A SURVEY OF CITRUS VIRUS DISEASES IN THE MEDITERRANEAN AREA[1]

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INTRODUCTION

In surveying the broad problem of virus diseases in the Mediterranean area, one encounters such difficulties as the clarification of conflicting hypotheses that revolve about the question of tristeza-xyloporosis relationships and the diversity of agricultural and climatic conditions under which citriculture is practiced in this extensive area. We acknowledge the help of various agencies in overcoming these difficulties.

First of all, I should like to mention the plant pathologists who have investigated citrus diseases in the Mediterranean countries and in the United States and have contributed to the clarification of the problems involved. Special mention should be made of the late Professor H. S. Fawcett, who was the first American plant pathologist to visit the Mediterranean area, and who discovered the existence of psorosis in this area and helped in observations of the xyloporosis disease. In recent times, Dr. J. F. L. Childs and Dr. E. O. Olson have helped clear up important problems connected with xyloporosis.

I wish, also, to thank the United States Overseas Mission for assistance in the form of subsidies, which, since 1955, have enabled us in Israel to continue our work with the help of a screenhouse in which we could carry out indexing verification of previous findings. I am also deeply grateful to that organization for having made it possible for Dr. J. M. Wallace to work with us for a short but valuable period during which we drew much from his rich experience.

Of crucial importance in enabling us to carry out the Mediterranean survey was the European and Mediterranean Plant Protection Organization (EPPO), under the direction of Dr. V. E. Wilkins. This organization effectively planned and implemented my exploratory mission by making arrangements with the various governments involved. I was thus able to visit seven citrus-producing countries: Cyprus, Greece, Yugoslavia, Italy, Spain, Portugal, and the Côte d'Azur (southern France) in a period of 4½ months.[3]

The insight gained on this tour of duty into conditions in the Mediterranean area as they relate to citrus virus diseases combined very well with the findings of Childs *et al.* (*3*) in Egypt in 1956, as well as with Frezal's (*5*) experiences in Algeria, and my earlier survey in southern Turkey (*11*). All these studies make it possible to present a clearer picture of the situation concerning citrus virus diseases in the Mediterranean area.

It should be emphasized that all my conclusions on the status of virus diseases in the

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Mediterranean countries, aside from Israel, where indexing tests on Mexican lime have been made, are based on observations and examinations of exterior clinical symptoms such as decline and pitting marks. It may be that indexing tests on differential hosts will reveal the presence of virus diseases not mentioned herein.

PROBLEMS AND AIMS

The problems which have most frequently beset our work in the determination of citrus virus diseases in the Mediterranean area have been, for the most part, a matter of disease diagnosis. Little difficulty was encountered with psorosis and exocortis, since these diseases were easily identified by their distinct and quickly recognizable symptoms. Tristeza, xyloporosis, and little leaf are much more difficult to deal with. They present one of the most complicated and controversial problems in plant virus diseases of the last five years. In this report, I shall pay special attention to these three diseases.

From the practical point of view, questions of primary importance for the area are the following:

1) Does tristeza exist in the Mediterranean countries?
2) Is there a relationship between tristeza and xyloporosis?
3) Are psorosis and exocortis important diseases?
4) Which rootstock-scion combinations are susceptible to xyloporosis?
5) By what means is xyloporosis transmitted, other than by budwood?

VERIFICATIONS

The data presented in this section are drawn from our studies in Israel, Turkey, and, very recently, in other Mediterranean countries.

Tristeza in the Mediterranean Area

Graft-indexing experiments for tristeza have been reported from two Mediterranean countries—Italy and Israel. Russo (*13*) found tristeza in a variety of Satsuma that had been grown for some time in Italy. Work in Israel (*9*) revealed that as many as 16 species and varieties of *Citrus* introduced to Israel from foreign countries (the United States, Australia, and South Africa) were carriers of the tristeza virus. No native varieties have as yet been found to be infected. In my tour of the Mediterranean countries I carefully searched for tristeza and examined most of the declining trees of sweet orange and mandarin on sour orange stock that were encountered, but in every case these trees turned out to have typical xyloporotic pitting.

Tristeza and Xyloporosis Relationship

The question of relationship between these diseases gained particular urgency with the publication of McClean's note (*6*) in 1950, in which he suggested that tristeza might indeed be identical with xyloporosis, which had previously been discovered in Palestine (*11*). Since then, citrus growers in all the Mediterranean countries have grown fearful for the future of their groves.

Much of the confusion surrounding the similarity of the two diseases was cleared up when graft inoculations of Mexican lime seedlings from tristeza-infected sources gave clear indications of the presence of tristeza by the visible reaction of vein-clearing, while inoculations of similar seedlings from xyloporosis sources gave no such symptoms (*9*). This gave decisive support to the contention that the two are distinct and separate (*15*).

There was some speculation that xyloporosis was a genetical condition rather than a virus disease (*15*). In our experiments, xyloporotic budwood was budded onto sweet lime in a screenhouse. Two years have now passed, and as yet no positive results have

been detected. However, in outside commercial nurseries, symptoms have appeared within two to three years. Childs gained positive results when xyloporotic buds were propagated onto sweet lime and Orlando tangelo seedlings (*2*).

Distribution of Xyloporosis, Psorosis, and Exocortis

Xyloporosis. Childs' observations in Spain (*1*), Frezal's in Algeria (*5*), and our own survey throughout the Mediterranean area have shown how very widespread xyloporosis disease is. Heretofore it had been assumed that xyloporosis was not to be found in the western Mediterranean countries. However, trees over 100 years of age in Cyprus, Greece, and Portugal were heavily marked with xyloporotic peg-pit symptoms.[4] This would indicate that xyloporosis is well established in all of the Mediterranean area and might even be indigenous to this area.

Psorosis. In Israel, psorosis (mostly type "A") is associated with Valencia orange and grapefruit and at present is of little importance economically as a citrus disease (*8*). Childs *et al.* (*3*) report heavy infection of most *Citrus* species in Egypt. Infection of Valencia orange there is described as up to 100 per cent in some orchards, and even the least infected citrus variety (Khaldi) has a toll of as much as 50 per cent. No psorosis-affected trees were found in Greece, Yugoslavia, southern France, or Portugal. In Italy single-tree cases were observed. But in Spain psorosis was found to be well established and doing great harm, particularly to Washington Navel and Valencia orange trees.[5] Childs (*1*) also reports great damage in Spain. The disease is said to be extensive in North Africa (*5*).

Exocortis. This disease manifests itself only in trees grafted on *Poncirus trifoliata* and some hybrids of this species. Only in Yugoslavia is *P. trifoliata* systematically used as a rootstock, and it is of importance there because of its capacity to resist frost.[6] We found many orchards inYugoslavia in which the trifoliate rootstocks were affected by exocortis and the scions showed decline. In Italy, several cases were found at the Citrus Experiment Station in Acireale.[7] Wallace observed a few cases in Cyprus. Single-tree cases are known in Israel. This disease has not been observed elsewhere in the Mediterranean area.

Stock-Scion Combinations

From our observations in Israel and throughout the Mediterranean area, we can state unhesitatingly that all the common commercial stock-scion combinations of citrus in these countries are susceptible to xyloporosis. This does not mean that the symptoms are always associated with decline. Quite the contrary. Many of the trees appear healthy, and yields are good despite the presence of the peg-pit symptoms. Among the examined affected trees, however, were individual trees that were entirely free of any pitting symptoms.

In Israel as in Cyprus, it is notably sweet lime-sweet orange combinations which suffer most drastically from xyloporosis. In 1933 I found similar conditions in Lebanon, Syria, and southern Turkey (Alexandrette) (*11*). On the other hand, where sour orange rootstocks were used, the trees in general seemed very healthy. Only in single cases did such grafted trees show poor growth.

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[4] Reichert, I. Unpublished. Reports on the results of a study of citrus virus diseases in Cyprus, Greece, and Portugal. Submitted to the respective ministries of agriculture. 1957.

[5] Reichert, I. Unpublished. Report on the results of a study of citrus virus diseases in Spain. Submitted to the Ministry of Agriculture, Spain. 1957.

[6] Reichert, I. Unpublished. Report on the results of a study of citrus virus diseases in Yugoslavia. Submitted to the Ministry of Agriculture, Yugoslavia. 1957.

[7] Reichert, I. Unpublished. Report on the results of a study of citrus virus diseases in Italy. Submitted to the Ministry of Agriculture, Italy. 1957.

It was in 1928 that many thousands of young sour-grafted sweet orange trees in Israel suddenly manifested stunted growth, little leaves, lopsided fruit, and decline. Some of the suffering trees also showed at the same time xyloporotic pitting at the union and on the rootstock.

We described this diseased stage of young trees as a separate disease under the name "little leaf" (*10*). However, after a period of years, sufficient data have been gathered to show that "little leaf" and xyloporosis are two manifestations of the same disease (*12*). Only a small percentage of sour-grafted sweet orange trees is affected by this "little-leaf" form of xyloporosis, seemingly because sour orange in Israel is, in general, tolerant of xyloporosis. However, there are sour orange clones or biotypes that are susceptible to this disease. The existence of clones of sour orange susceptible to xyloporosis is borne out by the fact that in an extensive grove experiment in Israel, the local Shamouti sweet orange suffered badly when grafted on rootstocks of Brazilian, California, and Floridian varieties of sour orange. The trees showed little leaves, some lopsided fruit, and decline; whereas, when they were grafted on the Palestinian sour orange variety, normal good growth occurred (*12*).

On my recent visit in Cyprus, I discovered the typical xyloporotic "little-leaf" symptoms on young Valencia trees grafted on sour orange, as found in Israel in 1928.[3] These young trees displayed little leaves, stunting, a certain amount of lopsided fruit, and pitting in the sour stock. In other Mediterranean countries we noticed only single older trees grafted on sour orange which showed withertip and decline. The number of such declining trees increased where growth conditions were poor. Most sour-grafted sweet orange trees (of all varieties of local sweet orange) showed good growth.

But the most interesting phenomenon was that nearly all the healthy sweet oranges on sour orange examined manifested xyloporotic pitting. These trees seem, therefore, to be carriers of xyloporosis virus without showing decline.

Mandarin trees were consistently and drastically affected by xyloporosis no matter in which combination they were found. In Cyprus, Greece, and Italy the mandarin showed the characteristic cachexia type of xyloporosis—that is, gum pockets on the inner side of the bark—whereas in Portugal and parts of Spain it showed no such symptoms.

The grafting of sour lemon on sweet lime is current practice only in Israel and Cyprus, and, on the whole, presents a total failure. When sour orange is used as a rootstock for lemon, however, the results are satisfactory throughout the Mediterranean area. Of course, where the scion is affected by mal secco, xyloporosis shows greater virulence. Most of the lemon trees that I examined in Italy, Spain, and Portugal were marked by xyloporotic pitting, sometimes associated with inverse pitting, a symptom described later in this paper.

Virus Transmission

In our first work on xyloporosis, in 1934 (*11*), we reported that sweet lime seedlings were found showing symptoms of xyloporosis. The possibility of transmission of this disease through the seed was therefore considered. Some experimental evidence reported by Childs (*2*), and now our new finding of xyloporosis-pitted lime seedling trees in Cyprus, support the opinion that the virus may be seed-transmitted. In my recent Mediterranean survey, I found sour orange seedling trees showing xyloporotic pitting in Cyprus, Greece, Yugoslavia, and particularly in Spain, where great plantations of sour oranges are cultivated. All of these seedling trees showed unmistakable symptoms of xyloporosis, but only a few showed any severe curtailment of growth.

Still more interesting are our findings on sweet oranges growing on their own roots. In Israel and Italy we observed xyloporotic pitting on single sweet orange seedling trees. In Portugal, however, we found an entire orchard of sweet orange seedling trees

showing pronounced symptoms of xyloporotic pitting. In another orchard, we also found a fair number of sweet orange seedling trees in a declining state.

All of these observations have made the supposition that xyloporosis may be transmitted through seed a more likely one. A final appraisal should not be made, however, until seedlings from infected trees can be grown under insect-free conditions. The question of insect transmission of xyloporosis therefore needs additional study. Limited tests made in Israel have given negative results (*9*).

Inverse Pitting

In 1952, an unusual symptom was brought to our attention and puzzled us somewhat, for it was found in association with an otherwise conventional xyloporosis syndrome. This symptom consisted of the appearance of very minute pits on the cambial face of the bark and very tiny pin-like pegs on the wood—the very reverse of the well-known peg-pit symptom of xyloporosis as it appears in most stricken trees (*12*). A similar symptom, described earlier in the United States and called "honeycombing," was considered by some workers as characteristic of tristeza (*4*). Trees showing inverse pitting associated with normal xyloporosis were indexed by us in Israel on Mexican lime and found to be negative with regard to tristeza. Olson *et al.* (*7*) obtained negative results with a similar disorder occurring on tangerine grafted on sour orange. It is not yet clear whether this is a new disease or not. Schneider's recent paper (*14*) on chronic decline attacking sweet orange trees on sour orange stock showing inverse pitting may also be mentioned in this connection.

In my survey I came across many declining trees of sweet orange, various mandarin varieties, citron, and lemon that showed inverse pitting. At times, the inverse pitting appeared alone; at other times, it appeared in association with xyloporosis symptoms. This inverse pitting was found quite often with lemons on sour orange in Reggio-Calabria, Italy. In Acireale, Sicily, I likewise found a group of Santa Maria lemon trees declining and showing inverse pitting. This puzzling symptom requires more study.

SUMMARY AND CONCLUSIONS

From this discussion of virus diseases of citrus in the Mediterranean area, the following points may be inferred:

1. Tristeza disease symptoms were not encountered on indigenous citrus varieties in any of the following countries: Israel, Turkey, Cyprus, Greece, Yugoslavia, Italy, southern France, Spain, or Portugal; nor are they to be found, according to Childs *et al.* (*3*) and Frezal (*5*), in Egypt or Algeria. In Israel and in other countries visited, all examined declining sweet orange trees grafted on sour orange showed xyloporotic type of pitting. On the basis of experimental tests in Israel, it is assumed that the tristeza virus is not present in these trees.

2. Exocortis was observed only on citrus varieties grafted on *Poncirus trifoliata* and is a significant disease only in Yugoslavia.

3. Psorosis seems to be a serious problem only in Spain and Egypt.

4. The disease which has become most widespread in citrus throughout the Mediterranean countries is xyloporosis. It is present in all species and varieties of *Citrus*.

5. The rootstock that is most susceptible to xyloporosis is sweet lime, which is still cultivated in parts of the eastern Mediterranean.

6. The rootstock most resistant to xyloporosis is sour orange, although certain clones or biotypes of this species seem to be susceptible. Healthy-appearing citrus trees often (but not always) show xyloporotic symptoms in both the stock and the scion, and are therefore carriers of the xyloporosis virus.

7. The scion most susceptible to the cachexia type of xyloporosis is the mandarin (all varieties). This susceptibility has become a serious matter in the eastern part

of the Mediterranean—Israel, Egypt, Cyprus, and Greece; it is less so from Yugoslavia westward to Portugal.

8. The fact that the two widely used rootstocks (sweet lime and sour orange), and the scion components of all native citrus varieties, were found to have symptoms of xyloporosis suggests that all the native *Citrus* species and varieties in the Mediterranean area carry the xyloporosis virus.

9. The fact that a certain number of trees were found to be without any symptoms of xyloporosis gives hope for a possible development of a certification system for the production of xyloporosis-free trees.

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