi-resistant strains being common, although the frequency of resistance can vary substantially from field to field. Therefore the risk of further resistance developing is high and a robust anti-resistance strategy must be employed when using fungicides against *Botrytis*, particularly where strawberries and raspberries are grown in close proximity.

Fungicide Groups for chemical control (some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) – FRAC code 3

Reduced sensitivity and loss of field control with DMIs has been reported in *Botrytis* of field vegetables. However, there are no reports of DMI resistance in strawberry *Botrytis*. Resistance to DMIs can evolve slowly via a number of small shifts in sensitivity meaning the initial stages of resistance development are easily missed.

Uses

- Resistance risk is medium to high
- Never use DMIs alone or repeatedly for *Botrytis* control
- Alternate or mix with fungicides of a different mode of action in repeat spray programmes

Quinone-outside inhibitors, Strobilurins (Qols) – FRAC code 11

Resistance to Qol fungicides in strawberry *Botrytis* is widespread in Europe, including the UK. In recent monitoring of UK isolates all were resistant to Qols. Cross-resistance is also reported.

Uses

- Resistance risk is high
- Qol fungicides should not be used for control of *Botrytis*

Succinate-dehydrogenase inhibitors, (SDHIs) - FRAC code 7

Resistance to SDHIs has been confirmed in strawberry *Botrytis* across Europe. Although the frequency of resistant strains varies from site to site and country to country, there has been a generally increasing trend since 2008.

Uses

- Resistance risk is medium to high
- Currently only available in mixture with a Qol or triazole. However, frequency of resistance to Qols is high in the UK
- SDHI/Qol mixtures should not be relied upon for control of *Botrytis*
- Use in mixture with another active group such as DMIs

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

AP-fungicides (Anilino-Pyrimidines) - FRAC code 9

Resistance to anilino-pyrimidines has been detected in Europe and the UK. The frequency of resistant strains in the population is moderate, fluctuating from field to field, and ranging from zero to high. However, the overall frequency of resistant isolates in monitored populations has remained stable over the last ten years.

Uses

- Resistance risk is medium to high
- Where up to three *Botrytis* treatments are made per season, the number of applications of AP-containing products is limited to one
- In situations where four to six *Botrytis* treatments are made per crop and season, a maximum of two applications with AP-containing products is recommended
- In specific situations where seven or more *Botrytis* treatments are required per crop and season, a maximum of three applications with AP-containing products is recommended with not more than two consecutive applications

KetoReductase Inhibitors (KRI fungicides), (SBI class III) - FRAC code 17

In 2020, monitoring was carried out in France, Germany, Italy, Norway, Poland and the UK. The frequency of resistant strains was low to moderate in France, Germany, Italy, Norway and Poland, and moderate in the UK. KRI fungicides should not be relied upon for the control of *Botrytis*.

Uses

- Resistance risk is high
- Use KRIs only protectively
- Use KRIs only in strict alternation
- In spray programmes with up to three *Botrytis* treatments per season, use no more than one application with KRIs
- In spray programmes with four to five *Botrytis* treatments/season, use a maximum of two applications with KRIs
- In spray programmes with six and more *Botrytis* treatments, no more than one third should include KRIs
- Not more than half of all botryticide-treatments should be made with KRI-containing mixtures

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Phenylpyrroles (PP fungicides) - FRAC code 12

Resistance to phenylpyrrole fungicides has been reported in a number of plant pathogens, including *Botrytis* on strawberry in Europe, the USA and China. Resistance management required.

Uses

- Resistance risk is high
- Only available in mixtures
- Use as a protectant treatment or in the earliest stages of disease development
- Do not apply more than twice in one season

Introduction

Strawberry crown rot destroys the crown of strawberry plants. It is found commonly in the UK, often in newly planted cold stored runners (frigoplants) or tray or module plants. Infected planting material is the main source of inoculum in the UK. The oomycete pathogen is well adapted to temperate areas of the world and causes economic losses to plants and fruits in all the strawberry growing countries of Western Europe. Fungicides have limited efficacy and crown rot resting spores are persistent, so it is essential that chemical control measures are used as part of an integrated disease management strategy. The most effective control comes from eradicating the disease in propagating stocks and keeping new plantings clean. Propagators are key to containing this disease.



Resistance status

Resistance to fungicides has been reported in *P. cactorum* in the USA and Europe, including resistance to metalaxyl. Resistance to metalaxyl is probably also present in the UK as much of the planting material comes from Europe. Resistance risk must be considered medium, particularly as there are limited modes of action authorised for use against crown rot.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Carboxylic acid amides (CAA fungicides) - FRAC code 40

Resistance to CAA fungicides has been reported in a number of *Phytophthora* species, though not the strawberry crown rot species of *Phytophthora*.

Uses

- Resistance risk is medium
- Apply preventatively at planting
- Make no more than one application per year
- CAA fungicides should not make up more than 50% of applications to control *Phytophthora* species

Phenylamides (PA fungicides) - FRAC code 4

Resistance to metalaxyl has been detected in *P. cactorum* in Europe.

Uses

- Resistance risk is high

Carbamates - FRAC code 28

Propamocarb hydrochloride is approved under an EAMU for protected soft fruit only in combination with fosetyl-aluminum as a drench treatment. No confirmed cases of field resistance to carbamate fungicides reported in *Phytophthora* species.

Uses

- Resistance risk is low to medium

Phosphonates - FRAC code P07

Fosetyl-aluminium is approved only in combination with propamocarb hydrochloride (see above). Resistance to phosphonates has only rarely been reported and not in *P. cactorum*.

Uses

- Resistance risk is low

Introduction

Black spot or anthracnose can affect all parts of the plant (fruit, crowns, leaves, petioles and runners). Three closely related species of fungus, *Colletotrichum acutatum*, *C. gloeosporioides*, and *C. fragariae* can be associated with anthracnose, although *C. fragariae* is rarely found in the UK. *C. acutatum* is the main pathogen associated with the fruit rot. The primary source of inoculum is transplants, older neighbouring plants and weeds, as the pathogen has a wide host range. The pathogen can grow in green tissue without showing any symptoms. Spread within crops is mainly by rain splash and so protected crops are at much lower risk.

Resistance status

Although resistance to fungicides has not been reported for *C. acutatum*, it has in the closely related *C. gloeosporioides* and so resistance risk should be considered medium.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) - FRAC code 3

Reduced sensitivity and loss of field control with DMIs has been reported for a number of crop pathogens. Resistance to DMIs can evolve slowly via a number of small shifts in sensitivity meaning the initial stages of resistance development are easily missed.

Uses

- Resistance risk is thought to be medium
- Never use DMIs alone or repeatedly for black spot control
- Alternate or mix fungicides with different modes of action in repeat spray programmes
- Maximum application number may differ between protected and field crops

Quinone-outside inhibitors, Strobilurins (Qols) - FRAC code 11

Resistance to Qol fungicides has been reported in *C. gloeosporioides* in the USA and is common in many other crop pathogens.

Uses

- Resistance risk is thought to be high
- Qol fungicides are very effective at preventing spore germination and should therefore be used at the early stages of disease development (preventive treatment)
- Follow the general anti-resistance guidelines for Qols in Table 1

Anilino-Pyrimidines (AP-fungicides) - FRAC code 9

Resistance to AP fungicides has been detected in Europe and the UK in some strawberry diseases. This should be taken into account when using AP fungicides for control of black spot.

Uses

- Resistance risk is thought to be medium
- Apply as a protectant spray at the beginning of blossom (white bud)
- Where up to three treatments are made per season, the number of applications of AP-containing products is limited to one
- In situations where four to six treatments are made per crop and season, a maximum of two applications with AP-containing products is recommended
- In specific situations where seven or more treatments are required per crop and season, a maximum of three applications with AP-containing products is recommended and not more than two consecutive applications

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Phenylpyrroles (PP fungicides) - FRAC code 12

Resistance to phenylpyrrole fungicides has been reported in a number of plant pathogens. Resistance in strawberry Botrytis has been reported in the USA. This should be taken into account when using PP fungicides to control black spot.

Uses

- The risk of resistance is medium
- Only available in mixture
- Use as a protectant treatment or in the earliest stages of disease development

Introduction

Soft rots caused by *Mucor* and *Rhizopus* can cause significant losses in strawberry production pre-harvest and especially post-harvest, with *Mucor* being the predominant causal agent. Both fungi cause similar symptoms and in ripe fruit, rot development is rapid and losses high. The disease thrives in heat and over-ripe berries and so tight picking schedules, essential for Spotted Wing Drosophila prevention, contribute significantly to its control. There are very few fungicides which are active against *Mucor* or *Rhizopus* so cultural control is a key part of managing the disease.



Resistance status

There are no reports of resistance to fungicides in either *Mucor* or *Rhizopus* species. However, there are few chemical control options, hence limiting the anti-resistance strategies that can be employed. Nevertheless, treatment choices should be made in the context of the fungicide treatment strategy for all diseases.



Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Anilino-Pyrimidines (AP-fungicides) - FRAC code 9

Resistance to AP fungicides has been detected in Europe and the UK in some strawberry diseases. This should be taken into account when using AP fungicides for control of soft rot.

Uses

- The risk of resistance is medium
- Apply as a protectant spray at the beginning of blossom (white bud)
- Where up to three treatments are made per season, the number of applications of AP-containing products is limited to one
- In situations where four to six treatments are made per crop and season, a maximum of two applications with AP-containing products is recommended
- In specific situations where seven or more treatments are required per crop and season, a maximum of three applications with AP-containing products is recommended and not more than two consecutive applications

Phenylpyrroles (PP fungicides) - FRAC code 12

Resistance to phenylpyrrole fungicides has been reported in a number of plant pathogens. This should be taken into account when using PP fungicides to control soft rot.

Uses

- The risk of resistance is low to medium
- Only available in mixture
- Use as a protectant treatment or in the earliest stages of disease development
- Do not apply more than twice in one season

Resistance Management Guidelines

Raspberries – General

Raspberry production in the UK now includes a significant proportion of protected crops (grown under glass or plastic) and also plants grown in pots. The traditional summer harvest period has been extended using canes lifted, chilled and stored for planting in late spring for late summer harvest under plastic, generally referred to as 'long cane' production. Pot grown plants avoid problematic soil-borne diseases but they typically only last three or four years, compared with soil-grown plants that can produce raspberries for 15 years. For long lasting healthy crops it is important to plant healthy propagation material from a recognised certification scheme and to control diseases throughout the life of the plantation, this includes appropriate management to avoid fungicide resistance issues.

Introduction

There are many different powdery mildew pathogens, each with specificity to a particular crop. The raspberry powdery mildew pathogen (*P. macularis*) is closely related to the strawberry powdery mildew pathogen (*P. aphanis*), but cross infection does not occur. Raspberry powdery mildew can affect both green and ripe berries as well as leaf tissue and primocanes. Severely infected berries fail to size properly and wither and die.



Resistance status

Powdery mildew pathogens are considered medium risk of developing resistance to fungicides, with many instances of partial or full resistance recorded. However, resistance in *P. macularis* has not been reported.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) – FRAC Code 3

Reduced sensitivity and loss of field control with DMIs has been reported in cereal powdery mildews. However, there are no reports of resistance in *P. macularis*.

Uses

- Resistance risk medium
- Never use DMIs alone or repeatedly for powdery mildew control
- Alternate or mix fungicides with different modes of action in repeat spray programmes.
- Include another mode of action with eradicant activity if powdery mildew is already active

Quinone-outside inhibitors, Strobilurins (Qols) – FRAC code 11

Resistance in powdery mildews pathogens to Qol fungicides is widespread but has not been reported in *P. macularis*.

Uses

- Resistance risk is high
- Qol fungicides are very effective at preventing spore germination and should therefore be used at the early stages of disease development (preventive treatment)
- See Table 1 for guidelines on use of Qols where multiple sprays are applied

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Azanaphthalenes - FRAC code 13

Azanaphthalene (AZN) fungicides have a spectrum of activity limited to powdery mildews. Resistance has been reported in some powdery mildew pathogens e.g. grape powdery mildew, (*Erysiphe necator*), but not in *P. macularis*.

Uses

- Resistance risk is medium
- Apply preventatively, in mixture with fungicides from other groups with a different mode of action before mildew is established. Will not control latent or established infections
- Use with a suitable eradicant partner for established infections
- AZN fungicides should not exceed 50% of the total number of powdery mildew applications per season, whether applied alone or with an effective mixture partner from a different cross-resistance group
- Do not exceed two consecutive applications of AZN fungicides per season

Succinate-dehydrogenase inhibitors, (SDHIs) - FRAC code 7

Resistance has been confirmed in other powdery mildew pathogens such as cucurbit powdery mildew (*Podosphaera xanthii*), but not *P. macularis*.

Uses

- Resistance risk is medium to high
- Although not a primary target for the SDHIs, products are authorised for use against powdery mildew
- Currently only available in mixtures
- See Table 2 for guidelines on use of SDHIs where multiple sprays are applied

Hydroxy (2-amino-) pyrimidines, Adenosine-Deaminase - FRAC code 8

Resistance has been detected in powdery mildew pathogens of barley and cucurbits but not *P. macularis*.

Uses

- Resistance risk is high
- Curative and protectant
- Maximum of three applications per year

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Anilino-Pyrimidines (AP-fungicides) - FRAC code 9

Anilinopyrimidines have been widely used since 1998 and no shifts in sensitivity to powdery mildew pathogens of any crop have been detected, though resistance in *Botrytis* has been recorded.

Uses

- Resistance risk not known but thought to be medium
- Use early in the spray programme to make the best use of the protectant activity of the fungicide
- Use with a suitable eradicant partner for established infections

Fungicides with multi-site activity - sulphur and potassium salts

There is no evidence of resistance developing to these multi-site fungicides and resistance risk is low. They are protectants offering alternative modes of action.

Uses

- Regular applications of potassium hydrogen carbonate can significantly reduce the incidence of powdery mildew and can be used to reduce the selection pressure on fungicides. It can also be used near to harvest to reduce the incidence of residues.

Introduction

Botrytis of raspberry can cause diseases on both cane and fruit, namely cane Botrytis and grey mould. Cane Botrytis has many features in common with spur blight, caused by the fungus *Didymella applanata* and it is common to find both diseases in the same planting or on the same canes. Cane Botrytis is generally considered to be the more damaging of the two diseases. Cane Botrytis is more challenging to control than Botrytis on fruits, though fruit Botrytis can be very damaging, causing up to 50% losses. The disease is usually more prevalent in autumn fruiting crops due to the more favorable weather conditions. Cultural control measures such as cane thinning to improve air circulation and cool chain management of the fruit at harvest are key to the integrated control programme.

Resistance status

Resistance to fungicides has been reported in *Botrytis cinerea* on raspberry, with strains resistant to five different modes of action having been reported from Germany. Resistance in Botrytis on strawberry as well as on a wide range of other crops has also been reported and so a robust anti-resistance strategy must be employed, particularly where these crops are grown in close proximity.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) – FRAC code 3

Reduced sensitivity and loss of field control with DMIs has been reported in *Botrytis* isolates affecting field vegetables. There are no reports of DMI resistance in raspberry *Botrytis*. Resistance to DMIs can evolve slowly via a number of small shifts in sensitivity meaning the initial stages of resistance development are easily missed.

Uses

- Resistance risk is medium to high
- Never use DMIs alone or repeatedly for *Botrytis* control
- Alternate or mix fungicides with different modes of action in repeat spray programmes

Quinone-outside inhibitors, Strobilurins (QoIs) – FRAC code 11

Although resistance to QoI fungicides in raspberry *Botrytis* has not been widely reported, resistance in strawberry *Botrytis* is widespread in Europe, including the UK. No QoI products are currently authorized for control of *Botrytis* on raspberry.

Uses

- Resistance risk is high
- QoI fungicides should not be used for control of *Botrytis* in raspberries

Succinate-dehydrogenase inhibitors (SDHIs) - FRAC code 7

Resistance to SDHIs has been confirmed in strawberry *Botrytis* across Europe, and in *Botrytis* on raspberry, though not as widely. No SDHI products are currently authorized for control of *Botrytis* on raspberry.

Uses

- Resistance risk is high
- SDHI fungicides should not be used for control of *Botrytis* in raspberries

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Anilino-Pyrimidines (AP-fungicides) - FRAC code 9

Resistance in raspberry *Botrytis* to anilino-pyrimidines has been detected in Europe, as well as resistance in strawberry, grape and vegetable *Botrytis*.

Uses

- Resistance risk is high
- A maximum of three applications per year
- Where only two applications are made per season, the number of anilino-pyrimidine products should be limited to one
- Where up to six treatments are made per crop and season, a maximum of two applications of anilino-pyrimidine-containing products are recommended
- Where more than six fungicide treatments are made per crop and season, three applications of anilino-pyrimidine-containing products can be made

Phenylpyrroles (PP fungicides) - FRAC code 12

Resistance to phenylpyrrole fungicides has been reported in a number of plant pathogens, including *Botrytis* on raspberry in Europe and *Botrytis* on strawberry in Europe, the USA and China.

Uses

- Resistance risk is high
- Only available in mixtures
- Use as a protectant treatment or in the earliest stages of disease development
- Do not apply more than twice in one season

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

KetoReductase Inhibitors (KRI fungicides), (SBI class III) - FRAC code 17

In 2020, monitoring of raspberry *Botrytis* was carried out in France, Germany, Italy, Norway, Poland and United Kingdom. The frequency of KRI-resistant isolates was low to moderate in France, Germany, Italy, Norway and Poland, and moderate in the UK.

Uses

- Resistance risk is high
- KRI fungicides should not be relied upon for the control of *Botrytis*
- Use KRIs only protectively
- Use KRIs only in strict alternation
- In spray programmes with up to three *Botrytis* treatments per season use no more than one application with KRIs
- In spray programmes with four to five *Botrytis* treatments/season use a maximum of two applications with KRIs
- In spray programmes with 6 and more *Botrytis* treatments no more than one third should include KRIs
- Not more than 50% of all botryticide-treatments should be made with KRIs-containing mixtures.

Introduction

Phytophthora root rot of raspberry brings about root death, leading to die back of both the floricanes (fruiting canes) and primocanes (non-fruiting canes). In severe cases whole plantations may be killed. The root rot can be caused by a number of species of the soil-borne oomycete *Phytophthora*, but the most important are *Phytophthora rubi* and *P. idaei*. Due to the persistent nature of *Phytophthora* spores, it is essential that chemical control measures are used as part of an integrated disease management strategy, with propagators having a significant part to play with control. Such action will then enable chemical treatments to be more effective.



Resistance status

Resistance has been reported to metalaxl in *P. rubi* the USA, but at very low frequency. Resistance is present in closely related *Phytophthora* species and so the risk should be considered low to moderate.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Carboxylic acid amides (CAA fungicides) - FRAC code 40

Resistance to CCA fungicides has been reported in a number of *Phytophthora* species, though not in *Phytophthora rubi* or *P. idaei*.

Uses

- Resistance risk is medium
- Apply preventatively at planting
- Make no more than one application per year
- CAA fungicides should not make up more than 50% of applications to control *Phytophthora* species

Phenylamides - FRAC code 4

Resistance to phenylamides is well known in various Oomycetes including *Phytophthora* spp.

Uses

- Resistance risk considered high
- Should only be used where it is essential
- Other methods of control, including cultural techniques should be used when possible
- Curative or eradicant use should be avoided

Carbamates - FRAC code 28

Propamocarb hydrochloride is approved under an EAMU for protected soft fruit only in combination with fosetyl-aluminum as a drench treatment. No confirmed cases of field resistance to carbamate fungicides reported in *Phytophthora* species.

Uses

Resistance risk is low to medium

Phosphonates - FRAC code P07

Fosetyl-aluminium is approved only in combination with propamocarb hydrochloride (see above). Resistance to phosphonates has only rarely been reported and not in *P. cactorum*.

Uses

- Resistance risk is low

Introduction

All succulent plant parts are subject to infection by *P. rubi-idaei*, but cane lesions are rarely observed and most infection is seen on the leaves and occasionally on fruit. Infected canes are often brittle and may break off when old fruiting canes are pruned out. Fruit may die on infected canes if leaf infection occurs early in the season. Defoliation of severely infected leaves is common towards the end of the season.

Resistance status

Instances of resistance to fungicides in rusts are relatively rare and there are no reported instances of fungicide resistance in raspberry yellow rust. However, sprays to target rust will select for other diseases present and so anti-resistance management should be employed when treating for rust.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) - FRAC code 3

Resistance to DMIs in rusts has been reported, but is very rare; there is no evidence of reduced sensitivity to DMIs in *P. rubi-idaei* in the UK. However, reduced sensitivity and loss of field control with DMIs has been reported in some diseases closely related to raspberry diseases. Resistance to DMIs can evolve slowly via a number of small shifts in sensitivity meaning the initial stages of resistance development are easily missed.

Uses

- Resistance risk is low
- Never use DMIs alone or repeatedly
- Alternate or mix fungicides with different modes of action in repeat spray programmes

Quinone-outside inhibitors, Strobilurins (QoIs) - FRAC code 11

Resistance to QoI fungicides has been widely reported in raspberry diseases and closely related diseases of other crops. Therefore general anti resistance guidelines for QoIs should be followed.

Uses

- Resistance risk is low
- QoI fungicides are very effective at preventing spore germination and should therefore be used at the early stages of disease development (preventive treatment)

Succinate-dehydrogenase inhibitors (SDHIs) - FRAC code 7

Resistance to SDHIs has been reported in some raspberry diseases and closely related diseases of other crops. Therefore general anti resistance guidelines for SDHIs should be followed.

Uses

- Resistance risk is low
- Currently only available in mixture
- Observe the general guidelines for SDHI use in Table 2

Introduction

Elsinoe veneta infection causes deep pits in canes that can expose vascular tissue. Leaves may also be attacked. Significant yield and quality reductions can occur, though some varieties show good resistance.

Resistance status

The available actives are limited, so resistance management is important.

Fungicide Groups

(Some actives and groups may be authorised under an EAMU)

Sterol demethylation inhibitors (DMIs) - FRAC code 3

Reduced sensitivity and loss of field control with DMIs has been reported in some diseases that are closely related to raspberry diseases. Resistance to DMIs can evolve slowly via a number of small shifts in sensitivity meaning the initial stages of resistance development are easily missed. Therefore general anti resistance guidelines for DMIs should be followed

Uses

- Resistance risk is medium
- Never use DMIs alone or repeatedly
- Alternate or mix fungicides with different modes of action in repeat spray programmes

Quinone-outside inhibitors, Strobilurins (Qols) - FRAC code 11

Resistance to Qol fungicides has been widely reported in raspberry diseases. Therefore, general anti resistance guidelines for Qols should be followed.

Uses

- Resistance risk is medium
- Observe the general guidelines for strobilurin use in Table 1

Succinate-dehydrogenase inhibitors (SDHIs) - FRAC code 7

Resistance to SDHIs has been reported in some raspberry diseases. Therefore general anti resistance guidelines for SDHIs should be followed.

Uses

- Resistance risk is medium
- Currently only available in mixture
- Observe the general guidelines for SDHI use in Table 2

Key diseases

The main disease of blackcurrants in the UK is Botrytis. A number of other diseases occur occasionally. Of these the most important are leaf spot caused by the fungus *Drepanopeziza ribis*, American gooseberry mildew (a powdery mildew caused by *Sphaerotheca mors-uvae*) and rust (*Cronartium ribicola*) on susceptible varieties. Most modern commercial blackcurrant cultivars show good resistance to American gooseberry mildew.

Resistance status

Though there are no reports of resistance in Botrytis on blackcurrants there are multiple reports of resistance in Botrytis on a wide range of other crops, resistance risk is therefore high. Resistance to DMI fungicides has been reported in *Sphaerotheca mors-uvae* in Poland and so similarly resistance risk is high. Robust anti-resistance strategies should be employed when treating these diseases. Although no DMIs are authorised in the UK for use against *S. mors-uvae*, their use against other disease will select for any resistant strains present.

Resistance management

Use of mixtures or alternation of fungicides with different modes of action in addition to cultural control and crop hygiene to lessen disease pressure will reduce the risk of resistance. For mode of action specific advice refer to strawberry and raspberry advice.

Key diseases

There are a number of diseases of blackberry that are of economic importance in the UK. Botrytis, downy mildew (*Peronospora sparsa*), verticillium wilt (*Verticillium dahliae*), spur blight (*Didymella applanata*) and purple blotch (*Septocya ruborum*) being the most important.

Resistance status

There are no reported cases of resistance to fungicides in blackberry diseases. However, there are reported cases of resistance in closely related diseases, for instance in other *Didymella* species, which cause spur blight, and some cases of resistance in *Verticillium* spp. (although fungicides are not used to control verticillium wilt). Therefore the risk of resistance developing to one or more fungal pathogens of blackberry is real and anti-resistance strategies should be employed.

Resistance management

Use of mixtures or alternation of fungicides with different modes of action in addition to cultural control and crop hygiene to lessen disease pressure will reduce the risk of resistance. For mode of action specific advice refer to strawberry and raspberry advice.

Key diseases

There are a number of diseases of blueberry that are of economic importance in the UK including Botrytis and anthracnose (*Colletotrichum acutatum*) and a very limited number of fungicides authorised to treat them.

Resistance status

As with diseases of blackberry and blackcurrant, although there are no specific reported instances of resistance to fungicides in blueberry diseases, there are reports of resistance in closely related species and so there is a risk of resistance developing.



Resistance management

Resistance management is challenging as there are only a small number of products with a limited range of modes of action authorised for use in the UK on blueberries. However, this makes it even more important to make use of the full range of available modes of action in addition to cultural control and crop hygiene to lessen disease pressure.

Key diseases

The most common diseases on red and white currants and gooseberries are leaf spot, caused by the fungus *Drepanopeziza ribis*, American gooseberry mildew caused by the fungus *Sphaerotheca mors-uvae* on susceptible varieties and Botrytis.

Resistance status

Although there are no reports of fungicide resistance on these crops there are in closely related diseases of other crops. And so there is a risk of resistance developing.

Resistance management

Anti-resistance measures should be employed when treating with fungicides, in addition to cultural controls and crop hygiene to reduce disease pressure.

Table 1

Guidelines for using Qol (strobilurin) fungicides in multiple spray programmes

Total number of sprays per crop	1	2	3	4	5	6	7	8	9	10	11	12	>12
Maximum number of solo Qol sprays	1	1*	2*	2	2	2	2	3	3	3	3	4	**
Maximum number of Qol sprays in mixture	1	2	2	2	2	3	3	4	4	5	5	6	**

* Mixtures are preferred

** When more than 12 fungicide applications are made in a season follow the guidelines below.

- If using Qols as solo products then the total number of Qol sprays should not exceed one third (33%) of all fungicide sprays.
- Where using Qols in mixtures with a fungicide with a different mode of action that has activity on the diseases targeted by the Qol, the total number of Qol containing sprays should not exceed half of all fungicide sprays.
- Where using Qols both in mixtures with a fungicide with a different mode of action that has activity on the diseases targeted by the Qol and as solo products, the total number of Qol containing sprays should not exceed half of all fungicide sprays.

Table 2
Guidelines for using SDHI fungicides in multiple spray programmes on soft fruit, irrespective of the target disease

Total number of sprays per crop	1	2	3	4	5	6	7	8	9	10	11	12	>12
Maximum number of solo SDHI fungicide sprays*	1	1	1	1	2	2	2	3	3	3	3	4	**
Maximum number of SDHI fungicide sprays in mixture***/***	1	1	1	2	2	3	3	3	3	3	4	4	**

* Apply in strict alternation with another mode of action that has activity on the target disease

** When more than 12 fungicide applications are made, observe the following guidelines:

- When using a SDHI fungicide as a solo product, the number of applications should be no more than one third (33%) of the total number of fungicide applications per season.
- For programmes in which tank mixes or pre-mixes of SDHI are utilized, the number of SDHI containing applications should be no more than half of the total number of fungicide applications per season.
- In programmes where SDHIs are applied as both solo products and mixtures, the number of SDHI containing applications should be no more than half of the total number of fungicide applications per season.

*** Apply a maximum of two consecutive applications

**** When mixtures are used for SDHI fungicide resistance management, applied as tank mix or as a co-formulated mixture, the mixture partner should:

- ⇒ provide satisfactory disease control when used alone on the target disease
- ⇒ must have a different mode of action.

Fungicide groups authorised¹ for the control of one or more of the listed diseases of soft fruit

Fungicide Group	FRAC Code	Chemical Family	Common name of active substance
DMI-fungicides (DeMethylation Inhibitors) (SBI: Class I)	3	Triazoles	difenoconazole tebuconazole myclobutanil penconazole
PA-fungicides (Phenyl-Amides)	4	Acylalanines	metalaxyl
Succinate-dehydrogenase inhibitors (SDHI)	7	Pyridine carboxamide	boscalid
		Pyridinyl-ethyl- benzamide	fluopyram
		Pyrazole carboxamide	fluxapyroxad
Hydroxy (2-amino-) pyrimidines	8	Hydroxy (2-amino-) pyrimidine	bupirimate
AP-fungicides (Anilino-Pyrimidines)	9	Anilino-pyrimidines	cyprodinil mepanipyrim pyrimethanil
QoI-fungicides (Quinone-outside Inhibitors)	11	Strobilurins	azoxystrobin kresoxim-methyl pyraclostrobin trifloxystrobin
PP-fungicides (PhenylPyrroles)	12	PhenylPyrroles	fludioxonil
Azaphthalene	13	Quinazolinones	proquinazid
KRI-fungicides (KetoReductase Inhibitors) (SBI Class III)	17	Hydroxyanilides	fenhexamid fenpyrazamine

¹ Not all groups are approved on all diseases or on all soft fruit crops. Check the FERA Liaison database for the latest information on authorised plant protection products (including EAMUs) on soft fruit and always use pesticides in accordance with their authorised conditions of use.

The latest information on Full Approvals and EAMUs is available from the Chemicals Regulation Division website:

Pesticides Register of Authorised Plant Protection Products

<https://secure.pesticides.gov.uk/pestreg/ProdSearch.asp>

Extension of Authorisation for Minor Use

<https://secure.pesticides.gov.uk/offlabels/search.asp>

Fungicide groups authorised¹ for the control of one or more of the listed diseases of soft fruit

Fungicide Groups	FRAC Code*	Chemical Families	Common name of active substance
CAA-fungicides	40	Cinnamic acid amides	dimethomorph
Carbamates	28	Carbamates	propamocarb hydrochloride
Amidoximes	U06	Phenyl-acetamide	cyflufenamid
Inorganics — carbonates	NA	Inorganic	potassium hydrogen carbonate
Inorganics—sulphur	M02	Inorganic	sulphur
Dithiocarbamate	M03	Dithiocarbamates	mancozeb
Phosphonates	P07	Ethyl phosphonates	fosetyl-aluminium
Elicitors	NA	Oligosaccharide elicitor	COS-OGA

* NA not applicable

¹ Not all groups are approved on all diseases or on all soft fruit crops. Check the FERA Liaison database for the latest information on authorised plant protection products (including EAMUs) on soft fruit and always use pesticides in accordance with their authorised conditions of use.

The latest information on Full Approvals and EAMUs is available from the Chemicals Regulation Division website:

Pesticides Register of Authorised Plant Protection Products

<https://secure.pesticides.gov.uk/pestreg/ProdSearch.asp>

Extension of Authorisation for Minor Use

<https://secure.pesticides.gov.uk/offlabels/search.asp>

Introduction

Biofungicides (biologicals) offer an alternative method of disease control and resistance management. Although subject to the development of resistance, they are considered low risk. However, biological pesticides are not direct replacements for conventional pesticides, rather they are tools to be used as part of an IPM programme. By understanding the strengths and weaknesses of individual biological pesticide products it is possible to build them into an IPM programme. When applied accurately in the right conditions, biological pesticides can work well. However, inconsistent results are often noted in commercial situations. The reasons for this is uncertain but is likely to be related to a number of factors.

Storage

Most currently available biofungicides are based on living micro-organisms and as a result need specific storage conditions to maintain the optimum viability of the product. Often this different to the storage requirements of conventional fungicides. All product information should be read in advance to establish the required conditions.

Mixing

Many biofungicides require sustained agitation of the formulation during application to maintain equal dispersal of the active ingredient and uniform dosing. Pay careful attention to mixing conditions on product labels.

Application equipment

Poor spray application generally has a more negative impact on the performance of biofungicides than conventional pesticides. Calibrate equipment regularly, ensure lines are clear and nozzles are checked and if necessary changed regularly.

Cleaning

Thorough pre-cleaning is essential to ensure residues of conventional products are removed from application equipment before using biofungicides. Research has shown that even washing equipment six times can leave identifiable residues. If possible, consider investing in a separate application equipment for biological and conventional pesticides.

Label guidance

Operators unfamiliar with biofungicides may have difficulties with label guidance and the limited technical information that is present on the product label. In such cases it is important to speak directly with the relevant manufacturer to gain additional technical information to assist in optimising application and product performance.

Compatibility

Biofungicides vary widely in their compatibility with other conventional fungicides and other plant protection products.

Biofungicides authorised for the control of one or more of the listed diseases of soft fruit

Species/ strain	FRAC code*	Crops	Targets	Harvest interval
<i>Ampelomyces quisqualis</i> strain AQ10	NA	Protected Strawberry, Blueberry, Blackcurrant, redcurrant	Powdery mildew	Nil
<i>Aureobasidium pullulans</i> strains DSM 14940 and DSM 14941	NA	Protected and outdoor Strawberry. Also Raspberry, outdoor and protected, Blackcurrants and Redcurrants, Outdoor Blueberries under EAMU	<i>Botrytis cinerea</i>	1 day
<i>Bacillus amyloliquefaciens</i> strain D747	BM02	Most protected soft fruit. Field grown crops under EAMU	<i>Botrytis</i> Powdery mildew	Nil
<i>Bacillus amyloliquefaciens</i> strain MBI600	BM02	Protected raspberry, blueberry, strawberry	<i>Botrytis</i> spp. <i>Sclerotinia</i>	BBCH89 end of fruiting (strawberry), nil (raspberry)
<i>Bacillus amyloliquefaciens</i> strain FZB24	BM02	Protected strawberry	Suppression of unspecified diseases	1 day
<i>Bacillus subtilis</i> strain QST 713	BM02	Strawberry (protected and outdoor) Raspberry (outdoor and protected) Blackcurrants and Redcurrants (O & P) Blueberries (O & P) EAMUs for other crops	<i>Botrytis cinerea</i> <i>Phytophthora</i> (may give incidental control of powdery mildew)	Nil
<i>Bacillus pumilis</i> QST2808	BM02	Protected strawberry, raspberry, redcurrant, blackcurrant	Powdery mildew	1 day
<i>Gliocladium catenulatum</i> strain J1446	BM02	Protected edibles Strawberry EAMUs for other crops	<i>Botrytis cinerea</i> <i>Didymella</i> <i>Phytophthora</i>	Apply in growing medium

* NA not applicable

In order to gain maximum benefit from these biofungicides careful attention should be paid to the conditions of use on the label and any accompanying technical information.

Biofungicides authorised for the control of one or more of the listed diseases in soft fruit

Species/ strain	FRAC code	Crops	Targets	Harvest interval
<i>Trichoderma asperellum</i> strain T34	BM02	Protected Strawberry, Raspberry, Blackcurrant, Redcurrant, Blueberry under EAMU	Reduction in <i>Fusarium</i> and <i>Pythium</i>	Apply in drip irrigation, in growing medium or as a drench
<i>Trichoderma harzianum</i>	BM02	Protected: Strawberry, Raspberry, Blackcurrant, Redcurrant, Blueberry under EAMU	<i>Fusarium, Pythium, Rhizoctonia</i>	Apply at propagation

In order to gain maximum benefit from these biofungicides careful attention should be paid to the conditions of use on the label and any accompanying technical information.

Resistance risk summary - Strawberries

Resistance risk associated with key diseases of strawberries and fungicides currently authorised for use on strawberries, either on label or through an EAMU

Fungicide group	FRAC Code	Disease				
		Powdery mildew	Botrytis (grey mould)	Crown Rot	Black Spot	Soft rot
DMI fungicides DeM ethylation Inhibitors) (SBI Class I)	3	M	H		M	
PA fungicides PhenylA mides	4			H		
Morpholines SBI (Class II)	5	M			M	
SDHI fungicides Succinate Dehydrogenase Inhibitors	7	H	VH			
Hydroxy (2-amino-) pyrimidines, Adenosine-Deaminase	8	M				
AP fungicides Anilino- Pyrimidines	9		H		M	L
QoI fungicides Quinone Outside Inhibitors (strobilurins)	11	H	VH		H	
PP fungicides Phenyl Pyrroles	12		H		M	L
Aza-naphthalenes	13	M		M		
KRI fungicides KetoR eductase Inhibitors (SBI Class III)	17		H			
Uncouplers of oxidative phosphorylation	29	M				
CCA fungicides Carboxylic Acid A mides	40					
Phenylacetamides	U6	M				
Multisite fungicides	M	L	L			

Risk of resistance: VH – very high; H – High; M – medium; L – low

Resistance risk summary - Raspberries

Resistance risk associated with key diseases of raspberries and fungicides currently authorised for use on strawberries, either on label or through an EAMU

Fungicide group	FRAC Code	Disease				
		Powdery mildew	Botrytis (grey mould)	Root rot	Cane spot (anthracose)	Yellow rust
DMI fungicides DeMethylation Inhibitors) (SBI Class I)	3	M	H		M	L
PA fungicides PhenylAmides	4			H		
Morpholines SBI (Class II)	5	M			M	L
SDHI fungicides Succinate Dehydrogenase Inhibitors	7	H				
Hydroxy (2 amino) pyrimidines, Adenosine-Deaminase	8	M				
AP fungicides Anilino-Pyrimidines	9	M	H			
QoI fungicides Quinone Outside Inhibitors (strobilurins)	11	H			M	
PP fungicides Phenyl Pyrroles	12		H	M		
Aza-naphthalenes	13	M				
KRI fungicides KetoReductase Inhibitors (SBI Class III)	17		H			
CCA fungicides Carboxylic Acid Amides	40					
Multisite fungicides	M				L	

Risk of resistance: VH – very high; H – High; M – medium; L – low

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<p>This leaflet and further information on resistance are available at https://ahdb.org.uk/knowledge-library/the-fungicide-resistance-action-group-frag-uk</p>	<p>Published March 2022 © FRAG-UK 2022</p>



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Fungicide resistance management in soft fruit