FACTSHEET 09/16

Hardy Nursery Stock

AHDB HORTICULTURE

AHDB Horticulture Project HNS 191

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Control of heuchera rust

This factsheet provides information concerning heuchera rust, its probable life cycle, typical plant symptoms and appropriate cultural and chemical control guidelines based on that known for other rust diseases.

Figure 1. A large-scale, commercial crop of various heuchera varieties

Action points

- Reject any incoming plant material showing symptoms of rust infection.
- Aim to quarantine plants (or a sample of each variety) for a month after delivery, without fungicide application, in order to allow symptoms to become visible if the disease is present.
- On a weekly basis, as part of any crop walking activity, closely inspect the foliage of all batches of heuchera on the nursery for rust pustule formation, especially in the spring and autumn.
- Remove infected leaves to prevent spores from the pustules infecting healthy tissue and to help return the plant to good health, as infection does not spread systemically.
- Remove old, senescing leaves from plants in the autumn to help prevent the fungus from overwintering in them, and also to open up the canopy so that environmental conditions are less favourable for infection.
- If possible, create a break in heuchera production to reduce the chance of infection continuing from year to year.
- Avoid overhead irrigation, or, if this is not possible, irrigate plants in the morning so that the leaf surfaces dry out rapidly preventing infection by the rust spores.
- Provide adequate ventilation within growing structures to speed up leaf surface drying on the crop.
- If rust is observed on protected crops, if able to do so, raise temperatures to above 21°C during the day, and 15°C at night to produce conditions less conducive to disease development.
- Use a protectant fungicide programme, especially if overhead irrigation is applied, or following periods of rain on outdoor plants that will favour infection.
- Consider discontinuing production of the more disease-prone varieties.

Background

Heuchera rust (*Puccinia heucherae*) is widespread in both the USA and East Asia, but, until relatively recently, only *Puccinia saxifragae* had been seen on plants in the closely related *Saxifraga* genus in the UK. *P. heucherae* was first reported in 2004 in UK gardens, and then on commercial nurseries during the following year. *Heucherella* species (heuchera x tiarella), have also been confirmed by molecular testing within AHDB Horticulture-funded project HNS 191 to be affected by *P. heucherae*, but tend to be less susceptible to the disease. *Tiarella* species have not yet been observed with rust infections.

Rust disease has been reported on commercial crops of heuchera across much of the UK. A range of heuchera species including *H. americana*, *H. micrantha*, *H. sanguinea* and *H. villosa* and also hybrids have been reported with the disease. In 2014 and 2015, fewer cases of heuchera rust were seen in the UK than in previous years, this may be a result of increased grower awareness leading to targeted control measures, including the implementation of protectant and curative fungicide programmes.

Disease symptoms

Infection generally results in the development of small circular brown spots, sunken depressions or raised bumps on the upper leaf surface. These symptoms correspond to raised, orange-brown spore-producing pustules on the underside of the leaves. These pustules sometimes break through to the upper leaf surface. Young leaves may become puckered, and distorted and heavily infected; older leaves may turn brown and shrivel. Leaf and flower stalks may also be affected by the disease. Although most obvious on leaves uppermost in the crown, older leaves within the canopy can often reveal pustules on their undersides. Spotting and pustules tend to be much more visible on varieties with lighter coloured leaves.

Pustules can pepper the leaf surface, or coalesce to form larger individual pustules. Pustules do not usually enlarge much beyond the initially formed lesion, although sometimes 'daughter pustules' form in a ring around the original pustule. The pustules are formed of a mass of orange-brown resting spores (teliospores). These orange-brown spores remain attached to the plant but the infection potential of them is currently unknown. Under humid conditions however, they produce smaller infective spores (basidiospores) which are visible as a greyish-white colour on the surface of the pustule (Figure 2). These tiny spores are spread on air currents and by water splash. The orange-brown pustules often become less conspicuous over the year as the spores darken and can become detached as the tissue under the pustule decays. Old infection spots may fall out giving a shot-hole appearance to the leaf. The remaining necrotic spots and dark-rimmed holes can often be mistaken for symptoms of other diseases (Figure 3).

Within commercial production, if plants do not receive suitable fungicide applications as part of a production programme, pustules may be seen throughout the year, with new symptoms developing anywhere on the plant at any growth stage. Fresh pustules tend to erupt on both young and older leaves from March to May, and then again from August to November and remain for the life of the leaf. Fresh pustules have been seen

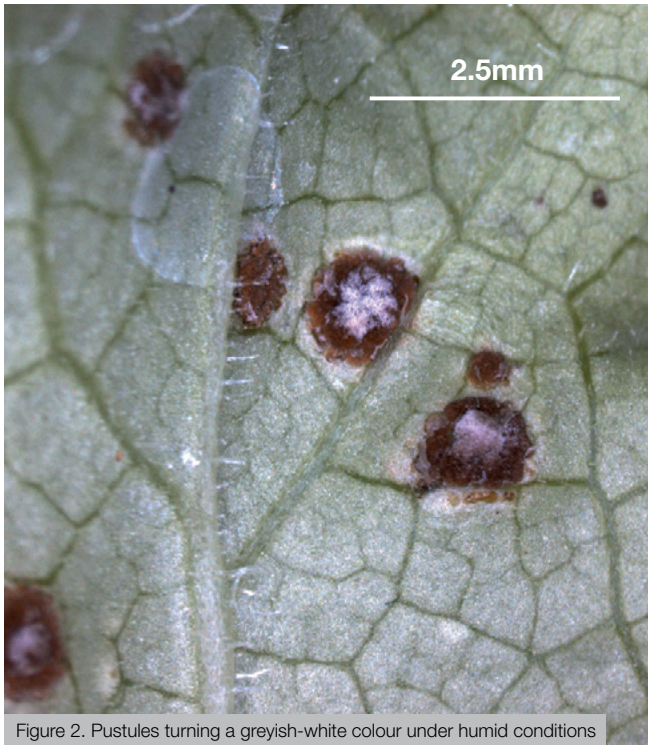

Figure 2. Pustules turning a greyish-white colour under humid conditions

within a fortnight of ceasing fungicide programmes in October, but it is not known whether such plants were infected after ceasing the fungicide programme, or whether the fungicides applied simply suppressed pustule eruption.

Plants can be infected by heuchera rust and show no pustules; the development of pustules in the spring, on previously symptomless overwintered plants, may result from some internal or external parameter triggering symptom expression.

Life cycle of the fungus

Rust fungi grow within the living tissue of plants. Although rust fungi do not rapidly kill plant tissue, severe infections can cause tissue to collapse and die prematurely. Other rust species have been shown to have complex life cycles with as many as five reproductive stages (sometimes requiring another host plant for life cycle completion). Observations of *P. heucherae* during AHDB Horticulture-funded project HNS 191 and literature sources indicate that this rust is likely to have only two spore types: orange-brown resting spores or teliospores, and much smaller white infective basidiospores (individually invisible to the naked eye). Only heuchera and heucherella are thought to be hosts for this pathogen.

The probable life cycle of heuchera rust begins when infective spores (basidiospores) land on the surface of a host plant (Figure 4). These spores germinate and grow inside the leaf. This period of fungal growth inside the leaf is known as latent or non-symptomatic infection and can last for five weeks or more. The fungus then forms a base from which stalked orange-brown resting spores are produced on the underside of leaves, or on leaf and flower stalks. Hundreds of resting spores form inside each rust pustule. The spores have thick walls and can survive for long periods on plant material through temperature and humidity extremes. Under the correct environmental conditions (high humidity), these resting spores germinate and produce infective spores. The spores are released and dispersed by wind and rain to infect new plant tissue or adjacent plants, but desiccate rapidly in the absence of free water or in dry conditions.

Figure 3. Lower and upper leaf symptoms on (from top to bottom) *Heuchera* 'Key Lime Pie' and *H.* 'Mahogany', and *Heucherella* 'Stoplight'

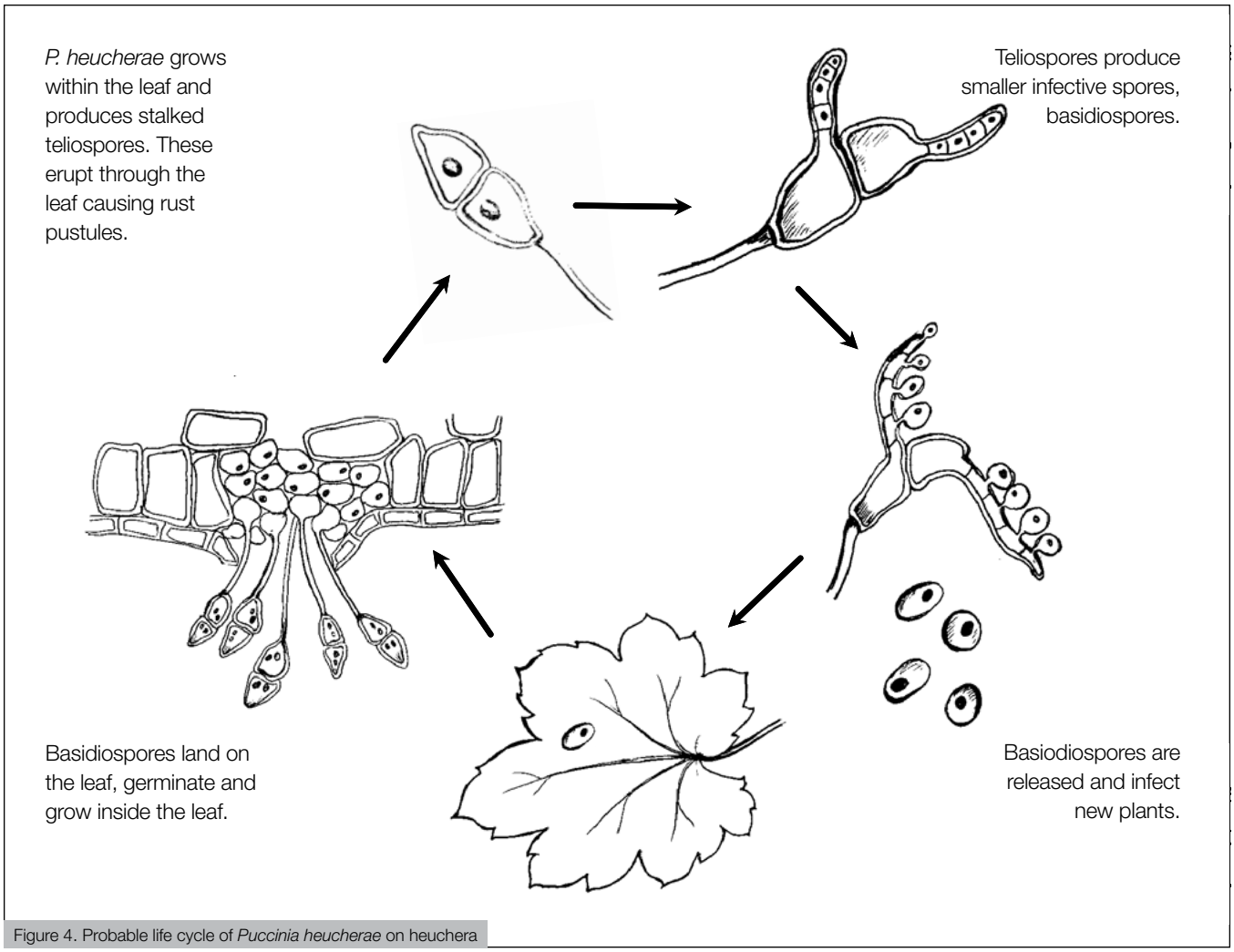

Figure 4. Probable life cycle of *Puccinia heucherae* on heuchera

Disease sources

As part of project HNS 191, samples of heuchera collected from UK nurseries in 2014 and 2015 were tested using a molecular test, based on a DNA analysis developed within the project, to detect *P. heucherae*. The technique was very sensitive and specific, however, the technique did not distinguish between dead and living pathogens.

Testing a range of plant material in the supply chain provided an indication of the potential disease sources. Within the period of testing, there was no evidence of the rust disease arriving within propagation material (either seed-raised or micropropagated). The disease is not believed to be seed-borne and infection of micropropagated plantlets arriving in agar pots is unlikely because they are grown away from any spore-producing plants, and systemic infection by heuchera rust has not been shown to occur.

Ten percent of the plants sampled from one of two supply chains in spring 2014, after overwintering, developed symptoms of rust, although they were initially symptomless. Symptoms were observed five weeks after the initial examination. Overwintered plants may, therefore, be an important source of infection in the spring and should be monitored closely and kept away from new plant material. However, *P. heucherae* was also confirmed to be present by molecular testing in some overwintered plants without pustules, and no pustules developed during the following nine months, so the test was not infallible as a method of predicting disease expression.

Rust pustules have also developed on overwintered plants from which tissue samples had tested negative using the molecular test. This probably indicates that these infections were not systemic and had developed from localised infection points. When the molecular test was used to test the root or crown section from a rust infected plant, it tested negative for *P. heucherae*. This confirmed that the infection was not systemic and did not appear to travel into the root or crown of the plant.

Conditions favouring disease development and spread

The orange-brown resting spores can remain on leaves throughout the lifespan of the leaf. Under high humidity they germinate to produce infective spores capable of infecting other areas of tissue on the same plant or adjacent plants (Figure 5). The infective spores are distributed by air currents, perhaps up to 700 metres, and by water splash over shorter distances, but are only able to survive for around five minutes at humidities below 80%.

The temperature range over which *P. heucherae* basidiospores infect is not known, but *P. horiana* (the pathogen that also only has teliospores and basidiospores and causes white rust disease on chrysanthemum) infects chrysanthemum leaves between 17°C–24°C within two to five hours when there is a film of water on the plant surface. In the case of white rust, the host leaves take between five and 14 days to develop the first visual symptoms following initial infection by the basidiospore – chlorotic spots at the point of infection.

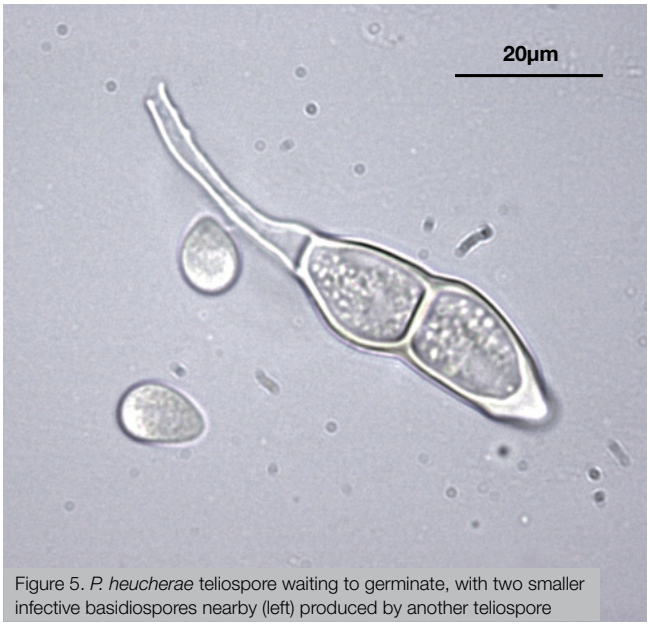

Figure 5. *P. heucherae* teliospore waiting to germinate, with two smaller infective basidiospores nearby (left) produced by another teliospore

Control strategies

Use of resistant varieties

The evidence gathered as part of project HNS 191 generally indicates that any heuchera variety can succumb to the disease, and the frequency of infection is likely to be a reflection of the relative popularity of the variety in cultivation. However, a number of varieties such as 'Fire Chief', 'Green Spice', 'Palace Purple' and 'Plum Pudding' did appear to be less prone.

Information from one of the major heuchera breeding companies indicated that, while all varieties can become infected, the lighter, more recessive foliage colours, in particular yellow, have tended to be more susceptible to the disease. Plants with relatively thinner leaves are also more likely to succumb, and so plant varietal breeding programmes are underway to select for tougher, thicker leaves and other different recessive leaf colours, such as lime. Work is in progress to use parent species with greater rust resistance to produce interspecific hybrids.

Varietal selection is, therefore, important in terms of disease management, and information should be sought from plant breeders about new varietal introductions and their relative disease resistance.

Cultural control measures

Incoming plant material

The type of starting material is also important in terms of disease management. Seeds will not be a source of the pathogen, and plantlets grown via micropropagation will be highly unlikely to be infected (Figure 6).

On arrival, plant material in general should be inspected for any signs of disease (pustules or shot-holes where pustules may have dropped out) and rejected if infected. There is evidence for delayed symptom expression (by at least five weeks) and so, where possible, all incoming plant material should be quarantined and regularly inspected for symptom development for at least this period, whilst withholding fungicide applications.

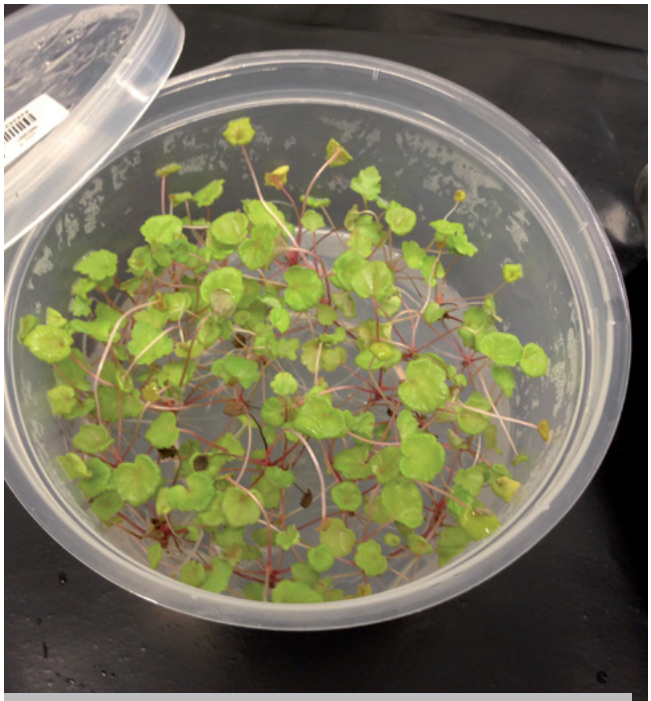

Figure 6. Micropropagated plant material prior to transplanting and weaning

Nursery hygiene and disease monitoring

Prior to standing plant material down, beds should be cleared of leaf debris and disinfected as required. Although their infection potential is not known, resting spores in leaves are able to survive for several months after pustule formation. Avoid placing new material down next to older plant material, especially plants that have been overwintered.

Ensure that all staff can recognise signs of heuchera rust disease and know who to report disease outbreaks to on the nursery. As part of any weekly crop walking activity on the nursery, inspect the foliage of heuchera plants for signs of pustule formation, giving particular attention to the lower leaves and those deep within canopies; bear in mind fresh symptoms are less likely to be seen during the months of June and July. Be aware that infection can remain symptomless within plants for at least a month.

Crop management

As infection is favoured by humid conditions, the growing environment should be manipulated where possible to create an atmosphere less conducive to disease development and spread via the following methods:

- Space plants adequately (Figure 7) and ensure growing structures are well ventilated to maximise air movement to aid leaf surface drying
- Avoid overhead irrigation, or irrigate in the morning so that the leaves dry rapidly and thus do not favour spore production and plant infection
- Adjust irrigation timings so that plants lose turgidity (flag) between irrigation periods, this may increase the resistance of leaves to infection, possibly through the development over time of a thicker leaf cuticle
- If the disease is noted in protected crops, try raising daytime temperatures to above 21°C, and night-time to 15°C for about a week to assist in the prevention of disease development and spread
- Trim back the older leaves on plants to improve air circulation immediately around plants to speed up leaf surface drying.

Figure 7. Well spaced heuchera plants on outdoor production beds

Leaves with pustules should be removed to prevent spores infecting other tissue on the plant and other plants. Ensure any infected leaves that have been removed are disposed of into a covered waste bin, not left on open compost heaps where spores can spread back onto the crop.

If possible, avoid overwintering plant material, particularly if fungicide protection cannot be maintained, as disease spread from overwintered plants appears to be the main route for disease transmission. This also creates a physical break in heuchera production, reducing the chance of spores being present and initiating infection on fresh plant material.

Where stock needs to be maintained over the winter, trim plants to remove any infected or old foliage; this opens up the canopy so that the leaves dry more quickly and conditions are then less favourable for infection through the autumn and early spring.

Fungicide programmes

Although all the cultural control measures mentioned previously should be adopted to minimise disease levels, protectant fungicide programmes will be required during conditions that lead to prolonged periods of leaf wetness and/or high levels of humidity and when varieties commonly reported with rust are grown.

A number of fungicides are available for the control of rust diseases on outdoor and/or protected ornamental crops (Table 1). The products listed have various modes of action as indicated in the Table, and it is important that fungicide programmes alternate products from different Fungicide Resistance Action Committee (FRAC) codes to reduce the chance of *P. heucherae* developing resistance. Products from at least two different fungicide groups should be used alternately or in mixtures (where permissible). In the specific case of QoI fungicides (those products containing active ingredients from the strobilurin fungicide group), ensure that no more than two applications of this type of fungicide are used per crop.

Most of the fungicide products are permitted to be used only once or twice on a crop and so with a protectant spray application interval of 14 days (reducing to seven days when environmental conditions are favourable for disease development) the implementation of a long-term fungicide programme will be problematic. As rust pustule development is infrequently seen during June and July, extending the spray application interval to 21 days during these months could be considered during periods of warm, dry weather.

Active ingredients such as chlorothalonil and mancozeb are protectant only, but there is also some curative activity available from active ingredients such as azoxystrobin (and other strobilurin based products), myclobutanil and propiconazole if applied at the early onset of visible infection. There are currently no biofungicides available in the UK able to provide control of rust diseases.

Further novel conventional plant protection products have been shown within AHDB Horticulture-funded project CP 124 to be effective against rust species in other ornamental plant species, and they could become available under Extensions of Authorisation for Minor Use (EAMUs) in the near future.

If using a plant protection product on a heuchera variety for the first time, or on young or tender plants, then a small number of plants should be initially test treated to determine the potential for phytotoxicity.

Spray application methods

As heuchera plants grow quickly and develop a dense leaf canopy, adequate spray coverage of the lower and central leaves will be difficult. Therefore, use appropriate nozzle types, application pressures and spray volumes to achieve the necessary spray coverage over foliage as it will be those leaves that are less exposed to any drying air currents that require the greatest level of protection from rust infection.

Table 1. **Some currently approved fungicide products available in the UK that can give control of rust diseases in ornamental crops (August 2016)**

Example product and MAPP number	Active ingredient and fungicide group	FRAC code	Approval status for ornamentals	Situation of use (outdoor O or protected P)	Maximum individual dose rate	Maximum total dose	Renewal date of UK product registration
Amistar (10443)	Azoxystrobin (Strobilurin)	11	EAMU 0443/09	O + P	1L/ha	4L/ha per year	30 Jun 2024
Bravo 500 (14548)	Chlorothalonil (Chloronitrile)	M5	EAMU 1130/11	O	2L/ha	One per crop	30 Apr 2020
Bumper 250 EC (14399)	Propiconazole (DMI)	3	EAMU 1274/14	O + P	0.4L/ha outdoor 0.5L/ha protected	Three per crop Five per crop	31 Jul 2019
Galileo (13252)	Picoxystrobin (Strobilurin)	11	EAMU 2855/08	O	1L/ha	Two per crop	30 Apr 2019
Karamate Dry Flo Neotec (14632)	Mancozeb (Dithiocarbamate)	M3	On label	O	2kg/ha	Four per year	31 Jul 2020
Signum (11450)	Boscalid + pyraclostrobin (Carboxamide + strobilurin)	7 + 11	EAMU 2141/12	O + P	1.35kg/ha	Two per crop	31 Jul 2019
Swift SC (11227)	Trifloxystrobin (Strobilurin)	11	EAMU 2882/08	O	500ml/ha	Two per crop	31 Jan 2019
Systhane 20 EW (09396)	Myclobutanil (DMI)	3	On label	O + P	225ml/750L water	No limit	30 Sep 2017*
Vivid (10898)	Pyraclostrobin (Strobilurin)	11	EAMU 2884/08	O	1L/ha	Two per crop	31 Jul 2019

This table has been collated using information from the Health and Safety Executive (HSE) website (pesticides.gov.uk) and from product labels and supplier technical leaflets. Important – regular changes occur to the approval status of plant protection products, arising from changes in the legislation or for other reasons. For the most up to date information, please check the HSE website or with a professional supplier or BASIS-qualified consultant, as information could have changed since the publication of this factsheet.

**Final date product can be used*

FRAC – Fungicide Resistance Action Committee.

EAMU – Extension of Authorisation for Minor Use.

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Any use of a plant protection product via an EAMU is at grower's own risk.

Further information

AHDB Horticulture factsheets and publications

Factsheet 06/15: Improving the efficacy of plant protection applications to ornamental crops via hand-held sprayers.

Factsheet 03/14: Use of chemical disinfectants in protected ornamental plant production.

Factsheet 01/13: Practical measures to prevent and manage insecticide, fungicide and herbicide resistance for horticultural crops.

Factsheet 10/07: Guidelines on nursery hygiene for outdoor and protected ornamental crops.

Factsheet 09/02: Control of rust diseases of protected bedding plants.

Factsheet 23/00: Rust diseases of bedding plants.

Crop Walkers' Guide – Hardy Nursery Stock.

AHDB Horticulture grower summaries and reports

HNS 191: The epidemiology and control of heuchera rust.

CP 124: Managing ornamental plants sustainably (MOPS) – Developing integrated plant protection strategies.

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