

Results of New Cultivar Selection Trials for Lemon in Arizona – 2008-09 and 2009-10¹

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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, 'Limoneiro Fino 49' and 'Cascade Eureka' compare favorably to 'Limoneira 8A'. In the 1998 trial, 'Dr. Strong Lisbon' compares favorably as well.

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 exterior 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.

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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 9-16-08, and then the remaining fruit was harvested on 3-20-09. The following year, the trees were selectively picked on 10-16-09 and the remaining fruit was harvested on 1-20-10. For 2008-09, trees in the 1998 trial were selectively picked on 9-08-08 and again on 1-28-09. The final harvest for that year was on 3-20-09. For the 2009-10 season, trees were selectively picked on 10-1-09 and 1-20-10. 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 the 2008-09 season for both trials.

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 2008-09 were quite a bit lower than those for 2007-08, and were similar to those of 2006-07. Yields for 2009-10 were higher, and were similar to those of 2007-08. Most of the selections are exhibiting alternate-year bearing, where high-yielding years alternate with low-yielding ones.

Yields for the individual harvests of 2008-09 are shown in Figure 2. There was no significant effect of selection upon yield for individual harvests or for total yield in the 2008-09 season. Yields for the first harvest ranged from 18 lbs per tree for ‘Berna’ to 88 lbs per tree for ‘Femminello’, but due to high variability, there were no significant differences. Yields for the second harvest on 3-20-09 ranged from 55 lbs per tree for ‘Allen Eureka’ to 192 lbs. per tree for ‘Limoneira 8A’. This selection had the greatest overall yield at 248 lbs per tree, followed closely by ‘Santa Teresa’ at 238 lbs per tree. The selection with the lowest overall yield for 2008-09 was ‘Allen’ Eureka with just 108 lbs per tree. There was no effect of selection upon fruit packout, fruit shape, fruit color or exterior fruit quality in 2008-09 (data not shown). There was also no effect of the selection upon interior fruit quality, with the exception of peel thickness, in 2008-09. Peels of ‘Arancino’ were significantly thicker than those of the other selections evaluated.

Yields for the 2009-10 season are shown in Figure 3. Yields for this season were about twice the yields of the previous season, although there were no significant differences in first harvest yields between the selections; yields for this harvest ranged from 175 lbs per tree for ‘Primofiori’ to 60 lbs per tree for ‘Santa Teresa’. For the second harvest on 1-20-10, ‘Limonero Fino 49’ had the greatest yield of 418 lbs per tree, followed closely by ‘Limoneira 8A Lisbon’ at 370 lbs per tree, and ‘Berna’ at 353 lbs per tree. ‘Allen Eureka’, ‘Cook Eureka’, ‘Corpaci’ and ‘Santa Teresa’ had the least 2nd harvest yield, from 100 to 200 lbs per tree. All others were intermediate. On the strength of the second harvest, total yields for ‘Limoneira 8A’ were the greatest for the entire 2009-10 season. ‘Yields for ‘Limoneira 8A’, ‘Verna’, ‘Cascade Eureka’, and ‘Primofiori’ were less than that of ‘Limonero Fino 49’, but not significantly less. ‘Santa Teresa’ had the least overall yield for the 2009-10 harvest year. There was no effect of selection upon fruit packout, fruit shape, fruit color or exterior fruit quality in 2009-10 (data not shown).

1998 Trial. 2001 to 2009 yields from this trial are found in Figure 4. Yields for this season are much greater than those for the previous season, and are greater than the yields for the 2005-06 harvest year. All of the seven selections had greater yields in 2008-09 than in 2007-08, and this was repeated in 2009-10.

Yields for the 2008-09 harvest season are shown in Figure 5. First harvest yields for all the selections ranged from 75 lbs per tree for the ‘Genoa’ to 39 lbs per tree for the ‘Dr. Strong Lisbon’. Only ‘Genoa’ had a first harvest yield significantly greater than the others. For the second harvest, ‘Dr. Strong’, ‘Monroe’ and ‘Limoneira 8A’ had the greatest yield, followed by ‘Walker’. All had second harvest yields ranging from 260 to 385 lbs per tree. For the

third harvest of 2008-09, 'Limoneira 8A' and 'Dr. Strong' had the greatest yields, while 'Taylor Eureka', 'Lapithiotiki', and 'Genoa' lagged. Third harvest yields ranged from 178 lbs per tree for 'Limoneira 8A' to 73 lbs for 'Lapithiotiki'. Overall yield for 2008-09 was greatest for 'Dr. Strong' and 'Limoneira 8A' at 590 and 552 lbs, respectively.

Packout for this trial for the 2008-09 harvest season is found in Figure 6. Unlike past years, when 'Lapithiotiki' had particularly large fruit, the largest fruit this season belonged to 'Genoa'. However, significant fruit size increases for this selection appeared only in size 75. 'Walker' had significantly more of fruit size 140 than did 'Monroe'.

Yields for 2009-10 are shown in Figure 7. Yields for this season were slightly greater than those for the 2008-09 season, and while there were differences for each of the interim harvests, there was no significant effect overall. For the first harvest, 'Lapithiotiki' had a good quantity (272 lbs) of large fruit. This is similar to the 2005-06 harvest season. Meanwhile, 'Walker Lisbon' had significantly fewer fruit (131 lbs) than did 'Lapithiotiki' or 'Genoa' (227 lbs) in the first harvest. In the second harvest for the season, 'Dr. Strong' had the greatest yield (498 lbs), while 'Lapithiotiki' had the least (264 lbs). All the other selections were intermediate. For overall yield, all the selections had between 536 and 649 lbs per tree.

Packout for the 2009-10 season is shown in Figure 7. 'Lapithiotiki' had the largest sized fruit, which marks a return to normal for this selection. 'Genoa' and 'Taylor' Eureka also had large fruit.

In 2009-10, there was a significant effect of the selections upon fruit color, shape and external quality, (Table 1). 'Lapithiotiki' and 'Taylor Eureka' had the most yellow colored fruit, while 'Walker Lisbon' had the greenest fruit. 'Genoa' and 'Taylor Eureka' had the roundest fruit, while 'Dr. Strong', 'Walker' and 'Lapithiotiki' had the most oblong fruit. Also, 'Walker' had fruit with the least exterior quality, while 'Taylor' had the greatest exterior quality.

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 generally has larger fruit size, although there was no significant effect in 2008-09 or 2009-10. Another is 'Cascade Eureka' which has had eight straight years of yields near the top. 'Primofiori' and 'Femminello Comune' 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 in 2007-08, it was only average in 2008-09 and 2009-10. 'Primofiori' performed well this year, and in 2005-06, but has not performed as well in the intervening years. 'Berna' performed well in 2009-10 for the first time. None of the other selections in the 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, only 'Dr. Strong Lisbon' has proved to be consistently better than 'Limoneira 8A'. '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. 2009-10 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	0.794 a	0.788 a	68.59 a	29.05 c	2.36 c
Monroe Lisbon	0.747 bc	0.782 ab	46.31 bc	39.70 abc	13.99 b
Dr. Strong Lisbon	0.755 bc	0.748 c	36.55 cd	49.52 a	13.92 b
Genoa Old Line	0.768 b	0.792 a	53.39 ab	41.81 ab	4.81 c
Lapithiotiki	0.794 a	0.750 c	59.06 ab	34.29 bc	6.62 b
Walker Lisbon	0.739 c	0.750 c	28.49 d	51.33 a	22.17 a
Limoneira 8A Lisbon	0.755 bc	0.761 bc	34.35 cd	47.89 a	17.74 ab

^zValue 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

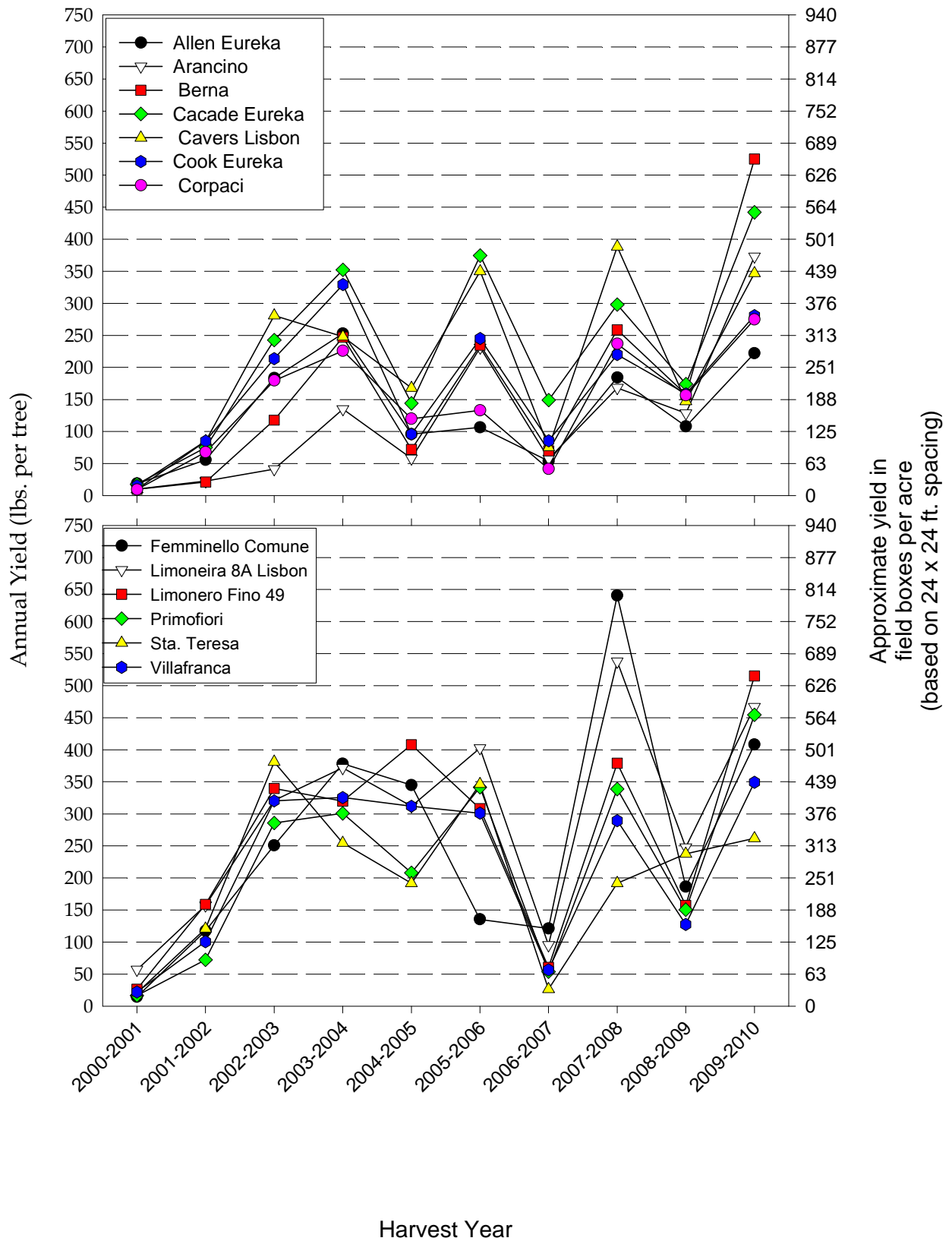


Figure 1. 2000-2009 yield of thirteen lemon selections budded to *C. macrophylla* rootstock.

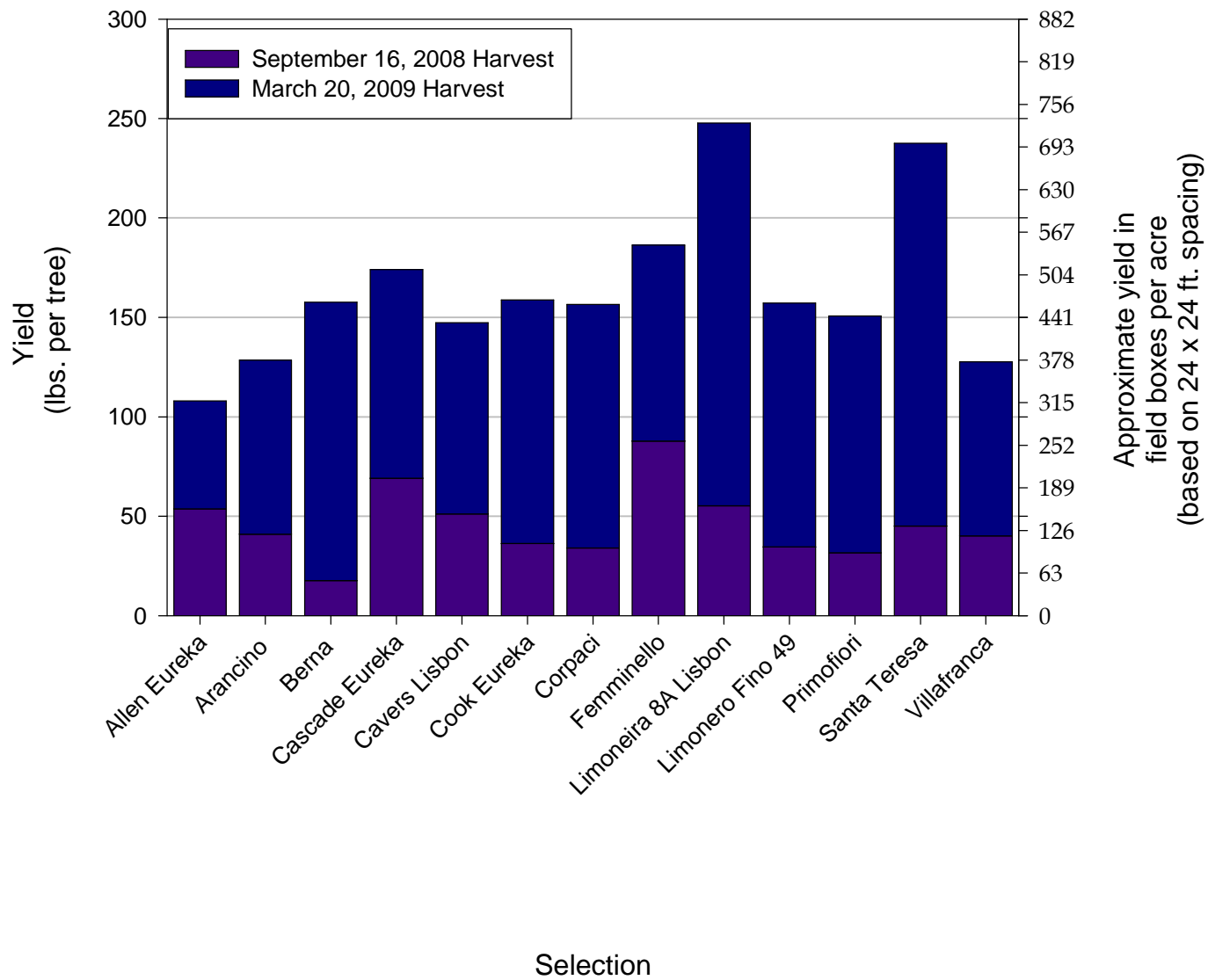


Figure 2. 2008-09 yield of thirteen lemon selections budded to *C. macrophylla* rootstock. There was no significant effect of selection upon yield.

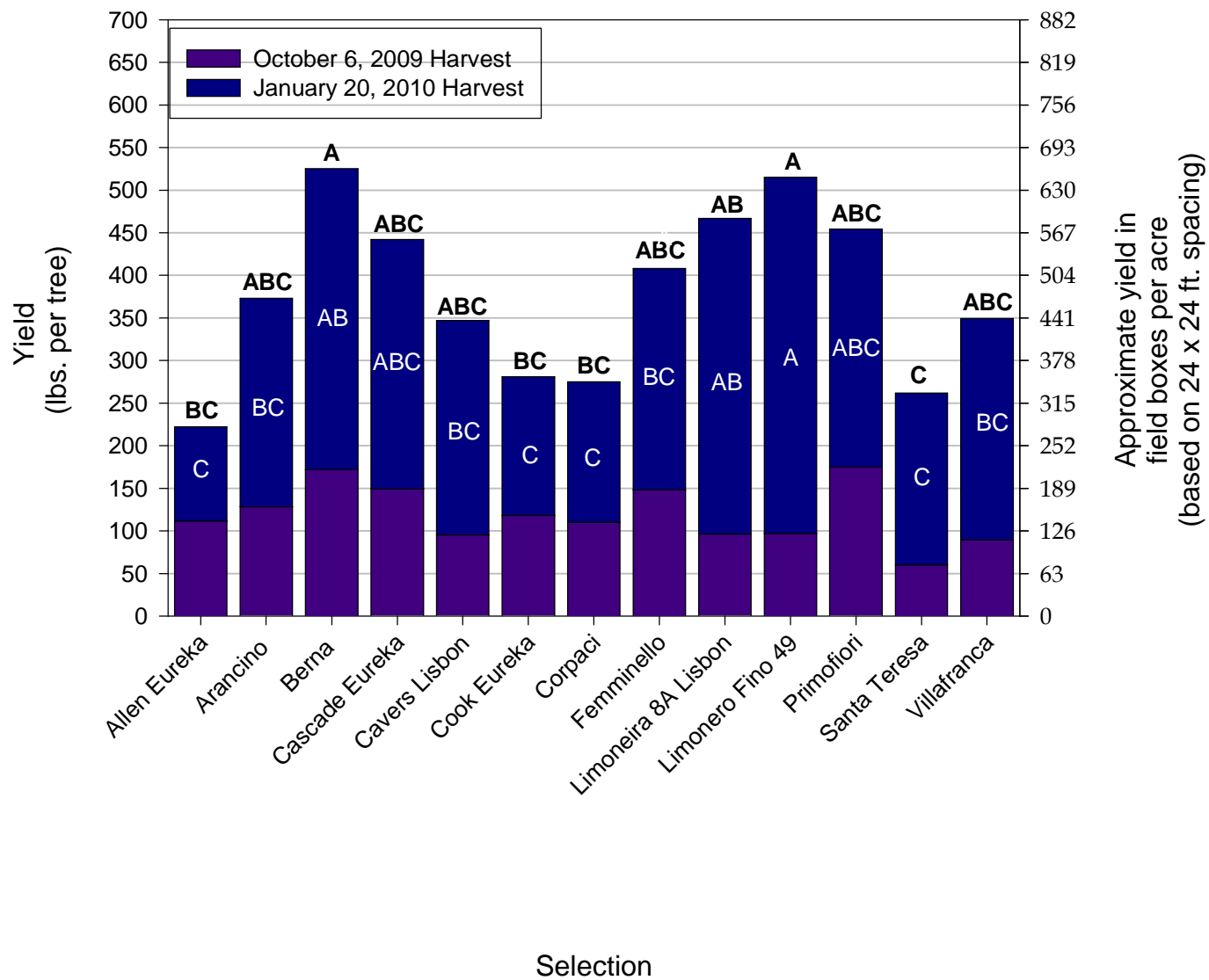


Figure 3. 2009-10 yield of thirteen lemon selections budded to *C. macrophylla* rootstock.

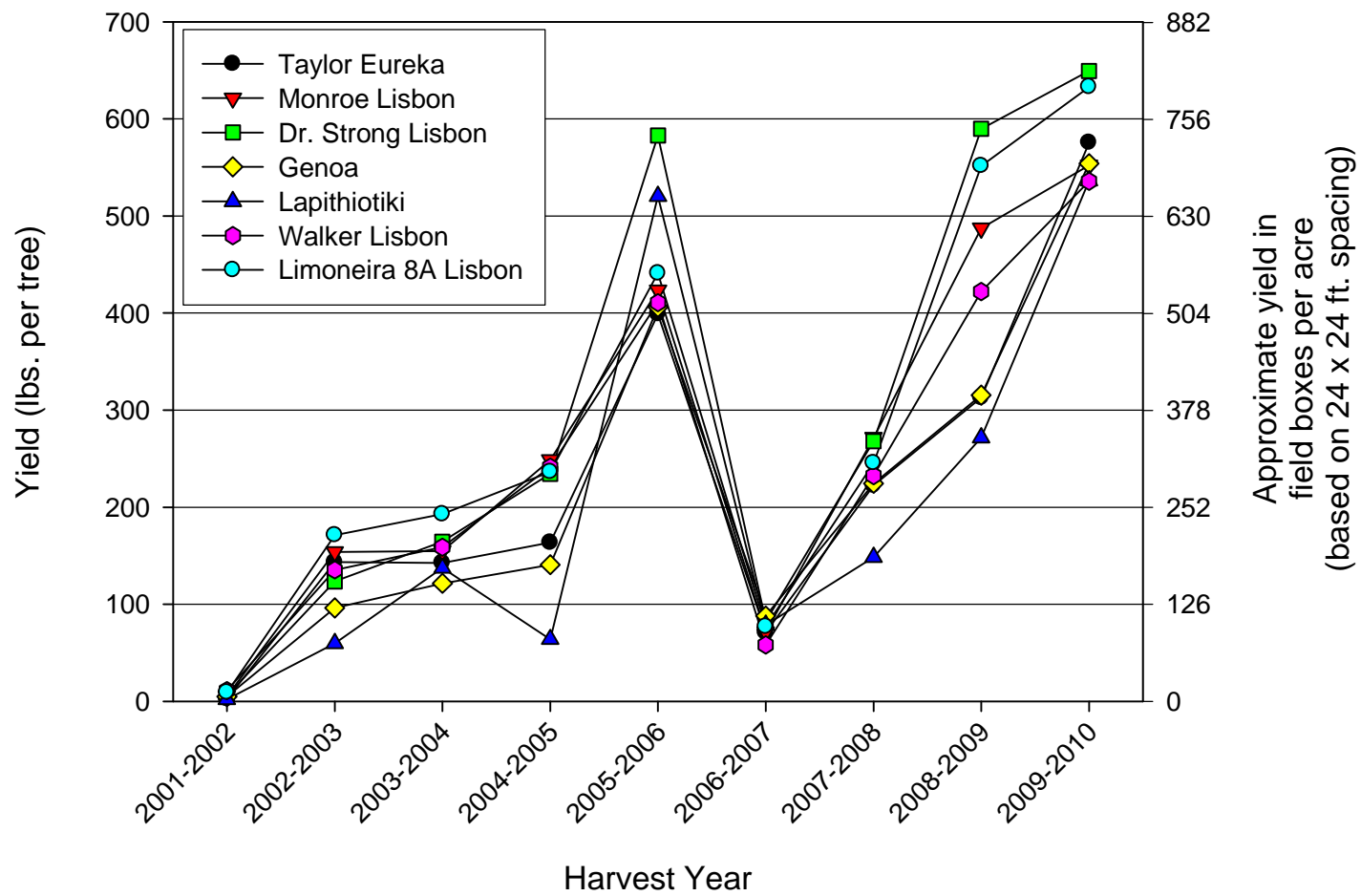


Figure 4. 2001-2009 yield of seven lemon selections budded to *C. macrophylla* rootstock.

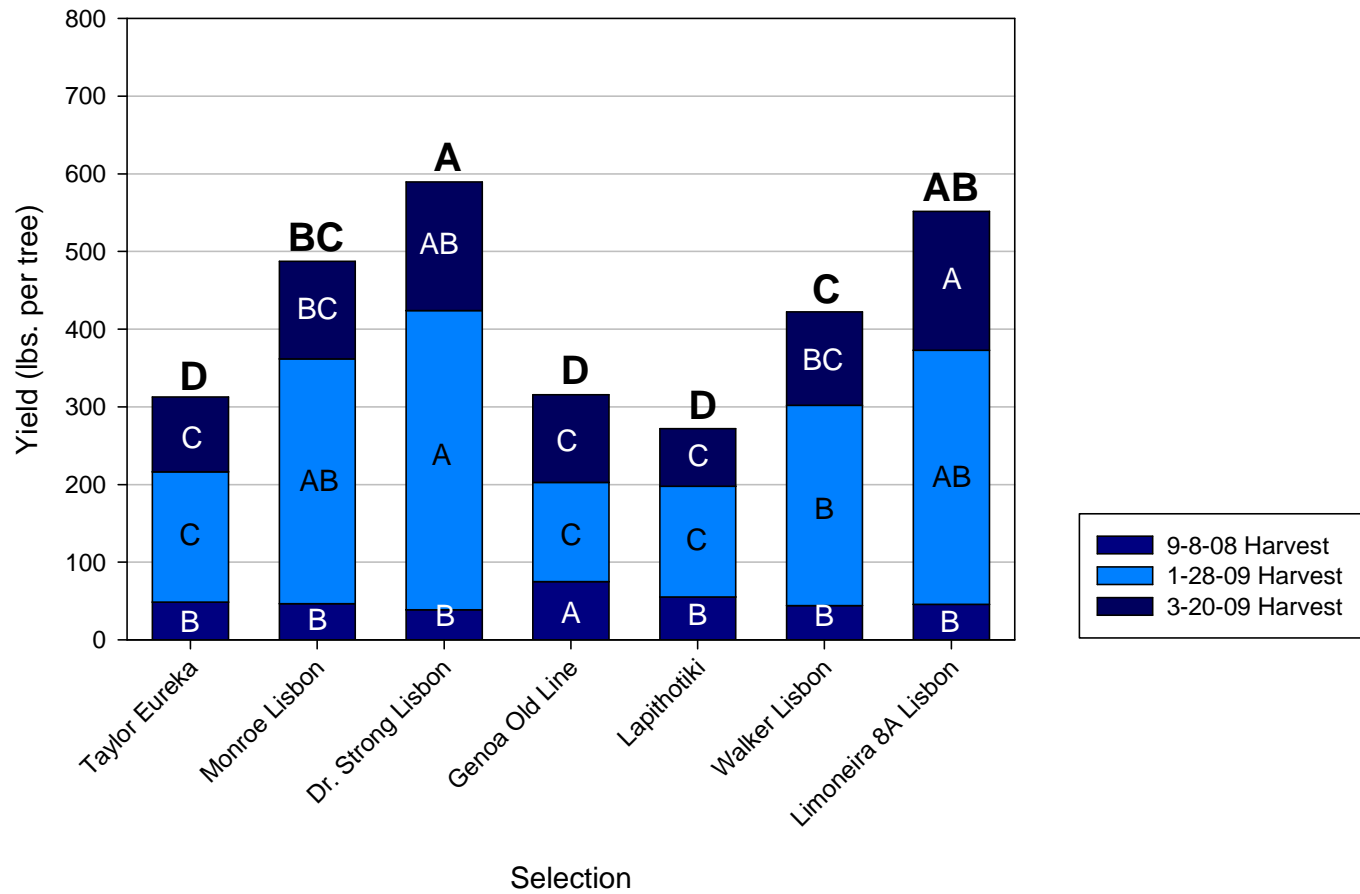


Figure 5. 2008-09 yield of seven lemon selections budded to *C. macrophylla* rootstock.

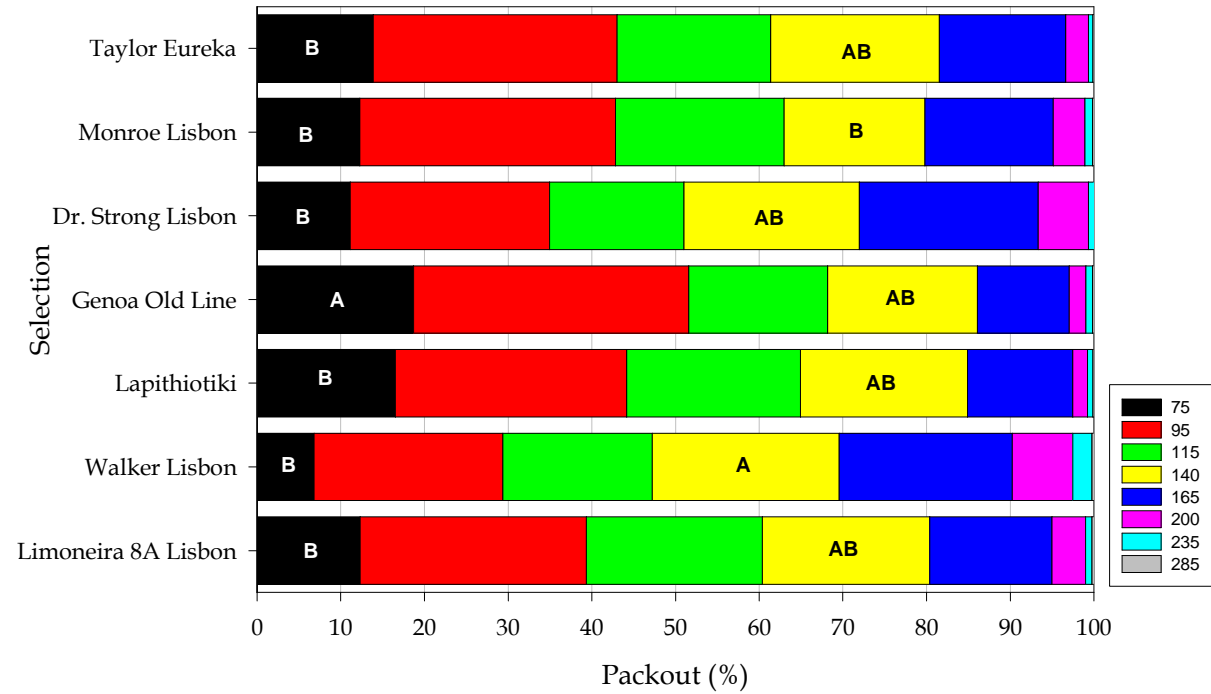


Figure 6. Packout of seven lemon selections on *C. macrophylla* rootstock for the 9-16-08 harvest. Bars of the same shade are significantly different if the lowercase letters within them are different. Bars of different shades cannot be compared.

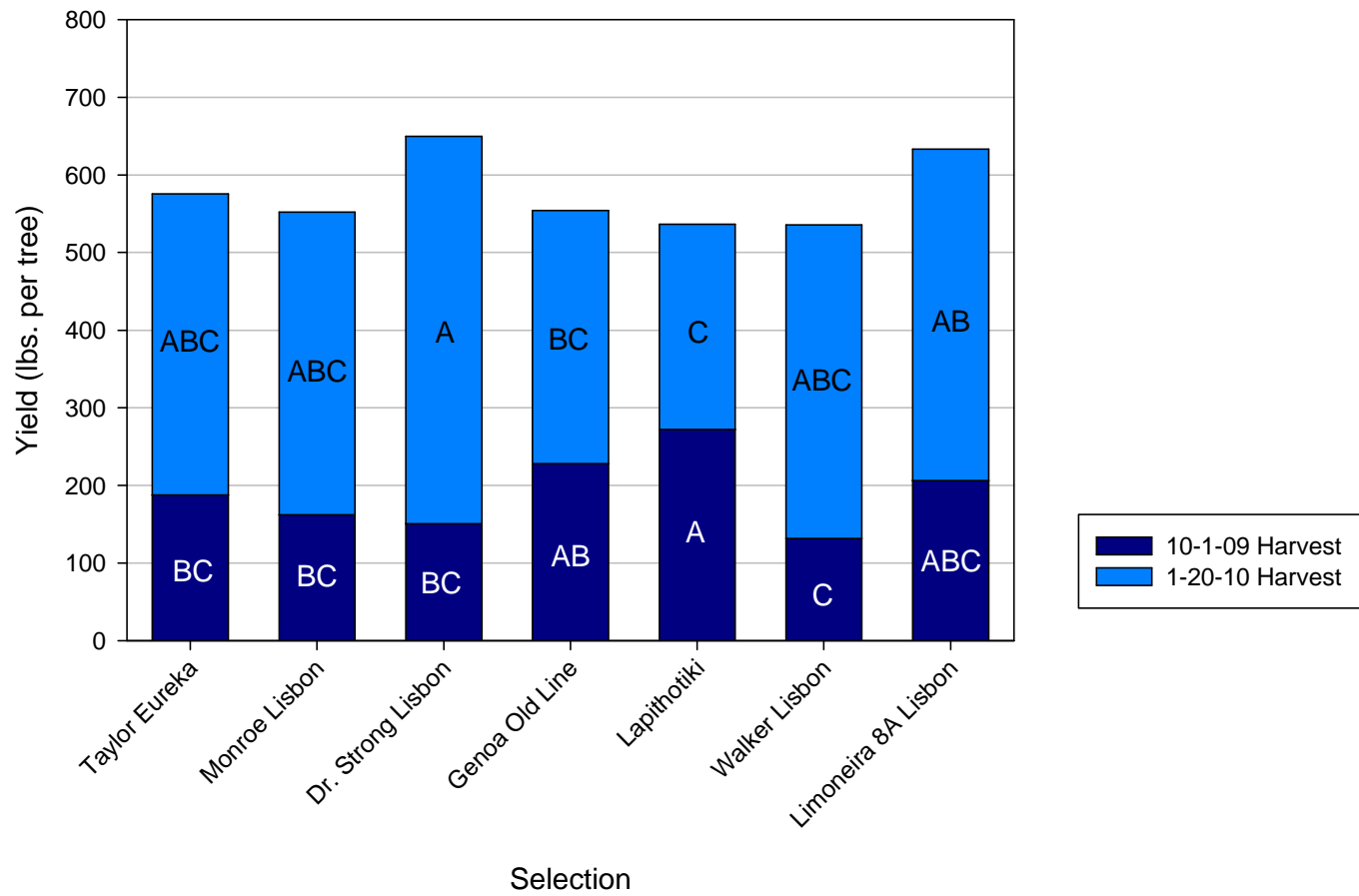


Figure 7. 2009-10 yield of seven lemon selections budded to *C. macrophylla* rootstock.

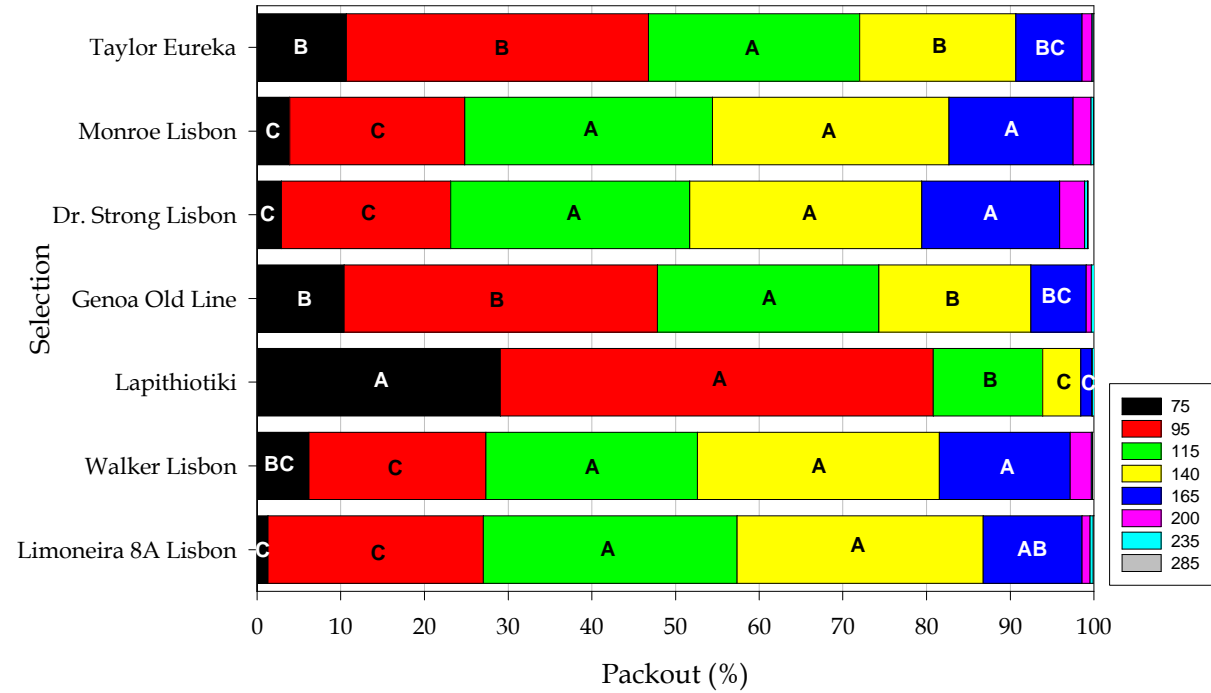


Figure 8. Packout of seven lemon selections on *C. macrophylla* rootstock for the 10-16-09 harvest. Bars of the same shade are significantly different if the lowercase letters within them are different. Bars of different shades cannot be compared.