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The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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HNS 151

Is feeding by the conifer aphid *Cinara cupressivora* causing the browning seen in conifer hedges?

Annual Report 2007

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Grower Summary

Headline

- Trimming Leyland and Lawson cypress hedges in the autumn months (especially in October) has been the most significant link with the occurrence of foliage dieback symptoms identified to date.

Background and expected deliverables

Leyland and Lawson cypress are extensively used to make quick growing hedges. Regular trimming of the hedges is needed to avoid excessive growth. Brown patches (dieback) are becoming more common on trimmed hedges. Conifer aphids can cause browning on conifers by their feeding activity, but it is not known if aphids are fully responsible for most of the damage seen or indeed which species are implicated. This research aims to investigate the scale of the problem of browning in hedges and to determine if feeding by aphids is a major cause of the damage seen.

The expected deliverables from this project are:

- An assessment of the incidence of dieback in conifer hedges
- An evaluation of the association between plant damage and aphid populations
- An understanding of the biology and behaviour of *C. cupressivora* in UK hedges
- Confirmation of the identity of any aphid species associated with plant damage

Summary of the project and main conclusions from year 1

In the first year of the project, a survey was conducted to gather information about possible links between where/how Leyland and Lawson cypress hedges are grown and managed, and the incidences of browning and dieback. An advertisement was placed in the Royal Horticultural Society (RHS) magazine *The Garden*, to obtain volunteers for the survey. A questionnaire was produced and sent to volunteers with both damaged and healthy hedges to enable a summary to be produced of the conditions (*e.g.* species, locality, management, presence of pests and diseases etc.) that may be linked with incidences of shoot browning. The questionnaire was also circulated at the RHS, East Malling Research (EMR) and the School of Biological Sciences at The University

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of Reading. Six members of the Association of British Conifer Growers (ABCG) also responded. In total, 316 respondents took part in the survey, the majority of which were members of the RHS living in the south-east of England. Responses to this questionnaire were summarised and analysed. In addition, data from the RHS Advisory Service database for 2005 and 2006, (relating to enquiries about browning and dieback in Leyland cypress) were collated.

In year 1, plant material was also collected and examined for the presence of aphids. Respondents to the questionnaire were sorted by geographical area. Seven respondents were selected from around Wisley in Surrey, and these gardeners were visited in May 2006. Five of these respondents had damaged hedges and two had healthy hedges. Seven respondents were selected from Kent and were visited in June/July 2006. All of these respondents had damaged hedges. Samples of plant material were taken from the hedges at each location and inspected for live aphids or signs that aphids had been present (cast skins or honeydew). Ten gardeners from other areas of the country were also approached and nine of these sent plant samples for assessment.

Main results from year 1

- Of the factors that could be analysed from the survey, only trimming the hedges in the autumn months (predominantly October) was significantly linked with the occurrence of foliage dieback in Leyland cypress.

- Although in some cases increased hedge recovery from progressive dieback coincided with irrigation of hedges, water availability alone was not related to the occurrence of the problem.

- There was no correlation between the appearance of dieback and any individual or combined environmental or soil factors.

- Respondents to the questionnaire were unable to provide detailed information about the occurrence of possible pests or diseases on hedges affected by dieback, so it was not possible to draw any conclusions on the impact of these factors.

- The majority of people who had experienced hedge dieback intimated that they were unlikely to plant Leyland hedges again.

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- The major concern of those who had not experienced dieback was that of high management requirements as such hedges mature.

- Damage in 24% of samples of Leyland cypress sent to RHS was attributed to aphids. Other significant contributors were honey fungus (18% of the samples) and physiological causes such as dry soil, dense planting of the hedge and excessive shoot pruning (14% of the samples).

- In the hedge sampling programme, not all hedges that were reported as damaged showed signs of aphid presence on the plant material examined. Evidence that *Cinara cupressivora* was or may have been present was seen in samples of plant material from only 11 of 21 locations sampled (52%).

- When the presence or absence of aphids was compared to the variety, the timing of appearance of symptoms, amount of foliage left after pruning and severity of dieback with time, there were no differences identified.

- Not all damage symptoms seen on the vegetation at sites where aphids were present appeared to be caused by aphid feeding

- Plant material from five damaged and two healthy hedges was examined to determine if a fungal pathogen could be responsible for the dieback symptoms. No correlation was found between the fungal spores present and the state of health of the plants examined.

Conclusions from year 1

In year 1, the project has demonstrated the widespread occurrence of dieback symptoms on Leyland and Lawson cypress hedges in the UK and has shown that not all the symptoms reported by gardeners are associated with the presence of aphids. However, pruning in autumn does appear to be associated with dieback symptoms.

Work in year 2

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In year 2 experiments will be undertaken on potted plants and on established hedges to clarify the biology and behaviour of *C. cupressivora* and the effects of aphid feeding on the occurrence of plant damage symptoms.

Financial benefits

It is hoped that this project will identify the cause of conifer browning and allow appropriate control measures to be identified. This will improve consumer confidence in conifer hedges and help to maintain or improve the sale of conifers to gardeners.

Action points for growers

There are no immediate action points for growers.

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Science Section

Introduction

Leyland cypress (× *Cupressocyparis leylandii*) and Lawson cypress (*Chamaecyparis lawsoniana*) are extensively used to make quick growing hedges that provide excellent backdrop for beds and borders as well as improving security and privacy. With the introduction of legislation (Anti-social Behaviour Act, 2003) and the frequent news coverage of issues associated with 'garden hedges', there is increased pressure for high level maintenance of evergreen hedges, by frequent trimming. Trimming is often required more than once a year to avoid excessive growth.

A major drawback of conifer hedges is the problem of brown patches (dieback) that can occur in place of the expected green foliage. This is thought to be a problem specific to mature hedges, and it appears that there are not only species specific differences but also cultivar differences in the occurrence of dieback. For example, Leyland cypress shows extensive browning on the golden foliar cultivar Castlewellan. RHS Advisory Service (see advisory leaflet #0805) believes that many brown patches result from adverse growing conditions such as drought, frost or cold drying winds inhibiting regeneration after trimming.

Feeding damage caused by conifer aphid (*Cinara cupressivora*) is also known to lead to browning of conifers. *Cinara cupressivora* has only been recognised as a species since 1999; both *C. cupressi* and *C. cupressivora* occur in UK, but *C. cupressivora* is believed to be the more abundant species (pers. comm. Sean Murphy, CABI Bioscience). In southern and eastern Africa, *C. cupressivora* (previously recorded as *C. cupressi*) is a serious plantation pest and feeding by large populations of aphids can cause tree death. The RHS Advisory Service reported that a significant proportion of samples sent from damaged conifer hedges could not be related to the presence of aphids (pers. comm. Guy Barter, Head of Advisory Service at the RHS). This lack of apparent relationship between aphid presence and hedge damage may be due to the biology of the aphid; aphids may move away from damaged plant material. The biology and phenology of conifer aphids in conifer hedges in UK is unclear. Some plant cultivars may show less damage in response to aphid feeding. Sooty moulds often develop in the honeydew produced by the aphids.

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It has been suggested that browning damage is more common on trimmed hedges; the RHS describe damage caused by aphids on clipped hedges as 'quite pronounced with the lower parts often more severely affected than the top', so it is possible that the damage seen is caused by interactions among different factors, *e.g.* aphid feeding and water stress.

The overall aim of this project is to determine if feeding by aphids is a cause of the damage found in hedgerows of Leyland and Lawson cypress.

Objective 1. **Undertake a survey of the incidence of browning in Leyland and Lawson hedges**

This research has, in its first year, investigated the scale of the problem of browning in hedges in England. This was done by designing and administering a questionnaire which was used to build a picture of the conditions, *e.g.*, species, locality, management practices, climatic and soil conditions, presence of pests (in particular aphids) and diseases, etc., that may be linked with incidences of shoot browning. In addition, data from the RHS Advisory Service database for 2005 and 2006, relating to enquiries about browning and dieback in Leyland cypress hedges, were collated and summarised.

Materials and Methods

The questionnaire for the survey was designed by RHS staff in consultation with EMR scientists. A copy of the questionnaire is included in the Appendix. The questionnaire comprised 32 questions. The first five questions were designed to collect basic information about the hedge (species, age, size). Questions 6-12 were designed to obtain information on the relationship between particular physiological or soil factors and the appearance of browning. For example, higher plant density in a hedge may be linked with lower light availability which may impact on the greenness of the foliage. Similarly, proximity to a barrier implies shading, with similar possible impact on the foliage. Proximity to the road was assessed because of the anecdotal link between foliage browning and the spray of salt from treated road surfaces. The anecdotal assumption that dieback occurs more on dry soils was also assessed (questions 10-12). Furthermore anecdotal evidence and the information in the RHS Advisory Database suggests that dieback in Leyland hedges is almost exclusively seen in trimmed hedges; questions 13-15 were designed to assess this. Questions 16-19 were designed to assess how the hedges were managed, and questions 20-22 to determine

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if any problems of browning or dieback were present. Finally, questions in the second section of the questionnaire (23–end) relating to hedges experiencing a problem, were designed to obtain information about the timing of browning occurrence, progressiveness of the symptoms and any possible recovery.

Three hundred and sixteen respondents took part in the survey, the majority of which were members of the RHS living in the south-east of England. Respondents were recruited by calling for participants in the RHS's magazine *The Garden* and by circulating the survey at the RHS, EMR and the School of Biological Sciences (The University of Reading). Out of the 23 commercial growers who are members of the Association of British Conifer Growers (ABCG) we achieved contact with 11, and, of those, six responded to the survey. As the sample of grower hedges was too small to be analysed separately, it was combined with the rest of the 'public' answers.

Forty-one respondents had hedges that showed no incidences of foliage browning/dieback or any other problem, and the remaining respondents had all experienced a recent and progressive dieback in their hedges. The majority of the hedges (170+43) were × *Cupressocyparis leylandii* (green Leyland and 'Castlewellan', respectively); there was a small number of hedges planted as a 'green Leyland - Castlewellan' mixture (22) or *Chamaecyparis lawsoniana* (Lawson's cypress, 17). All species/varieties were combined for the analysis.

Data from the survey were analysed with a statistical software package SPSS (Version 14.0) (SPSS Inc., Chicago, USA). For each question the frequencies of the hedges with or without browning problems were compared in relation to the particular question. For example, the frequency of hedges of various ages (< 5 years old, 5-10 years old, > 10 years old) was calculated in relation to whether a hedge had a problem or not. The significance of frequency differences was assessed with a Chi-Square test.

All hedges that had problems were then analysed question by question, in relation to whether there was or was not any improvement in the dieback symptoms. For example, the frequency of hedges of various ages (< 5 years old, 5-10 years old, > 10 years old) was calculated in relation to whether the dieback problem was worsening or not. As before, the significance of frequency differences was assessed with a Chi-Square test.

Results and Discussion

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Relationship between individual factors and the occurrence of foliage dieback

Initially the relationship between a number of individual factors and the occurrence of foliage dieback was analysed. For these analyses all the cases of dieback were grouped together irrespective of the extent of the damage or the progressiveness of the damage. The results are summarised, factor by factor, below.

Age

The majority of the hedges in the survey were >15 years old (76.3% and 70.5% of the hedges with and without dieback, respectively). It is therefore unsurprising that the majority of hedges with dieback are in the category of >10 years old.

Conifer species/variety

There were no differences between the genera *Chamaecyparis* (*C. lawsoniana*) and × *Cupressocyparis* (*C. leylandii*, including green Leyland and 'Castlewellan') in the occurrence of dieback.

Planting density

The majority of hedges (>85%) were planted with 0.5-1 m spacing. There did not appear to be any effect of planting density on the occurrence of dieback. For example, 85.7% of the hedges with 0.5 m tree-spacing had dieback symptoms, compared with 88% of the hedges with 0.8 m spacing, or 85.7 % of the hedges with 1.2 m spacing.

Orientation of the hedge axis

The direction down which the axis of the hedge was planted (and, consequently, the exposure of hedge to light and the microclimatic conditions) did not influence the occurrence of dieback: 85% of the hedges running East/West had a problem compared with 82.7% of the hedges running North/South.

Proximity to a barrier

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There was no effect of proximity of barriers on the occurrence of the problem; 58.2% hedges not close to the fence or other barrier had a problem. Similarly, 55.8% of the hedges unaffected by dieback symptoms were not close to the barrier.

Soil type

There were no differences between soil types in the incidences of dieback in the hedges.

Winter 'waterlogging'

It appeared that winter waterlogging was correlated with less incidences of dieback, but this difference was borderline statistically insignificant, P=0.078). 70% of the 'waterlogged' hedges had dieback, while 86.4% of the non-waterlogged hedges had a problem.

Summer 'drought'

Of the hedges that grew on soils frequently dry during summers, 86% had dieback, compared with soils that were not dry, where 78% of the hedges had a problem (this difference was not statistically significant). Similarly, 78.6% of healthy hedges were growing on soils dry during summer.

Watering

Only 13.4% of the survey respondents watered their hedges. Of the 41 hedges with no reported problems only one (i.e. 2.4%) was watered during periods of drought. This suggests that water availability alone has little to do with the occurrence of the problem.

Timing of trimming

There was a very wide difference in when and how often people trimmed their hedges. 70.2% of all respondents trimmed their hedge once a year. Out of this group the majority (53%) trimmed their hedge in the autumn months (September to November), followed by 30% who trimmed during the summer months (June to August). Of the

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people who trimmed their hedges twice a year, the majority did it in summer + autumn or spring + autumn.

Of the hedges that had no dieback, 31.7% were trimmed in summer, 22% in autumn and 17% in spring/autumn. Of the hedges with dieback, 39.9% were trimmed in autumn, 22.6% in summer and 11% each in spring + autumn and summer + autumn. There was, therefore, a bias to trimming in summer being better for the maintenance of dieback-free hedge (i.e. 81.2% of the 69 hedges trimmed in summer had a dieback problem, compared with 91.7% of 108 hedges trimmed in autumn, this difference being statistically significant). The negative impact of trimming in autumn came predominantly from the dieback associated with trimming in October, but not in September or November. Of the 90 survey participants who trimmed their hedge in October, 91.1% had problems with dieback, while in the population of people who trimmed their hedge in any of the other months, 83% had a problem (this difference was statistically significant).

Time of the appearance of dieback symptoms

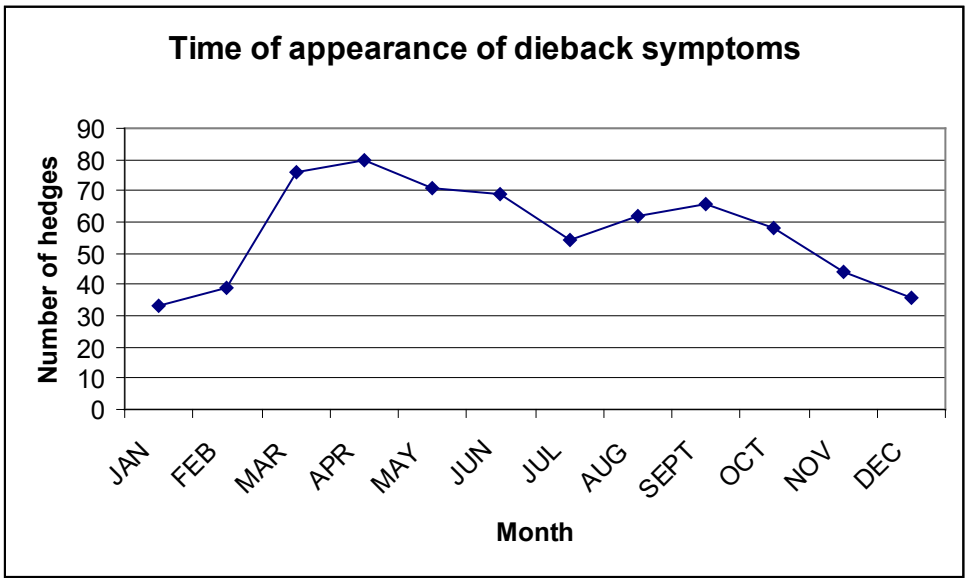

Figure 1: Monthly distribution of appearance of dieback symptoms in Leyland hedges

Distribution of the appearance of symptoms in the 258 affected hedges is shown in Figure 1. Some gardeners have, however, supplied more than one month as the time of the appearance of the symptoms. Although symptoms were appearing throughout the year, there is a suggestion of two peaks: in March/April and in September.

Pests or diseases

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These were only identified in 13% of the surveyed cases, with six incidents of reported aphid damage, three of red spider mite and occasional cases of moths, juniper scale and honey fungus. In addition, two sites surveyed had had aphid damage confirmed by the RHS in 2004.

The lifecycle of *C. cupressivora* in the UK is not completely understood. Work in Objectives 3 and 4 due to be undertaken in 2007 will add to our knowledge of the biology of this species. However, the timing of onset of damage shown in Figure 1 could be related to aphid lifecycle. Aphid numbers begin to increase with the onset of rapid growth of the plants in spring. Feeding by these aphids could be responsible for the damage symptoms first seen in April. Reports suggest that the aphid has a winged form that is produced from June to August and that egg laying females and males occur in autumn (Ciesla, 1991; Anon., 2003). Dispersal of the winged aphids in June-August onto new foliage could be responsible for the damage symptoms first observed in September.

Recovery

There has been some recovery of browning/dieback and a re-growth in approximately 30% of the surveyed cases, but also worsening of the symptoms in over 60% of the recently (past 2 years) affected hedges.

The majority of the people whose hedge had experienced a problem of dieback were deterred by this. Only 18% of them would plant a Leyland hedge again, compared with over 90% of the people with healthy hedges, who were generally only deterred by hedge management issues.

Interaction between droughted soil/time of trimming/appearance of the dieback

Eighty percent of hedges grown on soils that are not usually dry and that are trimmed during autumn had a dieback problem. On dry soil, hedges trimmed in the autumn showed dieback in 93% of cases, compared with 81% for summer trimming. It appears, therefore, that dry soil aggravates the negative effects of autumn trimming.

Interaction between soil type/time of trimming/appearance of the dieback

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There were most incidences of browning if a hedge growing on clay soil was trimmed in autumn (90%) or summer (80%). However, this is most likely due to the fact that most people in the survey grew their hedges on clay soil and trimmed in summer and autumn.

Overall, a 'multiple factor analysis' confirmed the results of the analysis of the individual factors (*e.g.* autumn, in particular October, trimming was linked to increased incidences of browning).

Relationship between individual factors and worsening of dieback symptoms

Following from the analysis of all cases of dieback together, the cases where there was a worsening of the dieback symptoms were analysed separately from the cases where there was some recovery after dieback.

The incidence of worsening dieback symptoms was similar irrespective of the effect of most of the analysed factors (*e.g.* hedge orientation, distance from barrier, type of the soil, occurrence of drought, amount of trimmed foliage). There were, however, 15% more cases of the worsening of dieback symptoms on the hedges that were trimmed in autumn (particularly October), compared to summer trimming.

There were 36 cases where affected hedges were watered during dry periods; this coincided with hedge recovery and new growth in 44.4% of the cases. When the affected hedges were not watered this coincided with the recovery in only 28.6% of the cases and this difference was statistically significant. Occasional occurrence of winter waterlogging coincided with 9% more hedge recovery.

There were 13 instances where insecticide was applied and it was effective in aiding hedge recovery in about 50% of the cases. In 11 cases, the active ingredient (a.i.) of the insecticide was recorded; nine gardeners applied a pyrethroid (1 cypermethrin and 8 bifenthrin) and two applied the neonicotinoid imidacloprid. One respondent made multiple applications of bifenthrin. These insecticide groups are broad spectrum and would kill a range of insect species found on the conifers including aphids. Six respondents reported a decrease in dieback symptoms after applying insecticide; five of these applications were made in April/May. Two respondents reported no effect of insecticide application; these applications were made in early summer/August. It is

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possible that early season application of insecticide reduced pest numbers and allowed some regrowth in the plants, whereas when the plants were sprayed later in the season the plants were unable to produce new growth within that season. However, it is also possible that the insecticide applications were not targeted effectively against the pests. All the materials used were compounds produced for gardeners and may have been applied as spot treatments in the damaged areas; aphids that may have caused the damage may have moved onto new shoots before the insecticide was applied. Even if applied to larger areas, it would be very difficult to spray a conifer hedge thoroughly without commercial equipment.

Fungicide was applied in only five cases which was insufficient for a statistical analysis. The a.i. of the fungicide used was generally not recorded.

Overall, there was little difference in the results of the analysis of all problem hedges together compared with the ones that were affected, but were beginning to recover. Analysis of the recovering hedges alone confirmed the increased incidences of dieback and less recovery in the hedges trimmed in the autumn months compared to summer trimming.

Watering alone did not prevent the dieback problem from occurring, but there may be a link between water availability in the latter part of the summer and a September dieback peak; *e.g.* if water was applied to browning hedges it had a small positive effect on recovery. However, results from our own experiments (Taylor, 2006; Taylor & Blanusa, unpublished) suggest that young Leyland trees in containers are able to grow under very low soil moisture (20% of the container capacity). Furthermore, shoot pruning/clipping of these trees under drought conditions did not result in foliage browning or dieback. Other work suggests that excised and dehydrated branches of Leyland cypress were able to effectively re-hydrate, and remained in good condition after rehydration (Hinesley and Snelling, 1997). Re-hydration was successful even when previous dehydration caused xylem water potential values to become as low as -5 MPa; these would be the values expected in leaves of soil-grown plants under extreme and prolonged drought stress. This implies that water availability is an unlikely sole cause of the dieback found in Leyland cypress hedges.

Leyland cypress is evergreen and therefore growing throughout the year. However, growth in the autumn and winter months is contributing only to a small percentage of the seasonal growth (Lindstrom, 1992). Pruning in the summer, which is followed by

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continued shoot growth, may therefore be advantageous in terms of providing sufficient new growth to supply assimilates for tree maintenance in the autumn and winter. Research would be needed to determine whether the remaining foliage after autumn shoot pruning, and reserves stored in tree bark and roots, (Loescher *et al*., 1990) would be sufficient to sustain tree metabolism without parts of the foliage dieing back until the new growth begins, usually in early spring. This possible link between shoot pruning in October, which appeared to have adverse effects, and the appearance of a peak of early spring dieback symptoms may need to be tested in future research.

Data from the RHS Advisory Service database

In 2005 and 2006, the RHS Advisory Service received a total of 78 inquiries relating to foliage browning and dieback in Leyland cypress (45 in 2005 and 33 in 2006). Months with most enquiries were August (with 9) in 2005 and July (with 6) in 2006.

Overall, the major single identified cause of browning was Cypress aphid (24%) followed by honey fungus (18%) and 'physiological' issues *e.g.* aftercare problems; dry soil; dense spacing of the hedge; excessive shoot pruning (14%) (Table 1). In a high proportion of samples (23%) no diagnosis was possible, either because the sample size was insufficient or because the cause could not be identified. This suggests that although aphid feeding appears to be an important cause of the damage seen in Leyland cypress hedges, not all incidences of dieback could be explained by aphid presence, and is in line with results obtained from the questionnaire (above) and the hedge sampling programme outlined in Objective 2.

Table 1: Causes of dieback in Leyland cypress hedges identified in samples received by the RHS Advisory Service in 2005 and 2006

Likely cause of dieback	No of samples	Percentage of samples
Cypress aphid	19	24
Honey fungus	14	18
Physiological (dense spacing, drought, extensive pruning)	11	14
Pestalotia-related disease	7	9
Juniper scale	2	3
Undiagnosed	16	21
Insufficient sample size	9	12
Total	78	

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Objective 2. Determine if there is an association between plant damage and aphid populations

In year 1, plant material from damaged and healthy hedges was examined to determine if there was an association between aphid occurrence and plant damage.

Materials and methods

Respondents to the questionnaire produced for Objective 1 were sorted by geographical area. Seven respondents were selected from around Wisley in Surrey, and these gardeners were visited by EMR and RHS staff in May 2006; 5 of these respondents had damaged hedges and two had healthy hedges. Seven respondents were selected from those in Kent and were visited by EMR staff in June/July 2006; all of these respondents had damaged hedges. Samples of plant material were taken from the hedges at each location. For the Surrey locations a bulk sample of material from damaged areas of the hedge, areas close to the damage and from apparently healthy areas was taken. For the Kent locations samples from the different areas on the hedge were kept separately. Each sample consisted of shoots approximately 15-20 cm long; this normally included material that had been behind the previous season's pruning cuts. The samples were returned to the laboratory and kept at 4ºC until examined. A tap sample was also taken from two of the Kent hedges; vegetation was tapped over a white bowl to dislodge any pests on the hedges. Ten gardeners from other areas of the country were also approached and nine of these sent plant samples to EMR for assessment. Each gardener sent separate material from dead and healthy parts of the hedge and material from close to the dead area. Thus hedges in a total of 23 locations were assessed for aphid occurrence; there were 52 separate samples. A photographic record of the hedge damage was made.

Ten shoots per sample were examined under a stereo microscope in the laboratory, and any aphids or other insect species present recorded. During development most aphid species moult four times, although there is a report that *C. cupressivora* has only three nymphal stages (Alleck & Seewooruthun, 2001), and in moulting produce a cast skin or *exuvium* (see Appendix 2). During feeding the aphids also produce a sticky waste product called honeydew on which sooty moulds often grow (see Appendix 2). The presence of any *exuviae* or honeydew, and the associated sooty mould growth, were recorded on each shoot sample. However, other insect species also produce

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exuviae and it is sometimes difficult to identify the species that has been present from the *exuvium* alone. Honeydew and associated sooty moulds may also be produced by other insect species, so on its own honeydew is also not a definite indication that aphids have been present. The presence of *exuviae* together with sooty moulds is a more reliable indicator that aphids have been present.

Damage symptoms on each shoot examined were recorded by assigning them to severe, moderate, slight and no damage categories.

Plant material from five damaged and two healthy hedges was examined to determine if a fungal pathogen could be responsible for the dieback symptoms. Plant material was placed on damp tissue paper in closed plastic boxes and kept at c. 20-25ºC for one week so that any pathogens present would sporulate. Spores were then examined under a compound microscope (by Dr Angela Berrie at EMR) and identified where possible.

Results and discussion

Photographs of representative damage on shoot samples and of hedge damage are in Appendix 2 to this report.

In the samples taken in May from Surrey, in four out of five damaged hedges there was evidence that *Cinara cupressivora* was or may have been present, with live aphids present at two sites (Table 1). The mean number of aphids per infested shoot from locations where aphids were present was 2.4. *Exuviae* were detected in both samples where aphids were present and also in one where no aphids were seen, but no honeydew was apparent in these samples. The remainder of locations sampled (one damaged and two recorded as healthy) showed no evidence that aphids had been present.

In the Kent locations sampled in June and July, aphids were present at three out of seven sites in the area close to the damaged patch (Table 2). *Exuviae* and honeydew were present on samples close to the damaged patch from these three, plus one additional location. In the damaged area, aphids were found in two locations, *exuviae* in one and honeydew in one. Thus aphids were present in the damaged area and the area close to the damaged part in two locations. The mean number of aphids per infested twig from locations where aphids were present was 1.0. In one location only

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honeydew and sooty mould was recorded on the shoots; since no aphids or *exuviae* were seen at this location it is possible that this mould resulted from some other insect infestation and this was not included as a site where aphids had been present. Thus four out of seven locations visited in Kent showed signs of aphid presence.

In the tap sample taken from hedges in two Kent locations in July, no aphids were found. Evidence of aphid presence (*exuviae*) was seen when plant material from these sites was inspected under a microscope (Kent samples 4 & 5 in Table 2), indicating that direct observation may be more effective when sampling for this pest. However, it would be useful to assess tap sampling earlier in the season when aphids may be present at higher numbers.

Postal samples were received in late July and early August from Cornwall (2 samples), Essex (2 samples), Leicestershire (2 samples), Lincolnshire (1 sample) and Pembrokeshire (2 samples). Only three locations showed evidence of aphid presence (Table 2) and no live aphids were found in any samples. *Exuviae* were found in the damaged area and the area close to the damage from all three locations. In the sample from Leicestershire, *exuviae* were found on nine twigs examined from the damaged area of the hedge; the maximum number recorded from one shoot was 11 (one *exuvium* resulting from each of 3 or 4 moults undergone by each aphid) indicating that these may have been from only three aphids. An *exuvium* was also found on the healthy area of the hedge from Essex.

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Table 2: Number of conifer shoots with evidence of aphid presence (out of 10 shoots examined per location) from locations where aphids were or had been present. The total number of aphids recorded from these samples is shown in parentheses. Surrey samples were collected on 25 May; Kent samples 1-3 on 20 June and samples 4-5 on 12 July. Postal samples were received during July and August

Location		Bulk samples		
		aphids	*exuviae*	honeydew
Surrey	1	6 (15)	4	0
	2	0	2	0
	3	3 (7)	2	0

Location		Separated samples					
		Close to damaged patch			Damaged patch		
		aphids	*exuviae*	honeydew	aphids	*exuviae*	honeydew
Kent	1	0	0	1*	0	0	1*
	2	1 (1)	1	3	2 (2)	0	7
	3	1 (1)	2	1	-	-	-
	4	1 (1)	1	0	4 (4)	2	0
	5	0	1	1	0	0	0
Leics		0	1	0	0	9	0
Essex		0	2	5	0	6	0
Pembs		0	2	0	0	1	0

* no other signs of aphid were present in this sample, so the honeydew may be the result of feeding by other insect species

In the samples where plant material was separated depending on its closeness to the damaged areas (Kent and postal samples), in a total of 16 samples, evidence of aphid presence was seen in seven samples of vegetation close to the damaged area and in five samples from the dead area. It is apparent that on the plant material examined, *Cinara cupressivora*, where present, was at very low densities. The maximum number of live aphids recorded from one shoot was eight (Surrey sample in May) and the maximum number of *exuviae* was 11 (Leicestershire sample). From this limited sample of hedges where aphids were or appeared to have been present, numbers of aphids appeared to be higher in June than in July or August. In 2006, sampling began later in the season than was ideal as it was necessary initially to distribute the questionnaire to obtain volunteers for the sampling programme, so it is not known if aphid numbers were higher earlier in the season.

When questionnaire responses (Objective 1) from gardeners whose damaged hedge samples were examined by EMR were analysed with respect to several factors that might affect or be related to aphid presence (variety of conifer, time of appearance of symptoms, amount of foliage left after pruning, worsening of the dieback symptoms over time), there were no differences between those damaged hedges that had signs of aphid presence and those that did not.

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It is clear from these results that not all hedges that were reported as damaged showed signs of aphid presence on the plant material examined; from a total of 21 locations inspected only 11 showed signs of aphid presence (52%). Also not all damage symptoms seen on the vegetation at sites where aphids were present appeared to be caused by aphid feeding; when the damage categories of shoots that had indications of aphid presence were assessed, 34 were categorised as severe, ten as moderate, sixteen as slight and five had no damage. In the remaining shoots from these locations, i.e. shoots where no signs of aphids had been detected although aphids were present somewhere on the examined hedge, 43 were categorised with moderate/severe damage. *Cinara cupressivora* has a relatively short rostrum (an external part of the mouthparts) and in aphids this is generally associated with being able to feed at locations on the plant where the bark is thin (*e.g.* Carter & Maslen, 1982). This implies that they will normally be found on recent plant growth. Feeding for only a short period (7-10 days) is reported to be sufficient to cause plant damage (Anon., 2003), and only the shoots that aphids are feeding on are reported to show damage symptoms (Winter, 1989). Since many of the damaged shoots examined in this research showed no signs of aphid presence and the material collected is from locations where they would have been expected to be feeding, if present, it seems unlikely that all the damage reported is due to aphid feeding. Research planned for 2007 on potted plants and on established hedges (Objectives 3 and 4) should enable us to clarify the effects of aphids on dieback symptoms.

Other insects were also recorded on the conifer samples. Scale insects were abundant and were present on healthy and damaged hedges, but were not found within the damaged patches. There was no correlation between scale presence and damage to the hedges. Caterpillar feeding damage was recorded from 10 out of 15 locations but did not appear to be correlated to hedge damage, although one gardener in Surrey had arranged to have an insecticide applied to control caterpillar populations.

On the samples that were assessed for fungal pathogens, no correlation was found between the spores present and the state of health of the plants. *Pestalotiopsis funerea* spores were seen in five of the seven samples, but one of these was from a healthy hedge, and one sample that had extensive dieback symptoms had no *P. funerea* spores. This pathogen is common on many conifers where it may cause minor needle blight (Phillips & Burdekin, 1992). However, in France it has been reported to be a

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major cause of severe browning in *Cupressaceae* (Morelet, 1982). It would be interesting to investigate the effect of this pathogen in more detail.

Objective 3. Determine if feeding by *Cinara cupressivora* results in the typical browning or 'die back' seen on Leyland and Lawson hedges

Because we were unable to initiate a *C. cupressivora* culture in the laboratory in 2006, EMR was unable to undertake the experimental work planned for Objective 3. After discussion with the HDC Project Manager this work is now scheduled for 2007, and the project will end in March 2008.

Objective 4. Understand the biology and behaviour of *C. cupressivora* in UK hedges

This work will be undertaken in 2007.

Objective 5. Confirm the identity of any aphid species associated with plant damage

Since low levels of live aphids were found on plant material during the sampling programme in 2006 only 18 were preserved for identification. Of these, using the criteria outlined in Watson *et al*. (1999), 14 were identified as *Cinara cupressivora*. The remaining four were nymphs and the species could not be determined. Some of the *exuviae* collected from the samples showed evidence that the aphids had moulted into a winged morph which would probably disperse to new plants; this part of the biology of *C. cupressivora* will be clarified in Objective 4 in 2007.

Conclusions from year 1 results

- Analysis of the responses to the survey suggests that, of the factors that were analysable, only trimming the hedges in the autumn months (predominantly October) was significantly linked with the occurrence of foliage dieback in Leyland cypress

- Although watering hedges that experienced progressive dieback coincided with increased hedge recovery in some cases, water availability alone was not related to the occurrence of the problem

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- There was no correlation between the appearance of dieback and any individual or combined environmental or soil factors

- Questionnaire respondents were unable to provide detailed information about the occurrence of possible pests or diseases on hedges affected by dieback and it was thus not possible to draw any conclusions on the impact of non-environmental factors

- The majority of the people whose hedge had experienced a problem of dieback said they were unlikely to plant Leyland hedges again. Gardeners who have not experienced dieback problems are only concerned about, what they perceive as, high management requirements as the hedge matures

- Analysis of the causes of foliage dieback in Leyland cypress hedges in the 78 samples sent to the RHS Advisory Service in 2005 and 2006 determined that in 24% of the samples damage could be attributed to aphids. Other contributors were honey fungus (in 18% of the samples) and physiological causes, *e.g.* aftercare problems; dry soil; dense spacing of the hedge; excessive shoot pruning (in 14% of the samples).

- In the hedge sampling programme, not all hedges that were reported as damaged showed signs of aphid presence on the plant material examined. Evidence that *Cinara cupressivora* was or may have been present was seen in samples of plant material from only 11 of 21 locations sampled (52%).

- In the locations inspected by EMR, there were no differences between damaged hedges that had signs of aphid presence and those that did not with respect to the variety of conifer sampled, the time of first appearance of symptoms, the amount of foliage left after pruning, or in worsening of the dieback symptoms over time, all factors that might affect or be related to aphid presence.

- Not all damage symptoms seen on the vegetation at sites where aphids were present appeared to be caused by aphid feeding

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- Of the samples that were assessed for fungal pathogens, no correlation was found between the spores present and the state of health of the plants.

Technology transfer

Olga Grant (2007). Hardy Nursery Stock Research at East Malling Research. Oral presentation to the Hardy Nursery Stock technical committee of the Horticultural Trades Association.

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Appendices

Appendix 1: Conifer Survey 2006

Conifer Hedge Questionnaire

Name:	
Address:	....
Postcode :	.....
Telephone:	.....
Email:	.....

1. What variety of hedge do you have?
   Green Leyland (*x Cypressocyparis leylandii)* ☐ Gold Leyland (*x Cypressocyparis leylandii*) ☐
   Lawson (*Chamaecyparis lawsoniana*) ☐ Other ☐ Unsure ☐
   If Other please specify which variety .....

2. How old is your hedge?
   Less than 5 years ☐ 5-10 years ☐ 10-15 years ☐ More than 15 years ☐ Unsure ☐

3. What is the approximate length of your hedge? .....

4. What is the approximate height of your hedge? .....

5. What is the approximate width of your hedge? .....

6. What is the planting density of the hedge? *Please measure distance between trunks at ground level*
   .....

7. What direction does the axis of the hedge run? (Only answer if the hedge runs in a straight line) *e.g. North/South, East/West* .....

8. Is the hedge close (less than a metre) to a wall, fence or other barrier for the majority of its length?
   YES ☐ NO ☐
   If YES what is the distance from the barrier .....
   Please describe the barrier .....

9. How close is your hedge to a road for the majority of its length?
   Less than 3 metres (9' 8") ☐ Please give distance .....
   More than 3 metres (9' 8") ☐

10. What type of soil do you have?
    Clay ☐ Chalk ☐ Sand ☐ Loam ☐ Unsure ☐

11. Is your soil frequently waterlogged for prolonged periods in winter?

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YES ☐ NO ☐ Unsure ☐

12. Is your soil frequently dry in the summer? YES ☐ NO ☐ Unsure ☐

13. Do you trim your hedge every year? YES ☐ NO ☐
If YES how many times? *Please state* 3

14. On average when do trim your hedge? *Please tick all monthly boxes that apply.*

J	F	M	A	M	J	J	A	S	O	N	D
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15. How much foliage do you remove when trimming?
2-4 cm (1") ☐ 5-10 cm (2-3") ☐ More ☐
If MORE, please specify.....

16. How much new growth do you leave when trimming?
None (back to previous trimming) ☐
2-4cm (1-1.5" approx) ☐
More than 4cm (more than 1.5") ☐ *Please state length* .....

17. What tool do you use for trimming?
Power strimmer ☐ Powered hedge trimmer ☐ Hand shears ☐Secateurs ☐ Other ☐

18. Do you water your hedge? YES ☐ NO ☐
If YES, how often?.....

19. Do you give your hedge fertiliser? YES ☐ NO ☐
If YES, please give the following details:

Product name(s)	.....
Amount applied	.....
Month(s) applied	.....

20. Do you apply fungicide to your hedge? YES ☐ NO ☐
If YES, please give the following details:

Product name(s)	.....
Amount applied	.....
Month(s) applied	.....

21. Do you apply insecticide to your hedge? YES ☐ NO ☐
If YES, please give the following details:

Product name(s)	.....
Amount applied	.....
Month(s) applied	.....

22. Have you experienced any problems with the hedge? YES ☐ NO ☐

If NO, please go to Q. 31 **If YES, please continue to Q. 23**

23. What problems have you experienced?

Dieback ☐ Browning ☐ Other change of colour ☐ Other problem ☐

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If Dieback, Browning or Other change of colour at which time of the year did you notice this? *Please tick all monthly boxes that apply.*

J	F	M	A	M	J	J	A	S	O	N	D
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

If you have observed dieback or browning, please describe the extent and distribution in more detail .....

If other problem please describe symptoms .....

24. If the hedge has damaged patches, please state the estimated number and average size of the damaged patches?

Number of patches	.....
Average size of patches (approximate diameter)	.....
Not measurable	☐
Not applicable	☐

25. Which year was the problem first seen (if known)?.....

26. Is the problem getting worse? YES ☐ NO ☐ Not applicable ☐
Comments (if any).....

27. Has there been any recovery? YES ☐ NO ☐
Comments (if any).....

28. Have you noticed any pests or diseases on your hedge? YES ☐ NO ☐
If pests/diseases have been identified, please give details if known .....

29. Will the problems with your hedge make you less likely to plant Leyland hedges in your garden in future? YES ☐ NO ☐

30. If your hedge has damage symptoms would you be able to send us samples/photos at regular intervals between May-September? YES ☐ NO ☐
Please Note: We will contact you in due course should we require photos.

31. If required could we come and inspect your hedge? YES ☐ NO ☐
Please Note: We will only be able to visit within an approximately 50km/30mile radius around Reading (Berkshire), East Malling (Kent) or Wisley (Surrey).

32. Do you have any other comments you would like to make regarding your hedge? .....

Thank you for taking the time to complete this questionnaire

The Horticultural Development Council and Royal Horticultural Society are funding this research. Results will be made available to the public on the RHS and East Malling Research websites, as well as the HDC website for the HDC members.

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Appendix 2: Damage to conifer hedges

Cinara cupressivora on conifer sample

Evidence that aphids have been present on the sample; aphid *exuvium* (cast skin) and sooty mould growing on honeydew

Evidence that aphids have been present on the sample; aphid *exuviae* (cast skins)

Examples of damaged hedges

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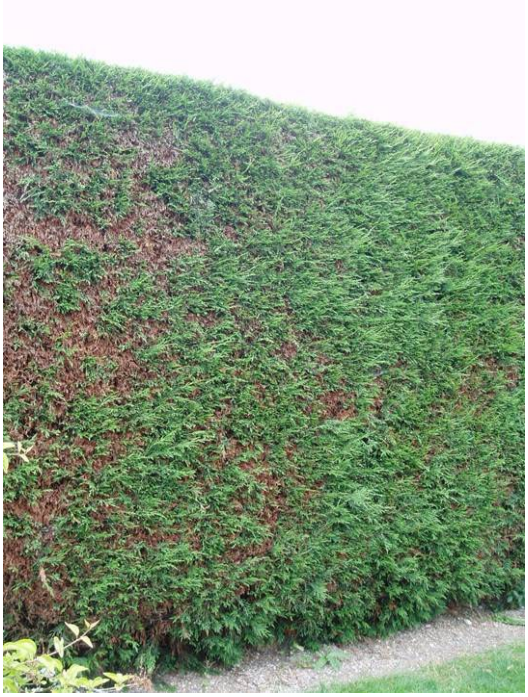

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