Results of New Cultivar Selection Trials for Orange in Arizona - 2003[1]

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Abstract

Three orange cultivar trials have been established in Arizona, one at the Yuma Mesa Agricultural Center, Yuma, AZ and one at the Citrus Agriculture Center, Waddell, AZ. For the navel orange trial in Yuma, 'Fisher' navel continues to have the greatest yield, but is unacceptably granulated For the Waddell trial, the second year data has been collected, and suggests that 'Fisher' and 'Beck-Earli' are outperforming the other cultivars tested to date.

Introduction

There is no disputing the importance of orange cultivars to desert citrus production. Oranges have been grown in Arizona since citrus was introduced into the state by the Spanish missionaries in the 1700's. Historically, the most commonly planted orange cultivar in Arizona was the 'Valencia'. Originally exported from the Azores Islands to England in the 1860's, and then to the United States in the 1870, there is no more widely planted citrus cultivar in the world. 'Valencia' trees produce late-maturing medium to large round fruit that are difficult to peel unless completely mature. Fruit contain two to four seeds. Segments are sometimes difficult to separate, and segment walls are tough, but juice quality is high, making the variety most popular for juicing.

The navel orange probably originated in China, then was transported to Spain and Portugal, then on to Brazil. Worldwide expansion of navel orange growing occurred following the importation of the 'Bahia' navel from Brazil to the United States in 1873. Navel trees produce seedless large fruit that are easily peeled and segmented, thus are ideal for eating fresh. Recently, navel oranges have become more important to the Arizona industry than 'Valencia' and other round oranges, because juicing fresh oranges in the household is becoming less common, and the American consumer prefers the convenience of eating fresh oranges. Consequently, prices received by the grower for navel oranges are consistently higher than those for 'Valencia' oranges. Thus, it is not surprising that while total orange acreage in Arizona has dropped from 10,400 acres to 6,200 acres since 1994, navel oranges have increased their share from 50% to 56% over the same period of time.

Whether navel, 'Valencia' or other cultivar, a successful orange for Arizona 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.

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From the late 1980's, to the early 1990's, Arizona orange growers have received their information about new navel or 'Valencia' 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 orange cultivar selection trials in the 1990's, two located at the Yuma Mesa Agricultural Center, and one located at the Citrus Agriculture Center in Waddell, AZ. Previous results from these trial have been reported in Wright (1997), Wright (1998), Wright et al., (1999), Wright and Peña (2000), and Wright and Peña (2001).

Materials and Methods

1995 Navel Orange Trial. This trial was established in March 1995 in Block 18 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. This trial contains the following navel orange selections on 'Carrizo' rootstock:

- 'Washington' – the 'Bahia' navel imported from Brazil. Produces round, slightly oval fruit with segments that separate easily. Excellent flavor. Tends to granulate if planted on a vigorous rootstock, or harvested late.
- 'Lane Late' – Discovered in the 1950's in Australia. Fruit is round, with a small navel. Matures up to four to six weeks later than 'Washington'. Susceptible to fruit drop. Fruit has typical low acid levels.
- 'Atwood' - An early maturing navel selection from California. Discovered in 1935, as a limb sport on a 'Washington' navel tree. Stores well on the tree.
- 'Fisher' – Another early maturing navel selection from California. Rind coloration lags behind legal maturity.
- 'Tulegold' - Another early maturing navel selection from California.

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/or winter. Trees are strip-picked for the 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. Fifteen to twenty-five fruit were harvested as a sample from each tree for juice quality analysis. Granulation values are determined by visual inspection of fruit cut longitudinally.

1999 Navel Orange Trial. This trial was established in March 1999 in Field 19 of the Citrus Agricultural Center, near Waddell, Arizona. This trial contains the following navel orange selections on 'Carrizo' rootstock:

- Beck – a limb sport of 'Washington', discovered in Delano, CA. Smaller trees are reported to be precocious and produce early maturing fruit.
- Cara Cara – Red-fleshed selection form Venezuela. Very similar to 'Washington' in all other respects.
- Chislett – Australian "ultra-late" selection. Reportedly can be harvested up to 3 weeks later than 'Lane Late'.
- Fisher - Early maturing navel selection from California. Rind coloration lags behind legal maturity.
- Fukumoto – Early maturing selection from Japan.
- Lane Late – Discovered in the 1950's in Australia. Fruit is round, with a small navel. Matures up to four to six weeks later than 'Washington'. Susceptible to fruit drop. Fruit has typical low acid levels.
- Powell – Another Australian "ultra-late" selection. Reportedly can be harvested up to 3 weeks later than 'Lane Late'.
- Spring – Another late navel selection.
- Washington - the 'Bahia' navel imported from Brazil. Produces round, slightly oval fruit with segments that separate easily. Excellent flavor. Tends to granulate if planted on a vigorous rootstock, or harvested late.
- Zimmerman – An improved selection of the 'Thomson', said to be 2 weeks earlier than 'Washington'.

Trees were planted on an 8-m x 8-m spacing. There are ten complete blocks of each of the ten scion-rootstock combinations possible. Fruit was harvested on 1/17 and 1/18/2002. Yields are expressed as lbs. fruit per tree. Yield data is collected during the fall and/or winter. Trees are strip-picked for the harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. 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. No juice quality data was taken in 2001-02 because of the small amount of yield per tree. We expect to begin twice-monthly juice quality data collection starting in fall 2002.

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

Results and Discussion

1995 Navel Orange Trial. 1997-2003 yields of the five orange cultivars are shown in Table 1. For both 1997-98 and 1998-99, 'Tulegold' had significantly higher yield per tree, up to double the yield produced by the other selections. However for in 1999-2000, 'Fisher' navels had the highest yield, followed by 'Washington' and 'Tulegold'. 'Lane Late' and 'Atwood' cultivars trailed the others. The early-maturing 'Fisher' had much higher granulation level (Table 2) than the other selections, although if the fruit from this selection had been harvested earlier, it is possible that the granulation level would have been less.

For 2000-01, 'Fisher' had significantly greater yield than the others, but also the highest level of granulation (Table 2). Again, 'Tulegold' and 'Lane Late' had similar yields, about 50% of that of 'Fisher' but almost no granulation. 'Tulegold' and 'Lane Late' also had the greatest juice content, and the highest TSS:TA ratio (Table 3). 'Atwood' and 'Washington' had the least yield for 2000-01, although not significantly less than the yield of 'Tulegold' and 'Lane Late' (Table 2). These two selections had an intermediate level of granulation, and their TSS:TA ratio was the lowest of the five selections tested (Table 3).

Data for 2001-02 and 2002-03 was similar to that of 2000-01. 'Fisher' again had the greatest yield for both years, but was unacceptably granulated (Table 2). For 2001-02, 'Lane Late and 'Tulegold' had intermediate yields, while 'Atwood' and 'Washington' yielded the least fruit. Fruit of 'Tulegold' and 'Lane Late' exhibited almost no granulation. 'Atwood' and 'Washington' again had intermediate levels of granulation. 'Tulegold' and 'Lane Late' also had the greatest juice content, while 'Tulegold' and 'Fisher' had the highest TSS:TA ratio (Table 4). 'Tulegold' also has significantly smaller trees than the other cultivars tested. For 2002-03, 'Washington' and Lane Late' had intermediate yields, while 'Atwood' and 'Tulegold' had the least. All the other cultivars had significantly less granulation than did 'Fisher'. Because of its granulation, 'Fisher' had the lowest juice content of all the navels tested, while 'Lane Late' had the highest (Table 5). All others were intermediate. There was very little difference in solids or acids level among the cultivars tested.

Annual yield for the five cultivars is plotted versus average Central Arizona navel orange yield for 1997-98 through 2000-01 (Figure 1). Central Arizona yield was chosen as a standard benchmark since most navel oranges grown in Arizona are grown in the Central area of the state. Although yields of the trees might not yet be expected to reach that of the benchmark, only 'Fisher' has approached that mark.

Packout for the five navel cultivars for the 2001-02 season is found in Figure 2. Fruit of 'Tulegold' is again significantly smaller than fruit of the others. Differences occurred for fruit sizes 36 through 88. For the others, 'Atwood' had significantly larger fruit of size 36 and significantly smaller fruit of size 48, compared with 'Washington'. 'Lane Late' and 'Fisher' had intermediate sized fruit compared with 'Atwood' and 'Washington'.

Packout for the five navel cultivars for the 2002-03 season is found in Figure 3. There was no difference between the cultivars for sizes 36, 40, and 56. 'Tulegold' is smaller than others, peaking on sizes 56 and 72, while the others peaked on sizes 48 and 56.

Unlike lemons, large navel orange fruit do not necessarily command a better price. We have collected wholesale price data for navel oranges since November 2000. For the week including 2/19/01 (experiment harvest date), size 48 through 72 navel fruit commanded the best prices. Yet for the week including 1/14/02, size 72 through 138 navel oranges received the highest prices. For the week including 2/12/03, sizes 48 and 56 received the highest prices. Therefore, for equivalent yields, Tulegold may bring better returns when the market demands smaller fruit, while the others may bring better returns when the market demands larger fruit.

1999 Navel Orange Trial. First year yields for this trial are shown in Figure 4. Yields ranged from 21 to about 37 lbs per tree. 'Cara Cara' had the least yield and 'Fisher' had the most. However, there were no significant differences among the cultivars evaluated. Packout from these same cultivars is shown in Figure 5. Significant differences were found only for sizes 56, and 88. 'Fisher' and 'Cara Cara' had significantly less fruit of size 56 than did 'Spring'. All other cultivars had intermediate amounts of fruit size 56. For size 88, 'Fisher' had the most fruit, followed by 'Cara Cara'. 'Chislett', 'Lane Late' and 'Spring' had the least fruit of this size category. All others were intermediate.

For 2002-03, yields are shown in Figure 6. Yields ranged from about 25 lbs per tree ('Chislett') to almost 90 lbs per tree ('Fisher'). 'Fisher' had significantly greater yields compared to all the others, except for 'Beck-Earli'. 'Chislett' and 'Powell' had the least yield; all the others were intermediate. 'Chislett' and 'Powell' had much larger fruit size than all the other cultivars tested; peaking on size 56, perhaps due to their lower yield (Figure 7). Most the other cultivars peaked on size 72, except 'Fukumoto' which peaked on size 88. 'Beck-Earli' had the most elongated fruit shape, while 'Chislett' had the roundest fruit (Table 6). Despite the reported differences in maturity between the cultivars, we did not see any significant difference in TSS:TA ratio for 2002-03.

Conclusions

Our results have not yet conclusively demonstrated that navel orange varieties other than 'Washington' can be grown successfully on the Yuma Mesa. Low yields are still a problem, except for 'Fisher'. However as the trees grow that may be overcome. Also, granulation may be offset, particularly for 'Fisher' if fruit were harvested earlier. 'Tulegold' is of interest because of its small tree and fruit size, and may achieve suitable yields per acre if planted closer together. The first year results from the 1999 navel trial in Central Arizona are insufficient to draw any conclusions; several more years of data are needed to characterize navel orange performance in these trials.

For the 'Valencia' trial, it is apparent that the vigorous rootstock and standard cultivar are the best performing combination to date.

Literature Cited

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Table 1. 1997-2003 Yields of five navel orange cultivars budded to Carrizo rootstock.

Scion[z]	1997-98 Yield per tree (lb.). 01/13/98	1998-99 Yield per tree (lb.). 02/15/99	1999-2000 Yield per tree (lb.). 12/17/99	2000-01 Yield per tree (lb.). 2/19/01	2001-02 Yield per tree (lb.). 1/14/02	2002-03 Yield per tree (lb.). 2/12/03
Lane Late	4.40 b[y]	12.44 b	12.03 c	47.08 b	62.83 b	55.35 b
Atwood	5.14 b	7.09 b	12.65 c	33.22 b	35.25 c	41.37 c
Fisher	6.51 b	9.33 b	35.09 a	98.67 a	102.03 a	96.63 a
Washington	7.05 b	8.39 b	28.32 b	37.76 b	41.67 c	58.56 b
Tulegold	11.84 a	32.78 a	24.48 b	45.49 b	65.56 b	39.79 c

[z] Yield values are the means of 12 trees.

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

Table 2. 1999-2003 Granulation of five navel orange cultivars budded to Carrizo rootstock.

Scion	1999-2000	2000-01	2001-02	2002-03
Lane Late	2.30 c[zy]	4.4 c	0.42 c	0.67 c
Atwood	3.09 c	12.4 bc	8.36 b	1.67 bc
Fisher	30.92 a	27.3 a	50.41 a	6.67 a
Washington	5.16 bc	15 0 b	12.08 b	2.00 bc
Tulegold	9.31 b	5.2 c	2.08 c	2.67 b

[z] Granulation values are the means of 25 fruit per tree in 1998-99 and 15 fruit per tree in the 1999-2000 through 2001-02 seasons, and 20 fruit in the 2002-03 season. For the 2002-03, values represent the number of fruit in the entire fruit sample with more than 20% granulation.

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

Table 3. 2000-01 Fruit Quality of five navel orange cultivars budded to Carrizo rootstock.

Scion	Percent Juice	TSS (%)	TA (%)	TSS:TA	Peel Thickness (mm)
Lane Late	41.42 a[z]	12.01 a	0.46 c	24.71 a	6.42 b
Atwood	35.04 b	10.62 b	0.53 a	19.80 c	6.83 ab
Fisher	31.24 c	11.57 a	0.47 bc	25.68 a	6.78 b
Parent Washington	34.88 b	11.34 a	0.50 b	22.76 b	7.37 a
Tulegold	41.37 a	11.36 a	0.45 c	25.17 a	4.83 c

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

Table 4. 2001-02 Fruit Quality of five navel orange cultivars budded to Carrizo rootstock.

Scion	Percent Juice	TSS (%)	TA (%)	TSS:TA	Peel Thickness (mm)
Lane Late	40.87 a[z]	11.00 c	0.45 a	24.56 c	5.76 c
Atwood	35.47 b	11.55 b	0.47 a	24.93 c	6.18 b
Fisher	25.49 d	11.66 b	0.39 b	29.67 b	5.73 c
Parent Washington	31.46 c	11.26 bc	0.44 a	25.51 c	6.49 a
Tulegold	41.30 a	12.62 a	0.41 b	31.24 a	4.12 d

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

Table 5. 2002-03 Fruit Quality of five navel orange cultivars budded to Carrizo rootstock.

Scion	Percent Juice	TSS (%)	TA (%)	TSS:TA	Peel Thickness (mm)
Lane Late	41.51 a[z]	12.73 a	0.46 bc	27.55 a	5.63 c
Atwood	36.26 b	12.84 a	0.47 bc	27.26 a	5.85 bc
Fisher	33.11 c	13.37 a	0.50 ab	26.94 a	6.12 ab
Parent Washington	36.57 b	12.18 a	0.52 a	23.40 b	6.22 a
Tulegold	36.09 b	12.27 a	0.44 c	28.79 a	4.95 d

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

Figure 1. 1997-2003 Navel orange yields plotted against the average Central Arizona orange yield for the same harvest years (Data not yet available for the 2002-03 Central Arizona Average)

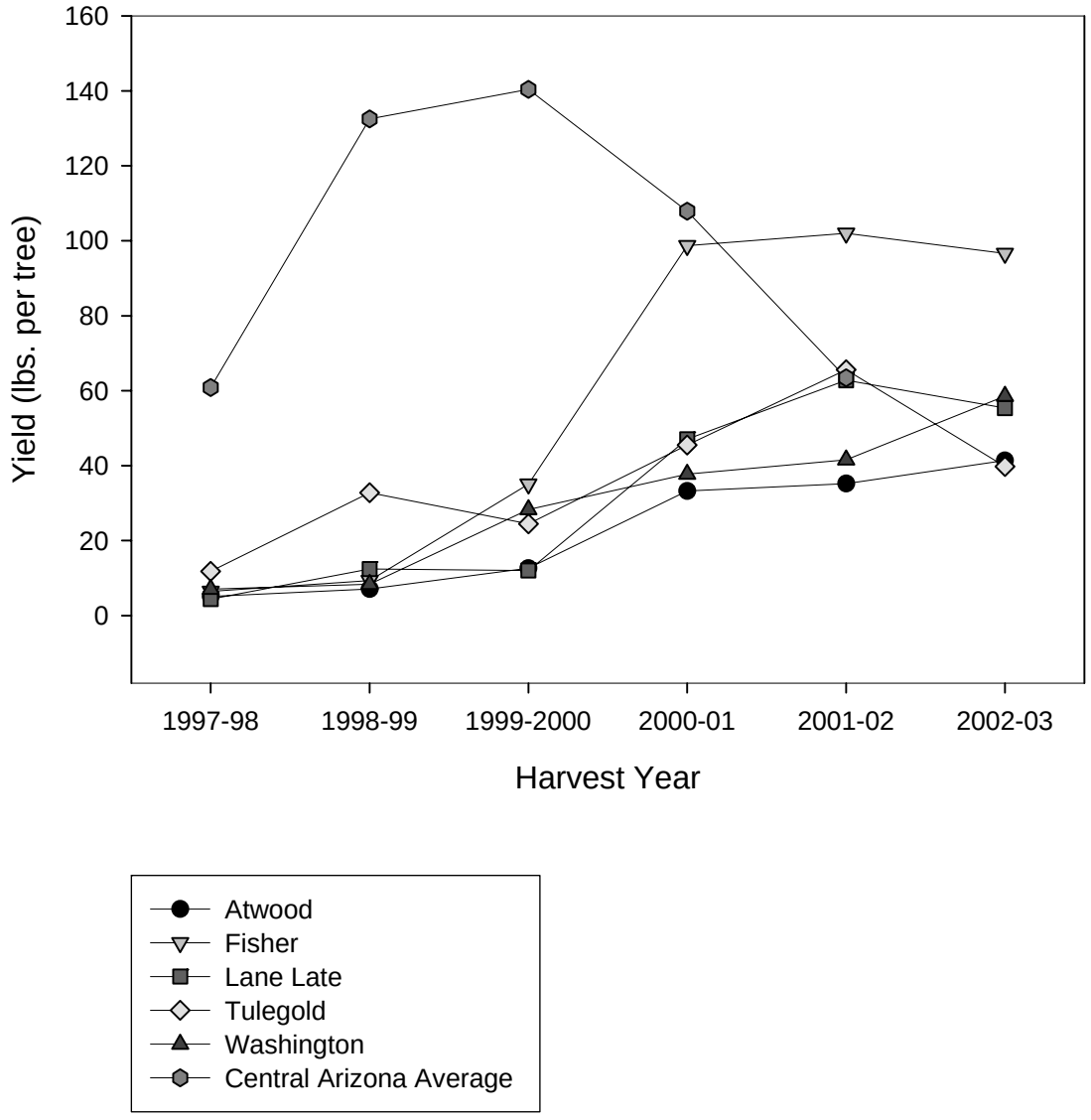

Figure 2. Packout of five navel orange cultivars harvested on 1/14/02.

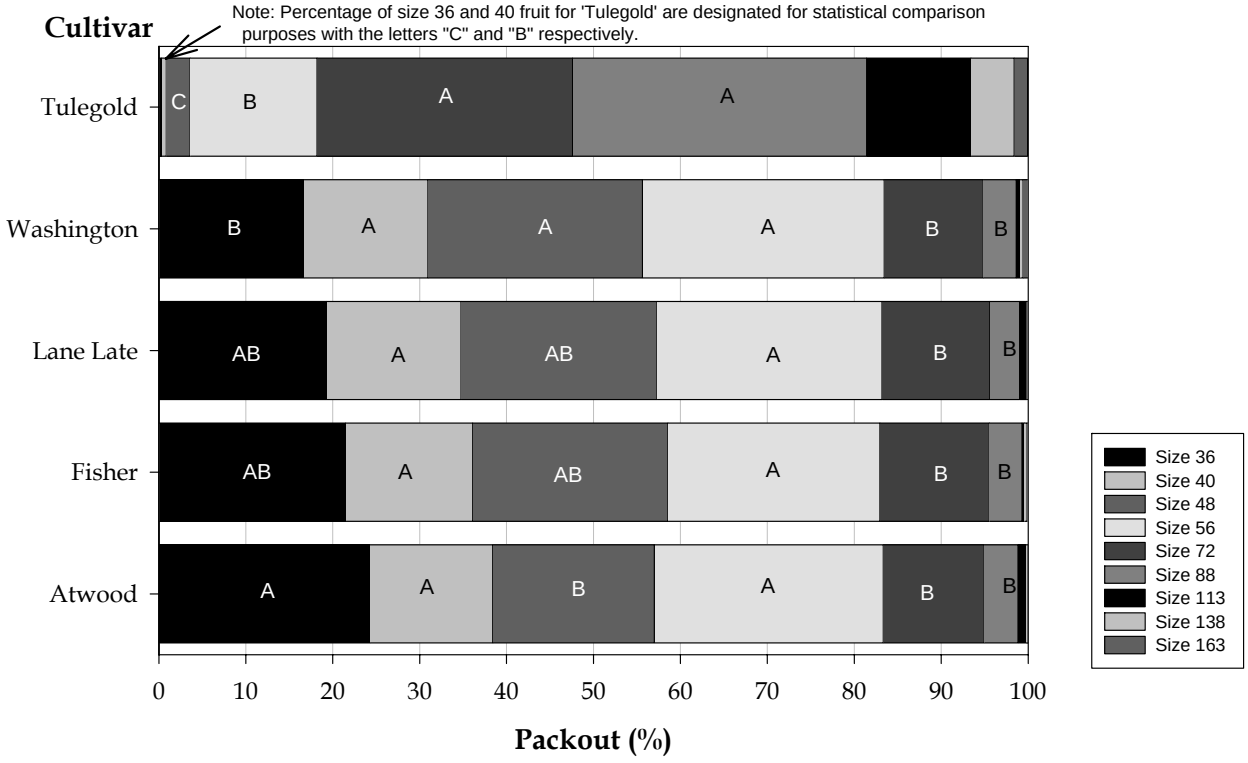

Figure 3. Packout of five navel orange cultivars harvested on 2/12/03

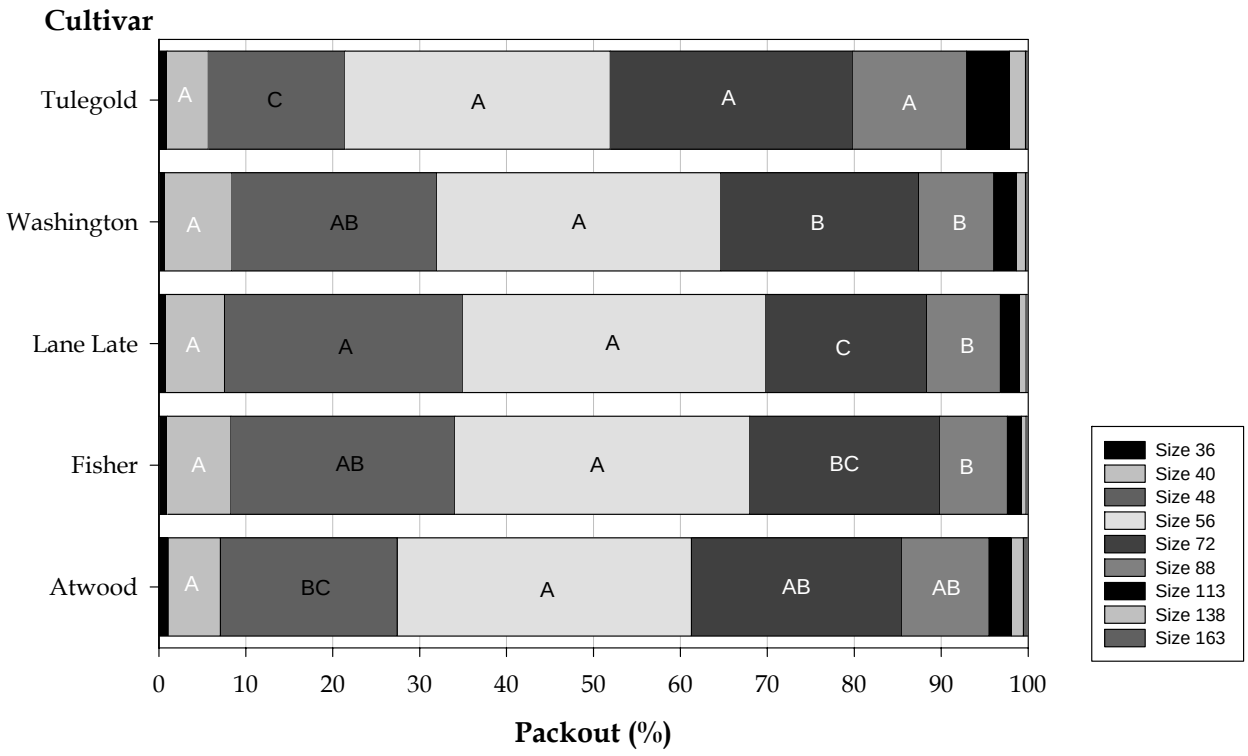

Figure 4. Yield of ten navel orange cultivars harvested on 1/17 and 1/18/02.

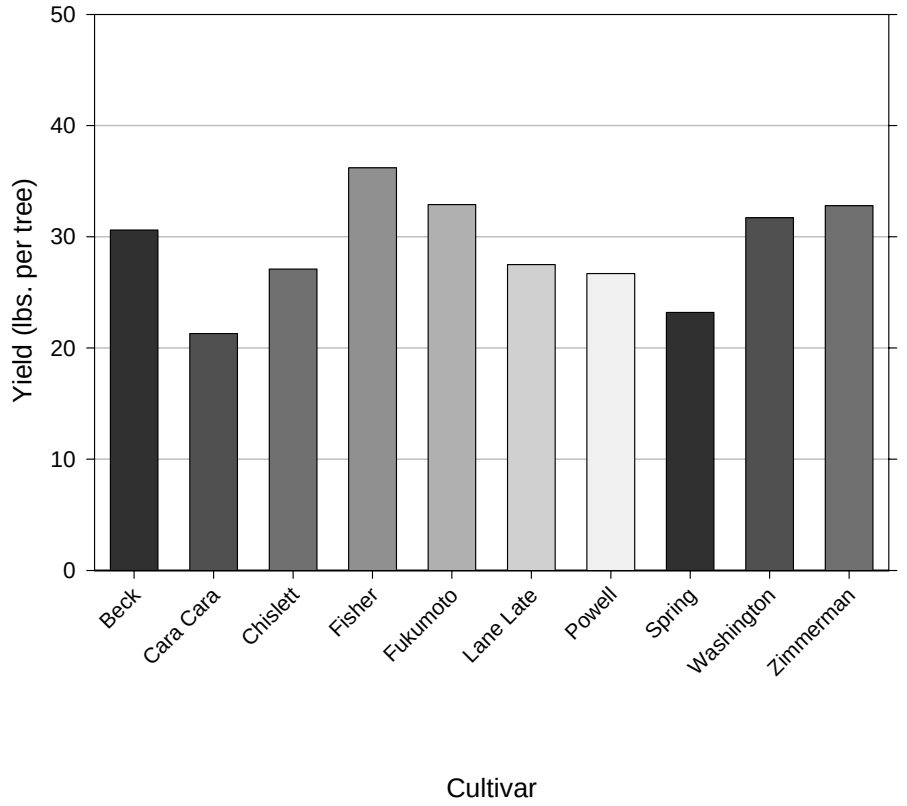

Figure 5. Packout of ten navel orange cultivars harvested on 1/17 and 1/18/02.

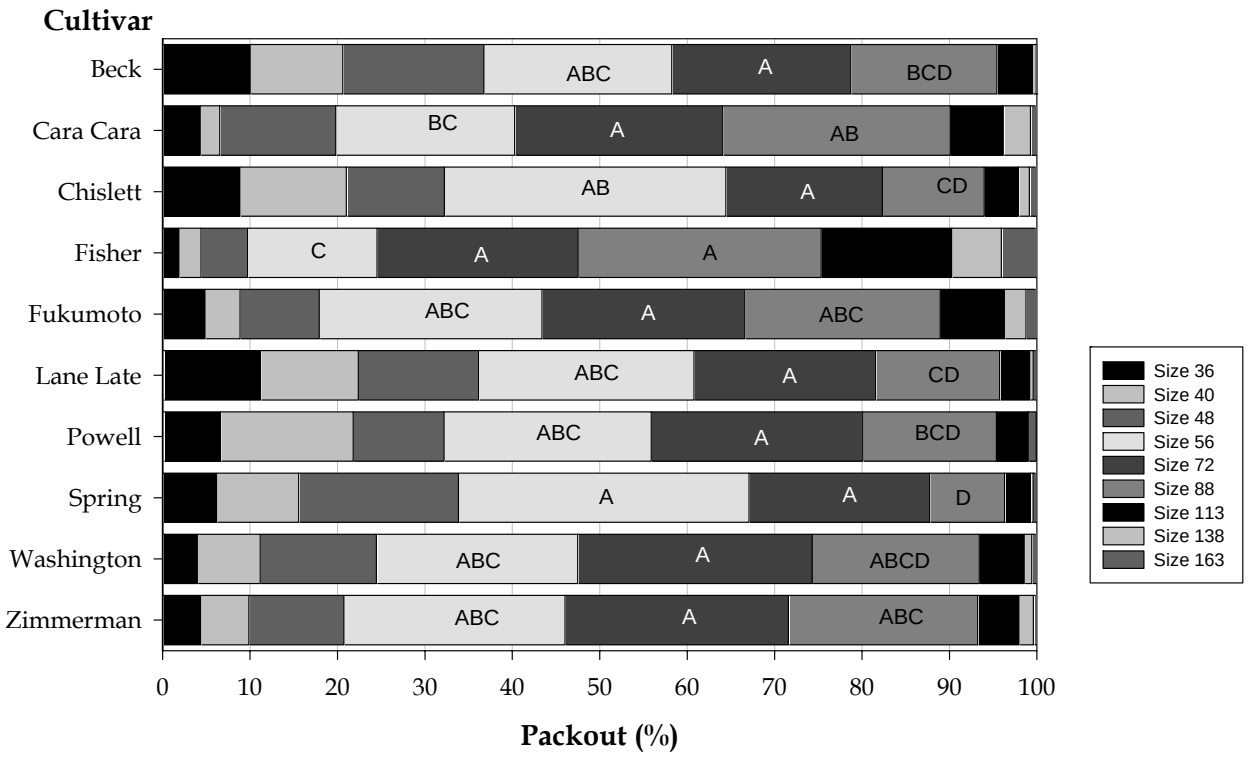

Figure 6. Yield of ten navel orange cultivars harvested on 12/12/02 and 1/31/03.

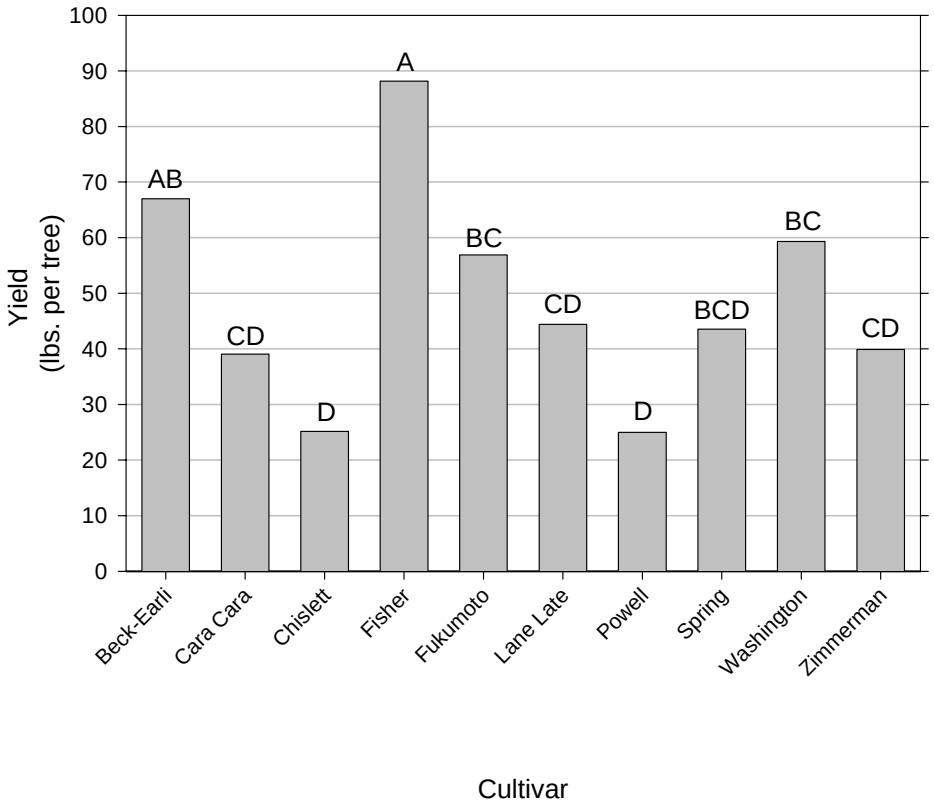

Figure 7. Packout of ten navel orange cultivars harvested on 12/12/02 and 1/31/03.

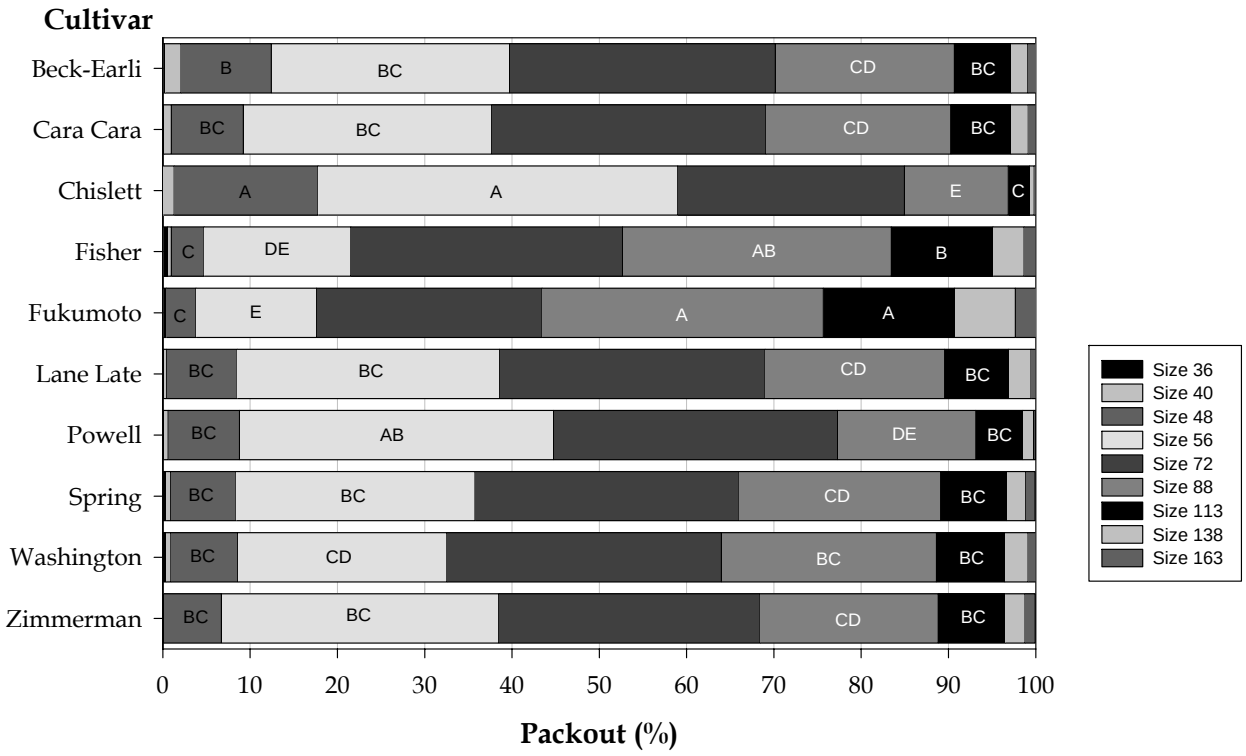

Table 6. 2002-03 Fruit quality of ten navel orange cultivars budded to Carrizo rootstock.

Scion[z]	Fruit Shape	Percent Juice	TSS (%)	TA (%)	TSS:TA
Beck-Earli	0.857 e[y]	36.01 bc	13.32 ab	0.56 a	24.64 a
Cara Cara	0.919 d	37.56 bc	12.97 abc	0.51 a	25.91 a
Chislett	0.941 a	40.12 abc	11.97 de	0.39 b	32.31 a
Fisher	0.918 d	38.24 bc	13.67 a	0.54 a	27.77 a
Fukumoto	0.919 d	36.87 bc	13.65 a	0.52 a	26.56 a
Lane Late	0.932 abc	41.21 ab	12.28 cde	0.49 a	26.32 a
Powell	0.936 ab	44.29 a	11.78 e	0.45 ab	27.60 a
Spring	0.926 bcd	41.72 ab	12.70 bcd	0.51 a	24.89 a
Washington	0.924 cd	38.92 abc	12.70 bcd	0.51 a	25.40 a
Zimmerman	0.927 bcd	35.39 c	12.49 cde	0.47 ab	28.07 a

[z] Quality values are the means of 3 fruit per tree.
[y] Means separation in columns by Duncan's Multiple Range Test, 5% level.