

Cut flowers

Project No. BOF 44

Control of powdery mildew diseases on cut flowers

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This factsheet provides guidelines for achieving effective control of powdery mildew diseases on outdoor and protected cut flowers. Information is provided on disease symptoms, spread, fungicide efficacy and crop safety and example spray programmes are provided for outdoor and protected crops.

Action points

Disease prevention

- Start fungicide treatment early in crop growth as powdery mildews can spread very quickly, from lower leaves to upper parts and also through the crop.
- With protected crops, avoid prolonged periods of high humidity to lessen the risk of rapid disease development.

Use of fungicides

- Use Frupica, Systhane 20EW, Stroby WG or Thiovit + Agral which have been shown to be effective in controlling powdery mildew.
- Always use two or more products from different fungicide groups in a spray programme, as there is a real risk of fungicide resistance developing.
- Protectant fungicides must be applied before the disease is seen. Ideally, curative fungicides should be applied as soon as the first symptoms are seen.
- If the disease is established when first seen, apply two sprays of curative fungicides within seven days.
- Do not use Thiovit + Agral or Frupica as the final spray before harvest because of the risk of spray deposit.



1 Solidago powdery mildew – note the sparse fungal growth over the leaves and the spotting on stems

Background

Aster, cornflower, delphinium, gypsophila, phlox, scabious, solidago, and some other cut flower species, are all very susceptible to one or more powdery mildew diseases. Most of these crops

are herbaceous multi-stemmed plants which inevitably form a dense canopy when grown in beds, creating the right environment (high humidity) for disease to establish. The diseases mark and deform the foliage and with severe attacks, premature leaf fall results.

Attacks on the upper part of the stem or foliage generally make the stem unmarketable even with a slight infection. Discussion with the industry indicates that losses from powdery mildew disease are around £340,000 per annum.

Disease symptoms and spread

Symptoms

The symptoms of powdery mildew disease range from discrete bright white spots to a filmy white, sparse fungal growth (Figs 1–4). On leaves, symptoms most commonly occur on the upper surface although occasionally the lower surface is also affected. Dried water droplets are sometimes mistakenly identified as powdery mildew. On stems, the mildew may appear as discrete white spots or as a discoloured area (eg purple marking on delphinium and scabious) with no obvious fungal growth. With a severe attack, yellowing and leaf drop results, which reduces plant vigour resulting in a reduction of both stem weight and length.

Host specialisation

There are many different species of powdery mildew and those commonly occurring on cut flowers in the UK are shown in Table 1. Usually one powdery mildew species attacks cut flowers of one family and not other families. For example, *Erysiphe cichoracearum* attacks aster, cornflower, chrysanthemum and solidago (all Compositae) but not delphinium (Ranunculaceae). This strong host specialisation means that a powdery mildew on one cut flower crop will not necessarily spread to infect crops of different plant species on a nursery.

Sources, spread and survival over winter

The main source of powdery mildew during the growing season are the dispersal spores (conidia) produced on the fungal growth visible on affected plants. These are spread by wind over short and long distances. Spread may also occur by water splash, insects and man, but these are much less important. Seed-borne infection is doubtful. Introduction of powdery mildew onto a



2 Bright white spots are typical of phlox powdery mildew



3a Delphinium powdery mildew appears as a white growth over the upper leaf surface and stems



3b Powdery mildew appears on the underside of delphinium leaves as a purplish-brown marking

nursery on young plants is possible though uncommon. Once present within a crop, spread both from lower parts to upper leaves and throughout a crop can occur very quickly.

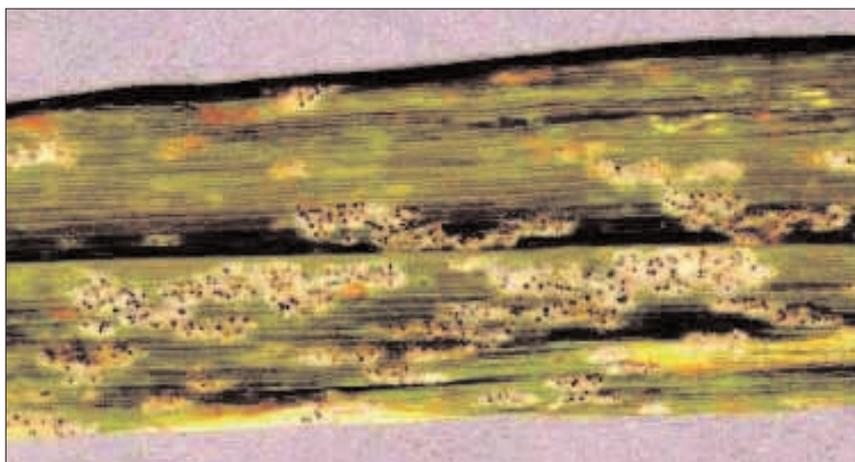
The powdery mildews only grow on living plant tissue. They commonly survive over winter, or in the absence of their host crop, as small black resting

bodies which are often just visible in the fungal mass (Fig 5). They are produced on the host tissue when environmental conditions are unsuitable for the fungus or as the crop reaches maturity. These resting bodies persist in crop debris and germinate in subsequent seasons to produce dispersal spores (ascospores) which are spread in air currents.

Powdery mildews may also overwinter as resting fungal strands (mycelium) within dormant buds of perennial crops. In areas with mild winters, or in greenhouse crops, powdery mildew can be active throughout the year.



4 Chrysanthemum powdery mildew is uncommon



5 Small, dark-coloured spore bodies (ascocarps) may develop within the mildew as the crop reaches maturity

Table 1
Powdery mildew diseases occurring on cut flower crops in the UK: causal fungi, occurrence and symptoms

Crop	Family	Powdery mildew species	Occurrence and symptoms
Aster (annual and perennial)	Compositae	<i>Erysiphe cichoracearum</i>	Common on perennial aster. Dense, white spots. Rare on annual aster
Chrysanthemum	Compositae	<i>Erysiphe cichoracearum</i>	Rare. Sparse, filmy growth
Delphinium	Ranunculaceae	<i>Erysiphe aquilegiae</i> <i>Sphaerotheca delphinii</i>	Common. Off-white, dense fungal growth. Stem purpling
Gypsophila	Caryophyllaceae	<i>Erysiphe buhrii</i>	Uncommon. Bright white spots, especially on lower leaves
Larkspur	Ranunculaceae	<i>Erysiphe aquilegiae</i>	Common. White spots. Leaves rapidly turn black
Phlox	Polemoniaceae	<i>Sphaerotheca fusca</i>	Common. Very bright white spots
Scabious	Dipsacaceae	<i>Sphaerotheca dipsacearum</i> <i>Erysiphe knautiae</i>	Common. Off-white, dense growth; stem purpling
Limonium (annual and perennial)	Plumbaginaceae	<i>Erysiphe limonii</i>	Quite common. Dense white spots
Solidago	Compositae	<i>Erysiphe cichoracearum</i>	Common. Sparse, filmy growth initially, leading to dense fungal growth and stem blackening

Infection conditions

The impact of environmental factors on the development of powdery mildews is well studied although the results are often contradictory. Infection usually starts with dispersal spores (conidia) and the infection process is strongly influenced by temperature, moisture, light and the condition of the plant. The precise impact of environmental factors varies with the fungal species and host.

Germination of conidia is usually optimal at 15–28°C with a minimum

temperature of 2–4°C and a maximum of 30–35°C. Best germination also occurs under high humidities. But, compared with other fungi, powdery mildew conidia can germinate at low humidities, due probably to their high water content. Subsequent growth of powdery mildew over and within plant tissues is influenced by environmental factors. Generally, warm dry weather favours development of the fungal mycelium over the plant surface and abundant production of conidia. This

can lead to epidemic development. Abundant development of mildew can occur in shade as well as in full light.

Young growing plants are especially susceptible to infection. High levels of nitrogen fertilisers generally result in a more severe attack. There is some evidence that potassium can increase resistance. The susceptibility of plant species in a glasshouse is often greater than that of the same species grown outdoors.

Control strategy

Cultural and environmental

Ensure that the soil potassium level is adequate (at least 300 ppm) and that nitrogen is not applied at excessively high levels (target level 100 ppm). Reduction of high humidity in greenhouse crops as practised for control of grey mould (*Botrytis cinerea*), will help to reduce the risk of rapid development of powdery mildew, but cannot be relied upon to maintain crops mildew-free.

Disease monitoring

As powdery mildews can spread very rapidly, it is critically important to regularly monitor all susceptible crops for first symptoms of the disease. Especially check young plants arriving on the

nursery and re-growth of cut-down crops, whether protected or outdoor. It is useful to record the varieties and species on which powdery mildew has occurred, and look out for early symptoms on these crops the following year. If powdery mildew is present on one crop, check all other crops. It is suggested that crops be monitored weekly. In a dense crop, mildew often starts low down in the canopy (Fig 6). Therefore, check plants in the centre of beds as well as those at the edge, and leaves at the base of the canopy as well as upper leaves. Once mildew is found in a crop, the spray programme should be started, or, where a preventative programme is being used, the spray interval reduced (see 'Disease management approaches and spray timing' overleaf).

Chemical control

Fungicides with activity against powdery mildew diseases and that have been shown to be safe to use on delphinium, gypsophila, solidago and phlox are listed in Table 2. This information is described fully in HDC project report BOF 44 (January 2003). A selection of additional fungicides which were not evaluated in HDC project BOF 44 but have potential to control powdery mildew on cut flowers are listed in Table 3. Note that the use of some products is permitted only on outdoor crops, and the use of others is permitted only on protected crops.

It is important to achieve good spray coverage. Adjust the spray pressure and volume in order to treat the lower as well as the upper leaf surface, and the full leaf canopy as far as is practicable.



6 Phlox powdery mildew commonly starts on lower leaves in the centre of beds

Table 2

Fungicides tested in HDC project BOF 44 and found to be effective against powdery mildew and safe to delphinium, gypsophila, phlox and solidago

Product and fungicide group	Permitted on		Trial spray rate	Approval status	Comments
	Protected Crop	Outdoor Crops	g or ml/100 litres/1000m ²		
Anilinopyrimidines Frupica	✓	✓	80 g	Extrapolation from on-label use	Obvious spray deposit. Protectant
Ergosterol biosynthesis inhibitors (EBI) Systhane 20EW	✓	✓	45 ml 30 ml	Extrapolation from SOLA 3195/02 Full label approval for use outdoors	Very little spray deposit. Systemic. Curative activity
Strobilurins Stroby WG	✓	✓	20 g	Extrapolation from on-label use	No spray deposit in trials Good trans-laminar activity. Protectant
Sulphur Thiovit Jet + Agral	✓	✓	200 g+6 ml 200 g+6 ml	Extrapolation from SOLA 3652/02 Extrapolation from on-label use	Risk of deposit and smell – do not use close to harvest. Protectant only

Crop safety

It is impossible to provide definitive crop safety guidance for the range of cut flower species grown commercially and so specific advice should be sought. Alternatively, test treat a small batch of plants first before a fungicide is used widely on a species or variety for the first time.

As a general guide, crop damage is more likely to occur: on young plants and soft growth; plants treated in hot, sunny weather or at high humidity; where products are used in mixtures with an additional wetter or other adjuvant (modern pesticides are usually pre-formulated with wetters/spreaders); when several spray treatments are applied to a crop in close succession.

Cuttings may also be more susceptible to damage than rooted plants, particularly if fungicides are applied at high humidity.

Ensure that your sprayer is calibrated correctly and that you apply fungicides at the recommended dose rates and intervals.



7 Aster powdery mildew produces dense white spots

Table 3

A selection of additional fungicides approved for use on ornamentals with potential to control powdery mildew on cut flowers but which were not evaluated in HDC project BOF 44

Product and fungicide group	Permitted on		Maximum spray rate g or ml/100 litres/1000m ²	Approval status	Comments
	Protected Crop	Outdoor Crops			
Ergosterol biosynthesis inhibitors (EBI) Dorado	x	✓	25 ml	Extrapolation from on-label use	Use must cease by 31 Dec 2003.
Fungaflor	✓	x	50 ml	Extrapolated from SOLA 0870/03	Resistance appears to be common
Strobilurins Amistar	✓	✓	100 ml 100 ml	Extrapolated from SOLA 1536/00 Extrapolation from on-label use	Resistant strains may develop. Max of 2 sprays. Protectant
Twist	x	✓	200 ml	Extrapolation from on-label use	35 day harvest interval. Resistant strains may develop. Max of 2 sprays. Protectant
MBC Bavistin DF	✓	✓	150 g 150 g	SOLA 0009/99 Extrapolation from on-label use	Systemic. Resistance strains may develop
Phthalonitrile Bravo 500	✓	✓	220 ml	Both uses are from on-label extrapolations	Partial control. Protectant
Quinoline Fortress	x	✓	15 ml	Extrapolation from on-label use	Limited information. No damage observed on solidago
Hydroxypyrimidine + EBI Nimrod T	✓	✓	320 ml	Both uses are from on-label extrapolations	Use must cease by 31 Dec 2003

The majority of the products listed in Tables 2 and 3 are permitted for use off-label via the Revised Long-term Arrangements for Extension of Use (2002). Although approved, off-label uses are not endorsed by the product manufacturer and such treatments are made entirely at the risk of the user. Before use, you must obtain a copy of the product label and the SOLA notice of approval (if relevant) and comply with the conditions within.

Note
Regular changes occur in the approval status of pesticides arising from changes in pesticides legislation or from other reasons. For the most up to date information, please check with a professional supplier or with the Information Office at the Pesticides Safety Directorate (PSD) Tel: 01904 640500; or on their website listing revocations (www.pesticides.gov.uk/raidinfo/rep-fp.cfm)

- Always read the label or Specific Off-Label (SOLA) notice of approval.
- Use pesticides safely.
- Check with suppliers for full details of any side effects on biological control agents.

Disease management approaches and spray timing

Three approaches to the management of powdery mildew on cut flowers were devised and tested on solidago in project BOF 44:

- 1 Protectant programme – routine sprays applied every 14 days.
 - 2 Disease monitoring – two early protectant sprays then disease monitoring.
 - 3 First symptoms – no sprays until mildew was observed in the crop.
- Example fungicide programmes for each of these approaches are shown in

Table 4. Products are applied at 14-day intervals initially, reducing to 7-days when mildew is found in a crop.

Table 4
Example spray programmes for control of powdery mildew on delphinium, gypsophila, phlox and solidago (protected and outdoor crops)

Management approach	Spray sequence (weeks after crop emergence)											
	0	1	2	3	4	5	6	7	8	9	10	11
1 Protectant programme (routine sprays every 14 days)	–	Thi	–	Sys	–	Thi	–	Sys or (Str)	–	Thi	–	Sys
2 Disease monitoring (two early protectant sprays, then monitor for disease. When seen, use the sequence given)	–	Thi	–	Thi	–	–	Sys	Sys	Thi	Sys or (Str)	Thi	Sys
3 First symptoms (no sprays until mildew is seen. When seen, use the sequence given)	–	–	–	–	–	–	Sys	Sys	Thi	Sys or (Str)	Thi	Sys

Thi – Thiovit+Agral; Sys – Systhane 20EW; Str – Stroby WG.
 These programmes are permitted on either protected or outdoor crops.

Notes

1 Protectant programme: apply fungicides at approximately 14-day intervals (maximum). Reduce the spray interval to 7–10 days as the crop grows. Alternate a protectant and a mildew-specific fungicide.

2 Disease monitoring programme: apply 2 sprays within 21 days of crop emergence, then none until first symptoms of the disease are seen, then 2 of a mildew-specific fungicide within 7 days if the disease is seen, then alternate a protectant

with a mildew specific fungicide every 7 days.

3 First symptoms programme: no sprays until mildew is seen, then 2 sprays of a mildew-specific fungicide within 7 days, then alternate a protectant with a mildew-specific fungicide every 7 days. *This approach requires frequent crop monitoring (eg weekly).*

Example programmes 2 and 3 assume mildew is first observed in week 6; start earlier or later according to when

mildew is first seen in your crop. To further reduce the risk of selecting fungicide resistant strains of mildew, consider replacing every other Systhane 20EW application with Stroby WG. Aim to finish the spray programme on a mildew-specific fungicide such as Systhane 20EW or Stroby WG, rather than Thiovit so as to prolong control during flower cropping and to reduce the risk of a sulphur taint on the harvested stems.

Fungicide resistance

Resistance development in powdery mildew fungi is relatively common. Where resistant isolates are present, treatment with these fungicides will provide little or no disease control. Where strains of powdery mildew are resistant to fungicides in a particular group (see Table 2 and 3) there is usually also resistance to all other members of the same fungicide group.

The following procedures should be followed in order to preserve the effectiveness of fungicides:

- Use fungicides according to the programmes listed (Table 4),

or similar programmes that have been designed to avoid resistance development.

- Use no more than two sprays of the same fungicide, or fungicide group, in sequence, then use a completely different fungicide group.
 - For strobilurin fungicides, use no more than 50% of the total sprays of this type of fungicide per crop.
 - Follow the label recommendations carefully and keep to the manufacturer's recommended dose rate.
- Do not rely on fungicides alone for disease control; follow the cultural control measures detailed in this factsheet, especially regarding crop monitoring.
 - For further advice on strategies to minimise the risk of selecting resistant strains of powdery mildew, see the FRAG-UK Technical leaflet: Fungicide Resistance, published in August 2001, which can be downloaded from: www.pesticides.gov.uk