THE BROWN-POCKET HEART ROT OF STONE-FRUIT TREES CAUSED BY TRAMETES SUBROSEA WEIR

By S. M. Zeller

Plant Pathologist, Oregon Agricultural Experiment Station

INTRODUCTION

The production of prunes and peaches is an important industry in the Pacific Coast States, and any factor which contributes to the lengthening of the productive life of these stone-fruit trees is worthy of consideration. The more the situation is studied the more it becomes apparent that wood decay in this region is the most serious factor which leads to early senility or decrepitude of producing prune and peach trees. The one predominating heart rot of these trees is that produced by Trametes subrosea Weir (4). In a previous paper the writer (6) referred to this fungus as T. carnea. The disease of red cedar caused by this organism was described by Von Schrenk (2, pp. 16-21), but its occurrence and destructiveness as an orchard disease has never been described, to the present writer's knowledge.

DISTRIBUTION

In stone-fruit orchards Trametes subrosea is found from the coastal and interior valleys of central California northward to the coastal districts of British Columbia. Wherever prunes and peaches are grown in western Washington and western Oregon, this fungus is found doing a major part of the heart-rot damage. In French prune orchards in California where this disease has been serious, this fungus has been responsible for 50 or 60 per cent of the wood decay according to W. W. Thomas, a student of this disease in that State. As is true of all such wood-inhabiting fungi, this disease is most frequently found in orchards which have insufficient care.

Being a wound parasite, Trametes subrosea occurs in relation to unprotected infection courts, such as pruning cuts and broken branches. Figure 1 shows the fruiting bodies of the fungus near two unprotected pruning cuts on peach wood.

NATURE OF THE HEART ROT

As the brown cubical rot produced by this organism is more or less restricted to definite pockets in the wood, it has been called brown-pocket rot. Figure 2 shows the decayed pockets in prune wood, in both longitudinal and cross sections, and illustrates the type of this decay.

The individual pockets contain a brown, punky wood which crumbles easily and is usually shrunken and cracked into cubical form.

The changes which the fungus causes in the wood of peach does not differ from that produced in prune. Great chemical changes take

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1 Received for publication Feb. 15, 1926; issued, October, 1926.
2 Reference is made by number (italic) to "Literature cited," p. 693.
place in the wood because of the digestive activity of the fungus, and it could be inferred a priori that the group of cytolytic enzymes which give other fungi the power to bring about brown rot must be active agents of *Trametes subrosea*. Nevertheless, the writer carried out some enzymic experiments with the mycelium of this organism grown on peach-wood sawdust, to supplement his observations on

![Fruiting bodies of *Trametes subrosea*](image)

*Fig. 1.*-Fruiting bodies of *Trametes subrosea* Wör near two unprotected pruning cuts which were improperly made. The host is peach

the glucoside-splitting and cellulose-hydrolyzing enzymes of *Lenzites saepiaria* (5). After a pure culture of *T. subrosea* had grown on the peach-wood sawdust for about nine months it was removed from the culture jars, dried, and ground. The sawdust was so thoroughly decayed that it was readily ground to a fine powder by rubbing between the palms of the hands. This fungous powder was used in the following experiments.
EMULSIN EXPERIMENT

To test for the presence of emulsin, a 1 per cent solution of amygdalin was used as a substrate, for this is perhaps the most prevalent glucoside in the wood of stone-fruit trees. Fifty cubic centimeter portions of the amygdalin solution were placed in each of two small flasks, and 2 gm. of the fungous powder were added to each. To each of two other flasks 2 gm. of moistened fungous powder were added, and they were autoclaved at 15 pounds for 5 minutes before the 50 c. c. of amygdalin solution were added. In another flask 50 c. c. of the amygdalin were placed as a control. To all five flasks sufficient toluene was added for antisepsis. The flasks were corked and allowed to stand at room temperature for five days, after which the two flasks with fungous powder which had not been autoclaved gave a strong odor of benzaldehyde and a very definite Prussian-blue test for hydrocyanic acid. The plain control gave neither of these tests, but the autoclave control gave a slight test for hydrocyanic acid. This is accounted for, perhaps, by the presence of small quantities
of amygdalin in the peach wood used as the culture medium. Thus it was demonstrated that the mycelium of *Trametes subrosea* secretes emulsin as an active digestive ferment.

**LIGNINASE EXPERIMENT**

A quantity of the cubical brown rot from the pockets produced by *Trametes subrosea* in prune wood was gathered, powdered, and soaked in the least possible amount of chloroformed water for about 24 hours, after which the water was filtered after being expressed from the decayed wood. The enzymes were precipitated with 95 per cent alcohol, collected on filter paper, and dried. This enzymic precipitate was dispersed in a small quantity of water and used in the following experiments.

Very thin shavings of sound prune wood were placed in a flask and digested in a 1 per cent diastase solution for 16 hours. After this they were soaked in several rinsings of distilled water for three days, to remove as much of the soluble substances as possible, and then the shavings were dried.

One gram of these shavings was placed in each of three test tubes. To one was added 10 c. c. of the enzyme dispersion; to another, 10 c. c. of distilled water; and to the third, 10 c. c. of the enzyme dispersion which had been autoclaved at 15 pounds' pressure. Toluol was added to all three, and then they were corked and incubated at room temperature for 25 days. After this time the liquids were decanted from the three tubes and saved, and the shavings were boiled in absolute alcohol for 15 minutes. When the alcohol was tested with phloroglucin acidified with HCl, a deep red color was given in the first tube, but the second and third remained clear and colorless. This is Czapek's (1) test for hadromal, and is an indication that *Trametes subrosea* liberates the extracellular enzyme, ligninase, which has the power of splitting lignin. Czapek says that lignin is a cellulose-hadromal ether which may be split by an enzyme.

The aqueous solutions which were decanted from the shavings were tested with Fehling's solution. The first reduced Fehling's solution, while the second and third yielded no trace of copper. The results show that these reducing substances are due to enzyme action, and that they must be aldoses. These sugars may be formed from various substances. There is probably some tannin and amygdalin in prune wood. Besides this there is the hydrolysis of the cellulose to reducing sugars, as demonstrated by the following experiment which was conducted simultaneously with the above.

**CELLULASE EXPERIMENT**

Very small bits of filter paper were placed in three test tubes. To the first was added 10 c. c. of the enzyme dispersion; to the second, 10 c. c. of the enzyme dispersion which had been autoclaved; and to the third, 10 c. c. of distilled water. Toluol was added to all three, and they were corked and incubated for 25 days.

After this liquid was decanted and tested with Fehlings' solution. The first tube gave a heavy precipitate of copper oxide, while there was not a trace in the second and third tubes. This indicated that cellulase was present as an active agent in the mycelium of *Trametes subrosea*.
HEMICELLULASE EXPERIMENT

Small chips of the paragalactan from the endosperm of date seeds were also used as a substrate in the same way as described above for prune-wood shavings and filter paper. In this case, when the first tube was tested with Fehling's solution a heavy precipitate of copper oxide was given, but none was evident in the control tubes. This demonstrates the presence of hemicellulase, an enzyme which splits the paragalactan, a hemicellulose, yielding a mixture of arabinose and galactose, both of which reduce Fehling's solution.

This combination of cytohydrolytic enzymes from the mycelium of *Trametes subrosea* is the explanation of the brown rot resulting from its wood-destroying activity in the peach and prune wood. Doubtless, also, the presence of emulsin makes available more food which exists in the wood in the form of glucosides. This ability of this fungus to make available as food these substances in rapidly grown orchard trees may be a partial explanation for the very rapid and devastating advancement of such forest parasites on these trees. For, it is a recognized fact that such forest-tree wound parasites as those represented by *Trametes subrosea* attack orchard trees more energetically than they seem to attack forest trees. Whether carbohydrates are more plentiful or more easily made available in the rapidly grown wood of orchard trees is not known.

DAMAGE TO ORCHARD TREES

The damage done by this heart rot is not easily estimated, because of the inability to estimate the cost of bringing trees into bearing and the cost of replacing trees made decrepit through the influence of heart rot produced by *Trametes subrosea*. Other difficulties arising in such estimates of damage are the many different phases of the damage. In the first place the wood decay is not limited to the heart wood. Especially is this true of prune trees. After a tree has been affected for a number of years, the decayed cylinder of wood increases in diameter until the amount of sapwood is relatively small. In such cases it is not uncommon to find (especially if one side of a tree has been affected by winter injury) long sunken areas where the decayed wood extends to the bark. These may extend well up into smaller branches. This encroachment upon the sapwood materially arrests the desired increment of bearing wood on the branches affected, or on all of the branches above such a sunken area on the trunk.

Wood decay produced by *Trametes subrosea* has a marked influence on the neighboring sapwood. In the healthy sapwood of both peach and prune, wood tyloses are found scatteringly in the larger vessels of the spring wood only, none having been found in the smaller vessels of the summer growth. Where only 3 to 6 annual rings of sapwood separate the decayed cylinder within from the bark, tyloses were extremely numerous in the larger vessels of the spring wood in rings 2 or more years old. In fact, in prune wood especially, vessels of spring wood have been found nearly filled with tyloses, and tyloses were also numerous in the vessels of the summer wood. Where several annual rings separate the decayed heart and the last year's wood growth, the toxic influence of the decayed wood on the production of tyloses in vessels 2 or 3 years old is nearly as great as where
the fungus is nearer. Stevens (3) has described a similar condition in Catalpa sapwood influenced by the decay produced by Polystictus versicolor in closely neighboring tissue.

Such disturbances surely influence the normal physiology of a tree, bringing about a weakened framework, increasing the mortality of crop-producing wood, and causing increased susceptibility to winter injury. There are also indications that the lack of water conduction in wood having such an abundance of tyloses has a direct contributary bearing on the physiological disturbances in prune trees known as leaf roll, June drop of fruit, and early yellowing and dropping of leaves.

An orchard survey was made to ascertain just how much damage is done by the wood decay caused by Trametes subrosea. Out of 1,261 prune trees in orchards having average horticultural care, 1,212 showed heart rot. Of these, 885 were affected by T. subrosea. That is, 73 per cent of the heart rot found in the orchards is caused by T. subrosea. Of the 885 trees affected with this disease, 619 (or about 70 per cent) had pruning cuts 2 inches or more in diameter. These pruning cuts had not been treated with an antiseptic wound dressing.

In Douglas County, Oreg., 100 trees were examined in each of two neighboring orchards of Italian prunes. One orchard showed extremely good care, all pruning cuts of about 1.5 inches in diameter having been treated with some type of asphaltum wound dressing. The other orchard showed lack of care in the protection of wounds. In the orchard showing good care, 91 per cent of the trees showed no evidence of wood decay, although 82 per cent of them had large pruning cuts. On the other hand, of the 100 trees in the orchard receiving meager care only 7 per cent were sound and all had large pruning cuts. Of the 93 trees showing wood decay, 78, or 83.9 per cent, had the brown-pocket rot due to Trametes subrosea, while all of the 9 trees showing decayed wood in the other orchard were affected by this organism.

In some localities within this active range of the fungus, vigorously growing older orchards do not seem to be affected by the heart rot. On river bottom land, such as that in the Days Creek Valley, Douglas County, Oreg., and in Clarke County, Wash., prune trees grow to large size. The lack of heart rot in many orchards of some of these communities seems to be related to the system of pruning adopted by the grower. In brief, heart rots are less prevalent in orchards where the system of pruning used does away with all pruning on the main leader branches and trunk, particularly where trees are so trained in early years that the removal of large branches is unnecessary later.

PREVENTIVE MEASURES

To prevent the wood decay of stone-fruit trees caused by Trametes subrosea, the measures usually suggested for prevention of infection by wood-destroying fungi are recommended, i.e., pruning properly so that the wound will heal in the shortest possible time, and treatment with a wound dressing. The writer has had success with a Bordeaux paint made up by mixing linseed oil into a Bordeaux dust until a thick, smooth paint is formed. Preferably, however, it is better to educate growers to a pruning system whereby large
pruning cuts which need treatment are unnecessary or reduced to a minimum.

SUMMARY

Trametes subrosea Weir causes a brown-pocket heart rot of peach and prune trees in orchard districts from central California to British Columbia. The brown rot has been demonstrated to have been produced by the cytohydrolytic enzymes ligninase, cellulase, and hemicellulase. Emulsin is also present in the mycelium of T. subrosea, making available the products from glucoside digestion in the wood.

The economic losses due to this decay in orchard trees are large but difficult to estimate. Also, the damage to the diseased tree is not limited to the heartwood, since the disease encroaches upon the sapwood, cutting down its volume and actually destroying the water conducting power of the remaining sapwood by the stimulation of the growth of tyloses in the xylem vessels, upsetting the physiological balance in the tree, and giving rise to "drouth effects" in the affected portions of the tops.

A survey in prune orchards showed 73 per cent of the heart rot to be produced by Trametes subrosea, and demonstrated that the presence of this heart rot is related to large, unprotected pruning cuts.

Preventative measures are (1) proper pruning to facilitate healing, (2) treating the wounds with an antiseptic dressing, and preferably (3) the use of a system of pruning such that large pruning cuts are unnecessary or are reduced to a minimum.

LITERATURE CITED
