Research reports

Susceptibility of European and Asian pears to pear scab

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Summary

A controlled study showed that leaves of young trees of the European pear cultivars Williams Bon Chretien and Packham's Triumph were highly susceptible (HS) to pear scab infection. European cultivars Buerre Bosc, Clapps, Red Sensation, Howell, Josephine de Malines and Conference were susceptible (S) to infection while leaves of the European cultivars Pound, Doyenne du Comice, Corella and Eldorado were resistant (R), and the Chinese pear cultivar Ya Li was also resistant (R) to infection. Japanese pear cultivars Hosui and Twentieth Century, the Chinese cultivar Tsu Li, and the rootstock *Pyrus calleryana* were immune (I) to infection. Leaves of two interspecific hybrids of crosses between European and Asian pears were also immune to infection.

Keywords: black spot, *Venturia pirina*, *Pyrus communis*, *Pyrus pyrifolia*.

Introduction

Pear scab, caused by *Venturia pirina* Aderh., is the most important fungal disease of European pear (*Pyrus communis* L.) in Victoria, Australia. The most important European pear cultivars grown in Victoria, Williams Bon Chretien and Packham's Triumph, are very susceptible to pear scab infection in the field (Washington and Villalta 1995). Pear scab can cause significant yield losses due to reductions in fruit quality and quantity if pear trees are not protected with several fungicide sprays during spring (Washington *et al.* 1998). The identification of scab-resistance in existing pear cultivars and the development of new scab-resistant pear cultivars are two strategies that could be used to reduce fungicide use in pear production in Australia.

Differences in pear scab resistance to biotypes of *V. pirina* have been reported for European pear cultivars and *Pyrus* species in Israel and England (Shabi *et al.* 1973, Stanton 1953a,b,c). Differences in scab-resistance to strains of *V. nashicola*, a species distinct to *V. pirina*, have also been reported for European, Chinese (*Pyrus ussuriensis* Maxim) and Japanese (*Pyrus pyrifolia* Nakai) cultivars and species in Japan (Abe and Kurihara 1993, Abe *et al.* 2000, Ishii *et al.* 1992). European pear cultivars have been reported as highly resistant to *V. nashicola* in studies in Japan, and Asian cultivars and species as resistant to *V. pirina* (Abe *et al.* 2000, Ishii and Yanase 2000). Consequently, Asian germplasm is considered useful for producing European-type pear cultivars with resistance to *V. pirina.* The level of resistance in European and Asian cultivars to Australian populations of *V. pirina* is unknown.

This work was carried out to investigate the susceptibility of leaves of a range of European and Asian pears to infection by conidia of *V. pirina* under controlled conditions.

Materials and methods

Pear material

Scions of European and Asian pear cultivars and species were collected during the dormant period and grafted to potted *Pyrus calleryana* rootstocks in winter. After grafting, plants were kept in a screenhouse for one year before use in the experiments. In June 1996, young potted trees were placed in a cool-room at 7±5°C in the dark for 2–3 months. This was done to ensure that pear trees had sufficient hours at low temperature to produce abundant leaf growth the following spring. This was repeated in early June 1997. During spring, four potted trees from each cultivar/species were sequentially taken outdoors to allow the pear plants to develop sufficient shoot growth before inoculations. Plants were watered and fertilized with slow-release fertilizer 18-6-12 (NPK) and insects and mites controlled as required. Twelve European pear (*Pyrus communis*), two interspecific hybrids (*Pyrus communis* × *Pyrus pyrifolia*), two Chinese pear (*Pyrus ussuriensis*), two Japanese pear (*Pyrus pyrifolia*) and one pear rootstock (*Pyrus calleryana*) were used in the experiments (Table 1).

Inoculum

Pear leaves bearing fresh scab lesions were collected during October and November in 1996 and 1997 from unsprayed >45 year-old William Bon Chretien (*P. communis*) pear trees planted in an organic orchard in northern Victoria. In the 10 years prior to this study, the pear orchard was sprayed only with sulphur based products for pear scab control. Conidia were dislodged from the scabbed leaves by vigorously shaking the leaves inside a 500 mL glass bottle containing distilled water plus one drop of Tween 20. The conidial suspension was then filtered through two layers of cheesecloth. The concentration of conidia in the suspension was determined with a haemocytometer and adjusted by dilution to approximately 5×10^4 conidia mL^{-1} for each of the three tests. Germination of conidia was determined by spreading a few drops of the spore suspension on the surface of two 1% water agar plates and incubating for 24 h at 20°C in the dark before assessing germination of several groups of 100 conidia.

Inoculation

The pear trees were inoculated inside a plastic tent which in turn was constructed inside a controlled temperature room. The plastic was suspended on PVC tubes enclosing an area approximately 2 × 3 × 4 m high. Two potted pear plants (replicates) were used from each cultivar/species in each of the three tests undertaken. A different group of plants each with 3–5 actively growing shoots were used in each test. The youngest fully expanded leaves were marked with a paint pen before inoculation. Both the upper and lower surface of leaves were sprayed with the conidial suspension to the point of runoff using a spray gun (DeVilbiss, Inc., PA) and an air-compressor calibrated at approximately 50 kPa. Continuous leaf wetness was provided by a Defensor 505 (Defensor™ AG, Pfaffikon, Switzerland) atomizing humidifier operated every hour. Inoculated plants were kept under dark conditions at 20±3°C for 24 h. The plants were then transferred to a glasshouse and arranged on benches using a fully randomized design. The glasshouse was kept at 20±8°C, 75±25% RH, and a 12 h photoperiod. Additional lighting was supplied by incandescent bulbs (~200 $\mu Em^{-2} s^{-1}$).

Two tests were conducted in 1996 and one in 1997 during November and December.

Assessment

Leaf responses to pear scab infection were

Table 1. Leaf responses of European and Asian pears to inoculation with conidia of *Venturia pirina* collected from scabbed leaves of cv. Williams Bon Chretien in Victoria, Australia.

Cultivar	Pear type and species	Scab rating[A]	Mean scab rating	Leaf response[B]
Williams Bon Chretien	European pear, *P. communis*	4,4,4	4.0	HS
Packham's Triumph	European pear, *P. communis*	4,4,4	4.0	HS
Buerre Bosc	European pear, *P. communis*	4,3,4	3.7	S
Clapps	European pear, *P. communis*	4,3,4	3.7	S
Red Sensation	European pear, *P. communis*	4,4,3	3.7	S
Howell	European pear, *P. communis*	3,4,4	3.7	S
Josephine de Malines	European pear, *P. communis*	3,3,3	3.0	S
Conference	European pear, *P. communis*	3,3,3	3.0	S
Pound	European pear, *P. communis*	2,2,2	2.0	R
Doyenne du Comice	European pear, *P. communis*	2,2,2	2.0	R
Corella	European pear, *P. communis*	2,0,2	1.3	R
Ya Li	Chinese pear, *P. ussuriensis*	0,1,2	1.0	R
Eldorado	European pear, *P. communis*	0,0,2	0.7	R
Hood	Hybrid, *P. communis* × *P. pyrifolia*	0,0,0	0	I
FlordaHome	Hybrid, *P. communis* × *P. pyrifolia*	0,0,0	0	I
Tsu Li	Chinese pear, *P. ussuriensis*	0,0,0	0	I
Hosui	Japanese pear, *P. pyrifolia*	0,0,0	0	I
Twentieth Century	Japanese pear, *P. pyrifolia*	0,0,0	0	I
Pear rootstock	Rootstock, *P. calleryana*	0,0,0	0	I

[A] Each number is the mean disease rating for one test, in which 3 shoots were assessed in each of the two potted pear plants tested per cultivar or species. Scab rating: 0 = no macroscopic evidence of infection; 1 = a few fine pits, no sporulation; 2 = irregular or regular necrotic and/or chlorotic lesions on a few leaves but with no sporulation; 3 = sparsely sporulating scab lesions on a few leaves, with little sporulation around necrotic and/or chlorotic lesions; and 4 = extensive lesions with abundant sporulation on several leaves.
[B] The leaf response, HS = highly susceptible, S = susceptible, R = resistant and I = immune indicate the pear leaf response to scab infection based on the scab ratings observed in the three tests.

assessed twenty and thirty days after inoculation. Leaves were visually examined for symptoms of infection, especially leaves immediately below the marked youngest leaf. Three shoots were assessed in each of the two potted plants inoculated per cultivar/species in each of three tests conducted. Leaf responses to inoculation were classified into four types according to the degree of scab susceptibility and resistance as described by Langford and Keitt (1942), Shay and Williams (1956) and Abe and Kurihara (1993). The disease ratings were 0= no macroscopic evidence of infection; 1= a few fine pits (<1 mm) without sporulation; 2= irregular or regular necrotic and/or chlorotic lesions on a few leaves but with no sporulation; 3= sparsely sporulating scab lesions on a few leaves, with little sporulation around necrotic and/or chlorotic lesions; and 4= extensive lesions with abundant sporulation on several leaves. To investigate sporulation, particularly with ratings 1 and 2, pieces of transparent sticky tape were placed onto lesions, removed carefully and mounted onto glass slides in a drop of lactophenol blue. The sticky tape was examined under a compound microscope (20X) for the presence of viable conidia. Pear plants with ratings 0 were classified as immune (I), 1 and 2 as resistant (R), 3 as susceptible (S) and 4 as highly susceptible (HS).

Results

Pear leaf responses to artificial inoculation with conidia of *V. pirina* are shown in Table 1. Conidial germination was >80% in all tests conducted. Inoculated leaves of the European pear cultivars Williams Bon Chretien and Packham's Triumph had extensive scab lesions with abundant sporulation on several leaves in all tests. The mean scab rating for these cultivars was 4. In these two cultivars, extensive scab lesions were also observed on the stems of young shoots (data not shown). Several inoculated leaves of the European cultivars Buerre Bosc, Clapps, Red Sensation and Howell had extensive scab lesions with abundant sporulation in two tests, and less abundant scab lesions in another test (rating 3). The mean scab rating for these four cultivars was 3.7. Inoculated leaves of the European cultivars Josephine de Malines and Conference had only sparsely necrotic and chlorotic scab lesions on a few leaves, with limited sporulation restricted to areas surrounding the scab lesions. The mean scab rating for these two cultivars was 3. The six European cultivars with scab ratings ≥3.0 were considered as susceptible to pear scab (S).

Inoculated leaves of the European cultivars Pound, Doyenne du Comice, Corella and Eldorado had only a few chlorotic and/or necrotic lesions on a few leaves, and no sporulation. Similarly, leaves of the Chinese cultivar Ya Li had a few necrotic lesions in one-test and fine pin-holes in another, all without sporulation. The four European cultivars and the Chinese cultivar (mean ratings between 0.7 and 2) were considered resistant to scab (R). Leaves of the two interspecific hybrids (*P. communis* × *P. pyrifolia*) Hood and FlordaHome did not show any symptoms of infection and therefore were classified as immune (I) to infection by conidia of *V. pirina*. Similarly, leaves of the Japanese cultivars Twentieth Century and Hosui, the Chinese cultivar Tsu Li, and the pear rootstock *P. calleryana* were immune to infection.

Discussion

In this study, a variety of leaf reactions to infection were observed among cultivars and species of European and Asian pears. Under high inoculum and optimum infection conditions, leaves of the widely grown European cultivars Williams Bon Chretien and Packham's Triumph were highly susceptible to pear scab infection. Leaves of the less widely grown European cultivars Buerre Bosc, Clapps, Red Sensation and Howell were also very susceptible to infection in two out of three tests. In the third test, pear scab infection was lower and only necrotic and chlorotic lesions were observed in these cultivars. Similar more resistant leaf reactions to infection were observed in the European cultivars Josephine de Malines and Conference in all three tests. In the three tests, conidia from Williams Bon Chretien infected leaves were collected during the period when ascospores and conidia infected leaf tissue in October-December. As a consequence, it is possible that the pathogenicity of inoculum was different in each of the three inoculations. Hence, the development of fewer scab lesions, with associated hypersensitive reactions, and reduced sporulation in leaves of six of the European cultivars may have been the result of resistance mechanisms (host-genotype resistance) in these cultivars to the different strains of *V. pirina* (Stanton 1953a,b). Leaves of the European cultivars Pound, Doyenne du Comice, Corella and Eldorado were not infected by conidia of *V. pirina*, but were associated with localized hypersensitive reactions (chlorotic and necrotic lesions). In one test, leaves of the Chinese cultivar Ya Li also showed hypersensitive reactions to infection that were expressed as fine pin-point pits. Shay and Hough (1952) reported apple scab resistant-type reactions to *V. inaequalis* similar to those observed in this study. These resistant reactions were induced also in experimental infections with young apple plants and included pin-point pits, necrotic non-sporulating lesions and restricted sporulating lesions. The development of hypersensitive reactions (plant cell death), either with or without sporulation, suggests the existence of host-genotype resistance in European cultivars to the strains of *V. pirina* used in this study (Stanton 1953a,b, Shay and Hough 1952). More studies will be required in Victoria to determine if these scab-resistant responses with young pear plants occur when more mature leaf and fruit tissue is inoculated under variable field conditions. A long-term field study is currently underway in Victoria to assess the degree of resistance of European and Asian pears to infection by *V. pirina* populations at two locations.

Leaves of the Chinese pear Tsu Li, and the Japanese pears Hosui and Twentieth Century were immune to infection as Asian pears are a non-host of *V. pirina* (Ishii *et al.* 1992, Ishii and Yanase 2000, Tanaka and Yamamoto 1964). Similarly, leaves of the non-commercial interspecific hybrids Hood and FlordaHome with Asian parentage were also immune to infection and possess resistance to *V. pirina* (G. McGregor personal communication). Conversely, European pears can transfer resistance against *V. nashicola* to progenies of crosses between European and Asian pears (Abe *et al.* 2000). Inheritance studies conducted by Abe *et al.* (2000) showed that leaves of a few seedlings of progenies from crosses between European (e.g. La France and Bartlett) and Asian (e.g. Chojuro) pears, developed necrotic symptoms without sporulation. They suggested that the necrotic scab-resistant reactions could be the result of genes from the European cultivars causing the necrotic phenotype to react against inoculum of *V. nashicola*.

Further work is required in Australia to understand the mechanisms of scab-resistance in European and Asian pears to *V. pirina*. This work should include studies of virulence patterns in *V. pirina* populations from the different geographical areas. Testing of single isolates of *V. pirina* on a broader range of pear cultivars and species will be required to detect the presence of specific pathotypes (races) of *V. pirina*. Previous studies have shown that populations of *V. inaequalis* are composed of numerous biotypes (races) with different virulences against various apple cultivars and *Malus* species (Gessler and Blaise 1994, Shay and Williams 1956). Pathogen specialization has also been reported for *V. pirina* in Israel (Shabi *et al.* 1973, Stanton 1953a) and for *V. nashicola* on Japanese pears (*Pyrus pyrifolia*) in Japan (Ishii *et al.* 1997). A better understanding of scab-resistance mechanisms will contribute towards the development of new pear cultivars with durable resistance. By identifying potential natural scab resistance in existing European cultivars, reduced fungicide use can be developed in Australia.

Acknowledgment

We acknowledge the financial support of the Horticultural Research and Development Corporation and Apple and Pear Australia Ltd., formerly AAPGA. We also thank David Bardon for technical assistance, Leigh Issell for providing the pear wood and John Washbourne and Paul Pierce for preparing and maintaining the grafted trees.

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