The Spread of a Powdery Mildew of Peach

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ABSTRACT

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In New South Wales, Australia, powdery mildew is found on peach fruits when roses are growing nearby. An *Oidium* sp. fungus spreads from roses in the spring, causing fruit blemishes. Only primary spread occurs. The percentages of peach fruits infected by the mildew fungus on trees at various distances from mildew-infected rose thickets were recorded in orchards at Leeton, New South Wales, and the relationship of disease frequency to distance from the source was examined by regression analysis for both the Gregory ($Y = aD^{-b}$) and Kiyosawa and Shiyomi ($Y = ae^{-bD}$) models of disease spread. The pattern of spread in all instances was better explained by the Gregory model. The relationship between disease incidence (Y) and distance (D) from the inoculum source was given as $Y = 11{,}885D^{-1.923}$ with a coefficient of determination (R^2) of 97.9% for one orchard in 1974, $Y = 763{,}836D^{-3.401}$ ($R^2 = 83.9\%$) for the same orchard in 1976, and $Y = 106{,}170D^{-3.00}$ ($R^2 = 95.9\%$) for a second orchard in 1976. Isolation distance of the inoculum source to the orchard required to hold disease to $\leqslant 5\%$ would be less than 60 m for all three epidemics.

Additional key words: disease gradients.

Powdery mildew (caused by an *Oidium* sp.) has been found commonly on peaches (*Prunus persica* [L.] [Batsch.]), and less frequently on nectarines (*P. persica* [L.] Batsch. var. *nectarina* [Ait.] Maxim.), apricots (*P. armeniaca* L.), and plums (*P. domestica* L.) in New South Wales (N.S.W.), Australia. There are no records of powdery mildew on Japanese plums (*P. salicina* Lindl.), sweet cherries (*P. avium* L.), or sour cherries (*P. cerasus* L.). In almost every instance of mildew on peaches, the inoculum appears to originate from mildewed rose bushes (*Rosa* spp.) adjacent to the peach planting. The causal organism is primarily a pathogen of *Rosa* spp., only attacking peaches during a very short period of time in the spring. The disease on roses is polycyclic, but it is essentially monocyclic on peaches, inoculum for the single infection cycle spreading from nearby roses. If the rose bushes serving as inoculum sources are removed, the disease does not occur on the stone fruits in subsequent years.

The exact identity of the causal fungus is not known because the perfect stage has never been found either on rose or peach in N.S.W. However, it does not appear to be either *Sphaerotheca pannosa* (Wallr.) Lev. var. *persicae* Woronich. or *Podosphaera oxyacanthae* (DC.) d By. which have been reported on peach in the USA (1). It differs from both of those pathogens in several of the following attributes: it attacks peach fruits but not peach leaves, is monocyclic on peach, does not overwinter on that host, is pathogenic to roses, and has not been recorded on cherries (1,3,6,9). Although there are some similarities, the disease is not rusty spot of peach, which is thought to be caused by *Podosphaera leucotricha* (Ell. and Everh.) Salm. (5,7,8). Lesions have a rusty appearance, but there is less necrosis than with rusty spot, colonies of the *Oidium* sp. readily can be found within the lesions, and there is no association with mildewed apple orchards. Rusty spot as described from the USA has not been detected in N.S.W., although *P. leucotricha* is present in apple orchards. Attributes of the N.S.W. *Oidium* sp. are most similar to those of two forms reported from apricots in California. Perfect stages were not found, but Yarwood (10) thought, on the basis of conidial characters, that they may have been races of *S. pannosa*.

The purpose of this paper is to report an analysis of the relationship of distance from the source of inoculum and powdery mildew incidence on peach fruit which was made to determine distances necessary for isolation of orchards from rose bushes.

MATERIALS AND METHODS

Spread of powdery mildew from an inoculum source, a thicket of bramble rose (*Rosa* × *Rehderana* Blackburn), into an adjoining planting of peaches (cultivar Golden Queen) was studied in an orchard on Farm 316, at Leeton in the Murrumbidgee Irrigation Areas of New South Wales, Australia, in 1974 and 1976. The area has a semi-arid climate similar to that of the San Joaquin Valley of California.

The bramble rose thicket had a mean height of about 1.5 m, was 25 m long, and 4 m wide and its central point was 11 m from the

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nearest peach tree. In both years the rose thicket had powdery mildew lesions on about 20% of its leaves at the time the disease spread to the nearby peaches. The peach trees in the orchard were approximately 3.5 m high, had a spread of about 4 m, and were planted 6.1 m apart. In 1974 and 1976 each tree had from 150 to 400 fruits. In 1976, the spread of powdery mildew into a second orchard of cultivar Golden Queen peach trees on the same farm was examined. The tree characters were similar to those in the first orchard, but the source rose thicket differed in some respects. It was 1 m high, 11 m long, and 4 m wide. The amount of disease in this thicket was similar to that in the first, but its central point was located 18 m from the nearest peach tree.

One hundred randomly chosen fruits around the periphery of each tree in a zone from 0.5 to 2.5 m in height were scored for the presence or absence of powdery mildew lesions.

To calculate distances between inoculum source and targets, the rose thicket was considered a point source with all measurements being taken from its central point. The disease frequency of each tree was considered to be located at the center of its planting site. This is a simplification of the real situation, because inoculum may originate at any point within the rose bush area and the target fruits were located randomly within the sampled portion of the tree canopy. Mean disease frequency in 10-m-deep zones emanating from the inoculum source (ie, 10–20 m, 20–30 m, etc.) were calculated by averaging the disease frequency of all trees within the respective zones. The mean disease frequencies were considered to occur at the middle of each zone. The relationship of mean disease frequency to mean distance from the source was then examined by regression analysis for both the Gregory (2) ($Y = aD^{-b}$), and Kiyosawa and Shiyomi (4) ($Y = ae^{-bD}$) models of disease spread, where disease percent (Y) at distance (D) in meters from a point source diminishes with a scaling factor (a) and the negative exponent (−b). The mathematical constant "e" is defined as 2.71828.

TABLE 1. Regression analyses of the spread of monocyclic powdery mildew into peach orchards from primary inoculum sources (See Fig. 2 for data)

Year	Orchard	Model	a[a]	−b	R^2 adj. (%)
1974	1	Gregory[b]	4.075	−1.923	97.9
		Kiyosawa and Shiyomi[c]	3.665	−0.029	94.5
1976	1	Gregory	5.883	−3.401	83.9
		Kiyosawa and Shiyomi	4.904	−0.084	81.9
1976	2	Gregory	5.026	−3.000	95.9
		Kiyosawa and Shiyomi	4.058	−0.079	94.4

[a] The regression coefficient a is, for the Gregory model (2) the $\log_{10}$ of the scaling factor. For the Kiyosawa and Shiyomi model (4) it is the natural log of a.

[b] $Y = aD^{-b}$ where Y is the expected value of disease at distance D from a point source. The rate of spread is given as −b, and a is considered a scaling factor. The transformed equation is $\log_{10} Y = \log_{10} a - b \log_{10} D$.

[c] $Y = ae^{-bD}$ in which the notation is identical to the Gregory model and e is the base of the natural log system. The transformed equation is $\ln Y = \ln a - bD$.

RESULTS

The pattern of spread in all three experiments was better explained by the Gregory model (2) (Table 1). This statement is based on the values of the coefficient of determination (R^2) adjusted for degrees of freedom. The data for Orchard 1 in 1974 was typical. Fig. 1 shows the percentage of infected fruits on individual trees, while Fig. 2 presents the same data aggregated by zones of distance. These data are presented in Fig. 3 as the transformed relationship of $\log_{10}$ percent infected fruits by $\log_{10}$ distance (in meters) from the inoculum source, which is, in effect, the Gregory model. The relationship between disease incidence and distance

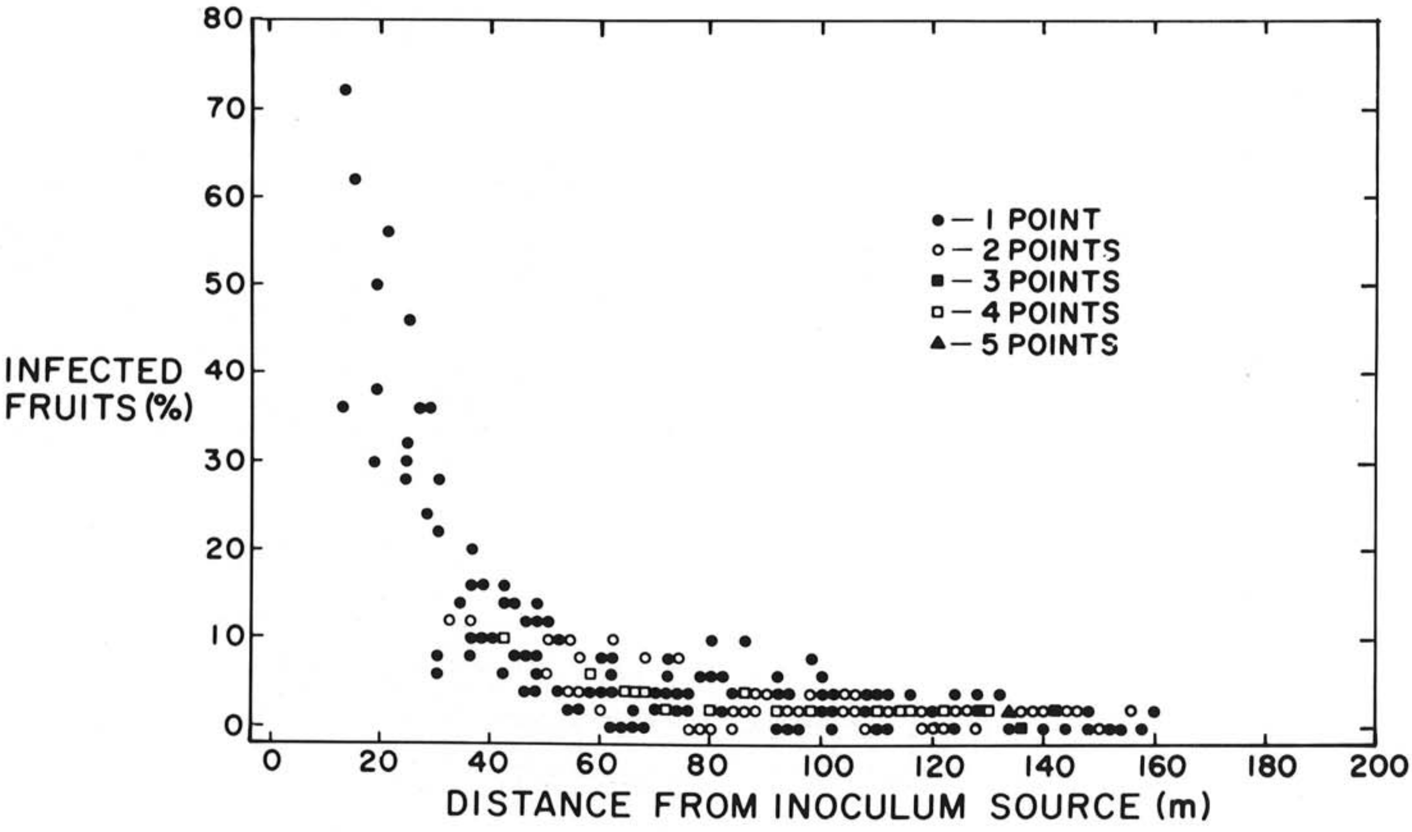

Fig. 1. Powdery mildew infection gradient in peaches. Percentage of fruits infected in 1974 on individual trees in Orchard 1 at distances from inoculum source. Multiple data points are indicated with symbols as described in the figure.

from the inoculum source in this instance is given as $Y = 11{,}885D^{-1.923}$. Similarly, the relationship for Orchard 1 in 1976 was $Y = 763{,}836D^{-3.401}$, and for Orchard 2 in 1976 was $Y = 106{,}170D^{-3.00}$. An examination of the plot of percentage of observed infections minus the percentage predicted by the model versus distance from the inoculum source for Orchard 1 in 1974 (Fig. 4) indicates that the Gregory model overpredicts near the inoculum source. However, the model and the data agree reasonably well as distance increases. This also happened with the two 1976 data sets. On the other hand, the Kiyosawa and Shiyomi (4) model under-predicted near the inoculum source in all three data sets.

Isolation distances required for predicted powdery mildew severities of 5% and 1% of infected fruits were calculated from the Gregory model (Table 2).

DISCUSSION

Eradication of inoculum sources for the control of plant disease is a common procedure. Eradication is more effective for monocyclic diseases in which disease severity is more directly related to the level of the source than for polycyclic diseases for which even low levels of initial infection may result in substantial disease development.

Powdery mildew of peach, which is initiated by inoculum spread from infected rose bushes, is an appropriate disease for control by eradication of rose bushes. The identification of a statistically valid disease spread model allows us to inspect the relationship of distance from the inoculum source and predicted disease severity. We can now estimate the distance from an orchard at which rose bushes cease to be a threat. Growers need this kind of information to identify the potential inoculum sources that should be removed. In stone fruit culture, losses from several causes of up to 5% of the crop or 5% lower quality fruit are commonly accepted. In view of the many potential causes of loss, most orchardists would not be prepared to carry out a control program designed to reduce losses much below 5%, but orchardists are likely to use available control procedures if losses from a disease are expected to exceed 5%.

For these reasons, isolation distances required to reduce disease incidence to 5% of fruits were calculated for the three data sets. Isolation distances required ranged from 27 to 71 m depending upon the orchard, the year, and the model of disease spread used. The Gregory model, which best described these data, gave isolation distances from 27 to 57 m. A number of variables will obviously affect disease spread, and hence isolation distance needed to achieve a particular reduction in disease incidence. These include size of the inoculum source plants, severity of infection on the source plants, and meteorological factors such as wind speed, direction, etc. Weather factors are almost certainly responsible for the differences in spread in Orchard 1 in 1974 and 1976. The size of the inoculum source, and the severity of infection on it were the same in both years, yet in 1976 the isolation distance needed to reduce disease incidence to 5% was only about 60 percent of the distance needed in 1974. In view of these factors and our results, it is likely that isolation distances of no more than 200 m will generally provide satisfactory reductions in powdery mildew incidence.

In a recent study of rusty spot of peach, Ries and Royse (8) demonstrated infection gradients in a peach orchard with the disease declining with distance from an adjoining apple orchard that was moderately affected by *P. leucotricha*. The gradients were very similar to those found with the *Oidium* sp. in the present study, although isolation distances required to reduce disease incidence to

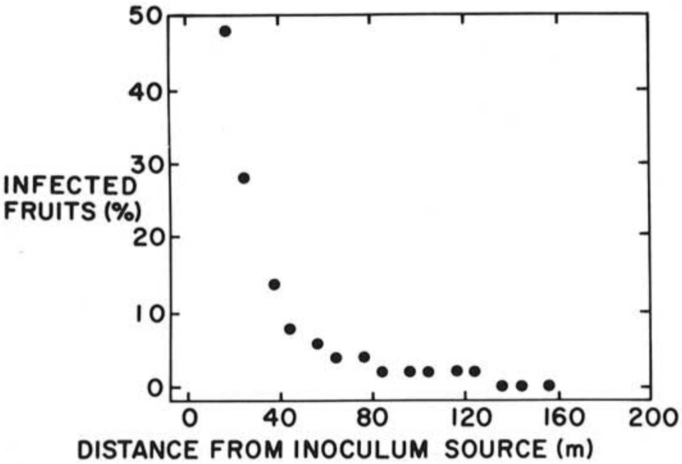

Fig. 2. Powdery mildew infection gradient in peaches. Percentage of fruits infected on trees at distances of 10.0–19.99 m, 20.0–29.99 m, etc., from inoculum source. Aggregated data of Fig. 1. Graph points at mean distances (15 m, 25 m, etc.). Orchard 1, 1974.

TABLE 2. Distances calculated by Gregory's model, for isolation of peaches from (potentially) infected roses required to limit powdery mildew to 5% and 1% disease severity

		Isolation (m) needed to limit disease to		Probable maximum disease[a] ($P = 0.05$)	
Year	Orchard	5%	1%	5%	1%
1974	1	57	132	6.1	2.2
1976	1	33	54	7.5	3.5
1976	2	28	47	6.6	2.5

[a]Upper limits of $P = 0.05$ confidence intervals for disease severities when expected levels are 5% and 1%, respectively.

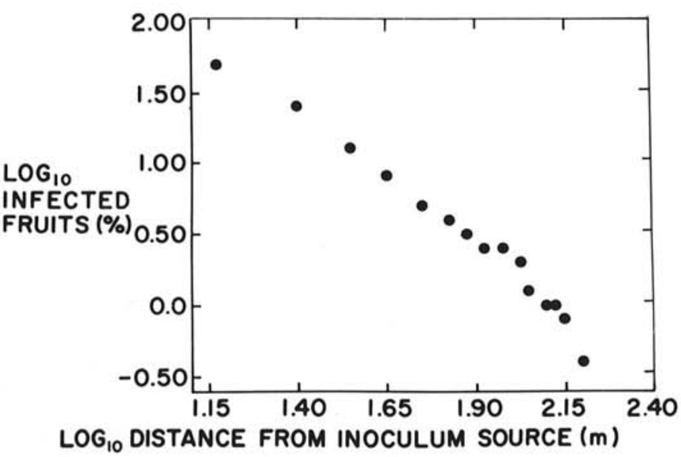

Fig. 3. Data of Fig. 2 (Orchard 1, aggregated 1974 data) plotted as the transformed relationship of the $\log_{10}$ percent infected fruits by $\log_{10}$ distance from the inoculum source according to the Gregory model (2).

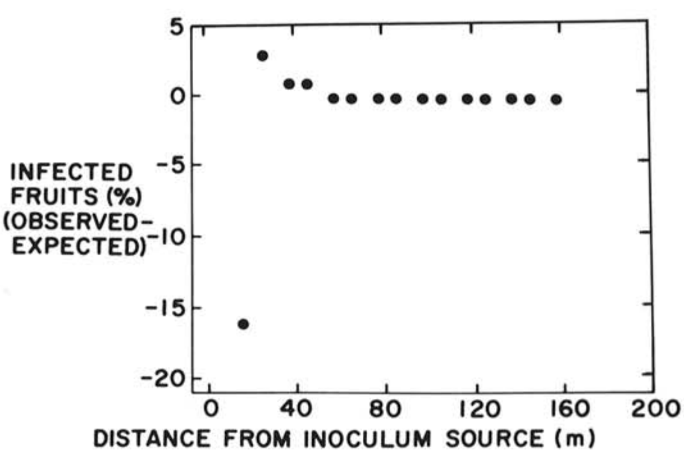

Fig. 4. Plotted deviation of the observed percentage of infected fruits given in Fig. 2 (Orchard 1, aggregated 1974 data) from the expected values according to the Gregory model (2).

5% or below were less (12–22 m). The rate of decrease in disease with distance from the source also was less in the rusty spot study.

The similarity of the disease gradients adds to the evidence that rusty spot is caused by a powdery mildew fungus, viz *P. leucotricha*. There are other similarities: Ries and Royse (8) found that rusty spot infection only occurred early in the growing season and that lesions expanded only by fruit growth. They also cite evidence that removal of apple orchards infected with *P. leucotricha* eliminated the disease, the same effect observed when roses infected with *Oidium* sp. are removed from the vicinity of peaches in N.S.W.

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