

Results of New Cultivar Selection Trials for Lemon in Arizona – 2007-08¹

Glenn C. Wright

Department of Plant Sciences, U. of A., Yuma Mesa Agriculture Center, Yuma, AZ

Abstract

Two lemon selection trials have been established in Yuma, AZ to determine whether any of the selections under test can surpass 'Limoneira 8A Lisbon' in yield, fruit size or exterior or interior fruit quality. In the 1997 trial, 'Limoneira Fino 49' had statistically equivalent yield and larger fruit size than 'Limoneira 8A'. 'Primofiori', 'Femminello Comune', 'Cavers Lisbon' and 'Cascade Eureka' may also be suitable, but none consistently equal or surpass 'Limoneira 8A Lisbon' lemon in terms of overall yield and/or earliness as often as does 'Limoneira Fino 49'. In the 1998 trial, 'Dr. Strong' Lisbon often has greater yield than does 'Limoneira 8A Lisbon'.

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', a selection of 'Villafranca' 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, these selections 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. Good fruit quality is indicated by smooth peel, large size, and high juice content. 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 a lemon cultivar selection trial in 1997 and another in 1998, both located at the Yuma Mesa Agricultural Center. These trial results are presented here.

¹ The author wishes to thank Mr. Marco Peña, and the Yuma Mesa Fruit Grower's Association for their assistance in completing this project. The author would also like to thank the Arizona Citrus Research Council for supporting this research. This is a partial final report for project 2007-02 – Citrus rootstock and cultivar evaluation for the Arizona citrus industry – 2007-08.

Materials and Methods

1997 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. Trees are irrigated and fertilized according to normal grower practices. This trial includes the following selections:

- ‘Allen Eureka’ – The most common and popular ‘Eureka’ selection planted in Arizona. Originated in Santa Paula, CA
- ‘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.
- ‘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.
- ‘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.
- ‘Limoneira 8A Lisbon’ – A vigorous selection originating from the Limoneira Ranch, Ventura County, CA. The most popular lemon planted in Arizona today.
- ‘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.
- ‘Primofiori’ – Originated in Spain. Similar to the ‘Limonero Fino 49’ described above.
- ‘Santa Teresa’ (Femminello Santa Teresa) – Similar to ‘Femminello Comune’, but resistant to the Mal Secco disease prevalent in Italy.
- ‘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.
- ‘Walker Lisbon’ – A vigorous selection from California, planted in 1997

1998 Trial. This trial, comprising 7 cultivar selections, was established in late September 1998 in Block 14 of the Yuma Mesa Agricultural Center. The land was laser leveled and fumigated prior to planting. Trees were planted on an 8-m x 8-m spacing. These trees are irrigated and fertilized according to normal grower practices. Fifteen trees of each selection were planted. This trial includes the ‘Limoneira 8A Lisbon’ and ‘Walker 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 and the 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.

Yield data is collected during the fall and winter. For the 1997 trial, trees were selectively picked for size on 10/2/07, and then the remaining fruit was harvested on 12/12/07. Trees in the 1998 trial were picked just once, on 9/25/07 since the yield was low, a consequence of the freeze of January 2007. For each harvest date, about 35 pounds of the entire quantity of harvested fruit from each tree was passed through an automated electronic sorter (Autoline, Inc., Reedley, CA), which provides weight, exterior quality, shape color, and size data for each fruit. Exterior quality is determined by the peel color. The sorter camera photographs the peel, and the computer records

the ratio of the surface area of the peel that has appropriate color (green or yellow) to the surface area of the peel that has inappropriate color (anything else), as determined by the sorter operator. Inappropriate color might be due to wind or insect scarring. Fruits with more than 90% of the appropriately colored peel surface area are designated as “Fancy”, those with 80 to 90% are “Choice”, and those with less than 80% are “Juice”. Fruit shape is determined by the sorter camera, and is calculated as a dimensionless ratio of the fruit width to the fruit length. A completely round fruit would have a value of 1.00. Fruit color is a dimensionless ratio of the red to green reflectivity of the fruit. Greater values indicated a more yellow piece of fruit, while lesser values indicate a greener fruit. Fruit packout data is the quantity of fruit found in each of eight size categories. These categories are 75, 95, 115, 140, 165, 200, 235 and 285 fruit per standard 37.5 lb. packed carton. These data are reported on a percentage basis. Fruit quality data, including juice %, peel thickness, °brix, % acid, and brix:acid ratio are reported for trees in the 1997 and 1998 trial. For the 1997 trial, these data were collected only for the 12/12/07 harvest.

All data was analyzed using SPSS 11.0 for Windows (SPSS Inc., Chicago, Illinois).

Results and Discussion

1997 Trial. Yields since the inception of this trial are shown in Figure 1. For ease of viewing, annual yields of seven cultivars are shown in the top portion of the graph, while yields of the remaining six are shown in the lower portion of the graph. Yields for 2007-08 rebounded compared with the previous year; there was a 2- to 8-fold increase compared with 2006-07. Yields for 2007-08 are similar to those of 2002-03 and 2004-05; both years had some of the higher yields recorded for these trees. Most of the selections are exhibiting alternate-year bearing, where high-yielding years alternate with low-yielding ones.

Yields for the individual harvests of 2007-08 are shown in Figure 2. For the first harvest (shown as the purple bar segment), several selections had similar yields. ‘Femminello’ had the greatest yield of 244 lbs per tree, however, due to high variability; the yield of ‘Arancino’ at 117 lbs. per tree was not statistically different. ‘Santa Teresa’, ‘Corpaci’, ‘Cook Eureka’ and ‘Allen Eureka’ had the lowest yields; ‘Allen’ occupied the lowest spot with only 58 lbs. of fruit per tree. For the second harvest on 12-12-07, ‘Femminello’ again had the greatest yield; almost 400 lbs. per tree. It was followed by ‘Limoneira 8A Lisbon’ with 318 lbs. per tree. ‘Cavers Lisbon’ (233 lbs. per tree), ‘Limonero Fino 49’ (214 lbs. per tree), and ‘Primofiori’ (180 lbs. per tree) were statistically the same as ‘Limoneira 8A Lisbon’, but less than ‘Femminello’. Second harvest yields for the remaining selections were statistically less than ‘Limoneira 8A Lisbon’, and the selection with the lowest yield was ‘Arancino’ with only 50 lbs. of fruit per tree. Overall yields in Figure 2 are indicated by the height of the stacked bar, and statistical differences are indicated by the letters located at the top of each bar. ‘Femminello’ had the greatest yield of 641 lbs. of fruit per tree for the 2007-08 season, while ‘Arancino’ with only 168 lbs. of fruit had the least yield. ‘Limoneira 8A Lisbon’ at 538 lbs. per tree was not statistically different than ‘Femminello’. ‘Cavers Lisbon’ (388 lbs. per tree), ‘Limonero Fino 49’ (379 lbs. per tree), and ‘Primofiori’ (339 lbs. per tree) were statistically the same as ‘Limoneira 8A Lisbon’, but less than ‘Femminello’. Second harvest yields for the remaining selections were statistically less than ‘Limoneira 8A Lisbon’, and ranged from 297 lbs. per tree for ‘Santa Teresa’ to the yield for ‘Arancino’ noted above.

For the fruit harvested on 10/2, there was no apparent effect of selection on fruit shape. Shape values ranged from 0.72 for ‘Cook Eureka’ to 0.78 for ‘Villafranca’. For the second harvest fruit, there was again no effect of selection on fruit shape, as values ranged from 0.72 for ‘Cavers Lisbon’ to 0.79 for ‘Femminello’.

Fruit color was not affected by the selections for either of the harvests. For the first harvest, color values ranged from 0.87 to 0.78, and for the second harvest, they ranged from 1.1 to 1.4, an indication that the fruit had turned color.

Packout for the 10/2 harvest is shown in Figure 3. Fruit of ‘Arancino’ were the largest, peaking on sizes 75 and 95, likely due to the fact that yield for this selection was the lowest for all under test. Other selections with large fruit size included ‘Allen Eureka’, ‘Berna’, ‘Cascade Eureka’, ‘Cavers Lisbon’, ‘Cook Eureka’, ‘Corpaci’, ‘Limonero Fino 49’, ‘Primofiori’ and ‘Villafranca’; all of these selections peaked on size 95. ‘Femminello’ peaked on size 115, ‘Santa Teresa’ peaked on size 140, and ‘Limoneira 8A’ Lisbon peaked on sizes 140 and 165.

Packout for the 12/12 harvest is shown in Figure 4. Because of high variability, there was no significant effect of the selections upon the packout for this harvest. All the selections peaked on size 95, but 'Arancino'. 'Cascade Eureka', 'Villafranca' and 'Limonero Fino 49' had the most fruit of sizes 75 and 95, while 'Cook Eureka' and 'Santa Teresa' had the least fruit in these two size categories.

For the 10/2 harvest, there was no significant effect of the selections upon fruit exterior quality, because of high variability (data not shown). All the selections ranged between 53% ('Primofiori') and 85% ('Berna') Fancy, between 13% ('Berna') and 35% ('Santa Teresa') Choice, and between 1% ('Arancino') and 13% ('Primofiori') Juice. Similarly, there was no significant effect of selections upon exterior quality for the 12/12 harvest. All the selections ranged between 68% ('Limoneira 8A Lisbon') and 86% ('Villafranca') Fancy, between 10% ('Villafranca') and 18% ('Limoneira 8A Lisbon') Choice, and between 4% ('Limonero Fino 49') and 14% ('Limoneira 8A Lisbon') Juice.

There was no significant effect of selection upon fruit juice percentage, juice pH, total soluble solids, total acids, solid:acid ratio, or peel thickness. For the selections as a group, juice percentage ranged between 40% and 49%, and the pH of that juice ranged between 1.59 and 2.06. Total soluble solids of the selections ranged between 7.7% and 8.5%, while total acids ranged between 4.4% and 5.2%. Solid to acid ratio ranged between 1.52 and 1.95. Peel thickness for the selections as a group ranged from 2.16 to 2.79 mm.

1998 Trial. 2001 to 2007 yields from this trial are found in Figure 5. Yields for this season are much greater than those for the previous season, yet not as great as the yields for the 2005-06 harvest year. The freeze of January 2007 may have led to this modest increase in yield.

Yields for the 2007-08 harvest season are shown in Figure 6. Yields for all the selections were similar, ranging from about 225 to 275 lbs per tree, except for the 'Lapithiotiki' selection which finished the year with only about 150 lbs. per tree.

Packout for this trial is found in Figure 7. As in past years, 'Lapithiotiki' had significantly more fruit of size 75; about twice the quantity, and significantly less fruit of size 115, compared with the other selections. All the selections peaked on size 95, ranging from 30 to 40%.

There was a significant effect of the selections upon fruit color, shape and exterior quality. Fruit of 'Dr. Strong Lisbon' had significantly more colored (yellow) than fruit of 'Monroe Lisbon', 'Genoa' and 'Limoneira 8A Lisbon'. All the other three selections had fruit colors that were intermediate between these two groups. 'Limoneira 8A Lisbon' had significantly rounder fruit than did 'Walker Lisbon', 'Genoa', and 'Taylor Eureka'. Again, the other three selections were intermediate. Finally, 'Monroe Lisbon' and 'Limoneira 8A Lisbon' had significantly less fruit in the fancy category, and significantly more fruit in the Choice and Juice categories as compared to the other selections.

Conclusions

Several selections in the 1997 trial compare favorably to 'Limoneira 8A Lisbon'. One is 'Limonero Fino 49' lemon, because its yields have been statistically similar to that of 'Limoneira 8A' and it consistently has larger fruit size. 'Primofiori', 'Femminello Comune', 'Cavers Lisbon' and 'Cascade Eureka' may also be suitable, but none consistently equal or surpass 'Limoneira 8A Lisbon' lemon in terms of overall yield and/or earliness as often as does 'Limonero Fino 49'. Although 'Femminello' performed well this season, it performed poorly in 2005-06. 'Primofiori' performed well this year, and in 2005-06, but has not performed as well in the intervening years. 'Cascade Eureka' fell off this year, following five years of superior performance, while 'Cavers Lisbon' performed well this year following an "off" year in 2007-08. None of the other selections in the 1995 and 1997 trial have had consistently better yield than 'Limoneira 8A Lisbon', although they all often surpass 'Limoneira 8A Lisbon' in fruit size.

In the 1998 trial, no selection has proved to be consistently better than 'Limoneira 8A', but 'Walker', 'Monroe' and particularly 'Dr. Strong' may be contenders. 'Lapithiotiki' has large fruit, but does not consistently have high yields. 'Eureka' lemons have typically performed poorly in comparison to the 'Lisbons', and should not yet be considered as a replacement for any of the high-yielding 'Lisbon' selections, with the exception of 'Cascade'.

Table 1. Fruit color, shape and exterior quality of seven lemon selections on *C. volkameriana* rootstock.

| Selection | Fruit color ^z | Fruit shape ^y | Exterior Fruit Quality (%) | | |
|---------------------|--------------------------|--------------------------|----------------------------|----------|--------|
| | | | Fancy | Choice | Juice |
| Taylor Eureka | 0.827 ab | 0.742 c | 76.4 a | 19.3 d | 4.3 ab |
| Monroe Lisbon | 0.802 b | 0.759 ab | 59.6 b | 31.2 a | 9.2 ab |
| Dr. Strong Lisbon | 0.834 a | 0.753 abc | 74.1 a | 21.4 bcd | 4.5 ab |
| Genoa Old Line | 0.805 b | 0.747 bc | 75.8 a | 20.6 cd | 3.6 b |
| Lapithiotiki | 0.820 ab | 0.753 abc | 65.5 ab | 28.8 abc | 5.7 ab |
| Walker Lisbon | 0.810 ab | 0.746 bc | 64.1 ab | 30.4 ab | 5.5 ab |
| Limoneira 8A Lisbon | 0.804 b | 0.766 a | 58.2 b | 31.8 a | 10.0 a |

^z Value represents the red to green color ratio of the peel. A larger number indicates a more yellow or orange fruit, while a smaller number indicates a greener fruit.

^y Shape indicates width to length ratio. A perfectly round fruit would have a value of 1.0.

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

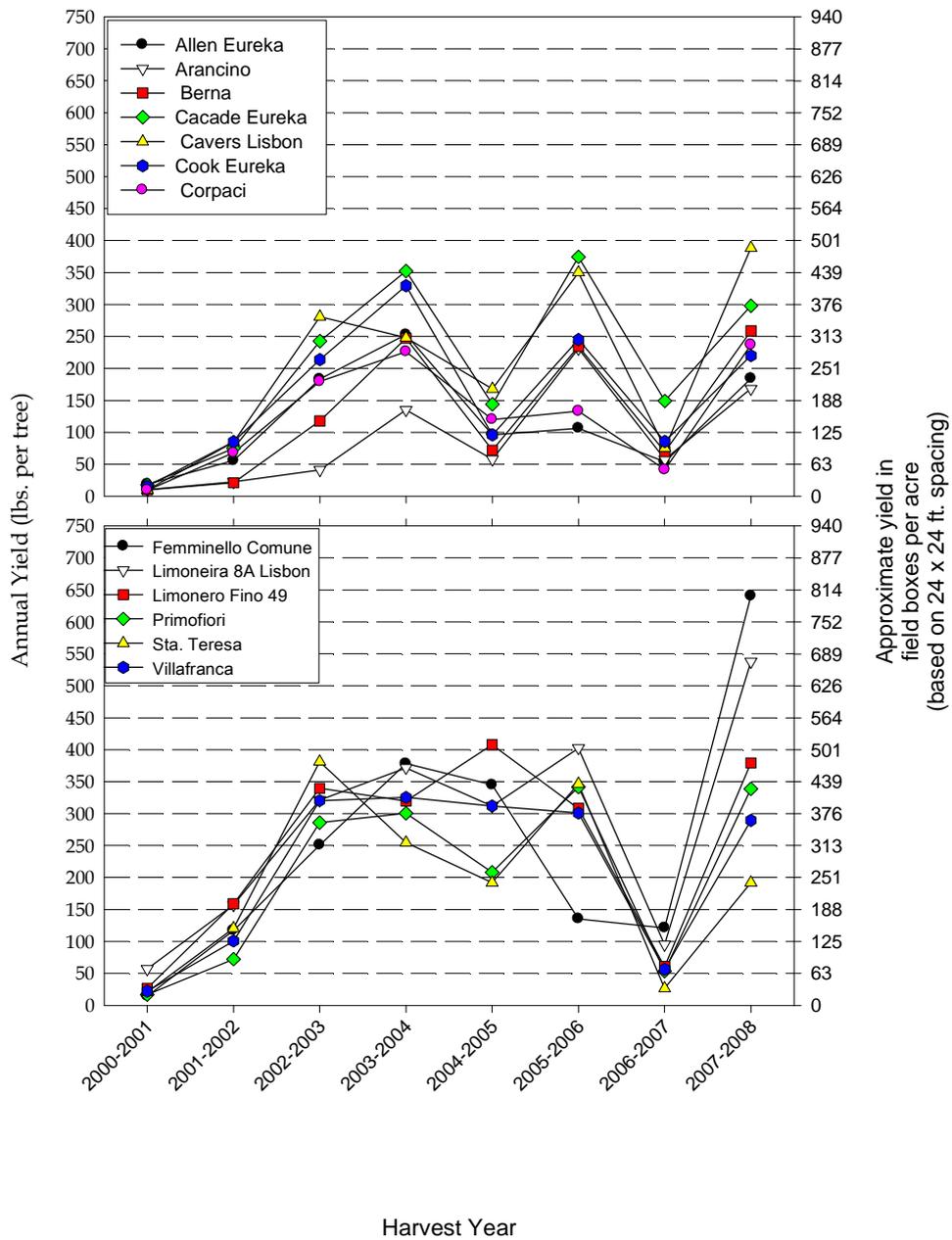


Figure 1. 2000-2007 yield of thirteen lemon selections budded to *C. macrophylla* rootstock.

2007-08 Block 22 Lemon Yields

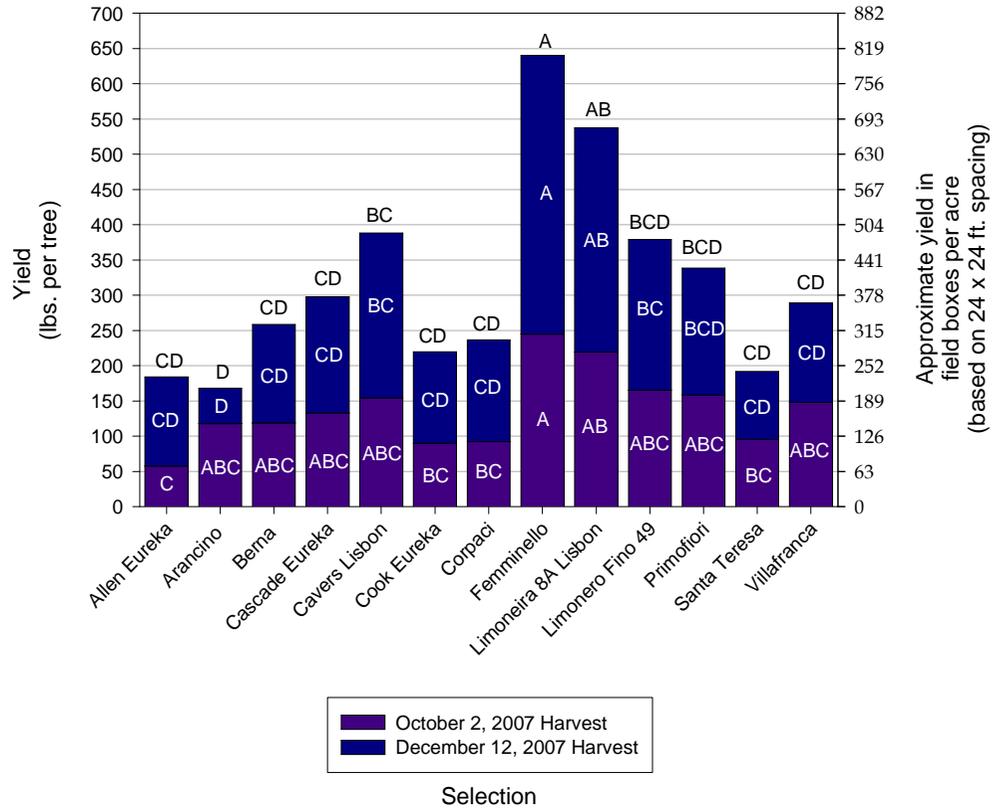


Figure 2. 2007-08 yield of thirteen lemon selections budded to *C. macrophylla* rootstock. Means separation by Duncan's Multiple Range Test ($\alpha=0.05$). Yields are significantly different if the letters within the bar segments or above the bars are different. Bar segments of different colors cannot be statistically compared, and overall yield cannot be statistically compared to the yields of the two harvests.

Cultivar

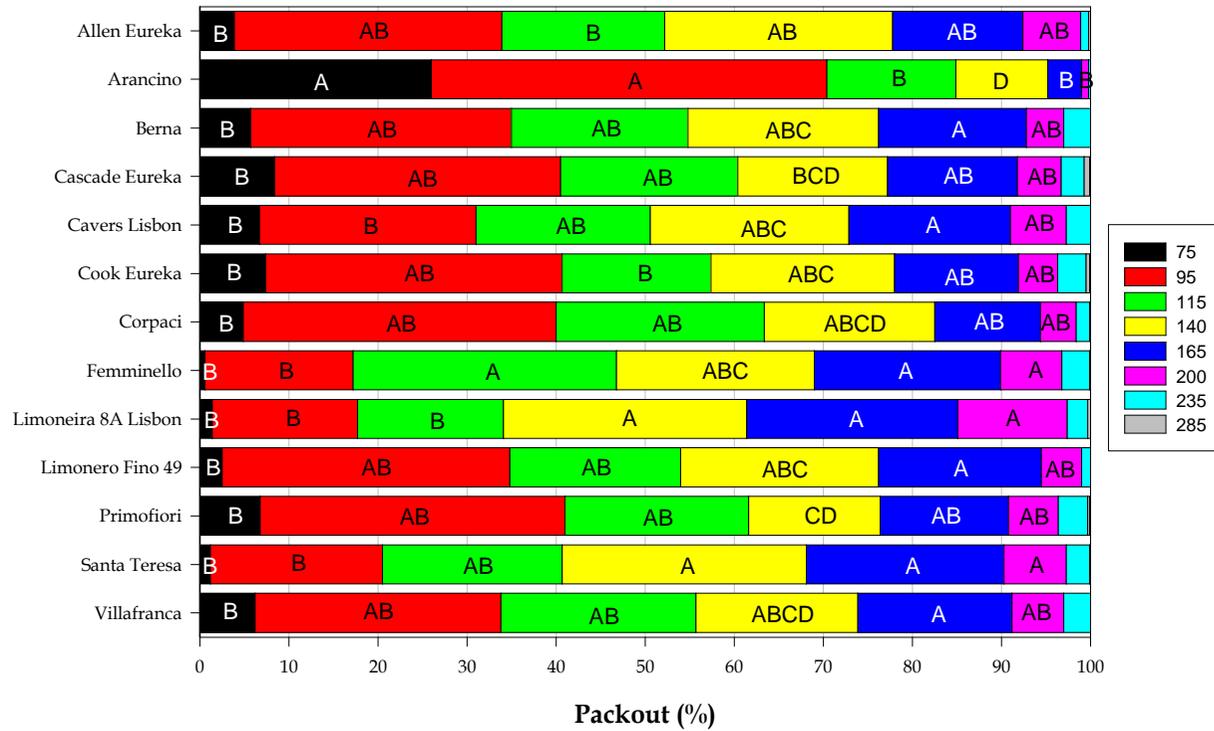


Figure 3. 2007-08 packout of 13 lemon selections on *C. macrophylla* rootstock for the 10-2-07 harvest. Means separation using Duncan's Multiple Range Test ($\alpha=0.05$). Only bars of the same color may be compared.

Cultivar

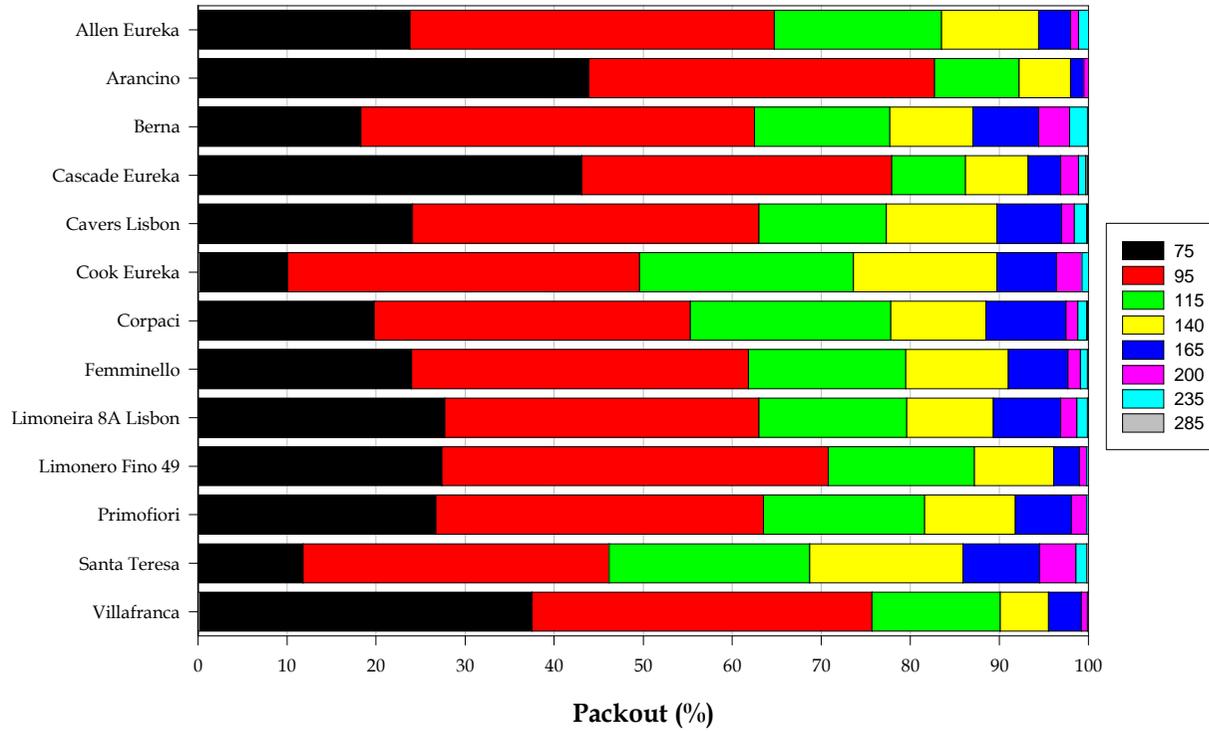


Figure 4. 2007-08 packout of 13 lemon selections on *C. macrophylla* rootstock for the 12-12-07 harvest. There were no significant effects of selection upon packout.

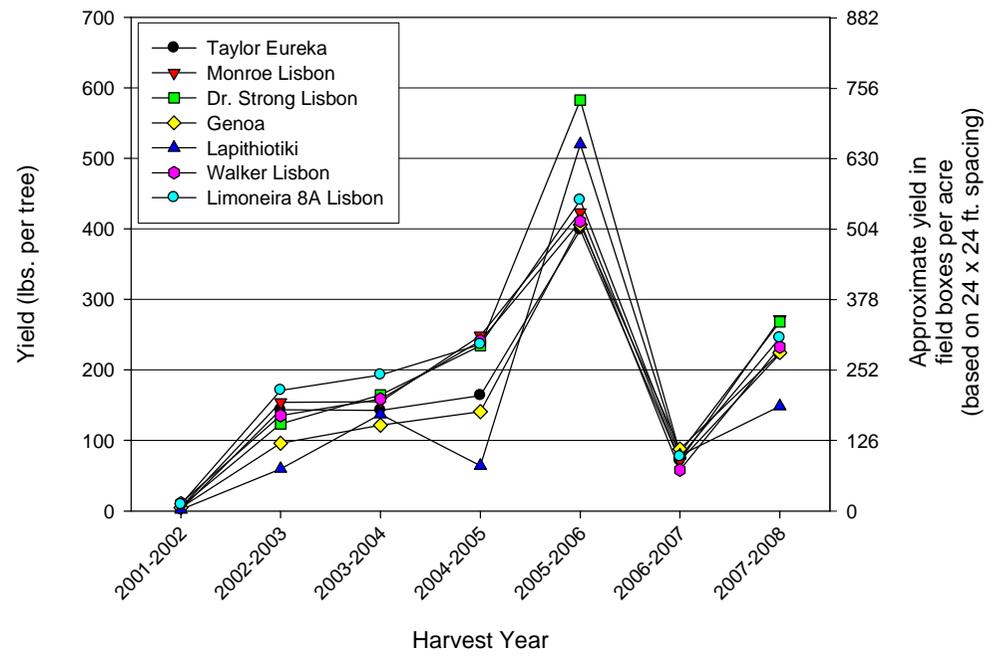


Figure 5. 2001-2007 yield of seven lemon selections budded to *C. macrophylla* rootstock.

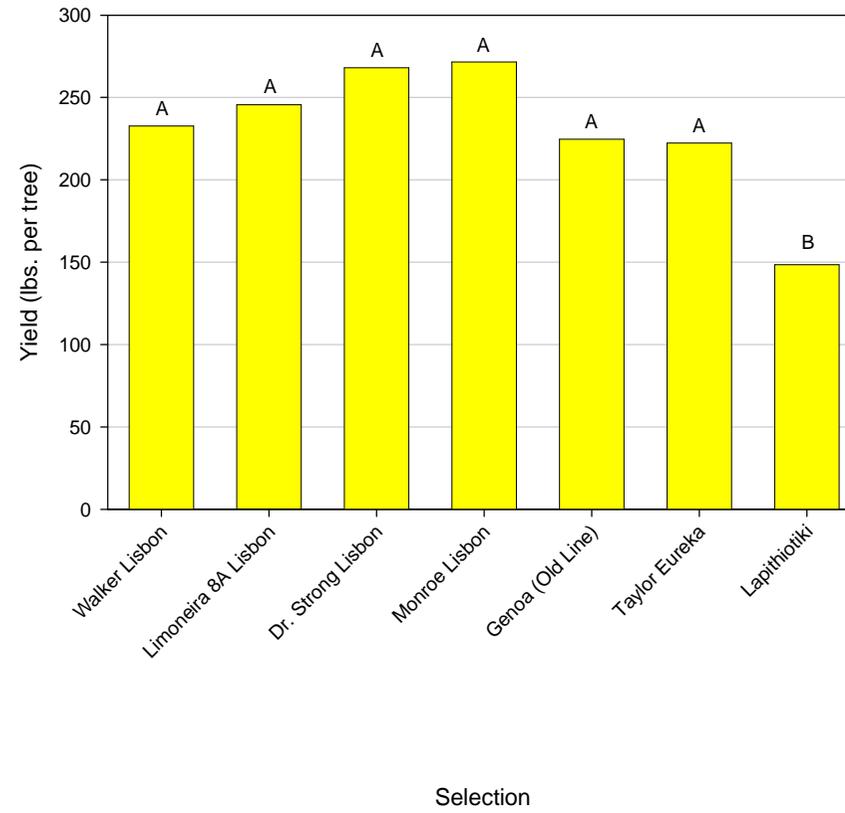


Figure 6. 2007-08 yield of seven lemon selections budded to *C. macrophylla* rootstock.

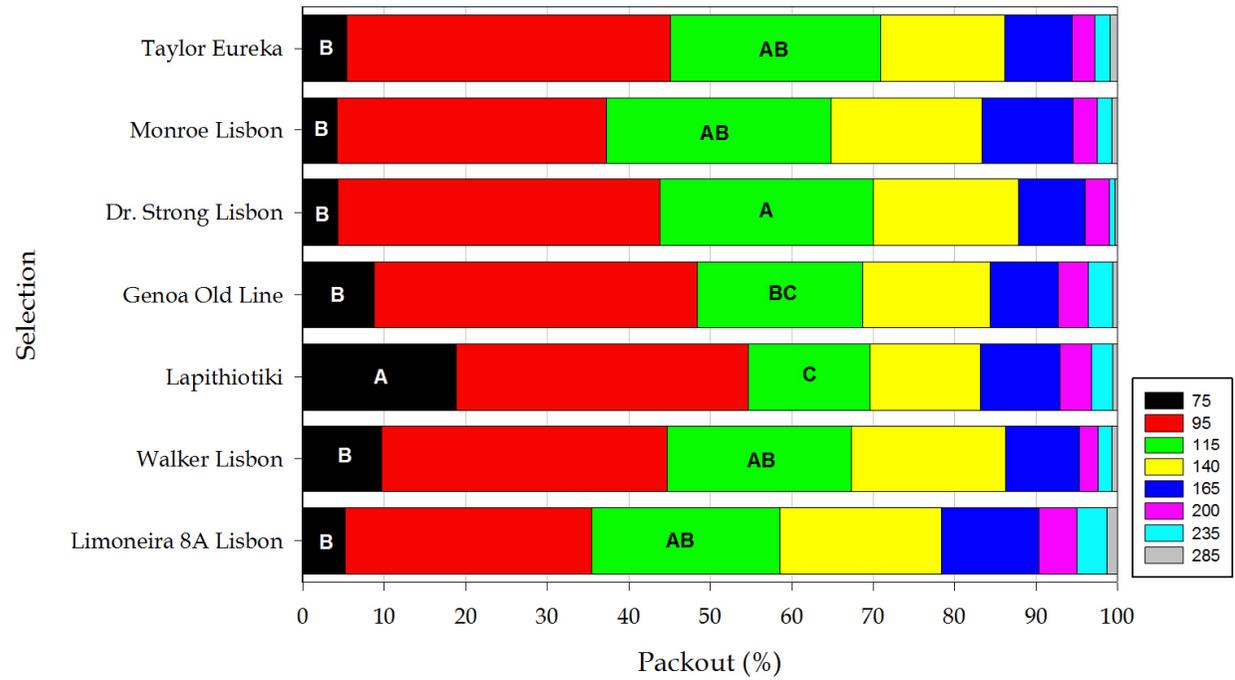


Figure 7. Packout of seven lemon selections on *C. macrophylla* rootstock for the 9-25-07 harvest. Bars of the same shade are significantly different if the lowercase letters within them are different. Bars of different shades cannot be compared.