**Factsheet 26/12** (HDC Project PC 291)

Protected ornamentals

# Bacterial diseases of protected ornamentals

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This factsheet provides guidelines for achieving effective recognition and control of bacterial diseases of protected bedding and pot plants. It provides information on disease identification, biology of the causal bacteria and methods of cultural and chemical control.

## Action points

**Glasshouses and equipment**

- Thoroughly clean and disinfect the glasshouse prior to introducing a new crop.
- If growing on the floor, make sure beds are level to minimise persistent wet areas and that there is good drainage.
- Only use new containers.
- Disinfect pruning knives and secateurs on which bacteria are easily transmitted.
- After an outbreak of a bacterial disease, review the nursery disease protocol to check if there are any weak links.

**Management of plants**

- Do not overwater plants; water crops early in the day so that foliage dries before night fall.
- Provide good air circulation within the plant canopy, by appropriate plant spacing and use of fans.
- Limit mechanical damage as much as possible during transplanting, spacing and other work in the crop.
- Control feeding insects and nematodes which may create entry points for bacterial pathogens.
- Regularly inspect crops and promptly remove and destroy any infected plants and plant debris which can harbour bacteria.

## Introduction

Bacterial diseases of bedding and pot plants are generally less common than fungal diseases but when they do occur they can cause substantial losses. In recent years, cyclamen bacterial soft rot (*Pectobacterium carotovorum*), wallflower bacterial wilt (*Xanthomonas campestris*) and bacterial blight of pelargonium and geranium (*Xanthomonas hortorum*) have all caused significant losses on individual nurseries. The value of cyclamen lost to bacterial soft rot has exceeded £50,000 in some crops. Outbreaks of notifiable bacterial diseases such as poinsettia bacterial leaf spot (*Xanthomonas axonopodis* pv. *poinsettiicola*) and geranium bacterial wilt (*Ralstonia solanacearum*) have also resulted in high losses due to the required destruction of infected and contaminated plant material.

There are no chemical controls recommended for bacterial diseases other than copper fungicides, which provide limited protective control. Disease avoidance through cultural control is therefore very important. Early and accurate identification

**1. Bacterial soft rot of cyclamen**

of bacterial disease problems is critical, so that the most appropriate control measures can be applied before significant plant losses occur. If the cause of a disease is not apparent, plant samples should be examined by a qualified person or sent to a laboratory for diagnosis.

## Disease recognition and biology

The more common bacterial diseases of ornamentals confirmed in UK crops in recent years are listed below. The symptoms and biology of these diseases are described in the following sections according to the major symptom type.

**Table 1. Some bacterial diseases of protected ornamental species recorded in the UK**

| Host | Disease | Casual bacteria |
|---|---|---|
| *Acanthus* | Leaf spot | *Pseudomonas syringae* |
| *Antirrhinum* | Leaf spot | *Pseudomonas syringae* |
| *Aquilegia* | Leaf spot | *Pseudomonas syringae* |
| *Begonia* | Blight | *Xanthomonas axonopodis* |
| *Chrysanthemum* | Crown gall | *Rhizobium radiobacter* |
| | Leafy gall | *Rhodococcus fascians* |
| *Cyclamen* | Soft rot | *Pectobacterium carotovorum* |
| *Delphinium* | Leaf spot | *Pseudomonas syringae* |
| *Erysimum* | Bacterial wilt | *Xanthomonas campestris* |
| *Hedera* | Leaf spot | *Xanthomonas hortorum* |
| *Hyacinth* | Soft rot | *Pectobacterium carotovorum* |
| *Impatiens* | Leaf spot | *Pseudomonas syringae* |
| *Lavandula* | Leaf blight | *Xanthomonas hortorum* |
| *Pelargonium* | Leaf spot | *Pesudomonas syringae* |
| | Bacterial wilt | *Ralstonia solanacearum** |
| | Bacterial wilt/blight | *Xanthomonas hortorum* |
| | Soft rot | *Pectobacterium carotovorum* |
| *Petunia* | Leafy gall | *Rhodococcus fascians* |
| *Poinsettia* | Leaf spot | *Xanthomonas axonopodis* pv. *poinsettiicola** |
| | Soft rot | *Pectobacterium carotovorum* |
| *Primula* | Leaf spot | *Pseudomonas syringae/ viridiflava* |
| | Soft rot | *Pectobacterium carotovorum* |
| *Rudbeckia* | Leaf spot | *Pseudomonas cichorii* |
| *Salvia* | Leaf spot | *Pseudomonas syringae* |
| *Schlumbergera* | Soft rot | *Pectobacterium carotovorum* |
| *Zantadeschia* | Soft rot | *Pectobacterium carotovorum* |
| *Zinnia* | Leaf spot | *Xanthomonas campestris* |

**Non-indigenous in UK*

The two most common bacterial leaf spots are caused by species of *Pseudomonas* and *Xanthomonas*. On many hosts leaf spotting caused by these bacteria can progress to cause a leaf rot and premature leaf fall, known as bacterial blight. Other symptoms caused by bacterial diseases are wilts, rots and galls.

### Pseudomonas leaf spots and blights

Pseudomonas leaf spot diseases occur sporadically on *Acanthus, Antirrhinum, Aquilegia, Delphinium, Impatiens, Pelargonium, Primula* and *Salvia*. The bacteria are usually spread from plant to plant by water splash. In general, *P. syringae* pathovars are capable of causing disease at relatively low temperatures (15-20ºC). Disease is exacerbated by high humidity and extended periods of leaf wetness.

**2. Pseudomonas leaf spot on salvia**

While Pseudomonas leaf spots initially appear as dark brown to black spots with water-soaked margins, with desiccation of infected tissue they become thin, pale brown, papery lesions. Pseudomonas leaf spots on *Antirrhinum, Impatiens, Pelargonium* and *Primula* are usually caused by host-specific pathovars of *P. syringae*. Consequently, a Pseudomonas leaf spot disease on one host will not necessarily spread to unrelated species.

#### *Impatiens*

There were several outbreaks of bacterial leaf spot and blight caused by *P. syringae* on pack-grown impatiens in spring 2010 affecting crops in unheated polythene tunnels. Infection is often associated with water pores (hydathodes) at the leaf margin. Initial symptoms are small, usually circular brown spots (3-5 mm in diameter) near the leaf edge. These enlarge and develop a grey-black greasy appearance. Adjacent areas of tissue turn yellow and the leaves die, generally without wilting. Severely affected plants may lose most of their leaves. Both impatiens and New Guinea impatiens are susceptible to Pseudomonas leaf spot. Other fluorescent *Pseudomonas* species have been associated with leaf spotting symptoms on impatiens including *P. marginalis* and *P. viridiflava* in the UK and *P. cichorii* in the USA.

Some *Pseudomonas syringae* leaf spot diseases are known to be seed-borne including *P. syringae* on *Antirrhinum*, but this is unproven for other hosts.

**3. Pseudomonas leaf spot on impatiens**

**4. Plant collapse due to *Pseudomonas* infection**

## Xanthomonas leaf spots and blights

Xanthomonas leaf spot diseases typically appear as corky, dryish lesions with irregular shaped margins. Hosts commonly affected are begonia and ivy and more recently poinsettia.

### *Begonia*

Bacterial blight of *Begonia* caused by *X. axonopodis* pv. *begoniae* is a major disease of elatior, fibrous-rooted and tuberous begonias. It is usually first seen as small, water-soaked spots towards the margin of older leaves. The spots enlarge and coalesce leading to a leaf blight. Infection arises from cuttings carrying latent infection or dried infested debris. The disease is readily spread by water-splash, by handling plants and on knives and by watering using sub-irrigation. There are no known resistant cultivars.

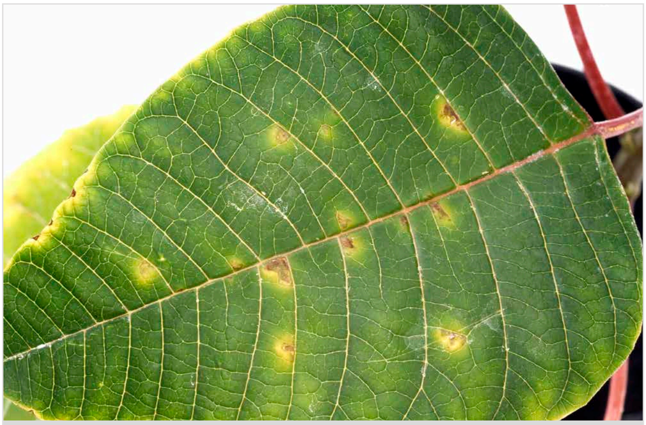
### Ivy

Xanthomonas leaf spot of ivy, caused by *Xanthomonas hortorum* pv. *hederae*, usually develops as circular or irregular shaped black lesions with a yellow halo and is visible on both leaf surfaces. Lesions may coalesce giving plants a blighted appearance. The same bacterium affects other members of the *Araliaceae* family including *Fatsia japonica* and *Schefflera arboricola*. Cultivars of ivy differ considerably in their susceptibility.

**5. Xanthomonas leaf spot on ivy**

### Poinsettia

In 2006-2010 the non-indigenous *Xanthomonas axonopodis* pv. *poinsettiicola* occurred as a leaf spot in some poinsettia (*Euphorbia pulcherrima*) crops. Bacterial leaf spot of poinsettia develops as small reddish angular brown spots which appear on the upper and lower surfaces of leaves and bracts. The spots usually have a light tan to chocolate-brown centre and a 'water-soaked' appearance. A pale green to yellow 'chlorotic halo' surrounds the spot where the leaf has lost its colour. The disease may be spread by water splash from infected leaves and plant debris, via plant-to-plant contact, during any process involving the handling of plants and on contaminated equipment. The pathogen infects plants of the *Euphorbiaceae* so weeds in the spurge family may act as a bridge for the disease between crops. This disease is listed for quarantine regulation.



**6. Xanthomonas leaf spot on poinsettia showing yellow halo around leaf spotting**

## Wilt diseases

Bacterial wilt diseases can be caused by species of *Ralstonia* and *Xanthomonas*.

### *Pelargonium*

Bacterial wilt of *Pelargonium*, a notifiable disease caused by the bacterium *Ralstonia solanacearum*, has similar symptoms to the bacterial blight and wilt caused by *Xanthomonas hortorum*. Early symptoms of infection include wilting of the lower leaves with rolling of the leaf margins; leaf yellowing and necrosis. Stems may show brown to black discolouration around the soil surface, both externally and internally when cut. Roots of infected plants are often brown or black. Wilting of infected *Pelargonium* is systemic, starting with lower leaves and petioles and eventually spreading; in some cases only one part of the stem may show wilting symptoms, but eventually the entire plant wilts, collapses, and dies. Although often considered a tropical disease, symptoms have been reported on plants kept at 21°C.

**7. Ralstonia wilt on pelargonium**

*Xanthomonas hortorum* pv. *pelargonii* is widespread and particularly affects zonal *Pelargonium* and *Geranium* species. On *Geranium* it causes dark brown angular leaf spots, sometimes surrounded by a red or yellow halo. The pathogen moves along the main veins causing dry necrotic sectors on the leaves. In *Pelargonium* it produces a black stem rot similar to that caused by *Pythium* though drier in appearance. Vascular discolouration may occur at stem nodes and spots or chlorotic V-shaped sectors develop on leaves. It is spread by water splash, but also on the knives and hands of staff. It can arise through cuttings carrying latent, systemic infection.

**8. Xanthomonas blight on pelargonium**

### Wallflower

In wallflower (*Erysimum*), pathovars of *Xanthomonas campestris* cause leaf blight. Yellow or pale brown necrotic areas can be mistaken for natural senescence. Lesions may develop to one side of the midrib or V-shaped lesions can form from the leaf tip along the midrib. In warm conditions, infected leaves wilt and dry rapidly. Leaf veins in chlorotic or necrotic lesions may darken.

**9. Xanthomonas wilt on field-grown wallflower (*Erysimum*)**

**10. Xanthomonas wilt on wallflower (*Erysimum*) showing leaf spot and yellowing**

## Bacterial soft rots

Bacterial soft rot caused by *Pectobacterium carotovorum* (previously known as *Erwinia carotovora*) is a serious disease of cyclamen and calla lily and affects a wide range of other ornamental crops including: hyacinth, pelargonium, poinsettia, primrose, schlumbergera and viola. A number of *Dickeya* species (all previously classified as *Erwinia chrysanthemi*) can also cause soft rots on a wide range of ornamentals under warm glasshouse conditions. Known host plant genera include: *Aechmea, Aglaonema, Aloe, Anemone, Chrysanthemum, Cyclamen, Dahlia, Dianthus, Dieffenbachia, Dracaena, Euphorbia, Gymnocalicium, Hyacinthus, Kalanchoe, Oncidium, Opuntia, Parthenium, Phalaenopsis, Philodendron, Polyscias, Rhynchostylis, Saintpaulia, Scindapsus* and *Syngonium*.

### *Cyclamen*

On cyclamen these bacteria cause a soft rot of the corm, resulting in a sudden wilting and collapse of the whole plant. The disease usually starts at the top of the corm. With collapsed plants, the top of the plant can be pulled away easily, leaving a slimy, foul-smelling corm rot. Infection arises following corm damage, such as that caused through growth cracks or following Fusarium wilt. There is some evidence that sciarid fly larvae feeding damage may predispose plants to bacterial soft rot. Drenching of plug plants can greatly increase the potential for the disease, probably associated with increased wetness duration. Extended periods of transportation, with associated long periods of high humidity, can increase the risk of bacterial soft rot on plants. The disease progresses rapidly at temperatures above 20ºC.

11. Bacterial soft rot of a cyclamen corm

### Calla lily

In the case of arum or calla lily (*Zantedeschia aethiopica, Z. elliottiaria* and *Z. rehmanii*), plants are attacked at the collar and the corms are rotted causing yellowing and death of foliage. The disease is considered to be spread through planting corms with latent infection.

### Other common hosts

*Primula obconica* affected by *P. carotovorum* develop a crown rot that may progress into the leaf petioles. In *Pelargonium*, poinsettia and many other hosts, the bacteria cause a soft rot of cuttings during rooting, developing from the base upwards. When conditions are optimum symptoms develop within 24-48 hours. Symptoms in cuttings include: wilting, vascular browning and dark, water-soaked stem and leaf lesions. In *Schlumbergera*, the bacterium causes a loss of healthy green colour in the phylloclades, progressing to necrosis, wilting and collapse.

12. Bacterial soft rot of *Primula obconica* showing leaf symptom

## Crown gall

Crown gall is caused by tumor-inducing strains of the bacterium *Rhizobium radiobacter* (formerly *Agrobacterium tumefaciens*). Although the disease does not usually affect plant growth, the development of unsightly galls renders plants unmarketable. Amongst many ornamental species the most commonly affected are chrysanthemum and rose. A few foliage plants are natural hosts of crown gall (for example *Ficus* and *Croton*).

Galls usually form at the crown of a plant but occasionally on roots, stems or leaves. The galls first appear as small masses of callus tissues but may enlarge to several centimetres in diameter. The galls are firm, whitish at first and later brown-black with a rough (warty) surface. Occasionally plants may die when crown galls become secondarily infected by soft rotting organisms. The bacterium can be transmitted between plants on pruning tools.

13. Crown gall on marigold

## Leafy gall

Leafy gall is caused by the bacterium *Rhodococcus fascians* carrying a fasciation-inducing plasmid. On ornamental crops it is most frequently found on chrysanthemum, pelargonium and sweet pea and less commonly on antirrhinum, dahlia, dianthus, gladiolus, petunia and phlox. Symptoms include production of excess shoots, proliferation of buds at the stem base, misshapen thickened flat leaves or shoots (fasciation) and amorphous growths arising from veins or leaf edges (leafy galls). The degree of symptom expression depends on the host species and cultivar, plant age at time of infection, growth conditions and bacterial strain. Moisture and high humidity are favourable for aerial infections. *R. fascians* can persist in a bacterial slime layer for many months prior to the production of symptoms. The optimum temperature for *R. fascians* is 25°C to 28°C.

Contaminated propagation material is probably the primary means by which *R. fascians* is introduced into new areas, for example when cuttings are taken from visibly healthy portions of infected plants.

*R. fascians* is known to be seed-borne in some hosts and can persist on infected plant material buried in soil for three months. In glasshouses especially, where multiple crops are grown over the course of a year, infested soil could be an important means of contaminating a new crop.

14. Leafy gall on petunia

## Emerging bacterial diseases

Findings of *Pseudomonas syringae* and *Xanthomonas* species on new hosts occur fairly frequently. For example, *P. syringae* has been found associated with leaf spot symptoms on a number of genera of flowering plants in recent years including: *Ageratum, Anemone, Argyranthemum, Cirsium, Cordyline, Fuchsia, Geranium, Helianthus, Lavandula, Tagetes* and *Verbena*.

*Xanthomonas hortorum* has been found causing a leaf spot on lavender on a number of occasions. *Xanthomonas* has also been recently associated with leaf spot diseases on *Anemone, Begonia, Hydrangea, Lobelia* and *Zinnia*. In the latter case, the pathogen was isolated from both zinnia seeds and the resulting symptomatic plug plants.

**15. Xanthomonas leaf spot on lavender**

In recent years there has been a significant increase in losses due to *Dickeya* in the European flower bulb industry. This has mostly affected hyacinth production but a number of other species have also been affected, including *Amaryllis, Anemone, Brodea, Dahlia, Freesia, Iris, Muscari, Narcissus, Triteleia* and *Zantadeschia*, The causal bacterium has been termed '*Dickeya solani*' due to its emerging importance as a potato pathogen. Another *Dickeya* species causes a slow wilt in dianthus.

**16. Xanthomonas leaf spot on lobelia**

**17. Dianthus slow wilt (*Dickeya dianthicola*)**

## Cultural control

### Healthy propagation material

Some bacterial diseases of bedding plants can be seed-borne (for example *Xanthomonas* species on *Pelargonium* and *Zinnia*, *Pseudomonas syringae* on *Antirrhinum*) and all can be introduced on infected plug plants or cuttings. Ensuring that propagation material is produced in disease free environments is therefore very important. Seed testing methods can require high numbers of seeds (10-30,000) and are therefore not usually an option for individual growers. Propagation from cuttings is particularly risky since rooting usually requires high temperature and humidity and cut stems are open to infections. Early detection and removal of diseased, young plants is critical in preventing secondary spread.

The introduction into Europe of *Ralstonia solanacearum* in infected *Pelargonium* cuttings imported from Africa is a good example of long distance spread of a quarantine pathogen on propagation material. Mother plants were initially infected through irrigation with surface water contaminated with the bacterium. Extensive spread of the disease occurred when infected cuttings were rooted and grown on by propagators with ebb and flow or flood irrigation systems prior to further distribution. This recent problem has now been overcome by raising hygiene standards (especially disinfection of surface water used for irrigation) during overseas production of cuttings and increasing levels of vigilance during propagation.

### Growing conditions

Since the development of most bacterial diseases is favoured by warm (20-25°C), wet conditions, manipulation of the growing conditions can have a large impact on disease incidence and severity. Good air circulation and appropriate plant spacing can help to keep leaf wetness to a minimum. Infection by bacteria is enhanced by extended periods of high humidity or leaf wetness, caused for example by incorrectly gapped thermal screens or overhead watering late in the day. Bacteria can spread via water splash resulting, for example, from overhead irrigation and condensation drips in structures.

Soft rot bacteria thrive in waterlogged conditions. Production on raised benches and the use of well drained growing media to improve drainage and aeration will help to prevent their multiplication and infection through roots.

Any damage to plant tissue creates entry points for bacterial pathogens. Mechanical handling of young plants can increase root and leaf damage during transplanting.

Plants with lush growth, grown under conditions of high relative humidity, are generally more susceptible to bacterial infections.

## Hygiene

In the absence of effective chemical control for bacterial diseases, strict glasshouse hygiene is essential to avoid the introduction and spread of bacterial pathogens. In addition to the action points on the first page of this factsheet, consider controlling entry into glasshouses and provide hand washing and clean protective clothing and footware in high health status areas.

**18. A bead steriliser for heat disinfection of knives**

## Disinfection

Plant pathogenic bacteria can survive on many different materials, sometimes for long periods. The success of surface disinfection is dependent on the nature and concentration of the disinfectant, duration of the treatment, the nature of the material to be disinfected and especially the amount of organic material present. An important precursor to disinfection therefore is thorough cleansing of the surface to be disinfected to remove as much organic matter as practical.

A range of disinfectants were identified in the HDC funded project PC 291 '*Protected Ornamentals: Evaluation of control options for bacterial diseases of pot plants*', with confirmed activity against *Pseudomonas syringae, Xanthomonas hortorum* and *Pectobacterium carotovorum* when applied at, or in some cases below, the manufacturers recommended concentration. Further investigation showed the efficacy of these products against all three bacteria smeared in high concentration on a range of different surfaces including glass, 'Mypex' type matting, concrete and aluminium. Disinfectants based on peroxygen chemistry were found to have the best overall bactericidal activity.

**Table 2. Activity of disinfectants against three bacterial plant pathogens on glass, 'Mypex' type matting, concrete and aluminium surfaces over two different treatment durations**

| Disinfectant product (active ingredient) | Surface type | *Pseudomonas syringae* pv. *syringae* | | *Xanthomonas hortorum* pv. *hederae* | | *Pectobacterium carotovorum* | |
|---|---|---|---|---|---|---|---|
| | | 0.5 hr | 1.0 hr | 0.5 hr | 1.0 hr | 0.5 hr | 1.0 hr |
| **1% Sanprox P** (hydrogen peroxide / peracetic acid) | Glass | - | - | - | - | - | - |
| | Mypex | - | - | - | - | - | - |
| | Concrete | - | - | - | - | - | - |
| | Aluminium | - | - | - | - | - | - |
| **2% Bleach** (sodium hypochlorite) | Glass | (+) | - | + | + | - | - |
| | Mypex | - | - | + | - | - | - |
| | Concrete | - | - | - | - | - | - |
| | Aluminium | - | - | - | - | - | - |
| **1% Virkon S** (peroxygen) | Glass | - | - | - | - | - | - |
| | Mypex | - | - | - | - | - | - |
| | Concrete | - | - | - | - | - | - |
| | Aluminium | - | - | - | - | - | - |
| **0.8% Hortisept** (quaternary ammonium compound) | Glass | - | - | - | - | - | - |
| | Mypex | - | - | + | + | + | - |
| | Concrete | (+) | (+) | + | + | + | (+) |
| | Aluminium | - | - | - | - | - | - |
| **1% Menno-Florades** (organic acids) | Glass | - | - | - | - | - | - |
| | Mypex | - | - | + | (+) | + | (+) |
| | Concrete | + | - | + | + | + | - |
| | Aluminium | - | - | - | - | - | - |
| **0.8% Fam 30** (iodine) | Glass | - | - | - | - | - | - |
| | Mypex | - | - | - | - | - | - |
| | Concrete | - | - | - | - | + | + |
| | Aluminium | - | - | - | - | - | - |

*- No bacteria recovered; + bacteria recovered; (+) trace bacterial populations only recovered*

## Chemical control

There are no products currently approved specifically for use as bactericides in the UK but two products approved for use as fungicides have been reported to have antibacterial activity.

Ornamental plant producers have mostly relied on the use of copper compounds as a barrier to bacterial plant diseases. Copper oxychloride (for example Cuprokylt FL) is the only copper fungicide currently available for use on protected ornamentals. Copper products can be phytotoxic, especially under high humidity, and can discolour foliage. The application rates and growth stages at which copper products can be used are therefore limited. Plant pathogenic bacteria have also developed resistance to copper in some instances.

The biopesticide Serenade ASO (*Bacillus subtilis*) has off-label approval (EAMU 0474/12 and 0475/12) for use on ornamentals and is known to have some activity against bacteria. In the HDC project PC 291 however, application of Serenade ASO as a foliar spray from immediately after potting for 6 weeks failed to control a severe attack of bacterial soft rot on cyclamen.

Both copper oxychloride and Serenade ASO work as protectants. Applications made after symptoms are widespread are therefore unlikely to have significant effect.

## Further information

HDC Factsheet 17/09. 'Seed-borne diseases of ornamentals: prevalence and control'.

HDC Factsheet 07/09. 'Energy management in protected cropping: humidity control'.

HDC Factsheet 06/09. 'Energy management in protected cropping: manipulation of glasshouse temperatures'.

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

HDC Factsheet 15/05. 'Use of chemical disinfectants in protected ornamental production'.

**Disease diagnosis is available at:**

Plant Clinics

Fera, Sand Hutton, York, YO41 1LZ.
Tel: 01904 462000

STC, Cawood, Selby, North Yorkshire, YO8 3TZ.
Tel: 01757 268275

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