Factsheet 07/14 (a revision of 19/02)
(HDC projects HNS/PO 190, PO 014, PC 230, PC 143 and PC 38)

Protected Ornamentals

Control of the important leaf and root diseases of pansy and viola

Andrew Jackson, (ex) Stockbridge Technology Centre (STC), Martin McPherson, STC and Wayne Brough, (ex) ADAS, updated by Martin McPherson, STC

This factsheet collates information from several sources to provide guidance on the biology and control of the various leaf and root diseases of pansy and viola. Information is provided on disease recognition and the basic biology of each pathogen to assist in the selection of the most appropriate cultural and chemical control strategies, thereby minimising the risk of crop damage by inappropriate fungicide use and reducing the potential for fungicide resistance development.

Action points

- Ensure nursery employees are familiar with the disease symptoms described in this factsheet.
- Examine bought-in plant material and monitor growing crops to ensure early detection of any disease symptoms.
- Where unusual symptoms are found, act quickly to isolate affected plants and if necessary submit a sample to a diagnostic plant clinic for identification purposes.
- Dispose of any infected plant material into sealed bins or bags to prevent pathogen spread.
- Minimise leaf wetness by irrigating crops early in the day so that foliage dries before the onset of evening.
- Provide good air circulation within plant canopies by appropriate plant spacing and structure ventilation.
- Disinfect production areas on a regular basis to minimise any background pathogen pressure.
- Devise and use an effective disease control programme using both cultural and biological and/or chemical treatments, the latter ideally applied as protectants, to prevent disease development. Consider the risk of pathogen resistance and alternate products from different fungicide groups.
- Review the control programme annually to take account of changes to fungicide availability.

1. A range of pansy varieties in commercial production

Background

Pansies and violas are now arguably the most important bedding plant species grown in the UK, being produced almost all-year-round. However, they are not trouble-free crops being prone to a number of foliar pathogens including downy mildew, powdery mildew and leaf spot diseases and a range of root and stem rots such as black root rot (*Thielaviopsis basicola*), and those caused by *Pythium* and *Phytophthora* species.

Whilst losses due to such diseases vary from season to season, it is not uncommon for some nurseries to lose up to 5-10% or more of specific batches of plants.

Many, if not all, of the pathogens are influenced by the prevailing weather or environmental conditions. Some of the pathogens, such as downy mildew, *Pythium* and *Phytophthora,* are more common in the spring and autumn due to their propensity for infection during periods of free water either on the foliage or in the substrate. Other pathogens, like powdery mildew, prefer a drier climate so tend to be more prevalent during the summer and early autumn. The presence of any one of these pathogens could potentially render a crop unmarketable or at the very least necessitate extra handling costs to replace diseased or dying plants by hand.

Disease symptoms, development and spread; pathogen survival and control

Downy mildew

Downy mildew caused by *Peronospora violae* is one of the most common and destructive diseases of pansy and viola. Like most downy mildew pathogens, *P. violae,* is host-specific and will not cross-infect other bedding plant species. It usually appears during the spring or autumn when weather conditions favour infection. Under warmer and drier summer conditions it can be relatively uncommon as the pathogen requires a cooler period with prolonged leaf surface moisture for infection.

Disease symptoms

On both pansy and viola the pathogen produces dull yellowish or grey-green blotches on the upper leaf surface but the fungus itself usually only appears on the underside of leaves, as sporulation occurs, so it is important to inspect the lower leaf surface regularly. Downy mildew pathogens in general can vary in colour and this can cause some confusion when attempting to diagnose the problem. In the case of both pansy and viola, the colour of the fungus on the leaf under-surface may start off white in appearance, but it then turns a brownish colour on sporulation. The leaves of infected plants also often roll downwards at the margins. Affected plants suffer from a lack of vigour, delayed flowering and reduced growth.

2. **Established infection of downy mildew on pansy showing the dull yellowish blotches on the upper leaf surface and the brownish fungal growth on the underside of the leaf**

Disease development, spread and pathogen survival

Infection and sporulation by *P. violae* is favoured by cool weather, high humidity levels and free water on the leaves of plants. The latter is essential for infection. The spores are disseminated on air currents but they can also be spread by water-splash. Intermittent periods of dryness can aid spore dispersal as the stalks on which the spores are produced twist around as they dry out. Equally, manual activity or even air circulation with fans in the glasshouse are sufficient to dislodge and disseminate the spores. Once released, the spores require a period (approximately four to five hours) of leaf surface moisture for successful germination and leaf infection.

3. **Close up of the dense mat of 'velvet-like' spores on the underside of the leaf**

Many downy mildew fungi also produce thick-walled resting spores in infected leaf or stem tissues. These tend to be fairly resilient to extremes of temperature and moisture levels so can serve as a means of survival during periods when crops are not present.

Downy mildew control

Downy mildew can be extremely difficult to eradicate once the disease is established and therefore preventative measures to stop infection occurring in the first instance are extremely important. Simple approaches like changing irrigation programmes to avoid prolonged leaf wetness can have a profound impact on infection potential, thus reducing the need for any spray applications.

Given the air-borne nature of downy mildew and the potential damage that can be caused if infection is not controlled early, a routine protectant spray programme should be applied when conditions are conducive to the disease. This is usually during the spring and autumn periods when the weather is cool and humidity levels are high as this allows free moisture to persist on leaves for sufficient time for the spores to germinate and infect the plant.

A full list of approved fungicides with known or expected activity against downy mildew and other diseases is presented in Tables 1 and 2 (see the pull out sheets in the pocket at the back of the factsheet). As the pathogen is prone to resistance development it is important to alternate products from different fungicide groups rather than relying on the repeated use of the same product or products from one group.

Powdery mildew

Powdery mildew, caused by *Podosphaera violae* (formerly *Sphaerotheca macularis)* is not to be confused with downy mildew especially as the conditions for infection and spread and the control measures for the two organisms are very different. Powdery mildew fungi like downy mildew fungi however, are extremely common pathogens and quite host-specific so cross-infection between different bedding plant species is unlikely. Pansy and viola cultivars differ in their relative susceptibility to powdery mildew so it is possible to select out and avoid those that are particularly prone.

Disease symptoms

Infection starts, unlike the downy mildews, on the upper leaf surface as small discrete, faint white patches that consist of numerous thread-like hyphae and spores of the causal fungus *Podosphaera violae*. Using a hand lens the hyphae can be seen radiating outwards from a central infection point on the leaf. These patches increase in size and lesions merge until the entire leaf surface is covered by the white 'powdery' fungus.

4. Early symptoms of powdery mildew on the upper leaf surface of pansy

Disease development, spread and pathogen survival

Infection by the pathogen is favoured by warm dry weather although leaf surface moisture is still required initially for spore germination and infection. Once initiated, infection progresses internally in the leaf tissues irrespective of the external conditions. The spores are disseminated on air currents to initiate new infections either on the same plant, the same crop or other pansy or viola crops some distance away.

Many powdery mildew fungi have two spore stages in the life cycle and, on some crop species, overwintering spore containing structures may be seen on old powdery mildew lesions. These structures can tolerate extremes of temperature and moisture levels so can survive periods when crops are not present. When mature, these structures release spores into the air which can travel long distances to infect crops.

Powdery mildew control

As a general rule, powdery mildew develops on the upper surface of the leaves whereas downy mildew develops on the lower leaf surface; occasionally, however, powdery mildew can also be found on the lower surface. Correct identification is important to ensure the relevant fungicide products are applied. For confirmation of the disease, plant samples can be submitted to a diagnostic plant clinic.

Cultural control measures are very important, but in this case the pathogen prefers warm drier conditions for epidemic development so it is more likely to be a problem during the summer and early autumn period. As some powdery mildews also have weed hosts it is advisable to actively maintain an effective weed control programme in and around the nursery.

The range of effective plant protection products that are available for powdery mildew control is very different to that for downy mildew control but, for similar reasons, it is important to devise an alternating spray programme and avoid reliance on a single product for long-term control. Tables 1 and 2 summarise a range of products with known or expected activity against powdery mildew fungi. In this case, biofungicide products are available and should, where possible and practicable, be included.

Ramularia leaf spot

Two species of *Ramularia* (*R. lactea* and *R. agrestis*) have been reported causing leaf spotting on pansy and viola. Both species of the fungus can spread rapidly through crops but are thought to be host-specific so shouldn't pose a threat to other plant genera on the nursery.

Disease symptoms

Initial symptoms usually occur as distinct, small dark leaf spots often on the older lower leaves of plants. *R. lactea* tends to produce small, purplish-brown 'greasy' spots enlarging with age.

5. Small purplish-brown 'greasy' leaf spots are usually associated with infection by *Ramularia lactea*

6. Characteristic 'papery, scorch-like' leaf spots are more often associated with infection by *Ramularia agrestis*

R. agrestis on the other hand tends to cause small tan coloured spots initially, which begin to merge or coalesce causing a light brown necrosis which is 'papery' or 'scorched' in appearance. These symptoms can be mistaken for damage caused by chemical scorch or stress as a result of under-watering. It is possible for both symptom types to occur in the same crop. Plant clinic diagnosis is usually necessary for accurate identification of the disease.

Disease development, spread and pathogen survival

The pathogen is usually most prevalent during cool, wet weather and is most commonly found during the autumn. The fungus produces and liberates a large number of spores from infected leaves. These are dispersed on air currents or by water splash. The pathogen is likely to survive on infected plants including leaf litter.

Ramularia leaf spot control

Crops need to be monitored regularly, especially during the early stages of production, for the tell-tale signs of leaf spotting on the older leaves. Where found, early intervention with a suitable fungicide is advisable to help prevent epidemic development. Tables 1 and 2 summarise a range of fungicides with expected activity against this pathogen. There is a risk of resistance development in the pathogen population so an alternating fungicide programme as outlined previously is advisable.

Other leaf spot diseases

Alternaria violae and *Cercospora violae* (and possibly other species) can also give rise to symptoms of leaf spotting on pansy and viola crops, they can sometimes also be found in association with *Ramularia* on crops.

Disease symptoms

The initial symptoms of *Alternaria violae* are greenish yellow to light buff lesions which can be water-soaked, later the lesions develop a brown centre. Concentric rings of light and dark brown become apparent as the spots enlarge and they can merge to form large necrotic areas. In the case of *Cercospora violae*, symptoms appear as a dry brown or greyish spot; these darken with the production of spores and may have a purplish border. Lesions may coalesce into a larger necrotic area. Plant clinic diagnosis is usually necessary for accurate identification of these diseases as control measures can differ from *Ramularia*.

Disease development, spread and pathogen survival

As for *Ramularia*, these pathogens are usually most prevalent during cool, wet weather and are most commonly found during the autumn period.

Alternaria and *Cercospora* control

Crops need to be monitored regularly, especially during the early stages of production, for signs of leaf spotting on the older leaves. Where found, application of a suitable fungicide is advisable to help prevent further disease development. Suggested fungicides with reported activity are listed in Table 2, further advice on fungicide suitability should be sought from a qualified consultant or representative.

Black root rot

This is a very important pathogen of pansy and viola crops and is seen very commonly on nurseries, often at moderate to severe levels, during the summer months affecting crop performance. However, it is often misdiagnosed and incorrectly treated as a result, thus compounding the problem. The disease is caused by the soil-borne fungus *Thielaviopsis basicola.* Unlike the mildews, this fungus is not host-specific and occurs commonly on many plant genera.

Disease symptoms

The fungus attacks the roots of the plant so its effects are not initially obvious. Infected plants grow poorly and often develop a purpling of the older leaves, which may be mistaken for those of a nutrient deficiency, especially during the early stages of disease development. As the disease progresses, the roots become heavily colonised by the fungus and eventually decay. When infection is severe, plants become severely stunted and may rot off at the substrate surface.

Where black root rot is suspected, it is essential that the roots are examined closely for root discoloration and to do this effectively the substrate has to be thoroughly washed from the roots prior to inspection using a hand lens or similar. If any roots are found to be black in colour this is indicative of infection by *Thielaviopsis* but a confirmatory diagnosis in a plant clinic facility may still be advisable. If instead the roots, whilst still decayed, are a pale-brown colour this is more indicative of infection by *Pythium*. Again, laboratory diagnosis is recommended to ensure appropriate control measures are used.

7. Early symptoms of black root rot (*Thielaviopsis basicola*) showing 'nutrient-like' deficiency symptoms (right)

8. **Root symptoms in plants affected by *Thielaviopsis basicola***

Disease development, spread and pathogen survival

The fungus produces two spore types on infected plants. One type is relatively short-lived but can aid in the rapid local spread of the pathogen whilst the other is black and thick-walled and found in infected roots and is capable of long-term survival and re-infection.

The disease develops under a wide range of conditions though it tends to be more severe where there is a high substrate moisture level coupled with poor aeration. The pathogen grows best at around 17 to 23°C and at a pH of 5.7 to 5.9. The thick-walled spores of the fungus can survive in contaminated substrate, in dried roots on trays, pots and matting and on previously used non-disinfected trays and pots.

The fungus can be spread locally during irrigation via water-splash, on fragments of old infected plant debris and on infected plants themselves due to the persistence of the thick-walled spores, and over longer distances via wind-blown contaminated substrate dust. Spore dissemination by sciarid flies has also been demonstrated.

Black root rot control

Effective hygiene measures are extremely important in terms of preventing root infection by *Thielaviopsis*. Overwatering should also be avoided as the disease is favoured by waterlogging or overly wet growing media. Where the pathogen is known to occur on a nursery, a routine protectant fungicide programme is advisable. Unfortunately, fungicides previously known to have activity against this pathogen have recently been withdrawn from use and few alternatives are currently available with known activity.

An HDC funded research project (HNS/PO 190) is seeking to identify alternative products for the control of this important root disease. A complete list of fungicides with expected activity against *Thielaviopsis basicola* is outlined in Tables 1 and 2.

Other root and stem rot diseases

Pythium and *Phytophthora* species can be troublesome in both pansy and viola crops. *Pythium* species tend to be more common, particularly on young seedlings during the propagation stage. This fungus-like organism infects the root tissues, often when the plant is weakened by some other factor, causing further loss of vigour.

In the last few years there have been an increasing number of reports of stem base rotting in pansy and viola and, where samples have been investigated in the plant clinic, a *Phytophthora* species has been isolated consistently. In this case, the roots have tended to be largely unaffected and this helps differentiate the infection from *Pythium* species. In both cases, laboratory examination is necessary for accurate diagnosis.

Disease symptoms

Pythium species cause a generalised pale-brown discoloration of the root tissues, often the outer tissues slough off when they are examined. In the early stages of infection the fine roots become infected and the disease progresses to the main roots reducing root function and overall plant vigour.

In the case of the *Phytophthora* found on pansy and viola the roots themselves show little or no discoloration especially in the early stages of the disease. Instead, often the first sign of infection is when the plant collapses due to a severe orange-brown decay of the stem base tissues; by which time it is too late to take intervention action. Examination at a plant clinic is necessary for accurate diagnosis.

Disease development, spread and pathogen survival

In both cases, these pathogens tend to infect the host via motile spores in contaminated water, lateral spread from plant to plant occurs by water splash and in water films at the base of pots in trays. Similarly both *Pythium* and *Phytophthora* species produce thick-walled resting spores either in the root tissues or in the stem base tissues and these can survive adverse climatic conditions to re-infect plants when the conditions are more conducive to infection.

Pythium and *Phytophthora* control

In many respects the control of these root and stem base pathogens is similar to that for downy mildew as they are related oomycete pathogens (see Tables 1 and 2). However, in the case of *Pythium* and *Phytophthora* species the target is the root and stem base tissues whereas for downy mildew the primary target is the foliage. Therefore, the application method is important along with the mode of action of the product itself. Products with systemic activity applied as either a high volume foliar spray or drench to the substrate are likely to be effective against both pathogens. It is important to check the approval status of each product to ensure the method of application proposed is approved, as this is a statutory condition of approval, whereas the target pathogen is not. The same guidance in terms of resistance management noted previously also applies with these pathogens.

General advice for effective disease management on the nursery

Cultural control

Careful management of environmental conditions is one of the key factors in avoiding serious disease outbreaks on the nursery and this is especially relevant in the case of foliar pathogens such as *Peronospora* (downy mildew), *Ramularia* and other leaf spot causing pathogens. When coupled with other suitable cultural control methods, infection pressure should be reduced, minimising the need for intensive fungicide applications.

- Thoroughly clean the relevant glasshouse area, including paths, benches and standing areas of crop debris and substrate dust before the arrival of any new plants. Remove any weeds that may be growing under the benches as these can harbour pests and possibly pathogens.
- Where possible, use new plug trays, packs and pots, if exposed to dust, wash and disinfect them prior to use.
- On arrival on the nursery, if possible, place all seedlings and other young plants in a temporary holding or quarantine area until they can be inspected and demonstrated to be disease-free. Check the foliage for leaf spot diseases and downy mildew remembering to look at the underside of the leaves for the latter pathogen. Remove a random selection of plants from the plug tray so that the roots can be examined carefully. Check for any orange-brown or black discoloration on the roots or stem base tissues which may indicate disease.
- If any foliar disease or root discoloration is found, either isolate the plants whilst a diagnosis is made and suitable treatment regime applied or reject the consignment altogether. As some pathogens may be latent in the early stages of infection, it is important to continue to monitor crops on a weekly basis for early disease detection. Use plant clinics for early diagnosis as necessary.

- Maintain a high level of nursery hygiene during the production and marketing process. Ensure raw materials (including water, substrate, pots, trays etc.) are correctly stored and covered to avoid dust contamination.
- Avoid standing plug trays on the glasshouse floor where there is contact with soil or other debris as this will significantly increase the risk of root infection. Keep the base of plug trays off bench tops and matting where possible as the root damage caused when they are prised off is likely to predispose the plants to root infection.
- Do not hold plants in plug trays for any longer than necessary.
- Monitor environmental conditions carefully – use ventilation, fans and, where necessary, pipe heat to reduce humidity within the crop to control downy mildew and other foliar pathogens. It is particularly important to reduce to a minimum the time when free water is present on the leaf surface as many pathogens require a period of leaf wetness for spore germination and infection to occur.
- Avoid overhead irrigation if possible, particularly in the evenings when prolonged leaf wetness can result. Check the growing structure for leaks, especially around the gutters, or other areas where condensation drips on to plants and rectify these as quickly as possible to avoid wet areas from where pathogens can subsequently be disseminated.
- Ensure crop watering is uniform, that substrate drainage is adequate, that substrate pH levels are around 6.0 and try to avoid high temperatures or rapid temperature fluctuations as such plant stress can exacerbate root diseases such as black root rot.
- If foliar or root pathogens do occur in a crop, dispose of severely infected plants and associated substrate directly into bags to avoid pathogen dispersal throughout the remainder of the crop and the nursery. Ensure that there is a thorough clean-up once infection has been detected, disposing of all fallen leaves and other debris that may otherwise allow pathogen carry-over.

Chemical control

General disinfectant strategy

Careful use of disinfectants to routinely clean glasshouses, production areas, recycled plug trays, containers and trolleys, will reduce the incidence of pathogen infection in crops. As the various disinfectant products tend to be inactivated rapidly in the presence of large quantities of organic matter, it is advisable to remove as much substrate and debris as possible by physical cleaning, using water with added detergent prior to the disinfectant treatment. There is a known risk of infection from *Thielaviopsis basicola* from plug trays when they are re-used. For more information on the use and efficacy of disinfectants refer to HDC Factsheet 03/14 'Use of chemical disinfectants in protected ornamental production'.

General crop protection strategy

Whilst a number of fungicides possess label recommendations for use on protected ornamental plants, there are a large number with Extensions of Authorisation for Minor Use (EAMUs) applicable to various ornamental crops and others which can still be used via the Long Term Arrangements for Extension of Use (LTAEU). It is important to note that such EAMU and LTAEU product uses are entirely at the growers own risk.

The over-riding strategy in the use of fungicides should be to:

1. Only apply fungicides that are safe to the crop, spray operator, workers and the environment.
2. Use the minimum number of treatments to provide effective control, ideally alternating between multi-site protectant fungicides where available such as chlorothalonil, mancozeb or thiram in the early stages of crop development and site-specific eradicant products once a specific pathogen has been identified. (Note however that products containing only chlorothalonil or only mancozeb are no longer permitted for use under protection).
3. Devise a programme that does not encourage resistance development in the pathogen population, this usually means restricting the total number of applications of a particular active ingredient or group of active ingredients within the same fungicide group.

To achieve effective disease control it is recommended that:

- Crops are regularly inspected and monitored for diseases and other problems and spray programmes are adjusted as necessary according to the outcome of these crop inspections.
- Protectant fungicides are applied to avoid any build up of disease, particularly where there is a history of disease outbreaks on the site.
- Full use is made of multi-site protectant fungicides, where available, as these are less prone to resistance development.
- Eradicant fungicides are applied at the very early stages of disease development to provide more effective control and minimise the risk of resistance development. It is important not to allow the pathogen to build up within the crop making disease control more difficult.
- Spray programmes are devised alternating products based on their fungicide groups (see Table 1 for a listing of products by their Fungicide Resistance Action Committee (FRAC) coding or fungicide group).
- The method of application, spray pressure and water volume are adjusted in order to treat the lower as well as the upper leaf surface whilst trying to avoid spray run-off into the substrate.
- The approved dose rate, either from the manufacturers label or the Extension of Authorisation for Minor Use (EAMU) document, is followed.
- The risk of crop damage from the intended fungicide treatments is assessed prior to use.

It is generally suggested that:

- Before using a new product a few plants are test treated first to check for potential phytotoxicity as some species/varieties are likely to be more sensitive than others.
- To minimise leaf scorch, any spray application is not undertaken in hot, sunny conditions.
- As appropriate, a copy of the product label or the EAMU document is obtained and complied with.

pocket for insert to go here

Disease diagnosis

Some example plant clinics are listed below:

Fera, Sand Hutton, York, YO41 1LZ. Website: www.fera.defra.gov.uk, e-mail: plantclinic@fera.gsi.gov.uk.

Plant Health Solutions Ltd., Ryton Gardens, Wolston Lane, Coventry, CV8 3LG. Website: www.planthealth.co.uk, e-mail: clinic@planthealth.co.uk.

STC, Cawood, Selby, North Yorkshire YO8 3TZ. Website: www.stc-nyorks.co.uk, e-mail: enquiries@stc-nyorks.co.uk.

The Plant Clinic, East Malling Research, New Road, East Malling, Kent ME19 6BJ. Website: www.emr.ac.uk/plantclinic, e-mail: Plant.Clinic@emr.ac.uk.

Further information

HDC Factsheets and publications

- HDC Factsheet 03/14. 'Use of chemical disinfectants in protected ornamental production'.
- HDC Factsheet 01/13. 'Practical measures to prevent and manage insecticide, fungicide and herbicide resistance for horticultural crops'.
- HDC Factsheet 10/07. 'Guidelines on nursery hygiene for outdoor and protected ornamental crops'.
- HDC Factsheet 17/04. 'Control of *Pythium*, *Phytophthora* and *Rhizoctonia* in pot and bedding plants'.
- HDC publication 'Pot and bedding plant crop walkers' guide'.

HDC Grower summaries and reports

- HDC Project HNS/PO 190: 'Treatments for the control of black root rot in bedding plants and hardy nursery stock'.
- HDC Project PO 014: 'Black root rot in containerised subjects – Chemical and biological options for control (review)'.
- HDC Project PC 230: 'Detection and control of downy mildew on ornamentals'.
- HDC Project PC 143: 'Bedding plants: Evaluation of fungicides for the control of black root rot and downy mildew'.
- HDC Project PC 38 (and related projects): 'Black root rot of pansy and other bedding plants: An investigation of control measures, including fungicide screening'.

Acknowledgements

The author would like to acknowledge the support from members of the British Protected Ornamentals Association (BPOA) in preparing this updated factsheet and also Dr Tim O'Neill, ADAS and Wayne Brough, HDC for technical comments.

Image credits

All images courtesy and copyright of Dr G M McPherson, STC Ltd except image 1 courtesy and copyright of Wayne Brough, HDC and image 8 courtesy and copyright of ADAS.

£8.75
where sold

HDC is a division of the Agriculture and Horticulture Development Board (AHDB).

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

HDC **Horticultural Development Company**

Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T: 024 7669 2051
E: hdc@hdc.org.uk
Twitter: @HDCtweets

www.hdc.org.uk

Table 1. Fungicides approved for use on protected and outdoor ornamental crops

Example commercial product	Active ingredient(s)	Mode of action *	Fungicide group	FRAC code	Approved for use		Approval status and additional comments
					Outdoor	Protection	
Amistar	Azoxystrobin	Systemic, translaminar and protectant	QoI	11	√	√	EAMU 0443/09. (Expires 30/06/2024)
AQ10	*Ampelomyces quisqualis* strain AQ10	Biocontrol	Microorganism	Not applicable	-	√	EAMU 1324/12. (Expires 31/01/2020)
Bravo 500	Chlorothalonil	Protectant	Chloronitrile	M5	√	-	EAMU 1130/11. (Expires 03/03/2015)
Bumper	Propiconazole	Systemic, curative and protectant	DMI	3	√	√	EAMU 0707/09. (Expires 31/07/2019)
Cercobin WG	Thiophanate-methyl	Systemic	MBC or benzimidazole	1	√	√	EAMU 1887/11. (Expires 20/04/2020). Drench treatment only
Clayton Concorde	Bupirimate	Systemic	Hydroxy pyrimidine	8	√	√	On-label approval for protected and outdoor ornamentals. (Final use date 31/12/2021). Important to check recommended crop uses and approved methods and rates of application
Dithane 945	Mancozeb	Protectant	Dithiocarbamate	M3	√	-	EAMU 2057/12 and 2058/12. (Expires 31/12/2018)
Fenomenal	Fenamidone + fosetyl-aluminium	Systemic and protectant	QoI + phosphonate	11 + 33	√	√	On-label approval for use as a drench treatment in ornamental plant production. EAMU 1990/13 for use as a spray. (Final use date 31/01/2019)
Flexity	Metrafenone	Curative and protectant	Benzophenone	U8	√	-	EAMU 2850/08. (Expires 31/12/2019)
Folio Gold	Chlorothalonil + metalaxyl-M	Systemic and protectant	Chloronitrile + phenylamide	M5 + 4	√	√	EAMU 0032/12. (Expires 30/06/2018)
Fortress	Quinoxyfen	Systemic and protectant	Azanapthalene	13	√	√	EAMU 2852/08. (Expires 31/10/2019)
Fubol Gold WG	Mancozeb + metalaxyl-M	Systemic and protectant	Dithiocarbamate + phenylamide	M3 + 4	√	√	EAMU 0217/12. (Expires 31/12/2018)
Galileo	Picoxystrobin	Protectant	QoI	11	√	-	EAMU 2855/08. (Expires 30/04/2019)

Table 1. Fungicides approved for use on protected and outdoor ornamental crops continued

Example commercial product	Active ingredient(s)	Mode of action *	Fungicide group	FRAC code	Approved for use		Approval status and additional comments
					Outdoor	Protection	
Infinito	Fluopicolide + propamocarb-hydrochloride	Systemic and protectant	Benzamide + carbamate	43 + 28	√	-	EAMU 0952/13. (Expires 31/12/2021)
Invader	Dimethomorph + mancozeb	Systemic and protectant	CAA + dithiocarbamate	40 + M3	√	-	EAMU 0109/12. (Expires 26/01/2015)
Octave	Prochloraz	Eradicant and protectant	DMI	3	√	√	On-label approval for use on ornamentals. (Final use date 31/12/2021). Drench treatment permitted
Paraat	Dimethomorph	Translaminar	CAA	40	-	√	EAMU 2585/11. (Expires 31/03/2020)
Penzole 100	Penconazole	Antisporulant and protectant	DMI	3	√	√	On-label approval for use on ornamentals. (Final use date 31/12/2021)
Percos	Ametoctradin + dimethomorph	Systemic and protectant	QoSI + CAA	45 + 40	√	√	EAMU 0819/13. (Expires 30/09/2014)
PlantTrust	Fosetyl-aluminium	Systemic	Phosphonate	33	√	√	On-label approval for ornamental production as substrate incorporation. (Final use date 31/07/2016). Restrictions on use apply
Potassium carbonate	Potassium hydrogen carbonate	Curative	Not applicable	Not applicable	√	√	Approved for use on non-edible crops. (Final use date 31/08/2019)
Previcur Energy	Fosetyl-aluminium + propamocarb-hydrochloride	Systemic and protectant	Phosphonate + carbamate	33 + 28	√	√	EAMU 1557/11 (drench) and 1845/13 (spray). (Expires 31/10/2019). Drench treatment permitted
Proplant	Propamocarb-hydrochloride	Systemic and protectant	Carbamate	28	√	√	EAMU 3100/12. (Expires 31/03/2020)
Revus	Mandipropamid	Protectant	CAA	40	√	√	EAMU 0487/12. (Expires 31/01/2015)
Rovral WG	Iprodione	Protectant	Dicarboxamide	2	√	√	EAMU 3200/11. (Expires 30/04/2019)
Scala	Pyrimethanil	Translaminar and protectant	Anilino-pyrimidine	9	√	√	EAMU 1315/11. (Expires 30 11 2019)

Table 1. Fungicides approved for use on protected and outdoor ornamental crops continued

Example commercial product	Active ingredient(s)	Mode of action *	Fungicide group	FRAC code	Approved for use		Approval status and additional comments
					Outdoor	Protection	
Serenade ASO	*Bacillus subtillis* QST 713	Biocontrol	Microorganism	44	√	√	EAMU 0706/13. (Expires 31/07/2019)
Signum	Boscalid + pyraclostrobin	Systemic and protectant	SDHI + QoI	7 + 11	√	√	EAMU 2141/12. (Expires 31/07/2019)
Stroby WG	Kresoxim-methyl	Protectant	QoI	11	√	√	On-label approval for use on ornamentals (roses). (Final use date 20/06/2024)
Subdue	Metalaxyl-M	Systemic	Phenylamide	4	√	√	On-label approval for use on ornamentals (soil-grown and container-grown plants). (Final use date 30/06/2018). Drench treatment only
Swift SC	Trifloxystrobin	Protectant	QoI	11	√	-	EAMU 2882/08. (Expires 31/01/2019)
Switch	Cyprodinil + fludioxonil	Systemic and protectant	Anilino-pyrimidine + phenyl-pyrrole	9 + 12	√	√	On-label approval for protected and outdoor ornamentals. (Final use date 01/11/2014). Important to check recommended crop uses and approved methods and rates of application
Systhane 20EW	Myclobutanil	Systemic, curative and protectant	DMI	3	√	√	On-label approval for use on ornamentals. (Final use date 31/12/2021)
Takumi SC	Cyflufenamid	Curative and protectant	Phenyl-acetamide	U6	√	√	EAMU 1294/13. (Expires 21/08/2016)
Thianosan DG	Thiram	Protectant	Dithiocarbamate	M3	√	√	On-label approval for use in ornamental plant production. (Final use date 31/12/2021)
Torch	Spiroxamine	Curative and protectant	Amine	5	√	-	EAMU 0230/13. (Expires 30/06/2024)
Valbon	Benthiavalicarb-isopropyl + mancozeb	Systemic and protectant	CAA + dithiocarbamate	40 + M3	√	-	EAMU 1513/10. (Expires 31/12/2018)
Vivid	Pyraclostrobin	Curative and protectant	QoI	11	√	-	EAMU 2884/08. (Expires 31/07/2019)

* Information from The UK Pesticide Guide 2014.

Information on fungicide availability based on the Liaison database (April 2014). The approval status of particular active ingredients and products is subject to change at short notice and growers/consultants must ensure that a particular use remains valid at the time of application.

Table 2. List of fungicides approved for use on ornamental crops and the expected[1] range of activity against important diseases of pansy and viola

Example commercial product	Active ingredient(s) and fungicide group	Anticipated activity against target disease/pathogen covered in this factsheet				
		Downy mildew (*Peronospora violae*)	Powdery mildew (*Podosphaera violae*)	Ramularia leaf spot (*Ramularia* species) and other leaf spot species (see footnote)	Black root rot (*Thielaviopsis basicola*)	Stem and root rots (*Pythium* and *Phytophthora* species)
Amistar	Azoxystrobin (11)	X	XX	XXX?[2,3]	-?	XX
AQ10	*Ampelomyces quisqualis* strain AQ10 (n/a)	-	X	-	-	-
Bravo 500	Chlorothalonil (M5)	X	X	X	X?	-
Bumper	Propiconazole (3)	-	XX	XX?	X?	-
Cercobin WG	Thiophanate-methyl (1)	-	-	XXX?	XXX?	-
Clayton Concorde	Bupirimate (8)	-	XXX	X?	-	-
Dithane 945	Mancozeb (M3)	XX	X?	-	-	X
Fenomenal	Fenamidone (11) + fosetyl-aluminium (33)	XX	-	-	-	XX
Flexity	Metrafenone (U8)	-	XX	X?	XX?	-
Folio Gold	Chlorothalonil (M5) + metalaxyl-M (4)	XXX*	X?	-	-	XXX
Fortress	Quinoxyfen (13)	-	XXX	X?	X?	-
Fubol Gold WG	Mancozeb (M3) + metalaxyl-M (4)	XXX*	X?	-	-	XXX
Galileo	Picoxystrobin (11)	X	X	X?	X?	X
Infinito	Fluopicolide (43) + propamocarb-hydrochloride (28)	XX	-	-	-	XX
Invader	Dimethomorph (40) + mancozeb (M3)	XX	-	-	-	XX
Octave	Prochloraz (3)	-	XX	XX?	XX?	-
Paraat	Dimethomorph (40)	XX	-	-	-	X
Percos	Ametoctradin (45) + dimethomorph (40)	XXX	-	-	-	XXX
Penzole 100	Penconazole (3)	-	XXX	X?	X?	-
PlantTrust	Fosetyl-aluminium (33)	X	-	-	-	XX
Potassium carbonate	Potassium hydrogen carbonate (n/a)	-	X?	-	-	-
Previcur Energy	Fosetyl-aluminium (33) + propamocarb-hydrochloride (28)	XX	-	-	-	XX
Proplant	Propamocarb-hydrochloride (28)	XX	-	-	-	XX
Revus	Mandipropamid (40)	XX	-	-	-	XX

Table 2. List of fungicides approved for use on ornamental crops and the expected[1] range of activity against important diseases of pansy and viola continued

Example commercial product	Active ingredient(s) and fungicide group	Anticipated activity against target disease/pathogen covered in this factsheet				
		Downy mildew (*Peronospora violae*)	Powdery mildew (*Podosphaera violae*)	Ramularia leaf spot (*Ramularia* species) and other leaf spot species (see footnote)	Black root rot (*Thielaviopsis basicola*)	Stem and root rots (*Pythium* and *Phytophthora* species)
Rovral WG	Iprodione (2)	-	-	X?[2]	-	-
Scala	Pyrimethanil (9)	-	X	X?	X?	-
Serenade ASO	*Bacillus subtillis* QST 713 (44)	-	X?	-	-	-
Signum	Boscalid (7) + pyraclostrobin (11)	XX	XX	X	X?	X?
Stroby WG	Kresoxim-methyl (11)	X	X	X?	X?	X
Subdue	Metalaxyl-M (4)	XXX*	-	-	-	XXX
Swift SC	Trifloxystrobin (11)	-	X	X?[3]	X?	X?
Switch	Cyprodinil (9) + fludioxonil (12)	-	X	X?	X?	-
Systhane 20EW	Myclobutanil (3)	-	XXX	X?[3]	X?	-
Takumi SC	Cyflufenamid (U6)	-	XXX	X?	-	-
Thianosan DG	Thiram (M3)	X	-	-	-	-
Torch	Spiroxamine (5)	-	XXX	X?	X?	-
Valbon	Benthiavalicarb-isopropyl (40) + Mancozeb (M3)	XX	-	-	-	XX?
Vivid	Pyraclostrobin (11)	X	X	X?	X?	X

[1] The range of expected activity against the listed target pathogens arises from several reference sources but also includes the authors personal trials experience in other crops.

[2] These fungicides have reported activity against *Alternaria violae*.

[3] These fungicides have reported activity against *Cercospora violae*.

XXX Good control expected, subject to the presence of resistant strains.

XX Moderate control expected, subject to the presence of resistant strains.

X Some disease suppression may be expected but not a primary target for this fungicide.

- No control expected (or no data available).

? Suggests some caution required due to limited knowledge of the expected efficacy of the specific fungicide.

* Resistant strains of the pathogen population are known to occur and control may be compromised.

Pesticides applied to ornamental plants under the Extension of Authorisation for Minor Use (EAMU) and via the Long Term Arrangements for Extension of Use (LTAEU) are undertaken at the grower's own risk. Before use, a copy of the product label or the EAMU notice of approval must be obtained and complied with.

Regular changes occur in the approved status of pesticides arising from changes in pesticide legislation or for other reasons. For the most up to date information check with your professional supplier, with the Information Section at the Chemicals Regulations Directorate (CRD) Tel: 08459 33 55 77, e-mail: pesticides&detergents@defra.gsi.gov.uk or website: www.pesticides.gov.uk or via the Liaison pesticide database on the HDC website.

Always read the label or the EAMU notice of approval. Use pesticides safely. Check with suppliers for full details of any side effects on biological control agents where they are being deployed as part of an integrated pest management (IPM) programme.

Mention of a product does not constitute endorsement, nor does failure to mention products imply criticism.