

Cultivar Selection Trials of Navel Orange in Arizona for 2006-07¹

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Abstract

Two 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, all the selections had reduced yields in 2006-07. 'Fisher' navel continues to have the greatest yield. Of the rest in the Yuma trial, 'Lane Late' had the best quality and yield. For the Waddell trial, the fourth year data has been collected, and suggests that 'Fisher', 'Beck-Earli' and 'Lane Late' 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'. 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.

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.

From the late 1980's, to the early 1990's, Arizona orange growers have received their information about new navel through word of mouth or from nursery sources, since there were no trials planted in the state. With this in mind, we have planted two new navel orange cultivar selection trials in the 1990's, one located at the Yuma Mesa Agricultural Center, and one located at the Citrus Agriculture Center in Waddell, AZ, just west of Phoenix.

Materials and Methods

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1995 Yuma 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. The Arizona industry standard.
- ‘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. Reportedly a heavy producer.
- ‘Tule Gold’ - Another early maturing navel selection from California. Reported in some publications to be “early ripening and heavy bearing”, but other sources report poor fruit quality.

Trees are planted on a 10-m x 10-m spacing. Twelve trees of each of five scions are planted, for a total of 60 trees. Yields are expressed as lbs. fruit per tree. As the field was harvested commercially, yield data was collected from November 30, 2006 through January 26, 2007. Trees are strip-picked for the harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. For 2006-07, the entire harvest from each tree was 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. We found no differences in exterior fruit quality, other than color between the selections. Ten fruit were harvested on 12-06 from each tree as a sample from each tree for juice quality analysis.

1999 Waddell 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-Earli’ (‘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 from 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. The Arizona industry standard
- ‘Zimmerman’ (Thomson Improved Zimmerman) – An improved selection of the ‘Thomson’, said to be 2 weeks earlier than ‘Washington’.

Trees are planted on an 8-m x 8-m spacing. There are ten complete blocks of each of the ten selections. Early-season selections were harvested on 11/14/06. This includes ‘Beck-Earli’, ‘Fisher’, and ‘Fukumoto’. Mid –season selection, ‘Washington’ was harvested on 12/8/06, followed by ‘Cara Cara’ and ‘Spring’ on 1/5/07. Late-season selections (‘Chislett’, ‘Lane Late’, ‘Powell’, and ‘Zimmerman’) were harvested on 1/12/2006. We harvested ‘Spring’ earlier than usual in 2006-07, and ‘Zimmerman’ later than usual because ‘Spring’ seemed to be sweeter, than ‘Zimmerman’. Yields are expressed as lbs. fruit per tree. Trees were 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. Fruit grade data is not reported, as there were no significant differences between the selections. Fruit quality data for all the selections was collected on their respective harvest dates. Five fruit were harvested as a sample from each tree for juice quality analysis, for a total of 50 fruit per selection. There was no effect of selection upon peel thickness or juice pH for 2006-07.

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

Results and Discussion

1995 Yuma Navel Orange Trial. (See Figures 1, 2 and 3 as well as Table 1.)

Atwood: Yields of 'Atwood' have historically been lower or 'within the pack', compared to the other selections tested in this trial, and 2006-07 was no exception, and the promise of higher yields that appeared in 2003-04 was not repeated. Yield was slightly less than the previous year. Fruit size for this season was typical of the other selections, peaking on size 40. Fruit color was neither as "green" as 'Fisher', nor as colored as 'Lane Late'. 'Atwood' had the highest juice content of the selections tested, along with the thinnest peel.

Fisher: Yields of 'Fisher' have been equal to or higher than the other selections tested in this trial, and 2006-07 was no exception. Yields for 2006-07 were about 30% less than the previous year. Fruit size for this season is comparable to the other selections, except 'Tulegold', peaking on sizes 40 and 48. Fruit color was the greenest of all the selections tested.

Lane Late: Yields of 'Lane Late' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2005-06 was no exception. Yield for 2006-07 was only 66% of the previous year. Fruit size for this season was typical compared to the other selections, peaking on sizes 40 and 48. Fruit shape is round, and color was not as good as the other selections under trial. Because of its greenness, this selection might be harvested later in the season. Fruit color was the most colored of all the selections tested.

Tule Gold: Yields of 'Tule Gold' have typically been lower than the other selections under test, although after 12 years in the ground, these trees are about 50% of the size of the other selections, thus if planting density were increased, yields per acre for this selection might equal the yields of the others. Yields of 'Tulegold' were only about 2/3 of 'Atwood', the next lowest yielding selection, and yields were about 30% less than the previous year. Fruit size was a much smaller than the other selections, peaking on sizes 72 and 88. Color was surprisingly green in 2006-07. 'Tulegold' had high juice content.

Washington: Yields of 'Washington' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2006-07 was no exception. Yield of 'Washington' was 33% less than the previous year. Fruit size for 2006-07 was larger than most of the other selections, except 'Tulegold', peaking on sizes 40 and 48. Fruit color was good, but juice content was rather low.

1999 Waddell Navel Orange Trial. (See Figures 4, 5 and 6 as well as Table 2.)

Selections harvested on 11-14-06

Beck-Earli: The 2005-06 yield for 'Beck-Earli' was slightly less than the 2005-06 yields. Still, yield only was 75% of that of 'Fisher'. Fruit size, however, was again the largest of all the early selections tested. 'Beck-Earli' peaked on size 40, but had appreciable numbers of fruit size 72. Percent juice was low, but total soluble solids, total acids and TSS:TA was average. The fruit was the most oblong of all the selections tested. Fruit was not as orange as 'Fukumoto' but not as green as 'Fisher' in mid-November.

Fisher: Yields of 'Fisher' were the highest for any of the selections tested in this trial, at about 165 lbs. per tree. This represented a 5 lb per tree decrease from the previous year, and a 10 lb. per tree decrease from

2004-05. For these early-maturing navels, fruit size was smaller than 'Beck-Earli' and 'Fukumoto', peaking on size 72 and 88. Fruit quality measurements suggest that percent juice of 'Fisher' is greater than 'Fukumoto', but solids, acids and TSS:TA were not different than the other three selections tested. 'Fisher' also had the roundest fruit, but had the least coloration of all the early-picked selections.

Fukumoto: 'Fukumoto' yields decreased from about 100 lbs. per tree in 2005-06 to 93 lbs. per tree in 2006-07 only about 60% of the yields of 'Fisher'. Fruit size was neither the smallest nor the largest of the three selections harvested early, but still peaking on size 72. There were fewer 'Fukumoto' fruit of size, 40, 48 and 56 than 'Beck-Earli' fruit in the same categories. Fruit quality measurements suggest that 'Fukumoto' had lower juice content than the other two early selections. 'Fukumoto' had a good round shape and the most coloration of all the early-picked selections.

Selection harvested on 12-8-06

Washington: 'Washington' continued to distinguish itself from the other selections, having a yield of about 135 lbs. per tree, the second highest in the entire trial. Fruit size was larger than 'Zimmerman', and 'Cara Cara', peaking on size 72, but there were no significant differences among the three. Fruit quality measurements of 'Washington' showed that it had the highest juice content of all the mid-season selections tested, but an average TSS level, because of low levels of acids. Fruit of 'Washington' was rather green at harvest.

Selection harvested on 1-5-07

Cara Cara: Cara Cara yields for the three years of this study have neither been exceptionally high nor low, but increased from about 90 lb. per tree for 2004-05 to 145 lbs. per tree for 2005-06, then decreasing to 103 lbs. per tree for 2006-07. 'Cara Cara' and 'Washington' had the greatest yields of the mid-season group. Fruit size of this selection peaked on size 72. Fruit quality for 'Cara Cara' was similar to most of the other selections, except this selection had higher acids than most others.

Spring: 'Spring' navel orange yields, at about 98 lbs. fruit per tree, higher than the 88 lbs. recorded last year. Fruit size peaked on size 72. Quality of 'Spring' fruit was typical of the other late selections tested, except that acids were low, leading to the highest solid:acid ratio among all the selections tested. Fruit coloration was the highest of all the selections under test.

Selections harvested on 1-12-07

Chislett: For 2006-07, 'Chislett' yields, about 91 lbs. per tree, fell to the middle of the group among the late-harvested orange selections. 'Chislett' has not performed as well as 'Washington' and 'Cara Cara' over the past two years. Fruit size for 'Chislett' was the largest for all the selections harvested late, peaking on size 40 and 72. Fruit quality of 'Chislett' was not particularly distinguishable from the other late selections tested, other than the solids level was high.

Lane Late: Yields of 'Lane Late' fell again below that of 'Washington' (20% less). Fruit size peaked on sizes 72. Most fruit quality parameters were similar to other selections harvested late.

Powell: Yields for 'Powell' for 2006-07 were slightly less than those of 2005-06, with yields of about 86 lbs. per tree, placing it in the middle of the selections. Fruit size was similar to 'Lane Late' peaking on size 72. 'Powell' had the most juice of any of the late navel orange selections, but the lowest solids level, leading to the lowest solid:acid ration among the late-season oranges tested..

Zimmerman: 'Zimmerman' had similar yields compared to the other mid-season navel selections, at about 82 lbs. per tree, about 40% less than 'Washington', but about 8% more than its own output for the 2005-06 season. Fruit size was similar to the other selections tested. Fruit size peaked on size 72. Juice content was low but solids level was high and exterior color was good.

Conclusions

Our results have not yet conclusively demonstrated that navel orange selections other than 'Washington' can be grown successfully on the Yuma Mesa. Low yields are still a problem, except for 'Fisher', but its higher yields are offset by the poor coloration problem. 'Tule Gold' is of interest because of its small tree and fruit size, and may achieve suitable yields per acre if planted closer together. We have not seen the fruit quality problems for this cultivar mentioned by others.

In Waddell, we can begin to draw some conclusions; yet several more years of data are needed to characterize navel orange performance in these trials. The performance of 'Fisher' is noteworthy, yet it is again accompanied by poor coloration (yet much less than in Yuma). 'Beck-Earli' may be improving its yields, and may be worth further notice. While 'Cara Cara', 'Lane 'Late' and 'Chislett' bear watching as this experiment continues because of last years' data, 'Washington' improved the most in 2006-07.

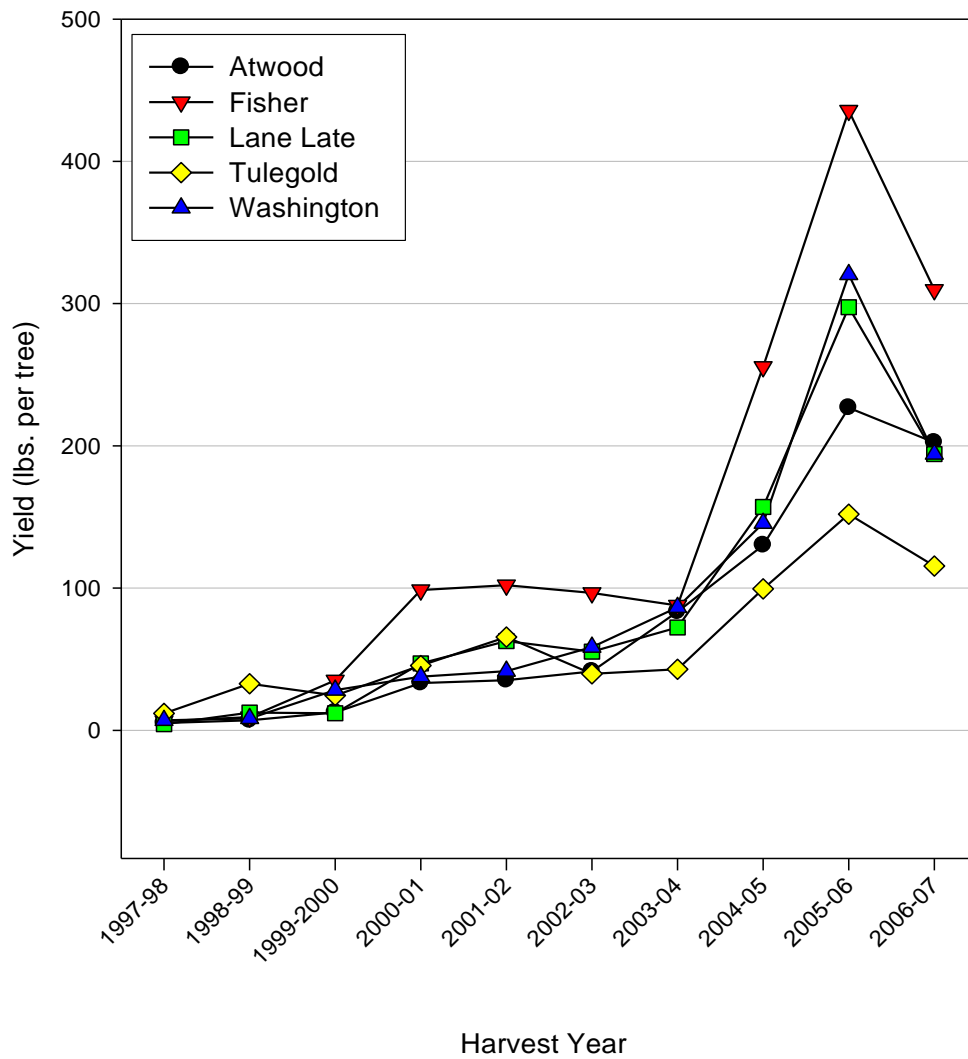
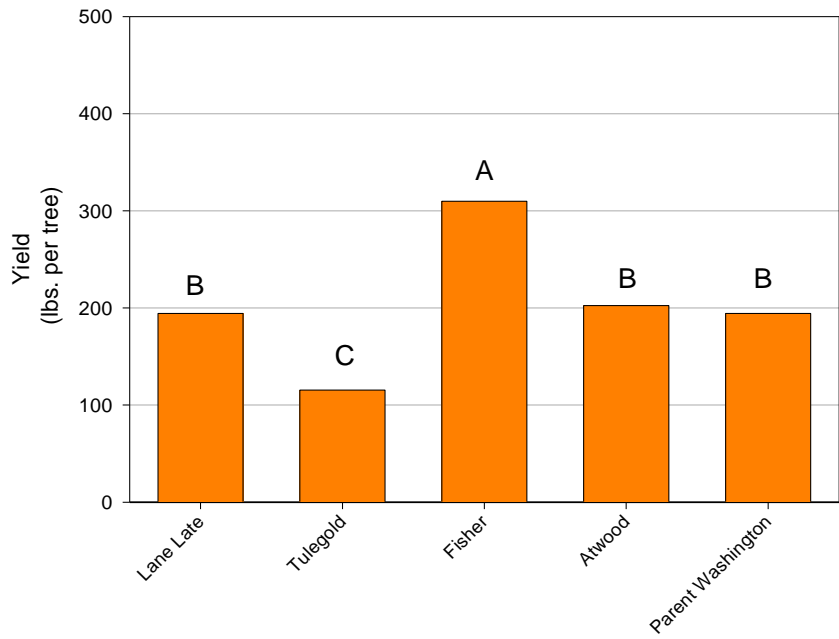


Figure 1. 1997-98 through 2006-07 yields of five navel orange cultivars budded to Carrizo rootstock.



Cultivar

Figure 2. 2006-07 yield of five navel orange cultivars. Letters indicate significant differences between selections, at a 5% level.

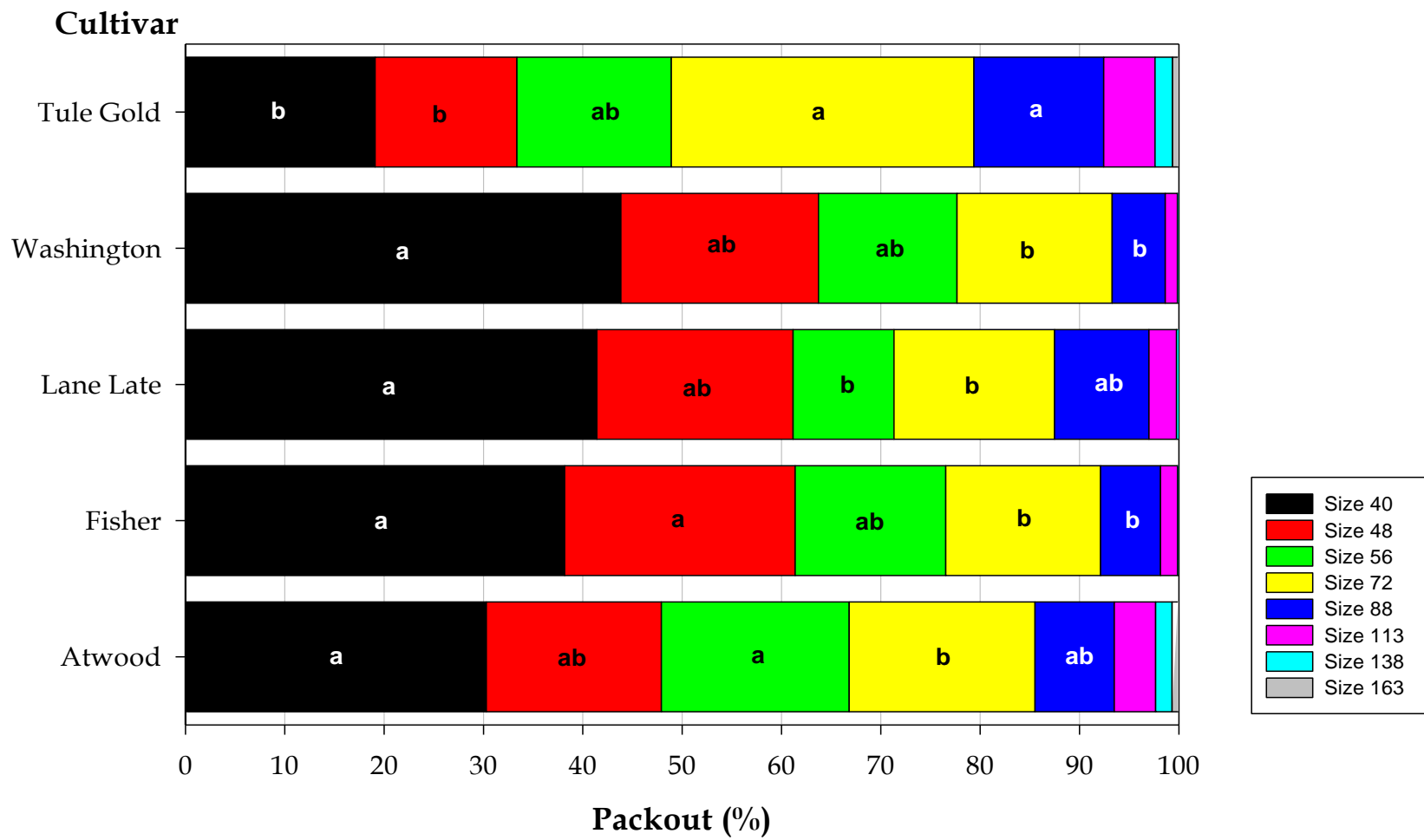


Figure 3. 2006-07 packout of five navel orange cultivars. Letters indicate significant differences between selections, for the same fruit size, at a 5% level.

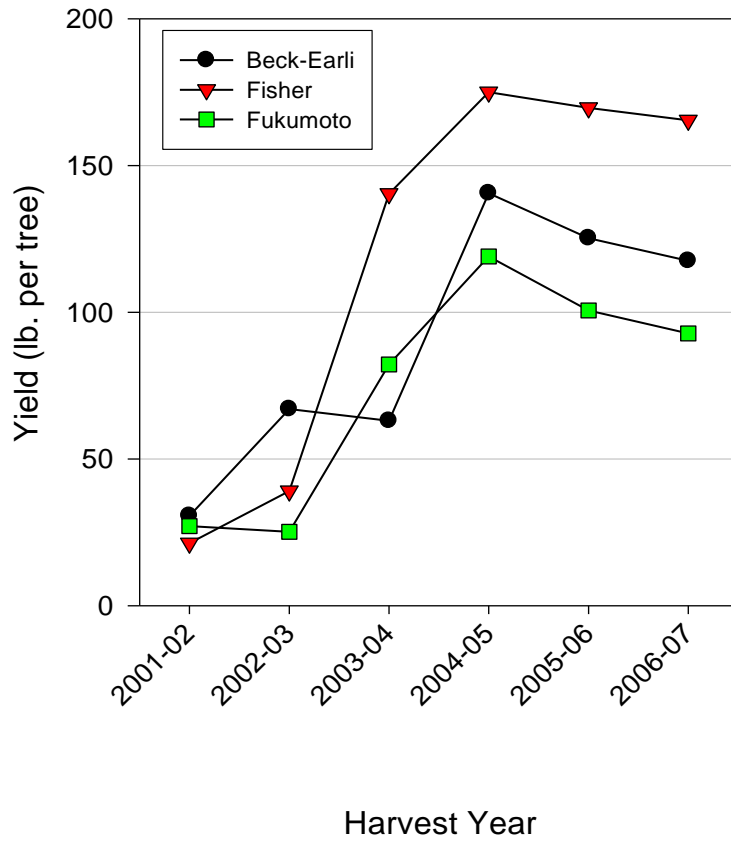
Table 1. 2006-07 Fruit shape and color of five navel orange cultivars budded to Carrizo rootstock. All fruit was sampled on 12-30-06

| Scion | Juice Content (%) | Peel thickness (mm) | R/G ^y |
|------------|-------------------|---------------------|------------------|
| Atwood | 46.9 a | 3.81 b | 1.58 b |
| Fisher | 41.6 b | 4.30 ab | 1.30 d |
| Lane Late | 45.7 a | 5.04 a | 1.91 a |
| Tule Gold | 46.5 a | 4.54 ab | 1.41 c |
| Washington | 42.3 b | 4.61 a | 1.62 b |

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

^y Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.

Early Season Oranges



Mid and Late Season Oranges

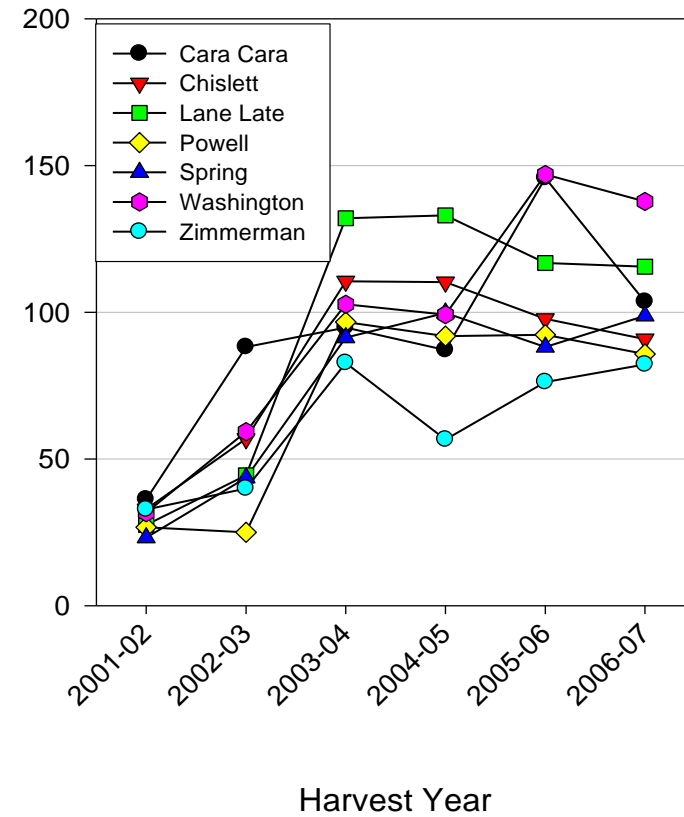


Figure 4. 2001-02 through 2006-07 yields of ten navel orange cultivars budded to Carrizo rootstock.

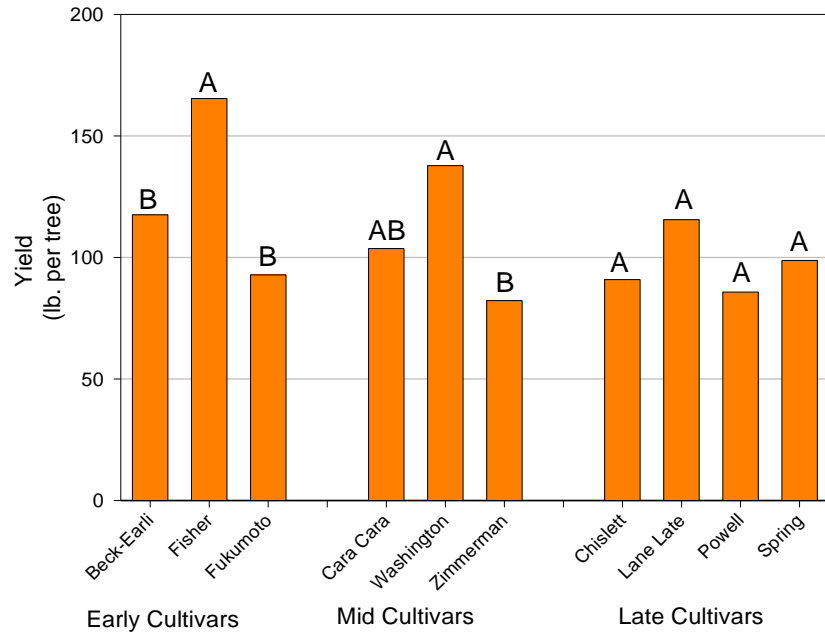


Figure 5. 2006-07 yield of ten navel orange cultivars budded to Carrizo rootstock. Letters indicate significant differences between selections, within the same group, at a 5% level.

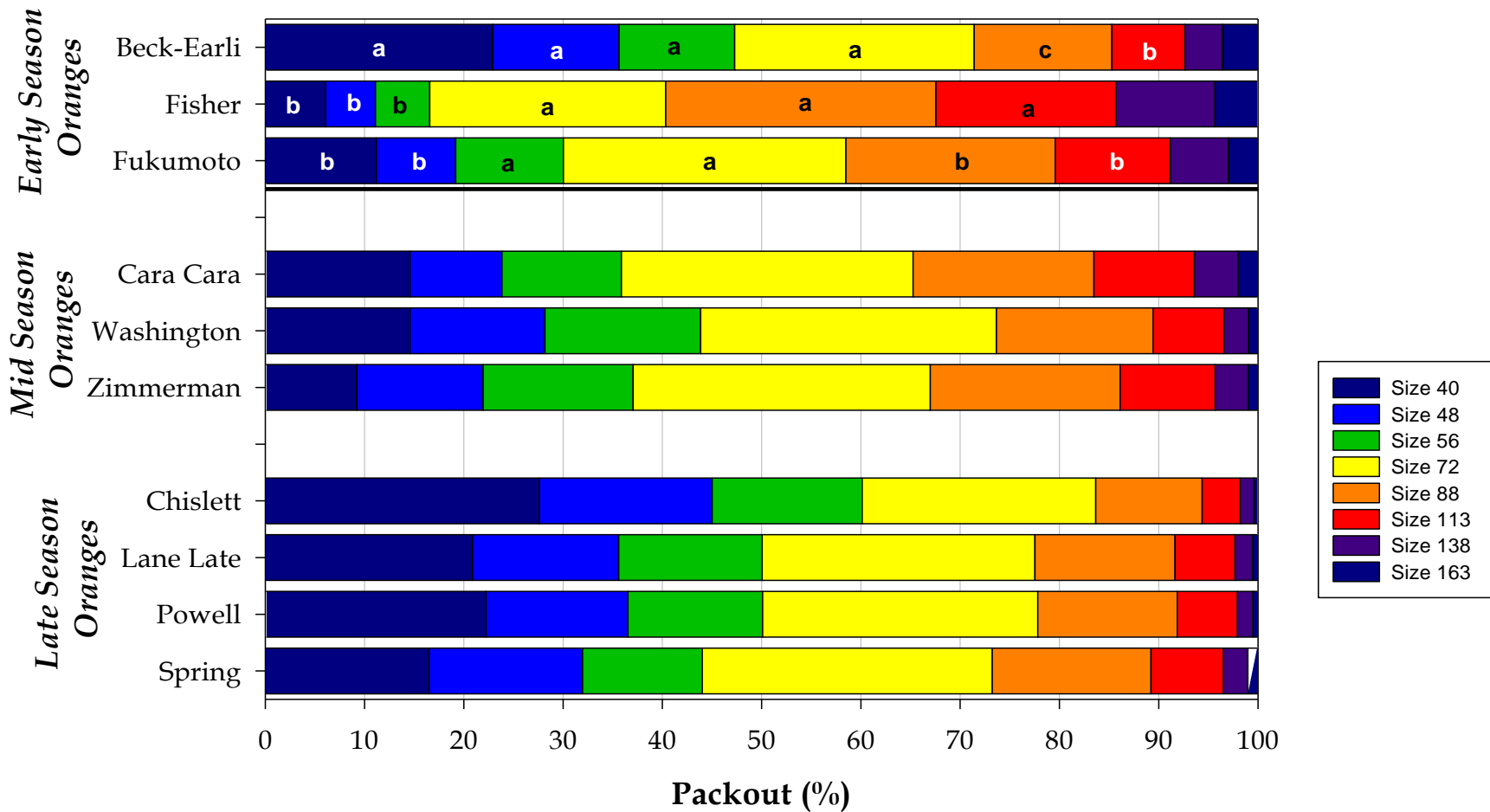


Figure 6. Packout of ten navel orange cultivars harvested in the 2004-05 season. Letters indicate significant differences between selections, for the same fruit size, at a 5% level.

Table 2. 2006-07 Fruit Quality of ten navel orange cultivars budded to Carrizo rootstock.

| Scion | Juice Content (%) | TSS (%) | Total Acids (%) | TSS:TA | Fruit Shape ^y | R/G ^x |
|------------|-------------------|---------|-----------------|-----------|--------------------------|------------------|
| Beck-Earli | 45.2 bc | 13.6 ab | 0.45 ab | 31.81 abc | 0.89 b | 1.24 b |
| Fisher | 58.8 a | 12.5 b | 0.44 ab | 28.72 bc | 0.94 a | 1.08 c |
| Fukumoto | 43.5 bc | 12.9 ab | 0.53 a | 24.83 c | 0.93 a | 1.34 a |
| ----- | | | | | | |
| Cara Cara | 48.1 bc | 13.8 ab | 0.53 a | 27.13 bc | 0.94 a | 2.03 b |
| Washington | 50.0 bc | 13.0 ab | 0.40 b | 32.94 abc | 0.93 a | 1.55 c |
| Zimmerman | 43.1 c | 14.4 a | 0.44 ab | 34.23 abc | 0.92 a | 2.16 a |
| ----- | | | | | | |
| Chislett | 49.2 bc | 14.5 a | 0.41 b | 38.40 ab | 0.93 a | 1.76 b |
| Lane Late | 47.5 bc | 14.2 a | 0.44 ab | 28.45 bc | 0.94 a | 1.75 b |
| Powell | 52.2 ab | 12.1 b | 0.43 ab | 33.02 abc | 0.94 a | 1.75 b |
| Spring | 47.2 bc | 13.0 ab | 0.41 b | 42.01 a | 0.94 a | 2.19 a |

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

^y A value of 1.00 signifies a completely round fruit.

^x Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.