TWIG LESIONS AS A SOURCE OF EARLY SPRING INFECTION BY THE PEAR SCAB ORGANISM

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INTRODUCTION

Pear scab (Venturia pyrina Aderh.) has been known to be present in the Hood River Valley of Oregon for the last 20 years but has become of commercial concern only since 1932. During that year two pear (Pyrus communis L.) orchards produced as much as 80 percent of scabby fruit, and in 1934 plantings at a distance of nearly 2 miles from the original infection centers showed some scab. The disease has increased also in parts of southern and western Oregon and western Washington.

In the course of experiments for scab control in the Hood River Valley, conducted by the writers, several new facts concerning the life cycle of the pear scab organism in relation to control measures were established. The early dispersal of conidia from overwintering scab lesions on twigs, the effect of spray materials in relation to this phase of the disease, and the comparative importance of conidia and ascospores in initiating primary infections are especially worthy of consideration in this connection.

TWIG INFECTION

HISTORICAL REVIEW

Frequent reference has been made to shoot infection on trees since Aderhold (1) first described pear scab as occurring on young branches. English writers generally agree that conidia produced from this type of carry-over are almost entirely responsible for primary spring infections, and that ascospore discharge from leaf material is of only minor importance (5, 14). The more outstanding contributions are reviewed by Marsh (14). In Australasia, workers generally have found that ascospores appear to be more important in initiating primary infections than conidia produced by the fungus overwintering on the young shoot growth. Data substantiating this view are found in publications by Cunningham (3), Curtis (4), Hearman (10), and Pittman (16) and in additional references cited in these papers. Dowson (6), however, emphasizes the importance of twig lesions as a source of infection at the time when sprayings are practically over.

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2 The writers wish to express their appreciation to J. R. Magness, John W. Roberts, and M. C. Goldsworthy, of the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, for suggestions in the preparation of the manuscript.
3 Reference is made by number (italic) to Literature Cited, p. 681.
Very few published data have appeared in the United States, especially in recent years, on the twig phase of pear scab, or on entirely effective control measures. Duggar (7) has given a general survey of earlier work in this country, and Heald (9) has supplemented it. Smith (17) found that under California conditions primary infections were due to spores liberated from scab pustules on wood growth of the past season. His observations and experimental work were substantiated by the results of commercial field tests for the control of the disease. Thomas (18), however, concluded that ascospores are the principal source of primary infections in California since a search in commercial orchards in 1929 revealed that the great majority of the current season's lesions had been circumscribed by a cork layer before the end of the growing season.

Differences of opinion appear to exist also among investigators of the Pacific Northwest. Fisher and Newcomer (5, 8, 7) state:

In the treatment of pear scab it is important to dispose of all possible sources of infection, and to this end twig cankers, if present, should be removed in pruning and the infected wood burned. Some disposition should also be made of fallen leaves which harbor the fungus over winter, and which are the most important source of early spring infection.

Although not ignoring the function of this ascospore material, Jackson (11) pointed out that the disease was more difficult to control in Oregon where twig infections were present, and that several seasons might be required to rid the orchard of this source of infection.

Other than a brief statement by Marsh (14) on twig scab control, the writers' preliminary report (13) appears to constitute the only record of the effect of sprays on this phase of the disease. Pathologists have tended to base control recommendations on results obtained with the closely related apple scab, but such recommendations have sometimes been found of doubtful application to pears, especially in relation to twig lesions as overwintering sources of infection.

**VARIETAL SUSCEPTIBILITY**

Approximately half the pear acreage of the Hood River Valley is planted to Anjou, a variety very susceptible to twig attack. Easter Beurre (planted mainly as a pollinator), Flemish Beauty, and Forelle are also very susceptible, but they constitute a minor portion of the plantings in this locality.

Fruit of the Bartlett, the second leading variety, is often slightly affected, especially when interplanted among other heavily infected trees, but twig infections are extremely rare. Bosc is intermediate between Anjou and Bartlett in respect to both fruit and twig attack.

The fact that various degrees of susceptibility have been assigned to these same varieties in other regions indicates that environmental responses or specialized strains of the organism may exert an influence on infection.

In a small planting bordering the Hood River Valley, Bartlett twigs have been found severely scabbed. The greater precipitation and humidity in this section appear to be the factors that allow the parasite to attack this variety so severely.

**CYCLE OF INFECTION**

New growth of susceptible twigs may be infected at any time during the growing season, but infection occurs more commonly in the Hood
River Valley during spring months when rainfall is frequent. During spring and summer months, new lesions appear merely as small blister-like cushions, often with a prominent lenticular spot at their centers, or on certain varieties as shallow spore-producing stromata. Occasionally the host forms a corky layer beneath the cushion or stroma and partially sloughs it off during the current season. This type is more easily seen, appearing as a small cankerlike injury. After the primary establishment of the fungus it usually remains more or less inactive until winter, when the trees become dormant. Active enlargement of the fungus fruiting structure then occurs, and by early spring conidial formation has started. Dissemination of these conidia takes place during rainy periods throughout the season or until the
pustules become sloughed off by renewed tree activity. (For a detailed account of the histological features of this cycle, see Marsh's article (14), which is substantiated by the writers' observations.) These twig infections (fig. 1) are generally sloughed off during the growing season or before the tree again becomes dormant, although occasionally a few remain partially attached and contain viable conidia the next season. In this case the fungus penetrates the host barrier and may form a new pustule unless a second abscission layer is successful in arresting its growth. Oftentimes 4- and 5-year-old wood still shows evidence of previous infections in the form of circular depressions. Only a short period of activity of these twig pustules is necessary to cause primary spring infections, a fact which Thomas (18) appears to have overlooked.

EXPERIMENTAL METHODS

Three orchards in the Hood River Valley were examined in 1934 and two of them again in 1935 to discover at what time primary infection occurred and which spore form was involved. The first orchard was severely infected in both years, and previous studies showed that humidity had reached 100 percent on all but four nights during the preceding summer. Scab had been present for several years, and conditions for its development were ideal, since 100 percent of the unsprayed fruit was affected. In the second orchard, which was believed to represent more closely the general run of orchards in which scab had obtained a foothold, less than 50 percent of the unsprayed fruit had been scabby the previous year. The Oregon State Experiment Station's orchard at Hood River, where scab had never been present, was used as a check plot.

Spore traps were made by tying together, back to back, two slides with outer surfaces coated with petrolatum. Three traps per tree were tied in a vertical free-hanging position at heights of 2, 8, and 16 feet above ground in a representative tree of each orchard. One square inch of each slide was examined under the microscope each week or after periods of heavy rain, for the purpose of recording spore catches.

Ascospore discharge records from overwintered leaves, brought to the laboratory and exposed to natural conditions, were also kept. Five leaves bearing perithecia were placed in a shallow box on a natural orchard soil covering. Ordinary glass slides were then placed directly over each leaf on narrow wood supports to keep them from being in contact with the leaf surface. This procedure is essentially the one described by one of the writers (2) in a report of apple scab studies. Discharged spores readily stuck to the glass surface. These slides were examined at the same periods as the spore traps hanging in the orchard. Because of the numbers involved, however, the average number of ascospores caught per square millimeter was used to bring these values in line with other charted data.

SEASONAL DEVELOPMENT AND SPORE LOAD IN RELATION TO SCAB

Records of the weather and of the volume of spores in relation to the prevalence of pear scab in the experiments of 1934 and 1935 are shown graphically in figures 2 and 3. Weather data in the charts are given
for the station at Hood River, since records are unavailable for the other orchards in which experiments were conducted.

**SPORE RECORDS FOR 1934**

It has been pointed out by previous workers that ascospore discharge occurs only during rainy periods and that conidia of the fungus are
Figure 3.—Weather and spore records in relation to pear scab, 1935: A, Maximum and minimum temperatures; B, scab infection on unsprayed trees; C, stages of development and infection of buds, blossoms, and fruit; D, record of spores; light lines coming to a point represent number of ascospores per square millimeter from captive leaves; black bars represent number of conidia per square inch (6¼ square centimeters) caught in orchard; E, record of rainfall.
readily dislodged by moisture but not by wind alone. Figure 2, \( D \) and \( E \), shows this relation for ascospores from captive leaves and for conidia caught on slides hanging in heavily infected trees during the 1934 season at Hood River. Although ascospores were caught in large numbers on slides placed directly above overwintered leaves, only three were captured during the entire season on the traps hanging in the trees. These three were recorded April 30, June 4, and June 25. Conidial catches in the trees, however, were comparatively large. A local shower fell in the orchard July 9, which explains why conidia were caught at that time. Although total rainfall was slightly higher in this orchard than at the Hood River station orchard, except for July 9, the periods of distribution were the same.

The first catch of conidia was made during the rainy period starting February 26. It is doubtful whether infection could have occurred at that time, since the buds were not open (fig. 2, \( C \)). Unusually high temperatures during the early spring months, however (fig. 2, \( A \)), favored rapid growth, so that by March 26, the start of the next rainy period, which yielded the first conidial catch of any consequence, the young leaves and flower buds were exposed.

An examination was made each day to determine the incubation period of the organism. The first scab symptom, a slight greenish fuzz, was found on young fruits April 14, 19 days after the beginning of the second rainy period, which, as previously stated, coincided with the first conidial catch of any consequence. Leaf infections were not found until a few days after the fruit-infection stage and were never numerous except on unsprayed trees. Figure 2, \( B \), illustrates the importance of twig lesions as primary infection sources on Anjou pears. It can be seen that even though the spore record shows a comparatively small catch of conidia, half of the fruits on unsprayed trees became infected from these sources.

These primary spots on fruits and other susceptible tissues produced new conidial spore material in such amounts that, with the following rainy period, practically all fruits became infected. Conidial spore catches on the traps in the orchard, of course, increased accordingly. Counts of infected fruits during several stages in their development showed that new spots appeared on susceptible varieties following each rainy period of sufficient duration to allow the fungus to become established. With certain varieties, such as Bosc, the fruits had developed such resistance by the time they were one-third grown that new infections were extremely rare. Scab spots already present gradually died out, and little evidence of scab was seen at harvest unless the fruit had become misshapen. Bartlett pears, which have never become excessively scabby in the Hood River Valley, exhibited a high degree of resistance throughout their cycle of development when associated with severely scabbed Anjous. It appears at this time that, even with an abundant source of spore material, Bosc pears require protection only during early spring, whereas control can be obtained on Anjous only by complete protection throughout the season.

Figure 4 records catches of conidia from the moderately infected orchard. Direct comparisons of unsprayed trees of the heavily and the moderately infected orchards cannot be made, since the owner of the latter did not wish to leave the fruits unprotected. By observing pears in the poorly sprayed treetops, however, it was roughly
estimated that approximately half as much scab developed in this orchard as on the unsprayed fruit of the heavily infected orchard.

No scab spores were caught on slides in the orchard which had not contained scab, and which was some distance from any infected orchard.

It was assumed that if the original spore load from infected wood could be reduced the percentage of scabby fruit showing primary lesions and the chances for reinfections to occur would be lessened accordingly. Figure 5 represents results from two trees that had received no spray in 1933 and that were used to test this assumption. One was left unsprayed; the other received three lime-sulphur sprays in 1934. It can readily be seen that infection was reduced, but reduction of fruit scab approximated only 50 percent because of poor spraying. Figure 4 contrasts the same unsprayed tree with one in a moderately infected orchard receiving three early sprays of a partially effective fungicide. Conidial catches were greatly reduced, but practically half the fruits became scabby because of infections resulting when spray coverages were largely dissipated.

Figure 6 compares conidial numbers caught on slide traps suspended on unsprayed trees at three elevations. The lower and middle heights yielded similar conidial ratios throughout the season, whereas the highest trap was noticeably most free from conidia at each period. Since conidia are washed downward by rains, they naturally are found in greater numbers at the lower tree levels; but it should be borne in mind that a few infected fruits or twigs in the top of the tree are more favorably situated to scatter conidia to healthy fruits than are those situated lower down. Since so few ascospores were caught in the trees, they were considered of minor importance in causing the heavier infection nearer the ground, where, because they are produced in leaves on the ground, they might be of importance if present in larger numbers.
The year 1935 threatened to be an exceptionally bad scab year, since new wood was heavily infected and the fungus had become established in practically all sections of the valley. Scab, however, did not develop to any considerable extent, for the following reasons:

(1) Before the trees became dormant the previous fall, 80 percent of the twig scab infections became sloughed off or inactivated. (Note the number of inactive scab pustules on twigs of the unsprayed plot in table 2.)

(2) In early spring there was only one rain sufficient to cause scab infection. Where spray recommendations were followed, there was nearly complete protection. (See fig. 3.)

(3) Few new infections appeared following the light rains in May, June, and July, principally because infective material was scarce. Inoculum for subsequent infections was much decreased by the dropping off of infected fruits at the time of the "June drop." Practically all fruits showing pedicel infections were lost at that time.

Prospects for a severe scab season were somewhat dissipated after the discovery that a large percentage of the twig lesions had become inactivated. For previous experiments to be substantiated it would have to follow that a correspondingly smaller number of conidia would be available for primary infections. That this was actually true can be determined from figure 3, D. It should be noted that actual conidial catches early in the 1935 season were slightly less than in the previous year, but the potential sources would have been far greater (see tables 1 and 2) if the wood lesions had overwintered in an active state. An increase in conidial material from secondary infections was small, owing to weather factors previously mentioned. As a result, fruit was much cleaner at harvest than during the previous season when secondary conidial material became increasingly larger up to midseason. Numerous primary infections and favorable moisture conditions later were responsible for the rapid increase of scab in 1934.

Three ascospores constituted the total catch for the 1934 season on nine traps hanging on trees in the orchard. Nine were captured during 1935 in comparable trials from March 1 to the last of May, five of which were recorded on April 21. The primary fruit infections appeared on May 15.

Neither conidia nor ascospores were captured in the check-plot orchard where scab had never been present.

The results of the writers' experience in orchard spraying on a commercial scale during past years correspond very closely with those reported above. When a thorough and properly timed spray was
applied before primary infections had become established and was followed later with a reasonable spray program, satisfactory control of scab was realized at harvest. If, however, the first spray was poorly applied or improperly timed, so that a few primary infections occurred in spite of careful and frequent subsequent sprayings there was considerable scabby fruit at harvest.

CONTROL OF TWIG SCAB

The data given above and observations made during past years indicate that primary spring infections resulted largely from conidia derived from active lesions on scabbed wood of the previous season's growth, and that these conidia were being dispersed even before susceptible tissues were exposed. Ascospore discharge was also recorded from the overwintered leaves, but whether this would occur every year remains to be determined. It is possible, however, that if early sprays are timed by ascospore discharge in orchards where active twig scab occurs, primary infections could already result from twig conidia before the regular spray schedule begins. It has been repeatedly pointed out for both pear and apple scab that the amount of early infection usually influences the number of scabby fruits present at harvest. Any practice that eliminates or checks dispersal of these twig conidia, then, is of paramount importance in control.

EFFECT OF SPRAYS

Data on the effect of fungicides in controlling twig scab are extremely meager. In the orchard used for scab-control experiments, twig infections were exceedingly common and evidence of their existence could be seen on wood several years old when spraying tests were started. Some variation in the total number of shoot pustules per tree occurred, but the orchard could be classified as severely infected and favorable for scab development.

A spray schedule consisting of lime-sulphur 1-12 applied in the delayed-dormant stage and of other materials applied in the pink and calyx stages was employed during the 1933 and 1934 seasons. One additional cover spray was applied in 1933 and two in 1934. Twig counts in the spring following such treatments yielded evidence that sprays measurably control the twig lesions (tables 1 and 2). It should

**Table 1.** Effect of sprays on pear twig scab the year following their application, 1933-34

<table>
<thead>
<tr>
<th>1933 spray treatment (Delayed-dormant lime-sulphur 1-12 plus 3 later applications)</th>
<th>Scab pustules, 1934</th>
<th>Total twigs infected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On 50 twigs</td>
<td>Average, per twig</td>
</tr>
<tr>
<td>None (west check)</td>
<td>364</td>
<td>7.3</td>
</tr>
<tr>
<td>None (east check)</td>
<td>230</td>
<td>4.6</td>
</tr>
<tr>
<td>Copper oxide-lime-bentonite (2-4-2-50)</td>
<td>30</td>
<td>.6</td>
</tr>
<tr>
<td>Copper phosphate-lime-bentonite (2-4-2-50)</td>
<td>16</td>
<td>.3</td>
</tr>
<tr>
<td>Wettable sulphur no. 1 (10-100) in pink and calyx stage plus bordeaux 3-6-50 in 2 later covers</td>
<td>74</td>
<td>1.5</td>
</tr>
<tr>
<td>Wettle sulphur no. 1 (10-100)</td>
<td>44</td>
<td>.9</td>
</tr>
<tr>
<td>Wettle sulphur no. 2 (10-100)</td>
<td>62</td>
<td>1.2</td>
</tr>
<tr>
<td>Folation sulphur (6-100)</td>
<td>25</td>
<td>.5</td>
</tr>
<tr>
<td>Lime-sulphur (14-50) and wettable sulphur no. 1 (10-100)</td>
<td>11</td>
<td>.22</td>
</tr>
<tr>
<td>Lime-sulphur (1-50) in pink, wettable sulphur no. 1 (10-100) later</td>
<td>20</td>
<td>.4</td>
</tr>
<tr>
<td>Lime-sulphur (1-50) in pink and calyx, then wettable sulphur no. 1 (10-100)</td>
<td>3</td>
<td>.06</td>
</tr>
<tr>
<td>Lime-sulphur (1-50) in pink, calyx, first cover, then wettable sulphur no. 1 (10-100)</td>
<td>8</td>
<td>.16</td>
</tr>
</tbody>
</table>
TABLE 2.—Effect of sprays on pear twig scab the year following their application, 1934–35

| 1934 spray treatment | Orchard no. | Scab pustules (1935) | | | |
|----------------------|-------------|---------------------|-----------------|-------|-------|-------|
|                      |             | On 50 twigs         | Average per twig | Maximum on 1 twig | Total twig infected |
|                      |             | Active 1 Inactive 2 | Active Inactive | Active Inactive | Number | Number | Number | Number | Percent |
| Check, no spray      | 1           | 41 429              | 0.82 8.58       | 7 30             | 88     |
| 2                    | 122 486     | 2.44 9.72           | 9 32 100        | 12 18           |
| Zinc sulphate-lime-sulphur (4-4-50) plus lime-sulphur (1-100) in covers | 1 16 21 | 3.2 4.2 | 3 12 18 | 12 60 |
| Copper silicate (3-100); thereafter 1½-100—- | 2 33 33 | .66 .66 | 4 4 60 | 60 |
| 2                    | 1 1 7       | .02 .14             | 1 2 12          | 12 |
| Bordeaux-lime-bentonite (1-2-50) | 2 6 6 | .12 .12 | 1 2 22 | 22 |
| Copper phosphate-lime-bentonite (2-4-2-50) | 1 1 0 | .02 .02 | 1 0 2 | 2 |
| Copper oxide-lime-bentonite (2-4-2-50) | 2 2 1 | .04 .04 | 1 2 6 | 6 |
| Lime-sulphur-bentonite (3-3-50) | 1 3 4 | .06 .08 | 1 1 14 | 14 |
| (1 pound lime)       | 2 1 8       | .02 .16             | 1 2 14          | 14 |
| Lime-sulphur (1-100) pink; wettable sulphur no. 1 (16-100) thereafter | 1 6 1 | .12 .12 | 1 1 14 | 14 |
| 2                    | 5 5         | .10 .10             | 1 1 18          | 18 |
| Lime-sulphur lime-bentonite (½-1-2-50) | 1 1 1 | .02 .02 | 1 1 4 | 4 |
| 2                    | 1 1         | .02 .02             | 1 1 4           | 4 |
| Wettable sulphur no. 1 (8-100) | 1 6 31 | .12 .62 | 1 10 26 | 26 |
| Bordeaux (1-50) plus oil (¼-100) in pink; (1-100) thereafter | 2 1 16 | .32 .88 | 2 4 62 | 62 |
|                      | 1 1 3       | .02 .06             | 1 2 4           | 4 |
|                      | 1 1 0       | .02 .02             | 1 0 2           | 2 |

1 Active scab pustules.
2 Sloughed or inactive pustules.

especially be noted that the wettable sulphur types of materials were much less effective in this control than the more caustic sulphurs or chemicals giving a longer coverage. The same general trend was apparent in fruit scab control. Where mild sprays were used during the early stages of growth it was very noticeable that control of scab on both fruit and twigs was comparatively poor, whereas their substitution at later periods showed less difference.

Figure 5 shows that conidial catches were greatly reduced on sprayed trees. To determine the exact cause of this decrease in conidial numbers early in the season, twigs with active scab pustules were brought into the laboratory and sprayed with certain fungicides. Table 3 gives the results of this test. Lime-sulphur completely inactivated such pustules by an actual "burning out" action. The entire spore-bearing surface was killed and the stroma soon became flat and crusty and did not revive when placed in a moist chamber. In contrast to this, although other fungicides tested caused a considerable decrease in active conidial material where the fungicide was in actual contact with the spore-bearing parts, penetration under the epidermal covering of the pustule was much inferior to that of lime-sulphur. Pustules sprayed with these chemicals, moreover, partially revived in moist chambers and produced some conidia. The same results were observed under field conditions.
TABLE 3.—Effect of sprays on conidia in pustules on excised twigs

<table>
<thead>
<tr>
<th>Spray treatment</th>
<th>Spore germination</th>
<th>Location of spores in pustule</th>
<th>Spray treatment</th>
<th>Spore germination</th>
<th>Location of spores in pustule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 29, 1935</td>
<td></td>
<td></td>
<td>1934</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check, no spray</td>
<td>76</td>
<td>Various points.</td>
<td>Wettable sulphur (10-100)</td>
<td>70</td>
<td>Edge.</td>
</tr>
<tr>
<td>Lime-sulphur (1-15)</td>
<td>0</td>
<td>Edge.</td>
<td></td>
<td>3.2</td>
<td>Center.</td>
</tr>
<tr>
<td>Bordeaux mixture (1-4-50)</td>
<td>45</td>
<td>Edge.</td>
<td></td>
<td></td>
<td>Center.</td>
</tr>
</tbody>
</table>

These results indicate that lime-sulphur applied after twig lesions are open and active should largely eliminate this source of infection. The majority of pustules at Hood River during past years opened before blossom buds became exposed. A small percentage, however, opened during or after this period. It was known from previous experience that lime-sulphur could not be used with safety on Anjou pears in this locality after the bud scales had dropped. For this reason it was believed that best results would be obtained in scab control by delaying the initial lime-sulphur application until the bud scales were just ready to drop. Where it is possible to use this caustic spray on other varieties at a later date, successful control should be possible in one season. Pustules that opened late or those that remained active during the summer contained viable spores at harvest and formed dangerous sources for fall fruit infections. Water sprouts remained susceptible to infection late in the season and required protection where scab was a problem.

A secondary influence of spray materials was apparent on sprayed trees. It appeared that during the spring the host was able to circumscribe scab lesions on twigs more quickly on sprayed trees than on those receiving no treatment. Whether this action was due to a partial killing of the parasite or to a favorable effect on the host was not determined.

RESIDUAL EFFECT OF SPRAYS

The severely infected orchard used for part of these experiments offered an extreme test of the cumulative value of proper and well-timed spray applications. When a part of this orchard was taken over by the writers for spray tests at the end of the 1933 season, 68.3 percent of the commercially but improperly sprayed fruit and 100 percent of the unsprayed pears were scabby. In the 1934 tests the applications of four sprays of various materials, following the delayed-dormant lime-sulphur spray, reduced scab to as low as 12 percent when the stronger fungicides were used. This plot was given back to the grower for the 1935 season because of certain conditions complicating records on fruit russet. However, comparison of this plot with the remainder of the orchard in the less severe scab year of 1935 showed that an average infection of 1.8 percent occurred in the previously well-sprayed section (including all materials tested), while 28 percent of scab was present in the part sprayed entirely by the grower during both years. These results, in conjunction with data given in tables 1 and 2, seem to warrant the conclusion that this
residual effect of spray materials was almost entirely due to the reduction of twig infections, since few ascospores were caught in the trees during either year.

**Effect of Dormant Sprays**

The possibility of killing the parasite on twigs in its inactive and overwintering form was tried by means of penetrating spray materials developed by Keitt (12) for dormant use. During this period the fungus is not exposed, and a penetrating material would be required to reach the vulnerable tissue. Although killing of the fungus occurred, a certain percentage of the pustules continued to become active in the spring, even on trees showing distinct and severe spray injury in the form of partially killed limbs. It is quite possible, however, that if further improved or used in different combinations such materials may find a useful place in the spray schedule for pear scab control. This point needs further investigation.

**Effect of Cultural Practices**

Certain horticultural practices may influence twig scab infections. The cutting out of infected shoot material has been generally recommended as an aid in controlling pear scab. This practice may be helpful in eliminating some of the original spore load, but even then it is usually not complete enough to be entirely effective without additional protection to new growth. Pruning stimulates the production of new wood, which must be protected to prevent reinfection. Since watersprout types of growth are especially susceptible to shoot infection, however, their removal from the central parts of the tree should be practiced. Pruning so as to produce the most open type of tree without sacrificing bearing surfaces appears to be most desirable from the standpoint of tree vigor, thorough spraying, and partial elimination of spore material.

Unpruned trees and trees very low in vigor have been found to show less infection, since they fail to produce much new and succulent growth.

**Discussion**

The results obtained on the relation of twig lesions to primary scab infections on pear trees are in accord with work done in England, and indicate that these lesions furnish the bulk of material for early infection under certain environmental conditions. Observations and the spraying of commercial orchards in Oregon during the last 4 years have further substantiated these data. A few twig pustules are easily overlooked in an orchard, but they may be surprisingly persistent in dissemination of the parasite and when favorable environmental conditions are at hand may cause serious epidemics. Where these twig infections are absent it has been relatively easy to control pear scab, even when ascospores from overwintering leaves have been plentiful. The latter, however, should not be ignored, since a certain percentage do find their way to susceptible tissues. Results from widely scattered countries suggest that environmental factors may influence their dissemination. The work of Wiesmann (19) and Palmiter (15) has shown that specialized strains of pear and apple scab exist, a fact that
gives further importance to this sexual stage in the possible production of new forms.

The long, dry growing season of 1934 was of special interest in its relation to twig attack. Most of the pustules occurred at the bases of the current season’s twigs, indicating that infection had taken place soon after they started growth. Twig lesions resulting from infections during the early part of 1934 were sloughed off or became inactive before the trees became dormant, and the majority failed to produce conidia in the spring of 1935. During years with shorter growing seasons and more rainfall, however, the host appeared to be unable to circumscribe incipient infections. As a result, practically all twig lesions remained active and produced conidia the following spring. This may explain the conflicting observations made by Smith (17) and Thomas (18) in California in different years. It may also explain the occasional and sudden decrease in scab following several seasons in which the disease was difficult to control.

The pronounced effect of spray materials in preventing twig infections and in keeping the old lesions from functioning as infection sources seems conclusive, and spraying appears to offer the most economical and practical means of coping with this phase of the disease. Since the more effective materials can be applied to certain varieties with safety only before the blossom cluster buds become exposed, they should be applied at that time carefully and thoroughly. When properly applied even mild fungicides give considerable protection from reinfection to new twig growth.

SUMMARY

Since 1932 pear scab has become a serious factor in pear production in the Hood River Valley of Oregon. The number of primary infections appeared to correlate closely with the amount of twig infections present. Primary spring infections resulted largely from conidia in overwintering pustules on the previous season’s wood rather than from ascospores, and few of the latter were ever trapped in trees. Moreover, conidia were being dispersed before bud tissues were exposed. Early sprays should be timed by conidial dispersion from twig lesions, where these occur, rather than by ascospore discharge, because infection results from these twig spores before ascospores are matured. Consistent and thorough spraying during the growing season largely prevented twig infections. Early-season sprays were more important in this district for control of twig scab as well as of fruit scab, because more precipitation occurred early in the season and because a certain amount of host resistance became apparent after that time.

Lime-sulphur was effective in “burning out” active twig pustules, but it could not be used on tender-skinned varieties after the young fruit was exposed, without causing injury. This fungicide was found to be dangerous if applied after the bud scales had dropped. Applied in the delayed-dormant stage, lime-sulphur reduced primary spore numbers so that additional sprays gave satisfactory protection against reinfection.

Environmental factors play an important role in natural control.
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