Effect of Exocortis Inoculation on Performance of Marsh Grapefruit Trees on Various Rootstocks

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Exocortis has been demonstrated to exist as strains producing stunting and other effects on infected trees intolerant of the virus (*3, 4, 7*). Infected trees on trifoliate orange rootstock may or may not show rootstock bark scaling, depending on the exocortis strain involved (*2*). Infection with exocortis is reported to reduce trunk circumference and fruit yield from trees on stocks such as Cleopatra and sweet orange, which are usually considered tolerant of the virus (*10*).

The stunting effects of exocortis infection are not necessarily always undesirable (*1, 5, 6*). Present trends favor the use of increased numbers of smaller, productive trees more closely spaced in the grove. Yield per acre is a better measure of the suitability of a stock-scion combination than is yield per tree (*8*).

This study was undertaken to determine the effect of different strains of exocortis virus on Marsh grapefruit trees on nine different rootstocks, including some usually considered tolerant and some considered intolerant of exocortis.

MATERIAL AND METHODS

Trees on all rootstocks were propagated with buds from a single tree of a productive nucellar Marsh grapefruit. Uninoculated trees were set out at normal spacing in June, 1965, in the Ald-Comp Groves in the Fort Pierce, Florida, area. Trees were inoculated in September, 1966, 32 months after budding and 15 months after final planting.

Sources of inoculum were single trees propagated from parents that had been indexed by the Florida Division of Plant Industry and found free of xyloporosis, psorosis, and tristeza (table 1). Inoculum source E-1 was rated as strong and E-7 as moderately strong on the basis of citron indexing and observation of the effect of these sources in field plantings. Inoculum source E-5, originally thought to be infected with a very mild strain of exocortis virus, is now believed to be free of exocortis.

Trees on Cleopatra mandarin, Hamlin sweet orange, *Citrus macrophylla*, Rangpur lime, Rough lemon, sour orange, and small-flowered trifoliate orange were inoculated with E-1, E-5, and E-7. Trees on Columbia sweet lime and large-flowered trifoliate orange were inoculated with E-1 and E-7 only. Six trees on each rootstock were inoculated singly with each source of inoculum, and six trees were left uninoculated as checks in a randomized block design.

Inoculation was accomplished by grafting two or three bark chips from the appropriate source into each experimental tree. Inoculation was repeated in all cases where less than two of the bark chips were alive three months after insertion. No bark chips were introduced into check trees.

Fruits were sampled each year for quality during the first week of December. Yield of each tree was noted when fruits were picked, usually in January.

RESULTS

Fruit quality for the four years during which commercial crops were obtained is summarized in table 1. The most consistent effect was the elevation

TABLE 1
EFFECT OF EXOCORTIS INOCULATION ON FRUIT QUALITY OF MARSH GRAPEFRUIT
(Four-year averages for fruit from seven-year-old trees)

Rootstock	Exocortis inoculum*	Fruit characteristics				
		Av. wt.†	Juice	Brix†	Acid†	Brix/Acid† ratio
		gm	per cent	per cent	per cent	
Rough lemon	E-1	419.0	49.3	8.19	1.01b	8.19
	None	409.6	50.1	8.40	1.05a	8.04
	E-5	436.4	48.8	8.11	1.03b	7.97
	E-7	373.5	50.7	8.24	1.01b	8.25
Average		409.7	49.7	8.24	1.02	8.11
Sour orange	E-1	386.0	50.9	9.50	1.08	8.86
	None	394.8	50.7	9.30	1.09	8.62
	E-5	383.0	51.0	9.36	1.11	8.53
	E-7	390.5	50.9	9.25	1.09	8.60
Average		388.6	50.9	9.35	1.09	8.66
Columbia sweet lime	E-1	380.3c	52.8	9.00a	1.00	9.04a
	None	430.8a	51.5	8.35b	1.00	8.40b
	E-7	400.9b	52.4	8.86a	1.02	8.70c
Average		404.0	52.2	8.74	1.01	8.72
Rangpur lime	E-1	392.1	51.0	8.80b	1.01	8.82
	None	383.1	51.9	8.50c	1.00	8.55
	E-5	402.8	51.1	8.61c	1.01	8.60
	E-7	392.6	52.3	9.08a	1.04	8.81
Average		392.6	51.6	8.75	1.01	8.70
Trifoliate (large-flower)	E-1	384.5a	50.8	9.34a	1.01	9.29
	None	395.4a	51.7	8.84b	1.01	8.83
	E-7	361.7b	51.3	9.20a	1.00	9.27
Average		380.5	51.3	9.13	1.01	9.13
Trifoliate (small-flower)	E-1	347.3	50.7	9.90	1.09	9.14a
	None	384.4	50.9	9.11	1.06	8.67b
	E-5	384.9	51.1	9.21	1.09	8.51b
	E-7	364.6	50.6	9.51	1.02	9.44a
Average		370.3	50.8	9.44	1.06	8.94
Cleopatra mandarin	Average	381.5	52.3	9.10	1.06	8.60
Hamlin sweet orange	Average	400.4	50.6	9.06	1.07	8.52
Citrus macrophylla	Average	418.6	50.6	8.39	1.01	8.37

* E-1 = strong exocortis; E-5 = believed to be free of exocortis; E-7 = moderately strong exocortis.

† Averages followed by the same letter are not significantly different at the 5 per cent level, according to Duncan's multiple-range test.

TABLE 2
EFFECT OF EXOCORTIS ON FRUIT YIELD AND TREE SIZE OF MARSH GRAPEFRUIT
(Data from seven-year-old trees)

Rootstock	Exocortis inoculum*	Av. no. boxes per tree† 1971–72 only	Av. no. boxes per tree† 4-yr. av. (1967–72)	Tree canopy† Av. diam.	Tree canopy† Height	Av. trunk circum.†
				meters	meters	cm
Rough lemon	E-1	7.7	4.9	4.30	4.15	54.8
	None	7.3	4.6	4.26	3.99	57.1
	E-5	6.8	3.9	4.03	4.09	55.8
	E-7	6.9	4.3	4.11	4.06	56.1
Average		7.2	4.4	4.17	4.07	56.0
Sour orange	E-1	7.2	4.1	4.22	3.98	56.6
	None	6.1	3.4	4.23	4.45	58.9
	E-5	8.0	3.9	4.60	4.41	59.4
	E-7	7.4	4.2	4.10	4.03	57.6
Average		7.2	3.9	4.29	4.22	58.1
Columbia sweet lime	E-1	6.3	4.3	3.41c	3.23c	50.0c
	None	8.9	5.5	4.65a	4.35a	60.7a
	E-7	6.3	5.1	3.97b	3.58b	55.6b
Average		7.2	4.9	4.01	3.84	55.4
Rangpur lime	E-1	8.7	5.5	3.99b	3.64c	53.8c
	None	8.8	5.7	4.58a	4.21a	64.0a
	E-5	7.7	5.1	4.06b	4.00b	58.9b
	E-7	7.5	4.7	3.81b	3.61c	53.3c
Average		8.2	5.2	4.11	3.87	57.5
Trifoliate (large-flower)	E-1	3.0c	2.0c	2.49c	2.42c	32.5c
	None	5.5a	3.1a	4.19a	3.66a	47.5a
	E-7	4.1b	2.7b	3.08b	2.77b	38.8b
Average		4.2	2.6	3.25	2.95	39.6
Trifoliate (small-flower)	E-1	2.5	1.6	1.87c	1.80c	28.9c
	None	5.2	2.9	3.38a	3.60a	44.4a
	E-5	4.4	2.8	3.45a	3.37a	44.4a
	E-7	3.7	2.5	3.04b	2.68b	35.5b
Average		3.9	2.4	2.94	2.86	38.3
Cleopatra mandarin	Average	6.7	3.7	4.40	4.02	57.8
Hamlin sweet orange	Average	7.9	4.4	4.62	4.36	63.5
Citrus macrophylla	Average	8.1	5.4	4.23	3.89	55.0

* E-1 = strong exocortis; E-5 = believed to be free of exocortis; E-7 = moderately strong exocortis.
† Averages followed by the same letter are not significantly different at the 5 per cent level, according to Duncan's multiple-range test.

of the Brix level for Columbia sweet lime, Rangpur lime, and both selections of trifoliate orange when they were infected with either the E-1 or the E-7 strain of exocortis virus. Differences among the four treatments were insignificant for trees on Rough lemon, sour orange, Cleopatra mandarin, Hamlin sweet orange, and *Citrus macrophylla*. All three inoculum sources reduced the acid level for trees on Rough lemon. Only average ratings are given in table 1 for trees on Cleopatra, Hamlin, and *Citrus macrophylla*.

Variations in yield of 40-kg boxes of fruit and in tree size are shown in table 2. Exocortis reduced the yield of trees on Columbia sweet lime and the two trifoliate orange stocks. The retarding influence of exocortis on these combinations is increasing with time as can be seen by comparing the 1971–1972 averages with the four-year averages. Rangpur lime, usually considered to make a combination intolerant of exocortis when used as a rootstock for grapefruit, has suffered no appreciable reduction in yield from trees inoculated with the E-1 strain. There is a small reduction in yield from trees receiving the E-7 strain, however. Differences among the four treatments were generally without significance for trees on Rough lemon, sour orange, Cleopatra, Hamlin, and *Citrus macrophylla*. As in table 1, only average ratings are given for trees on Cleopatra, Hamlin, and *Citrus macrophylla*.

All rootstocks were checked in July, 1972, for bark scaling. Inoculation with the E-1 strain produced severe bark scaling on all trees on small-flowered trifoliate orange and on five of six trees on large-flowered trifoliate orange. The E-1 strain induced milder symptoms of bark scaling on four of the six inoculated trees on Rangpur lime.

Only one tree inoculated with the E-7 strain showed symptoms of bark scaling; mild symptoms were found on a tree on small-flowered trifoliate orange. Neither of the sources of exocortis virus induced any bark scaling on any of the other stocks in the experiment.

DISCUSSION AND CONCLUSIONS

The effect of exocortis on tree size is very clear. The average size of exocortis-inoculated trees on intolerant stocks, by all measurements, is significantly smaller than that of the comparable uninoculated trees. Exocortis inoculation did not reduce the size of trees on exocortis-tolerant rootstocks.

The effect of strain E-1 on trees on Rangpur lime rootstock is most interesting. E-1-inoculated trees are smaller in size and bear fruit with a higher percentage of soluble solids, but are essentially equal in yield to comparable uninoculated trees. The high quality and high yield of some exocortis-infected Ruby red grapefruit trees on Rangpur lime have been described (*5, 6*).

It is too early to determine with finality whether exocortis in some of the other nontolerant combinations has produced dwarfed but productive trees which, when properly spaced, could maintain a high level of productivity per acre with greater ease of picking and spraying. Apparently, however, such a desirable effect is still likely for some stionic combinations. Continuation of this experiment may eventually provide such information.

No reductions were seen in yield and trunk circumference of tolerant combinations as a result of exocortis infection, as reported for navel orange trees in Louisiana (*10*). The general lack of debilitating effect of exocortis infection on nontolerant combinations supports the observations of Olson *et al.* (*9*), that there is no demonstrable advantage in having citrus trees free of viruses that they tolerate.

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