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Observations and Research on Impietratura

AN ALTERATION of orange fruits called impietratura (from Italian *pietra,* stone; that is, hardening like a stone) has long been known to Sicilian citrus growers. Only in the last few decades, however, have the frequency and severity of this pathological phenomenon increased to such a degree as to attract the attention of scientists and growers (6). On the other hand, observations which I made during recent years in other Italian countries and on Sallustiana oranges from Spain, together with observations made by Chapot (private correspondence) in orange groves of Lebanon, Greece, and Turkey, allow the assumption that this disease is widely spread among Mediterranean countries. The disease has a systemic character similar to that of virus diseases (7). It affects chiefly oranges, but has been found in grapefruit and recently also on Clementine mandarin and tangelo trees. It has never been found on lemons.

Symptoms

At first sight, the disease can be easily detected, especially when fruits are green and actively growing, by noting the presence of very small fruits (1/4 to 1/3 normal size) close to normal-sized ones in the same tree. The percentage of small fruits may vary considerably, but in extreme cases we can find trees which produce only small fruits. It seems that in time the percentage of hardened fruits increases to 50 per cent or more.

While small fruits always show the severe internal characters of the disease, normal-sized fruits have milder symptoms or sometimes no symptoms at all.

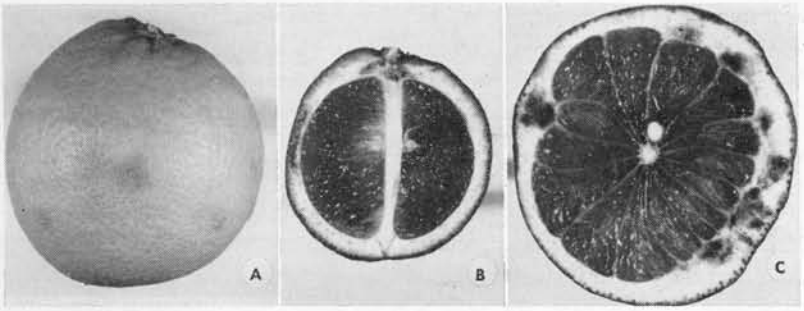

FIGURE 1. *Symptoms of impietratura. A. On an orange fruit, with three characteristic spots of petecchia velata or slight peteca. B. Spots in the albedo of an orange fruit, near the stem and on one side. C. On grapefruit; symptoms are identical to those of lumpy rind as found in Florida.*

Diseased fruits are very hard and inelastic, especially on peel areas whose corresponding albedo is brown and resistant to a knife cut.

By cutting across the fruit near the base, chiefly in the part under the stem, some hard, brown, and gum-kneaded areas in the albedo may be seen. Gum is present also in fibrovascular bundles which branch off from the stem and in the woody vessels as much as several centimeters away from the fruit.

In the most severe cases, the formation of brown areas, that is of gum-containing tissues, may advance from one side towards the pulp, thus affecting the central axis (core) and the peripheral vesicles which become dry and brown, and from the other side towards the glandular and interglandular tissue. This tissue, as seen from the exterior side, is a little depressed and contains brown glands, which resemble the spots of petecchia velata or slight peteca (3). Sometimes the interglandular tissue may not be depressed but rather jutting out, and the affected area is well distinguished by the brown color of the single glands as seen from the exterior side. By tangentially cutting the jutting areas, cavities with fluid or with coagulated gum as great as one cubic centimeter in volume may be evidenced in the albedo.

The albedo is not always brown at the fruit base. Sometimes the symptoms, especially in the fruits which succeed in reaching maturity, appear only on the exterior sides of the browned glands. However, when fibrovascular bundles are considerably affected and the albedo develops an early browning at the fruit base, the fruit very likely drops, especially in

summer (August-September). Fruits which drop in this season may even show their pulp completely brown and gum-kneaded.

The diseased trees yield a smaller crop than healthy ones not only because their fruits drop but also because fruits are much inclined to split.

It is less easy to detect the disease on trees with ripe fruits, as, at this time, most of the diseased fruits have dropped. Undoubtedly, the presence of brown spots (as in peteca, but harder to the touch) is a clear external symptom. However, the hardened fruits do not always show this symptom; in this case, the only way to detect the disease is to cut the suspected fruits transversely and to look for the characteristic brown spots in the albedo. Also, the pericarp cells (peel) and particularly those of the mesocarp, are smaller than normal and have very thick walls, such as to constitute a very compact tissue, even where the brown spots are absent.

Experiments on Transmission

As early as 1953, we tried to transplant live bark pieces from diseased trees onto healthy orange trees. At the same time, inoculations were made with juice extracted from the bark of diseased trees. During subsequent years, however, the crop of the inoculated plants showed no impietratura symptoms.

In the spring of 1956 another series of experiments was started, which involved grafting buds from an orange tree which produced hardened fruits every year onto about 100 sour orange seedlings. In the spring of 1957, these plants were top-worked with buds from ten different impietratura-free trees, including Belladonna, Washington Navel, Torocco, Valencia Late, Ovale, Sanguinello Moscato, Moro, Sanguinello Doppio Moscato, and Sanguinello Di Spina oranges and Santa Teresa lemon. Between the first graft on sour orange and the second one on the hardened orange, a 10-15 centimeter sandwich was left.

Both the 1959 and the 1960 crop of all 9 orange varieties showed the typical characters of impietratura: browned albedo at the fruit base, small fruit, trend to fruit drop, and splitting even after September. No impietratura symptom was detected on the lemon fruits.

Field experiments, undertaken at about the same time, which involved the top-working of a number of adult impietratura-affected orange trees and their regrafting directly on sour orange with buds from healthy Clementine mandarin trees, gave results analogous to the above-

mentioned ones for the 9 orange varieties. Not all fruits, however, showed the impietratura characters; most fruits were normal. From this we conclude that Clementine mandarin is more resistant than orange.

Further experiments are being carried out on other Citrus varieties, such as Avana mandarin, Marsh grapefruit, and bergamot. Meanwhile, we deduce fom the present results that the impietratura disease, because of its systemic character, is a virus disease. We deduce further that lemon behaves as a healthy carrier.

Comment and Conclusion

We do not know whether impietratura can be transmitted by some vector or by seed. The presence of normally-producing orange trees near the plants of the above-mentioned experiments, as well as field observations on single trees which have had impietratura for several years, suggest that a vector is not presently spreading this disease.

The detection in Morocco of a tangelo tree (surely of American origin) with hardened fruits growing in the middle of a large field with a number of other citrus trees, chiefly oranges, in which I could not find any impietratura-affected fruit, supports my suspicion that impietratura is present also in the United States of America, and very likely in grapefruit, which, among the two parent species of tangelo, seems the most sensitive to impietratura.

I think that a careful investigation of this matter will be worth while, especially in Florida among citrus trees whose fruits show symptoms of lumpy rind (5). Bryan (1) assumed that this alteration could be caused by boron deficiency, analogously to what had been demonstrated for hard fruits of Rhodesia (4); however, it seems to me that no systematic nor definitive experiments on this matter (2) have been carried out in Florida. I, too, at first, thought that impietratura, because of the similarity to Rhodesian hard fruits, could be caused by boron deficiency; however, the experiments carried out on this subject and the results of leaf analyses did not confirm this hypothesis (6). Recent leaf analyses of grapefruit trees grown in Sicily, whose fruits show lumpy rind symptoms identical with those observed in Florida (4), have also revealed a rather normal boron content (40-54 ppm). Maybe an identity of symptoms corresponds to two causes, a nutritional one in Florida and South Africa, and a pathological one in Sicily and other Mediterranean countries. The possibility cannot be excluded, however, that in any geographical area either boron deficiency or presence of a virus may work; and, therefore,

transmission experiments and leaf analyses could be helpful in clearing up any doubt.

To avoid spread of impietratura in Mediterranean countries where the disease has been found, a more careful choice of mother plants, from which propagation buds are to be taken, and the elimination of severely attacked trees are to be recommended. It will be helpful in controlling the disease if the experts who carry out the preliminary selection of citrus (particularly orange) trees for freedom from tristeza, psorosis, xyloporosis, and exocortis will look for fruits with lumpy rind or impietratura symptoms.

Literature Cited

1. Bryan, D. C. 1940. Malnutrition symptoms of citrus with practical methods of treatment. Florida State Dept. Agr. Bull. (n.s.) 93: 34-35.
2. Camp, A. F., Chapman, H. D. and Parker, E. R. 1949. Symptoms of citrus malnutrition, p. 308-310. Chapter IX of Hunger Signs in Crops. The American Society of Agronomy and The National Fertilizer Association. Washington, D.C.
3. Fawcett, H. S. 1936. Citrus diseases and their control. Second ed. McGraw-Hill Book Co., New York and London. 656 p. (See the spot at the center of fruit E, Fig. 145.)
4. Mossir, A. A. 1938. Some observations on the effects of boron treatment in the control of "hard fruit" in citrus. J. Pomol. Hort. Sci. 16 (2): 167-181.
5. Rhoads, A. S., and Debusk, E. F. 1931. Diseases of citrus in Florida, p. 164-166. Florida Agr. Expt. Sta. Bull. 229.
6. Ruggieri, G. 1955. Le arance impietrate. Riv. Agrumicoltura 1: 65-69.
7. Ruggieri, G. 1959. Present position of citrus virus diseases in Italy. Report of the International Conference on Virus Diseases of Citrus, p. 53. Acireale.