JAMES B. SINCLAIR and RALPH T. BROWN

Reaction of Rootstocks to Exocortis

IT WAS RECENTLY REPORTED (2) that trifoliate orange (*Poncirus trifoliata*) and Rangpur lime (*Citrus* sp.) in Louisiana show typical symptoms of exocortis when infected, whereas Cleopatra mandarin (*Citrus reticulata*) and sweet orange (*C. sinensis*) are symptomless carriers of the virus. This report presents results from investigations of effects of the virus on growth (trunk circumference) and yield of Valencia orange (*C. sinensis*) scions budded on these and other rootstocks and describes the symptoms produced on the stock.

Methods and Materials

Three series of rootstock tests were planted at the Plaquemines Parish Experiment Station, Port Sulphur, Louisiana. The first series was budded in the spring of 1951 with Valencia orange, Washington Navel orange (*Citrus sinensis*), Owari satsuma (*C. nobilis*), and Pineapple sweet orange (*C. sinensis*) onto the rootstocks listed in Table 1. The second series was budded in the spring of 1952. Valencia orange, Washington Navel orange, Owari satsuma, and Ruby Red grapefruit (*C. paradisi*) were budded onto the rootstocks listed in Table 2. In the third series, Valencia orange, Owari Satsuma, Ponkan mandarin (*C. nobilis*), Orlando tangelo (*Citrus* sp.), and Washington Navel orange, budded in the spring of 1956 onto the rootstocks listed in Table 3, were planted in the field in January, 1957. All 3 series were planted in 2 replications with 4 trees per replicate. Trunk circumferences in cm taken 15 cm above the bud union, total yield in pounds per tree, and symptoms produced were recorded.

TABLE 1. TRUNK CIRCUMFERENCE MEANS[a] (T) IN CM AND YIELD MEANS (Y) IN POUNDS OF FRUIT PER TREE OF EXOCORTIS-INFECTED VALENCIA ORANGE BUDDED IN 1951 ON CLEOPATRA MANDARIN, CARRIZO CITRANGE, MORTON CITRANGE, RUBIDOUX TRIFOLIATA, RANGPUR LIME, AND WILLIAMS TANGELO FOR THE YEAR AFTER BUDDING INDICATED. SERIES 1 OF EXPERIMENTS AT PORT SULPHUR, LOUISIANA

Rootstocks	Years after budding										
	1	2	3	4	5	6		7		8	
	T	T	Y	Y	Y	T	Y	T	Y	T	Y
Cleopatra	1.3	3.6	5	9	72	38	172	44	238	50	232
Carrizo	2.2	5.4	22	105	130	39	259	44	329	48	329
Morton	2.6	4.9	43	95	150	35	243	38	296	40	244
Rubidoux	2.0	3.6	11	21	53	25	115	27	128	32	130
Rangpur	2.9	5.0	55	78	98	31	201	34	220	37	255
Williams	2.0	3.9	1	16	62	31	83	37	114	41	130
LSD .05	0.2	ns	ns	17	22	4	29	4	41	5	43
.01	ns	ns	ns	26	ns	ns	46	6	ns	ns	ns

[a]Mean of 2 replications.

There were 2 plantings made for the purpose of recording the effects of exocortis on Rusk citrange and to determine whether or not exocortis virus could be transmitted through Owari satsuma budwood. In the first, Rusk citrange (*Citrus* sp.) rootstocks were budded with exocortis-infected Valencia orange scions and used as guard trees in the 1953 planting. In the second, budwood from Owari satsuma trees growing on *P. trifoliata* rootstocks, some of which showed typical exocortis symptoms and some that did not show symptoms, were budded on exocortis-free *P. trifoliata* and planted as guard trees in 1953. The source of infected budwood for this second test came from Owari satsuma grafted onto *P. trifoliata* rootstock previously infected by grafting exocortis-infected Valencia orange budwood onto the stock and then cutting the latter out before grafting Owari satsuma budwood onto the same stock.

Experimental Results and Conclusions

No trees in these 3 series were free from exocortis that could be used for comparison with infected trees. In order to evaluate these data it was necessary to use previously reported results from another test plot on the station (2). It was shown in this test that Rangpur lime and Cleopatra mandarin were affected by exocortis, the former showing typical exocortis symptoms, the latter no symptoms, but both showed significant reductions in trunk circumferences when compared to their virus-free counterpart. Exocortis-infected Rangpur lime had trunk circumferences significantly below those of exocortis-infected Cleopatra mandarin. There were no significant differences in trunk circumferences between the 2 rootstocks, when both were free of exocortis, until the eighth year after budding. Since the reaction of these 2 rootstocks to the virus was known, Cleopatra mandarin was included in series 1 and 2 and Rangpur lime was included in the first series, and all other rootstocks in the first series were compared to them and to Cleopatra mandarin in the second series. In the third series, the rootstocks were compared to Troyer citrange, which was shown to be very susceptible in the second series.

Symptoms of exocortis, consisting of bark scaling along roots near the soil line, appeared 2 years after budding on Rubidoux trifoliata and Morton citrange; symptoms developed more rapidly on the latter. Rangpur lime showed gumming and bark sloughing 2 years after budding. All rootstocks of Rubidoux trifoliata, Carrizo, Morton, and

Troyer citranges, Rangpur lime, and Williams tangelo were showing bark scaling within 5 years after budding. Of these, Rubidoux trifoliata and Carrizo citrange produced no gumming. Bark scaling did not progress so rapidly on Carrizo, Morton, and Troyer citranges as on Rangpur lime. The amount of scaling increased each year on all susceptible rootstocks until scaling reached the bud union. Rootstocks of Williams tangelo, whether budded with exocortis-free or exocortis-infected scions, produced gumming and bark sloughing, but these symptoms were not like those produced on other rootstocks infected with exocortis. Bark scaling and gumming did not appear on Cleopatra mandarin, sour orange, Citremon C46216, rooted cuttings of Valencia orange, or Norton and Uvalde citranges. Data on trunk circumference and yield by years after budding are summarized in Tables 1, 2, and 3.

TABLE 2. TRUNK CIRCUMFERENCE MEANS[a] (T) IN CM AND YIELD MEANS (Y) IN POUNDS OF FRUIT PER TREE OF EXOCORTIS-INFECTED VALENCIA ORANGE BUDDED IN 1952 ON CLEOPATRA MANDARIN, CARRIZO CITRANGE, MORTON CITRANGE, TROYER CITRANGE, NORTON CITRANGE, AND UVALDE CITRANGE FOR THE YEAR AFTER BUDDING INDICATED. SERIES 2 OF EXPERIMENTS AT PORT SULPHUR, LOUISIANA

Rootstocks	Years after budding							
	1		4		5		6		7	
	T	Y	T	Y	T	Y	T	Y
Cleopatra	1.6	61	33	134	38	236	44	247
Carrizo	1.6	58	34	153	40	274	46	302
Morton	1.9	32	26	73	29	169	34	205
Troyer	2.3	76	33	145	39	285	43	307
Norton	2.0	78	39	123	44	302	49	324
Uvalde	1.7	77	38	142	44	267	48	337
LSD .05	0.1	9	1	ns	1	29	2	19
.01	0.2	14	2	ns	2	ns	3	29

[a]Mean of 2 replications.

Observations on guard trees budded with exocortis-infected Valencia orange on Rusk citrange rootstock failed to reveal any exocortis symptoms on the rootstock 8 years after budding, indicating that it may be a symptomless carrier or resistant to the virus. In the case of the Owari satsuma test, typical exocortis symptoms appeared on those rootstocks budded with scions from inoculated trees in the third year after budding. Where exocortis-free scions were used, no symptoms appeared 7 years after budding.

It was reported that Cleopatra mandarin was a symptomless carrier

TABLE 3. TRUNK CIRCUMFERENCE MEANS[a] (T) IN CM AND YIELD MEANS (Y) IN POUNDS OF FRUIT PER TREE OF EXOCORTIS-INFECTED VALENCIA ORANGE BUDDED IN 1956 ON TROYER CITRANGE, RUBIDOUX TRIFOLIATA, SOUR ORANGE, ROOT CUTTINGS OF VALENCIA ORANGE, AND CITREMON C46216 FOR THE YEAR AFTER BUDDING INDICATED. SERIES 3 OF EXPERIMENTS AT PORT SULPHUR, LOUISIANA

Rootstocks	Years after budding			
	2		3	
	T	Y	T	Y
Troyer	26	82	32	116
Rubidoux	15	19	19	38
Sour	27	91	33	126
Valencia	27	126	35	147
Citremon C46216	30	140	33	170
LSD .05	ns	33	ns	ns
.01	ns	ns	ns	ns

[a]Mean of 2 replications.

of exocortis virus and was affected by the disease as shown by trunk circumferences and yield (2). Results from the present work substantiated these findings about Cleopatra mandarin. They also suggest that 4 additional rootstocks and rooted cuttings of Valencia orange may be symptomless carriers of the virus or resistant to it. These are Norton and Uvalde citranges, sour orange, Citremon C46216, and rooted cuttings of Valencia orange. Norton and Uvalde citrange budded with Valencia orange gave yields significantly above those of Cleopatra mandarin in the sixth and seventh year after budding.

It may be too early to give a positive evaluation based on these tests for sour orange, Citremon C46216, and rooted cuttings of Valencia orange. These 2 rootstocks and the rooted cuttings of Valencia orange have given yields greater than those of the susceptible Troyer citrange and Rubidoux trifoliata, with the differences showing up in the second year. Norton and Uvalde citranges had significantly larger trunks than either Cleopatra mandarin or the 3 other citranges in the fifth, sixth, and seventh year.

Trunk circumferences of sour orange, rooted cuttings of Valencia orange, and Citremon C46216 were not significantly larger than those of Troyer citrange and Rubidoux trifoliata in the third series.

Although Carrizo citrange showed symptoms, it has consistently yielded significantly higher than Cleopatra mandarin and its trunk circumferences have been close to those of Cleopatra mandarin or exceeded

them. It may be that this rootstock will become more affected as it grows older.

Observations on guard trees budded with exocortis-infected Valencia orange on Rusk citrange rootstock failed to reveal any exocortis symptoms on the rootstock 8 years after budding, indicating that it may be a symptomless carrier or resistant to the virus. In the case of exocortis-infected scions of Owari satsuma budded on *P. trifoliata*, observations showed that Owari satsuma can carry the virus and may have escaped becoming infected in Florida as suggested by Knorr and Reitz (1).

Literature Cited

1. KNORR, L. C., and H. J. REITZ. 1959. Exocortis in Florida. p. 141-150. *In* J. M. Wallace [ed.], Citrus virus diseases. Univ. Cal. Div. Agr. Sci., Berkeley.
2. SINCLAIR, J. B., and R. T. BROWN. 1960. Effect of exocortis disease on four citrus rootstocks. Plant Disease Reptr. 44:180-183.