

PEAR DECLINE RESEARCH

A Report of the University of California Research Committee on Pear Decline—1964

TREE LOSSES from pear decline in California during 1963 were considered light. This was probably due to previous deaths of trees on susceptible scion-rootstock combinations and possibly to improved control of pear psylla. Adequate rainfall and cool summers also reduced stress on affected trees during 1962 and 1963. Indications are that the heavy losses in the Sacramento Valley and Sierra districts are now over. However, new cases of decline increased 100% in Mendocino County and 50% in Santa Clara County last year. Pear decline was also identified for the first time in Calaveras, Los Angeles, Madera, Marin, Mariposa, Merced, and Trinity counties. Although it is now believed that pear decline has run its course, there are still some districts of the State, notably the coastal regions, where many susceptible trees remain and where serious outbreaks of decline continue to be a threat. The University of California Research Committee on Pear Decline presented a summary of research progress through 1962 in *California Agriculture*, February, 1963. Foremost among the important test results since then was the demonstration that quick decline is caused by an insect-transmitted virus. These and other important recent findings relating to the cause and control of this disease are summarized in the following report—*M. L. Peterson, Director, University of California Agricultural Experiment Station.*

EXPERIMENTAL WORK in Washington implicated the pear psylla as being related to the pear decline problem. This research was subsequently confirmed by work in California. Some of the California results suggested, however, that the psylla might be a carrier of a virus that could be causing pear decline—rather than producing the disease by means of a non-viral insect toxin, as was indicated by experiments in Washington. Results of tests in progress for several years now confirm that the pear psylla does, in fact, play such a role.

Several independent experiments conducted at Davis and Riverside have shown that psylla-transmitted virus causes quick decline in pear trees. In one experiment at Davis, adult psylla that had previously fed on trees in a slow decline orchard, were caged experimentally on a single branch of each of 42 healthy field plot trees growing on susceptible (Oriental-type) rootstocks. The insects were allowed

to feed for only five to eight days and were then killed by sprays that also destroyed the eggs that had been laid. These trees received no other psylla feeding during the season. In September, seven to ten weeks after the test feedings occurred, pear decline symptoms developed in 26 of the test trees. Eighteen trees wilted with quick decline. Before collapsing, six of these developed chlorosis of the foliage on the youngest shoots—as did eight trees that failed to wilt. Seventy psylla-free control trees remained healthy.

Microscopic examination of bark samples taken at the graft union of 19 of the virus test trees revealed that 17 had injury typical of pear decline, two were undeterminable and none were normal.

Pear psylla not previously fed on pear decline trees, and apparently free of virus, were also caged on 35 field trees of the same type used in the virus experiments. They were allowed to feed and reproduce on the test trees throughout a three-to-

four month period. Large populations of psylla developed and ultimately defoliated most of the infested branches. Only one of the 35 trees wilted or showed any summer growth symptoms different from the untreated control trees. Some trees developed more red foliage late in November, however, than occurred on the untreated controls.

Results obtained in these experiments indicate that a psylla-transmitted virus causes the sudden wilting or mild foliage chlorosis of pear trees and that psylla toxin—in relatively large and continuous doses over a period of three to four months—does not cause quick decline in vigorously growing trees in the absence of virus.

A second series of trials with pear psylla were conducted independently at Riverside. Presumably virus-free pear psylla were allowed to feed on leaves of pear decline-affected trees for varying lengths of time before being transferred

to young pear trees on Oriental rootstocks. The results of these tests are shown in the table. When psylla were not allowed to feed on diseased leaves before being transferred to the test plants, no disease developed. However, when the insects were allowed a short acquisition feed, one out of 35 trees developed pear decline symptoms, and when they were allowed a long feed, over 17% of the test trees became diseased. These results, as at Davis, indicated that psylla acquired a virus from the diseased trees and transmitted it to the test trees.

TESTS OF PSYLLA PYRICOLA AS A VECTOR OF PEAR DECLINE VIRUS CONDUCTED AT RIVERSIDE

Acq. feed	Tests	Psylla	Psylla per test	Infect.	% infect.
None	45	959	21.3	0	. .
Short	35	779	22.3	1	2.9
Long	70	1281	18.3	12	17.1

Finally, in a third series of experiments conducted at Davis, it was shown that the agent causing quick decline could be transmitted from tree to tree by grafting. Buds from diseased trees were grafted to young Bartlett trees on Serotina rootstocks. An equal number of trees were grafted, as controls, with buds from healthy trees. In two different experiments of this type, significantly higher amounts of quick decline developed in the inoculated trees than in the controls. One of these was carried out in a screenhouse where the test trees were protected against feeding by pear psylla.

Graft transmissibility is characteristic of viruses which cause diseases in tree crops. Therefore, these results provide further evidence that quick decline is virus-induced, and that under experimental conditions, the virus can cause the disease in the absence of pear psylla. Although virus alone can cause quick decline, it appears to be spread in commercial orchards by the pear psylla. In addition to carrying the virus, pear psylla itself can seriously damage pear trees. Prolonged heavy infestations are injurious even to trees on French rootstocks and even if the psylla are virus free.

Bud-union anatomy

For accurate field diagnosis and interpretation of experimental work, it is essential to know whether bud-union pathology is caused by both psylla toxin and by virus and, if so, the individual effects of each.

Histological studies were conducted on small trees growing at Davis which had been fed on by several hundred virus-

free psylla for three months. There was a uniform reduction in the width of phloem on both sides of the bud union of six trees, such as might be expected in trees weakened from any cause. In two of the trees there were bud-union effects; however, characteristic, drastic, anatomical changes of pear decline were absent. From this it appears likely that the bud-union pathology as already described for pear decline-affected orchard trees is virus induced, and that under these conditions psylla toxin produces only slight effects in the phloem.

Identification of species

Since rootstocks of different species vary in their susceptibility to pear decline, an accurate means of identifying rootstocks is badly needed. This is particularly true where decline may be affecting trees on *Pyrus communis* rootstocks or where hybrid rootstocks could exist. Since classical morphological procedures of identification have proven unsatisfactory, biochemical methods have been developed which allow more accurate identification of most pear species.

When extracts of rootstock trunk or root bark were separated by paper chromatography, some differences among groups of species were noted. However, since samples had to be taken from several locations on the rootstock and since hybrids were not distinguishable, use of material from the woody parts of the plant was of limited value.

When extracts of leaves are similarly chromatographed, most pear species and a number of hybrids can be identified. The following major species are readily distinguishable from each other: *P. communis*, *P. serotina*, *P. ussuriensis*, *P. calleryana*, and *P. betulaeifolia*. Extracts of *P. betulaeifolia* provide a pattern more similar to *P. communis* than to the three Oriental species. Eight other Oriental species, which may be either hybrids or varieties of the major Oriental species, are being evaluated. Some of these are readily identifiable, while others require additional work to establish their relationship, if any, to parent species. Fourteen species of European or west Asian origin, many of which are also hybrids within this group or possibly varieties, are very similar to *P. communis*. Pending additional work, they can only be grouped as being of *P. communis* type.

A number of hybrids have been examined, and in practically all cases, the parentage of these hybrids could be established. Current work is being directed toward establishing the degree to

which parentage can be determined in hybrids, or controlled crosses. It is recommended that where questions arise concerning identity, pear rootstocks should be induced to sprout and produce leaves for analysis.

Control of pear decline

Considerable progress has been made in developing methods of controlling pear decline. Primarily, these methods are based on the use of nonsusceptible trees for replanting or use in new plantings and control of pear psylla:

Nonsusceptible trees—Since pear decline first appeared in California it has been evident that trees on domestic French (*P. communis*) rootstocks as well as trees grafted on rooted Old Home cuttings, and commercial varieties on their own roots are highly resistant to pear decline. Extensive experiments have been conducted during the past four years to develop methods of propagating pear varieties on their own roots to give resistance to pear decline. This goal has been attained and practical methods of propagating both Bartlett and Old Home from cuttings have been developed and made available to growers and nurserymen.

In University experiments almost 100% rooting of Old Home pear softwood cuttings was obtained if they were taken in early summer, treated with indolebutyric acid (IBA) at 6,000 ppm by the concentrated-dip method, and rooted under intermittent mist.

Hardwood cuttings of Old Home were rooted up to 72%, if the cuttings were taken in late October and the bases were soaked in IBA at 100 ppm for 24 hours—followed by a storage treatment in slightly moist peat moss at 70°F for about three weeks, and then planted in the nursery row.

Bartlett pear softwood cuttings were rooted under intermittent mist in the greenhouse. Best rooting was obtained when the cuttings were treated with relatively high concentrations of IBA—8,000 to 10,000 ppm. Rooting was obtained when cuttings were taken from either container-grown, greenhouse-forced trees, or from orchard trees.

Bartlett pear hardwood cuttings were rooted when taken in late November and held upright in peat moss over bottom heat, but with the tops exposed to winter-chilling conditions for three weeks before planting. Best rooting was obtained with bottom heat of 75°F and an IBA treatment of 150 ppm.

In addition to these means of developing decline-resistant trees, several clones

of *P. communis* have been propagated from rootstocks of orchard trees which showed marked field resistance to decline. These are being multiplied to further test their resistance and possible incorporation into the long-range rootstock breeding program—so that other economic characters, such as blight resistance can be combined into their progenies.

Pear psylla control

Studies regarding the effect of intensive psylla-control spray programs on the development of pear decline in commercial orchards were continued. Bartlett trees on *P. communis* rootstock showed improved vigor by greater shoot growth under two years of psylla-eradicator sprays. Trees on *P. serotina* rootstock showed little or no recovery under the program and continued to decline. The rate of decline, however, was much slower than in past years under relatively poor psylla control.

Because of the probability that pear psylla will become resistant to current insecticides, investigation of the effectiveness of oil and oil-insecticide combinations was initiated. Oils of varying viscosity were tested and oils alone and in combination with reduced dosages of insecticide show much promise.

Studies on natural control of the pear psylla demonstrated that an anthocorid (*Anthocoris antevolens*, White) and both green and brown lacewings were effective predators. In unsprayed orchards the predators kept the pear psylla population below an economic level on trees with rootstocks that are not susceptible to pear decline. The currently recommended materials for codling moth are toxic to the predators; therefore, a program aimed at finding selective compounds was initiated. Two compounds evaluated—Perthane and Phosphamidon—did not provide adequate codling moth control. In addition, they were toxic to predators and would not fit an integrated control program.

A means of controlling codling moth, without adversely affecting psylla predators, remains the important unsolved problem in the integrated control of the pear psylla. A search has also been initiated for microorganisms such as fungi or bacteria which cause diseases of pear psylla and which might be useful in biological control of the insect. In the laboratory the pear psylla was exposed to three species of fungi: *Paecilomyces farinosus* (Dicks, ex Fr.) = *Spicaria farinosa* (Fries) Vuillemin, *Metarrhizium anisopliae* (Metchnikoff) Sorokin, and *Ento-*

mophthora coronata (Costantin) Kevorkian. The psyllids were exposed to the fungi by gently brushing the fungus spores on them. Each individual was reared separately in a sterilized plastic tube attached to a leaf on the plant. Six tests were conducted with the most promising fungus, *Paecilomyces farinosus*. These tests indicated that the fungus was infectious for the psyllid. There was some indication that *Metarrhizium anisopliae* was also infectious, but *Entomophthora coronata* was noninfectious. These studies will be continued with greater emphasis placed on a search for naturally occurring pathogens affecting psylla in pear orchards.

Continuing and proposed studies

Although much has been learned about pear decline, there are still many phases of research which must be continued or initiated before long-range control of the disease can be assured. Studies are now in progress, or planned, as follows:

- (1) A study of the factors affecting graft transmission for the purpose of increasing the efficiency of transmission for use in testing resistance in potential pear rootstocks.
- (2) Among the relationships of pear decline virus to its psylla vector still to be determined are the following: efficiency of virus transmission; duration of feeding necessary to acquire or transmit virus; whether the virus can be transmitted immediately after pear psylla feeds on a diseased tree or if the virus must go through an incubation period in the vector for several days or weeks; how long the virus can be carried by pear psylla after feeding on a diseased tree; and whether the virus can overwinter in the psylla.
- (3) Psylla will be used to infect trees of various root and scion combinations to evaluate them for resistance to pear decline virus.
- (4) Virus-free psylla will be fed on recently infected pear trees to determine how soon virus can be recovered from the old and new foliage of the test trees.
- (5) More information is needed on the long time effects of psylla toxin on pear trees in the absence of virus.
- (6) Taxonomic studies will continue on the species of *Psyllidae* that breed on pear trees.
- (7) Studies will be continued upon means of controlling codling moth without detrimental effects upon natural enemies of pear psylla.

- (8) Further studies will be made of the effectiveness of oils for controlling pear psylla, the proper timing of treatments, compatibility with other pesticides, and the effect of the oils on tree growth and fruit quality.
- (9) Continued search for resistant stocks in several pear-growing districts.
- (10) Continued studies on the relation between slow decline and quick decline.
- (11) Continued studies of the effect of intensive psylla-control spray programs on the control of pear decline and the ability of trees to recover from different stages of the disease.
- (12) Continued studies on phloem pathology caused by pear decline virus and pear psylla toxin.
- (13) Refinement of rootstock identification using biochemical methods.
- (14) Fundamental studies on the physiology of rootstock susceptibility and resistance.
- (15) Studies on the effect of soil moisture and other factors on growth and survival of pear replants.
- (16) An exhaustive search will be made for predators or pathogens of pear psylla as potential means of biological control.

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