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Comparative Reactions of Orlando Tangelo and Palestine Sweet Lime to Cachexia and Xyloporosis

WHETHER cachexia and xyloporosis are caused by distinct viruses or the same one is a matter of controversy (4, 6, 8). Consequently, in this paper, xyloporosis refers to a wood-pit and gummy-peg disease of sweet lime, *Citrus limettioides* Tanaka, and sweet lemon, *C. limetta* Risso, and cachexia to a similar disease of mandarin orange, *C. reticulata* Blanco, and tangelo, *C. reticulata* Blanco x *C. paradisi* Macf. The paper itself deals with results obtained when sweet lime and tangelo seedlings were grafted with buds from trees having symptoms of cachexia, xyloporosis, or lignocortosis (wood pocket), or from trees of eastern Mediterranean origin that possibly carry xyloporosis virus.

Materials and Methods

Seedlings of Palestine sweet lime and Orlando tangelo were grown in a glasshouse for six months and transferred in July, 1956, to the nursery. In 1957 they were grafted with buds from one or another of the old-line trees described below, with buds from a young-line Shamouti orange, *C. sinensis* (L.) Osbeck, which carries vein enation virus, or with young-line grapefruit, *C. paradisi* Macf. Some of the young-line Shamouti orange and young-line grapefruit propagations were inoculated by grafting them subsequently with buds from one or another of the old-line trees listed below:

1. Marsh grapefruit; 2 trees more than 25 years old, 1 on sweet lime and 1 on Millsweet sweet lemon stock; both with symptoms of xyloporosis.

2. Shamouti orange 25 years old on Cuban shaddock (a lemon hybrid) stock, infected with vein enation and exocortis viruses.

3. Egyptian blood orange 40 years old on Rough lemon, *C. jambhiri* Lushington, stock infected with exocortis, psorosis, and vein enation viruses.

4. Washington Navel orange 26 years old on Millsweet stock with mild symptoms of xyloporosis.

5. Valencia orange 29 years old, a stunted tree on Millsweet stock with severe symptoms of xyloporosis.

Routine indexing of these budwood source trees, started in 1957, has remained negative for exocortis, psorosis, tristeza, and vein enation, except as recorded above.

Experimental trees of the combinations listed in Table 1 were planted in the field, with 10' x 12' tree spacing, in the spring of 1958. The 20 old-line grapefruit trees, those on Orlando tangelo alternating with those on Palestine sweet lime stocks, were planted in 1 row and the other 78 trees were planted nearby. All received standard cultural practice. Additional indicator plants for cachexia and xyloporosis, having been budded from trees affected by lignocortosis or by cachexia, were planted in 1958 for comparison with the 98 trees listed above.

In November 1959, a ½-inch strip of bark, extending ½ inch above and 2 inches below the bud union, was removed from each budded tree. Bark and exposed wood were examined for gumming, pegging, and pitting. Similar examination was made about 3 to 6 inches above ground on trunks of seedlings. In September, 1960, a square section of bark was removed from each tree, near ground level, to determine the amount of wood pitting and gum deposition. Abnormalities visibly associated with dormant buds and thorns were not recorded.

Results

Symptoms of cachexia were noted in 9 of 26 inoculated tangelo plants in November 1959. The 15 tangelo controls were normal. Xyloporosis symptoms were found in 8 of 41 inoculated sweet lime plants. Eight more inoculated sweet lime plants were classed arbitrarily as disease suspects because only 1 or 2 pits were found in each. On the same basis, 8 sweet lime controls were suspects.

Disease readings made in September, 1960, are in Table 1. Most pits in the wood of tangelo were concave depressions, 0.2-0.5 mm deep, with slight vertical elongation (Fig. 1A), but some were laterally flattened

TABLE 1.—DISEASE READINGS, SEPTEMBER, 1960, ON CACHEXIA AND XYLOPOROSIS INDICATORS INOCULATED IN 1957

Inoculum source[a]	Indicator variety or combination[a]	Apparent disease incidence[b,c] number of plants +	number of plants ?	number of plants —	Plants[b] with gum	Average number[b] of pits per cm^2
Marsh GF	OT seedling	3	0	0	3	8.9
	INOC/OT	8	2	0	6	25.8
	INOC/PSL	6	4	0	6	1.3
	Shamouti YL/PSL	2	0	0	2	3.6
	PSL seedling	3	4	0	2	2.1
Shamouti OL	INOC/OT	1	1	0	1	3.0
	INOC/PSL	0	3	0	0	0.5
Blood	INOC/OT	0	0	2	0	0.0
	INOC/PSL	2	0	0	0	2.9
	Shamouti YL/PSL	0	3	1	0	0.6
Navel	INOC/OT	0	1	1	0	0.1
	Shamouti YL/PSL	2	1	0	1	7.3
Valencia	OT seedling	0	0	2	0	0.0
	INOC/OT	0	0	5	0	0.0
	INOC/PSL	1	2	1	0	0.7
	Shamouti YL/PSL	0	1	1	0	0.1
	PSL seedling	0	2	2	0	0.3
None	OT seedling	0	1	6	0	0.1
	GF YL/OT	0	1	7	0	0.1
	Shamouti YL/PSL	1	1	2	0	0.8
	PSL seedling	2	6	4	1	0.8

[a]GF=grapefruit; INOC=scion propagated from inoculum source; OL=old line; OT=Orlando tangelo; PSL=Palestine sweet lime; YL=young line. See text for detail.

[b]Based on macroscopic examination of bark and wood in an area 4.5 cm^2 about 1 inch above ground on the south side of each tree.

[c]+ column contains plants having gum and 1 or more pits, or no gum and at least 5 pits; ? column contains other pitted plants; — column contains plants with no pits in the sample.

inverted cones. Severe pinholing, or inverse pitting (9, 10), of the bark occurred in several diseased tangelo stocks (Fig. 1B). Severe symptoms of cachexia were found considerably below ground level on some trees (Fig. 1C). Many diseased tangelo plants had a layer of gum in the bark and spots of gum associated with pits in the wood. The phloem of these plants usually was more discolored than the phloem of sweet lime plants having symptoms of xyloporosis. Similar findings have been reported from Florida (3) and Texas (8).

Wood pitting of a conoid type (5, 12) was more severe in some of the young sweet lime plants, including some plants of the inoculated groups and some of the controls (Table 1), than on the diseased sweet lime stock of the old grapefruit tree (Fig. 1D, E, and F). Thirty-six of 41 inoculated and 10 of 16 control plants of sweet lime were found with wood pitting. Average concentration of wood pits in samples from inoculated trees was $1.7/cm^2$; from control trees it was $0.8/cm^2$. Two control plants were more intensively pitted than all but 5 of the inoculated plants. Gum, confined almost entirely to bark pegs, was found in 10 of 19 sweet lime plants inoculated with buds from old-line Marsh grapefruit, and in 1 of 16 controls. Bark-cracking occurred in sweet lime plants grafted with buds from trees known to be infected with exocortis virus (11).

Pitting of the wood and gumming of the bark developed more quickly, severely, and consistently in tangelo than in sweet lime when plants of these 2 varieties were grafted with scions from old-line Marsh grapefruit. Inoculation with old-line Shamouti orange buds transmitted cachexia to tangelo, but sweet lime stocks grafted with scions from the same Shamouti orange tree, thus far, have no definite symptoms of xyloporosis. Conversely, some of the sweet lime plants with grafts from Egyptian blood or Washington Navel orange have symptoms of xyloporosis, while tangelo plants grafted from the same sources have remained normal. Tangelo plants with grafts from Valencia orange have no symptoms of cachexia and, with 1 exception, sweet lime plants with Valencia grafts have not developed definite symptoms of xyloporosis. The average frequency of wood pitting in control plants of sweet lime is slightly higher than in sweet lime grafted with buds from old-line Shamouti or Valencia orange (Table 1).

Severe foliar chlorosis, not always associated with severe wood pitting and gum, was noted, in April, 1960, on Marsh grapefruit trees having tangelo stocks. In June, 9 of the 10 trees of this combination were very chlorotic and the other had mild chlorosis. One grapefruit tree on sweet lime stock was slightly chlorotic; the other 9 appeared normal. The remaining plants of this experiment had normal color except for chlorosis in the 2 Shamouti trees on tangelo stock and in the tangelo seedlings inoculated from Marsh grapefruit. Most chlorotic trees regained normal color by September.

Seedlings of Orlando tangelo and Palestine sweet lime grafted in 1956 with buds from old-line or from young-line semidense Lisbon lemon, *C. limon* (L.) Burm., trees having wood-pitting and other symptoms of lignocortosis have not developed symptoms of cachexia or xyloporosis. Sweet lime plants grafted in 1957 with buds from one or another of 2 cachexia-infected trees, a Clementine and a Willow-Leaf mandarin (2), developed symptoms of xyloporosis within 3 years.

Discussion

Xyloporosis has been reported in ungrafted seedlings of Orlando tangelo (7), Palestine sweet lime, and Shamouti sweet orange (9). Pitting resembling that of xyloporosis occurs in many Tahiti lime, *C. aurantifolia* (Christm.) Swing. and semidense Lisbon lemon trees affected by lignocortosis (1), and seems to be a part of the syndrome of this apparently noninfectious disease. It also has been observed by the authors in ungrafted field-grown seedlings of several species and varieties of citrus. Some wood pitting may be due to psorosis, tristeza, cachexia, or xyloporosis and some to noninfectious disorders or injuries. The authors have found pitting associated with California red scale, *Aonidiella aurantii* (Mask.). Other workers also have reported wood pitting caused by insects (5, 6). It is apparent, therefore, that wood pitting per se does not constitute proof of the presence of xyloporosis virus. It follows that it is impossible to diagnose xyloporosis on the basis of slight wood pitting alone, under local conditions.

Results of the inoculations from Marsh grapefruit and mandarin support the hypothesis (3) that cachexia and xyloporosis have the same

FIGURE 1. *Cambial faces of wood and bark of Palestine sweet lime and Orlando tangelo: A. Cachexia symptoms with shallow pitting of wood and pegging of bark in infected tangelo rootstock of 3-year-old Marsh grapefruit. B. Pinholing and pegging of bark and pitting and pegging of wood in cachexia-infected tangelo rootstock of 3-year-old Marsh grapefruit. C. Severe symptoms of cachexia about 8 inches under ground in main root from same tree as B. D. Xyloporosis symptoms in infected sweet lime rootstock of 3-year-old Marsh grapefruit. E. Xyloporosis symptoms in sweet lime stock of 26-year-old Marsh grapefruit tree used as the source of scion budwood for stocks shown in A, B, C, and D. F. Wood pitting in ungrafted 4-year-old seedling sweet lime.*

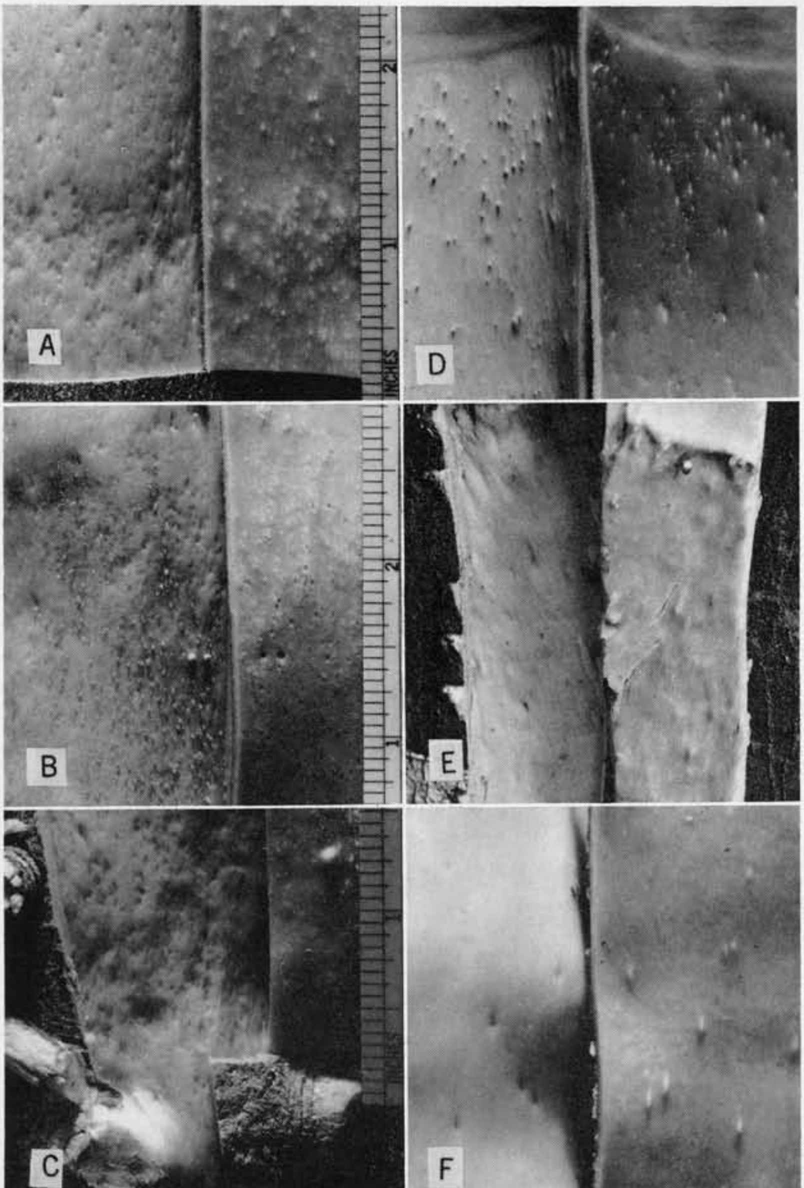

FIGURE 1

cause. Conversely, results of inoculations from other diseased trees support the suggestion by Grant *et al.* (6) that xyloporosis and cachexia have different causes. For example, the positive reaction of some Palestine sweet lime stocks grafted with old-line navel or blood orange buds contrasts with the negative readings on Orlando tangelo inoculated from the same source.

Although the variety of citrus used as tops may have influenced symptoms produced on the indicator rootstocks, it seems probable that not all source trees having pitted sweet lime and sweet lemon rootstocks had the same virus content. Perhaps the Valencia inoculation source had a mild strain of xyloporosis, or none, despite severe rootstock pitting.

Orlando tangelo has been a faster and more reliable indicator than Palestine sweet lime for cachexia in California. The value of Orlando tangelo as an indicator for xyloporosis has not, however, been demonstrated in these experiments. Its failure thus far to react to inoculations from 2 sweet orange trees, having sweet lemon stocks, with xyloporosis symptoms may be interpreted to mean that buds from the diseased navel and Valencia trees either contained no virus or had a virus content different from the cachexia virus strain or mixture transmitted from old-line Marsh grapefruit.

Some of the results from indexing old-line Shamouti, navel, and blood oranges still are inconclusive due to the small numbers of indicator plants used and the possibly inadequate ($3\frac{1}{2}$ year) incubation period. Contaminating viruses present in the inoculations from Shamouti and blood oranges may also have influenced symptom development in the indicator plants. The old-line Shamouti may carry xyloporosis virus bud-perpetuated from an earlier generation in Palestine, which is the type locale of xyloporosis, as Childs (4) has indicated, but in $3\frac{1}{2}$ years it has caused only bark-cracking on sweet lime stocks.

Summary and Conclusions

1. Orlando tangelo is a faster, more reliable indicator than Palestine sweet lime for the causal agent of cachexia present in some citrus clones.

2. Palestine sweet lime is a variable and, in small numbers, an unreliable index variety for xyloporosis because wood pitting may occur as severely in ungrafted seedlings as in plants grafted from trees having xyloporosis.

3. Certain old-line mandarin oranges with cachexia and some Marsh grapefruit trees with xyloporotic rootstocks contain the causal agent or agents of cachexia, and apparently that of xyloporosis; old-line Shamouti orange carries a virus mixture including cachexia and exocortis. The causal agent, or agents, of wood pitting in some sweet lemon stocks under Valencia and naval orange tops is different from the cachexia virus transmitted from Marsh grapefruit in these experiments.

4. Inoculations from trees with lignocortosis wood pitting have not induced cachexia or xyloporosis symptoms in indicator plants.

5. The presence of wood pitting per se is not sufficient evidence for diagnosis of cachexia or of xyloporosis.

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