Results of Scion and Rootstock Trials for Citrus in Arizona - 1997[1]

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Abstract

Five rootstocks, 'Carrizo' citrange, Citrus macrophylla, Rough lemon, Swingle citrumelo and Citrus volkameriana were selected for evaluation using 'Limoneira 8A Lisbon' as the scion. Early results indicate that trees on C. volkameriana and C. macrophylla are superior to those on other rootstocks in both growth and yield. 'Swingle' and Carrizo' are performing poorly. In a similar trial, Four 'Lisbon' lemon selections, 'Frost Nucellar', 'Corona Foothills', 'Limoneira 8A' and 'Prior' from the University of Arizona Citrus Budwood Certification plot were selected for evaluation on Citrus volkameriana rootstock. Early results indicate that the 'Limoneira 8A Lisbon' selection is outperforming the other selections in both growth and yield. Preliminary results from another lemon cultivar trial and a navel orange cultivar trial are presented as well.

Introduction

There is no disputing the importance of citrus cultivars and rootstocks to desert citrus production. A successful citrus cultivar must be adaptable to the harsh climate, (where average high temperatures are often greater than 40°C), must be vigorous and must produce high yields of good quality fruit of marketable size. Likewise, the ideal citrus rootstock must be compatible with the scion, be adaptable to the appropriate soil and climactic factors and should also improve one or more of the following characteristics: pest and disease resistance, cold tolerance, harvest date, internal and external fruit quality, yield and post-harvest quality. Ultimately, the value of a rootstock lies in its ability to improve production and/or quality of the fruit.

Therefore, we expect that the first scion and rootstock cultivar trials that we initiated in 1993 will reveal the appropriate lemon scions and rootstocks for the Arizona industry. The lemon scion trial includes 'Limoneira 8A Lisbon', 'Prior Lisbon', 'Frost Nucellar Lisbon', and 'Corona Foothills Lisbon' lemon on *C. volkameriana* as the rootstock. The lemon rootstock trial includes rough lemon (*C. jambhiri*), *C. volkameriana, C. macrophylla,* 'Carrizo' citrange and 'Swingle' citrumelo as the rootstocks and 'Limoneira 8A Lisbon' lemon as the scion. Data collected from these trials includes tree growth, mineral nutrition, fruit quality, fruit size and total yield. Previous results from this trial have been reported in Wright (1997), Wright (1996) and Wright (1995).

We are now also able to collect lemon yield data from the citrus variety block. This trial, established in 1995, contains 'Allen Eureka', 'Cascade Eureka', 'Cook Eureka', 'Cavers Lisbon', 'Frost Nucellar Lisbon', 'Limoneira 8A Lisbon', 'Prior Lisbon', 'Rosenberger Lisbon', 'Limonero Fino 49' and 'Villafranca' all on *C. volkameriana* rootstock.

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Finally, 1997 was the first year that we were able to get data from the navel orange trial. This trial, established in 1995, contains 'Lane Late', 'Atwood', 'Fisher', 'Parent Washington', and 'Tulegold' navel orange cultivars on 'Carrizo' rootstock.

Materials and Methods

1993 Lemon Scion and Rootstock. These trials were established in March 1993 in Block 26 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on a 10-m x 10-m spacing. Ten replicates of each of the 5 rootstocks were planted, and 12 replicates of each of the 4 scions were planted, for a total of 98 trees. Experimental design is randomized complete block.

Irrigation is border flood, and normal cultural practices are used. Growth data, expressed as trunk diameter, is taken annually in March. Measurements are taken about 4 inches above the bud union. These locations are permanently marked with paint. Trunk diameters are taken annually in March, so as to quantify and differential growth rates that might have occurred. Canopy volume data was collected in February 1997, and is expressed as m^3 canopy per tree. Leaves are collected annually in August for mineral analysis, however there have been no significant differences. Fruit diameter data was collected semiweekly in 1997. One fruit of a representative size per tree was tagged, and was measured until harvest. Replacement fruits of approximately the same size were selected if a fruit was harvested or if it abscised. Yield data is collected during the fall and winter. Trees were ring or strip-picked as noted below. About 30 lbs of fruit is sampled from each tree, and fruit packout data is collected from the sample. Fruits are then sized and graded, and reported on a percentage basis. Fruit quality data was collected at each harvest time. These data include °brix, peel thickness, percentage juice, pH, and total soluble solids to total acid ratio. There was no effect of scion or rootstock on fruit quality (data not shown). Data was analyzed using SPSS for Windows (SPSS Inc., Chicago, Illinois).

1995 Lemon Scion. These trials were established in March 1995 in Block 17 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on a 10-m x 10-m spacing. Three to five trees of each scion were planted. Yields are expressed as lb. fruit per tree. Yield data is collected during the fall and winter. Trees were ring or strip-picked as noted below. Data was analyzed using SPSS for Windows (SPSS Inc., Chicago, Illinois).

1995 Navel Orange. These trials were established in March 1995 in Block 18 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on a 10-m x 10-m spacing. Twelve trees of each of five scions were planted, for a total of 60 trees. Yields are expressed as lbs. fruit per tree. Yield data is collected during the fall and winter. Data was analyzed using SPSS for Windows (SPSS Inc., Chicago, Illinois).

Results and Discussion

1993 Lemon Scion and Rootstock. Trunk diameters of 'Limoneira 8A Lisbon' trees on *C. volkameriana* were the greatest at planting (Table 1), followed by 'Carrizo' citrange, Rough lemon, *C. macrophylla* and 'Swingle' citrumelo. Lemons on *C. volkameriana* still have had the greatest trunk diameter after four years, while trees on *C. macrophylla* and rough lemon have been close behind. These growth rates resulted in cumulative trunk growth increases that were greatest for *C. volkameriana, C. macrophylla* and rough lemon, and less for trees on 'Carrizo', and 'Swingle'. Canopy volumes taken during 1997 show similar trends, although trees on *C. volkameriana* are significantly larger than those trees on *C. macrophylla* or rough lemon.

'Corona Foothills Lisbon' had the smallest trunk diameter at planting (Table 2) and in 1997. 'Prior Lisbon' trees had significantly larger trunk diameters than 'Limoneira 8A Lisbon' trees, while 'Frost Nucellar Lisbon' trees were intermediate. These differences did not translate into larger yields (See below). There was no difference in canopy volume among the four scions.

Fruit diameter increase from May 1997 until December 1997 is shown in Figure 1. During 1997, fruit diameter of trees on *C. volkameriana* was usually larger than any other scion-rootstock combination, beginning in August. For 1997, these data suggest that fruit of trees on *C. volkameriana* are larger because the trees have greater water intake typical of *C. volkameriana*, which would lead to increased fruit cell growth. Similar results were noted in 1996 (Wright, 1997). Fruit diameter of trees on *C. macrophylla* was slightly less, beginning in late July, a time that was notable for high temperatures (< 45°C). This suggests that young trees on *C. macrophylla* are less able to withstand those high temperatures. Rough lemon, 'Swingle' and 'Carrizo' had intermediate fruit diameters.

Figure 2 is the equivalent of Figure 1, but for the lemon scion trial. These graphs indicate that fruit of 'Prior Lisbon' was smaller than the fruit of the other three scions beginning in July. This is the first time that fruit of 'Prior' has been smaller than the other scions tested.

Yield of trees in both studies was quite limited during the 1994-95 season. Nonetheless, significant yield differences appeared in the rootstock trial (Table 3), where trees on *C. volkameriana* rootstock had four to twelve times the yield of any other scion rootstock combination. From 1995-96 through 1997-98, both *C. macrophylla* and *C. volkameriana* gave the best yield (three to five times more than 'Carrizo' or 'Swingle'). It is notable that 1997-98 was the first year that trees on *C. macrophylla* had more yield than those trees of *C. volkameriana*, although the difference was not significant. This trend bears watching.

Trees on Rough lemon produced intermediate yields, while those on 'Carrizo' and 'Swingle' produced the least. This is due to the reduced vigor of these two rootstocks. When the yield is expressed as kg fruit per m^3 of canopy, *C. macrophylla* performs best, because of its smaller tree size. All three lemon-type rootstocks had significantly more fruit harvested early than did 'Carrizo' or 'Swingle'.

There was very little effect of rootstocks on fruit grade (Table 4). *C. volkameriana, C. macrophylla'* and Rough lemon had the greatest numbers of fruit of size 195 or more.

There were no yield differences among the scions tested during the 1994-95 harvest season (Table 5). Yields across the entire experiment in 1995-96 were light, but 'Limoneira 8A Lisbon' trees had 2 to 2.5 times the yield of the other scion cultivars. This same trend was repeated in 1996-97. For 1997-98, the yield of 'Limoneira 8A' was 2 to 3.7 times higher than the other cultivars tested. 'Limoneira 8A' had the greatest percentage of fruit harvested early as well. 'Frost Nucellar' in particular appears to be performing poorly as far as early fruit sizing. This is surprising because this cultivar was originally planted in Arizona because of its early sizing capabilities.

For the scions tested (Table 6), there was little affect of scion on fruit grade. 'Prior' had significantly less large fruit than did 'Corona Foothills' and 'Frost Nucellar'.

1995 Lemon Scion. Yields of the ten cultivars tested are shown in Table 7. Cultivars are grouped according to type. 'Eureka' lemons are shown in normal font, 'Lisbons' in bold font, and other types in Italics. For the first harvest, all the 'Eureka' lemons had significantly less yield than the 'Lisbon' and other lemons, except the 'Frost Nucellar'. 'Villafranca', 'Rosenberger Lisbon' and 'Cavers Lisbon' had the highest yields for the first harvest, while 'Rosenberger' had the best yield for the second harvest. 'Limonero Fino 49', 'Villafranca' and 'Cavers' had the greatest percentage of fruit harvested early. All of these cultivars should be watched and data should be collected in the coming years.

1995 Navel Orange. Yields of the five orange cultivars are shown in table 8. 'Tulegold' had significantly higher yield per tree than did the other trees.

Conclusions

It is still apparent that 'Carrizo' and 'Swingle' are unsuitable as rootstocks for lemon in Arizona. Reduced vigor, late fruit sizing and ultimate small fruit size are characteristics that cannot be overcome. Differences between *C. volkameriana*, *C. macrophylla* are not yet clear, however it appears as if trees on rough lemon may not be as vigorous as those on the other two lemon rootstocks. It remains to be seen if yield or fruit size will decrease, especially for *C. macrophylla*, as has occurred on older groves in Arizona.

For the scions, 'Limoneira 8A' appears to be superior to the others at this point. Whether it will remain superior will not be known for several years. 'Prior' is beginning to exhibit the lateness that has characterized it in the past.

Growers and researchers should continue to watch other lemon and navel orange cultivars that appear promising for Arizona. These include 'Villafranca' lemon 'Cavers Lisbon' lemon, 'Rosenberger Lisbon' lemon, 'Limonero Fino 49' lemon, and 'Tulegold' navel orange.

Literature cited

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Table 1. Trunk diameter and canopy volume of 'Limoneira 8A Lisbon' lemon trees on five different rootstocks.

Rootstock[z]	Scion Trunk Diameter (mm) 1993	1997	Growth Increase (mm) 1993-97	Canopy Volume (m^3) 1997
'Carrizo' Citrange	17.39 b[y]	69.07 b	51.68 b	5.23 c
C. macrophylla	15.12 c	98.23 a	83.11 a	11.87 b
Rough Lemon	17.17 b	96.76 a	79.59 a	12.29 b
'Swingle' Citrumelo	14.50 c	76.71 b	62.21 b	4.81 c
C. volkameriana	20.81 a	98.26 a	77.45 a	14.61 a

[z] Values are the means of 10 trees.

[y] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 2. Trunk diameters of four 'Lisbon' lemon cultivars budded to *C. volkameriana* rootstock.

Cultivar[z]	Scion Trunk Diameter (mm) 1993[y]	1997	Growth Increase (mm) 1993-97	Canopy Volume (m^3) 1997
'Corona Foothills Lisbon'	11.04 b[x]	103.8 c	90.8 c	16.07 a
'Frost Nucellar Lisbon'	12.98 a	113.7 ab	102.6 ab	12.98 a
'Limoneira 8A Lisbon'	12.34 a	107.8 bc	95.5 bc	14.13 a
'Prior Lisbon'	12.89 a	119.2 a	106.3 a	15.94 a

[z] Values are the means of 12 trees.

[y] March 1993 measurements were collected at planting.

[x] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 3. Yields and percentage of fruit harvested early of 'Limoneira 8A Lisbon' lemon trees on five different rootstocks.

Rootstock[z]	Yield per tree (lb.). 1994-95	1995-96	1996-97	1997-98	Pct. Fruit Harvested Early[y]
'Carrizo' Citrange	0.33 b[x]	10.16 c	11.80 c	23.61 c	35.53 b
C. macrophylla	0.11 b	29.70 a	58.25 a	103.47 a	62.98 a
Rough Lemon	0.13 b	19.60 b	40.52 b	53.54 b	57.17 a
'Swingle' Citrumelo	0.15 b	11.66 c	11.13 c	37.96 bc	37.84 b
C. volkameriana	1.28 a	36.20 a	57.71 a	84.62 a	67.56 a

[z] Values are the means of 10 trees.
[y] Fruit harvested on 26 September 1995, 12 November 1996, and 23 October 1997 as a percentage of the entire yield 1995-96 through-1997-98.
[x] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 4. October 23, 1997 harvest fruit grade and fruit size, expressed as a percentage, of 'Limoneira 8A Lisbon' lemon trees on five different rootstocks.

Rootstock[z]	Fruit Grade (%) Cull	2nd Grade	First Grade	Fruit Size (%) 165	140	115	95 or more
'Carrizo' Citrange	36.3 b[y]	21.3 a	37.4 a	20.1 a	19.2 a	10.4 ab	51.5 c
C. macrophylla	46.8 ab	24.2 a	29.0 a	9.6 b	5.5 a	7.1 b	77.9 ab
Rough Lemon	44.2 ab	23.1 a	32.7 a	11.1 ab	7.4 a	9.2 ab	71.7 ab
'Swingle' Citrumelo	36.0 b	25.0 a	39.0 a	14.1 ab	8.4 a	13.1 a	66.2 b
C. volkameriana	54.6 a	21.4 a	24.0 a	7.4 b	5.4 a	6.4 b	80.0 a

[z] Values are the means of 10 trees.
[y] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 5. Yields and percentage of fruit harvested early of four 'Lisbon' lemon cultivars budded to *C. volkameriana* rootstock.

Scion[z]	Yield per tree (lb.). 1994-95	1995-96	1996-97	1997-98	Pct. Fruit Harvested Early[y]
'Corona Foothills Lisbon'	0.13 a[x]	4.98 b	11.33 b	18.42 b	54.50 ab
'Frost Nucellar Lisbon'	0.07 a	3.97 b	14.48 b	26.62 b	43.55 b
'Limoneira 8A Lisbon'	0.13 a	10.56 a	27.71 a	69.04 a	62.53 a
'Prior Lisbon'	0.00 a	3.90 b	15.19 b	34.92 b	47.86 b

[z] Values are the means of 12 trees.

[y] Fruit harvested on 26 September 1995, 21 November 1996 and 23 October 1998 as a percentage of the entire yield 1995-96 through 1997-98.

[x] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 6. October 23, 1997 harvest fruit grade and fruit size, expressed as a percentage, of four 'Lisbon' lemon cultivars budded to *C. volkameriana* rootstock.

Rootstock[z]	Fruit Grade (%) Cull	2nd Grade	First Grade	Fruit Size (%) 165	140	115	95 or more
'Corona Foothills Lisbon'	61.1 a[y]	26.0 a	12.9 a	2.6 a	5.5 a	2.3 b	89.6 a
'Frost Nucellar Lisbon'	41.4 b	36.7 a	21.9 a	2.1 a	2.9 a	5.8 b	89.2 a
'Limoneira 8A Lisbon'	56.1 ab	21.7 a	22.2 a	3.7 a	4.9 a	4.7 b	86.7 ab
'Prior Lisbon'	55.9 ab	21.9 a	22.2 a	5.7 a	6.2 a	12.0 a	76.1 b

[z] Values are the means of 12 trees.

[y] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 7. Yields and percentage of fruit harvested early of ten lemon cultivars budded to *C. volkameriana* rootstock.

Scion[z]	Yield per tree (lb.). 29 October 1997	8 January 1998	Total	Pct. Fruit Harvested Early[y]
Allen Eureka	22.87 c	16.72 b	39.60 c	56.67 cd
Cascade Eureka	25.36 c	19.13 b	44.50 c	57.40 cd
Cook Eureka	19.06 c	22.30 b	41.36 c	49.53 d
Cavers Lisbon	**72.50 a**	**29.30 b**	**101.80 a**	**71.52 ab**
Frost Nucellar Lisbon	**34.95 bc**	**22.10 b**	**57.05 bc**	**62.35 bc**
Limoneira 8A Lisbon	**59.42 ab**	**35.62 ab**	**95.04 ab**	**63.04 bc**
Prior Lisbon	**63.00 ab**	**32.75 b**	**95.75 ab**	**66.15 bc**
Rosenberger Lisbon	**69.92 a**	**52.05 a**	**121.97 a**	**57.52 cd**
Limonero Fino 49	*75.40 a*	*19.02 b*	*94.42 ab*	*79.72 a*
Villafranca	*89.82 a*	*34.45 b*	*124.27 a*	*71.05 ab*

[z] Values are the means of 3 to 5 trees.
[y] Fruit harvested on 29 October 1998 as a percentage of the entire yield 1997-98.
[x] Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 8. Yields of five navel orange cultivars budded to Carrizo rootstock.

Scion[z]	Yield per tree (lb.). 13 January 1998
Lane Late	4.40 b
Atwood	5.14 b
Fisher	6.51 b
Parent Washington	7.05 b
Tulegold	11.84 a

[z] Values are the means of 12 trees.
[x] Means separation in columns by Duncan's Multiple Range Test, 5% level.

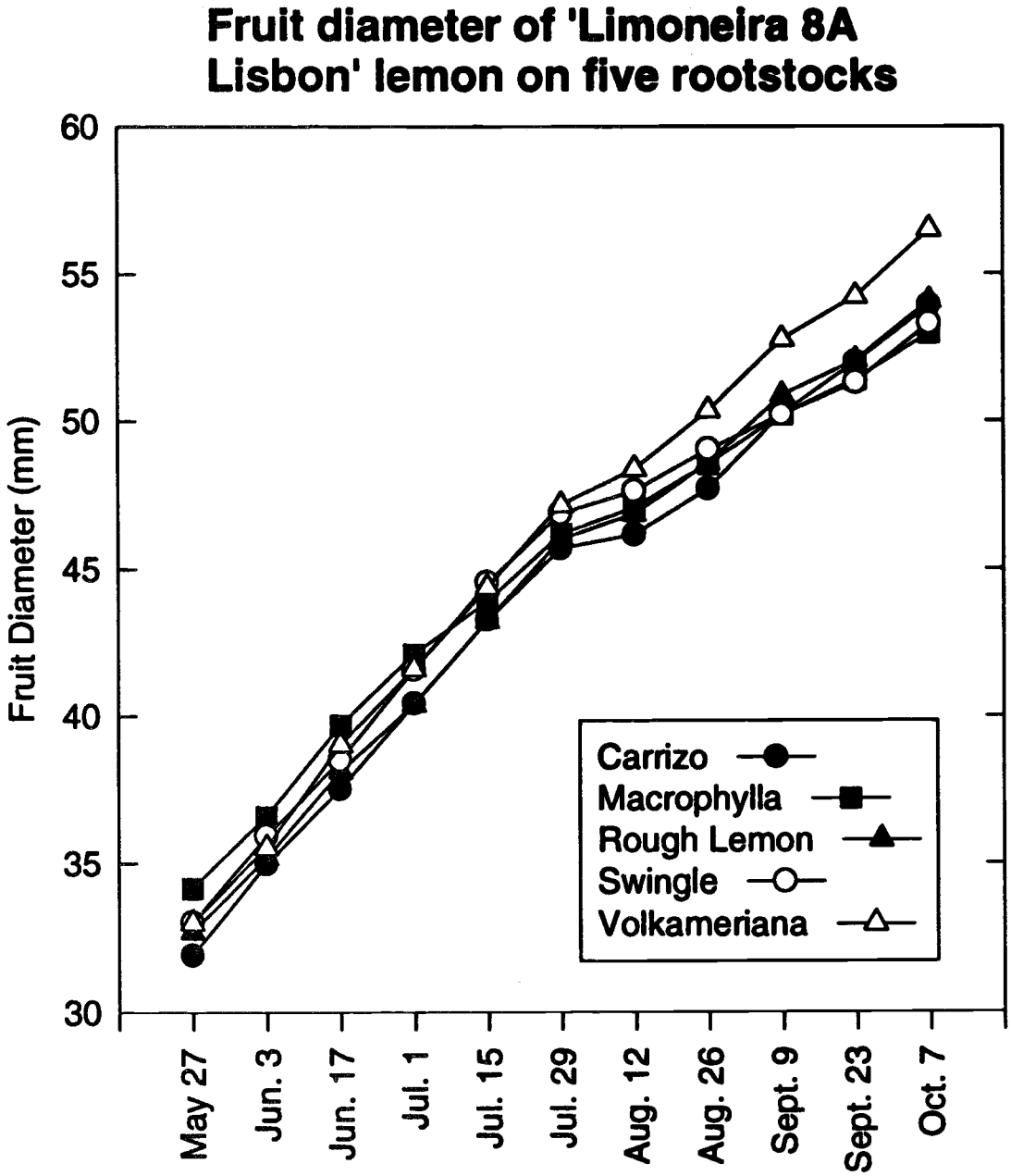

Figure 1. 1997 Biweekly fruit diameter of 'Limoneira 8A Lisbon' lemons on five rootstocks.

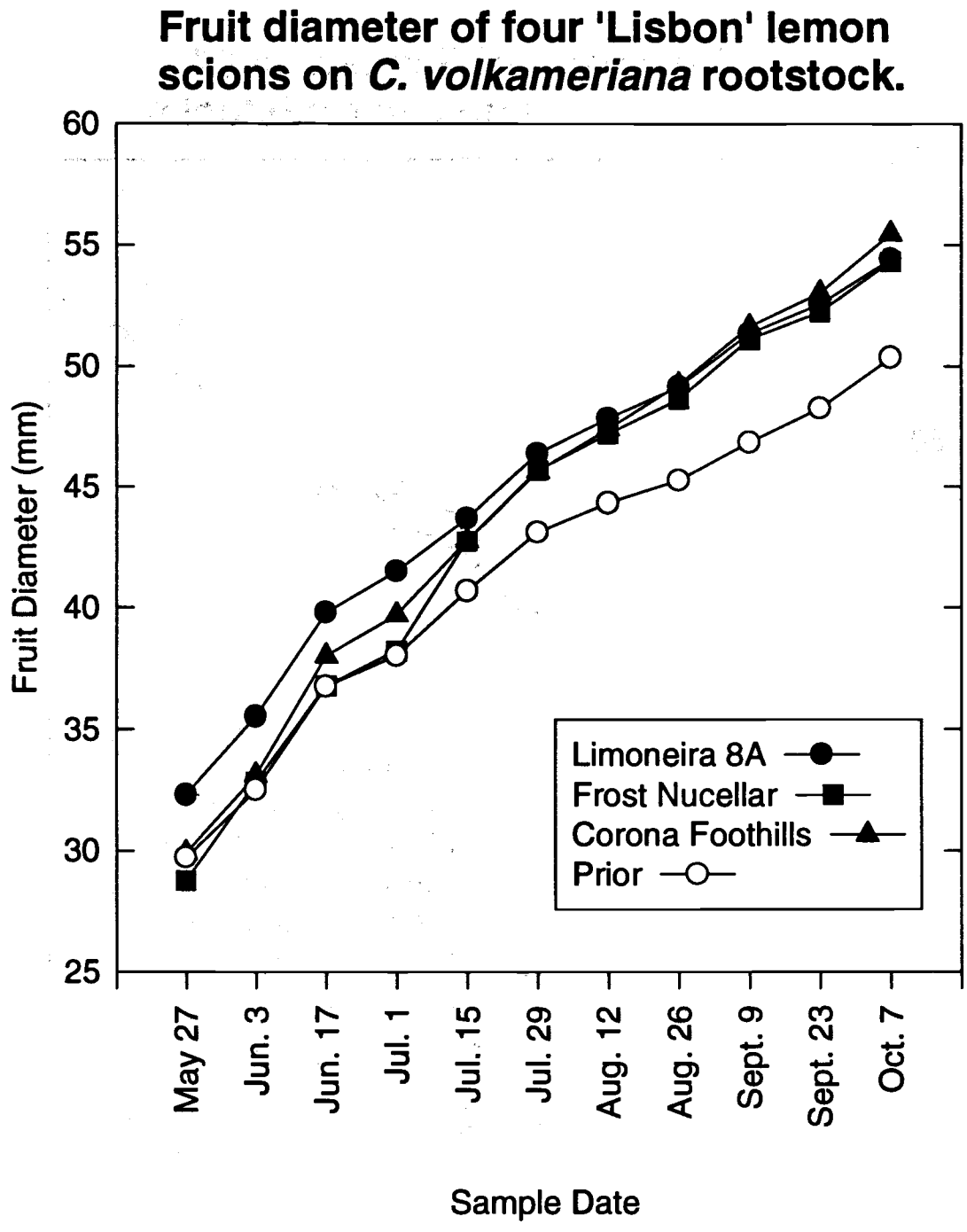

Figure 2. 1997 Biweekly fruit diameter of four 'Lisbon' lemon scion cultivars *on C. volkameriana* rootstock.