

**Project title:** Hardy Nursery Stock: Bacterial diseases

**Report:** Final Report (October 1997)

**Project Number:** HNS 71

**Project Leader:** Dr S J Roberts  
Horticulture Research International  
Wellesbourne  
Warwick  
CV35 9EF

**Key workers:** Dr P J Hunter (Research Officer)  
Mrs J Brough (Research Assistant)

**Location:** HRI Wellesbourne and nurseries in England

**Project Coordinator:** Mr John Richards

**Date Commenced:** 01 October 1996

**Date Completed:** 31 September 1997

**Keywords:** Hardy Nursery Stock, bacterial disease, importance

Whilst reports issued under the auspices of the HDC are prepared from the best available information, neither the authors of the HDC can accept any responsibility for inaccuracy or liability for loss, damage or injury from the application of any concept of procedure discussed.

© 1997 Horticultural Development Council

No part of this publication may be reproduced in any form or by any means without prior permission from the HDC

## TABLE OF CONTENTS

<b>PRACTICAL SECTION FOR GROWERS</b>	<b>1</b>
<b>Objectives and background</b>	<b>1</b>
<b>Summary of results</b>	<b>1</b>
<b>Action points for growers</b>	<b>2</b>
<b>Practical and financial benefits</b>	<b>3</b>
<b>SCIENCE SECTION</b>	<b>4</b>
<b>Introduction</b>	<b>4</b>
<b>Materials and Methods</b>	<b>5</b>
Survey strategy	5
Design of database	6
Nursery visits	6
Laboratory examination and isolation	6
Characterisation of isolates	7
Additional data	7
Analysis	7
<b>Results</b>	<b>7</b>
Survey	7
Plant Clinic Data	8
<b>Discussion</b>	<b>8</b>
Shot-hole of cherry laurel	10
Leaf spot of ivy	10
Frost damage	11
Chemical control	11
<b>Conclusions</b>	<b>11</b>
<b>Recommendations for further work</b>	<b>11</b>
<b>Acknowledgements</b>	<b>12</b>
<b>References</b>	<b>12</b>
<b>APPENDIX I</b>	<b>14</b>
<b>APPENDIX II</b>	<b>22</b>

## PRACTICAL SECTION FOR GROWERS

### Objectives and background

There is a wide range of bacterial diseases of hardy nursery stock (HNS), but most have been little studied. Reports of losses and problems caused by bacterial diseases of HNS appear to have increased over the last few years. These diseases do not appear to be controlled effectively by the use of currently approved chemicals and there are no definitive guidelines for their control. There has therefore been an increasing demand for “something to be done”

Inevitably due to the diversity of crop species in the sector, it is difficult to obtain reliable information on the prevalence and importance of different diseases, and therefore difficult to define targets for research. This project was therefore aimed at obtaining accurate and reliable data on the extent of and importance of the different bacterial diseases in HNS to distinguish real from perceived problems and to allow targeting of future research. It was intended as a first step in the development of a programme of research targeted towards improving our understanding and knowledge-base for bacterial diseases of HNS with the ultimate aim of devising effective control strategies.

### Summary of results

Eight commercial nurseries located in six regions were visited on separate occasions during a period of approximately one year. At each nursery, stock was examined for symptoms typical of bacterial disease, and samples collected for laboratory examination. Samples were examined microscopically and attempts made to isolate the pathogen onto agar plates. Suspected pathogens were then identified as far as possible within the limitations of time available.

A total of 220 samples of suspected bacterial diseases representing 39 genera were collected and examined in the laboratory. Suspected bacterial pathogens were isolated from 117 of the samples representing twenty-one genera. Records of bacterial diseases in an additional eleven genera were also obtained from ADAS Plant Clinic, Wolverhampton and SAC Crop Health Centre. The ten most prevalent diseases are shown in Table 1.

The majority of the diseases were caused by strains of *Pseudomonas syringae*. In some cases the pathogen has been presumptively assigned to a distinct pathovar (pv.). In effect this means that the pathogen can't infect other hosts (e.g. pv. *philadelphi* only infects *Philadelphus*, pv. *berberidis* only infects *Berberis*). In most cases, however, the pathogen has not been assigned to a pathovar and it is not known whether these strains can infect other hosts. Some of the diseases found have not previously been recorded in the scientific literature.

MAFF has already been funding work on shot-hole of cherry laurel and these results clearly support a need for it to continue. It is hoped that this may serve as a model system to identify control strategies which can then be applied to other similar diseases. *Xanthomonas* leaf spot of ivies was also widespread and causing considerable concern to growers. In common with many of these diseases, there is very little known about it, and as the pathogen belongs to a different genus, it presents an ideal secondary target for future research effort.

Table 1. Ten most prevalent diseases of HNS in England, based on a survey of eight nurseries and plant clinic records from ADAS and SAC.

Rank	Crop	Pathogen	Symptoms	No of sites <sup>1</sup>
1	<i>Prunus laurocerasus</i> and <i>lusitanica</i>	<i>Pseudomonas syringae</i> pv <i>syringae</i>	leaf spots, shot-holes, dieback	8
2	<i>Hedera</i> spp.	<i>Xanthomonas hortorum</i> pv <i>hederae</i>	leaf spots, dieback	7
3	<i>Philadelphus</i> spp.	<i>Pseudomonas syringae</i> pv <i>philadelphii</i>	leaf spots	7
4	<i>Spirea</i>	<i>Pseudomonas syringae</i>	leaf spots, dieback	6
5	<i>Berberis</i>	<i>Pseudomonas syringae</i> pv <i>berberidis</i>	leaf spots, defoliation, dieback	5
6	<i>Cornus</i> spp.	<i>Pseudomonas syringae</i>	leaf spots, dieback	4
7	<i>Mahonia</i> spp.	<i>Pseudomonas syringae</i>	leaf spots, defoliation	4
8	Deciduous <i>Prunus</i>	<i>Pseudomonas syringae</i> pvs <i>syringae/morsprunorum</i>	leaf spots, shot-hole, canker	4
9	<i>Cotoneaster</i>	<i>Pseudomonas syringae</i> , <i>Erwinia amylovora</i>	dieback	3
10	<i>Syringa vulgaris</i>	<i>Pseudomonas syringae</i> pv <i>syringae</i>	leaf blight, dieback	3

<sup>1</sup>No of sites with the disease out of a maximum of ten (eight surveyed plus two plant clinics).

At the present time, copper-based compounds are the only approved pesticides for use against bacterial diseases. Experience and perceived efficacy was very variable, both from nursery to nursery and for different crop species within a nursery. In addition, control is also being attempted by the use of disinfectants. The application of surface sterilants (disinfectants) to plants for the control of bacterial diseases is not approved by the Pesticide Safety Directorate and is thus illegal.

#### Action points for growers

- It is important to get correct diagnosis of diseases to avoid wasting money on ineffective sprays
- Not all “frost damage” is a direct result of frost, but may be caused at least in part by bacterial infection
- Copper-based compounds are the only approved pesticides for the control of bacterial diseases
- Experience with copper sprays has been very variable
- Be aware that that applying disinfectants as sprays contravenes the pesticide regulations
- Good hygiene and prompt disposal of old, infected stock should not be neglected

### **Practical and financial benefits**

The major benefit of this project has been to identify the major bacterial disease problems currently facing growers of HNS, thus providing HDC with the information needed to support and more effectively target future research effort by both MAFF and HDC.

## SCIENCE SECTION

### Introduction

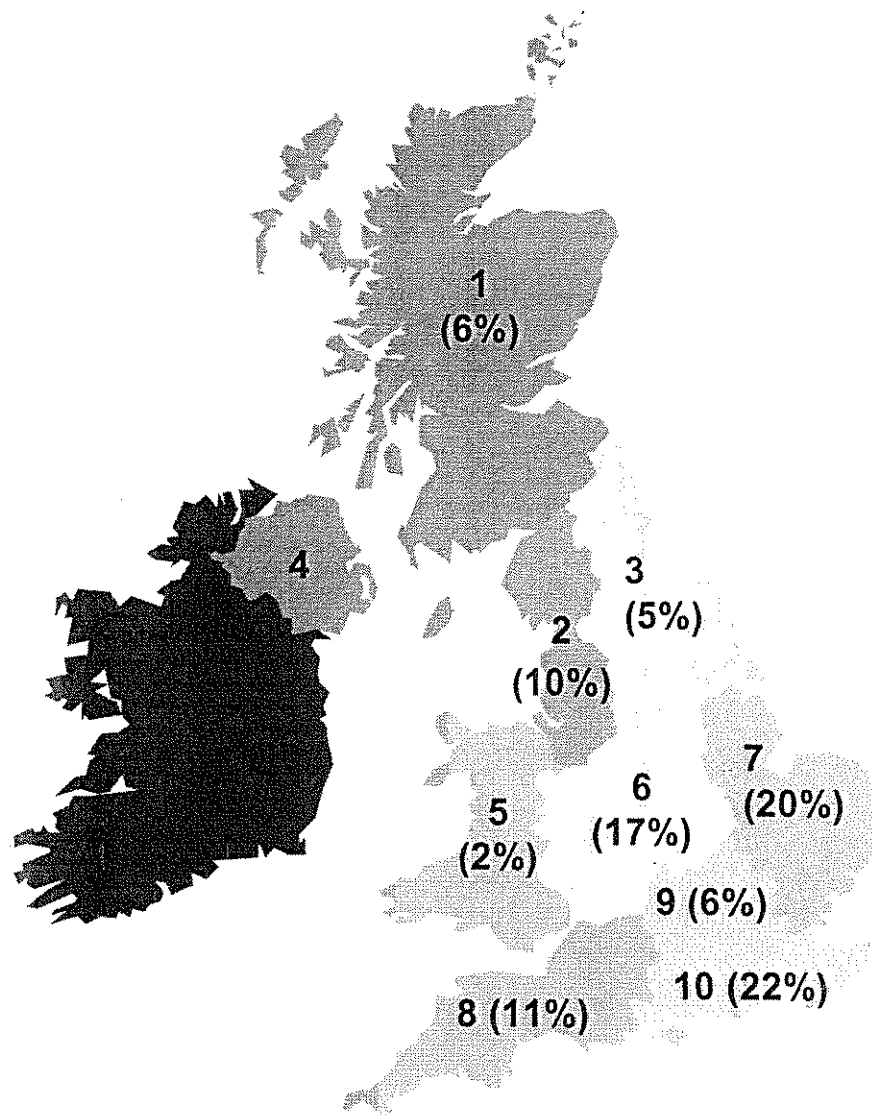
There is a wide range of bacterial diseases of hardy nursery stock (HNS), but with the exception of a few, which also affect economically important fruit crops (fireblight, crown gall, bacterial canker of stone fruits), they have been little studied. Although bacterial diseases have been causing considerable losses to growers of HNS for many years, they seem to have become more important in the last few years. The reasons for this are not clear, but are probably due to a combination of some of the following: increasing demands for stock of the highest quality; effective control of fungal diseases with chemicals, leaving the uncontrolled bacterial diseases more apparent; changes in production practices; introduction of new diseases (either into the UK or onto individual holdings) due to the increased mobility of stock around the UK and Europe.

Most losses result from rejection of poor quality plants, but may also result from reductions in growth rates, death of shoot tips or even entire plants. Some diseases which have been known to cause particular problems are: leaf spot of *Berberis*, shot-hole of cherry laurel, canker of ornamental cherries, fireblight on a range of species, leaf spot of *Philadelphus*. There have also been reports of bacterial diseases caused by *Pseudomonas syringae* on *Acer*, *Sorbus*, *Cotoneaster*, *Hamamelis*, *Viburnum* and *Magnolia*, however the reliability of this information has been difficult to ascertain. There is sometimes a reluctance amongst growers to admit to problems and, because it is perceived that there is little that can be done to control bacterial diseases, problems are often "lived with", with the result that a proportion of production may be unmarketable or lost each year.

At present, bacterial diseases are not controlled effectively by existing sprays and their presence, in the absence of correct diagnosis, often leads to the application of ineffective treatments, which are not only costly to the grower but, may be detrimental to the environment.

The major problem in this commodity area is the diversity of host species and pathogens involved. A single host/pathogen rarely assumes overriding importance for the industry as a whole, but may be extremely important for a particular grower that has the disease. It also is not clear whether isolates of *P. syringae* from one particular host will infect others or whether they are host specific - this has important implications for the control strategy of these diseases.

It would be impossible to develop a programme of research on all bacterial diseases of HNS. This project was therefore aimed at obtaining accurate and reliable data on the extent of and importance of the different bacterial diseases in HNS to distinguish real from perceived problems and to improve targeting of future research. It was intended as a first step in the development of a programme of research targeted towards improving our understanding and knowledge-base for bacterial diseases of HNS with the ultimate aim of devising effective control strategies.



**Figure 1.** Distribution of nurseries in different UK regions. Percentages represent the proportion of holdings in each region.

## Materials and Methods

### *Survey strategy*

The sampling strategy was intended to provide an unbiased sample of nurseries and plant species representative of the UK industry as a whole, given the financial and time constraints of the project.

The UK was divided into nine areas (see Figure 1 and Table 1). A list of HNS growers was obtained from HDC and each was assigned to an area. The proportion of UK holdings within each area was then calculated and nurseries were selected for sampling from within each area in relation to the proportion of holdings in each area. Only medium and large nurseries were targeted to ensure efficient coverage of as wide a range of subjects as possible.

**Table 1.** Percentage of nurseries in each region and number visited

Area No.	Area	% of Holdings	No sites visited
1	Scotland	6	0
2	North West	10	1
3	North East	5	1
4	N. Ireland	Not included	
5	Wales	2	0
6	Midlands	17	2
7	East Anglia	20	1
8	South West	11	0
9	Home Counties	6	1
10	South East	22	2

### *Design of database*

A database to hold the information obtained from the survey was constructed using *VisualdBase*. This included details of each sample collected: sample no., source, species, cultivar, production system, symptoms, diagnosis, severity, value, grower priority rating, additional notes.

### *Nursery visits*

Each of the selected nurseries was visited once. The visits to nurseries were spread throughout the period August 96 to September 1997. During the visit, the aims and background to the project were explained to the contact person. At each site the contact person was asked to highlight any specific known or perceived bacterial disease problems and samples were collected from these subjects. In addition, at each site, an attempt was made to inspect all species and stages of production for the presence of bacterial diseases. If the presence of bacterial disease was suspected, samples were collected. Samples were kept in polythene bags and efforts were made to minimise the possibility of cross-contamination between samples (i.e. secateurs, knives, hands were disinfected between samples)

### *Laboratory examination and isolation*

Following return to the laboratory, samples were stored in a coldroom until examination. Nearly all samples were examined within 24-48 h of collection. Each sample was logged on a sample record sheet (see Appendix II), symptoms recorded and in most cases a photographic record made. Due to time limitations, only two isolation attempts were made from each sample.

Individual spots or lesions or the leading edge of larger lesions were cominuted in a drop of sterile tap water on a sterile microscope slide, covered with a cover slip and allowed to stand for 5-30 min. Material was then examined microscopically and the presence of bacterial exudate or fungal spores and mycelium noted. If at this stage it was clear that the symptoms were fungal in origin, an attempt was made to identify the fungus based on spore morphology but no further action was taken. In all other cases the resulting suspension was streaked onto agar plates of both King's Medium B (King et al. 1954) and Nutrient Agar containing 5% (w/v) sucrose (SNA) or plates of Yeast Dextrose Chalk Agar (YDC) when a *Xanthomonas* was suspected as the causal organism. Following incubation for 2-4 d at 25°C plates were examined for the presence of suspected bacterial pathogens. Where present, representative colonies of suspect pathogens were sub-cultured for further characterisation and identification.



**Table 2.** Summary of numbers of samples and genera examined and positive for the presence of bacterial pathogens during a survey of eight nurseries and combined with ADAS and SAC Plant Clinic records

	Samples		Genera	
	Total	Positive	Total	Positive
Survey	220	117	39	21
Combined	256	153	46	32

### *Characterisation of isolates*

Production of fluorescent pigment was examined on plates of King's Medium B, production of levan (an extracellular polysaccharide) was examined on plates of SNA. Oxidase reaction was tested by inoculating a filter paper soaked in 1% (w/v) NNN-tetramethyl diamine with growth scraped from a 24-48 agar culture with a sterile wooden toothpick. Arginine dihydrolase, tobacco hypersensitivity and acid from sucrose were tested using the methods of Lelliot and Stead (1987).

### *Additional data*

Plant clinic records of bacterial diseases on HNS were obtained from Dr John Scrace, ADAS Plant Clinic and Dr Audrey Litterick, SAC Crop Health Centre. For the purposes of data analysis each of the plant clinics was considered to be a single additional site.

### *Analysis*

Records of each sample were maintained in the database. For all samples for which the presence of a suspected bacterial pathogen had been confirmed, information on the value and importance of the crop species was requested from the growers. Data for each plant genus was summarised across all sites, in terms of the number of sites at which a positive diagnosis was made, the mean importance of the crop in terms of the % of production represented by the crop and the mean priority given to the disease by the growers. These values were then used to rank the different diseases.

## **Results**

### *Survey*

A total of eight nurseries in six geographical regions were visited. Three regions (6,7,10, Table 1) contain 60% of the UK nurseries, five of the nurseries were in these three regions. A total of 220 samples of suspected bacterial diseases representing 39 genera were collected and examined in the laboratory (Table 2). The complete database of results can be found in Appendix I and is summarised in Table 3. Suspected bacterial pathogens were isolated from 117 of the samples representing twenty-one genera. In most cases the suspected pathogen was a strain of *Pseudomonas syringae*. It was not possible to confirm the identity of strains to the pathovar level without considerable additional effort, beyond the scope of this project. Therefore the designation of strains as particular pathovars is presumptive only and is based on prior knowledge of the existence of a distinct pathovar which attacks the host. It is likely that some of the strains isolated which have not been assigned to a pathovar may also represent distinct pathovars.

### *Plant Clinic Data*

Additional records of bacterial diseases diagnosed at ADAS Plant Clinic and SAC Crop Health Centre which were not recorded during the survey are listed in Table 4.

The ten most prevalent diseases, based on the combined survey and plant clinic records are listed in Table 5. Not all of the nurseries responded with information on the importance of the different crop species, priorities, etc., therefore the summaries are based on the average for the sites that did respond.

### **Discussion**

These results clearly demonstrate that bacterial diseases are widespread amongst the genera of HNS. The results are based on isolation and identification of the organisms in the diseased tissues and can thus be considered to have a high degree of reliability. However, the pathogenicity of most of the isolates was not tested, it is therefore possible that in some cases the organisms isolated were not pathogenic. The survey was limited to only eight nurseries, but the results can be considered to be broadly representative of the industry as a whole, given the range of HNS genera grown at these sites and that they were distributed throughout the major nursery stock production areas.

Despite limiting the survey to eight nurseries, 220 samples of suspected bacterial diseases were examined in the laboratory. As a result, the amount of effort on each sample had to be limited, and for most samples only two isolations were attempted. This would not generally be considered adequate for reliable diagnosis of some diseases, where consistent isolation of the primary pathogen may not always be possible due to: poor growth of the primary pathogen relative to saprophytes on isolation media, the presence of secondary organisms, death of the primary pathogen in old lesions, etc. Thus it is possible that some of the "negative" samples, although not confirmed by isolation, were the result of bacterial infection. Hence the overall results may underestimate both the number of genera affected by bacterial diseases and their prevalence.

The majority of the diseases recorded appear to be caused by strains of *Pseudomonas syringae*. In a few cases the suspected pathogen was assigned to a distinct pathovar which was previously known to cause the disease. In most cases, however, it is not known whether the strains isolated form a distinct pathovar. A pathovar is defined on the basis of its pathogenicity to one or more hosts and assignment of a group of strains to a pathovar implies a degree of host specificity. Thus *P. s. pv. berberidis* only infects *Berberis* spp., *pv. philadelphia* only infects *Philadelphus* spp., but *pv. syringae* infects *Syringa*, *Prunus* and a wide range of other species. Thus, in many cases, it is not known whether the strains isolated from one particular host can infect others. Extensive pathogenicity studies would be required to determine the pathovar status of such strains and hence potential for cross-infection between different hosts. This is a key question for many of these diseases which has considerable implications for practical control of these diseases on the nursery, however it [control] is achieved. If cross-infection is possible, it will be necessary to control the disease on all genera affected by a particular pathovar, even though it may only be a major problem on one. By analogy with bacterial diseases of vegetables and arable crops, a further complication

**Table 3.** Summary of samples collected and results in a survey of bacterial diseases in hardy nursery stock at eight nurseries.

Genus	Symptom	Samples		Sites		Pathogen
		Total	No positive	Total	No positive	
<i>Acer</i>	Dieback/brown spots	5	4	3	2	<i>Pseudomonas syringae</i>
<i>Aesculus</i>	brown lesions	2	0	1	0	
<i>Berberis</i>	black spots, defoliation	17	7	6	4	<i>Pseudomonas syringae</i> pv <i>berberidis</i>
<i>Buddleia</i>	brown lesions	2	0	1	0	
<i>Ceratostigma</i>	dark lesions	1	0	1	0	
<i>Chaenomeles</i>	dieback	1	0	1	0	
<i>Cissarincium</i>	"rust" spots	1	0	1	0	
<i>Cornus</i>	brown lesions, blight	4	3	3	3	<i>Pseudomonas syringae</i>
<i>Cotoneaster</i>	dieback	2	2	2	2	<i>Pseudomonas syringae</i>
<i>Deutzia</i>	brown angular lesions	1	1	1	1	<i>Pseudomonas syringae</i>
<i>Eleagnus</i>	corky stem lesions	2	(1)	1	(1)	<i>Pseudomonas syringae</i>
<i>Eucalyptus</i>	dark spots	1	1	1	1	<i>Pseudomonas syringae</i>
<i>Forsythia</i>	dieback/shoot blight	4	2	3	2	<i>Pseudomonas syringae</i>
<i>Geranium</i>	brown spots	2	0	1	0	
<i>Hamamelis</i>	angular lesions/dieback	3	0	1	0	
<i>Hebe</i>	corky stem lesions	1	0	1	0	
<i>Hedera</i>	dark leaf spots	28	21	6	6	<i>Xanthomonas</i> <i>hortorum</i> pv <i>hederae</i>
<i>Hydrangea</i>	brown angular lesions	3	2	2	1	<i>Pseudomonas</i> <i>syringae/viridiflava</i>
<i>Ilex</i>	small dark spots	1	1	1	1	<i>Pseudomonas syringae</i>
<i>Juglans</i>	small black spots	1	1	1	1	<i>Xanthomonas</i> <i>arboricola</i> pv <i>juglandis</i>
<i>Lonicera</i>	brown angular lesions	3	2	2	2	<i>Pseudomonas syringae</i>
<i>Magnolia</i>	brown angular lesions + halo	7	3	1	2	<i>Pseudomonas syringae</i>
<i>Mahonia</i>	black angular lesions/defoliation	4	4	4	4	<i>Pseudomonas syringae</i>
<i>Malus</i>	dieback	1	0	1	0	
<i>Paulonia</i>	large brown lesions	1	0	1	0	
<i>Philadelphus</i>	brown angular lesions + halo	16	14	6	6	<i>Pseudomonas syringae</i> pv <i>philadelphii</i>
<i>Physocarpus</i>	brown lesions/blight	1	1	1	1	<i>Pseudomonas syringae</i>
<i>Prunus</i> (decid.)	shot-holes/canker	22	6	7	2	<i>Pseudomonas syringae</i>
<i>Prunus</i> (ever.)	leaf spots/shot-holes	51	28	7	6	<i>Pseudomonas syringae</i>
<i>Pyrus</i>	brown spots	1	0	1	0	
<i>Rhododendron</i>	brown lesions	4	0	1	0	
<i>Robinia</i>	brown spots	1	0	1	0	
<i>Sambucus</i>	black stem collapse	1	1	1	1	<i>Pseudomonas</i> <i>viridiflava</i>
<i>Sorbus</i>	brown lesions	2	0	1	0	
<i>Spirea</i>	brown leaf spots/dieback	9	8	5	5	<i>Pseudomonas syringae</i>
<i>Syringa</i>	brown angular lesions	6	2	3	2	<i>Pseudomonas syringae</i>
<i>Viburnum</i>	brown spots/dieback	4	0	2	0	
<i>Weigela</i>	brown angular lesions	4	(2)	3	(1)	<i>Pseudomonas syringae</i>

**Table 4.** Additional records of bacterial diseases of HNS from ADAS Plant Clinic and SAC Crop Health Centre.

Genus	Symptom	Pathogen
<i>Aesculus</i>	basal rot of cuttings	<i>Pseudomonas syringae</i>
<i>Cotoneaster</i>		<i>Erwinia amylovora</i>
<i>Choisya</i>		<i>Erwinia carotovora</i>
<i>Delphinium</i>		<i>Pseudomonas syringae</i>
<i>Euonymus</i>		<i>Pseudomonas syringae/viridiflava</i>
<i>Fraxinus</i>		<i>Pseudomonas syringae</i>
<i>Lavandula</i>		<i>Pseudomonas syringae</i>
<i>Leucantheum</i>		<i>Pseudomonas syringae</i>
<i>Penstemon</i>		<i>Pseudomonas viridiflava</i>
<i>Pyracantha</i>		<i>Pseudomonas syringae</i>
<i>Pyrus</i>		<i>Pseudomonas syringae</i>

which may have to be considered is the prospect of races within pathovars which affect particular varieties.

In a number of cases the diseases have not previously been recorded in the scientific literature

#### *Shot-hole of cherry laurel*

The most prevalent disease was a shot-hole, leaf spot and dieback of the cherry and Portuguese laurels (*Prunus laurocerasus* and *lusitanica*). These evergreen *Prunus* sp. constitute one of the most important HNS species groups and the disease was invariably assigned a medium or high priority by the growers. A number of growers were either considering or actively reducing production of these species as a direct result of problems with shot-hole. This in turn is likely to lead to an increase in imports of these species to fulfil the demand in the landscape market. Clearly, this disease should have the highest priority for future research. A project on this disease has been funded by MAFF at HRI-Wellesbourne, during the last three years. The cause of the disease was confirmed as *Pseudomonas syringae* and pathogenic strains conformed to pv. *syringae*. Methods were developed for pathogenicity testing and for detection in epidemiological studies. Preliminary results of these studies on two commercial nurseries indicate that the pathogen is present on symptomless leaves at all stages of production: stock plants, cuttings, liners, finals. A further proposal to continue this work with the emphasis on developing a control strategy based on the production of pathogen-free plants has been submitted to MAFF. It is hoped that the principles and control strategy developed for this disease can be applied to others caused by the same pathogen species.

#### *Leaf spot of ivy*

Bacterial leaf spot and dieback of ivies caused by *Xanthomonas hortorum* pv. *hederae* was ranked second in the survey and was found on six of the eight sites. The disease was found on almost all species and cultivars grown, both under-protection and in the open, and on rooted cuttings. Some growers are suffering major losses from this disease resulting in death of significant numbers of finals, and again are considering ceasing production as a direct result of their inability to control it. Losses have also been reported post-sale, with death of plants used in landscape plantings. In contrast to the majority of the other diseases recorded, the pathogen belongs to the genus *Xanthomonas*; this may have implications for its epidemiology and control. Pathogenicity of a limited number of isolates was confirmed by

inoculation. There is no recent information on this disease in the scientific literature, and therefore as the secondmost prevalent diseases it should therefore be a target of future research.

### *Frost damage*

Symptoms on a number of species were considered by growers to be the result of frost damage. In nearly all cases of "frost damage" *Pseudomonas syringae* was isolated from the lesions, often in pure culture. Strains of *P. syringae* are known to be Ice Nucleation Active (INA<sup>+</sup>), this means that they can induce the formation of ice crystals and hence frost damage at higher temperatures than would otherwise occur. Thus, in the absence of INA<sup>+</sup> bacteria temperatures as low as -10°C may occur without damage, but if present, damage may occur at temperatures between 0 and -5°C. This damage then allows entry and multiplication of the pathogen in the plant tissues. As a result, outbreaks of bacterial diseases are often associated with and may be confused with frost damage.

### *Chemical control*

A common theme throughout discussions with growers was the use of chemical sprays to control bacterial diseases. At the present time, copper-based compounds are the only approved pesticides for use against bacterial diseases. Experience and perceived efficacy was very variable, both from nursery to nursery and for different crop species within a nursery. In addition, control is also being attempted by the use of certain disinfectants. However, the industry must be aware that the application of disinfectants (surface sterilants) to plants for the control of bacterial diseases is not approved by the Pesticide Safety Directorate and is thus illegal.

## **Conclusions**

The aim of this project was to obtain accurate and reliable data on the extent and importance of bacterial diseases of HNS. It is clear that bacterial diseases are widespread amongst HNS subjects and cause a range of symptoms including: leaf spots, shot-holes, defoliation, shoot-blight ("frost damage"), dieback, and cankers. The most prevalent and important diseases/crops affected are indicated in the tables and should therefore be targeted in further work. There is very little known about many of these diseases and there are currently no consistently effective, approved chemical control options

## **Recommendations for further work**

- Further studies on the epidemiology and control of some key diseases in order to develop control strategies which can then be applied more generally.
- Taxonomic and pathogenicity studies to define the pathovar status and determine the potential for cross-infection of isolates from "new" diseases.
- Objective studies on the efficacy of currently approved chemicals and (if appropriate) development of guidelines for their use

## Acknowledgements

The author would like to thank all of the nurseries visited during this project for their cooperation, discussions and in allowing free-access to their stock. The author would also like to thank Dr. John Scrace, ADAS Plant Clinic, Wolverhampton and Dr Audrey Litterick, SAC Crop Health Centre for additional disease records.

## References

- King, E.O., Ward, M.K. and Raney, D.E. (1954) Two simple media for the demonstration of pyocyanin and fluorescein. *Journal of Laboratory Medicine* **44**, 301-307.
- Lelliot, R.A. and Stead, D.E. (1987) *Methods for the diagnosis of bacterial diseases of plants*, Oxford: Blackwell Scientific Publications.

**Table 5.** Ten most prevalent diseases of HNS in England, based on a survey of eight nurseries and plant clinic records.

Rank	Crop	Pathogen	Symptoms	No of sites <sup>1</sup>	Importance <sup>2</sup>	Priority <sup>3</sup>
1	<i>Prunus laurocerasus</i> and <i>lusitanica</i>	<i>Pseudomonas syringae</i> pv <i>syringae</i>	leaf spots, shot-holes, dieback	8	2.4	2.3
2	<i>Hedera</i> spp.	<i>Xanthomonas hortorum</i> pv <i>hederae</i>	leaf spots, dieback	7	1.8	2.1
3	<i>Philadelphus</i> spp.	<i>Pseudomonas syringae</i> pv <i>philadelphii</i>	leaf spots	7	1.4	1.7
4	Spirea	<i>Pseudomonas syringae</i>	leaf spots, dieback	6	1.6	1.9
5	Berberis	<i>Pseudomonas syringae</i> pv <i>berberidis</i>	leaf spots, defoliation, dieback	5	0.3	1.9
6	<i>Cornus</i> spp.	<i>Pseudomonas syringae</i>	leaf spots, dieback	4	1.3	1.6
7	<i>Mahonia</i> spp.	<i>Pseudomonas syringae</i>	leaf spots, defoliation	4	1.0	1.7
8	Deciduous <i>Prunus</i>	<i>Pseudomonas syringae</i> pvs <i>syringae/morsprunorum</i>	leaf spots, shot-hole, canker	4	0.3	1.5
9	Cotoneaster	<i>Pseudomonas syringae</i> , <i>Erwinia amylovora</i>	dieback	3	1.0	2.3
10	<i>Syringa vulgaris</i>	<i>Pseudomonas syringae</i> pv <i>syringae</i>	leaf blight, dieback	3	0.6	2.0

<sup>1</sup>No of sites with the disease out of a maximum of ten (eight surveyed plus two plant clinics).

<sup>2</sup>Importance of the crop expressed as the average % of production represented by the crop.

<sup>3</sup>Average priority given to the disease by the growers (1 = lowest priority, 3 = highest priority)

## APPENDIX I

**Table I.** Complete listing of all samples collected during survey of bacterial diseased on eight nurseries

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
<i>Site: 001</i>					
0001	<i>Acer</i>	Brilliantissimum	leaves	brown spots	<i>Pseudomonas syringae</i> Gp Ia/Ib
0002	<i>Acer pseudoplatanus</i>	Prinz Handjery	leaves	brown lesions	<i>Pseudomonas syringae</i> GpIb
0003	<i>Robinia pseudoacacia</i>	Frisia	leaves	brown spots	Fungal
0004	<i>Sorbus</i>	November Pink	leaves	transparent flecks	NPI
0005	<i>Prunus mume</i>	Beni-shidari	shoot tips	brown lesions	NPI
0006	<i>Hamamelis mollis</i>	Brevipetala	plant	dieback	NPI
0007	<i>Hamamelis</i>	Arnold Promise	leaves	angular lesions	NPI
0008	<i>Hamamelis primavera</i>		twig	dieback	NPI
0009	<i>Prunus subhirtella</i>	Pendula Rubra	leaves	shot-hole	NPI
0010	<i>Prunus</i>	Cheals	leaves	shot-hole/dieback	NPI
0011	<i>Prunus subhirtella</i>	Pendula Rubra	leaves	shot-holes	NPI
0013	<i>Sorbus hupensis</i>		leaves	brown lesions	NPI
0015	<i>Acer</i>	Carnival	leaves	black necrotic areas	<i>Pseudomonas</i>
No of samples for site:			13		
<i>Site: 002</i>					
0016	<i>Prunus laurocerasus</i>	Zabeliana	leaves	brown lesions, shot-holes	<i>Pseudomonas syringae</i> Ib
0017	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	thin brown lesions	<i>Pseudomonas syringae</i> Ib
0018	<i>Hedera</i>	Helix Green Ripple	leaves	dark w/soaked lesions	NPI
0019	<i>Prunus laurocerasus</i>	Low and Green	leaves	brown lesions, shot-hole	<i>Pseudomonas syringae</i> Ib
0020	<i>Prunus laurocerasus</i>	Renault Ace	leaves	shot-holes, brown lesions	NPI
0021	<i>Prunus lusitanica</i>		leaves	small delimited spots	<i>Pseudomonas syringae</i>
0022	<i>Hedera helix</i>	Green Ripple	leaves	brown/black lesions	<i>Xanthomonas hortorum hederiae</i>
0023	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	brown lesions, shot-holes	<i>Pseudomonas syringae</i>
0024	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	delimited spot/areas	<i>Pseudomonas syringae</i>
0025	<i>Prunus avium</i>		wood chips	dieback	NPI
0026	<i>Prunus avium</i>		young leaves	shot-holes	<i>Pseudomonas syringae</i>
0027	<i>Prunus avium</i>		lower leaves	shot-holes	NPI
0028	<i>Prunus avium</i>		stem piece	canker	NPI
0029	<i>Prunus avium</i>		leaves	shot-holes, brown lesions	NPI
0030	<i>Paulonia tormentosa</i>		leaves	large brown lesions	NPI
0031	<i>Prunus avium</i>		old crown galls	crown gall	NPI
0032	<i>Prunus avium</i>		leaves	shot-holes	<i>Pseudomonas syringae</i>
0033	<i>Syringa vulgaris</i>		leaves	brown lesions	NPI
0034	<i>Juglans regia</i>	Frankette	leaves	small black spots	<i>Xanthomonas juglandis</i>
0035	<i>Acer pseudoplatanus</i>	Neg. Flamingo	leaves	brown marginal lesions	Fungal?
0036	<i>Spirea japonica</i>		leaves	brown spots	<i>Pseudomonas?</i>
0037	<i>Prunus armeniaca</i>	Dwarf Gdn Aprigold	leaves	delimited spots	<i>Pseudomonas syringae</i>
0038	<i>Berberis thunbergii</i>	atropurpurea	leaves	greasy black spots	<i>P. syringae</i> pv <i>berberidis</i>



Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0039	<i>Berberis</i>	Green Carpet	leaves	dark 2-3 mm spots	<i>P. syringae</i> pv <i>berberidis</i>
0040	<i>Berberis gagnepainii</i>		leaves/shoots	black shoots, leaf spots	NPI
0041	<i>Syringa vulgaris</i>	Mme Lemoine	leaves	brown lesions	NPI
0042	<i>Forsythia</i>	Gold Tide	leaves/shoots	shoot dieback	NPI
0043	<i>Syringa vulgaris</i>	Firmament	leaves	brown lesions	NPI
0044	<i>Lonicera</i>	PGR trial	leaves	brown ang. lesions + halo	<i>Pseudomonas syringae</i>
0045	<i>Cornus</i>	Kelsy Gold	leaves	brown spots + red margin	Fungal (Septoria?)
0046	<i>Cornus</i>	Maas	leaves	brown spots + red margin	<i>Pseudomonas syringae</i>
0047	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	shot-holes, brown lesions	NPI
0048	<i>Magnolia stellata</i>	Royal Star	leaves	brown lesions	NPI
0049	<i>Magnolia stellata</i>		leaves	dark angular lesions	NPI
No of samples for site:			34		
Site: 003					
0000	<i>Hedera helix</i>		leaves	black spots	<i>Xanthomonas hortorum hederiae</i>
0051	<i>Geranium</i>	Pink Pillow	leaves	black veins/necrosis	NPI
0052	<i>Buddleia fallowiana</i>		leaves	brown ang. lesions	NPI
0053	<i>Berberis</i>	Red Tears	leaves	dark ang. lesions	NPI
0054	<i>Prunus tenella</i>	Fire Hill	leaves	shot-holes	<i>Pseudomonas syringae</i>
0055	<i>Cissarincium? striatum</i>	variegatum	leaves	rust spots	Fungal?
0056	<i>Philadelphus coronarius</i>		leaves	brown ang. spots + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0057	<i>Magnolia</i>	Heaven Scent	leaves	Dark ang. lesions + halo	NPI
0058	<i>Magnolia</i>	Ricky	leaves	brown ang. lesions + halo	NPI
0059	<i>Spiraea japonica</i>	Gold Mound	leaves	brown spots	<i>Pseudomonas syringae</i>
0060a	<i>Philadelphus coronarius</i>	Aureus	leaves	brown ang. spots + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0060b	<i>Philadelphus coronarius</i>	Variegatus	leaves	brown ang. lesions + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0061	<i>Hydrangea</i>	Pink Diamond	leaves	large ang. lesions	<i>Pseudomonas syringae</i>
0062	<i>Buddleia</i>	Summer Beauty	leaves	brown lesions + halo	Fungal
0063	<i>Weigela</i>	Variegata	leaves	brown ang. lesions	unidentified bacterium
0064	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	brown lesions new leaves	NPI
0065	<i>Magnolia</i>		leaves	brown ang. lesions	<i>Pseudomonas syringae</i>
0066	<i>Magnolia</i>	Susan	leaves	brown ang. lesions + halo	<i>Pseudomonas syringae</i>
0067	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes	<i>Pseudomonas syringae</i>
0068	<i>Berberis thunbergii</i>		leaves	dark 2-3mm spots	NPI
0069	<i>Prunus mume</i>	Omoi-No-Mama	leaves/shoots	shot-hole/dieback	<i>Pseudomonas syringae</i>
0070	<i>Prunus laurocerasus</i>	Rotundifolia	leaves/shoots	large necrotic lesions	NPI
0071	<i>Prunus laurocerasus</i>	Reynvanii	leaves	1 mm shot-holes	<i>Pseudomonas syringae</i>
0072	<i>Prunus lusitanica</i>		leaves/shoots	spots/tip dieback	<i>Pseudomonas syringae</i>
0073	<i>Weigela</i>	Sunny Princess	leaves	angular lesions	<i>Pseudomonas syringae</i>
0074	<i>Prunus laurocerasus</i>	Reynvanii	leaves	shot-hole/large lesions	<i>Pseudomonas syringae</i>
0075	<i>Prunus</i>	Pendula Rubra	leaves/stem	shot-holes/canker	NPI
0078	<i>Rhododendron</i>	Dopay	leaves	ang. lesions	NPI Insect/Fungal?
0079	<i>Rhododendron</i>	Grace Seabrook	leaves	brown lesions	Fungal?

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0080	<i>Rhododendron</i>	Pink Cherub	leaves	3-4 mm dark lesions	Fungal
0081	<i>Rhododendron</i>	Buttermint	leaves	small diffuse spots	NPI
0082	<i>Prunus laurocerasus</i>	Reynvanii	leaves	necrotic edge lesions	NPI
0265	<i>Hydrangea sP.</i>		leaves	brown spots	<i>Pseudomonas viridiflava</i>
0300	<i>Berberis thunbergii</i>		leaves	dark spots	NPI
0301	<i>Mahonia aquifolium</i>		leaves	Dark ang lesions + halo	<i>Pseudomonas syringae</i>
0302	<i>Magnolia sP.</i>		leaves	dark spots + halo	<i>Pseudomonas syringae</i>
0303	<i>Geranium sP.</i>		leaves	brown spots	NPI
No of samples for site:			37		
Site: 004					
0090	<i>Aesculus</i>		leaves	brown lesions +chl. halo	Fungal
0091	<i>Prunus</i>		leaves/wood chips	shot-holes/canker	NPI
0092	<i>Pyrus</i>	Chanticleer	leaves	circular brown spots	Fungal?
0093	<i>Aesculus</i>	Baumanii	leaves	brown lesions + chl halo	Fungal
0094	<i>Malus floribunda</i>		Twigs	dieback	NPI
0095	<i>Prunus</i>	Tai-Haku	Leaves	shot-holes	NPI
0096	<i>Weigela floribunda</i>	nana	leaves	brown spots	NPI
0097	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes, delim. spots	NPI
0098	<i>Philadelphus</i>	Belle Etoile	leaves	brown ang spots + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0099	<i>Philadelphus coronarius</i>	Aureus	leaves	brown ang. lesions	<i>P. syringae</i> pv <i>philadelphii</i>
0100	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	brown lesions + halo	NPI
0101	<i>Prunus avium</i>		leaves	shot-holes	NPI
No of samples for site:			12		
Site: 005					
0163	<i>Hedera helix</i>	Glacier	leaves	dark/black leaf spots	<i>Xanthomonas hortorum hederæ</i>
0164	<i>Hedera helix</i>	Goldheart	leaves	dark/black leaf spots	NPI
0165	<i>Philadelphus coronarius</i>	Aureus	leaves liners	from brown spots/areas	NPI
0166	<i>Hedera hibernica</i>		leaves	dark spots	NPI
0167	<i>Hedera helix</i>	Green Ripple	leaves/stem	shoot dieback, leaf spots	<i>Xanthomonas hortorum hederæ</i>
0168	<i>Hebe rakaiensis</i>		stems	corky stem lesions	NPI
0169	<i>Eleagnus pungens</i>	maculata	stems	corky stem lesions	( <i>Pseudomonas syringae</i> )
0170	<i>Prunus avium</i>		leaves/stem	leaf spots, stem canker	NPI
0171	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	brown marginal necrosis	NPI
0172	<i>Prunus laurocerasus</i>	Otto Luyken	Leaves	Shot-holes, progressing	<i>Pseudomonas syringae</i>
0173	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	brown spots/chlor. halo	NPI
0174	<i>Prunus laurocerasus</i>	Otto luyken	leaves	shot-holes, brown spots	NPI
0175	<i>Hedera helix</i>	Glacier	leaves	dark spots	NPI
0176	<i>Hedera hibernica</i>		leaves/stems	defoliation, leaf spots	<i>Xanthomonas hortorum hederæ</i>

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0177	<i>Cotoneaster damneri</i>		stems	severe dieback	<i>Pseudomonas syringae</i>
0178	<i>Prunus lusitanica</i>		leaves	shot-holes	<i>Pseudomonas syringae</i>
0179	<i>Hedera hibernica</i>		rooted cuttings	dark lesions + haloes	<i>Xanthomonas hortorum hederae</i>
0180	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes	NPI
0181	<i>Chaenomeles x superba</i>	Nicoline	Stems	dieback	Fungal infection
0182	<i>Philadelphus</i>	Belle Etoile	leaves	leaf spots/larger lesions	<i>P. syringae</i> pv <i>philadelphii</i>
0183	<i>Philadelphus coronarius</i>	Aureus	leaves	brown spots/areas	<i>P. syringae</i> pv <i>philadelphii</i>
0184	<i>Cornus alba</i>	Sibirica	leaves	brown lesions/areas	<i>Pseudomonas syringae</i>
0185	<i>Philadelphus x virginalis</i>	Virginal	leaves	brown spots/areas	<i>P. syringae</i> pv <i>philadelphii</i>
0186	<i>Spirea japonica</i>	Goldmound	leaves/shoots	leaf spots/dieback	<i>Pseudomonas syringae</i>
0187	<i>Hedera helix</i>	Goldheart	leaves liners	from large dark leaf spots	<i>Xanthomonas hortorum hederae</i>
0188	<i>Hedera helix</i>	Green Ripple	leaves liners	from leaf spots w/soaked edges	<i>Xanthomonas hortorum hederae</i>
0189	<i>Hedera helix</i>	Eve	Leaves liners	from dark lesions	NPI
0189a	<i>Hedera helix</i>	Goldheart	leaves liners	from dark leaf spots	NPI
0190	<i>Hedera</i>	Gloire de Marengo	leaves liners	from small brown lesions	NPI
0191	<i>Eucalyptus</i>		leaves liners	from dark spots + purple edge	<i>Pseudomonas syringae</i>
0192	<i>Mahonia japonica</i>		leaves	black lesions/senescence	<i>Pseudomonas syringae</i>
0193	<i>Ilex aquifolium</i>		leaves	small dark spots	( <i>Pseudomonas syringae</i> )
0194	<i>Hedera hibernica</i>		rooted cuttings	dark leaf spots	<i>Xanthomonas hortorum hederae</i>
0195	<i>Hedera hibernica</i>		rooted cuttings	dark leaf spots	<i>Xanthomonas hortorum hederae</i>
0196	<i>Hedera hibernica</i>		rooted cuttings	dark w/soaked spots	<i>Xanthomonas hortorum hederae</i>
0197	<i>Prunus laurocerasus</i>	Rotundifolia	rooted cuttings	necrotic leaf tips	NPI
0198	<i>Eleagnus pungens</i>	Maculata	stems	corky stem lesions	NPI
0199	<i>Forsythia spectabilis</i>		shoots	dieback	<i>Pseudomonas syringae</i>
0200	<i>Prunus lusitanica</i>		leaves/shoots	shot-holes/black shoots	<i>Pseudomonas syringae</i>
0201	<i>Prunus laurocerasus</i>	Rotundifolia	leaves/shoots	brown lesions	<i>Pseudomonas syringae</i>
0202	<i>Berberis verruculosa</i>		leaves	black spots/senescence	( <i>Pseudomonas</i> )
0203	<i>Berberis coxii</i>		leaves	black spots + senescence	<i>P. syringae</i> pv <i>berberidis</i>
0204	<i>Berberis gagnepainii</i>		leaves	black spots/senescence	<i>P. syringae</i> pv <i>berberidis</i>
0205	<i>Viburnum davidii</i>		leaves	Angular spots	NPI
No of samples for site:			44		
Site: 006					
0206	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes + red margins	NPI
0207	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes	<i>Pseudomonas syringae</i>
0208	<i>Syringa vulgaris</i>	Charles Jolly	shoots	blight + ang lesions	<i>P. syringae</i> pv <i>syringae</i>
0209	<i>Berberis julianae</i>		leaves	black spots/defoliation	<i>P. syringae</i> pv <i>berberidis</i>
0210	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	slight necrosis	NPI
0211	<i>Prunus laurocerasus</i>	Zabeliana	leaves/stems	shot-holes/stem lesions	NPI
0212	<i>Prunus laurocerasus</i>	Rotundifolia	leaves/shoots	brown lesions	<i>Pseudomonas syringae</i>

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0213	<i>Prunus lusitanica</i>		Shoots	blight/dieback	<i>Pseudomonas syringae</i>
0214	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	brown lesions/spots	<i>Pseudomonas syringae</i>
0215	<i>Prunus lusitanica</i>		leaves/shoots	dieback/shot-holes	<i>Pseudomonas syringae</i>
0216	<i>Berberis julianae</i>		leaves	black spots/defoliation	NPI
0217	<i>Prunus cerasifera</i>		leaves/shoots	brown lesions/blight	<i>P. syringae</i> pv <i>morsprunorum</i>
0218	<i>Prunus laurocerasus</i>	Zabeliana	leaves/stem	shot-holes/stem lesions	<i>Pseudomonas syringae</i>
0219	<i>Philadelphus</i>	Silver showers	leaves	brown ang. lesion + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0220	<i>Philadelphus coronarius</i>		leaves	brown ang. lesions + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0221	<i>Hedera hibernica</i>		leaves	large black spots + halo	<i>Xanthomonas hortorum hederiae</i>
0222	<i>Prunus laurocerasus</i>	Rotundifolia	leaves from cuttings	tip necrosis	NPI
0223	<i>Prunus lusitanica</i>		leaves/shoots	shot-holes/stem lesions	<i>Pseudomonas syringae</i>
0224	<i>Berberis gagnepainii</i>		leaves	black spots	
0225	<i>Cornus alba</i>	Sibirica	leaves/shoots	brown lesions, "frost"	<i>Pseudomonas syringae</i>
0226	<i>Spirea japonica</i>	Goldmound	leaves/shoots	necrosis/dieback	<i>Pseudomonas syringae</i>
0227	<i>Deutzia</i>	Pride of Rochester	leaves	brown ang lesions + halo	<i>Pseudomonas syringae</i>
0228	<i>Forsythia intermedia</i>		shoots	blight, "frost"	<i>Pseudomonas syringae</i>
0229	<i>Philadelphus x virginalis</i>	Virginal	leaves/shoots	ang lesions + halo/blight	<i>P. syringae</i> pv <i>philadelphii</i>
0230	<i>Mahonia aquifolium</i>		leaves	black lesions/defoliation	<i>Pseudomonas syringae</i>
0231	<i>Physocarpus</i>		leaves/shoots	brown lesions/blight	<i>Pseudomonas syringae</i>
0232	<i>Forsythia intermedia</i>	Spectabilis	leaves/shoots	leaf spots/shoot blight	
0233	<i>Hedera helix</i>	Green Ripple	leaves	dark spots +halo	<i>Xanthomonas hortorum hederiae</i>
0234	<i>Lonicera telmaniana</i>		leaves	chlorotic mottled lesions	NPI
0235	<i>Lonicera fragrantissima</i>		leaves	brown ang. lesions + halo	<i>Pseudomonas syringae</i>
0236	<i>Acer palmatum</i>	Ozakazuki	leaves/shoots	dieback of new shoots	<i>Pseudomonas syringae</i>
0237	<i>Spirea japonica</i>	Gold Flame	leaves/shoots	brown lesions/blight	<i>Pseudomonas syringae</i> Ib
No of samples for site: Site: 007			32		
0244	<i>Hedera hibernica</i>		leaves	black spots + w/soaked ma	<i>Xanthomonas hortorum hederiae</i>
0245	<i>Prunus laurocerasus</i>	Zabeliana	leaves	shot-holes/spots	<i>Pseudomonas syringae</i>
0246	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	shot-holes/spots	NPI
0247	<i>Spirea arguta</i>		leaves	brown ang. lesions	NPI
0248	<i>Spirea japonica</i>	Little Princess	leaves	brown ang. spots	<i>Pseudomonas syringae</i> Gplb
0249	<i>Spirea x bumalda</i>	Anthony Waterer	leaves/shoots	leaf spot/dieback	<i>Pseudomonas syringae</i> GplA
0250	<i>Mahonia aquifolium</i>		leaves	black ang. lesions/defol.	<i>Pseudomonas syringae</i> GplA
0251	<i>Prunus laurocerasus</i>	Rotundifolia	leaves	early shot-holes	<i>Pseudomonas syringae</i> GplA
0252	<i>Prunus lusitanica</i>	Variegata	leaves	delim. spots	NPI
0253	<i>Berberis thunbergii</i>	Red chief	leaves	black leaf spots/dieback	<i>P. syringae</i> pv <i>berberidis</i>

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0254	<i>Hedera helix</i>	Glacier	leaves	black lesions	<i>Xanthomonas hortorum hederæ</i>
0255	<i>Spirea japonica</i>	Gold Flame	leaves	dark ang lesions	<i>Pseudomonas syringae</i> GpIa/Ib
0256	<i>Prunus laurocerasus</i>	Zabeliana	leaves	circ. brown lesions	NPI
0257	<i>Cotoneaster</i>	Oakwood	shoots	dieback	<i>Pseudomonas syringae</i> Gp Ia
0258	<i>Prunus spinosa?</i>		leaves	leaf spots	Fungal - <i>Stigmina carpophila</i>
0259	<i>Philadelphus x virginalis</i>	Virginal	leaves	brown ang. lesions	<i>P. syringae</i> pv <i>philadelphii</i>
0260	<i>Hedera helix</i>	Glacier	leaves	black lesions + w/soaked	<i>Xanthomonas hortorum hederæ</i>
0261	<i>Hedera helix</i>	Green Ripple	leaves	black lesions	<i>Xanthomonas hortorum hederæ</i>
0262	<i>Prunus lusitanica</i>		new shoots	dieback	<i>Pseudomonas syringae</i> GpIa
0263	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	marginal brown lesions	NPI
0264	<i>Prunus laurocerasus</i>	Zabeliana	leaves	delimited spots	<i>Pseudomonas syringae</i>
No of samples for site:			21		
Site: 008					
0267	<i>Prunus laurocerasus</i>	Otto Luyken	leaves	delim. brown spots.	NPI
0268	<i>Prunus laurocerasus</i>	Zabeliana	leaves	shot-holes/spots	<i>Pseudomonas syringae</i> GpIa
0269	<i>Prunus lusitanica</i>		leaves	brown spots + halo	NPI
0270	<i>Prunus laurocerasus</i>	Rotundifolia	leaves/shoots	Stem lesions/dieback	NPI
0271	<i>Viburnum tinus</i>		leaves/shoots	brown spots/dieback	NPI
0272	<i>Viburnum tinus</i>	Eve Price	shoots/leaves	dieback/brown spots	NPI
0273	<i>Berberis thunbergii</i>	Atropurpurea nana	leaves	spots	NPI
0274	<i>Weigela</i>	Rubidor	leaves	brown ang lesions	NPI
0275	<i>Berberis</i>	Rose Glow	shoots	dieback	NPI
0276	<i>Syringa vulgaris</i>	Charles Joly	leaves	brown lesions	NPI
0277	<i>Berberis thunbergii</i>	Banana Gold	Leaves	dark spots	NPI
0278	<i>Hedera hibernica</i>		leaves	dark w/soaked spots	<i>Xanthomonas hortorum hederæ</i>
0279	<i>Hydrangea spp.</i>		leaves	brown lesions near petiole	NPI
0280	<i>Ceratostigma wilmotianum</i>		leaves	dark lesions	NPI
0281	<i>Sambucus racemosa</i>	Sutherland	shoots	black stem collapse	<i>Pseudomonas viridiflava</i>
0282	<i>Berberis thunbergii</i>	Harlequin	old leaves	black leaf spots	NPI
0283	<i>Philadelphus</i>	Belle Etoile	leaves	brown ang spots + halo	<i>P. syringae</i> pv <i>philadelphii</i>
0284	<i>Viburnum sargentii</i>	Onondaga	leaves	brown lesions	NPI
0285	<i>Prunus glandulosa</i>	Beau. Plena.	leaves	shot-holes	Fungal - <i>Stigmina carpophila</i>
0286	<i>Philadelphus x lemoinei</i>	Manteau d'hermine	leaves	brown ang spots + halo	NPI
0287	<i>Hedera algeriensis</i>	Gloire de Marengo	leaves	dark water soaked lesions	<i>Xanthomonas hortorum hederæ</i>
0288	<i>Hedera colchica</i>	Dentata Variegata	leaves	dk w/soaked lesions	<i>Xanthomonas hortorum hederæ</i>
0289	<i>Prunus lusitanica</i>		leaves liners	from brown spots + halo	<i>Pseudomonas syringae</i> GpIb
0290	<i>Prunus laurocerasus</i>	Otto Luyken	leaves liners	from shot-holes	<i>Pseudomonas syringae</i> GpIa

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
0291	<i>Syringa vulgaris</i>		leaves	from brown ang. spots	<i>Pseudomonas syringae</i> Gpla
0292	<i>Philadelphus coronarius</i>	Aureus	leaves	brown spots	<i>P. syringae</i> pv <i>philadelphi</i> NF
0293	<i>Hedera sP.</i>	Various	leaves	w/soaked lesions	<i>Xanthomonas hortorum hederiae</i>
No of samples for site:		27			
Site: 009 (SAC Crop Health Centre)					
0000	<i>Prunus lusitanica</i>		leaves	shot-hole	<i>Pseudomonas syringae</i>
0000	<i>Prunus laurocerasus</i>		leaves	shot-hole	<i>Pseudomonas syringae</i>
0000	<i>Delphinium</i>				<i>P. syringae</i> pv. <i>delphinii</i>
0266	<i>Prunus lusitanica</i>		leaves	shot-holes/irreg. lesions	<i>Pseudomonas syringae</i>
No of samples for site:		4			
Site: 010 (ADAS Plant Clinic)					
0000	<i>Prunus laurocerasus</i>	Zabeliana	leaves	shot-hole	<i>Pseudomonas syringae</i>
0000	<i>Philadelphus sP.</i>		leaves	spots	<i>P. syringae</i> pv. <i>philadelphi</i>
0000	<i>Magnolia sP.</i>		leaves	spots	<i>Pseudomonas syringae</i>
0000	<i>Pyrus</i>	Chanitcleer			<i>Pseudomonas syringae</i>
0000	<i>Prunus sargentii</i>				<i>Pseudomonas syringae</i>
0000	<i>Syringa vulgaris</i>				<i>Pseudomonas syringae</i>
0000	<i>Pyracantha</i>				<i>Pseudomonas syringae</i>
0000	<i>Magnolia</i>				<i>Pseudomonas syringae</i>
0000	<i>Cornus alba</i>	Elegantissima			<i>Pseudomonas syringae</i>
0000	<i>Choisya</i>		cuttings	basal rot	<i>Erwinia carotovora</i>
0000	<i>Cotoneaster</i>				<i>Erwinia amylovora</i>
0000	<i>Hedera sP.</i>				<i>Xanthomonas hortorum hederiae</i>
0000	<i>Aesculus hippocastanum</i>	Baumanii			<i>Pseudomonas syringae</i> Gplb
0000	<i>Fraxinus ornus</i>				<i>Pseudomonas syringae</i>
0000	<i>Spirea sP.</i>				<i>Pseudomonas syringae</i>
0000	<i>Cotoneaster</i>				<i>Pseudomonas syringae</i>
0000	<i>Cornus stolonifera</i>				<i>Pseudomonas syringae</i>
0000	<i>Euonymous</i>				<i>Pseudomonas syringae</i>
0000	<i>Hebe rakiensis</i>				<i>Pseudomonas syringae</i>
0000	<i>Cotoneaster</i>				<i>Erwinia amylovora</i>
0000	<i>Hedera helix</i>	Gold Child			<i>Xanthomonas hortorum hederiae</i>
0000	<i>Euonymous</i>				<i>Pseudomonas viridiflava</i>
0000	<i>Penstemon</i>				<i>Pseudomonas viridiflava</i>
0000	<i>Leucanthemum</i>				<i>Pseudomonas syringae</i>
0000	<i>Berberis julianae</i>				<i>P. syringae</i> pv <i>berberidis</i>
0000	<i>Euonymous</i>	Sunspot			<i>Pseudomonas syringae</i>
0000	<i>Euonymous</i>	Canada Gold			<i>Pseudomonas syringae</i>
0000	<i>Delphinium</i>				<i>P. syringae</i> pv. <i>delphinii</i>
0000	<i>Philadelphus</i>				<i>P. syringae</i> pv. <i>philadelphi</i>
0000	<i>Lavandula</i>				<i>Pseudomonas syringae</i>
0000	<i>Hedera helix</i>	Green Ripple			<i>Xanthomonas hortorum hederiae</i>
0000	<i>Hedera sP.</i>				<i>Xanthomonas hortorum hederiae</i>

Sample No.	Species	Cultivar	Plant Part	Symptom	Result <sup>1</sup>
No of samples for site:			32		

<sup>1</sup>NPI = no pathogen isolated

## APPENDIX II

Exp No	Date	Reported
Sample No	Person	Photographs
Species		
Source		
Material		
Description of symptoms		
Microscopic examination		
Isolation method		
Result		
Conclusion/Diagnosis		