

# Cultivar Selection Trials of Navel Orange in Arizona for 2004-05<sup>1</sup>

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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 improved yields in 2004-05. 'Fisher' navel continues to have the greatest yield, but is quite granulated. 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', 'Chislett' 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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<sup>1</sup> The author wishes to acknowledge the assistance of Mr. Phillip Tilt, Mr. Marco Peña, Mr. Arturo Moreno, Mr. James Truman, and Mr. Enrique Madrigal in the data collection of this experiment, Also, the assistance of Mr. Russ Tanita of First Choice Farms is appreciated. The author wishes to thank the Arizona Citrus Research Council for supporting this research. This is a partial final report for project 2004-08 – Citrus rootstock and cultivar breeding and evaluation for the Arizona citrus industry – 2004.

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 2, 2004 through January 20, 2005. Trees are strip-picked for the harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. For 2004-05, 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 shape and color between the selections. Ten fruit were harvested on 11-02 from each tree as a sample from each tree for juice quality analysis. Granulation values are determined by visual inspection of fruit cut longitudinally, and a fruit considered granulated is one in which more than 20% of the flesh is granulated.

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 scion-rootstock combinations possible. Early variety fruit was harvested on 12/14/04. This includes 'Beck-Earli', 'Fisher' and 'Fukumoto'. Mid-season fruit was harvested on 1/14/05. This includes 'Cara Cara', 'Washington' and 'Zimmerman'. All other selections ('Chislett', 'Lane Late', 'Powell', and 'Spring') were harvested on 2/2/2005. 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. Ten fruit were harvested as a sample from each tree for juice quality analysis. Granulation values are determined by visual inspection of fruit cut longitudinally, and a fruit considered granulated is one in which more than 20% of the flesh is granulated.

All data was analyzed using SPSS 7.0 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 2004-05 was no exception, and the promise of higher yields that appeared in 2003-04 was not repeated. Fruit size for this season was large, compared to the other selections, peaking on size 36. Percent juice was comparable to all the other selections, as was total soluble solids and peel thickness. Granulation was somewhat low. Fruit shape is rather oblong, compared to the others, and color was superior.

Fisher: Yields of 'Fisher' have been equal to or higher than the other selections tested in this trial, and 2004-05 was no exception. Fruit size for this season is comparable to the other selections, except 'Atwood' and 'Washington', peaking on sizes 72 and 88. Percent juice is rather low, and granulation was unacceptably high. An earlier harvest might have avoided this problem. Total soluble solids were one of the highest of all the selections tested. Peel thickness was average. Fruit shape was rather oblong, compared to the other selections tested. Color was comparable to the other tested selections.

Lane Late: Yields of 'Lane Late' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2004-05 was no exception. Fruit size for this season was small compared to the other selections, peaking on sizes 56, 72 and 88. Percent juice is higher than all the other selections. Total soluble solids were lower than the other selections tested. Peel thickness was thin, and granulation was low. Fruit shape is round, and color was not as good as the other selections under trial. Because of its greenness and lack of granulation, this selection might be harvested later in the season.

Tule Gold: Yields of 'Tule Gold' have typically been lower than the other selections under test, although after 10 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. Fruit size was a little smaller than the other selections, peaking on size 72, 88 and 113. Juice content and peel thickness was similar to the other selections tested, but TSS was the highest of all the selections tested. Granulation was low, and the fruit was round. Color was surprisingly green in 2004-05.

Washington: Yields of 'Washington' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2004-05 was no exception. Fruit size for 2003-04 was larger than most of the other selections, except 'Atwood', peaking on sizes 36 through 56. Juice percentage was low, perhaps due to the higher level of granulation. Peel thickness was greater than the other selections. Total soluble solids were similar to the others, and fruit was round. Fruit color was good.

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

*Selections harvested on 12-14-04*

Beck-Earli: The 2004-05 yield for 'Beck-Earli' greatly increased in relation to the 2002-03 and 2003-04 season yields, increasing to over twice the 65 lbs. per tree of the previous year. For the first year, we can see the precocity reported in other publications. Still, yield only was 80% of that of 'Fisher'. Fruit size, however, was the largest of all the early selections tested. 'Beck-Earli' peaked on size 36 and 56, but had

appreciable numbers of fruit size 40 and 48, and had significantly more of size 36 fruit, and significantly less of size 56 fruit, than the two other selections harvested on this date. Percent juice was low, but total soluble solids and pH was highest. Fruit peel was the thickest and 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-December.

Fisher: Yields of 'Fisher' were the highest for any of the selections tested in this trial, at about 175 lbs. per tree. It is instructive to note that when comparing the 2 trials, 4th-year yields of 'Fisher' at Waddell were about 75% more than the 4th-year yields of 'Fisher' in Yuma, and 3<sup>rd</sup> year Waddell yields were only surpassed by the 2004-05 yields in Yuma. For these early-maturing navels, fruit size was smaller than 'Beck-Earli' and 'Fukumoto', peaking on size 56. Fruit quality measurements suggest that percent juice and pH of 'Fisher' are similar to 'Fukumoto', but solids were not different than the other three selections tested. Peels of 'Fisher' were the thinnest of all the early selections tested, and unlike the previous year, this selection had no granulation (compare the Yuma trial). 'Fisher' also had the roundest fruit, but had the least coloration of all the early-picked selections.

Fukumoto: 'Fukumoto' yields increased to about 120 lbs. per tree, about 50% more than the previous year, but only about 68% 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 56. There were fewer 'Fukumoto' fruit of size 36, 40 and 48 than 'Beck-Earli' fruit in the same categories. Fruit quality measurements suggest that percent juice was higher and pH and peel thickness was lower than that of 'Beck-Earli', and higher than that of 'Fisher'. Total soluble solids, was similar to the other selections tested. 'Fukumoto' had no granulation, but had a good round shape and the most coloration of all the early-picked selections.

#### *Selections harvested on 1-14-05*

Cara Cara: Cara Cara yields for the three years of this study have neither been exceptionally high nor low, and stayed at about 90 lb. per tree for 2004-05. Fruit size of this selection was the smallest of the three selections harvested at this date, peaking on size 56. This selection had the fewest fruit of sizes 36, of all the selections tested. Fruit quality for 'Cara Cara' was similar to most of the other selections, except this selection had the exterior color.

Washington: 'Washington' did not distinguish itself from the other selections, having a yield of about 100 lbs. per tree. Fruit size was smaller than 'Zimmerman', and slightly larger than 'Cara Cara', peaking on size 56. Fruit quality of 'Washington' was neither higher nor lower than the other selections tested, except that it had slightly greener fruit.

Zimmerman: 'Zimmerman' had drastically lower yield compared to the other mid-season navel selections, just under 60 lbs. per tree, about 40% less than 'Washington', and 25% less than its own output for the 2003-04 season. Perhaps as a consequence, fruit size was larger than any of the other selections tested. Fruit size peaked on sizes 36. Fruit quality of 'Zimmerman' was similar to the 'Cara Cara' and 'Washington'.

#### *Selections harvested on 2-2-05*

Chislett: For 2004-05, 'Chislett' yields, about 110 lbs. per tree, were second only to 'Lane Late' among the late-harvested orange selections. This yield is about the same as the 2003-04 season yield, but a marked improvement over the 2002-03 season when yields for this selection were clustered with several others at about 40 lbs. per tree. If the yields for this selection would have increased, compared to the 2003-04 season, we would have suggested it as a candidate for large-scale planting, but that determination will have to wait for another year. Fruit size for 'Chislett' was the largest for all the selections harvested late, peaking on size 40 and 48. 'Chislett' had the lowest juice content, and the highest pH and peel thickness of the four selections harvested on this date. Fruit had acceptable solids and was round, but the exterior coloration was rather green.

Lane Late: Yields of 'Lane Late' were the greatest of any of the late-harvested cultivars, at about 133 lbs. per tree, about 20% higher than the 'Chislett'. Fruit size peaked on sizes 40 and 48. Most fruit quality parameters were similar to other selections harvested late.

Powell: Yields for 'Powell' for 2004-05 were similar to those of 2003-04, with yields of just less than 100 lbs. per tree, placing it in the middle of the selections. Fruit size was similar to 'Lane Late' peaking on size 40 and 48. 'Powell' had the most juice of any of the navel orange selections, a rather low pH, and no granulation. This suggests that granulation may not be a problem if the fruit is harvested late. Yields must improve before this cultivar can be recommended for the desert.

Spring: 'Spring' navel orange yields, at about 100 lbs. fruit per tree, were similar to those of 'Powell'. Fruit size was just smaller than that of 'Powell', peaking on size 40 and size 48. Quality of 'Spring' fruit was similar to the other 3 selections harvested late, but fruit coloration was the highest of all the selections under test.

## 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 tremendous granulation 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, but it will be interesting to see if the fruit grade problem persists.

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 granulation (yet much less than in Yuma). 'Beck-Earli' is improving its yields, and may be worth further notice. 'Lane 'Late' and 'Chislett' bear watching as this experiment continues.

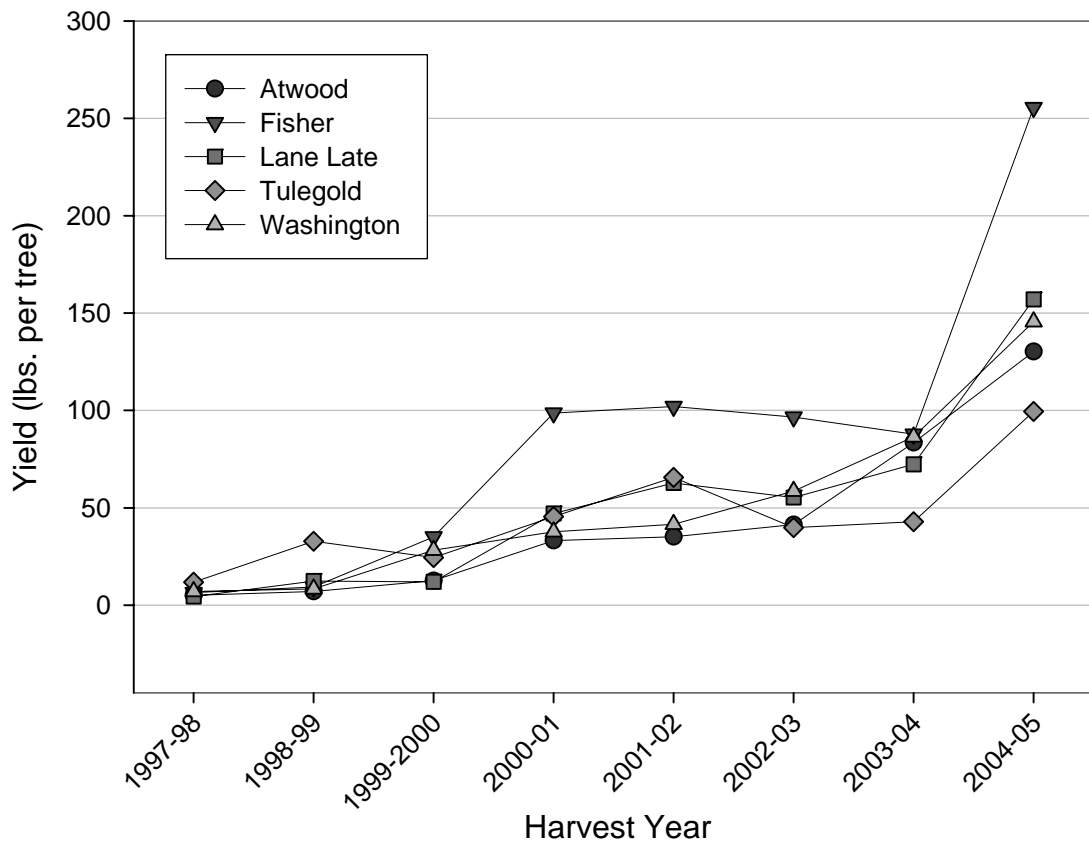


Figure 1. 1997-98 through 2004-05 yields of five navel orange cultivars budded to Carrizo rootstock.

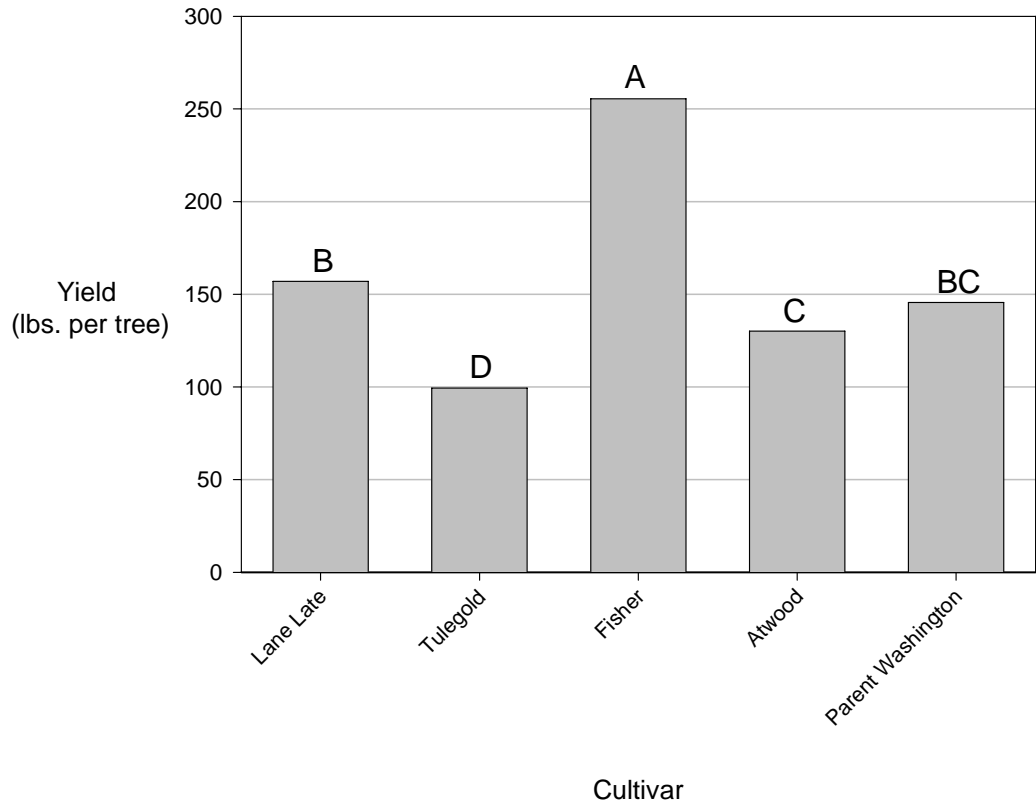


Figure 2. 2004-05 yield of five navel orange cultivars. Letters indicate significant differences between selections, at a 5% level.

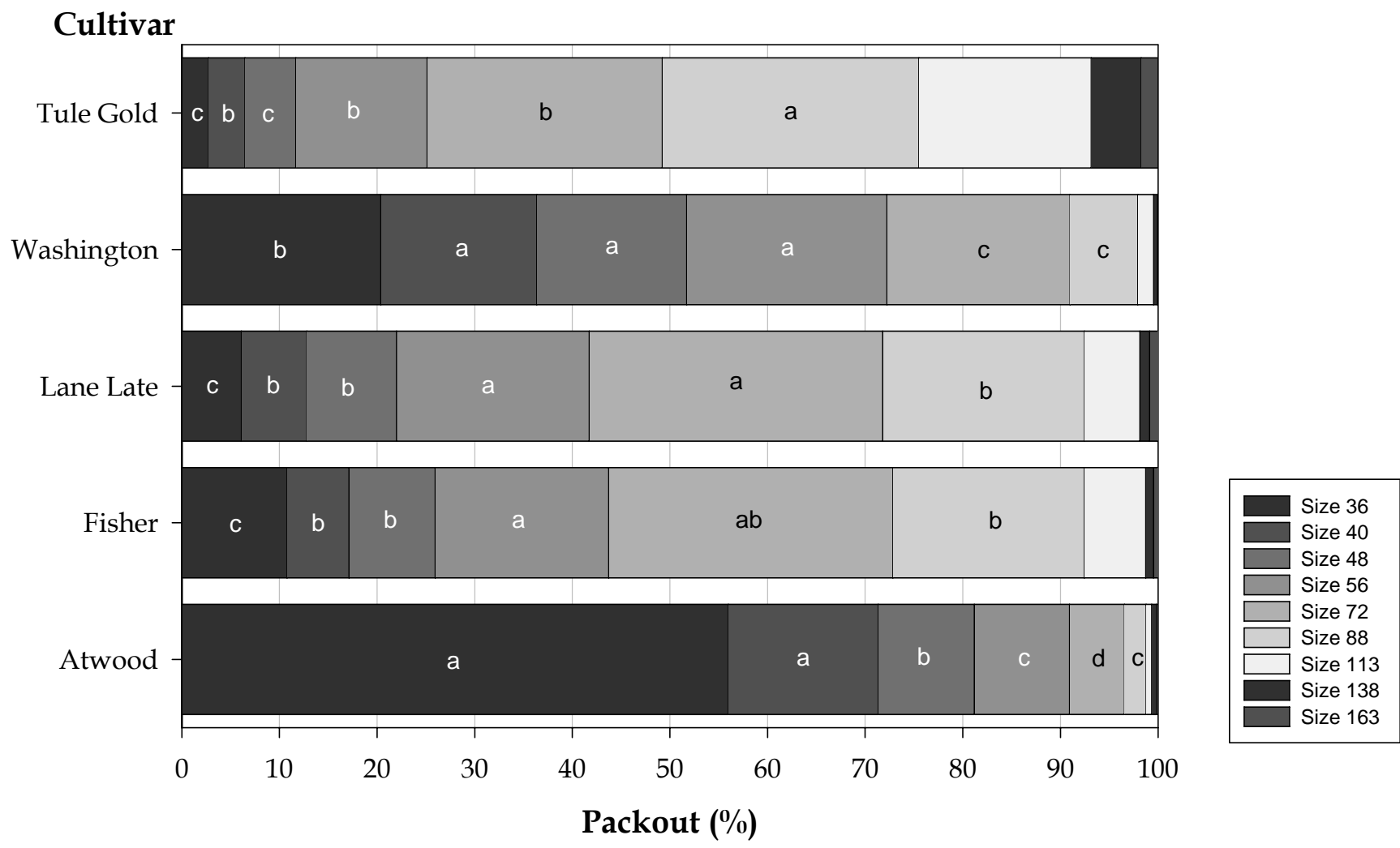


Figure 3. 2004-05 packout of five navel orange cultivars. Letters indicate significant differences between selections, for the same fruit size, at a 5% level.



Table 1. 2004-05 Fruit Quality of five navel orange cultivars budded to Carrizo rootstock. All fruit was sampled on 11-2-05

Scion	Juice Content (%)	TSS (%)	Peel Thickness (mm)	Granulation <sup>y</sup> (%)	Fruit Shape <sup>x</sup>	R/G <sup>w</sup>
Atwood	33.7 ab	10.9 ab	5.72 b	7.5 b	0.81 b	2.40 a
Fisher	30.4 bc	11.1 ab	5.71 b	19.2 ab	0.81 b	1.92 b
Lane Late	35.9 a	10.2 c	5.60 b	5.0 b	0.87 a	1.79 c
Tule Gold	31.8 b	11.3 a	5.62 b	6.7 b	0.87 a	1.60 d
Washington	27.5 c	10.7 bc	6.62 a	23.3 a	0.89 a	2.42 a

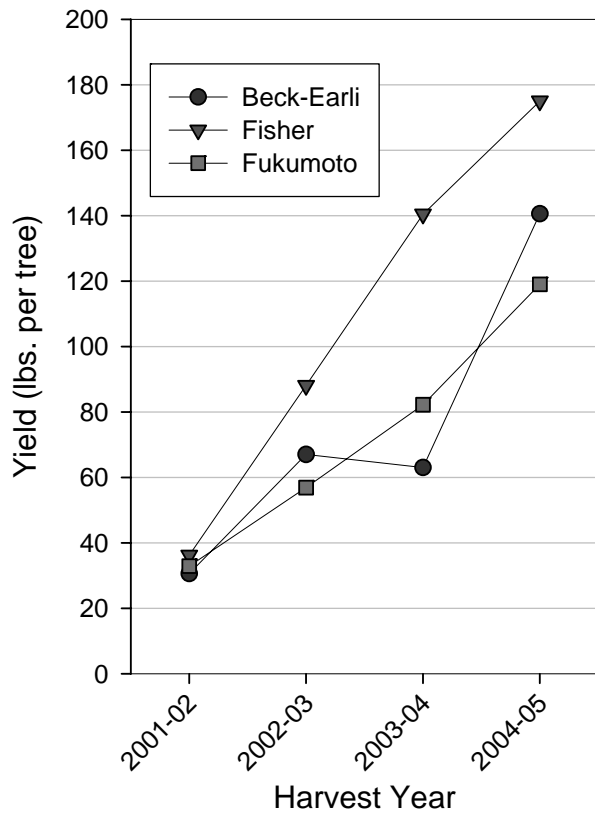
<sup>z</sup> Means separation in columns by Duncan's Multiple Range Test, 5% level.

<sup>y</sup> Granulation values are taken from 10 fruit per tree. Values represent the percentage of fruit in the entire fruit sample with more than 20% granulation.

<sup>x</sup> A value of 1.00 signifies a completely round fruit.

<sup>w</sup> 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

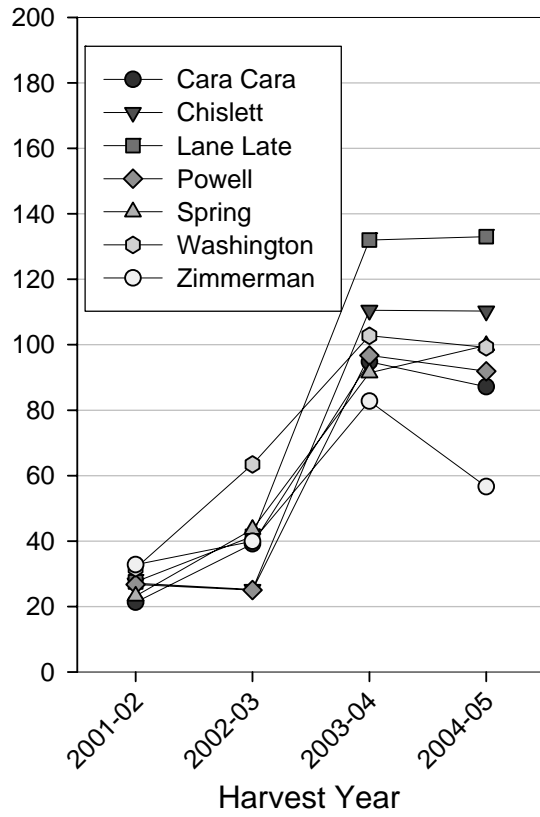


Figure 4. 2001-02 through 2004-05 yields of ten navel orange cultivars budded to Carrizo rootstock.

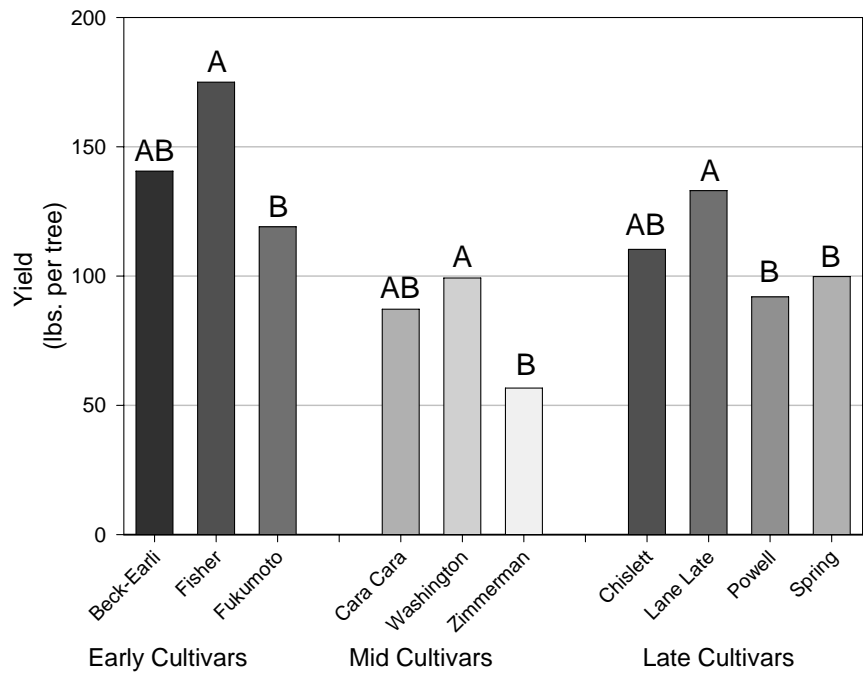


Figure 5. 2004-05 yield of ten navel orange cultivars budded to Carrizo rootstock. Letters indicate significant differences between selections, for the same harvest date, at a 5% level.

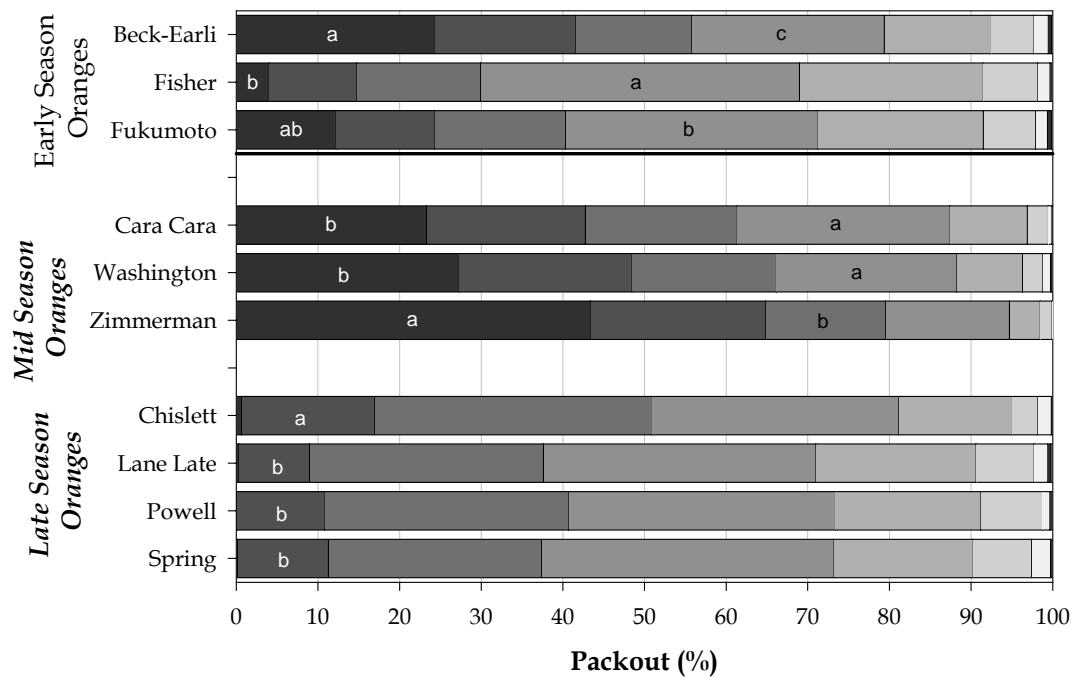


Figure 6. Packout of ten navel orange cultivars harvested in the 2004-05 season. Letters indicate significant differences between selections harvested on the same date, for the same fruit size, at a 5% level.

Table 2. 2004-05 Fruit Quality of ten navel orange cultivars budded to Carrizo rootstock.

Scion	Juice Content (%)	pH	TSS (%)	Peel Thickness (mm)	Granulation <sup>y</sup> (%)	Fruit Shape <sup>x</sup>	R/G <sup>w</sup>
Beck-Earli	35.6 b	4.30 a	13.15 a	5.73 a	0.0 a	0.81 b	1.97 b
Fisher	40.0 a	4.18 b	12.83 a	4.69 b	0.0 a	0.84 a	1.86 c
Fukumoto	41.0 a	4.18 b	13.03 a	5.22 ab	0.0 a	0.84 a	2.11 a
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Cara Cara	36.7 a	4.16 a	12.55 a	5.82 a	1.00 a	0.90 a	2.26 a
Washington	37.0 a	4.24 a	11.90 a	5.75 a	0.00 a	0.90 a	2.19 b
Zimmerman	35.3 a	4.25 a	12.08 a	6.07 a	8.33 a	0.89 a	2.24 ab
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Chislett	36.2 b	4.29 a	12.32 a	6.04 a	4.00 a	0.85 a	1.93 c
Lane Late	44.2 a	4.18 b	11.89 a	5.50 ab	0.00 a	0.84 a	2.08 b
Powell	44.9 a	4.18 b	11.98 a	5.24 b	0.00 a	0.85 a	1.93 c
Spring	42.3 ab	4.24 ab	12.48 a	6.08 a	0.00 a	0.85 a	2.49 a

<sup>z</sup> Means separation in columns by Duncan's Multiple Range Test, 5% level.

<sup>y</sup> Granulation values are taken from 10 fruit per tree. Values represent the percentage of fruit in the entire fruit sample with more than 20% granulation.

<sup>x</sup> A value of 1.00 signifies a completely round fruit.

<sup>w</sup> Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.