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Unproductivity of Navel Orange Trees in Spain; a New Disease?

P. Moreno and M. Aparicio

A few years ago a severe low production problem was detected on sweet orange trees in different orchards in the northern area of Valencia, Spain and, recently, increasing numbers of trees have been affected by this problem. Most of the trees are Washington navel orange, but a few affected Valencialate trees have been found. All diseased trees are on sour orange, the common rootstock in that area. In some orchards, the disorder occurs only in a few trees, while in others up to 50 per cent are affected.

The abnormal trees are not infected by tristeza virus. Other citrus "viruses" (exocortis, psorosis, xyloporosis, etc.) are so common in Spain (Navarro *et al.*, 1980) that they are not considered to be the cause of this problem. Some symptoms of affected trees resemble those of trees with stubborn, and it was generally believed that unproductivity was related to that disease (Calavan, 1972; Sanchez-Capuchino *et al.*, 1974). This paper reports the symptomatology of affected trees and some experiments directed mainly to determining whether or not the low production problem is due to stubborn.

SYMPTOMATOLOGY

The disorder usually appears on 15- to 20-year-old normal-bearing trees. Affected trees produce very low or no crops. Foliage frequently appears thin and dull-green, especially in early spring. Abnormal twig dieback occurs mainly in autumn. Mature leaves are usually small, abnormally rounded and cupped or boat-shaped and may show mottling or zinc deficiency patterns (fig. 1). The spring flush is frequently delayed and few shoots are produced. A heavy spring bloom usually occurs. Most of the flowers are produced on very short shoots without new leaves, appearing as clusters (fig. 2). Off-season blooms and fruits of several ages occur on the same tree but affected trees produce normal fruits. In certain cases, symptoms appear in only one sector of a tree, then eventually the whole tree becomes affected.

No difference has been observed between trunks or roots of normal and affected trees. Yields and symptom intensity vary from year to year and from orchard to orchard.

EXPERIMENTS AND RESULTS

Attempts to perpetuate the disease. Buds from seven unproductive navel trees were propagated on sour orange, Troyer citrange, and rough lemon seedlings. Three propagations on each rootstock were made from each tree. Two years later, the young budlings showed no abnormality.

Graft-transmission experiments. Three normal 41-year-old navel trees on sour orange were topworked with 20 bud-patches from each of the seven unproductive navel trees used in the above experiment. Three additional trees were topworked with bud-patches from healthy navel trees. Two years after grafting, buds from abnormal trees have produced shoots with normal appearing foliage.

In these topworked trees, part of the original tree was allowed to grow. Two years after grafting, foliage of the original navel trees appeared normal and no difference in blooming was observed between inoculated and control trees.

Unproductive trees were tested for stubborn by side-grafting two budsticks from each abnormal tree to Pineapple or Madam Vinous sweet orange seedlings. A minimum of three indicator plants was used in each experiment. Inoculated seedlings were cut back above the upper budstick and kept in a warm greenhouse, minimum 27° and

Fig. 1. Zinc deficiency pattern in small leaves of an unproductive tree.

Fig. 2. Heavy blooming in abnormal tree. Note flowers in clusters and small cupped leaves.

maximum 32°C. In some cases, additional tests were made by grafting young leaves, less than 2 cm long, produced by these budsticks onto Madam Vinous sweet orange seedlings. The inoculated plants also were grown in the warm greenhouse. Indicator plants inoculated with a California stubborn isolate were used as positive controls and self-inoculated seedlings were included as negative controls. Positive control plants showed good stubborn symptoms but inoculum from the 100 field trees tested induced no specific symptoms on any indicator seedlings.

Attempts to culture *Spiroplasma citri*. We attempted to culture *S. citri* by the method of Fudl-Allah *et al.* (1972). We made 113 attempts to culture from shoots of field trees in the summer and 230 attempts to culture from shoots of Madam Vinous seedlings inoculated in the greenhouse. We also cultured 40 shoots from positive control plants. *Spiroplasma* growth was obtained in 31 of 40 positive controls but no *Spiroplasma* was obtained from any other sources.

Attempts to detect spread of *S. citri* in the field. Madagascar periwinkle plants were placed in orchards with unproductive trees to detect possible spread of *S. citri* in the field (Granett *et al.*, 1976). A total of 240 periwinkles were put in 13 orchards in summer 1977 and 400 periwinkles in 20 orchards in summer 1978. None of these plants was infected by *S. citri* while growing in orchards for 3-5 months.

Experiments with tetracycline treatment. Trunks of unproductive navel trees were injected with 0, 0.5, 1.0, or 1.5 g of tetracycline hydrochloride in 10 ml of 7.5 per cent aqueous solution of citric acid (Sands *et al.*, 1975). Six slanted holes 7 mm in diameter and 5 cm deep were drilled around the trunk 25 cm above the bud union and the 10 ml of solution was injected with a syringe into the holes and taken up naturally by the trees. Injections were done at blossom time in 1978 on seven trees/treatment. None of the treatments produced any significant effect on foliage or fruit production.

DISCUSSION AND CONCLUSION

Absence of stubborn symptoms in graft-inoculated indicator seedlings and consistent failure to culture *S. citri* from field trees and from greenhouse-inoculated plants suggest that navel unproductivity in the Valencia area is not caused by stubborn.

Isolation of *S. citri* has been reported from a few trees in the northern area of Valencia (Alfaro *et al.*, 1976) but we have been unable to confirm its presence in unproductive trees selected from the same area. *Scaphytopius nitridus* (De Long) and *Circulifer tenellus* (Baker), natural vectors of stubborn in other countries (Oldfield *et al.*, 1976, 1977) have not been found in Valencia area citrus groves (Hermoso de Mendoza and Medina, 1979) and no stubborn infection has been detected in periwinkles growing near unproductive trees. These findings provide additional evidence that the low production of an increasing number of trees is not due to *S. citri*.

Negative response to tetracycline treatments does not exclude *S. citri* or some other mycoplasmalike organism (MLO) as the possible causal agent of the disorder (Calavan and Gumpf, 1974). Nevertheless, no MLO has been found in young shoots from abnormal field trees in a limited number of observations by electron microscopy.

Diseased navel trees resemble, in certain aspects, citrus declines described from different countries (Schwarz, 1977). Diagnosis of declining trees is difficult due to inconsistent graft transmission and lack of specific indexing methods. Some indirect diagnostic methods have been proposed. Trees affected by young tree decline in Florida take up less water by gravity injections of their trunks (Cohen, 1974) and accumulate more zinc and water soluble phenolics in the wood (Wutscher *et al.*, 1977*b*) than healthy trees. Zinc and water soluble phenolics also accumulate in the wood of trees affected by marchitamiento repentino in Uruguay (Wutscher *et al.*, 1977*a*). In preliminary trials, normal and abnormal navel trees have not shown significant differences in water

uptake nor in concentrations of zinc and water soluble phenolics in the wood.

Young propagations from unproductive trees on sour orange, Troyer citrange, and rough lemon, and inoculated mature navel trees on sour orange have not yet reproduced symptoms of the disease.

In summary, present evidence suggests that unproductivity of navel trees in the Valencia area is not caused by stubborn. Additional work will be required to clarify the nature of the problem. Presently, it does not seem to be caused by any known citrus virus or viruslike pathogen. The disorder might have a genetic or physiological origin, but the possibility of a new disease should not be discarded.

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