Infection of Anjou Pear Fruit by *Podosphaera leucotricha*

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ABSTRACT

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A study was conducted to determine seasonal changes in susceptibility of Anjou pear fruit to infection by *Podosphaera leucotricha*, concentrations of airborne conidia during periods of fruit susceptibility, and sources of primary inoculum. Fruit infection first occurred when individual, unopened flowers were separating in the inflorescence and lasted about 6 wk, until petal fall. Mildew appeared 2–3 wk after inoculation. After mid-June, no fungal structures could be seen on infected fruit, and mildew russet was not clearly distinguishable from russet caused by pesticides or frost. Airborne conidia of *P. leucotricha* were first detected 4 days before or after full bloom, and concentrations were lower than $10/m^3$ during the period of fruit susceptibility. Shoots emerging from infected apple buds apparently constituted the source of inoculum.

Infection of Anjou pear (*Pyrus communis* L.) fruit by the apple powdery mildew fungus, *Podosphaera leucotricha* (Ell. & Ev.) Salm., has produced serious losses in the Mid-Columbia region of Oregon and Washington. Mildew infection often causes surface russet, which reduces the market value of the fruit.

In 1921, Fisher (3) reported an outbreak of powdery mildew on pears in central Washington. Anjou fruit was considerably more susceptible than Bartlett. Abnormal fruit drop appeared to be related to mildew infection. In 1927, Woodward (9) showed that infection and sporulation occurred when pear leaves were inoculated with powdery mildew conidia from apple. Although extensive studies have been conducted concerning *P. leucotricha* on apple (*Malus sylvestris* Mill.), the factors affecting infection of pear have not been studied.

This study was conducted to determine 1) seasonal changes in susceptibility of Anjou pear fruit to infection by *P. leucotricha*, 2) concentrations of airborne conidia during periods of fruit susceptibility, and 3) sources of primary inoculum.

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MATERIALS AND METHODS

Orchard inoculations. Scaffold limbs on mature Anjou pear trees at the Mid-Columbia Experiment Station, Hood River, OR, were selected, and one limb was enclosed weekly in a portable cage (5) modified by replacing mylar on the side panels with cheesecloth (Fig. 1). Two or three potted apple seedlings infected with *P. leucotricha* were suspended in the enclosure and replaced five times each week with recently infected seedlings that had been maintained in a greenhouse to induce abundant sporulation. Inoculations began on 18 March 1981 (tight-cluster bud stage) and 23 March 1982 (blossom buds first exposed) and continued for 11 wk. Conidial concentrations in the enclosure were monitored with a Rotorod spore sampler in 1981 and a Burkard volumetric spore trap in 1982. Temperature was measured with a hygrothermograph (Belfort Instrument Co., Baltimore, MD) mounted inside the limb enclosure. All fruit on each inoculated limb were examined visually for mildew beginning 3 and 1 wk after petal fall in 1981 and 1982, respectively. Infected fruit were marked by loosely wrapping twist-ties around the stems. Healthy and infected fruit on each limb were counted every 10–14 days until no new infections appeared and fruit drop ceased.

Monitoring airborne conidia. Concentrations of conidia of *P. leucotricha* were monitored with a Burkard volumetric spore trap in an apple orchard (cultivars Golden Delicious and Rome Beauty) 350 m from the inoculated Anjou trees in 1979, 1980, and 1981. Sampling began in late February or early March, before opening of apple or pear buds, and continued throughout the season. The sampler orifice was located 1 m above the ground, air was sampled at 10.5 L/min, and conidia were trapped on a silicone grease-coated Melinex tape. The tape was examined at ×250 to count conidia.

Sources of primary inoculum. Shoots with morphologically abnormal terminal buds appearing similar to mildew-infected apple buds (1,8) were removed on 17 February 1982 and 18 January 1983 from Anjou limbs inoculated with *P. leucotricha* in 1981 and 1982 and on 25 February 1982 from Anjou trees in a commercial orchard where severe mildew occurred in 1981. Shoot bases were placed in water and held at 20 C to force growth of terminal buds. Emerging leaves were examined microscopically at ×30 for sporulation of *P. leucotricha*.

A commercial pear orchard with a history of mildew-infected fruit, located about 5 km southeast of the experiment station, was monitored for disease in

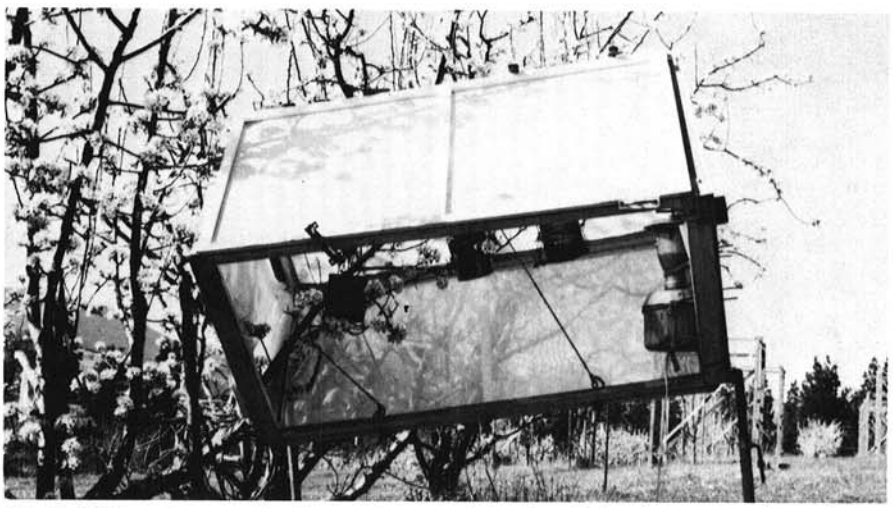

Fig. 1. Limb enclosure with side panel removed showing Burkard spore sampler and pots containing infected apple seedlings. Anjou pear limb enters enclosure through end panel.

1982. Tree rows were 7 m apart, and the first row was about 10 m east of an apple orchard (cultivars Red Delicious and Newtown). The percentage of fruit infected by mildew was determined on 15 June 1982 by visually evaluating 25–50 fruits per tree. Fruit on Bartlett trees in the four rows closest to the apple orchard were also evaluated for mildew.

RESULTS

Orchard inoculations. Mildew was observed on inoculated Anjou pear fruit beginning in early May of 1981 and 1982. Sporulation of *P. leuocotricha* was evident and initial necrosis of epidermal cells was visible (Fig. 2A). By mid-June, infected fruit showed extensive russeting but mycelium and conidia of *P. leucotricha* were sparse (Fig. 2B). In late July, mildew-infected areas on the fruit surface appeared rough and platelike without fungal structures (Fig. 2C). At harvest in early September, russet areas were smoother than in July and margins were diffuse (Fig. 2D). Because mildew russet could not be distinguished easily from russet caused by frost or pesticides after mid-June, mildew infection data were taken when mycelium and conidia of *P. leucotricha* were visible on the fruit.

In 1981, maximum fruit infection resulted from inoculation 2 wk before bloom, when individual, unopened blossoms were separating in the inflorescence (Table 1). In 1982, maximum infection resulted from inoculation at late bloom. In both years, almost all fruit infection occurred during the period from 3 wk before to 2 wk after bloom.

Average concentrations of conidia of *P. leucotricha* inside the limb enclosures during the inoculation period resulting in fruit infection were 80 and 173/m^3 in 1981 and 1982, respectively. Spore concentrations fluctuated greatly both hourly and daily.

The average daily temperature during the 3 wk of maximum susceptibility in 1981 was lower than during the remaining 7 wk (Table 1). In 1982, the average daily temperature during the 2 wk of maximum susceptibility was intermediate between earlier and later weeks. The minimum and maximum temperatures during the inoculation period resulting in fruit infection were −1.1 and 24 C in 1981 and 0 and 16.5 C in 1982.

During 1981 and 1982, 224 mildew-infected and 660 healthy fruits were observed through the growing season on inoculated Anjou limbs. Average drop was 52 and 76% for infected and healthy fruit, respectively, and the difference was significant ($P = 0.05$).

Monitoring airborne conidia. Conidia of *P. leucotricha* were first detected on 25, 19, and 15 April in 1979, 1980, and 1981, respectively (Fig 3). These first spore catches were within 4 days before or after full bloom in all 3 yr. Conidial concentrations remained lower than 10/m^3 in April of 1979–1981 and only exceeded 10/m^3 on 2 days in May of 1980 and 1981.

Sources of primary inoculum. Twelve dormant, abnormal Anjou terminal buds from enclosed limbs and 20 similar buds from a commercial orchard were forced to break dormancy in the laboratory. No sporulation of *P. leucotricha* was observed on leaves emerging from these

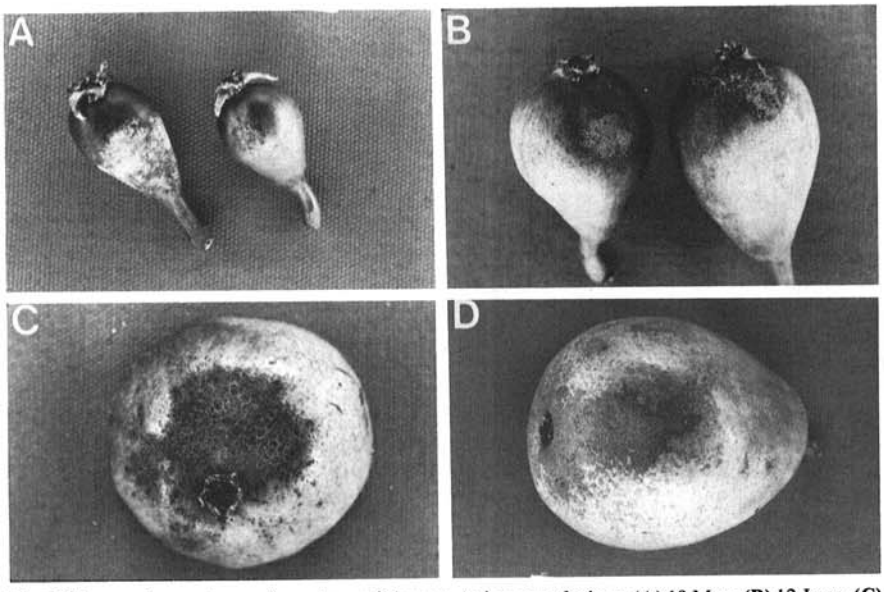

Fig. 2. Signs and symptoms of powdery mildew on Anjou pear fruit on **(A)** 19 May, **(B)** 12 June, **(C)** 28 July, and **(D)** 3 September 1981.

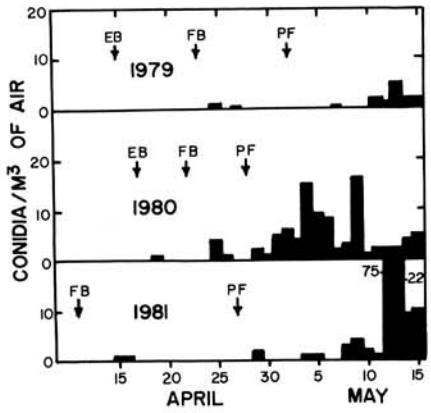

Fig. 3. Concentrations of airborne conidia of *Podosphaera leucotricha* during April and May of 1979–1981. EB = early bloom, FB = full bloom, and PF = petal fall stage of Anjou pear.

Table 1. Weekly infection of Anjou pear fruit by *Podosphaera leucotricha* and average daily temperatures in 1981 and 1982

Time of inoculation relative to bloom (wk)	1981		1982	
	Fruit infected (%)	Avg. daily temp. (C)	Fruit infected (%)	Avg. daily temp. (C)
4 (Before bloom)	...	...	4	7.5
3	17	10.1	14	5.6
2	67	8.4	8	7.2
1	39	6.8	10	5.6
0 (Bloom)	30	6.1	26	10.6
1	10	11.3	33	10.6
2 (Petal fall)	18	12.6	14	10.0
3	8	13.0	3	12.8
4	3	12.3	6	15.0
5	5	13.2	4	13.9
6	3	15.7	1	12.2
Control	5[a]	...	3	...

[a] Fruit on uninoculated trees.

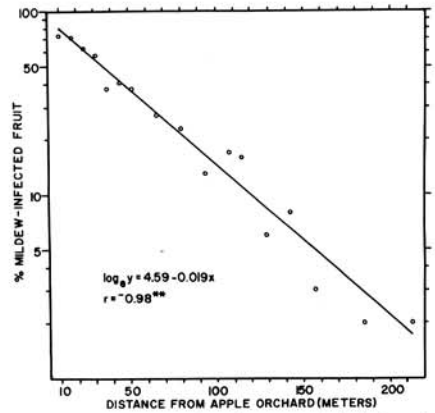

Fig. 4. Percentage of Anjou pear fruit infected by mildew on trees located 10–213 m from an apple orchard.

buds.

In the commercial pear orchard downwind from an adjacent apple orchard, mildew infection of Anjou fruit decreased as distance from the apple orchard increased (Fig. 4). Although in the pear row adjacent to the apple orchard, 73% of the Anjou fruit were infected, only 2% were infected in the row 213 m from the apple trees. The correlation ($r = -0.98$) between fruit infection and distance from the apple orchard was highly significant ($P = 0.01$). Although no infected fruit was found on 11 Bartlett pear trees in the four rows closest to the apple orchard, Anjou fruit infection in these four rows averaged 66%.

DISCUSSION

Infection of Anjou fruit resulted from inoculations made when individual flowers were separating in the inflorescence before bloom. The period of susceptibility lasted about 6 wk. After petal fall in early May, fruit became resistant to mildew infection. Bartlett fruit was resistant throughout the entire growing season. Recently, powdery mildew infections of apple fruit were reported to occur during the pink stage when blossom clusters were separating, and mildewcide applications begun in the bloom or petal fall stages failed to provide protection against mildew fruit russet (2).

Mildew signs and symptoms on Anjou fruit appeared 2–3 wk after inoculation. The average temperature during infection and incubation periods in 1981 and 1982 was less than 11 C. Molnar (6) reported that temperatures lower than 15 C were inhibitory to *P. leucotricha* on apple foliage. After mid-June, no fungal structures could be seen on infected fruit, and mildew russet could not be distinguished clearly from russet caused by pesticides or frost.

Fisher (3) reported but presented no data showing that mildew caused abnormal drop of Anjou fruit. According to data presented in this report, drop of healthy fruit was 24% greater ($P = 0.05$) than for mildew-infected fruit. The reasons for this discrepancy with the previous report are not known.

Airborne conidia of *P. leucotricha* were first detected within 4 days before or after Anjou full bloom in 1979–1981 and probably originated from infected, expanding apple shoots. Mildew-infected apple buds were at the 1-cm-green stage about 2 wk before Anjou bloom, and sporulation on emerging apple shoots was observed often. Concentrations of airborne conidia were under $10/m^3$ during the period of fruit susceptibility. Although conidial concentrations in late May and June often exceeded $70/m^3$, pear fruit were resistant at that time.

No mildew was observed on leaves emerging from abnormal pear buds. Similarly, no mildew-infected, emerging pear shoots have been observed in the orchard. The gradient showing diminishing pear fruit infection with increasing distance from an apple orchard provided additional evidence that shoots emerging from infected apple buds constitute the main source of primary inoculum for pear fruit infections. Similar fruit infection gradients have been reported for apricot (10) and peach (4) powdery mildew from rose and peach rusty spot from apple (7).

Several unique features of the Hood River fruit district provide insight concerning the Anjou fruit mildew problem. More than 2,000 ha of Anjou pear are grown in close proximity to more than 650 ha of Newtown apple, a mildew-susceptible cultivar. Often, Anjou and Newtown trees are interplanted. In addition, temperatures lower than −24 C, unfavorable for survival of mildew-infected apple buds (8), have occurred at Hood River in only 8 yr since 1910.

ACKNOWLEDGMENTS

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