A progress report . . .

Effect of citrus rootstock on size of scion is shown in photo above of Lisbon lemon on Nansho daidai (*Citrus taiwanica*) to left; and Lisbon lemon on Bessie sweet orange, to right.

L. J. KLOTZ · W. P. BITTERS · T. A. DEWOLFE

Citrus Rootstocks Resistant to Phytophthora Root Rot

VALENCIA oranges observed on trifoliate rootstocks in this experiment at the Citrus Research Center, Riverside, and Valencia and navel trees in commercial orchards have performed well on this stock for many years; similarly, standard Lisbon lemon varieties have done well on trifoliate rootstock for the 13 years they have been observed. However, a high incidence of the exocortis virus in budwood of Eureka lemon and creasing of the bud union preclude its use on trifoliates or citranges.

Carrizo and Troyer citrange rootstocks were found usable under oranges, mandarins, grapefruits, and Lisbon lemons. Rootstocks of Nansho daidai, siamelo, and the four mandarin varieties are overgrown by lemon scions but are compatible with oranges, mandarins, and grapefruits. Citremon 1449 is apparently safe as a rootstock for both oranges and lemons.

Since severe pitting occurs when alemow is budded with oranges and grapefruit, these combinations should be avoided. Although mild pitting and overgrowth of alemow occur when the species is budded with lemon, the combination tolerates soils with high concentrations of borates, sulfates, or other salts.

Although Ichang lemon has exhibited resistance to *Phytophthora* gummosis, the performance of trees on this rootstock to date is not good enough to suggest recommendation.

Testing procedure

These tests involved two plantings of Valencia orange and Lisbon lemon trees on 27 different rootstocks. They were set out at the Citrus Research Center, Riverside, in April, 1960, with inocula of *Phytophthora parasitica* and *P. citrophthora* added to the planting holes. Two hundred forty-eight trees of each scion variety were tested on two adjacent fields, both trapezoidal in shape. The fungi were isolates from these same fields. The south end portions of the fields were marked off to form two right triangular areas whose hypotenuses bordered an arroyo, which induced more rapid drainage than in the larger adjacent rectangular areas to the north. In these larger areas, each rootstock had five replicates with the Valencia orange tops and the Lisbon lemon tops. Each replicate was checked against a nearby tree with a Valencia or Lisbon top on Bessie sweet orange rootstock for comparison (see photos). The triangular areas provided room for only four replicates of each rootstock with Valencia tops and four with Lisbon tops. Since conditions were somewhat different in the two locations, the tests were treated as two different experiments.

The volume of the foliage canopies was calculated from measurements of vertical and horizontal diameters to determine the success or failure of the root systems in the presence of the root parasites (tables 1 and 2). The rate of trunk growth was also determined by measuring the girth 6 inches above the bud union and 2 inches below the bud union every October. Tables 3 and 4 show the increments of growth (circumference) of the tree trunks from October, 1963, to October, 1964.

Performance

Performance of the trees on the trifoliate varieties and certain trifoliate hybrids (citranges) was outstanding in growth and the absence of gummosis infections on rootstocks. As rootstocks for sweet orange tops, Nansho daidai, King mandarin, citremon 1449, Batangas mandarin, and Ponkan mandarin also placed among the ten fastest growers. As rootstocks for lemon tops, the Batangas mandarin, citremon 1449, Nansho daidai,

Effect of citrus rootstock on size of scion is shown in photo above of Lisbon lemon on Bessie sweet orange; right, Lisbon lemon on trifoliate orange.

TABLE 2, VOLUME OF CANOPY OF VALENCIA ORANGE TOPS AND LISBON LEMON TOPS ON ROOTSTOCKS IN TRIANGULAR AREAS

Rootstock No.	Rootstock (4 replicates)	Vol. (cu. ft.)	Rootstocks with gummosis %
	VALENCIA ORANGE TOPS		
22	Rangpur lime	50.5	0
23	Ichang lemon #1	35.8	0
21	Nasnaran*	33.1	0
24	N. Mexican trifoliate	29.7	0
25	English trifoliate	23.8	0
26	Argentine trifoliate	20.1	0
0	Bessie swt. (24 CHECKS)	36.7	12.5
	LISBON LEMON TOPS		
24	New Mexican trifoliate	438.4	0
25	English trifoliate	338.7	0
23	Ichang lemon #1	299.7	0
26	Argentine trifoliate	273.0	0
21	Nasnaran*	220.9	0
22	Rangpur lime	210.6	25
0	Bessie swt. (24 CHECKS)	200.0	46

* Nasnaran is *Citrus amblicarpa.*

TABLE 1, VOLUMES OF CANOPIES OF VALENCIA ORANGE AND LISBON LEMON TOPS ON ROOTSTOCKS IN RECTANGULAR PLOTS

Order of size (without gummosis): 1 = greatest	Rootstock No.	Rootstock (5 replicates each)	Vol. (cu. ft.)	Rootstocks with gummosis %
VALENCIA ORANGE TOPS				
1	20	Pomeroy trifoliate	87.7	0
2	15	Nansho daidai*	81.6	0
	8	Rough lemon	78.2	40
3	7	Carrizo citrange	76.4	0
4	11	Citremon #1449	69.8	0
5	9	Troyer citrange	69.8	0
6	12	Alemow*	69.2	0
7	14	U.S.D.A. trifoliate	62.3	0
	16	Madm. Vinous sweet orange	56.9	40
	3	Koethen sweet	47.5	20
8	2	King mandarin	45.0	0
9	18	Siamelo	44.9	0
10	1	Barnes trifoliate	44.9	0
	17	Texas trifoliate	43.6	0
	4	Ponkan mandarin	42.6	0
	0	Bessie sweet (100 CHECKS)	42.2	47
	5	Shekwasha*	40.2	0
	6	Cleopatra mandarin	36.5	0
	19	Ichang lemon #2	36.2	0
	10	Batangas mandarin	31.3	0
	13	Calamondin*	5.2	0
LISBON LEMON TOPS				
1	7	Carrizo citrange	404.0	0
2	12	Alemow*	391.2	0
3	14	U.S.D.A. trifoliate	374.5	0
4	11	Citremon #1449	327.3	0
5	17	Texas trifoliate	308.9	0
6	20	Pomeroy trifoliate	300.4	0
	8	Rough lemon	293.5	60
7	15	Nansho daidai*	268.7	0
8	1	Barnes trifoliate	268.4	0
	16	Madm. Vinous sweet orange	231.5	40
9	19	Ichang lemon #2	220.6	0
10	9	Troyer citrange	207.3	0
	2	King mandarin	206.9	20
	10	Batangas mandarin	202.6	0
	18	Siamelo	198.1	0
	3	Koethen sweet	185.4	100
	4	Ponkan mandarin	175.3	20
	6	Cleopatra mandarin	170.2	20
	0	Bessie sweet (100 CHECKS)	146.4	73
	5	Shekwasha*	122.7	20
	13	Calamondin*	88.0	0

* Nansho daidai is *Citrus taiwanica;* alemow is *C. macrophylla;* Shekwasha is *C. depressa;* Calamondin is *C. mitis.*

TABLE 3, RESISTANCE OF CITRUS ROOTSTOCKS TO PHYTOPHTHORA AS MEASURED BY TRUNK CIRCUMFERENCES IN THE RECTANGULAR PLOTS (Oct. 1963 to Oct. 1964)

Number	Name	Number of trees	Number with gummosis	Average increase in circumference of rootstock 2" below bud union	Average increase in circumference of scion 6" above bud union	Order of rate of scion growth (1 = greatest)*
Valencia orange scions on the following rootstocks:						
				Millimeters		
0	Bessie swt. orange	100	47	29.5	24.7	
1	Barnes trifoliate	5	0	58.4	46.0	4
2	King mandarin	5	0	52.8	45.2	6
3	Koethen sweet orange	5	2	39.6	32.8	
4	Ponkan mandarin	5	0	43.2	39.4	10
5	Shekwasha†	5	0	33.8	32.8	
6	Cleopatra mandarin	5	0	42.4	36.8	
7	Carrizo citrange	5	0	61.2	48.0	2
8	Rough lemon	5	5	39.0	37.4	
9	Troyer citrange	5	0	66.4	47.0	3
10	Batangas mandarin	5	0	42.8	39.4	9
11	Citremon #1449	5	0	57.4	43.6	7
12	Alemow†	5	0	34.8	31.6	
13	Calamondin†	5	1	14.4	12.4	
14	U.S.D.A. trifoliate	5	0	58.6	43.4	
15	Nansho daidai†	5	0	56.6	45.6	5
16	Madm. Vinous swt. orange	5	2	33.0	27.4	
17	Texas trifoliate	5	0	61.6	49.8	1
18	Siamelo	5	0	45.0	37.6	
19	Ichang lemon #2	5	0	45.8	36.6	
20	Pomeroy trifoliate	5	0	54.0	39.6	8
Lisbon lemon scions on the following rootstocks:						
0	Bessie swt. orange	100	84	31.6	30.2	
1	Barnes trifoliate	5	0	81.0	75.6	2
2	King mandarin	5	1	61.0	54.4	
3	Koethen swt. orange	5	5	39.6	39.0	
4	Ponkan mandarin	5	0	53.2	46.4	
5	Shekwasha†	5	1	48.6	42.6	
6	Cleopatra mandarin	5	0	56.2	52.6	9
7	Carrizo citrange	5	0	71.2	62.0	5
8	Rough lemon	5	3	55.6	45.2	
9	Troyer citrange	5	0	68.6	54.8	7
10	Batangas mandarin	5	0	59.6	63.4	4
11	Citremon #1449	5	0	67.8	58.2	6
12	Alemow†	5	0	51.0	47.4	
13	Calamondin†	5	0	31.0	33.2	
14	U.S.D.A. trifoliate	5	0	88.6	80.0	1
15	Nansho daidai†	5	0	59.4	53.0	8
16	Madm. Vinous swt. orange	5	2	52.2	50.6	
17	Texas trifoliate	5	0	80.0	66.4	3
18	Siamelo	5	0	59.2	50.8	
19	Ichang lemon #2	5	0	65.0	51.8	10
20	Pomeroy trifoliate	5	0	69.4	50.2	

* Those varieties having gummosis of trunk were not included in rating.

† Nansho daidai is *Citrus taiwanica;* alemow is *C. macrophylla;* Shekwasha is *C. depressa;* Calamondin is *C. mitis.*

Cleopatra mandarin, and Ichang lemon were among the ten best. One of the five lemons on King mandarin had gummosis. When the volumes of foliage canopies were measured in July, 1964, 73 of the 100 Lisbon lemon check trees on Bessie sweet orange rootstocks had contracted *Phytophthora* gummosis on the stock, and the number of infected stock checks had increased to 84 by October, 1964. The number of Valencia orange check trees on Bessie sweet orange rootstocks that were visibly infected with gummosis on the stock remained at 47 of the 100 during that period. Past research has shown the influence of the two species of tops on susceptibility of the sweet orange rootstock to *Phytophthora* gummosis.

TABLE 4. RESISTANCE OF CITRUS ROOTSTOCKS TO PHYTOPHTHORA AS MEASURED BY TRUNK CIRCUMFERENCES IN THE TRIANGULAR PLOTS (Oct. 1963 to Oct. 1964)

Number	Name	Number of trees	Number with gummosis	Average increase in circumference: rootstock 2″ below bud union	Average increase in circumference: scion 6″ above bud union	Order of rate of scion growth (1 — greatest)*
Valencia orange scions on the following rootstocks:						
				Millimeters		
0	Bessie swt. orange	24	4	36.0	30.6	
21	Nasnaran†	4	0	46.5	43.0	3
22	Rangpur lime	4	0	35.0	35.2	5
23	Ichang lemon #1	4	0	45.8	38.0	4
24	New Mexican trifoliate	4	0	59.5	44.8	1
25	English trifoliate	4	0	53.8	44.0	2
26	Argentine trifoliate	4	0	60.0	44.8	1
Lisbon lemon scions on the following rootstocks:						
0	Bessie swt. orange	24	12	49.9	46.9	
21	Nasnaran†	4	0	60.8	61.5	3
22	Rangpur lime	4	1	41.0	39.8	
23	Ichang lemon #1	4	0	70.5	60.2	5
24	New Mexican trifoliate	4	0	77.7	61.0	4
25	English trifoliate	4	0	79.0	63.0	2
26	Argentine trifoliate	4	0	78.8	64.2	1

* Those varieties having gummosis of trunk were not included in the rating.
† Nasnaran is Citrus amblicarpa.

Table 4 shows results for the trees on the triangular plots with only four replicates. Three trifoliate varieties, Nasnaran and Ichang lemon showed no gummosis infection. Under the lemon scion, one of the four trees on Rangpur lime had gummosis; this stock under the Valencia orange showed no disease symptoms. Here again, the lemon top made the sweet orange rootstock more susceptible to *Phytophthora* gummosis than did the sweet orange top (12 of the former and four of the latter were infected).

L. J. Klotz is Plant Pathologist and Professor of Plant Pathology Emeritus; W. P. Bitters is Professor and Horticulturist; and T. A. DeWolfe is Specialist, University of California Citrus Research Center and Agricultural Experiment Station, Riverside. *Layout of plantings was by M. J. Garber. Po-Ping Wong assisted by budding the rootstocks.*

Biological Control of Olive Scale

C. E. KENNETT · C. B. HUFFAKER · K. W. OPITZ

For nearly thirty years, olive scale, Parlatoria oleae (Colvée), has been the most important insect pest of olives in California. Prior to the introduction of the Persian wasp, Aphytis maculicornis (Masi), in 1952, olive scale was also a most serious pest on deciduous fruits and many species of ornamentals in the Central Valley area. Since then, establishment of the Persian wasp, as well as one other parasite, Coccophagoides sp., has drastically reduced the severity and frequency of scale infestations in California, as reported in this study.

OLIVE SCALE has two generations during the year in California. Young scales of the spring generation are produced by overwintered females of the fall generation. The eggs hatch, and the young crawlers settle on the twigs and leaves during May. The male scales develop and emerge as adults during July, when they fertilize the female scales. The females become fully mature in late July, and eggs are produced during August and September.

The crawlers of the fall generation hatch and settle on the twigs, leaves, and fruits of olive trees during August and September, causing areas of discoloration (premature ripening) and sometimes distortion. These scale-marked fruits are culled by the olive processor. The male scales develop and emerge as adults during October and November, at which time they fertilize the immature female scales. The females of this generation overwinter in the immature third instar and mature in late April.

During the period of colonization and widespread establishment of the Persian *Aphytis*, many studies were conducted in olive groves to determine the effect of this parasitic wasp on densities of olive scale. Because most of the commercial acreage of olives in California is annually treated with parathion to control olive scale, the studies were often limited to small untreated blocks of not more than one to four acres. However, a few growers initiated biological control throughout entire groves with *Aphytis*.

The success of *Aphytis* in maintaining adequately low and commercially acceptable levels of olive scale was excellent in certain groves each year. In other groves, the level of scale-marked fruits was often too high. (A commercially acceptable level of fruit marking is 2 to 5%.)

The *Aphytis* wasp is an external parasite of olive scale. The female wasp deposits its eggs, one per scale host, on the scale body beneath the scale covering or "armor." Upon hatching from the egg the *Aphytis* larva feeds externally on the