

Results of New Cultivar Selection Trials for Lemon in Arizona - 2002¹

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Abstract

Three lemon cultivar selection trials are being conducted at the Yuma Mesa Agriculture Center in Somerton, AZ. Data from these trials suggest that 'Limoneiro Fino 49' selections may be a suitable alternative for the varieties most commonly planted in Southwest Arizona today. 'Cavers Lisbon' and 'Villafranca' might also be planted on an experimental basis

Introduction

The Arizona lemon industry has historically relied on a small number of lemon cultivar selections. In the 1950's, the industry was established with 'Desert Lisbon', however within a few years, 'Desert Lisbon' was eclipsed in popularity by 'Frost Nucellar Lisbon' the only nucellar clonal selection of the 'Lisbon' cultivar. Other minor selections of 'Lisbon' that were planted in Arizona from the 1960's through the 1980's included 'Monroe', 'Prior', and 'Rosenberger'. Beginning in the late 1980's, new plantings were established using 'Limoneira 8A Lisbon'. More recently, 'Corona Foothills Lisbon' is increasingly popular. 'Allen Eureka' has also been occasionally planted in Arizona.

All of these represent clonal selections of outstanding trees that were then propagated. Typically, they are identified by their originator or place of origin, and are valuable to Arizona growers because of their high vigor, high productivity, precocity (trees bear at an early age), earliness (a high percentage of the fruit can be harvested before 1 November), short thorns and good fruit quality. When a commonly grown lemon cultivar selection is gradually replaced in the industry, the new selection typically is improved in one of these characteristics. Sometimes a cultivar selection may be replaced because of a negative characteristic. Such was the case with 'Frost Nucellar Lisbon' which appears to be susceptible to brown heartwood rot.

From the late 1980's, to the early 1990's, Arizona lemon growers have received their information about new cultivar selections through word of mouth or from nursery sources, since there were no trials planted in the state. With this in mind, we have planted three new lemon cultivar selection trials in the 1990's, all located at the Yuma Mesa Agricultural Center. Previous results from these trial have been reported in Wright (1995), Wright (1996), Wright (1997), Wright (1998), Wright et al., (1999), Wright and Peña (2000), Wright and Peña (2001), and Wright and Peña (2002).

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Materials and Methods

1995 Lemon Cultivar Selection Trial. This trial, comprising 10 cultivar selections was established in March 1995 in Block 17 (Foundation Block) of the Yuma Mesa Agricultural Center, near Yuma, Arizona. As it exists within the citrus variety collection, it is not a large trial, nor is it replicated. The experimental area 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 cultivar selection were planted. This trial contains the following selections, all on *C. volkameriana* rootstock:

- ‘Allen Eureka’ – The most common and popular ‘Eureka’ selection planted in Arizona. Originated in Santa Paula, CA
- ‘Cavers Lisbon’ – A vigorous ‘Lisbon’ selection originating in Upland, CA.
- ‘Cascade Eureka’ – Another, less-commonly planted, vigorous selection that originated in San Diego County, CA.
- ‘Cook Eureka’ – A selection from Limoneira Del Mar Ranch, Ventura County, California.
- ‘Frost Nucellar Lisbon’ – Vigorous nucellar selection derived by Dr. H.B. Frost of the Citrus Research Station, Riverside, CA
- ‘Limoneira 8A Lisbon’ – A vigorous selection originating from the Limoneira Ranch, Ventura County, CA. The most popular lemon planted in Arizona today.
- ‘Prior Lisbon’ – A selection from California. Originated at the Rancho Sespe, near Fillmore, CA. Has a reputation for lateness.
- ‘Rosenberger Lisbon’ – Although considered a ‘Lisbon’, possibly a hybrid of ‘Lisbon’ and ‘Villafranca’. Vigorous and productive. Originated in Upland, CA.
- ‘Limonero Fino 49’ – The chief winter lemon of Spain. Reportedly vigorous, thorny and highly productive. Early producer with uniform yield. Fruit is spherical to oval, with a smooth rind and a relatively short nipple. Relative high acid and about five seeds per fruit.
- ‘Villafranca’ – Said to be of Sicilian origin, introduced into Florida in 1875. Formerly planted in California, but of little importance there today. Fruit and tree characteristics similar to ‘Eureka’, but produces mainly a winter crop.

1997 Lemon Cultivar Selection Trial. This trial, comprising 13 cultivar selections, was established in March 1997 in Block 22 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on an 8-m x 8-m spacing. Fifteen trees of each selection were planted. This trial includes the ‘Allen Eureka’, ‘Cook Eureka’, ‘Cascade Eureka’, ‘Cavers Lisbon’, ‘Limoneira 8A Lisbon’, ‘Limonero Fino 49’ and ‘Villafranca’ described above as well as the following additional cultivar selections:

- ‘Arancino’ – A minor Italian cultivar, with rounded fruit, a short nipple and thick rind. Fruit is seedy.
- ‘Berna’ (‘Verna’) – The common summer lemon of Spain. Thornless tree produces medium to large fruit with few seeds.
- ‘Corpaci’ – A minor Italian cultivar from Sicily. Vigorous, thorny trees are reportedly productive. Fruit matures early and has few seeds.
- ‘Femminello Comune’ – Italian, everbearing cultivar.
- ‘Primofiori’ – Originated in Spain. Similar to the ‘Limonero Fino 49’ described above.
- ‘Santa Teresa’ – Similar to ‘Femminello Comune’, but resistant to the Mal Secco disease prevalent in Italy.

1998 Lemon Cultivar Selection Trial. This trial, comprising 7 cultivar selections, was established in late September 1998 in Block 14 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on an 8-m x 8-m spacing. Fifteen trees of each selection were planted. This trial includes the 'Limoneira 8A Lisbon' described above as well as the following additional cultivar selections:

- 'Dr. Strong Lisbon' –Originated at the Glen Good ranch, Santa Paula, CA. Large fruit, but tree is reportedly precocious.
- 'Genoa' – Similar to the 'Villafranca', imported from Italy to the U.S. in 1881.
- 'Lapithotiki' – Originated in Cyprus. Reportedly harvested from September until March. Fruit is tapered at both ends.
- 'Monroe Lisbon' – Vigorous selection. Reportedly bears early, but fruit is small and coarse.
- 'Taylor Eureka' – A nucellar selection, originating in Australia. Reportedly produces late.
- 'Walker Lisbon' – Vigorous selection from California.

For each of the three trials, yields are expressed as pounds fruit per tree. Yield data is collected during the fall and winter. Trees are commercially ring picked for the first harvest and strip-picked for the final harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. Prior to 1999-2000, approximately 30 lbs of fruit was sub-sampled from the harvested yield of each tree for packout determination, and these were sized by hand using rings and graded by visual observation. Since 1999-2000, the entire harvest from each tree has been passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis.

All data was analyzed using SPSS 7.0 for Windows (SPSS Inc., Chicago, Illinois).

Results and Discussion

1995 Lemon Selection Trial. 1997-2001 yields of the ten cultivar selections tested are shown in Table 1. Selections are grouped according to type. 'Eureka' lemons are shown in normal font, 'Lisbons' in bold font, and other cultivars in italics. For 1997-98, the 'Eureka' lemons had as much as 58% less yield than the 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.

For 1998-99, 'Cascade' and 'Cook Eureka' again performed poorly, while the 'Allen Eureka' was much improved over the previous year, with a yield surpassing all the 'Lisbon' lemon selections except 'Cavers'. Like the previous year, 'Cavers Lisbon', 'Limonero Fino 49' and 'Villafranca' had both large overall yield and a large percentage of their fruit harvested early. As in 1997-98, 'Frost Nucellar' had relatively low total yield, as did 'Limoneira 8A', 'Prior', and 'Rosenberger'. From 41 to 93% of the fruit on a particular tree was harvested early in 1998-99 harvest year, with 'Limonero Fino 49' as the earliest selection tested.

For 1999-2000, the 'Eureka' selections again performed poorly. Yields of the 'Eureka' selections were as much as 50% less than the yields of the best performing selections. Also, the 'Limoneira 8A' and 'Rosenberger' Lisbon lemons again performed poorly. For the third year in a row, the 'Cavers Lisbon' the 'Limonero Fino 49' and the 'Villafranca' performed the best, with yields similar to that of the previous years. No selection was significantly earlier than any other for 1999-2000.

For 2000-01, 'Cavers', and 'Limonero Fino 49' performed the best, followed by 'Rosenberger' and 'Frost Nucellar Lisbon'. This harvest season was the first that 'Frost Nucellar Lisbon' was among the highest yielding trees. Again, the 'Eureka' selections yielded less. 'Cavers', 'Limonero Fino 49' and 'Villafranca' had the greatest percentage of early fruit.

For 2001-02, data is presented in graphical format. First harvest, second harvest and total yields are presented in Figure 1. For the first harvest, much like in previous years, 'Cavers Lisbon' had significantly more yield than the other selections tested. Several other cultivars had intermediate first harvest yields, and 'Rosenberger' again had the smallest yield. For the second harvest, 'Limonero Fino 49', 'Frost Nucellar Lisbon', 'Prior Lisbon', and 'Rosenberger Lisbon' had the greatest yields. For total yield, 'Limonero Fino 49' was superior, followed by 'Frost Nucellar Lisbon', 'Prior Lisbon', 'Cavers Lisbon', and 'Cascade Eureka'. There was no significant difference among these selections. 'Allen Eureka', 'Cook Eureka' and 'Rosenberger Lisbon' had the least total yield for the year.

Packout for both harvests of 2001-02 is shown in Figures 2 and 3. 'Cascade Eureka' is not included in the data as it was inadvertently not harvested at the first harvest time. For the first harvest, there were significant differences only for sizes 95 through 165. 'Cook Eureka', 'Cavers Lisbon' and 'Limonero Fino 49' had the greatest amount of size 95 fruit. These selections, as well as 'Villafranca', 'Limoneira 8A Lisbon', 'Frost Nucellar Lisbon', and 'Prior Lisbon' had the most fruit of size 115. Most of the selections had large amounts of fruit of size 140, except 'Cook Eureka' and 'Allen Eureka'. For the second harvest of 2001-02, 'Limonero Fino 49' and 'Cavers Lisbon' had the most size 75 fruit, and these selections as well as 'Limoneira 8A Lisbon' and 'Prior Lisbon' had the most fruit of size 95. 'Allen Eureka' and 'Rosenberger Lisbon' had the smallest fruit for the second harvest.

Yields for the 2002-03 season are shown in Figure 4. As in previous years, 'Cavers' Lisbon had the greatest first harvest yield. 'Villafranca' had the next greatest first harvest yield, but not significantly different than 'Cavers'. A group of cultivars, including 'Limonero Fino 49', 'Allen Eureka', 'Frost Nucellar' and 'Cascade Eureka' had intermediate first harvest yields, while 'Prior', 'Limoneira 8A', 'Cook' and 'Rosenberger' had the least first harvest yield. Second harvest yields did not lead to significant yields between the cultivars. Final yields were similar among all of the cultivars; only 'Cook Eureka' was significantly lower than the rest.

Packout for both harvests of 2002-03 is shown in Figures 5 and 6. For the 10/16/02 harvest, 'Cascade Eureka' and 'Limonero Fino 49' had the most fruit of size 75 and 95, while 'Prior Lisbon' and 'Limoneira 8A' had the least. All the other cultivars tested were intermediate. The second harvest was very late in the season, so fruit size was very large. The three 'Eureka' cultivars, along with 'Limoneira 8A' and 'Cavers' had the greatest amount of size 75 fruit. For size 95, 'Limoneira 8A' had the most fruit, followed by the other Lisbon's, except 'Cavers'. In general, 'Limoneira 8A' had the largest fruit for this harvest, which may be explained by its smaller fruit for the first harvest.

For ease of viewing, 1997-98 to 2002-03 annual yields for this trial are shown in Figure 7. Since inception of the trial, 'Cavers Lisbon' and 'Limonero Fino 49' have had superior yields, although 'Limonero Fino 49' fell off slightly this year, but not significantly, especially compared to 'Limoneira 8A Lisbon', the industry standard. 'Frost Nucellar Lisbon' has been improving in the last three years, although fruit size of this selection is a little smaller. 'Limoneira 8A Lisbon' has not performed as well as expected, until this year. 'Cook Eureka' has generally had lower yields than the rest of the tested cultivars. Given the small size of this trial, conclusions drawn from this data alone are tentative. However, the continual superior performance of both 'Cavers' and 'Limonero Fino 49' suggests that they may have potential as additional lemon cultivars for the Arizona citrus industry.

1997 Lemon Selection Trial. First year yields for this trial are found in Table 2. 'Arancino' and 'Verna' are not included in the yields, since some of those trees were planted one year later than the rest of the selections. 'Limoneira 8A' had significantly more fruit than any of the other selections tested for the 2000-01 harvest season. There was no significant difference among the other selections. We also measured fruit length to width ratio. Round fruit have ratios closer to 1.0. 'Corpaci' appears to be a round fruit, while 'Cascade Eureka' is the most elongated.

For 2001-02, both 'Limoneira 8A Lisbon' and 'Limonero Fino 49' had the greatest overall yield (Fig.). 'Limonero Fino 49' also had the greatest yield for the first harvest, although 'Limoneira 8A', which had somewhat lower yield for the first harvest, was not significantly different. 'Santa Teresa' also performed well, but most of its accumulative yield was harvested at the second harvest date. 'In this trial, 'Cavers Lisbon' performed poorly. Also, the 'Allen', 'Cascade' and 'Cook Eureka's' did not perform as well as some of the 'Lisbons'. Finally, 'Arancino' and 'Berna' had the least overall yield, however since several of these trees are one year younger than the rest of the trees in the block, this is not entirely unexpected. Yields for these two selections for 2001-02 are not different than 2000-01 yields for the other selections found in Table 4.

First and second harvest packouts for five of the 13 selections evaluated in 2001-02 are found in Figures 9 and 10. For the first harvest, 'Cavers Lisbon' and 'Limonero Fino 49' had the largest fruit of size 95 and 115. It is notable that 'Cavers' has large fruit size despite the fact that it does not have the greatest yield for that harvest. These results are similar to those reported in the 1995 lemon selection trial. 'Femminello', 'Santa Teresa', and 'Limoneira 8A' had significantly smaller fruit. For the second 2001-02 harvest, 'Limonero Fino 49' and 'Cavers Lisbon' again had the most fruit in both the 75, 95 and 115 size categories. 'Limoneira 8A Lisbon', 'Femminello' and 'Santa Teresa' also had the most fruit in the 95 and 115 sizes.

For 2002-03, 'Santa Teresa', 'Limonero Fino 49', 'Limoneira 8A', and 'Villafranca' had the greatest overall yield, while 'Arancino' and 'Berna' had the least (Fig. 11). Both 'Limonero Fino 49' and 'Primofiori' yielded about 50% of its fruit in the first harvest; an amount greater than all other cultivars. 'Santa Teresa' had the most fruit in the second harvest, indicating that it is rather late-maturing. It is somewhat surprising that 'Cavers' was not among the best-performing cultivars. For the first harvest, packout of five of the 13 cultivars is shown in Figure 12. 'Limonero Fino 49' peaked on size 95 and 115, while 'Limoneira 8A', 'Cavers', 'Femminello' and 'Santa Teresa' peaked on sizes 115 and 140. Second harvest packout for the same five cultivars is shown in Figure 13. All the cultivars peaked on size 95, but 'Limonero Fino 49', 'Cavers' and 'Limoneira 8A' had greater numbers of size 75 fruit than did 'Femminello' and 'Santa Teresa'.

This trial is similar to the 1995 trial in that 'Limonero Fino 49' is proving to be a superior lemon cultivar. Although its yields in this trial are similar to those of 'Limoneira 8A' it has had superior fruit size, leading to a greater percentage of first harvest yield. 'Santa Teresa' also has had the greatest yields, but it appears to size fruit slower than either 'Limonero Fino 49' or 'Limoneira 8A'. Other cultivars, including 'Cavers', 'Femminello', 'Primofiori' and 'Villafranca' appear to have slightly less yield than the aforementioned three. 'Allen', 'Cascade', and 'Cook', all Eureka's, have intermediate yield, and there is nothing to distinguish one from the other to this point. 'Arancino', 'Berna' and 'Corpaci' bring up the rear.

1998 Lemon Cultivar Selection Trial. 2001-02 yields from this trial are found in Figure 14. Yields were minimal, but 'Walker Lisbon' and 'Limoneira 8A Lisbon' had the greatest yields. Yields for 2002-03 increased ten-fold over the previous year (Fig. 15). Again, 'Limoneira 8A' had the greatest yield, but not significantly different than the yields of 'Monroe Lisbon' and 'Taylor Eureka'. 'Walker Lisbon' and 'Dr. Strong Lisbon' had intermediate yields, followed by 'Genoa' and 'Lapithotiki'. Harvest was late this year, so fruit size was large; all the cultivars peaked on size 75. However, 'Lapithotiki' had significantly larger fruit than all the other cultivars tested; almost 90% of its yield was of fruit size 75. 2002-03 Packout from the other six cultivars is shown in Figure 16. 'Dr. Strong Lisbon' appeared to have the largest fruit size, followed by 'Limoneira 8A' and 'Monroe'. Several more years of data are necessary to show consistent differences among these cultivars.

Conclusions

One new lemon cultivar selection appears promising for Arizona. This is 'Limonero Fino 49' lemon. 'Cavers Lisbon' and 'Villafranca' may also be suitable, but neither consistently equals or surpasses 'Limoneira 8A Lisbon' lemon in terms of overall yield and/or earliness as often as does 'Limonero Fino 49'. 'Santa Teresa' appears to have excellent yield, but is hobbled by its lateness. No other new selections stand out at this time; however this may change as more data is collected. 'Eureka' lemons have typically performed poorly in comparison to the 'Lisbons', and should not be considered as a replacement for any of the high-yielding 'Lisbon' selections.

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Table 1. 1997- 2001 Yields of ten lemon cultivar selections budded to *C. volkameriana* rootstock.

Selection ^z	Yield (lbs. per tree)			
	1997-1998	1998-1999	1999-2000	2000-2001
Allen Eureka	39.7 c ^y	164.5 cd	142.4 bc ^x	210.1 cd
Cascade Eureka	44.5 c	93.5 f	143.3 bc	303.8 bcd
Cook Eureka	41.4 c	129.2 def	103.8 cd	177.0 d
Cavers Lisbon	101.9 a	272.3 a	279.1 a	454.4 a
Frost Nucellar Lisbon	57.1 bc	123.9 def	203.0 ab	349.0 abc
Limoneira 8A Lisbon	95.0 ab	152.3 def	101.0 cd	304.5 bcd
Prior Lisbon	95.7 ab	104.9 ef	188.5 b	326.9 abc
Rosenberger Lisbon	121.9 a	132.5 def	45.0 d	360.2 ab
<i>Limonero Fino 49</i>	<i>94.4 ab</i>	<i>233.9 ab</i>	<i>226.2 ab</i>	<i>434.3 ab</i>
<i>Villafranca</i>	<i>124.3 a</i>	<i>199.7 bc</i>	<i>220.2 ab</i>	<i>313.7 bcd</i>

^z Values are the means of 3 to 5 trees.

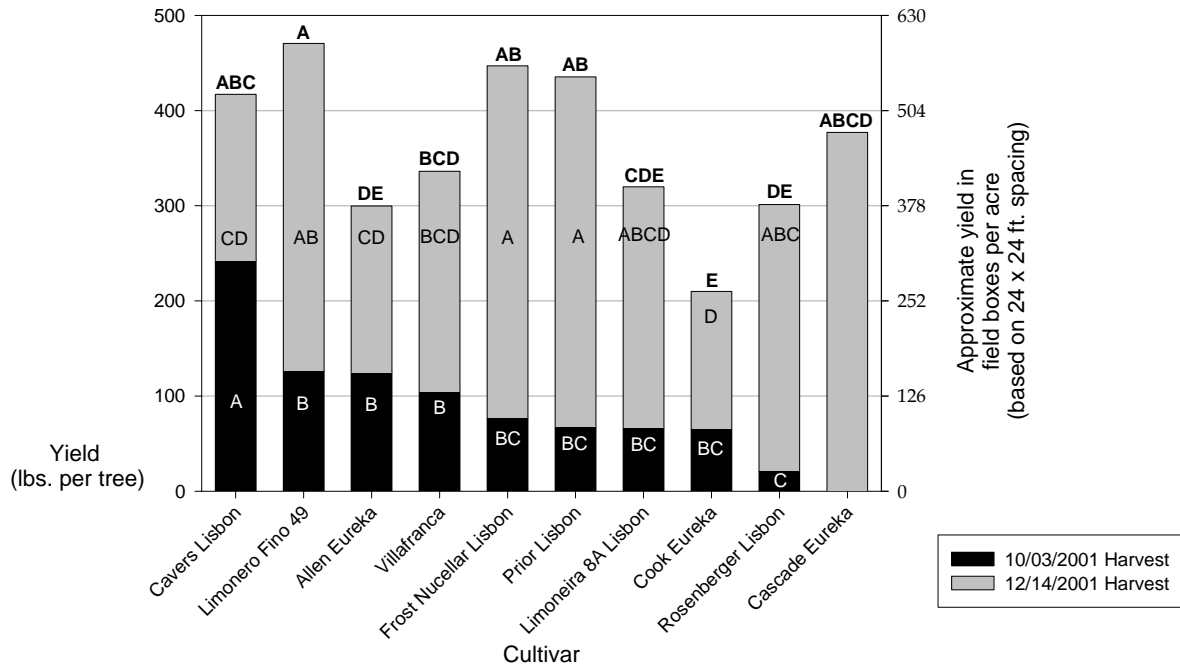
^y Means separation in columns by Duncan's Multiple Range Test, 5% level. Values in the same columns with the same letters are not significantly different.

Table 2. 2000-2001 Yields and fruit shape of eleven lemon cultivar selections budded to *C. volkameriana* rootstock.

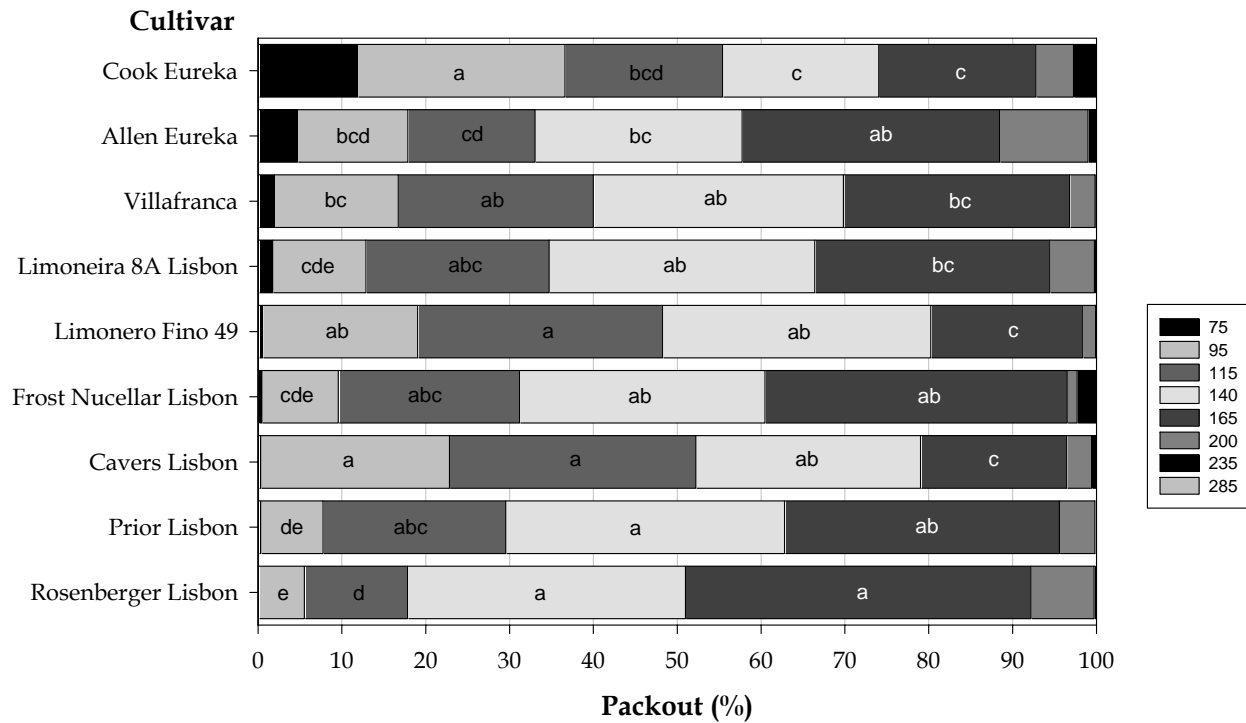
Selection ^z	Total Yield (lb.)	Fruit shape Width to Length ratio
Corpaci	9.5 b ^y	0.865 a
Cavers Lisbon	9.7 b	0.847 abc
Femminello Commune	14.6 b	0.815 bcd
Cook Eureka	15.4 b	0.817 bcd
Primofiori	16.5 b	0.810 cd
Cascade Eureka	17.9 b	0.793 d
Allen Eureka	18.7 b	0.820 bcd
Sta. Teresa	20.9 b	0.810 cd
Villafranca	22.3 b	0.857 ab
Limonero Fino 49	26.5 b	0.813 cd
Limoneira 8A Lisbon	56.9 a	0.810 cd

^z Values are the means of 15 trees.

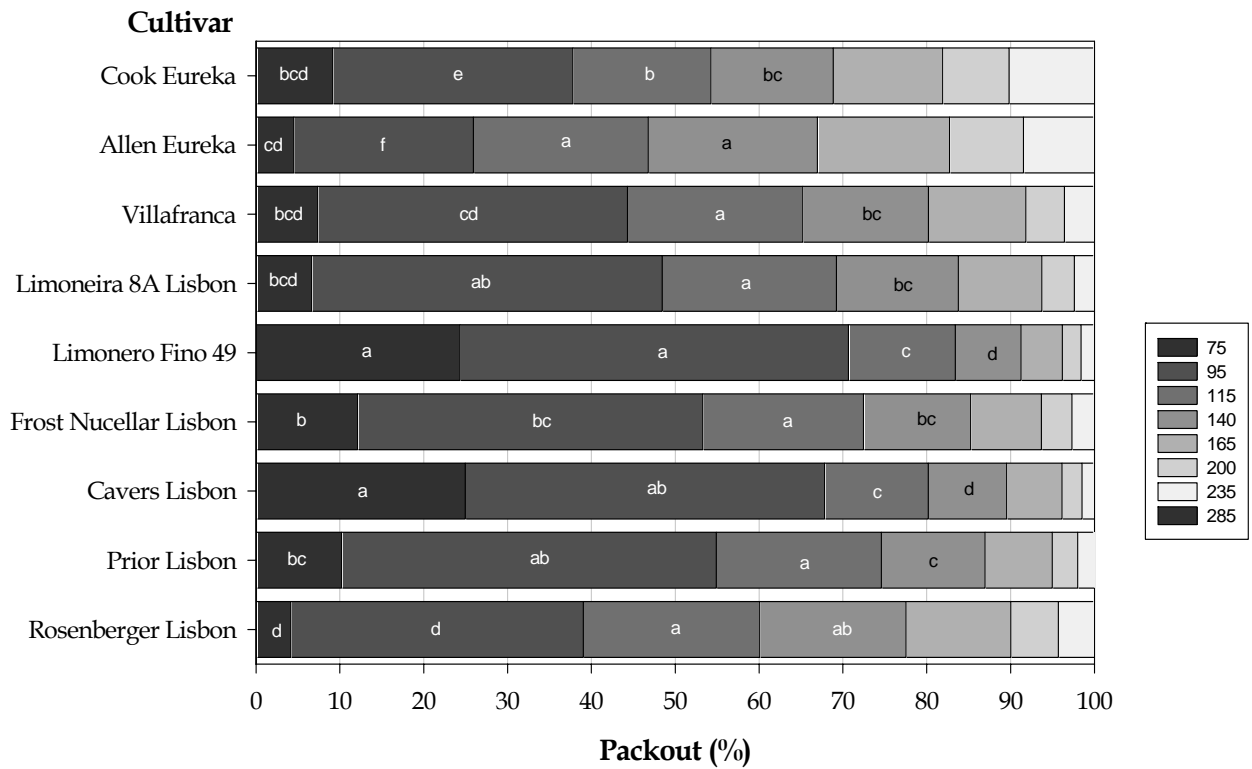
^y Means separation in columns by Duncan's Multiple Range Test, 5% level.



Letters indicate significant differences, within harvest dates or for total yield (bold letters), between cultivars tested.
 Figure 1. 2001-02 Yields for the 1995 Lemon Cultivar Selection Trial.

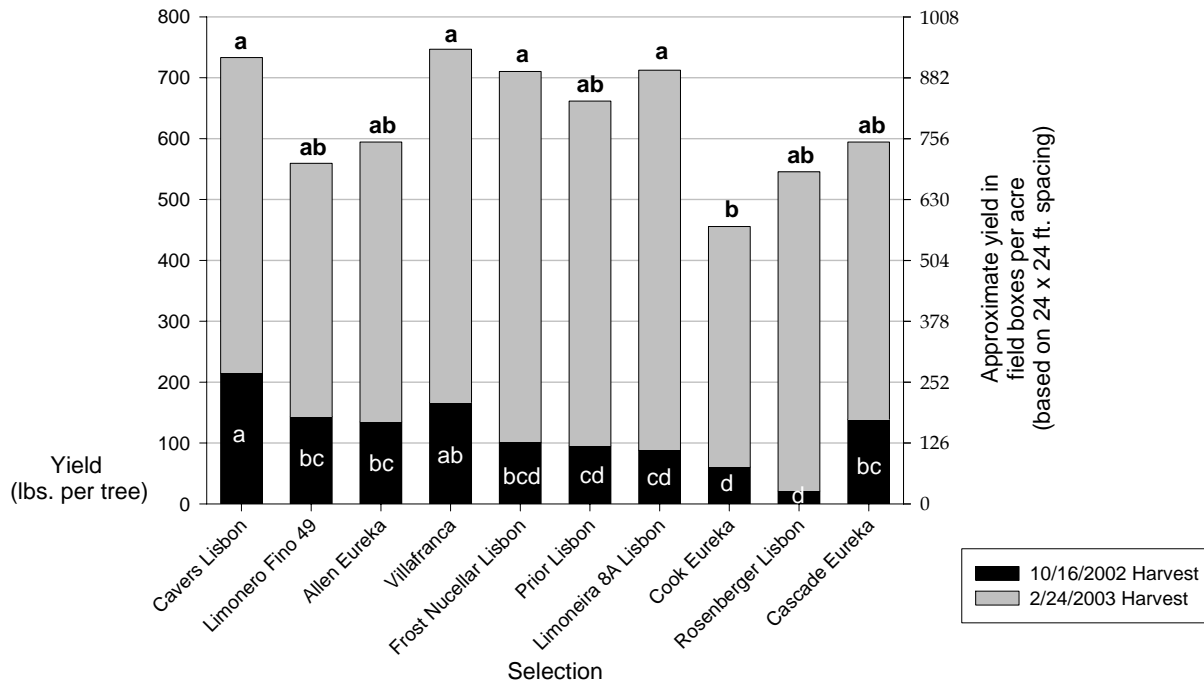


Letters indicate significant differences, within fruit sizes, between cultivars tested.
 Figure 2. 10/3/01 Packout for the 1995 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within fruit sizes, between cultivars tested.

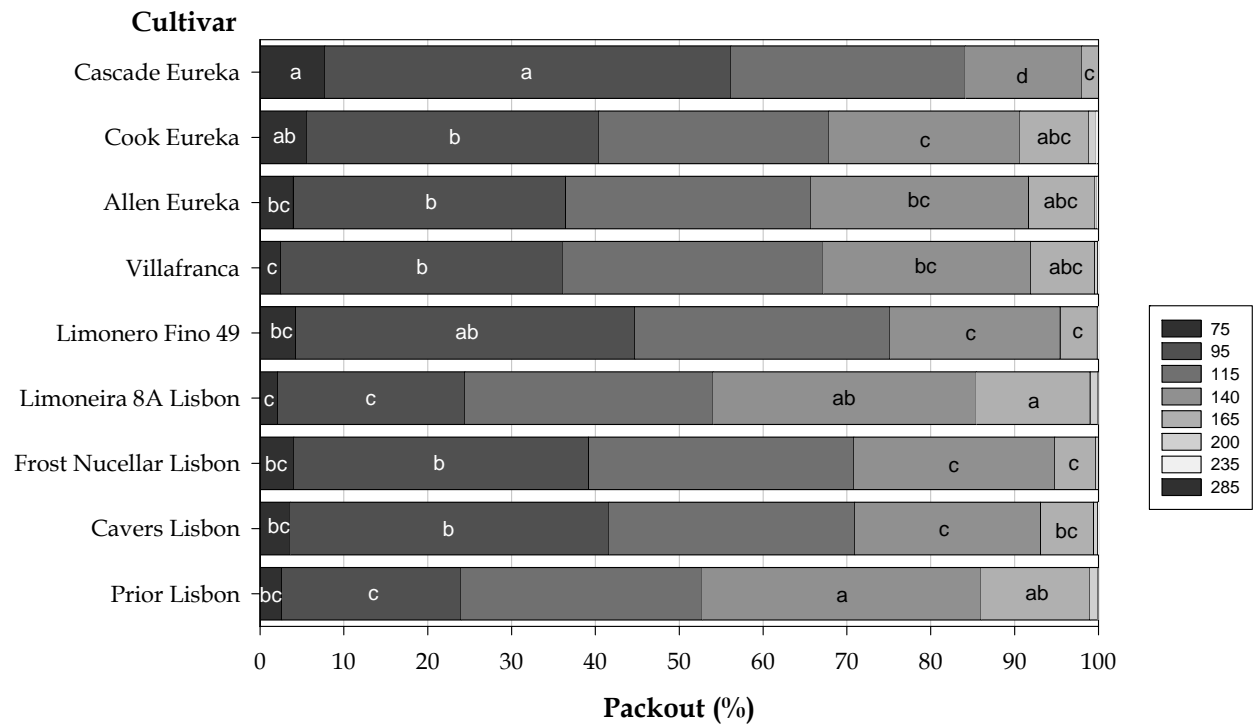
Figure 3. 12/14/01 Packout for the 1995 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within harvest dates or for total yield (bold letters), between selections tested.

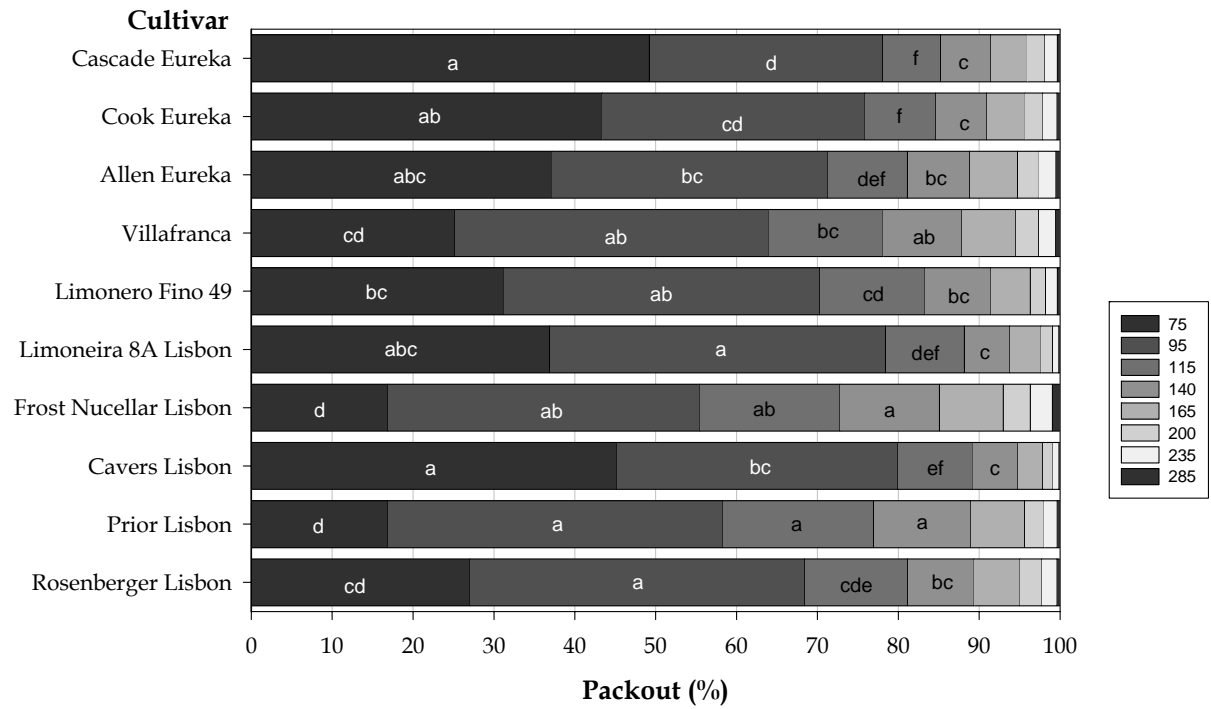
There was no significant effect of selection upon second harvest yield.

Figure 4. 2002-03 Yields for the 1995 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within fruit sizes, between cultivars tested.

Figure 5. 10/16/02 Packout for the 1995 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within fruit sizes, between cultivars tested.

Figure 6. 2/14/03 Packout for the 1995 Lemon Cultivar Selection Trial.

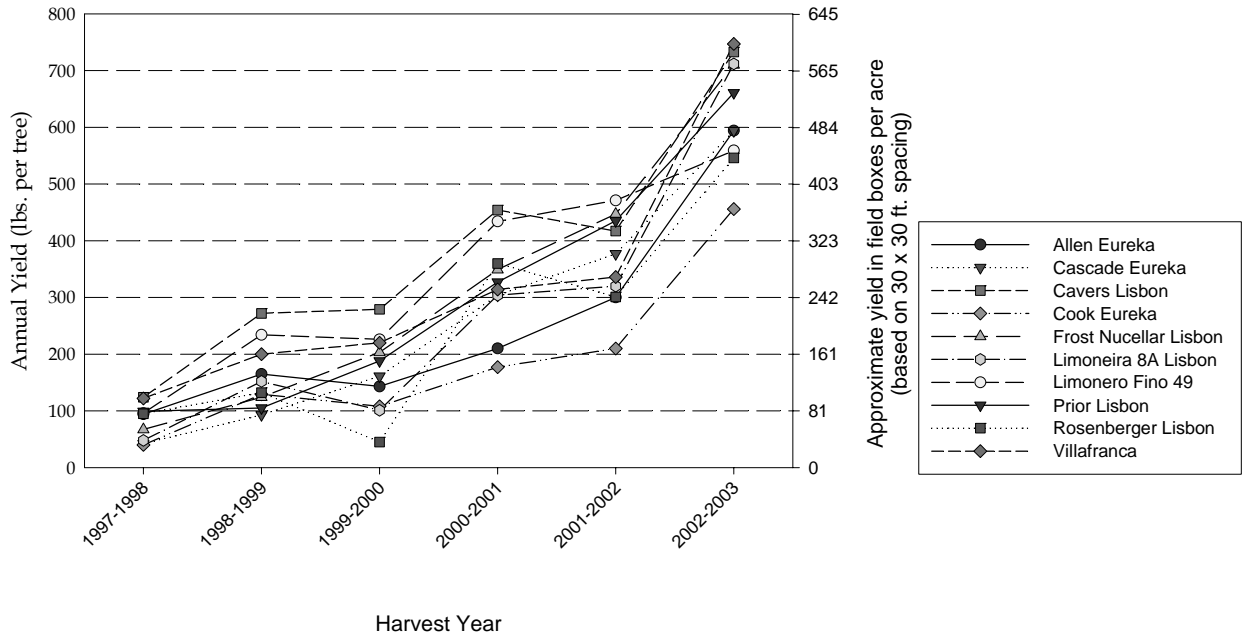
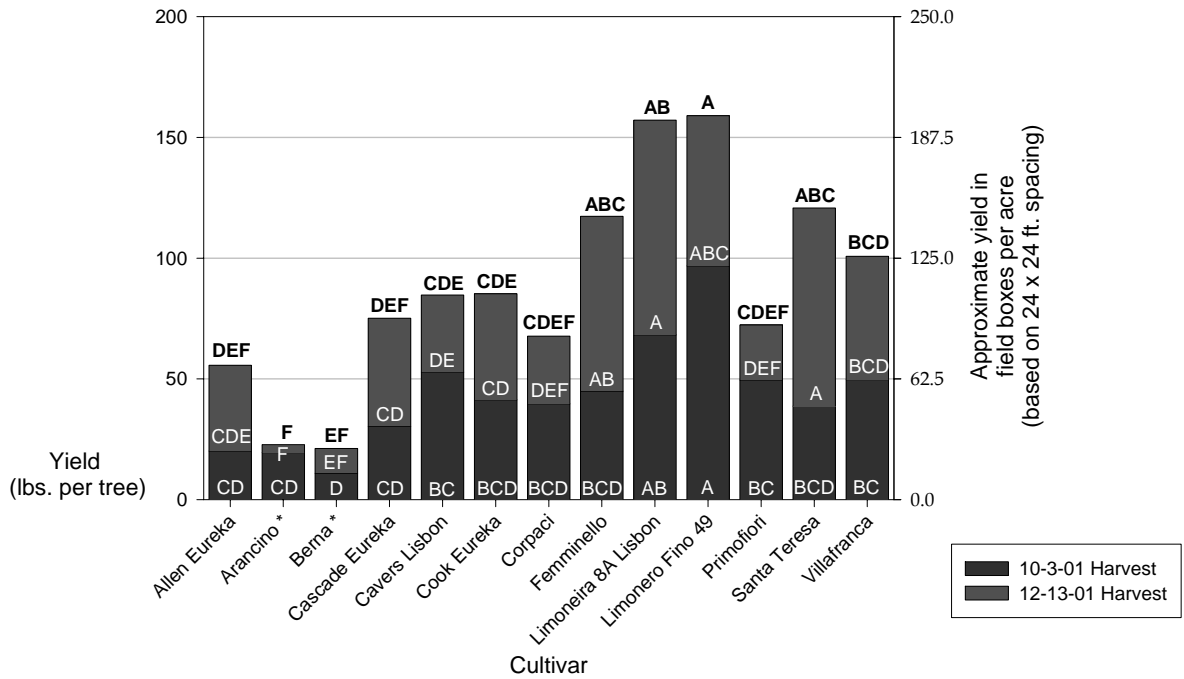
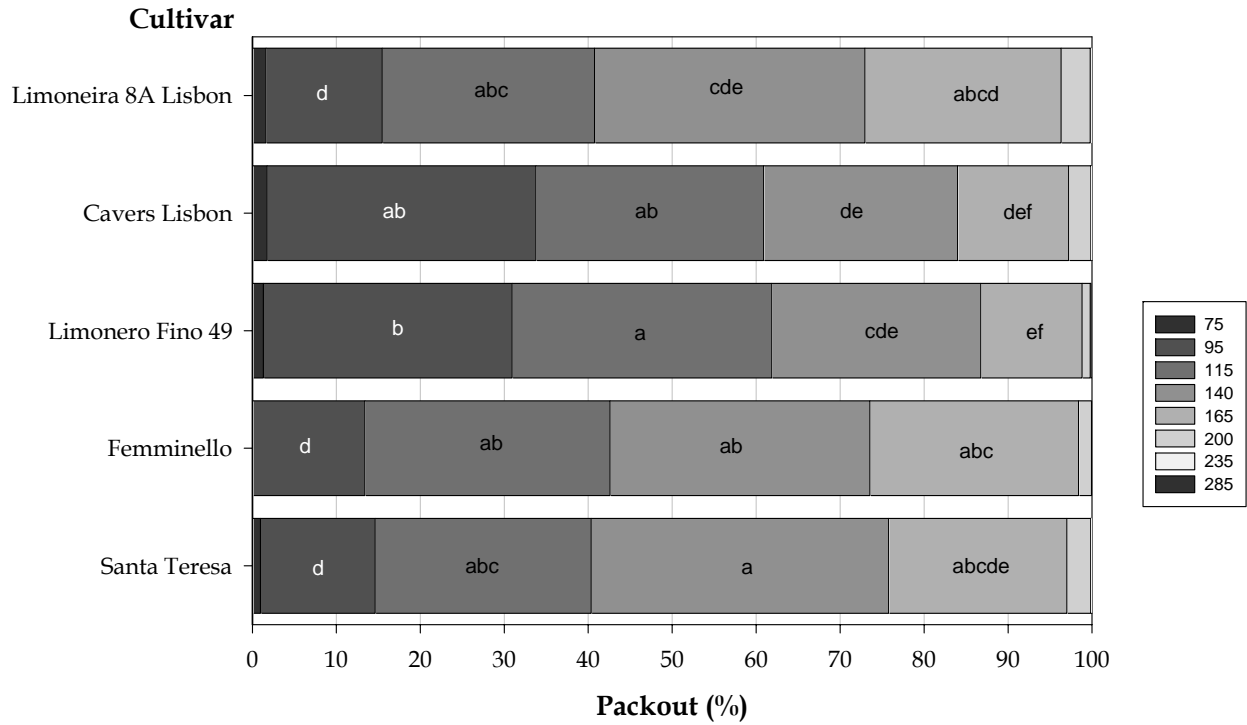


Figure 7. 1997-2003 Yields for the 1995 Lemon Cultivar Selection Trial.



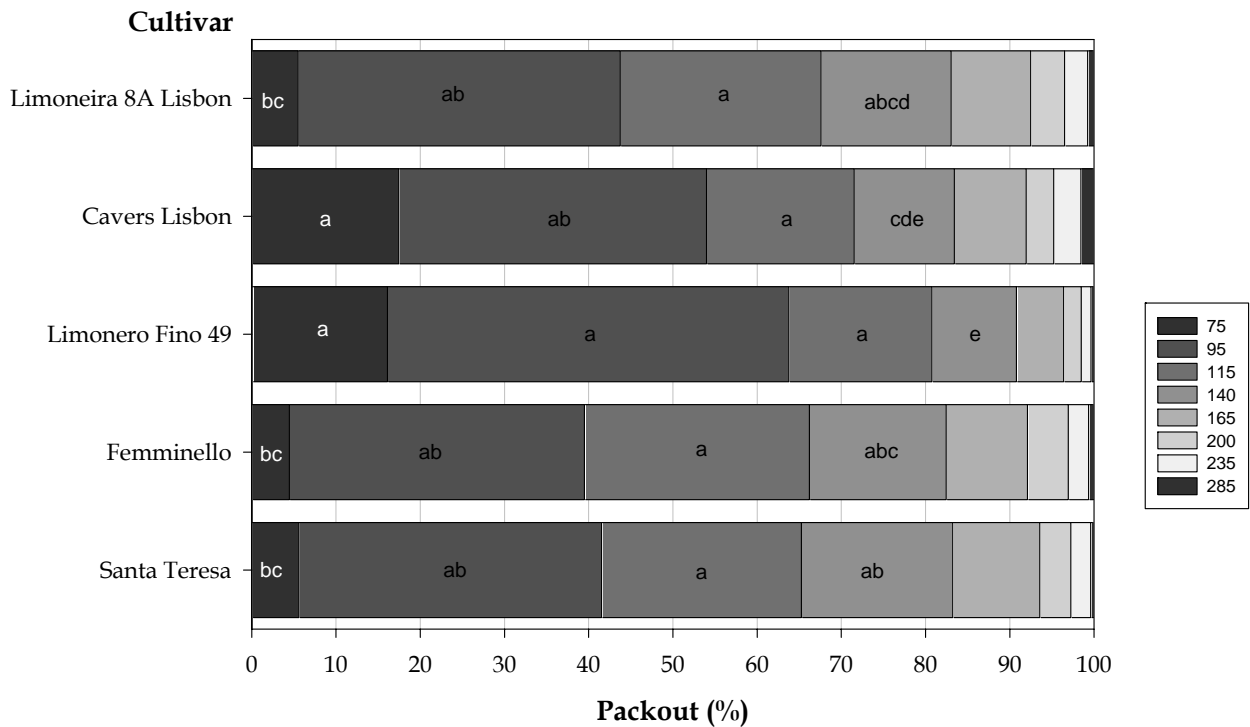
Letters indicate significant differences, within harvest dates or for total yield (bold letters), between cultivars tested.

Figure 8. 2001-02 Yields for the 1997 Lemon Cultivar Selection Trial.



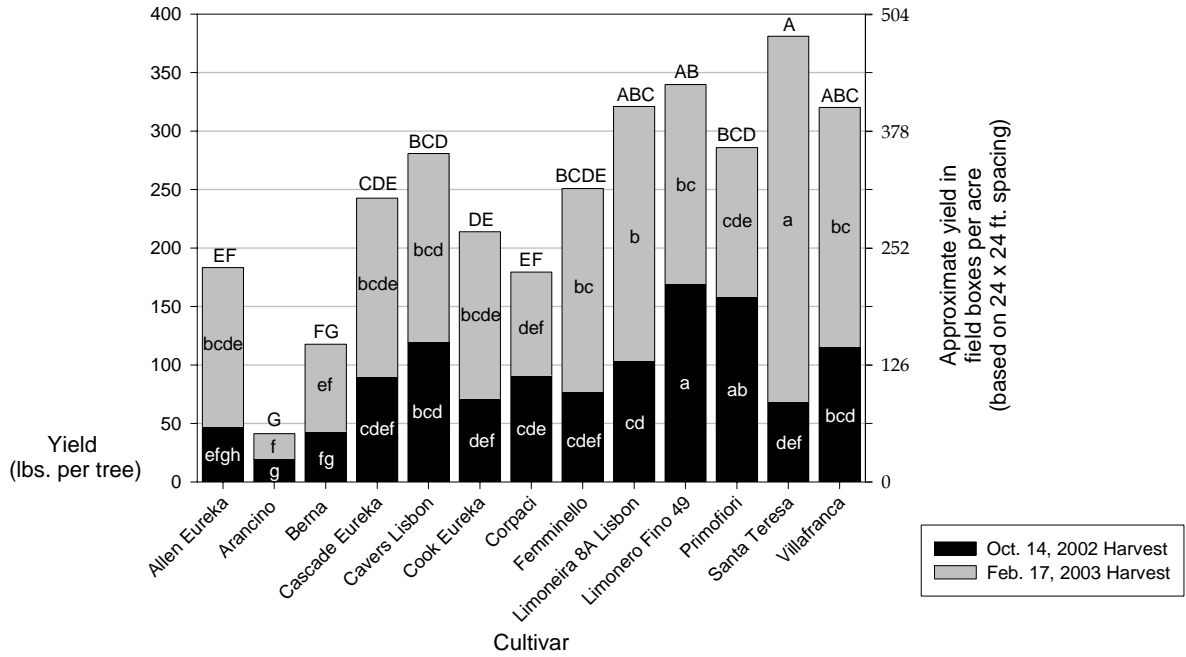
Letters indicate significant differences, within fruit sizes, between cultivars tested.

Figure 9. 10/3/01 Packout for five selections tested in the 1997 Lemon Cultivar Selection Trial.

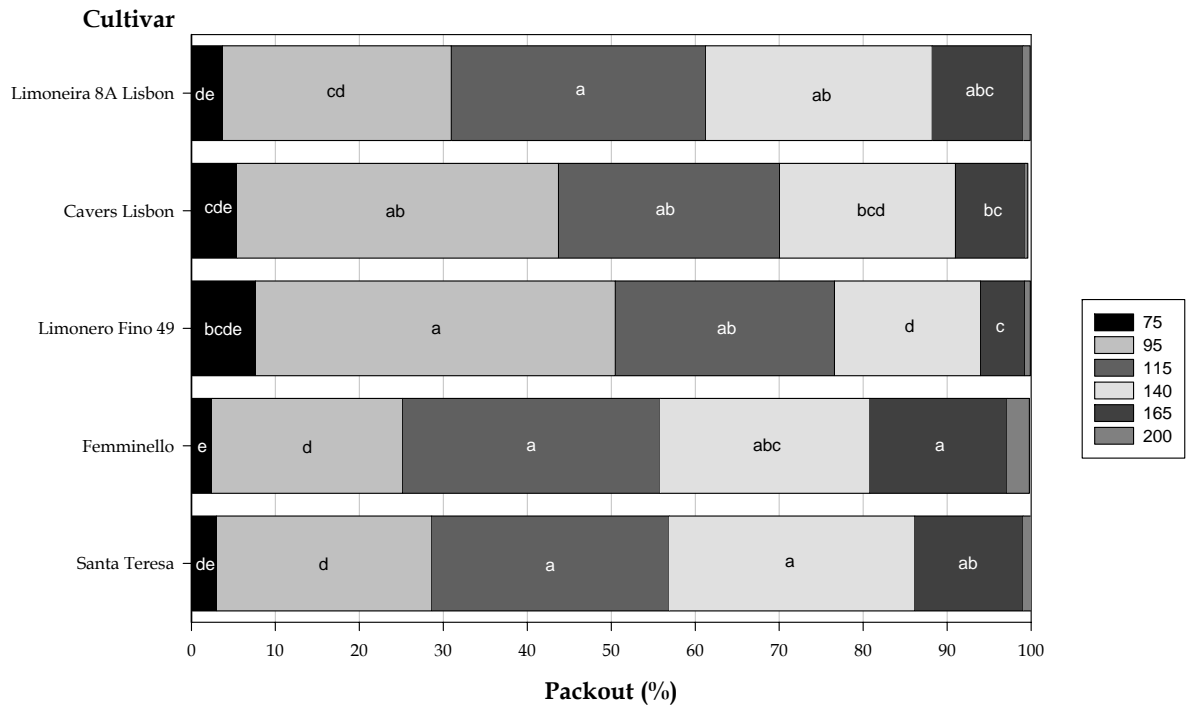


Letters indicate significant differences, within fruit sizes, between cultivars tested.

Figure 10. 12/13/01 Packout for five selections tested in the 1997 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within harvest dates or for total yield (bold letters), between cultivars tested.
 Figure 11. 2002-03 Yields for the 1997 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within fruit sizes, between cultivars tested.
 Figure 12. 10/14/02 Packout for five selections tested in the 1997 Lemon Cultivar Selection Trial.

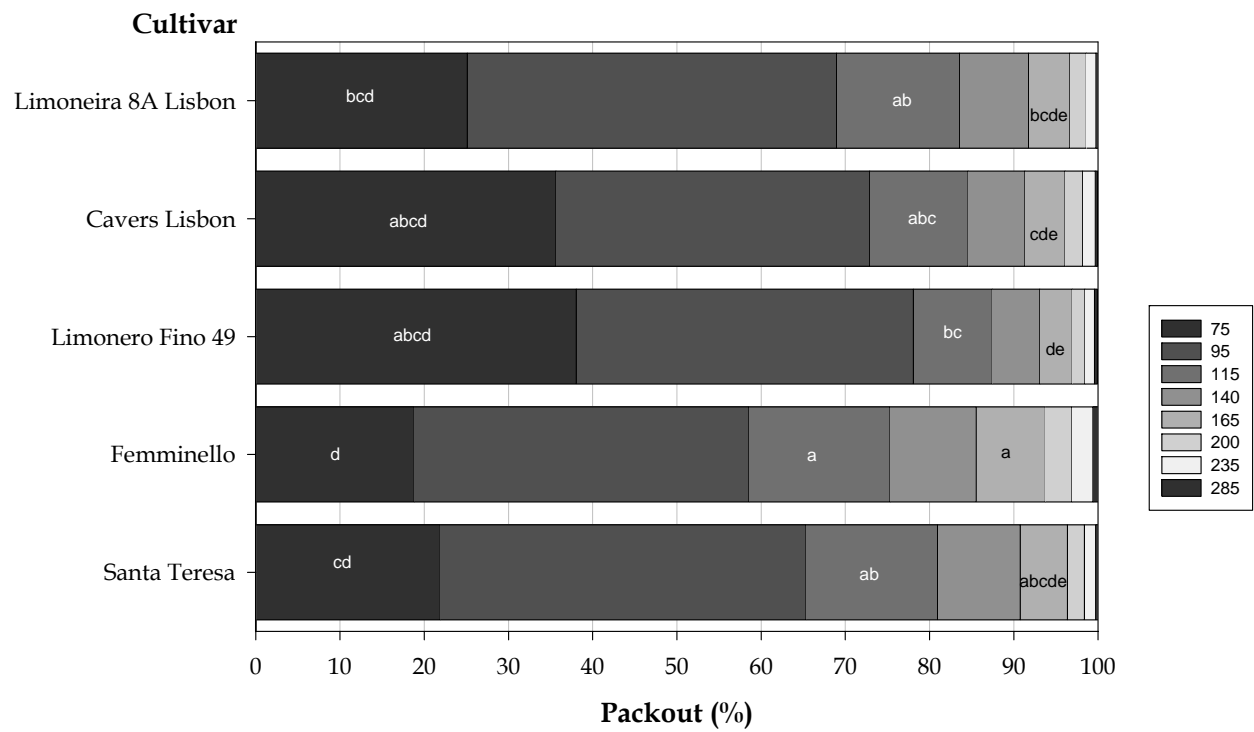


Figure 13. 2/17/03 Packout for five selections tested in the 1997 Lemon Cultivar Selection Trial.

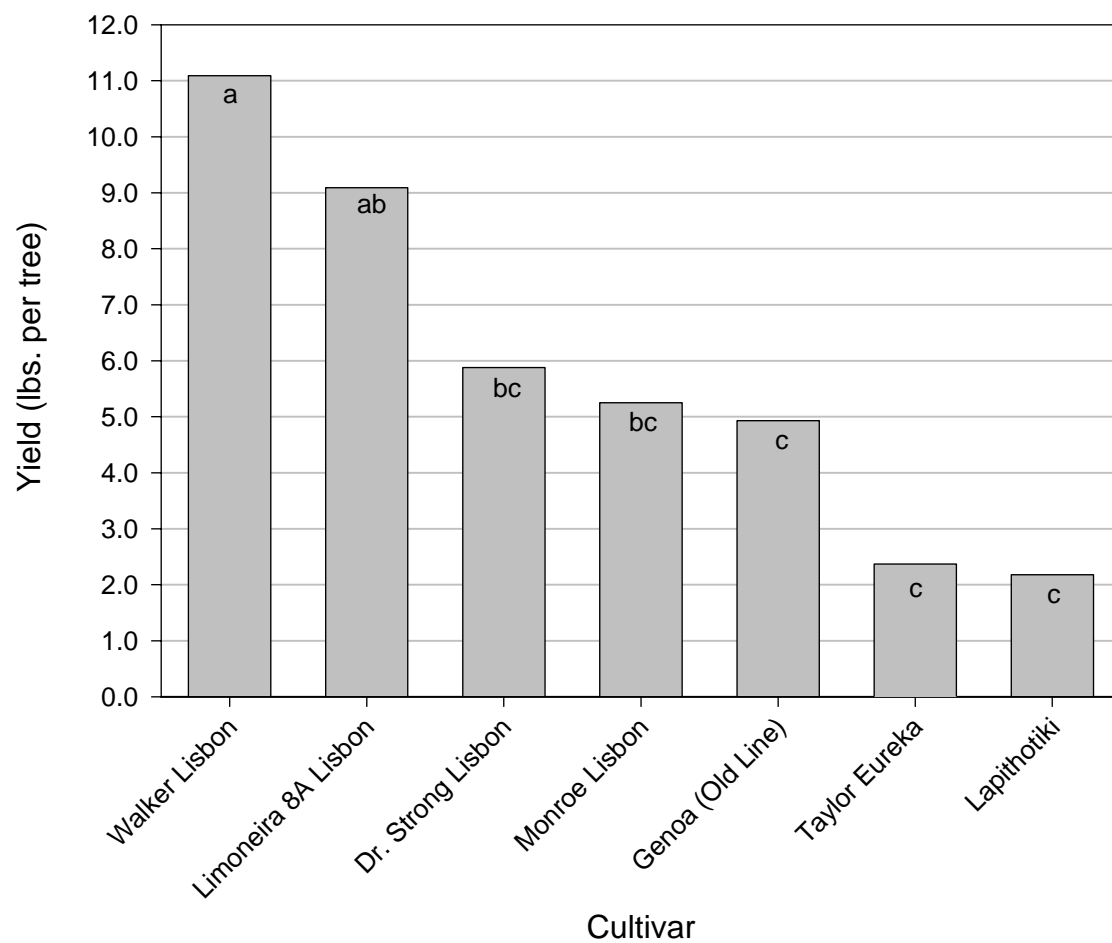


Figure 14. 2001-02 Yields for the 1998 Lemon Cultivar Selection Trial.

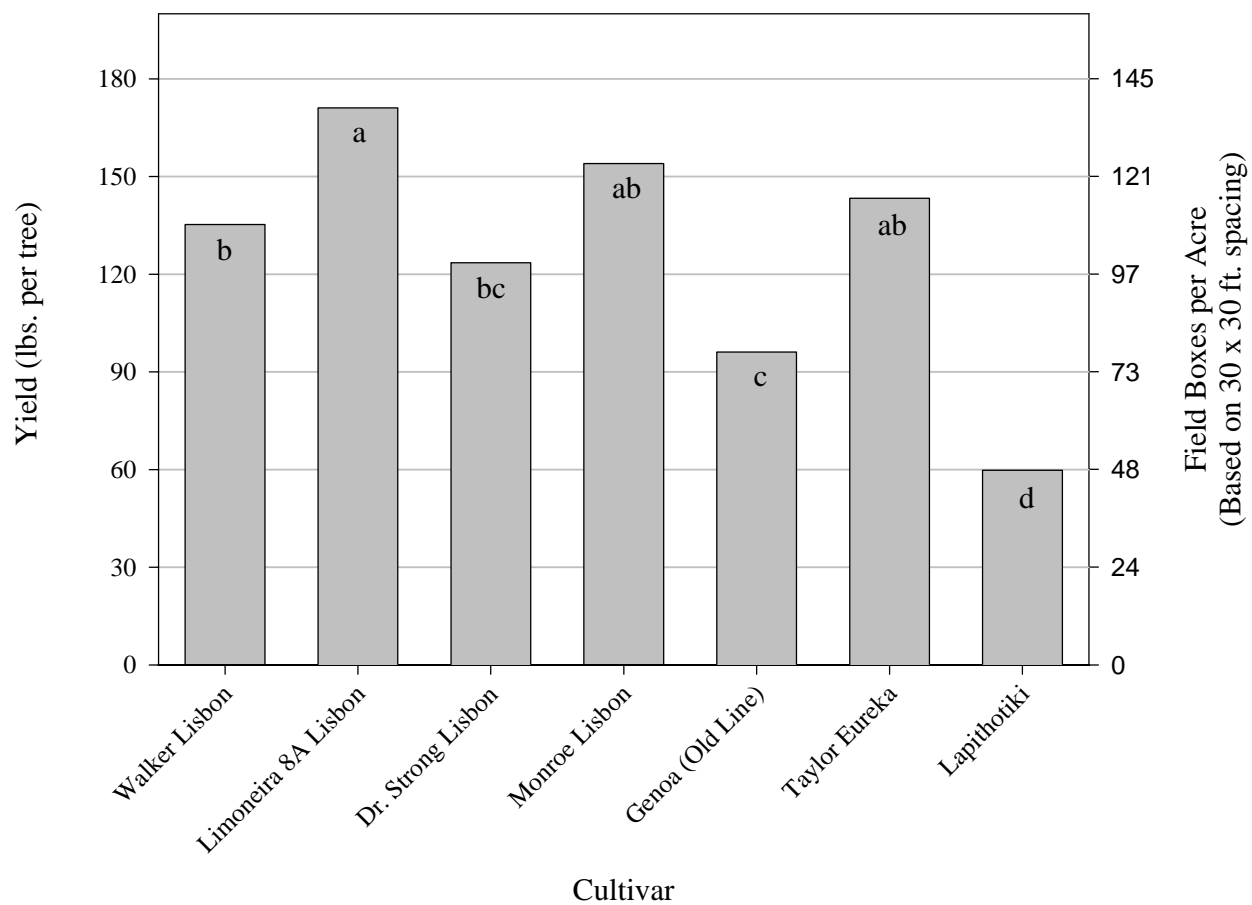
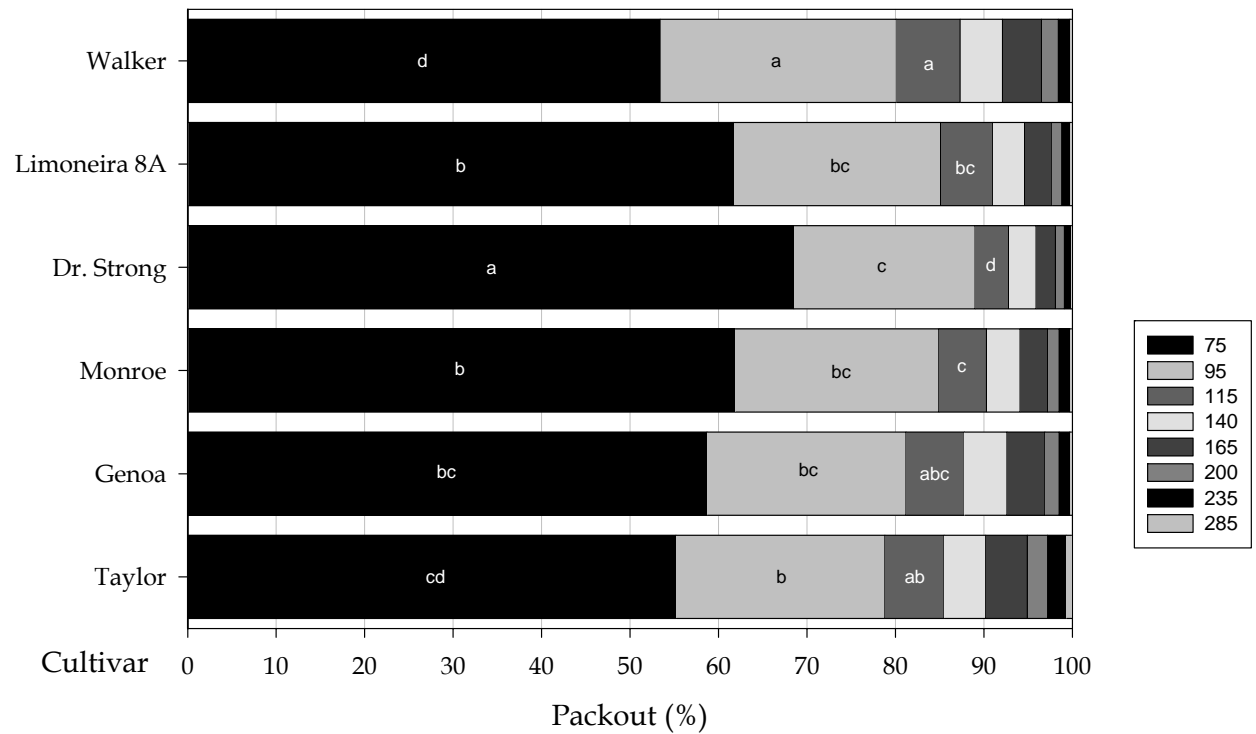


Figure 15. 2002-03 Yields for the 1998 Lemon Cultivar Selection Trial.



Letters indicate significant differences, within fruit sizes, between cultivars tested.
 Figure 16. 2/17/03 Packout for six selections tested in the 1998 Lemon Cultivar Selection Trial.