

they might find usage in special cases. Copper sprays, while not usually causing russet at this time, will intensify any russet already present on the fruit. When scabby fruits or leaves are present on the trees after midsummer, a late outbreak of scab may appear if heavy dews or late summer rains occur. Ferbam or ziram, at the rate of 1 to 1½ pounds to 100 gallons of water, may be added to the last codling moth spray to protect the fruit from late infections or storage scab. This practice is not recommended generally, since the residues are difficult to remove after late applications, and scab should be controlled by the earlier sprays if they are applied in the proper way.

AFTER PEAR FRUITS are picked from the trees at harvest they are no longer susceptible to scab infections. Clean fruits picked from scabby orchards do often develop new scab spots while in common or cold storage, but they result from late infections in the orchard. If rains occur 10 to 14 days ahead of harvest, fruit infections may become visible shortly after the fruit is placed in storage. If the infections occur only a few days before harvest, however, the appearance of scab spots on the fruit in cold storage may be delayed until December or January. To prevent scab from appearing on stored fruit it is necessary to control the fungus in the orchard.

Visible scab spots enlarge only slightly during the storage life of the fruit, but the occurrence of several scabby spots causes the fruit to be discarded or sold for less value. Scabby pears transpire and lose weight more rapidly than sound pears in storage, but generally less than 1 pound per box difference can be measured after 5 months in cold storage.

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Fire Blight of Pears in California

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Outbreaks of fire blight wiped out the pear orchards in the San Joaquin Valley and southern California at the turn of the century. It threatened the industry in the Sacramento Valley and was found elsewhere in northern California in 1904. M. B. Waite, of the Department of Agriculture, was sent to California to inaugurate control procedures. He demonstrated the method of removing blighted parts by cutting below the point of infection and using a disinfectant on tools and cuts in the tree. The procedure, somewhat modified, has been the only control method available until recent years.

The application of copper compounds in sprays or dusts during the blossom period is now an established practice in most orchards of Bartlett pears in the districts of California where blight flourishes. Nearly all the experience with this preventative procedure is with the Bartlett pear, which accounts for more than 85 percent of the 39,000-odd acres of pears in California.

The successful program of fire blight prevention now in use in many pear orchards in California is based on facts and hypotheses developed by workers in the California Agricultural Experiment Station and elsewhere. In 1934 H. Earl Thomas and P. A. Ark published the results of a study on the relationship of pear nectar concentrations to the fire blight organism. George H. Vansell had pointed out

that the sugar concentration of nectar of fruit trees may vary from less than 3 percent to 55 percent, the higher concentration occurring during periods of low humidity and the low concentration of nectar when the atmospheric humidity was near saturation.

The studies of nectar and various sugar solutions showed that the fire blight bacteria ceased to multiply when the sugar concentration exceeded 20 or 30 percent. Thereupon a theory was developed as to the conditions that give rise to an epidemic of fire blight and explain the observed cases of control with copper sprays. The theory was that most of the activity of blossom-visiting insects occurred during warm days and nights when the nectar concentration was too high to permit the organism to multiply. When such periods of insect activity and blight distribution are followed by rain or high humidity, the nectar is diluted sufficiently to permit multiplication of the blight organism and its entry into the floral parts. The pear growers in California have frequently observed that epidemics of fire blight follow that pattern.

The essential aspects of the fire blight situation in California are:

1. Main blossom period. Epidemics of fire blight have one or more waves of infection during this period. It is sporadic, but the most disastrous phase. Under California conditions the blossom period usually lasts 3 weeks or longer. Epidemics originating in this period appear to be almost entirely due to dissemination by insects. Blossom infection from rain-borne inoculum is infrequent and not commercially important.

2. Late blossom period. The Bartlett variety quite regularly produces some blossoms for a month or so after the main blossom period. Late blossoms are not numerous but they are frequently blighted and are a concern to the pear grower. Part of the control program is usually directed toward control of blight in the late blossoms. That can be done in part by adding a

copper-containing material to the codling moth or other insecticidal sprays.

3. Shoot infection. Infection of succulent vegetative shoots during the summer occasionally is an additional problem. No direct preventative measures against this type of infection are known. We have not seen serious damage from blight infections originating in shoots in orchards which have not had an abundance of blossom blight.

4. Fruit infection. Direct infection of fruit near harvesttime has occasionally caused damage in orchards in which considerable blight is present. In several orchards where fruit infections developed, insecticidal oil sprays greatly increased the number of blighted fruit. In one orchard in 1943, 10 trees sprayed with an insecticide plus oil had an average of 17 percent blighted fruit per tree. Ten trees in an adjoining row sprayed with the same insecticide without oil had 0.5 percent blighted fruit per tree. All cases of serious loss of fruit brought to our attention have been related to the use of insecticidal oil sprays near harvesttime. There has been no explanation for this fact.

5. Fall blossoms. Defoliation of Bartlett pear trees after harvest by spider mites or by certain spray materials is usually followed by light to heavy production of blossoms. Pear growers are worried when it occurs, because there have been a few cases of serious blight infections in this unseasonable bloom. No investigations have been made of ways to control this phase of fire blight, but it is assumed that sprays or dusts would be as effective as for the normal blossom period.

During the epidemic of blight in El Dorado County in 1945 it was demonstrated that bordeaux mixture consisting of one-half pound each of copper sulfate and lime in 100 gallons of water was as effective as stronger mixtures. Growers have claimed protection from considerably less copper. One careful operator has apparently controlled blight by using 15 pounds an acre per application of a dust containing 4.5 percent copper.

Observations in California pear orchards indicate that the main function—if not the only one—of copper is to prevent growth of the blight organism in nectar. Probably the organism is carried to blossoms by insects when the nectar is too concentrated to permit its growth as well as when the nectar is greater in volume and lower in sugar concentration. When the nectar is sufficiently diluted by rains or high humidity the organism reproduces and invades the flower through the nectaries. The objective therefore is to place a little copper in the nectar before periods of high humidity and to renew the applications as new blossoms open.

Several operators of orchards where blight has been particularly damaging have carried on a program for seven consecutive years which is designed to afford maximum insurance against the disease. Because of the long blossoming periods common in California and the need for preventing blight in the late bloom, the operators may make up to eight applications in addition to adding copper compounds to the sprays for codling moth. Besides bordeaux mixture and copper-lime dust, a number of fixed or proprietary copper materials are used. We have seen no difference in results from sprays or dusts applied by the various types of ground and air equipment provided that there is adequate distribution of the material. Those using a program for maximum feasible protection will make applications at intervals not to exceed 5 or 6 days in "blight weather" and an interval of about 10 days when the weather remains relatively dry.

The number of applications that would give adequate protection could be reduced if it were possible to predict periods of rain or high humidity accurately for the various pear districts. Many growers feel that they cannot make extensive use of weather predictions. They make four to eight special applications solely for blight control. A few growers have been fairly successful in depending on

weather predictions and using the airplane or helicopter two or three times in the season for rapid and timely application of a copper dust at critical periods.

Copper compounds are the only chemicals clearly demonstrated by extensive usage to be effective. Since it is generally accepted by pear growers that control can be had with such small amounts of the copper compounds that no appreciable russetting of Bartlett pear fruit results, there has been no serious demand for other chemicals. Sulfur and ferbam have failed to prevent blight.

No unusual amount of russetting has been reported from the use of sprays or dusts which do not exceed 1 pound of metallic copper an acre. Bordeaux mixture, 800 gallons (one-half pound each of copper sulfate and lime in 100 gallons of water, or its equivalent in other copper compounds) contains 1 pound of metallic copper. Less than 800 gallons is usually adequate for a thorough coverage of pear trees at blossom time. With dusting equipment that requires 30 to 40 pounds of dust to cover an acre adequately it is desirable to use a dust that does not exceed 3.5 percent of metallic copper. The commonly used 7 percent copper dusts often cause excessive russetting when applied at 30 to 40 pounds an acre. The 7 percent dusts are used by a few pear growers who have ground or air equipment that gives effective distribution at 10 to 15 pounds an acre.

Experienced growers have learned it pays to remove blossom infections as soon as detected. When blight cutting is delayed until the following fall or winter, the operation is more expensive in terms of labor required and loss of future production because of heavier cutting and the danger of leaving more hold-over infections.

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