Project title:	**Japanese Maples (*Acer* spp.): An examination of the causes of stem disease problems**
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Objectives and background

A number of pathogens are known to cause stem disease in Japanese maples, and related ornamental species, including the fungi; *Verticillium* spp., *Nectria* spp., *Fusarium* spp. and *Botrytis cinerea* as well as the bacterium *Pseudomonas syringae* (Vertrees, 1978; Foss & Byther, 1994). These pathogens can cause a range of symptoms including neck and collar rots, wilting, vascular discolouration, necrotic rots, diebacks and cankers and some diseases may be more important to the industry as a whole than others. Losses to stem diseases in general vary from year to year and with tree age and production system, but have been estimated to average about 20%. In some years losses can be as high as 50% and in highly susceptible varieties as high as 80%.

The distribution and importance of individual stem disease problems in the UK industry is not known and before research can be focussed to deal with individual disease problems, work is required to define the true nature and extent of stem disease problems in UK Japanese *Acer* production. The objectives of this pilot study were to carry out a survey to:

a) provide basic information on the distribution and importance of stem diseases in the UK industry,

b) to identify potential key environmental and cultural factors linked to crop loss,

c) provide a reasonably accurate estimate of the actual losses experienced by growers,

d) carry out a small number of isolations from diseased material in an attempt to identify the pathogens causing the main symptom types highlighted in the survey.

Summary of Results

Views were canvassed from 25 growers whose scale of *Acer* production ranged from 100-200 through to 65,000 plants per year, with a combined total annual production of 72,500 outdoors, 132,941 under protection. A summary of the main findings of the survey are detailed below.

- Stem disease problems cause overall losses of Japanese maples ranging between <1 and 40% (average = 14.6%) depending on varieties and year.

- In susceptible varieties, losses vary from 5 to 100% (average = 28.2%) depending on variety and year.

- Five common stem disease symptom-types are widely seen in UK production: (i) tip dieback, (ii) black or dark necrotic rot, (iii) 'paper bark' rot, (iv) wilt and (v) canker.

- Aggressive tip dieback, black or dark necrotic rot and 'paper bark' rot were the most commonly reported stem disease symptoms, with 68%, 84% and 40% of survey respondents reporting problems with each symptom type respectively.

- Many varieties are susceptible to stem disease problems but particularly problematic are varieties of *Acer palmatum* var. *atropurpureum* and *Acer japonicum* 'Aureum'.

- Stem disease is a problem in both field-grown and containerised plants, but protection can cut down losses.

- Environmental conditions likely to cause wounding in *Acer* tissues, such as severe frosts and scorching winds, were considered important factors in increasing stem disease incidence. Also, plant surface wetness and high humidity were considered important and may provide favourable conditions for infection by opportunistic pathogens like *Fusarium, Botrytis* and *Pseudomonas* spp.

- Isolations from the small amount of material assessed in this survey suggest that opportunist pathogens such as *Fusarium oxysporum* may be responsible for stem rots and that the dark necrotic rot, 'papery bark rot' and aggressive tip dieback symptoms may all be the result of tissue wound exploitation by such pathogens.

Benefits from study and recommendations for future R & D

From this study we now know that the dark necrotic rot, 'papery bark' rot and aggressive tip dieback are all important stem disease problems in UK Japanese maple production. They cause significant losses and can affect plants of a wide range of ages, reducing quality and garden performance. The three symptom-types may represent different stages of the same disease, and thorough isolation work is required to determine this. Before stategies for control can be developed, the biology of these three diseases needs to be understood. To achieve this, a programme of isolations from diseased plants from a number of UK nurseries needs to be undertaken, with isolations being made at different times of the year and the pathogenicity of isolated organisms confirmed by inoculation experiments. Pathogenicity tests might also be improved by manipulation of the growing environment to simulate factors such as frost damage.

Based on the results of these pathogenicity studies, a viable control strategy needs to be developed, possibly involving both cultural techniques and/or targeted use of fungicides.

EXPERIMENTAL SECTION

INTRODUCTION

In UK production, serious losses of Japanese maples are apparently being caused by a number of stem disease problems, some of which remain undiagnosed. Stem disease can kill plants, make them unsalable or reduce their quality by killing key branches and spoiling tree/bush architecture. Stem disease problems have also been partly blamed for the, not necessarily deserved, reputation of Japanese acers as 'difficult plants' in gardens.

A number of pathogens are known to cause stem disease in Japanese maples, and related ornamental species, including the fungi; *Verticillium* spp., *Nectria* spp., *Fusarium* spp. and *Botrytis cinerea* as well as the bacterium *Pseudomonas syringae* (Vertrees, 1978; Foss & Byther, 1994). These pathogens can cause a range of symptoms including neck and collar rots, wilting, vascular discolouration, necrotic rots, diebacks and cankers and some diseases may be more important to the industry as a whole than others. Losses to stem diseases in general vary from year to year and with tree age and production system, but have been estimated to average about 20%. In some years this figure can be as high as 50% and in highly susceptible varieties as high as 80%.

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a) provide basic information on the distribution and importance of stem diseases in the UK industry,

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MATERIALS AND METHODS

Questionnaire

A simple questionnaire that could be conducted by telephone was prepared. This consisted of 10 simple but broad questions that were used as a guide for telephone conversations with growers. The questions were aimed at identifying the nature and scale of each respondent grower's production, the scale of disease problems (if any) on each holding, the nature of stem disease symptoms seen, and collecting anecdotal evidence to help identify important cultural and environmental factors involved. The questions were as follows:

1) How many Japanese maples and Snake bark maples do you produce annually?
   (a) Field-grown
   (b) Under protection

2) % Losses associated with stem disease/canker problems in:
   (a) Field-grown plants
   (b) Containerised plants
   (c) Container-grown - i) Outdoors
   ii) Under protection

3) Are any particular species/varieties more susceptible to disease? Yes/No

4) If so:
   (a) Which species/varieties?
   (b) What % of total losses would you associate with these 'problem' varieties?

5) Is there more than one stem disease symptom-type seen on your nursery? Yes/No

6) Description of symptom types seen

7) Does the problem vary significantly from year to year?
   If so: Which years = good, and which = bad?

8) What type of irrigation do you use?

9) Brief outline of growing media and techniques used.

10) Are there any environmental factors you think may influence stem disease problems? (e.g. heavy summer rainfall, severe frosts, vigorous but 'soft' shoot growth etc.).

A total of 25 growers were contacted, all of whom were very helpful in their responses to the questions. Answers to the questions were written out on questionnaire forms during the telephone conversations for analysis later.

Isolations and disease assessments

Samples of Japanese maples showing a range of different stem disease symptoms were obtained from three different nurseries. Plant species, variety, culture and age were all recorded and the disease symptoms were recorded. Isolations were attempted from pieces of diseased tissue by cutting out and surface sterilising pieces of 'leading edge' in sodium hypochlorite and plating these out on a range of selective and general isolation media [potato dextrose agar (PDA), BNPRA- Phycomycete selective agar (Pettitt & Pegg, 1991), '*Fusarium* selective' agar (Parry, 1990), King's B medium (King *et al.*, 1954)].

RESULTS & DISCUSSION

Questionnaire

The number of growers selected for the questionnaire (25) was sufficiently small to allow using the telephone. This received a good response rate (i.e. 100%!) and all respondents were very helpful with their responses to the questions.

Scale of production

The scale of production by the respondents ranged from 100-200 to 65,000 plants per year, representing an overall production of 72,500 plants outdoors and 132,941 plants under protection each year.

Overall losses to stem diseases

Due to the diverse nature of Japanese maple production it was difficult for respondents to answer the question about overall losses to stem disease with great accuracy. Eight respondents stated that over their entire Japanese *Acer* production they experienced no problems. Four of these qualified this statement by saying that stem disease problems are very variety specific. Estimates of total losses averaged at 14.6% with 5 - 40% losses in field-grown plants and < 1 - 35% under protection.

Susceptible species and varieties

All respondents considered certain individual species/varieties to be more susceptible to stem disease problems. Some general groups were also identified as being problematic. For example many (but not all) varieties of *Acer palmatum* var. *dissectum, A. palmatum* var. *linearilobum* and of *A. japonicum.* Individual varieties identified as being susceptible to stem disease problems are listed in Table 1. Two varieties widely stated as being susceptible were *A. palmatum* var. *atropurpureum* and *A. japonicum* 'Aureum'. Other susceptible varieties were *A. palmatum* var. *dissectum* 'Brocade' and *A. palmatum* 'Ōsakazuki'. Interestingly, respondents' experiences with the latter variety were contradictory, with 3 identifying it as a 'problem' variety and 2 suggesting that it was relatively problem-free. These differences can possibly be explained by differences in site, plant culture and the age of plants being handled by each nursery in question (eg. fresh grafts or nearly finished plants). As would be expected, the estimated losses of susceptible varieties were higher than overall losses, with an average of 28.2% and a range from 5-100% dependant on variety and year.

Symptoms observed

Five distinct stem disease symptom-types were described by respondents:

1) Shoot tip dieback: this can be non-aggressive and part of the natural 'self pruning' process or become aggressive when a pathogen invades the dieback tissues.

2) A very dark brown/black necrotic rot: this normally starts off as small (5-10mm) dark coloured streaks that can occur on any part of the stem, although most often in the lower 20 cm. These streaks rapidly spread and join to form large, normally soft and sunken lesions that often girdle and kill branches or entire plants.

3) Another form of stem lesion which may be linked to 2) but has a distinct silver-grey appearance. These lesions often appear in similar locations to 2) on trunks and branches. They have a dark-coloured leading edge, with silver grey colour towards the centre of the lesion due to the lifting of the dead bark in this area. These lesions also frequently lead to death of branches and entire plants.

4) Wilting, normally associated with *Verticillium* spp. but also could result from the effects of undiagnosed 2) and 3).

5) Cankers: the most commonly seen cankers are caused by weakly pathogenic *Nectria cinnabarina* coral spot.

The most commonly seen of these symptom-types was the non-aggressive form of tip dieback.

Of the aggressive symptoms, the dark nectrotic rot and aggressive tip dieback were the most frequently reported, with 21 (84% of respondents) growers citing the necrotic rot and 17 (68% of respondents) citing aggressive tip dieback as important causes of plant losses.

Silvery bark lesions were less frequently seen (10 growers; 40% of respondents) but are still an important cause of plant losses.

Much less frequently reported were *Verticillium* wilt and *Nectria* canker (both reported by 6 growers; 24% of respondents) and in all cases these were only occasional problems and probably more important in old established plants in mature gardens.

Year to year variation in disease

The majority of respondents (68%) considered the problem of stem diseases, especially the dark necrotic rot, to vary considerably from year to year. The remaining 32% were divided equally between those who did not feel that problems varied from one year to the next and those who were uncertain. When questioned as to which particular years were good and which bad, only a few respondents suggested specific years. Whether particular seasons were considered 'good' or 'bad' also seemed, to some extent, to be dependent on the presence/absence of protection. The severe late frosts of 1997 meant that this year was identified as a bad year for stem disease problems outdoors. Some outdoors producers also considered the wet spring of 1998 as 'bad' whereas 2 growers producing protected crops regarded spring 1998 as a reasonably good early season.

Environmental factors

Many of the environmental factors identified in this survey as conducive to the development of stem disease in Japanese *Acer* spp., are capable of inducing tip dieback. The most frequently identified factor was frost/chilling damage. Although capable of causing the death of young shoots, these environmental factors may not be directly responsible for stimulating the establishment of pathogens in damaged tissues. Many respondents to the questionnaire identified wet conditions as favourable to infection and disease development and a combination of frost damage quickly followed by climatic conditions leaving the foliage wet may be an important deciding factor in the establishment of aggressive tip dieback symptoms. Japanese maples are fairly resistant to low temperatures and several respondents suggested that in dry cold winter conditions, plants showed very high rates of survival. What seems important is rapid drops in temperature, especially if soft young tissues are present, and the greatest dangers of damage arise with severe frosts in otherwise warm springs. For this reason, varieties which start their first new season's growth early in spring, are likely to have more problems. One respondent pointed out that aggressive tip dieback can be avoided after severe frosts if frost-damaged tips are pruned out within a few days. Avoidance of the destructive effects of frost, wind and wet weather have led 3 respondents to move either some or all of their production of Japanese maples under protection, with subsequent reductions in their plant losses. Large amounts of vigorous and soft shoot growth seem to be best avoided. Overfeeding with nutrients in some varieties greatly increases the development of susceptible tissue. This appears to be a particular problem in *A. palmatum* var. *dissectum* varieties.

Systems of production

The majority of UK producers of Japanese maples use overhead sprinkler irrigation for watering the crop during the growing season, with very sparing application, mostly by hand, during the winter months. All respondents agreed watering regimes were critical and on 3 nurseries the use of capillary beds was found to reduce plant losses to stem disease problems. All respondents were using potting media that were open structured allowing free drainage.

Isolations from samples of diseased stem tissue

The results of this preliminary set of isolations are summarised in Table 2. From these data it can be seen that the dark necrotic rot and the silvery 'paper-bark' rot affect plants of a wide range of ages, whereas *Verticillium* wilt appeared to be more of a problem in mature plants. Isolations from dark necrotic rot and 'paper-bark' rot samples produced a large number of opportunistic pathogens such as *Fusarium* spp. (especially *F. oxysporum*) and *Botrytis cinerea*. *Pseudomonas syringae* was not isolated from the small number of samples checked, but this may be a function of the time of year when the samples were collected. The best time for obtaining *P. syringae* isolates from affected *Acer* material seems to be early to mid-spring (Steve Roberts, HRI Wellesbourne, Personal communication). These results tend to support the idea of stress wounding, (eg from frost damage), leading to infection by opportunistic ('secondary') pathogens, being the route to developing these stem rots, although further isolations and inoculation experiments are required to verify this.

Table 1: Stem disease problems in Japanese maples: summary of susceptible varieties

No. of respondents identifying particular species/varieties as susceptible	
5	*Acer palmatum* var. *atropurpureum* (Red leaf Japanese maples)
1	*Acer palmatum* var. *dissectum* 'Seiryu' (Laceleaf Japanese maple)
2	*Acer palmatum* var. *dissectum* 'Brocade' (Fine red dissectum)
3	*Acer palmatum* var. *linearilobum*
1	*Acer palmatum* 'Chishio improved'
2	*Acer palmatum* 'Katsura'
1	*Acer palmatum* 'Mapi-nō-Machiheni' ('Little Princess')
3	*Acer palmatum* 'Ōsakazuki'
1	*Acer palmatum* 'Sango kaku' ('Senkaki'. Coral bark or Cinnabar wood maple)
1	*Acer palmatum* 'Shindeshōjō'
1	*Acer palmatum* 'Ukigumo' ('Floating clouds')
6	*Acer japonicum* 'Aureum' ('Golden full-moon maple')
1	*Acer griseum* (Paper bark maple)

Table 2: Results of isolations from samples of Japanese maple stem tissue, of different ages and from three different UK nurseries, showing a range of different stem disease symptoms.

Symptoms[a]	Host details	Nursery (A, B or C)	Pathogen/suspected pathogens isolated[b]
Tip dieback	2 yr old field-grown stock	A	*Botrytis cinerea*
Tip dieback	Mature *Acer palmatum* tree in garden	-	*Fusarium oxysporum*
Tip dieback	2 snake barks (old symptoms)	A	*Botrytis cinerea*
Tip dieback	*Acer palmatum*, 2nd year grafts	B	*Botrytis cinerea*
Tip dieback and black necrotic rot	2 yr old field-grown stock	A	*Fusarium oxysporum*
Black necrotic rot (Lower stem)	2 yr old field-grown stock	A	*Fusarium oxysporum*
Black necrotic rot	2 yr potted plants (old symptoms)	A	*Fusarium oxysporum; Botrytis cinerea*
Black necrotic rot	*Acer palmatum* var. *atropurpureum*, 2yr field plants	C	*Botrytis cinerea*
Black necrotic rot	*Acer palmatum* 'Mapi-nō-machiheni' *('Little princess')*	B	Unknown
Black necrotic rot	*Acer palmatum*, 2nd year grafts	B	*Fusarium oxysporum*
'Papery bark' rot	2 yr old field-grown stock (plants heeled in for 2 months prior to isolations)	A	*Fusarium sambucinum; Botrytis cinerea*
'Papery bark' rot	'Ōsakazuki' 4 year old plants	B	*Fusarium oxysporum*
'Papery bark' rot	*Acer palmatum*, 2nd year grafts	B	*Diplodina acerina*?
Wilt and some stem necrosis; much olivaceous discolouration of vascular tissues	Mature bush 'Katsura'	B	*Verticillium dahliae; Rhizoctonia* spp.
Wilt	Mature *Acer palmatum* tree in garden	-	Unknown, possibly *Verticillium* spp.
Wilt	Mature *Acer palmatum* tree in garden	-	*Verticillium dahliae*
Wilt	*Acer palmatum* var. *atropurpureum*, 2yr field plants	C	*Verticillium* spp.
Wilt	Mature *Acer palmatum* tree in garden	-	*Verticillium dahliae*

[a] See main text for details of symptom-types.

[b] Pathogenicity was not proven in the case of any of these isolates, although the presence of *Fusarium oxysporum* in the leading edge region of so much of the affected material does imply involvement in rot development.

CONCLUSIONS

- Stem disease problems cause overall losses of Japanese maples ranging between <1 and 40% (average = 14.6%) depending on varieties and year.

- In susceptible varieties, losses vary from 5 to 100% (average = 28.2%) depending on variety and year.

- Five common stem disease symptom-types are widely seen in UK production: (i) tip dieback, (ii) black or dark necrotic rot, (iii) 'paper bark' rot, (iv) wilt and (v) canker.

- Aggressive tip dieback, black or dark necrotic rot and 'paper bark' rot were the most commonly reported stem disease symptoms with 68%, 84% and 40% of survey respondents reporting problems with each symptom type respectively.

- Many varieties are susceptible to stem disease problems but particularly problematic are varieties of *Acer palmatum* var. *atropurpureum* and *Acer japonicum* 'Aureum'.

- Stem disease is a problem in both field-grown and containerised plants, but protection can cut down losses.

- Environmental conditions likely to cause wounding in *Acer* tissues, such as severe frosts and scorching winds, were considered important factors in increasing stem disease incidence. Also, plant surface wetness and high humidity were considered important and may provide favourable conditions for infection by opportunistic pathogens like *Fusarium, Botrytis* and *Pseudomonas* spp.

- Isolations from the small amount of material assessed in this survey suggest that opportunist pathogens such as Fusarium oxysporum may be responsible for stem rots and that the dark necrotic rot, 'papery bark' rot and aggressive tip dieback symptoms may all be the result of tissue wound exploitation by such pathogens.

RECOMMENDATION FOR FURTHER WORK

The dark necrotic rot, 'papery bark' rot and aggressive tip dieback are all important stem disease problems in UK Japanese maple production. They cause significant losses and can affect plants of a wide range of ages reducing quality and garden performance. The three symptom-types may represent different stages of the same disease, and thorough isolation work is required to determine this.

Before strategies for control can be developed, the biology of these three diseases needs to be understood. To achieve this, a programme of isolations from diseased plants from a number of UK nurseries needs to be undertaken, with isolations being made at different times of the year and the pathogenicity of isolated organisms confirmed by inoculation experiments. Pathogenicity tests might also be improved by manipulation of the growing environment to simulate factors such as frost damage.

Based on the results of these pathogenicity studies, a viable control strategy needs to be developed, possibly involving both cultural techniques and/or targeted use of fungicides.

Plate 1: Stem disease symptoms in Japanese maple

← Early symptoms of 'papery bark' rot

← Girdling stem lesion of 'papery bark' rot

Black necrotic rot

← high up on stem

At stem base →

Plate 2: Stem disease symptoms in Japanese maple

'Papery bark' rot in young plant

Aggressive tip dieback
(symptoms are very similar to 'papery bark' rot)

Vascular and woody tissue discoloration Due to infection by *Verticillium dahliae*

REFERENCES

Foss, C.R. & Byther, R.S. (1994). Diagnosing Maple problems. *Washington Park Arboretum Bulletin* **57**, 12-15.

King, E.O.; Ward, M.K. & Raney, D.E. (1954). Two simple media for the demonstration of pyocyanin and fluorescin. *Journal of Laboratory and Clinical Medicine* **44**, 301-307.

Parry, D.W. (1990). The incidence of *Fusarium* spp. in stem bases of selected crops in winter wheat in the Midlands U.K. *Plant Pathology* **39**, 619-622.

Pettitt, T.R. & Pegg, G.F. (1991). The quantitative estimation of *Phytophthora cactorum* in infected strawberry tissue. *Mycological Research* **95**, 233-238.

Vertrees, J.D. (1978). *Japanese Maples: Momiji and Kaede.* Timber Press, Forest Grove, Oregon, U.S.A. 178pp.