CITRUS CANKER IN CALIFORNIA*

ALTHOUGH citrus canker has been described as one of the most destructive plant diseases known, the principal effects are not so much an actual killing of the tree as a disfiguration and spoilage of the fruit for market. Canker causes a development of brown, corky, scabby spots and areas on all parts of the tree above ground, especially on the fruit, leaves, and twigs when they are still fairly young and tender. The affected growth becomes disfigured and weakened and the fruit is ruined for market. Under favourable conditions the disease spreads rapidly and becomes very abundant, injuring a large percentage of the fruit.

Citrus canker is a bacterial disease, caused by *Bacterium citri,* which attacks all varieties and species of citrus to a greater or less extent. These bacteria live and multiply abundantly in the affected tissue and are easily carried from one tree to another.

Canker is considered the worst disease of citrus trees which has ever been introduced into this country and its eradication after it had become well established in Florida must be looked upon as an achievement of the greatest importance to the citrus industry.

Hosts.—Citrus canker varies in its seriousness in different species and varieties of citrus. Of the important citrus fruits in Florida the disease is most virulent on the grapefruit and next on the sweet orange. There is some difference in susceptibility between the different varieties. The Washington Navel orange is very susceptible. The lemon in Florida is somewhat less susceptible than the sweet orange, the Satsuma orange is less susceptible than the lemon, and the Mandarin orange is very resistant.

History and Geographic Distribution.—Canker is not widely distributed throughout the citrus-growing countries of the world but is very prevalent in the Orient. It is usually believed to be native to China but has been present in Japan and the Philippine Islands for a long time. Some recent evidence from old herbarium specimens indicates that it may have originated in India (Fawcett and Jenkins, Phytopathology, in press). The disease also spread to many parts of the Orient, the Hawaiian Islands, North Australia, and South Africa.

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TABLE

SUMMARY OF QUARANTINES AGAINST CITRUS CANKER

Commodity affected	Degree of exclusion	Quarantine	Districts quarantined against
Citrus fruit	Total	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona
	Total except oranges of the Mandarin class may enter under permit	Fed. Quar. No. 28	India, Siam, Indo-China, Malayan Archipelago, Philippine Islands, Oceania (excepting Australia, Tasmania, and New Zealand), Japan, including Formosa and islands adjacent to Japan, Union of South Africa.
Citrus seed	May be imported under permit and treatment	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona.
Citrus trees, scions, etc.	Total	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona.
	Total	Fed. Quar. No. 19	All foreign countries and localities.

In the United States citrus canker was observed in a single case in Florida in 1912, and again in 1913. It was probably first introduced at some time between 1908 and 1911. The disease was not generally recognised as a serious menace until 1914, and its true course was not discovered until 1915. It seems therefore that canker did not attract attention as a serious citrus disease anywhere in the world until it had been introduced into Florida. The disease has been found in Texas, Mississippi, Alabama, Louisiana, and Florida. It has never been observed in California or Arizona nor in Cuba or Puerto Rico. After canker was discovered in Florida it spread rapidly and a vigorous campaign was started by state and federal authorities to eradicate the disease from Florida and the other Gulf states. As a result of this energetic campaign there has been no commercial damage to Florida citrus groves from this disease since 1922 and no infections have been found since 1927. It appears that canker has

been completely eradicated from Florida, Alabama, Mississippi, and Texas and all except one non-commercial area in Louisiana. It also appears to have been eradicated from Northern Australia and South Africa.

Economic Importance.—In Japan the Satsuma and other types of citrus which are commonly grown are not very susceptible to canker and the disease is not considered serious. In fact, it had attracted very little attention there and was generally confused with scab before its outbreak in Florida. On sweet oranges in Japan, however, there is considerable loss from canker.

In Florida both climatic conditions and the types of citrus most commonly grown seem to be particularly favourable to the development of this disease. The grapefruit, which is of especial commercial importance in Florida, is very susceptible, and the sweet orange is also very readily attacked. Citrus canker is therefore of much greater concern to Florida than to any other part of the world where the disease has occurred. In view of the rapid development of canker which took place in Florida between the time of its first appearance and the commencement of the eradication program and the destructive effect which it showed during that period, there can be little question that the Florida citrus industry would have been very badly affected if the disease had been allowed to continue. Unless some method of control could have been found it seems reasonable to believe that a very large percentage of all the oranges and grapefruit would have become affected in a disastrous manner.

During the eradication campaign it is stated that between 1914 and 1931 more than $2,500,000 of state, federal, and private funds were spent in combating citrus canker in Florida alone and the total cost of this disease to the state was much greater than this, since in the eradication campaign 257,745 grove trees and 3,093,110 nursery trees were destroyed incidental to the eradication of this disease, which occurred in 515 properties scattered through 26 counties.

Possibility of Control.—Some control of citrus canker has been obtained in the Orient (and in South Africa before eradication) by spraying the trees. By this means it is possible to prevent the disfiguration of the fruit at least to a certain extent. The possibilities of such control are very limited, however, especially where conditions are favourable to the disease, so that in Florida and also in South Africa campaigns were undertaken to eradicate canker from the affected regions. This work was carried out by a systematic inspection of citrus groves and nurseries and immediate destruction by fire of all affected trees as soon as discovered. By this method, which was repeated as long as any case could be found, eradication was successfully accomplished in Florida and according to Doige (1929), in South Africa.

Adaptability to the California Environment.—The climatic conditions most favourable to citrus canker have been studied quite thoroughly by Peltier (1926) with the following conclusions:

Considering the temperature factor alone citrus canker could develop in all the citrus regions of the world some time during the growing season. The period over which it would be active depends on the number of months having a mean temperature of 68°F or above. The disease would be most severe at points having the greatest number of months with mean temperatures of 80°F or above. Temperature is in no case a limiting factor for the development of canker in any of the citrus regions of the world. Considering the moisture factor, a deficiency of precipitation during the growing season is the limiting factor in the development of citrus canker. Whenever the temperature and precipitation curves are ascending and rounding curves as they are for localities like the Gulf Coast states, China, and even South Africa, conditions essential for the development of canker

are at hand, as these same conditions stimulate the rapid growth of the host plants and thus make them more susceptible. On the other hand, no canker has ever been found in those localities where, while the temperature curves are ascending and rounding ones, the precipitation curves are descending. In California when the highest monthly mean temperatures are reached the amount of precipitation is at its lowest point. If most of the annual rainfall occurred during the summer months rather than during the winter season, canker could develop to some extent as conditions would then be similar to those prevailing in South Africa and at Laredo, Texas, in 1916. The amount, frequency, and seasonal distribution of precipitation is a limiting factor. Apparently the seasonal distribution is the most important factor to consider, for on the seasonal distribution of rainfall depends to a large extent the development or inhibition of this disease in the citrus regions of the world. According to the observations and conclusion of Peltier it does not seem probable that citrus canker would thrive under California conditions, owing to the dry summers. It will be seen from Peltier's conclusions that for the development of this disease it is necessary to have a combination of wet weather and high temperature. In other words citrus canker is most active in regions with a warm, rainy summer, and least likely to develop in places where the summer is dry and rainfall occurs mainly in the cooler part of the year. This would suggest that citrus canker might not flourish in California, or that if it should become established it might be rather easily controlled and eradicated. If it should become established here, however, it might result in anti-California quarantines, even though it occurred in a very mild state.

Methods of Dispersal and Avenues of Entrance.—Canker is spread locally by wind, insects, pruning or other tools, and by any agency which might pass from one citrus tree to another. Over long distances the disease may be carried either on nursery stock or on citrus fruit, since both the tree and the fruit are attacked. In the case of the introduction of citrus canker into the Gulf states, and no doubt elsewhere into new countries, the disease has spread by means of infected nursery stock. In this country it appears to have been introduced first on seedling trees of trifoliate orange shipped from Japan to Texas, Mississippi, Alabama, and Florida, where it spread to other varieties. It was also introduced on Satsuma orange trees shipped from Japan. In Florida, canker also developed in shipments of trifoliate orange trees from Texas. There is no evidence that the disease has ever been spread over long distances on citrus fruit. The most probable method by which citrus canker might be introduced into California would be by the shipment of infected citrus nursery trees from the Orient. If such trees should be brought in and planted in this state the disease would presumably develop on them. After that it might either continue to develop and spread to other adjacent trees, if conditions were favourable, or otherwise it might die out and disappear. Next in importance would be the danger of the introduction of canker on affected citrus fruit, probably either sweet oranges or grapefruit. In this case the only way in which the disease could become established here would be for orange or grapefruit rinds having cankers that contained live germs of the disease to be thrown out and left in some place close to citrus trees. Even then the likelihood of the establishment of the disease in such trees is not very great. Since no case of canker has been found in Florida since 1927 there would seem to be very little danger of its introduction on citrus fruit from that state.