Distribution of Stubborn Disease in Iran

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The incidence of stubborn disease of citrus in Iran has been variously reported from rare to nearly universal (Chapot, 1970, 1975; Wallace, 1973). This variance is due to the extreme difficulty of stubborn diagnosis. Electron microscopic demonstration of the presence of the causal organism *Spiroplasma citri*, and cultural techniques could simplify the problem but until adequate equipment is available in Iran diagnosis must be made on visual symptoms in the orchard and transmission to test trees in the greenhouse. Unmistakable cases of stubborn were seen on Marsh grapefruit, Gillette navel and local tangerine in the Geroft valley in south central Iran and on local sweet orange in the Chapoor valley near Kazerun. The orchard trees showed characteristic stubborn symptoms of small misshapen fruit, sparse fruiting, aborted seeds and dieback (Calavan and Carpenter, 1965; Calavan, 1969). Some trees were only partially affected suggesting recent infection. Transmission from the Gillette navel to pineapple orange seedlings in the greenhouse confirmed the field diagnosis.

FOLIAGE DISTORTION ASSOCIATED WITH HIGH TEMPERATURE

Diagnosis of stubborn by visual symptoms is complicated in Iran by atypical growth responses during the hot season, some of which simulate symptoms of stubborn. Maximum daily temperatures in the Khuzestan range between 44-48°C, with occasional peaks above 50° during June 15 to August 15. At temperatures above 46°C old citrus leaves in the direct sun may scorch, but young shoots develop atypical growth. The midrib is shortened and leaves become ovoid with blunt and rounded apices instead of their normal elliptical shape. Some develop the pinched-in tip similar to that described for stubborn (Calavan, 1969) but without the characteristic mottling (Calavan, 1969; and Olson, 1969). Leaves also become cupped and in extreme cases the midrib becomes so shortened it causes heart-shaped leaves. On large trees there is more distortion on the south and west sides which receive more sun exposure than the other side of the trees. No abnormal leaf distortion was seen on trees in the area of the Caspian sea where temperatures seldom reach even 37°C.

The atypical growth is most pronounced on seedy sweet orange cultivars such as Pineapple, Madam Vinous, Valencia, and Dezful orange. Some deformities occur on Navel, Tarocco, Salustiana orange, Chandler pummelo, and to a lesser extent on Marsh grapefruit and sour orange. The distorted growth appears to be cyclic on shoots with short internodes produced during the hot season. Abnormal growth characteristics, to this point, seem to fit well into the described stubborn syndrome. However, cultivars like Dezful orange which develop strikingly distorted foliage in the hot climate bear good crops of fruits with good seeds and no embryo abortion. Unbudded sweet orange seedling liners in the nursery are uniformly and more strikingly affected than larger trees. Small seedbed stock under six months old developed off-shaped leaves as soon as exposed to hot weather. All attempts to transmit from such affected trees have been negative in the greenhouse.

OTHER STUBBORN SUSPECTS

Wallace (1973), in addition to pointing out the distorted foliage, raised questions about certain dwarfed navel trees at the Safiabad Research Center Station and unfruitful sweet orange trees in local gardens. All attempts to transmit from

the dwarfed trees at Safiabad have been negative. Some of these have been shown to be affected by exocortis. The unfruitful condition of sweet orange trees in local gardens has been related to juvenility. Most are thorny and vigorous and other than distorted foliage have no symptoms of stubborn. Some growers of old gardens still prefer seedlings to budded trees and have selected the thorny juvenile types as indicative of the true Dezful orange. All attempts to transmit stubborn from the juvenile type trees have been negative.

DISCUSSION

The presence of stubborn disease in Iran has been established by observation, electronmicroscopy (D.A. Newcomb, personal communication, 1974), and transmission tests. The amount of stubborn, however, is still unknown due to the difficulty of diagnosis. Calavan and Carpenter (1965) reported the stubborn syndrome to include bunchy upright growth, shortened internodes, smaller than normal leaves, of which some were buckled, cup-shaped, heart-shaped, mottled and characteristically pinched near the apex. The syndrome also included small, lopsided or acorn-shaped fruit, stylar-end greening, blue albedo, seed abortion, and early mummification. Not all symptoms occurred on all trees. Calavan (1969) presented clear illustrations of the type of leaf malformation and chlorosis produced by stubborn on Madam Vinuous seedlings in the greenhouse. None of his illustrations in this paper show the kind of ovoid, blunt- and round-apexed or heart-shaped leaves commonly present in Iran. Olson (1969), reporting work done in the Coachella Valley of California where temperatures approach those in the Khuzestan plain of Iran, dealt mostly with efforts to relate visual symptoms on suspect trees to transmission in the greenhouse. He considered the mottle-leaf syndrome produced on grapefruit seedlings as his best evidence of transmission. In his fig. 1. labeled "Stubborn foliage" of a 5-year-old nucellar Valencia at Indio, California, distorted and heart-shaped leaves of the type seen in Iran are readily discernible. He apparently did not relate these to stubborn by transmission.

Wallace (1973) made careful observations of the distorted foliage and heart-shaped leaves in the Khuzestan but did not have time to relate these to stubborn transmission. He was also careful to point out that such symptoms, while similar to those described for stubborn, must be confirmed by transmission. He sent budwood from affected trees to the laboratory of the Institut National de la Recherche Agronomique, Bordeaux, France, for examination and transmission tests. No *Spiroplasma citri* was found and transmission was negative (J.M. Wallace, personal communication, 1974).

If the type of leaf distortion and heart-shaped leaves which occur so widely are true symptoms of stubborn then we can only conclude that stubborn is nearly universal in sweet orange in Iran. Opposed to this conclusion, however, is the fact that many Dezful orange trees with much leaf distortion and many heart-shaped leaves bear good crops of fruit with a full complement of seeds. Such trees do not have other symptoms of the stubborn syndrome. When buds from such affected trees are forced in the greenhouse under day/night temperatures of 37/25°C (Chapot, 1970) shoots from them bear only normal leaves and no transmission results. The fact that distorted growth occurs only during the high temperature season and is more prevalent on the sun-exposed sides of trees is further evidence of its relationship to heat. The occurrence of distortion on small seedlings in seed beds, if indicative of stubborn, would signify an unlikely, extremely high rate of spread. Extreme distortion of shoots, with off-shaped, miniature leaves in roses, apricots, and plums grown during the hot season in Khuzestan supports the premise of heat-induced abnormal growth. It should be reemphasized that citrus in the Khuzestan is grown under higher temperatures than in any other commercial citrus growing area.

We do not wish to be hasty in our conclusion, but with the current information we believe that most of the growth distortion occurring on citrus in the Khuzestan is a response to heat and not indicative of stubborn. We also raise a question whether such heat-induced distorted growth in other high temperature areas such as in the Coachella Valley of California should have been included in the stubborn syndrome. We have effected transmission only from trees having upright rigid growth, fruit symptoms and other characters indicating general unthriftiness. With these explanations we are of the opinion that most of the trees in southern Iran diagnosed as stubborn are actually distortions associated with a heat response and that stubborn is relatively rare.

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