damage was not considered economically significant (1). Citrus nematodes were not detected at the 6 to 12 inch soil depth in the grove. Fruit from the Temik treated plots was significantly larger in diameter than fruit from the non-Temik treated plots (Table 1). This increase in size was not due to an increase in peel thickness (Table 1). The increase in fruit size did not result in a decrease in total yield in boxes/acre. Trees from the Temik treated plots produced 38% more boxes/acre than the non-Temik treated plots (Table 2). Increases in lb. juice/box, in lb. solids/box, Brix/acid ratio as a result of Temik application were small (Table 2). Thus, the increase in net boxes/acre was the most significant benefit of Temik at this location.

Table 2. Fruit quality and yield of Temik vs. non-Temik treated 'Valencia' oranges—Lake Wales, FL 1982[z].

Treatment	Acres	Trees/ acre	Yield (net boxes/ acre)	Juice yield (lb./ box)	Brix/ acid ratio	Lb. solids/ box
Temik	8.40	116	392.18	40.20	13.88	4.26
Non-Temik	9.08	116	283.80	39.96	13.87	4.17

[z]No statistical comparison conducted.

Yield data from the grove in La Belle showed only minor differences between the Temik and non-Temik treated plots. Non-Temik treated plots averaged 464.39 gross boxes/acre compared to 461.23 gross boxes/acre for the Temik treated plots (Table 3). If processing data had been available for this grove, it is assumed that the non-Temik treated plots would have shown a greater profit return than the Temik treated plots. This grower has already made the decision not to continue using Temik for economic reasons.

Table 3. Fruit yield of Temik vs. non-Temik treated 'Pineapple' orange —La Belle, FL 1981[z].

Treatment	Acres	Trees/ acre	Yield (picked boxes)	Yield (gross boxes/ acre)	Yield (boxes/ tree)
Temik	8.64	106	3,985	461.23	4.35
Non-Temik	7.16	106	3,325	464.39	4.38

[z]No statistical comparison conducted.

A comparison of profit and costs for the Lake Wales grove is based upon data presented in Table 2 showing the boxes/acre and lb. solids/box. The fruit in this grove was harvested during April 7-21, 1982. Delivered-in processor prices paid for the fruit was determined using industry averages for this period (2). Gross profit per acre was $1,921.29 for the Temik treated plots as opposed to $1,360.96 for the non-Temik treated plots (Table 4).

Table 4. Profit and costs comparison of Temik vs. non-Temik treated 'Valencia' oranges—Lake Wales, FL 1982.

Treatment	Gross return/ acre[z] ($)	Additional pesticide costs/acre ($)		Net return/ acre[y] ($)	Increased return/ acre[y] ($)
Temik	1,921.29	33 lb. Temik −66.00 24 oz. Vendex	Application −9.50 Helicopter application	1,845.79	517.81
Non-Temik	1,360.96	−22.98	−10.00	1,327.98	–

[z]Using $1.15/lb. solids as reported in reference 3 (No. 54-56).
[y]Less pesticide costs with all other costs held constant.

Grove management and pesticide costs common to all plots were not deducted from the gross profit per acre. Costs peculiar to the Temik-treated and non-Temik treated plots were determined using industry averages (3). Net returns were $1,845.79 for the Temik-treated plots as opposed to $1,327.98 for the non-Temik treated plots. This was a difference of $517.81 or a 39% increase using Temik in this grove (Table 4).

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TRISTEZA DECLINE IN FOUR GRAPEFRUIT CULTIVARS AT THE BUDWOOD FOUNDATION GROVE, DUNDEE, FLORIDA

C. O. Youtsey and L. H. Hebb
Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Bureau of Citrus Budwood Registration, 3027 Lake Alfred Road, Winter Haven, FL 33880

Additional index words. infection rate, rootstocks, vectoring.

Abstract. **Natural spread rate and visible tree symptoms for citrus tristeza virus (CTV) were observed in a 7 1/2-yr-old planting of 'Marsh', 'Duncan', 'Ruby', and 'Star Ruby' grapefruit,** Citrus paradisi **Macf., on 13 rootstocks. Fifty-nine % of the trees were naturally infected with CTV. Forty % of the trees on sour orange** (Citrus aurantium **L.) are in various stages of decline and more than 26% are dead or out of production. Only minor symptoms of CTV were observed in trees on 12 other rootstocks.**

Serious losses due to CTV have been observed in sweet oranges on sour orange rootstock in certain commercial citrus areas of Florida (5). For this reason growers have been frequently advised of the risk of tree loss due to this disease. Risk of loss in grapefruit has been considered acceptable due to apparent low rate of spread and lack of serious tree losses experienced to date in commercial grapefruit groves.

The Citrus Budwood Registration Bureau maintains a foundation grove for the purpose of preserving valuable budlines and making comparative horticultural evaluations. From 1960 until 1973, this grove was located in the Central

Ridge area of the state near the intersection of U. S. Highway 27 and Interstate 4. The spread of citrus tristeza virus (CTV) in this grove was monitored using the standard Key lime, *Citrus aurantifolia* (Christm.) Swingle, indexing method (6). Rate of natural infection in grapefruit, *Citrus paradisi* Macf., was much lower than in sweet orange, *Citrus sinensis* (L.) Osb. Only 4% of the grapefruit and 93% of the sweet orange became naturally infected between 1961 and 1971 (2). The effects of CTV in this grove were mild. No trees of any commercial variety on sour orange, *Citrus aurantium* L., rootstocks declined as an obvious result of CTV. The only difference observed between infected and noninfected trees was a slight reduction in tree size, particularly in the trees infected at an earlier age. The presence and effect of CTV in this grove are typical of that found in many commercial citrus groves of the state.

In 1973, the Budwood Foundation Grove was moved approximately 20 miles south to the Dundee area to avoid an encroaching tourist attraction and commercial development on adjacent properties. Increased acreage, improved facilities, and a warmer location were additional benefits. This demonstration planting serves as a reserve of valuable citrus budlines and affords increased horticultural evaluation of scions and rootstocks for use in Florida.

The purpose of this paper is to record observations of a high rate of CTV spread in grapefruit and subsequent severe tree decline on sour orange rootstock at the Budwood Foundation Grove at Dundee, Florida.

Materials and Methods

The block consists of 12 rows of 52 trees and one row of 51 trees, totaling 675 trees. The spacing is 25 ft (7.6 m) by 24.5 ft (7.5 m). Each of the 13 rows consist of a different rootstock. Each row contains 13 selections of 'Marsh', 7 selections of 'Ruby', one selection of 'Star Ruby', and 5 selections of 'Duncan', replicated twice on each rootstock and planted in groups by variety to facilitate record keeping, horticultural evaluation, and harvest operations. The trees for this block were propagated on the property in 1974 using sources selected from the original foundation grove. Selections of 2 'Marsh', 2 'Ruby', and one 'Duncan' were infected with CTV when propagated. Other bud sources were indexed free of CTV.

The rootstocks used are: sweet lime, *Citrus aurantifolia* (Christm.) Swingle; Rangpur lime, *C. limonia* Osbeck; Smooth Flat Seville. *Citrus* sp.; Carrizo citrange, *P. trifoliata* (L.) Raf. x *C. sinensis; C. macrophylla* Wester; Cleopatra mandarin, *C. reticulata* Blanco; rough lemon, *C. limon* (L.) Burm. f.; Swingle citrumelo, *P. trifoliata* x *C. paradisi;* sour orange, *C. aurantium;* a hybrid of Rangpur lime x Troyer citrange (*P. trifoliata* x *C. sinensis*); Volkamer lemon, *C. limon* Burm. f.; citrumelo F-80-7 and citrumelo F-81-14.

The block was planted in February 1975 and maintained using the recommended cultural practices for young trees planted on deep fine sand, typical of the ridge area. The trees became established quickly and grew uniformly according to the vigor of each individual rootstock with only 4 resets required. Field symptoms of CTV were not observed until the summer of 1980.

Until April 1980, indexing on Key lime was used to monitor natural CTV spread in the grove. Because of limited greenhouse facilities, early tests were limited to trees propagated on the intolerant rootstocks, sour orange, sweet lime, *C. macrophylla,* and Smooth Flat Seville. Since 1980, a rapid serological test, enzyme-linked immunosorbent assay (ELISA) (1) has been used to index trees. Trees have been indexed since October of 1975 at various times of the year using one or both of the above methods. The latest tests were performed in February 1982. Some individual trees in this planting have been tested 9 times. In June 1982, a visual survey was made to record tree conditions. A follow-up survey was conducted in September. Sections of bark approximately 1/2 inch (1.3 cm) by 3 inches (7.6 cm) were removed from the trunks across the bud union of many trees to inspect for CTV pitting sypmtoms (4). Fruit yields from individual trees have been routinely recorded by weight for the last 3 yr for horticultural comparisons and provided a base for comparing infected and noninfected trees.

Results and Discussion

Indexing results until September 1982, are summerized in Table 1. These results indicate that CTV was not transmitted at a high rate by bud propagations from CTV-infected sources, but that extensive natural spread has occurred. Of the 130 trees propagated from CTV-infected parents, only 14 (10.8%) were indexed positive in 1977 and 1978. Since these 14 trees had also been exposed to natural insect vectoring, it can only be stated that bud transmission of CTV was 10.8% or less. The remaining 390 trees indexed CTV positive are the result of aphid vectoring. Trees propagated from tristeza-negative sources after 7 yr of exposure to natural field-vectored CTV have approximately the same percent of trees infected as those propagated from CTV-positive sources. This also indicates that most CTV infection was vector rather than bud-transmitted. The low transmission rate by bud propagation may have been due to poor distribution of the mild CTV within the trees which supplied budwood for propagation.

Table 1. Tristeza status of 675 grapefruit trees in the Dundee Foundation Grove planting as of September 1982.

Scion varieties	Bud source CTV status	Total no. trees	No. CTV neg.	CTV % neg.	CTV % pos.
Marsh	CTV neg.	285	98	34.4	65.6
"	CTV pos.	52	17	32.7	67.3
Ruby	CTV neg.	130	51	39.2	60.8
"	CTV pos.	52	19	36.5	63.5
Duncan	CTV neg.	104	68	65.4	35.4
"	CTV pos.	26	18	69.2	30.8
Star Ruby	CTV neg.	26	0	0.0	100.0
All varieties	CTV neg.	545	217	39.8	60.2
" "	CTV pos.	130	54	41.5	58.5
Total trees		675	271	40.1	59.9

There are no trees with footrot, or citrus blight, and only 3 trees are affected by cold damage in this 7 1/2-yr-old grapefruit block. The results of visual surveys made in June and September 1982, are shown in Table 2. Grapefruit trees on rough lemon, Volkamer lemon, Cleopatra mandarin, Swingle citrumelo, and citrumelo F-80-7 appear uniform and healthy. Trees on Rangpur x Troyer hybrid are not uniform in size and are generally smaller than others in the planting. This condition cannot be attributed to CTV infection, but could be partly due to severe cold injury from the 1977 freeze and the influence of natural dwarfing as described by Castle and Phillips in 1977 (3).

With the exception of one unthrifty tree on Carrizo citrange and one cold-damaged tree on Rangpur lime, trees on these stocks appear normal and productive. There were 6 trees on citrumelo F-81-14 rootstock that were less vigorous

Table 2. Summary of tree condition observed in 675 grapefruit trees on 13 different rootstocks in the Dundee Foundation Grove planting, September 1982.

Rootstock	No. CTV[z] pos./total trees	Total no. of unthrifty trees	Cold damaged trees	CTV symptoms	Trees dead	Unknown cause
Citrus macrophylla[y]	32/52	8	1	7	0	0
Carrizo citrange	37/52	1	0	0	0	1
Rangpur lime	31/52	1	1	0	0	0
Rough lemon	37/52	0	0	0	0	0
Volkamer lemon	31/52	0	0	0	0	0
Palestine sweet lime[y]	29/52	2	0	0	0	2
Smooth Flat Seville[y]	31/52	3	0	1	0	2
Cleopatra mandarin	22/52	0	0	0	0	0
Swingle citrumelo	30/52	0	0	0	0	0
Sour orange[y]	28/52	21	0	21	4	0
Rangpur lime x Troyer citrange	32/52	20	0	0	0	20
Citrumelo F-80-7	32/52	0	0	0	0	0
Citrumelo *F-81-14*	32/51	6	1	0	0	5

[z]CTV = citrus tristeza virus.
[y]Generally considered to be CTV-intolerant.

than average. One was less vigorous because of cold injury. Cause for the lack of vigor in 5 trees could not be determined, but CTV may have been a contributing factor.

Trees propagated on Smooth Flat Seville are normal with the exception of 3 trees. Possible lightning injury may be causing one tree to decline. Lack of normal growth in one tree is associated with CTV, but no apparent reason can be found for lack of growth in the third tree. The cause of unthrifty growth in 2 trees on Palestine sweet lime is apparently not due to CTV. Only in trees on *C. macrophylla* and sour orange rootstocks are the effects of CTV clearly seen (Figs. 1 & 2). Of 8 unthrifty trees on *C. macrophylla*,

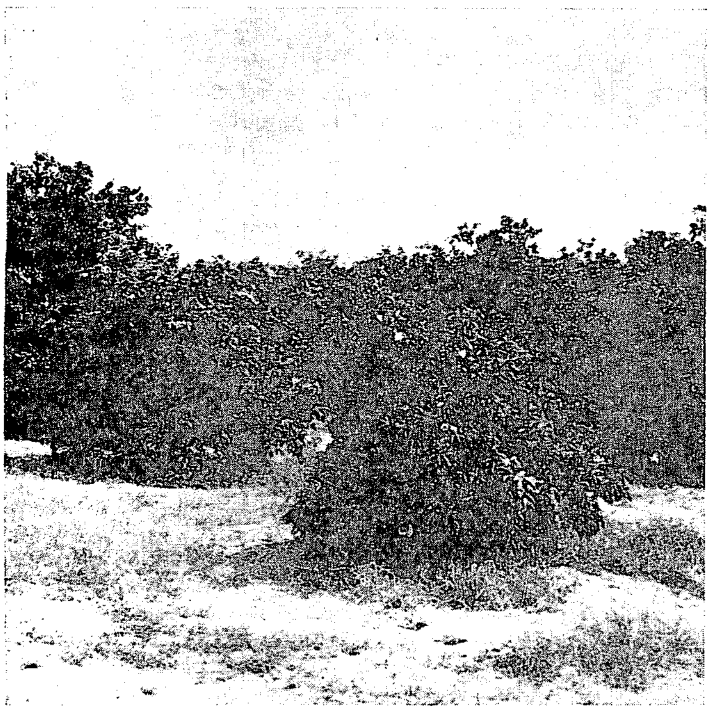

Fig. 1. 'Ruby' grapefruit on sour orange rootstock, 7 1/2-yr-old. Two tristeza stunted trees in foreground.

one is the result of a cold injury and the remainder are plainly associated with the presence of CTV. The trees on sour orange are in the worst condition by far. Over 40% (21 trees) are in various stages of decline or have already been removed or replaced. Trees of 'Marsh', 'Ruby', and 'Duncan' on sour orange rootstock showing field symptoms

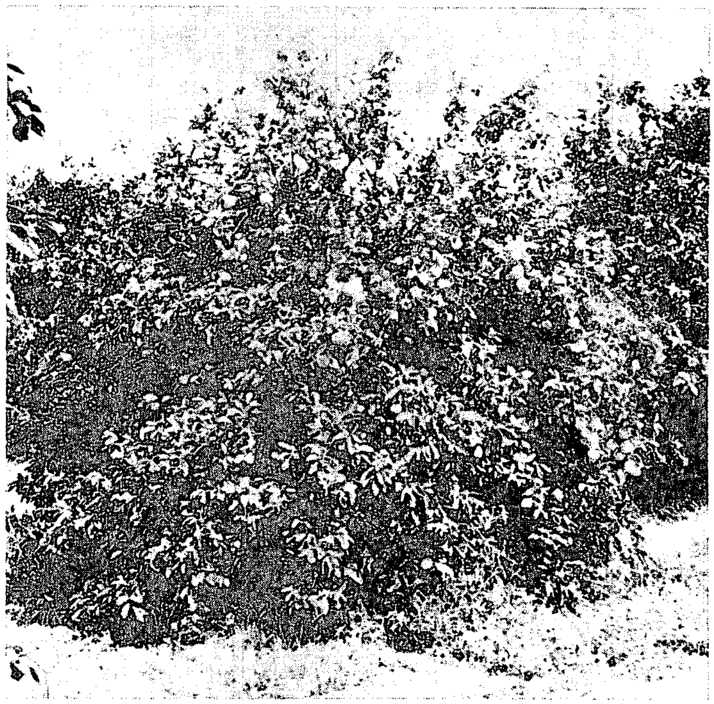

Fig. 2. Early effect of tristeza in 7 1/2-yr-old 'Marsh' on sour orange rootstock showing wilt and lack of new growth.

of CTV produced 42%, 48.6%, and 95.6% less fruit, respectively, than healthy trees on the same rootstock. All trees of 'Star Ruby' have been infected through field spread and the 2 trees on sour orange, found infected May 1978, were removed in February 1980, because of poor condition.

Natural spread of field-vectored CTV during 7 1/2 yr has resulted in the infection of 59% of the grapefruit trees in this planting. This is a drastic change in effects of CTV in grapefruit as previously reported (2). Approximately 46% of all registered grapefruit trees are being propagated on sour orange rootstock. Considering the potential risk for loss from CTV, it appears increasingly urgent for grapefruit growers to consider rootstocks other than sour orange for future plantings and replacement trees.

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NATURAL ENEMIES OF DIAPREPES ABBREVIATUS LARVAE IN FLORIDA[1]

J. B. Beavers, D. T. Kaplan
U.S. Department of Agriculture, Agricultural Research Service, 2120 Camden Road, Orlando, FL 32803

C. W. McCoy
University of Florida, IFAS, AREC, 700 Experiment Station Road, Lake Alfred, FL 33850

Additional index words. fungi, nematodes, weevil, citrus.

Abstract. **A survey of the subterranean natural enemies of** Diaprepes abbreviatus **(L.) larvae was conducted monthly from June 1979 through December 1980 in 9 citrus groves and 1 ornamental nursery in central Florida. Four entomopathogenic fungi,** Metarhizium anisopliae, Beauveria bassiana, Paecilomyces lilacinus **and** Aspergillus ochraceous, **and 2 entomogenous nematodes,** Neoaplectana carpocapsae **Weiser and** Heterorhabditis **sp. Poinar, were found active in the soil and infectious to** D. abbreviatus **larvae. Fungus-infected larvae were most prevalent from May through July, while nematode parasitism was most predominant from May through November. A subsequent survey conducted in 55 citrus groves throughout Florida in August 1980 and again in February 1981 showed that 27.0% and 45.0%, respectively, had detectable populations of** N. carpocapsae **or** Heterorhabditis **sp., or both species.**

Diaprepes abbreviatus (L.), the sugarcane rootstock borer weevil, is a major curculionid pest of citrus and sugarcane in Puerto Rico and the West Indies. A single adult of this weevil was detected on citrus in Orange County, Florida, in 1964. In 1968, a high population was discovered and a quarantine area of ca. 2,500 acres (1,000 ha) was established (15). This weevil threatens the citrus, ornamental, and sugarcane industries in Florida, and its quarantine area has been increased to ca. 79,000 acres (31,000 ha) in Orange, Seminole, Lake, and Broward counties. The adult weevils feed on young, succulent foliage of citrus and other host plants and deposit their eggs in masses between mature leaves, which are held together by an adhesive secretion. The hatchling larvae burrow into the soil, where they remain for 1 to 2 yr (14) and cause serious root injury to the host plant.

Biological control has been investigated as a means to reduce populations of other developmental stages of *D. abbreviatus*. An exotic hymenopterous egg parasite, *Tetrastichus haitiensis* Gahan, has been introduced from Puerto Rico and successfully established in Florida (2). Buren and Whitcomb (5) found first-instar *D. abbreviatus* on the soil surface vulnerable to predation by several species of ants. However, no information was available on the natural enemies of the subterranean larval stage of this pest.

Therefore, we conducted a study from June 1979 through March 1981 to 1) identify the natural enemies present which attack the subterranean larvae of *D. abbreviatus,* 2) determine the relationship of select environmental factors on the natural enemies, and 3) determine the distribution of the predominant soil-inhabiting, natural enemies in selected citrus groves outside of the known *D. abbreviatus*-infested areas of Florida.

Materials and Methods

Two studies were conducted. In the first, within the *D. abbreviatus* regulated area of central Florida, 9 citrus groves and 1 ornamental nursery which have had high weevil populations in the past were selected for the natural enemy survey. Three groves were in Lakeland (thermic, coated typic quartzipsamments) and 6 in Blanton (loamy, siliceous, thermic grossarenic paleudults) soil types, the nursery was planted in Everglades (euic, hyperthermic typic medihemists) mucky, peat soil. All sites had been treated previously with chlorinated hydrocarbon soil insecticides during weevil eradication efforts in the early 1970's, but had no chemical treatment during this study.

Diaprepes abbreviatus larvae (4-6 months old) reared on artificial diet (1) were placed individually in 3- x 5-inch (7.5- x 12.5-cm) wirescreen cages and buried at 6- and 12-inch (15- and 30-cm) depths under the canopy of a single tree at each site on a monthly basis from June 1979 through December 1980. Six cages were buried at each depth (12 cages/tree) at each site. Each cage was filled with soil taken from the depth at which it was buried. The location was marked by an 18-inch (45-cm) wire attached to the cage with a color-coded ribbon attached to the opposite end. After 3 wk, the cages were recovered from the soil and all larvae (alive or dead) were placed individually in 1-oz plastic cups for observation and subsequent diagnosis of pathogens. Soil temperature was recorded in the field at each depth at the time larvae were placed in the soil. Also, pH and gravimetric moisture determinations were made from each soil depth at each site. Rainfall was also recorded at a central location monthly.

Gross analyses of all larvae recovered were made with a dissecting microscope. Larvae containing nematodes were held for emergence, and the nematodes were either 1) preserved in a 3.0% formalin and a 3.0% glycerin solution for later identification, or 2) used to inoculate fresh *D. ab-*

[1]This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the USDA, nor does it imply registration under FIFRA. Mention of a commercial or proprietary product does not constitute an endorsement by the USDA and does not imply its approval to the exclusion of other products or vendors that may also be suitable.