Cost-benefit analysis of management options for the control of impatiens downy mildew caused by *Plasmopara obducens*

Summary

Impatiens downy mildew caused by *Plasmopara obducens* was a significant problem in the UK impatiens industry in 2003. An investigation, which included a cost-benefit analysis, was undertaken into various management options for the control of impatiens downy mildew in the UK. The main pathway of entry of the pathogen into the industry is by infected propagation material. It is possible that the source of an outbreak in 2004 was a nursery in Guatemala. There is currently no evidence that diseased wild species of *Impatiens* or resting spores of the pathogen are important local sources of infection. A major UK supplier to the industry has shown initiative in treating growing impatiens material with a systemic/protectant fungicide active against downy mildew before dispatch to growing-on nurseries. However, it is not known how effective such treatments are at eliminating an infection. There is a danger that the infection may only be suppressed and develop later at growing-on nurseries.

If the industry can successfully control the disease itself, cost-benefit analysis shows that there is no benefit from government intervention. However, if the industry fails to control the disease and outbreaks occur nationwide with losses of between 10 and 50%, then the benefit of a government programme range from 1:6 to 1:33.

The most cost effective option for the government would be for the industry to police itself in the future as regards this disease. This option is favoured by certain sectors of the industry. However, nurseries should be made aware of the risks from imported cuttings and the need to isolate and treat this material with an effective systemic fungicide. UK suppliers to the impatiens industry should be encouraged to adopt practices that would reduce chances of further outbreaks. Serious outbreaks could reoccur if the industry does not adopt appropriate measures. Discussions with the industry would be beneficial to reinforce the risks if precautions are not taken with imported plugs/cuttings and to gauge opinion on whether self-management is feasible. A watching brief should be maintained on the disease situation.

Introduction

Downy mildew of impatiens, caused by the fungus-like organism *Plasmopara obducens*, caused significant damage to ornamental impatiens (derived from *Impatiens balsamina*) in the UK in the summer of 2003. In one garden centre, 100% of plants in outdoor beds were diseased, though elsewhere levels of 20-50% were usual. Diseased plants either failed to flower or flowered poorly. This had a serious impact on the attractiveness of garden displays in private gardens and public parks. The *I. balsamina* industry in the UK has been estimated to be worth £40M/year (S. Coutts, British Bedding and Pot Plant Association, 2004, personal communication).

Most outbreaks at outdoor locations and nurseries that were reported to PHSI could be traced back to one major UK supplier of plugs. This supplier had 25% of 5000 plants comprising eight important cultivars affected when inspected. Cross infections between cultivars may have occurred at this and/or another supplier with commercial links. It was not possible to pin-point the original affected material, but it may have

been introduced from overseas as seed or cuttings. At least one growing-on nursery receiving material from the supplier with affected plants is in financial difficulties because a major customer has refused to pay for bedding plants that were later found to be diseased.

Emergency statutory action was taken by the Plant Health and Seeds Inspectorate (PHSI) in 2003 under Article 22 of the Plant Health Order 1993. The impatiens downy mildew pathogen was declared notifiable and this use of emergency legislation is to remain in force during 2004. Those with diseased plants or suspected diseased plants are obliged to notify the PHSI.

Aims

Defra Plant Health Division (PHD) asked CSL to undertake a cost-benefit analysis (CBA) to establish the costs of different management options associated with possible future control strategies.

Control Strategy Options

There are three main options to be considered: -

1) Proposing legislation to the EU that will regulate the industry in terms of official controls that should minimise the impact of the pathogen on the industry.

Under this approach, the possibilities include declaring the pathogen an EU IIAII quarantine pest (a requirement before all *Impatiens* spp. can be plant passported) or an EU regulated non-quarantine pest (RNQP). Both legislative approaches are considered in the CBA.

A survey of impatiens production sites by each EU Member State would be required to determine the status of the pathogen in the bedding plant industry before legislative measures could be considered.

Records for Europe indicate that *P. obducens* is present on wild *Impatiens noli-tangere* in Bulgaria, Czech Republic, Denmark, Finland, Germany, Romania, Russia (Anon., 2003) and Lithuania (Z. Jovaisiene, Lithuania, 2003, personal communication). *Impatiens noli-tangere* has not been found infected with *P. obducens* in the UK (C. Sansford and C. Lane, CSL, 2003, personal communications). The pathogen has, therefore, been recorded on a wild host in five EU countries. It is possible that the pathogen may be more widespread given that *I. noli-tangere* is found in most of Europe except the extreme north and parts of the south (Tutin *et al*., 1968). However, surveys of wild plants in EU Member States would be needed to confirm this.

There has been a report of a downy mildew on ornamental New Guinea impatiens (*Impatiens* x *hawkeri*) in the Netherlands in about 2001, but no herbarium specimens were prepared so the pathogen's identity cannot be confirmed (J. Meffert, Netherlands, 2003, personal communication). New Guinea impatiens is currently included in the plant passporting scheme.

The only definite records of *P. obducens* on ornamental *I. balsamina* and *I walleriana* (Buzy Lizzie) in Europe have been in the UK. Serious outbreaks occurred on *I. balsamina* in 2003 and one outbreak has so far occurred on *I. walleriana* in 2004. However, there is an unofficial report that the pathogen has been found in Spain this year on imported *Impatiens* cuttings (P. Barber, PHSI, 2004, personal communication). Nothing is known on the current status of the disease on cultivated *Impatiens* in all other EU countries.

2) Retaining UK emergency statutory action into the foreseeable future

This option is the one currently in place. It was decided by PHD/PHSI to extend the emergency UK action from 2003 to 2004 because of some concerns within the industry that there may be further crop losses without official controls.

3) Letting the industry take control of measures to prevent another disease outbreak

In this option, the industry takes responsibility for management of the disease without government intervention. In this case, the disease would not be notifiable. This option is preferred by certain sectors of the industry. PHD has received communications from some industry representatives advocating this approach.

The views of the industry on how management would be achieved were sought so that they could be costed. Although the industry has so far failed to disclose any strategy that it proposes to recommended to growers, it is known that at least one major supplier of plugs is treating material with an appropriate systemic/protectant fungicide before release.

Existing costs of growing *Impatiens*: Gross margin budgets

ADAS Consulting Ltd. were contracted to provide information on normal production costs within the impatiens industry.

The suppliers of plugs grow small plants from seed in 405, 350 and 100 cell units. These suppliers sell their plugs to nurseries that grow the material on for sale to growing-on nurseries. The gross margin for plug production shown in Table 1 is based on a crop area of 1000m² with 90% of production sold. The selling price of each plug is about 7.5p on this costing.

Table 1: Gross margin budget for impatiens plugs raised from seed in a 405 cell polystyrene tray in 2004. Based on a crop area of 1000m² with 90% of the production sold.

Output (no.trays)	4,320
Sale price per tray (£)	30.30
	£
Sales	130,896
Variable costs *	(44,833)
Gross margin	86,063

*Variable costs include: trays, labels, seed, compost, water, heating

oil, electricity and application of growth regulator and fungicide

Bulk buyers of plugs can negotiate a substantial reduction in the listed price from suppliers. However, this discount is variable and not known. The price used in ADAS calculations of gross margins for growing-on nurseries is 7.7p/plug. This is the pre-discount cost of plugs produced in a 350-cell polystyrene pack.

Impatiens is grown at growing-on nurseries for bedding in a wide variety of containers, pots and packs.. Three common forms of production using plugs grown from seed were chosen for this budget analysis. These were 9 cm pots marketed in trays of 18 pots, 13 cm pots marketed in trays of 8 pots and 'double six' polystyrene packs (two joined packs each holding six plants).

Glasshouse production in this analysis is based on a 'warm' regime of 15ºC during the day and 12ºC during the night. Crop area in all cases is 1000m². All figures exclude the fixed costs of constructing or renting glasshouses. The growing media is a proprietary peat based potting compost. Plants are marketed in trays and dispatched on 'Danish trolleys'. Figures are based on 95% of production being dispatched. The gross margin budget for three types of impatiens production using plugs raised from seed is given in Table 2. The gross margin budget for two types of impatiens production using cuttings is given in Table 3. The 9 cm pot production method is uneconomical if cuttings are used. In Tables 2 and 3 variable costs include: trays, labels, plugs, pots, compost, water, heating oil, electricity and application of growth regulator.

Table 2: Gross margin budgets for three methods of impatiens production and marketing in 2004. Plants grown from plugs raised from seed. Based on a crop area of 1000m² with 95% of production sold.

	Impatiens production and marketing method		
Detail	Grown from plugs in 9 cm pots	Grown from plugs in 13 cm pots	Grown from plugs in 'double-six' pack
Output (no. plants)	80,370	35,720	107,160
Sale price per plant (£)	0.30	0.825	0.1583
	£	£	£
Sales	24,111	29,469	16,967
Variable costs *	(14,344)	(12,525)	(13,649)
Gross margin	9,767	16,944	3,318

Table 3: Gross margins budgets for three methods of impatiens production and marketing in 2004. Plants grown from cuttings. Based on a crop area of 1000m² with 95% of production sold.

	Impatiens production and marketing method		
Detail	Grown from cuttings in 9 cm pots	Grown from cuttings in 13 cm pots	Grown from cuttings in 'double-six' pack
Output (no. plants)		35,720	
Sale price per plant (£)		0.825	
	Uneconomical	£	Uneconomical
Sales		29,469	
Variable costs *		(21,995)	
Gross margin		7,474	

Application of fungicide and roguing to control impatiens downy mildew

A major plug supplier routinely uses fungicide to treat plug plants. Changing to a fungicide more suited to the control of impatiens downy mildew is not expected to substantially increase costs outlined in Table 1 although the price of the original fungicide is unknown.

Additional costs for the management of impatiens downy mildew at growing-on nurseries should an outbreak occur will primarily result from the cost of fungicide application and roguing of affected plants.

The cost of application of Fubol Gold® (mancozeb + metalaxyl-M), a fungicide with protectant and systemic components that may be effective against *P. obducens*, is given in Table 4. It has been assumed that most nurseries will have a knapsack sprayer to apply fungicides.

Table 4: Cost for one fungicide application to control impatiens downy mildew in 2004. Costs cover the spraying of 1000m² using a knapsack sprayer

Labour rate (£/hr)	7.00
Time to spray (hours)	2.5
	£
Labour cost	17.50
Chemical cost	2.37
Treatment variable cost	19.87

The costs of treatments were provided by ADAS and are based on the 2004 list price of chemicals and recommended rates of application. ADAS has estimated the cost of labour at £7.00/hour. ADAS have calculated that it will take 15 minutes to mix chemicals, fill and washout a 1.5-litre knapsack sprayer. Further, it will take 30 minutes to spray 250m² with a 1.5–litre knapsack sprayer. Therefore, the estimated time to spray 1000m² will be 120 minutes. Given that extra time will be needed between sprays for refilling the sprayer, the total time would be around 150 minutes. Total labour costs for 150 minutes would be £17.50. The cost of chemicals for 1000m² has been calculated at £2.37 for Fubol Gold ®, which is a systemic and protectant fungicide. Therefore, the total cost of one spray application is about £20.00. This figure has been used in calculations.

For the roguing of diseased plants, the labour cost has been estimated at £7.00/hour.

Rationale for fungicide application

The application of a protectant fungicide would be appropriate during production if there was a risk of infection. However, a systemic fungicide with a curative action would be more appropriate if it was possible that plants were already infected.

One problem in 2003 was that it was not known at what stage plants became infected. The disease was recognised in many cases after plants had been dispatched from growing-on nurseries. Many plants had been bedded in displays or were in home

gardens before symptoms were seen. However, infection from local alternative hosts (wild *Impatiens* spp.) is considered extremely unlikely. The disease had been seen at many growing-on nurseries producing plants from plugs. It is possible that young plants in plugs bought from suppliers by the growing-on nurseries were infected, but showing no symptoms. This could have been either as a result of infected seed producing infected seedlings in plugs, infected cuttings growing into infected plants and also possible spread between plug and cutting batches in the supplier's nursery. Some secondary spread may have occurred unnoticed at growing-on nurseries and also in bedding plant displays. A hanging basket approximately 200m from a nursery with the disease was found in 2003 with infected plants. The infected plants did not originate from the affected nursery. Spread between sporulating plants at the nursery and the hanging basket remains a possibility (S. Coutts, British Bedding and Pot Plant Association, 2004, personal communication).

There has been one reported outbreak of impatiens downy mildew so far in 2004. This occurred in a glasshouse that contained *Impatiens* trial material from Guatemala and the Netherlands. Locally propagated material of Dutch origin was also on trial. A manager of the nursery where the outbreak occurred reported to the PHSI that he was aware of a similar outbreak on the same Guatemalan material in a nursery in Spain (P. Barber, PHSI, 2004, personal communication). This suggests that the source of the outbreak may have been the plants grown from the cuttings imported from Guatemala. The origin of the infection in the Dutch material is less certain because there have been no reports of the disease in the Netherlands and no other Dutch material has been reported with the problem. Losses of all impatiens on trial were estimated at 100%.

Assuming that infected cuttings may also have initiated the 2003 epidemic, a control strategy could be to treat all young growing plants derived from cuttings with an effective systemic fungicide before dispatch to growing-on nurseries. The fungicide would be expected to cure any infections arising from infected cuttings, but this is not certain, as no experimental work has been undertaken. There is a danger that infections may only be suppressed and that they could develop and symptoms appear later. A protectant fungicide would be expected to prevent infection should some infections survive the treatment with systemic fungicide and the pathogen sporulate. Some fungicides combine both a systemic and a protectant. To wait until symptoms became noticeable before spraying would probably be too late to control impatiens downy mildew given experiences in the 2003 and 2004.

A precautionary treatment by the plug and cutting suppliers might offset any danger of subsequent disease development and further fungicide treatment at growing-on nurseries may not be necessary if there are no additional sources of infection. If infection does arise from secondary sources, such as wild *Impatiens* spp. near glasshouses, old infected plants in glasshouses or overwintering spores in soil, further fungicide treatment at growing-on nurseries would be warranted. However, no infections arising from secondary sources have been recognised so far in 2004. Time will tell if the pathogen is established in impatiens beds that experienced disease in 2003.

Precautionary treatments are not usually recommended, as they may be unnecessary if starting material is pathogen-free. Only by leaving a proportion of the crop untreated could some idea of the actual disease risk be known. However, leaving the crop

unprotected until there is a visible risk may be dangerous given the biology of the pathogen.

Should the disease appear in a nursery, then 2 applications of a systemic fungicide alternating with an application of a protectant fungicide or 3 sprays of combined systemic and protectant fungicides may be necessary to obtain some form of control. However, disease symptoms on many plants would mean that they would not be marketable. The timing of the application would also be important. An outbreak may be difficult to control if the pathogen is allowed to sporulate and spores are distributed widely.

There is a possibility that some systemic fungicides used for control may be ineffective due to the pathogen having developed resistance. There is no evidence for this happening with downy mildew of impatiens, but resistance to other downy mildews has been documented.

Control Option 1. Government involvement in the control of *P. obducens* within the impatiens industry – introduction of EU legislation

As previously mentioned, PHD has the option of proposing that the EU consider legislation to control the pathogen within the EU impatiens industry. Emergency statutory action will continue in the UK in 2004 while PHD considers its future involvement. However, this action will not control the source of infection if it lies overseas. The recent 2004 outbreak seems to have originated in cuttings imported from a third country. EU Legislative action would enable measures to be put in place that would require EU Member States and third countries to check places of production for pathogen freedom.

The first requirement if this option were to be pursued would be for EU Member States to undertake surveys to determine the distribution of the pathogen in each country. Consideration could then be given to determining if the situation warranted the declaration of *P. obducens* as a IIAII quarantine pest or a RNQP.

In developing this option, a number of assumptions have been made. One is that, as an EU IIAII quarantine pest or a RNQP, the level of tolerance for *P. obducens* in batches of imported and locally produced seed, plugs and cuttings would be zero. In the case of a RNQP, zero tolerance must be advocated because the pathogen has a latent infection stage and can sporulate rapidly at the same time as the first symptoms become noticeable. Thus the pathogen can spread between very many plants in a short space of time before any control action could be taken. Any tolerance of the pathogen would mean that the pathogen may be able to infect many plants before intervention. Only zero tolerance would ensure that epidemics would not occur. This option is envisaged to have the following costs: -

The cost to the government of having the introduction of EU legislation discussed at SCPH and enacted by the EU.

The first expense would be the cost of a survey to determine the status of *P. obducens* in the UK. This would involve PHSI inspecting all of the plug and cutting supply

nurseries and many of the growing-on nurseries. A UK survey has been estimated to cost about £10,000. Other EU Member States would also incur costs.

The second expense would be the introduction of legislation. This would involve:-
(a) the salary time of PHD officials negotiating the issue,
(b) the salary time of CSL personnel preparing relevant documentation, such as a PRA,
(c) Defra lawyer's costs for the wording of appropriate documents and incorporating this wording into the UK legislation after incorporation into the EU Directive.

One could argue that this cost is absorbed into the normal budgeted costs for Defra, PHD and CSL. It would be very difficult to estimate as an independent cost. However, a figure of £5000 has been proposed for PHD costs. This would be a one-off cost.

Once enacted, there would be further costs to the government associated with routine inspections by PHSI, policing disease outbreak sites to ensure the pathogen is eradicated and not disseminated, notification of outbreaks to the EU and the diagnosis of specimens sent to CSL. This cost is also difficult to estimate and could be said to be absorbed in the current budget. A conservative estimate would be 1% of the current budget for monitoring, which would be approximately £10,000/year. This would be a continuing cost.

Summary of estimated costs to government = £15,000 in first year
= £10,000 in subsequent years

The cost to the industry after the adoption of EU quarantine legislation assuming no disease occurs

EU legislation should result in the industry being supplied with clean propagating material. However, suppliers may need to raise the price of plants a little to cover increases in costs due to better glasshouse hygiene and disposal of surplus/unthrifty material plus the cost of official inspections if these charges are recovered by governments. The costs associated with visits from the PHSI in the UK to confirm the health status of plants at the supplier under the plant passporting scheme are £81 per hour. Other countries may charge similarly. If charges are made to the industry for this service, then costs may be passed on to the customer. Plugs may have to rise in price by 0.5p/plug to 8.2p/plug and cuttings by 2.0p to 35.0p/cutting.This would reduce the profit margin and the difference may have to be passed on to the growing-on nursery and ultimately the consumer. Increased costs may diminish the popularity of impatiens and have a deleterious effect on the industry.

Depending upon the production process, the cost of plugs varies from approximately 10% of sales value (plugs grown in 13 cm pots) to 51% of sales value (plugs grown in 'double-six' packs). The cost of cuttings used to produce 13 cm pots are approximately 42% of sales value. Without knowing the proportion of sales arising from each production system, it is difficult to make estimates concerning the cost of the industry as a whole resulting from the estimated price rises. Nevertheless, if it is assumed that each of the four systems have an equal share of a £40M market then the material purchased by growing-on nurseries in 2004 cost around £12.2M annually. Increasing the cost of plugs by 0.5p/plug and cuttings by 2.0p/cutting would result in

increasing the growing-on industry's costs by 2.3% (approximately £564K) to about £12.8M annually.

One major supply nursery has substituted a fungicide that was routinely used for another that is effective against downy mildew. As fungicide costs are a small component of total application costs, a simple substitution means that costs for fungicide application at supply nurseries may not be expected to substantially increase production costs. However, the price of the original fungicide used is unknown.

The legislation would need to ensure that the suppliers of plugs were pathogen-free. If this were achieved, nurseries growing-on would have no need to take extra precautions, such as a fungicide application, as the pathogen should not be present. Therefore, the cost of plants sold by growing-on nurseries to the end user may not increase. Of course, if a disease outbreak did occur at a growing-on nursery, all plants in the glasshouse in question would have to be destroyed and plants in other glasshouses would be quarantined and treated with fungicide at cost to the grower.

Summary of estimated costs to industry without disease = PHSI inspections at £81/hour (if passed on by government), which may lead to a possible 0.5p rise in the cost of a plug and a 2.0p rise in the cost of a cutting.

The cost to the industry after the adoption of EU quarantine legislation if disease occurs

If disease did occur, then additional costs to the industry would depend on the extent of the outbreak. Experience has shown that the pathogen can spread rapidly in growing-on glasshouses under the right conditions. If a batch of cuttings or plugs were infected at planting, then it is possible that all plants in the glasshouse may become infected before appropriate control action could be taken.

Financial losses to growing-on nurseries producing impatiens in 9cm pots from plugs raised from seed under different disease incidences are costed in Table 5. However, under EU quarantine legislation, it is likely that losses would be close to 100% because eradication would require all infected plants to be destroyed and the remainder quarantined to prevent the pathogen escaping. Quarantined plants may lose their value if held for extended periods.

Control option 2. Government involvement in the control of *P. obducens* within the impatiens industry – continuation of emergency statutory action

The cost to the government of continuing emergency statutory action

Actions proposed for March/April 2004 under statutory action were described at the Defra Quarantine Trilateral meeting held at CSL on 5 February 2004. Government costs here would be associated with the following actions: -

(a) PHSI Inspectors discussing impatiens downy mildew with relevant clients with the aid of the HDC factsheet (Jones and O'Neill, 2004) during routine nursery visits.

(b) PHSI Inspectors visiting propagators at least once in the growing season to inspect growing crops and any wild impatiens growing around the nursery for disease. Specimens of plants with suspicious symptoms would be sent to CSL for diagnosis.
(c) PHSI Inspectors supervising the destruction of infected plants, the application of a precautionary fungicide treatment to unaffected plants and the dispatch of any residual seed (if the crop was raised from seed) to CSL.
(d) CSL Mycologists testing seed stocks for infection/overwintering spores.
(e) Administrative costs at PHD and CSL in providing recommendations and maintaining statistics, notifications, etc.

The cost of the above would be similar to that calculated for disease monitoring and taking action should outbreaks occur as discussed in the previous option. This was £10,000/year.

Summary of estimated costs to government = £10,000 a year inspection and testing costs

The cost to the industry of continuing emergency statutory action assuming no disease occurs

Costs to the industry under continued emergency statutory action would depend on what actions individual suppliers/nurseries in the industry might take in the future to safeguard impatiens material. Uncertainty over the health of stocks from overseas suppliers under this option may mean that supply nurseries will treat all introductions with a systemic fungicide after establishment as a safeguard.

One major UK plug supplier is already applying fungicide effective against downy mildews to the growing material. This cost does not seem to be being passed on to the growing-on nurseries. Again, the PHSI may want to pass on the cost of inspections (£81/hour) to growers in the future. If these are passed on, suppliers may increase the price of plugs as before and growing-on nurseries could charge more for bedding plants.

Approximately 60% of plugs and cuttings utilised in the UK industry come from the Netherlands and Belgium. One uncertainty for the UK industry is a lack of knowledge of fungicides or other chemicals that may have been used on the material before dispatch. An additional treatment with a protectant/systemic fungicide with activity against downy mildews in the UK may well result in a phytotoxic reaction, especially on young plug seedlings (S. Coutts, British Bedding and Pot Plant Association, 2004, personal communication).

If the current emergency statutory action situation policed by the PHSI were to continue and the industry did nothing to reduce risks of disease introduction, then it is possible that outbreaks could occur in the future as they did in 2003. Suppliers of plugs in the UK now know of the dangers. Imported seed is regarded with suspicion. As mentioned above, at least one plug producer is treating plugs with a systemic fungicide that is effective against downy mildew before release. More extension work to warn nurseries of the dangers from imported seeds/cuttings, especially those originating in Central America, which may be the source of the 2004 outbreak, may lead to risks being substantially reduced.

able 5: Gross margin budgets for impatiens production under four levels of disease in 2004. Based on impatiens grown from plugs raised from seed with a crop area of 1000m² and 95% of roduction marketed in 9cm pots normally sold.

oss due to owny ildew	0%	10%	50%	100%
etail	Crop is free of disease	Disease spread is halted by three fungicide applications and 10 hours roguing.	Disease is partially controlled after three fungicide applications and 20 hours of roguing.	Disease uncontrollable after three fungicide applications and 20 hours of roguing
utput number of rays each ontaining 8 plants)	4,465	4,019	2,232	0
rice per tray £)	5.40	5.40	5.40	-
	£	£	£	£
ales	24,111	21,700	12,056	0
ixed ariables	14,344	14,344	14,344	14,344
ungicide	0	60	60	60
oguing	0	70	140	140
	(14,344)	(14,474)	(14,544)	(14,544)
ross margin	9,767	7,226	(2,488)	(14,544)
rop in argin (£)	0	2,541	12,255	24,311
rop in argin (%)	0	26	125	249

It is still not known if the disease can be detected at supplier's nurseries and so prevent spread with infected plugs/cuttings to growing-on nurseries. However, it is likely that PHSI inspections in 2004 will detect the disease in growing-on nurseries before sale to the end-user and planting out.

Summary of estimated costs to industry = PHSI inspections at £81/hour (if passed on by government), which may lead to possible 0.5p rise in the cost of a plug and a 2.0p rise in the cost of a cutting.

The cost to the industry of continuing emergency statutory action if disease occurs

Under the emergency statutory action option, the PHSI will be policing all places of production, which includes growing-on nurseries, because plugs cannot be guaranteed as pathogen-free. If the disease were detected by the PHSI, this would result in substantial losses as diseased plant batches would be destroyed and other batches at the same nursery would be treated with fungicide and quarantined. Again losses would be close to 100% (Table 5).

Control Option 3. Industry controls without government involvement

In this option, there would be no costs to the government, as industry would be managing the problem without outside help.

It can be assumed that measures undertaken by industry to self-manage downy mildew would be based on the close inspections of plugs and their routine treatment with a suitable systemic fungicide. One major supplier of plugs (under the supplier's own initiative notwithstanding the government emergency statutory control measures being in force) is treating propagating material with a protectant/systemic fungicide effective against downy mildew before dispatch. However, not all suppliers may be as diligent. If the industry does not impose the same standard precautionary control measures across all supply nurseries, then there is a possibility that the disease may reappear and spread again in the future. The outbreak in 2004 may have been prevented if the imported cuttings had been treated with an effective systemic fungicide. Outbreaks will continue as long as overseas sources of new cultivars do not take precautions to prevent infection and importers do not isolate and treat new introductions. Even then, there is still the possibility that a systemic fungicide will just suppress rather than cure an infection or be ineffective due to the development of fungicide resistance in the pathogen.

Dutch suppliers claim that they have no problem with downy mildew and are not treating material with a precautionary fungicide application (P. Reed, CSL, 2004, personal communication). Should downy mildew become a problem in the Netherlands, risks would increase. At present, the suppliers in the Americas represent the only known threat, but infected material from there could be sold-on from European markets.

No government involvement; no special precautionary measures introduced by the industry

If PHSI were not inspecting impatiens at supplier's premises and growing-on nurseries and growers were not taking any precautions to prevent introduction and spread of the pathogen, then the chances of diseased material being passed on down the supply chain to the end user would be the same as in 2003. This would result in continuing uncertainty, continued losses for nurseries due to end users refusing to pay for diseased material and perhaps a collapse in confidence in impatiens as a bedding plant. The industry based on *I. balsamina*, estimated to be worth £40M/year, could be in jeopardy.

Financial losses to growing-on nurseries producing impatiens in 9cm pots from plugs raised from seed under different levels of disease incidence are costed in Table 5. This is based on unaffected stock still being sold to the customer and not destroyed as would occur under government control. It is estimated from interpolation of Table 5 that the break-even point would come after about a 38% disease incidence. If disease incidence increased above this level then the grower would make a loss.

Summary of estimated costs to government = £0
Summary of estimated costs to industry = see Table 5

No government involvement; special precautionary measures introduced by the industry

For the industry to control the disease, all plug/cuttings producers would need to ensure that their impatiens material is *P. obducens*-free. This may mean demanding certification from their suppliers that *P. obducens*. did not occur at breeding/propagating/seed producing nurseries. Growing-on nurseries may in turn need certification that plug/cutting supplier's premises were free of *P. obducens*. As a precaution, suppliers would need to routinely spray plugs/cuttings with a systemic/protectant fungicide that is known to cure infections before sale to growing-on nurseries.

Routine spraying is being undertaken in 2004 at a major UK plug supplier. Because the fungicide has replaced another that was routinely applied before downy mildew was discovered, the cost of plugs has remained the same. What the previous fungicide was being applied to control and whether the target pathogen or pathogens may now become a problem again if not controlled by the new fungicide is not known.

The fungicides that have been recommended control other downy mildews and are seen as the most appropriate for use to control impatiens downy mildew. However, no experimental work has been undertaken to confirm their efficacy. It is not known with any certainty which systemic fungicide, if any, can cure plants infected with impatiens downy mildew. Suppression of the infection and its re-emergence later would be dangerous. Another uncertainty is whether the pathogen has developed resistance to any particular systemic fungicide.

The outcome here would be similar to normal costings for industry presented in Tables 1, 2 and 3. Plugs and cuttings should be pathogen-free and growing-on nurseries consequently free of disease. However, if industry could not police itself, then large outbreaks could occur with substantial losses.

Summary of estimated costs to government = £0
Summary of estimated costs to industry = see Table 5

Cost-benefit analysis

In the scenarios used to estimate the costs involved with Control Options 1 (introduction of EU legislation) and 2 (continuation of emergency statutory action), it is assumed that there are no disease outbreaks. Costs that would be incurred if there were disease outbreaks were not evaluated. Government and industry costs are

incurred in both of these options. Over a ten-year period discounted costs have a present value of £5.354 to £5.359M (Table 6).

Table 6: Annual government and industry costs for Control Options 1 and 2 over the next ten yea

		Option 1			Option 2		
Year	Discount factor	Govt costs (£'000)	Industry costs (£'000)	(Govt + industry) x discount factor (£'000)	Govt costs (£'000)	Industry costs (£'000)	(Govt + indu x discount fa (£'
0	1	15	564	579	10	564	
1	0.9662	10	564	555	10	564	
2	0.9426	10	564	541	10	564	
3	0.9021	10	564	518	10	564	
4	0.8717	10	564	500	10	564	
5	0.8423	10	564	483	10	564	
6	0.8139	10	564	467	10	564	
7	0.7865	10	564	451	10	564	
8	0.7601	10	564	436	10	564	
9	0.7345	10	564	422	10	564	
10	0.7099	10	564	407	10	564	
				5,359			5

Grossing up figures in Table 5 to an industry wide scale, 10% losses and 50% losses would represent annual financial impacts of between £3.6M and £19.1M (Table 7). Over ten years, such impacts have a present value of between £33.6M and £178.4M (Table 8).

Table 7: National impacts of 10% and 50% losses in *Impatiens balsamina*

	Plugs in double six pack	Plugs in 9cm pots	Plugs in 13cm pots	Cuttings in 13cm pots	sum
Sales / 0.1ha (£)	16,967	24,111	29,469	29,469	
National sales apportioned by £40M (£'000)	6,786	9,643	11,786	11,786	40,000
National margins (£'000)	1,327	3,906	6,777	2,989	14,999
10% loss led to 74% of normal margin (see Table 5)					
Revised national margins with 10% losses (£'000)					11,399
Impact (£'000) (14,999-11,399) =					3,599
50% loss led to 125% loss of normal margin (see Table 5)					
Revised national margins with 50% losses (£'000)					(4,128)
Impact (£'000) (14,999- -4128) =					19,127

Table 8: Present value of annual costs for the next ten years resulting from 10% and 50% losses in *Impatiens balsamina.*

Year	Discount factor	Present value of costs (10% losses) (£'000)	Present value of costs (50% losses) (£'000)
0	1	3,599	19,127
1	0.9662	3,478	18,480
2	0.9426	3,393	18,029
3	0.9021	3,247	17,253
4	0.8717	3,138	16,672
5	0.8423	3,032	16,110
6	0.8139	2,930	15,567
7	0.7865	2,831	15,043
8	0.7601	2,736	14,537
9	0.7345	2,644	14,049
10	0.7099	2,555	13,577
		33,584	178,444

This analysis assumes that that either Control Option 1 or 2 would prevent the impacts of disease outbreaks described in Option 3.

The costs of Control Option 1 and 2 can be set against the benefits of industry not incurring losses described in Option 3. This forms the cost-benefit analysis and is given in Table 9.

Table 9: Cost-benefit ratios of Control Options 1 or 2 (govt.+ industry costs) versus industry costs outbreaks (Option 3)

Option	Present cost of control action £'000	% Losses (Option 3)	Present value of losses avoided (benefits) £'000	Cost: benefit rati
1	5,359	0	0	no benefit from taking action
1	5,359	10	33,584	1:6.3
1	5,359	50	178,444	1:33.3
2	5,354	0	0	no benefit from taking action
2	5,354	10	33,584	1:6.3
2	5,354	50	178,444	1:33.3

When the industry successfully controls the disease itself without government intervention, and there are no losses, there is clearly no benefit from either Control Option 1 or 2[1]. However, if the industry fails to control the disease and outbreaks occur nationwide with losses of between 10 and 50%, then the benefit of a government programme range from 1:6 to 1:33.

Conclusions

[1] In these circumstances, no cost: benefit ratio is given in Table 8 since you cannot divide by 0.

The cost-benefit analysis shows that the government would be faced with substantial costs in declaring *P. obducens* an IIAII quarantine pest or RNQP and inspecting nurseries for disease. The costs of inspection, diagnosis and administration could be passed on to the nurseries in the future and this may result in a slight rise in the price of plugs and plants to the industry and their customers. Although the accompanying legislation would stipulate that EU and third country nurseries supplying the EU market be free of the pathogen, there is no guarantee that the material would be pathogen-free.

Continuing emergency statutory action would not have costs associated with introducing EU legislation, but it would have continuing inspection, diagnostic and administrative costs, which may or may not be passed on to the industry. Although this option would lessen the risk on the UK industry suffering another epidemic, it could not guarantee that the pathogen would not be introduced in material, such as cuttings from the Americas, in the future.

The most cost-effective management strategy for PHD would be to allow the industry to police itself as regards impatiens downy mildew. This option would not require the PHSI to inspect nurseries. However, there would be a much greater chance of a disease outbreak and substantial losses to the industry. A disease incidence of 10% would result in gross margins falling around 26%. A 26% fall in margins industry-wide would result in overall margins for *I. balsamina* falling from £15M to approximately £11.4M, a drop of approximately £3.6M. A 50% disease incidence across the entire industry is viewed as unlikely, but if it occurred, sales of *I. balsamina* would drop from approximately £40M to £20M and gross margins would fall from £15M to a loss of £4.13M, a drop of approximately £19.13M.

Evidence from the UK and USA to date suggests that the origin of infected material may be Central America. Impatiens cultivars are bred and propagated in Central America and distributed to the USA and elsewhere. Controls may need implementing at supply nurseries in countries in this region in the first instance. This investigation shows that measures taken by UK/EU suppliers raising plugs from seed and propagating cuttings are critical for local pathogen control. Careful control measures in plug/cutting supply nurseries should ensure no disease is passed on to growing-on nurseries. This may involve the routine application of a systemic fungicide to seedlings grown from imported seed and also imported cuttings to counter possible pathways of introduction. For the UK industry to undertake its own in-house controls, similar measures to prevent disease introduction and/or establishment would need to be adopted if overseas seed plug and cutting suppliers could not guarantee pathogen-freedom.

A major supplier in the UK is already treating plugs routinely with a fungicide active against downy mildews, but other local suppliers and also continental suppliers may be reluctant to take these steps. However, it would be in the supplier's own commercial interest to ensure material was pathogen-free. Any plug or cutting supplier that sold material that led to disease outbreaks maybe at a commercial disadvantage. The only problem with this option would be if outbreaks could not definitely be traced back to the suppliers and the origin of the outbreak identified,

which often occurs. There would also be problems if suppliers failed to take the necessary measures one would anticipate for self-preservation of the industry.

There has been only one outbreak of downy mildew on impatiens in the UK so far in 2004 in a variety trial. This was in a glasshouse that contained imported cuttings. The disease was not immediately recognised and put down to physiological causes. When the problem was diagnosed, the pathogen had spread to most other plants in the trial. This incident illustrates the problem that the industry may face in the future. If the industry is to police itself as regards downy mildew, care would need to be taken to isolate new material and destroy any infected material promptly before spread can occur. The routine treatment of introduced cuttings with an effective systemic fungicide may also become a necessity. However, there is a serious danger here that a treatment may suppress symptoms and allow the pathogen to pass along the propagation chain until reaching the growing-on nursery. More extension work would alert importers and propagators to the dangers. It is recommended that discussions be held with industry to gauge opinion on whether self-management is realistic.

If industry believes that self-management is feasible, a course of action could be to maintain a watching brief on developments over the next few years. Although downy mildew is beginning to appear more regularly on impatiens in the USA, it is possible that the problem with the suppliers in the Americas will be solved in the future. As mentioned previously, sources of infection may lie in Central America, which is the location of impatiens breeding programmes and the origin of much seed used in the industry.

Observations

The conclusions and recommendations above are based primarily on knowledge of the pathogen and the impatiens industry.

The precautionary measures now being taken by the main UK plug supplier are a step in the right direction assuming that the fungicide being used cures infections rather than suppresses them until fungistatic effects diminish. However, all suppliers of plugs and cuttings would need to take similar precautions in order to prevent a major outbreak similar to the one that occurred in 2003. Education of overseas suppliers and minor UK plug suppliers to take similar precautions, if they are not already doing so, is recommended to make the industry safe from the disease in the future. PHSI's future role could be one of educating UK plug and cutting importers and suppliers as to correct procedures to follow to prevent a widespread outbreak. There is still a significant danger that infected plugs/cuttings originating in Central America could infiltrate the marketing system in continental Europe and be sold on to the UK as Dutch or Belgium produce. All introduced plants should be regarded as suspect until confidence is restored.

The precautionary measures now being taken by the major plug supplier do not appear to be altering the cost structure of the industry. An inappropriate fungicide application has been replaced a by a more appropriate application without increasing costs. However, it should be noted that an outbreak of another disease, such as the *Alternaria* sp. recently found causing necrotic lesions on impatiens at two locations in

the UK, could require a reconsideration of fungicide application recommendations. Any additional or alternative fungicide application could increase costs, though this may not be sufficient to raise the price of supplier's plugs and cuttings to growing-on nurseries.

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