Factsheet **11/09**

Impatiens

Protected Crops

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Impatiens downy mildew

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Downy mildew (*Plasmopara obducens*) was found affecting *Impatiens walleriana* for the first time in the UK in 2003. It remained absent or at low levels during 2004–2006 but re-appeared in 2007 and subsequently caused severe infection in UK crops, particularly in 2008. The disease has been reported previously from overseas on both wild and cultivated species of *Impatiens*. This factsheet provides updated information about the disease, its biology and control.

Action points

- Purchase seed and cutting raised plant material from reputable sources and request evidence of any preventative cultural and fungicide treatments made to the plant material.
- Prior to delivery of young plant material ensure a thorough nursery hygiene programme has been undertaken and that any self-seeded impatiens have been removed from inside and around the glasshouses.
- Review the glasshouse environmental management regime to ensure good air circulation and ventilation.
- Apply an effective systemic fungicide for downy mildew control either pre-or post-sowing/post-rooting, preferably as a drench treatment to the module substrate.
- On delivery of plant material keep seed and cutting-raised plants separate and segregate cutting material from different sources.
- Where possible, keep other impatiens crops eg *I. hawkeri* ('New Guinea' types) and *I. hybrida* separate from *I. walleriana* cultivars to minimise disease pressure on these crops.
- Treat plants with an effective fungicide programme, taking note of what products were applied pre-delivery and alternate products with different modes of action for resistance management purposes.
- Inspect plants on a regular basis for signs of downy mildew, if confirmation is required, submit plants for laboratory analysis.
- Remove any infected plant material and place it in a covered skip or bin to go to land-fill.
- Where possible sub-irrigate crops to minimise leaf wetness.
- If overhead irrigation systems are used ensure water is applied early in the day and on days when the crop can dry out quickly.
- Prior to dispatch apply a final systemic fungicide to provide as long a period of protection post-planting out as possible (taking into consideration the potential risk of fungicide product deposits on leaves).

1 Sporulation on the lower leaf surface of impatiens identifies the problem as *P. obducens*

Background

What is the disease situation in the UK?

During spring 2003, downy mildew was found for the first time in the UK on *Impatiens walleriana* in Southern England and the pathogen responsible identified as *Plasmopara obducens* (Figure 1, previous page). During the summer that year the disease was subsequently found more widely on both seed and cutting-raised impatiens in various locations around the UK, including nurseries, garden centres, civic floral displays and private gardens. Most of the outbreaks were first observed after planting out. Severely affected plants either died during establishment or pre-flowering outdoors whereas those less affected lost much of their ornamental value through partial or complete defoliation. In some planting schemes the disease differentially affected cultivars and even flower colours within a series suggesting that either only certain cultivars or series were originally affected or that differences in cultivar susceptibility exist.

Following the initial disease outbreaks in the UK, Defra Plant Health Division introduced emergency phytosanitary measures. Following the completion of a Pest Risk Analysis **(www.defra.gov.uk/planth/pra/pobducens.pdf)** and widespread industry consultation, a decision was taken to remove the emergency measures and allow the industry to manage the disease in a similar manner to other downy mildew pathogens on protected ornamentals.

Between 2004 and 2006, the disease remained absent or at low levels in commercial crops reappearing at moderate levels in 2007. In 2008, due in part to extremely favourable environmental conditions for the disease, infection was widespread in material planted outdoors and was also found within growing crops on nurseries where plants had to be treated or disposed of as appropriate.

There have been unsubstantiated reports from both the Netherlands and the UK that the disease has also been found on 'New Guinea' impatiens; an ornamental hybrid derived from *I. hawkeri*. Yet, in other situations 'New Guinea' types growing alongside severely infected *I. walleriana* have remained disease-free. In 2008, there was also one UK report of the pathogen affecting *I. hybrida*, which is claimed to have some *I. walleriana* in its genetic background.

Where did the disease originate?

The exact origin of the disease has not been determined, but it is most likely to have gained entry to the UK via impatiens material imported from overseas. Whilst the disease was not found in the UK until 2003, it has been known to occur in several other countries in Europe and elsewhere for some time. It may therefore have been introduced earlier but remained undetected at low levels until environmental conditions were more conducive to its development.

Where else has the disease been found and on which hosts?

Plasmopara obducens was first described in Germany in 1877 on *Impatiens noli-tangere* (touch-me-not balsam), a wild species of *Impatiens* native to many temperate countries in the northern hemisphere, including some parts of the UK. The fungus was subsequently reported on the same host in Bulgaria, Czech Republic, Denmark, Finland, Lithuania, Romania and Russia. It is likely to be quite widespread on *I. noli-tangere* throughout northern and central Europe although, it has not been reported on this wild host in the UK.

In North America, *P. obducens* was identified in the 1880s on native *Impatiens* species including *I. capensis* synonym *I. biflora* (orange jewelweed) and *I. pallida* (yellow jewelweed). The pathogen has also been found in China and India primarily on *I. balsamina* (garden balsam). The popular impatiens bedding plant *I. walleriana* is apparently derived from *I. balsamina*, which originates from the Indomalayan region.

There are so far no records of *P. obducens* on *I. glandulifera* syn. *I. roylei* (Himalayan or Indian balsam) which has become very prevalent on river banks and wetlands since its original introduction to the UK around 1839.

Although specific reports of the pathogen have largely come from the countries identified above, its distribution has been described as worldwide. Certainly, in recent years there have been similar outbreaks of downy mildew on *I. walleriana* cultivars in other European countries, South Africa, Australia, Japan and the USA. This potentially implies a common dissemination route, or is an indication that *P. obducens* is more widespread in wild plants within the genus *Impatiens* than has currently been reported.

Symptoms

Usually, the first symptom of downy mildew infection on impatiens is a pale green to slight yellow discoloration on the upper leaf surface, often with a downward curling of the leaf (Figure 2). A few days later the same leaves can exhibit a white 'downy' growth largely on the lower leaf surface. Following infection *P. obducens* symptoms can remain unseen (latent) for anything from a few days to several weeks depending on the growing temperature. Sporulation may not occur for several days after initial symptom expression, only appearing under favourable conditions (generally following an extended period of leaf moisture and high humidity).

The white 'downy' growth may be either sparse (Figure 3) or cover the entire lower leaf surface except for the main veins (Figure 4). Usually as symptoms develop leaves fall prematurely from the plant leaving a series of unattractive bare stems, in some circumstances however leaf fall can occur with minimal levels of associated sporulation making disease identification difficult. Plants infected early are likely to be stunted and produce small, pale green or yellow leaves. Flowering is usually reduced or absent as a consequence of infection.

2 Early disease symptoms on impatiens – leaf paleness and curling

3 Diffuse, white, spores and spore-bearing structures of *Plasmopara obducens* on the lower surface of an impatiens leaf

4 A dense, white layer of spores and spore-bearing structures of *Plasmopara obducens* on the lower surface of an impatiens leaf

Biology

Spread and survival of impatiens downy mildew

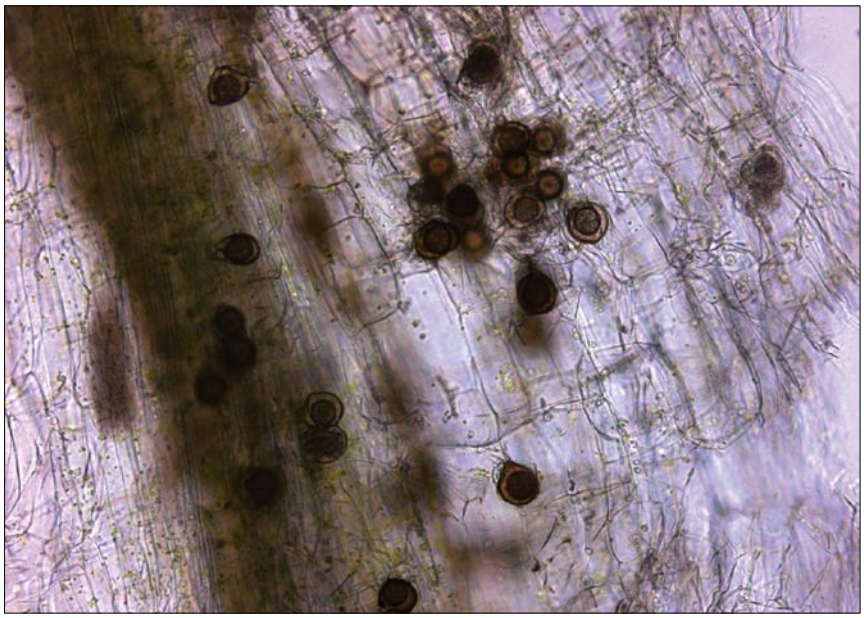
Under conditions of high humidity, *P. obducens* produces spore-bearing structures that are visible as a white 'downy' growth on the underside of the leaves. The spores are spread from plant to plant by water splash and over longer distances on air currents.

Leaf wetness caused by condensation on the leaf surface, rain and irrigation water is required for successful spore germination and infection. If the environmental conditions are unfavourable for spore germination and infection these spores soon die. However, once infection occurs the pathogen can quickly colonise the plant internally, sometimes systemically. It is capable of invading all parts of its host (Figure 5) until the nutrient supply is exhausted and the plant dies.

Just prior to the death of the host plant tissues, downy mildew pathogens often produce long-lived survival or over-wintering spores. These spores can survive in decaying host tissue and soil for many years, thus allowing carry-over as new infections from one season to the next. Such spores were found for the first time in infected impatiens stem tissues during 2008 (Figure 6).

In India, over-wintering spores of *P. obducens*, as well as vegetative strands of the pathogen, have been detected inside seed harvested from diseased *I. balsamina* plants. When sown, such infected seed was reported to have given rise to systemically infected plants. The HDC funded project PC 230, has shown that many seed-lots were contaminated with the DNA of *P. obducens*, yet when such seed-lots were grown on under conditions conducive to downy mildew development, no disease symptoms were expressed. The significance of the pathogen DNA in or on seed-lots therefore remains unclear at the current time though perhaps suggests the detected pathogen is non-viable.

5 Diffuse sporulation on impatiens flower bud



6 Microscopic image of resting spores of *Plasmopara obducens* inside the stem tissue of impatiens

Pathways for the pathogen to enter impatiens production systems

The pathogen is most likely to have been introduced into commercial production systems in the UK and elsewhere as symptomless infections on cuttings and/or possibly seed. Another potential possibility is that the disease may have originated from wild plants growing in close proximity to nurseries. There are a small number of indigenous or introduced *Impatiens* species that grow wild in the UK, including *I. noli-tangere*, *I. glandulifera* and *I. capensis* (orange balsam) and one or all of these may be susceptible to the disease and capable of harbouring the pathogen. However, evidence to date, which includes the lack of records of *P. obducens* in the UK until 2003, suggests that it is unlikely that the outbreak originated from wild species in the UK.

Conditions that favour disease development

The optimum conditions for germination and infection by downy mildew are relatively cool

temperatures (around 15°C) and high humidity (around 95–100%), preferably with prolonged (greater than 5 hours) leaf surface moisture. Disease outbreaks usually occur after a period of wet weather or when crops are irrigated inappropriately. Moisture raises humidity levels and permits the pathogen to sporulate, whilst prolonged periods of surface water on leaves allows spore germination and infection. In protected environments, overhead irrigation systems create high humidity levels and surface moisture which encourages disease development (Figure 7). A single diseased plant can potentially generate sufficient spores to infect hundreds of others in the confined space of a glasshouse.

7 Extensive disease symptoms (including plant death) in a crop of pot grown impatiens

Management and control

What should be done to prevent the disease occurring?

Pathogen exclusion

The most effective form of control is to exclude the pathogen from nursery production. This can only be achieved if sources of propagating material (both seed and cuttings) are free of the pathogen, therefore sources of seed/stock material should be selected carefully. Suppliers of young plants (both UK and overseas based) should undertake precautionary measures to ensure nursery-freedom from downy mildew and provide evidence of an effective disease control programme.

Monitoring for disease

On delivery of plant material keep seed and cutting-raised plants separate and segregate cutting material from different sources. Incoming vegetative cutting material from different sources should ideally be kept in temporary isolation upon receipt and inspected thoroughly for any possible signs of downy mildew. If confirmation is required submit plants for laboratory analysis. Ensure batches of plants are labelled upon receipt and that the labels remain with the crop throughout its life on the nursery to provide full traceability back to the supplier in the event of problems with downy mildew. Seed-raised and cutting-raised plants (including any wild impatiens species adjacent to nurseries), should be checked regularly for signs of disease. However, it is important to appreciate that the disease can have a long latent period, especially under cooler environmental conditions. In contrast, under ideal conditions for the pathogen, symptom expression, spore release and infection of surrounding plants may occur very quickly in succession and before being noticed. As such, regular crop inspections are very useful as the first signs of the disease may be detected before spread has occurred (Figure 8, overleaf).

Hygiene

Any self-seeded impatiens plants in or around glasshouses should be destroyed. Wild *Impatiens* species growing as weeds near to glasshouses should be checked for downy mildew and destroyed if diseased. Where diseased plants are found on nurseries they should be carefully placed into a plastic bag or a covered bin and removed from the nursery to land-fill. Hard surfaces such as benching and standing down areas should be regularly swept, washed with water and then treated with a suitable disinfectant between crops eg Jet 5 and at the end of the season eg Horticide, as these are known to be effective against the spores of related pathogens. Diseased plants and associated debris in floral displays and gardens should be removed as soon as possible not left to decay in

situ (Figure 9). The material should be discarded via land-fill facilities as the over-wintering spores of the pathogen can survive in the soil for several years to potentially re-infect new plantings in the same location. Soil where poorly performing impatiens plants have been rotovated or dug-in may be contaminated with over-wintering spores and extra care may be needed to protect plants from infection the following season.

Cultural practices

Good ventilation and air movement in glasshouses should help prevent the build-up of high humidity levels and prolonged leaf surface wetness that favours disease development. Adequate levels of plant spacing will also help to minimise humidity levels within the crop canopy. Rapid drops in temperature within glasshouses should be avoided as this can lead to the development of condensation on the crop. Drip or ebb and flood irrigation systems reduce the chances of moisture on plant surfaces thereby lowering the risk of infection. Overhead irrigation should only be used when the leaves are likely to dry quickly.

During dispatch, avoid transporting wet plants long distances in poorly ventilated lorries as this could encourage pathogen sporulation and further plant infection.

Don't let crops of impatiens become starved, especially towards the point of marketing, as this could make the plants more prone to disease establishment.

Any impatiens plants remaining on nurseries at the end of the season that are not specifically required should be removed or destroyed as a precautionary sanitation measure.

Fungicide treatments

Impatiens crops have not previously required much in the way of fungicide applications but, given the recent increased prevalence and severity of the disease consideration should now be given to a routine preventative programme for downy mildew control. Regular early treatments with fungicides are advisable from the outset to minimise any risk from potential seed-borne infection and introduction via vegetative cuttings. The use of systemic products with good activity should be used where possible. Non-systemic protectant fungicides are also important in a programme of sprays to reduce the risk of resistance developing. Fungicides that have been used successfully to control downy mildew diseases of various crops and are permitted on protected and outdoor ornamentals (at growers own risk) are shown in Table 1.

8 Early symptoms of leaf yellowing and stunting on a crop of impatiens

9 Impatiens plants in a floral display showing signs of severe infection

Table 1 Commercially-available fungicides with potential for the control of impatiens downy mildew and permitted for use on ornamental crops

Fungicide group and products	Active ingredient(s)	Contact or systemic	Protectant or curative	Permitted on crops		Approval status and comments	Resistance risk
				Protected	Outdoors		
Carbamate							
Filex	Propamocarb-hydrochloride	Systemic	Protectant	✓	✓	Label approval for use on ornamentals	Low to medium
Flash				✓	✓		
Pan PCH				✓	✓		
Previcur N				✓	✓		
Propeller				✓	✓		
Proplant				✓	✓		
Carbamate + phosphonate							
Previcur Energy	Propamocarb-hydrochloride + fosetyl-aluminium	Systemic	Protectant and curative	✓	✓	SOLA approval 2667/08	Low to medium
Carboxylic acid amide							
Paraat	Dimethomorph	Systemic	Protectant and curative	✓	✓	Continuation of LTAEU from SOLAs 1751/06 and 2777/07	Low to medium
Revus	Mandipropamid	Systemic	Protectant and curative	×	✓	SOLA approval 2867/08	Low to medium
Carboxylic acid amide + dithiocarbamate							
Invader	Dimethomorph + mancozeb	Contact and systemic	Protectant and curative	×	✓	Continuation of LTAEU from potatoes and various outdoor vegetable crops	Low to medium
Valbon	Benthiavalicarb-isopropyl + mancozeb	Contact and systemic	Protectant	×	✓	SOLA approval 0240/07	Low to medium

Table 1 continued...

Table 1 continued...

Fungicide group and products	Active ingredient(s)	Contact or systemic	Protectant or curative	Permitted on crops		Approval status and comments	Resistance risk
				Protected	Outdoors		
Cyanocetamide + dithiocarbamate							
Curzate M WG	Cymoxanil + mancozeb	Contact and systemic	Protectant	×	✓	Continuation of LTAEU from potatoes	Low to medium
Dinitroaniline							
Shirlan	Fluazinam	Contact	Protectant	✓	✓	Continuation of LTAEU from SOLAs 2168/03 and 0597/08	Low
Tizca				✓	✓		
Dithiocarbamate							
Karamate Dry Flo Newtec	Mancozeb	Contact	Protectant	✓	✓	Label approval for use on ornamentals	Low
Thianosan DG	Thiram	Contact	Protectant	✓	✓	Label approval for use on ornamentals	Low
Triptam				✓	✓		
Microbial disrupter (biological)							
Serenade ASO	*Bacillus subtilis*	Contact	Protectant	✓	✓	SOLA approval 0246/09	Low
Multi-site contact (inorganic)							
Croptex Fungex	Cupric ammonium carbonate	Contact	Protectant	✓	✓	Label approval for use on ornamentals	Low
Phenylamide							
Fongarid Gold	Metalaxyl-M	Systemic	Protectant and curative	✓	✓	Label approval for use on ornamentals	High
Subdue				✓	✓		
Phenylamide + dithiocarbamate							
Fubol Gold WG	Metalaxyl-M + mancozeb	Contact and systemic	Protectant and curative	✓	✓	Continuation of LTAEU from protected lettuce (SOLA 2142/03)	Medium

Phenylamide + phthalonitrile							
Folio Gold	Metalaxyl-M + chlorothalonil	Contact and systemic	Protectant and curative	×	✓	Continuation of LTAEU from various outdoor vegetable crops	Medium
Phosphonate							
Aliette 80 WG	Fosetyl-aluminium	Systemic	Protectant and curative	✓	✓	Provisional approval	Low
Fosal				✓	✓		
Route one Fosetyl 80				✓	✓		
Standon Fullstop				✓	✓		
Phthalonitrile							
Bravo 500	Chlorothalonil	Contact	Protectant	✓	✓	Label approval for use on ornamentals	Low
Repulse (and equivalent products)				✓	✓		
Strobilurin							
Amistar	Azoxystrobin	Systemic (translaminar)	Protectant	✓	✓	SOLA approval 0443/09	High
Beem WG	Kresoxim-methyl			✓	✓	Label approval for use on ornamentals	
Kresoxy 50 WG				✓	✓		
Stroby WG				✓	✓		
Galileo	Picoxystrobin			×	✓	SOLA approval 2855/08	
Vivid	Pyraclostrobin		Protectant and curative	×	✓	SOLA approval 2884/08	
Swift SC	Trifloxystrobin		Protectant	×	✓	SOLA approval 2882/08	

Table 1 Notes – A potentially wider choice of fungicides are available for use outdoors.

- Always read the label or specific off-label approval.
- Use pesticides safely.
- Check with suppliers for full details of any side effects on biological control agents.

Fungicide selection

This new downy mildew disease on impatiens should be treated in much the same way as downy mildews are managed on other bedding plant crops. Early application of a systemic fungicide eg metalaxyl-M (Subdue) is advisable to protect both seed crops from potential seed-borne infection and vegetative cutting crops from latent systemic infections. Regular (every 7–14 days) use of alternative protectant products eg dithiocarbamate (Karamate Dry Flo Newtec) or strobilurin (Amistar) will help to minimise any resistance risk in the pathogen population (see Table 2). Prior to dispatch a further application of an effective systemic fungicide is advisable to give a further 10–14 days protection from the disease once the plants leave the nursery, but potential risks of fungicide product deposits on foliage should be taken into consideration at this stage.

Curative activity

The systemic fungicides listed in Table 1 (previous page) and Table 2 that are likely to have good to moderate curative action against downy mildew of impatiens grown under protection include those containing the following active ingredients:

- fosetyl-aluminium (eg Aliette 80 WG; Standon Fullstop etc)
- metalaxyl-M (eg Subdue, Folio Gold; Fubol Gold WG etc)
- propamocarb hydrochloride (eg Filex, Proplant etc).

Crop safety

Some of the fungicides listed in Table 1 (previous page) and Table 2 have been tested on a limited basis for their safety to impatiens as part of the HDC funded project PC 230 and few problems were found. However, as it is not possible to check all impatiens species or cultivars being grown, growers should test treat a small number of plants before large batches are treated.

Resistance management

Downy mildew pathogens worldwide are recognised as being prone to resistance development, especially with some of the site-specific systemic fungicides eg metalaxyl-M. Therefore, fungicides should be used in a planned resistance management strategy to reduce the chances of the development of resistance. Some commercial products are formulated with a protectant, such as mancozeb, as well as a curative fungicide, as a mechanism to reduce the risk of selecting resistant strains.

It is not known if populations of *P. obducens* found on impatiens have developed resistance to any of the fungicides listed in Table 1 (previous page) and Table 2. In order

Table 2 Example fungicide spray programme for impatiens crops from propagation stage onwards*

Crop stage	Pre or post-sowing/ post-rooting	Post-emergence and growing on	Pre-transplanting	Post-transplanting
Fungicide treatment	Apply a high volume spray/drench of a systemic product, for example: 1 metalaxyl-M (eg Subdue). 2 propamocarb hydrochloride (eg Filex). 3 fosetyl-aluminium (eg Aliette 80 WG). 4 A mixture of 2. + 3. (eg Previcur Energy).	Apply protectant sprays of a dithiocarbamate fungicide (eg Karamate Dry Flo Newtec) at 7–14 day intervals. Adjust spray timings depending upon weather conditions, extending the interval if the weather is not conducive to downy mildew.	Apply a high volume spray/drench of a systemic product, for example: 1 metalaxyl-M (eg Subdue). 2 propamocarb hydrochloride (eg Filex). 3 fosetyl-aluminium (eg Aliette 80 WG). 4 A mixture of 2. + 3. (eg Previcur Energy). Ensure a different product is used to that at sowing/ rooting.	Apply alternate sprays of metalaxyl-M + mancozeb (eg Fubol Gold WG) with strobilurin (eg Amistar) every 7–14 days. Adjust spray timings depending upon weather conditions. Ensure final spray prior to dispatch to maintain protection from downy mildew.

*Note this spray programme is for example purposes only, the listed products have not been tested on all the available impatiens species and cultivars, so small numbers of plants should be test treated first before wider scale applications are made.

to minimise the risk of selecting resistant strains of the pathogen, it is recommended that:

- Fungicide products from different active ingredient groups are alternated.
- Strobilurins should not comprise more than 50% of the total applications of fungicide per season.
- Label recommendations should be followed carefully, especially advice on application rates.
- Fungicides should not be relied on alone for disease control; monitoring, cultural and hygiene measures detailed in this factsheet should also be followed.

Permitted products

On-label approvals: There are no fungicides with a specific on-label approval for the control of impatiens downy mildew. However, several fungicides are available that do have approved uses on ornamentals. Some of these have known activity against fungi related to downy mildew eg *Pythium* and *Phytophthora* and therefore control could also be expected. As the pathogen target is not a statutory condition of use, such products can be used on impatiens at growers' own risk, but it is important to emphasise that crop safety on a range of cultivars should be assured first.

Specific off-label approvals: Some fungicides may be used on ornamental crops, including impatiens, via specific off-label approvals (SOLAs). It is important to recognise that these uses are not supported by manufacturers and therefore are, in all cases, at the growers' own risk. Crop safety must therefore be checked in advance especially when using the product for the first time on a specific ornamental crop or new cultivar.

Use by extrapolation: For many years growers of ornamental crops have been able to use many pesticides approved on other arable and horticultural crops at their own risk via the Long Term Arrangements for Extension of Use (LTAEU). Due to changes in EU pesticide legislation the LTAEU are being gradually phased out and replaced (in some cases) with specific off-label approvals (SOLAs). A number of active substances have already been evaluated and SOLAs issued where possible. For these active substances the LTAEU cease to apply on 1 June 2009. For all other active substances the LTAEU continue until such time that the product comes up for re-registration. For more information on the changes to the LTAEU see: **www.pesticides.gov.uk/approvals.asp?id=2634**.

It is also important to remember that the location of the crop to be treated is relevant in relation to pesticide availability. For crops grown under protection there is a more limited range of products that can be used due to the requirements for operator and worker safety. Crops grown under protection also tend to be more sensitive to pesticide application and the risk of phytotoxicity can be higher. It is important therefore to test treat a few plants of different cultivars prior to large-scale use of a particular product on the nursery.

Further information

HDC funded project PC 230 'Detection and control of downy mildews on ornamentals'.

Good horticultural practice for the prevention and control of impatiens downy mildew (*Plasmopara obducens*).

Acknowledgements

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Photographs of symptoms are reproduced here with the kind permission of Martin McPherson, STC, Ryan Goodwin and Connall Oosterbroek of the South African Bedding Plant Growers Association (SABPGA), Ball Horticultural Company and the Food and Environment Research Agency (Fera).

Additional information:

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