

Cultivar Selection Trials of Navel Orange in Arizona for 2007-08¹

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Abstract

A navel orange trial was established in Arizona, at the Citrus Agriculture Center, Waddell, AZ. After seven years, the data suggest that 'Fisher', 'Washington' 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'. However, 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 orange 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. Navels are often subject to yield losses in the late spring, when high temperatures lead to fruitlet drop. This drop may be one reason why yields for navels in Arizona are consistently less than yields in comparatively cooler areas of California. Some navel growers in Arizona are considering removing the trees because of this low yield.

'Washington' ('Parent Washington'), has been the most commonly planted navel in Arizona for many years, but there are many newer selections available. These selections are both earlier maturing and later maturing than 'Washington', but have not been tested in the state.

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, a new navel orange cultivar selection trial was established at the Citrus Agriculture Center in Waddell, AZ, just west of Phoenix.

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Materials and Methods

This trial was established in March 1999 in Field 19 of the Citrus Agricultural Center, near Waddell, Arizona. This trial contains ten trees of each of 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-flesh 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 to the United States in the 1800’s. 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 single-tree blocks of each of the ten selections. Maturity was late in 2007, so early-maturing selections were harvested on 12-17-07. This includes ‘Beck-Earli’, ‘Fisher’, and Fukumoto. Mid-season selections, ‘Washington’, ‘Cara Cara’ and ‘Zimmerman’ were harvested on 1-4-08. Late-season selections ‘Chislett’, ‘Lane Late’, ‘Powell’, and ‘Spring’) were harvested on 1/25/2008. 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 (Aweta-Autoline, Inc., Reedley, CA), which provides fruit weight, fruit diameter, peel color, exterior peel blemish (fruit grade, expressed as fancy, choice and juice grade) for each fruit. Fruit packout data is reported as the percentage of fruit of the size that corresponds to 40, 48, 56, 72, 88, 113, 138 and 163 fruit per standard 38 lb. carton. Fruit grade data is reported as the percentage of fruit in the three grade categories which correspond to 90 to 100% blemish free (fancy), 80 to 89% blemish free (choice), and less than 80% blemish free (juice). Fruit juice quality parameter data for all the selections was collected on their respective harvest dates, and ten fruit were harvested as a sample from each tree for juice quality analysis, for a total of 100 fruit per selection. Juice quality parameters measured included fruit juice percentage, juice pH, total acids (TA), total soluble solids (TSS), and TSS:TA ratio Peel thickness was measured on each of those 10 fruit using a digital caliper.

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

Results and Discussion

Early-maturing selections harvested on 12-17-07

Beck-Earli: Yields of ‘Beck’ were greater than they have ever been in this trial, at about 157 lbs. per tree (Fig. 1). This yield was significantly less than ‘Fisher’, and statistically the same as ‘Fukumoto’. Yield of ‘Beck’ for 2007-08 was about 72% of that of ‘Fisher’. This level of yield also keeps this cultivar in the position as the second-highest yielding early maturing cultivar; a position it has held every year since the 2001-02 season, except for the 2003-04 season (Fig. 2). ‘Beck’ generally had larger fruit than ‘Fukumoto’ (Fig. 3), and peaked on size 72. Juice content, juice pH, TSS, TA, and TSS:TA were similar to the other early-maturing selections (Table 1), but fruit of this selection was significantly more oblong than either

'Fisher' or 'Fukumoto', but was more colored than 'Fisher'. Peels of 'Beck' were thicker than those of 'Fukumoto'.

Fisher: Yields of 'Fisher' were the highest for any of the selections tested in this trial, at about 219 lbs. per tree (Fig. 1). This level of yield was significantly higher than either of the other two selections harvested on this date, and maintains 'Fisher' as the most consistently high yielding selection for the duration of the trial, a position it has held since 2002-03 (Fig. 2). This season's yield represents the greatest production for this selection since the inception of the trial; surpassing the yield of 175 lbs. per tree that occurred in 2004=05. Fruit of 'Fisher' peaked on size 72, and was not larger than 'Beck', but was larger than 'Fukumoto' (Fig. 3). Like 'Beck', juice content, juice pH, TA, TS and TS:TA were not different than the other early-maturing selections (Table 1). Fruit shape was more round than 'Beck', and the peel thickness was thinner than 'Beck', but the fruit colored the least of all the selections tested in this experiment. 'Fisher' had the greatest percentage of fancy grade fruit, and the least choice and juice grade fruit. (Table 2).

Fukumoto: 'Fukumoto' trees produced 134 lbs. of fruit per tree, about 60% of the yield of 'Fisher', a significant reduction (Fig. 1). Of the three early selections, 'Fukumoto' consistently has the least yield, a position it has held every season except for 2003-04 (Fig. 2). Nonetheless, this season's production represents the greatest yield for this selection since the initiation of the experiment, surpassing the 119 lb. per tree yield of the 2004-05 season. 'Fukumoto' fruit was the smallest of the three early-maturing selections (Fig. 3), having significantly less fruit of size 48 and 56 and significantly more fruit of size 88 compared with 'Beck', yet still peaking on sizes 72 and 88. Juice quality parameters were similar to those of 'Beck' and 'Fisher' (Table 1), the fruit was round, color was more orange than 'Beck; and the peel thickness was significantly thinner than the other two early selections. Exterior fruit quality was intermediate (Table 2), having more fancy grade and less choice and juice grade fruit than 'Beck', and having less fancy and choice and juice grade fruit than 'Fisher'.

Mid-season selections harvested on 1-04-08

Cara Cara: Of the mid-season selections, the 129 lb. per tree yield of 'Cara Cara' is intermediate, being greater than that of 'Zimmerman' while less than that of 'Washington', and not significantly different than either (Fig. 1). Considering all of the mid- and late-season selections, yields of 'Cara Cara' have been in the "middle of the pack" (Fig. 2), yet this season's production is the greatest for this selection since the beginning of the experiment. The 129 lb production for this selection caps a slow but steady increase in yield that is over three times the first season yield in 2001-02. There were no significant differences in packout between the three mid-season selections, and 'Cara Cara' peaked on size 72 (Fig. 3). Juice content, juice pH and TSS of 'Cara Cara' were not significantly different than the other mid-season cultivars (Table 1), but the selection did have a greater TA level than did 'Zimmerman', but this did not lead to a lower TSS:TA ratio, due to a greater TSS level. Fruit shape was almost round, and the peel color was significantly less green but significantly thicker than 'Zimmerman'. 'Cara Cara' had significantly less fruit of the fancy grade; and significantly more fruit of the choice and juice grade than the other mid-season cultivars tested (Table 2).

Washington: 'Washington' continued to distinguish itself from the other mid-season selections, having a yield of about 179 lbs. per tree (Fig. 1), the second greatest yield in the entire trial; and a quantity that was significantly greater than the yield of 'Zimmerman', but not significantly greater than that of 'Cara Cara'. This yield represents about 82% of the yield of 'Fisher'. 2007-08 is the third season in a row that 'Washington' had the greatest yield of the mid-season selections (Fig. 2), and it is also the harvest season that this selection produced its greatest yield, about a 17% increase over the 147 lbs per tree recorded for 2005-06. 'Washington' navel fruit peaked on size 72 (Fig. 3). Most juice quality parameters were not different than the other two mid-season selections analyzed, except for TSS:TA for 'Washington' that was significantly lower than that of 'Zimmerman' and 'Cara Cara', and was the least for all ten selections tested in this experiment. Fruit was almost round with a good color, but with a significantly thicker peel than 'Zimmerman; fruit.

Zimmerman: 'Zimmerman' had the least yields of all the mid-season navel selections, at about 100 lbs. per tree, about 44% less than the yield of 'Washington', and about 23% less than that of 'Cara Cara' (Fig. 1). Furthermore, 'Zimmerman' is typically one of the lower-yielding selections under test (Fig. 2). Nonetheless, this quantity was about 17% more than its previous maximum production of 83 lbs. per tree

recorded for the 2003-04 season. Fruit size was similar to the other mid-season selections tested, peaking on size 72 (Fig. 3). Juice content was low but solids level was high and exterior color was good. Juice quality parameters for 'Zimmerman' were similar to the other mid-season selections, except that TA was significantly lower than that of 'Washington', leading to a greater TSS:TA ratio (Table 1). Fruit was round, but significantly more green than either 'Washington' or 'Cara Cara'. Exterior quality was the best for the three mid-season selections, with significantly more fancy fruit and significantly less choice and juice fruit than the other two selections tested.

Late-season selections harvested on 1-25-08

Chislett: For 2007-08, 'Chislett' yield, about 101 lbs. per tree, was significantly less than that of 'Lane Late' but equal to 'Powell' and to 'Spring' (Fig. 1). 'Chislett' yields have fallen every year since the 2003-04 harvest season, when they peaked at 110 pounds per tree. Over the last four years yields have dropped by about 10% (Fig. 2). Fruit of this selection was quite large, peaking on size 40, similar to 'Powell', and significantly larger than 'Lane Late' and 'Spring' (Fig. 3). For 2007-08, there were no differences in juice quality parameters among the four late-harvested selections tested, but 'Chislett' trees had fruit of intermediate shape, but were significantly greener than the other three late-maturing selections tested (Table 2). Fruit of 'Chislett' had neither the best nor the worst external quality (Table 2).

Lane Late: Yields of 'Lane Late' were about 12% below that of 'Washington' and 24% less than that of 'Fisher', but were the greatest of all the late-maturing selections, at about 166 lbs. per tree. This amount was significantly greater than any of the other three late-maturing selections tested (Fig. 1). 'Lane Late' has had the greatest yield of the late-maturing selections since the 2003-04 season (Fig. 2). This selection had rather small fruit, peaking on size 72, when compared to the other three (Fig. 3), and had significantly more fruit of sizes 72, 88 and 113, and less of size 40 than 'Chislett'. Fruit was also less colored than 'Spring', but more so than 'Chislett' (Table 1), and had the greatest exterior quality among the four late-maturing selections (Table 2).

Powell: Yields for 'Powell' for 2007-08 of 94 lbs. per tree were about 10% more than those of 2006-07, with yields of about 85 lbs. per tree (Fig. 1), but still significantly less than that of 'Lane Late'. Since 2003-04, yields of this selection have remained at 100 lbs. of fruit per tree or less (Fig. 2). Similar to 'Chislett', fruit of 'Powell' was quite large, peaking on size 40 (Fig. 3), and was much larger than that of 'Lane Late' and 'Spring'. There was nothing noteworthy about the interior juice quality of 'Powell', but the fruit was significantly less colored than that of 'Spring' (Table 1). 'Powell' fruit had exterior quality typical of the other late-maturing selections tested (Table 2).

Spring: 'Spring' navel orange yields, at about 92 lbs. fruit per tree, were slightly lower than the 98 lbs. recorded last year, and significantly less than that of 'Lane Late' (Fig. 1). Like 'Chislett' and 'Powell', yields of 'Spring' have remained at about or just less than 100 lbs. per tree since the 2003-04 season (Fig. 2) Fruit size peaked on size 72 (Fig. 3). Juice quality and fruit shape of 'Spring' fruit was typical of the other late selections tested. Like last year, fruit coloration was the highest of all the selections under test (Table 3). Exterior fruit blemishes were a little higher than the other late-maturing fruit tested (Table 2).

Conclusions

We can continue to draw some conclusions; yet a few 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. 'Beck-Earli' does not appear to be improving its yields, and may not be worth further notice. 'Washington' and 'Lane Late' continue to outperform the other mid-season and late-maturing selections, respectively.

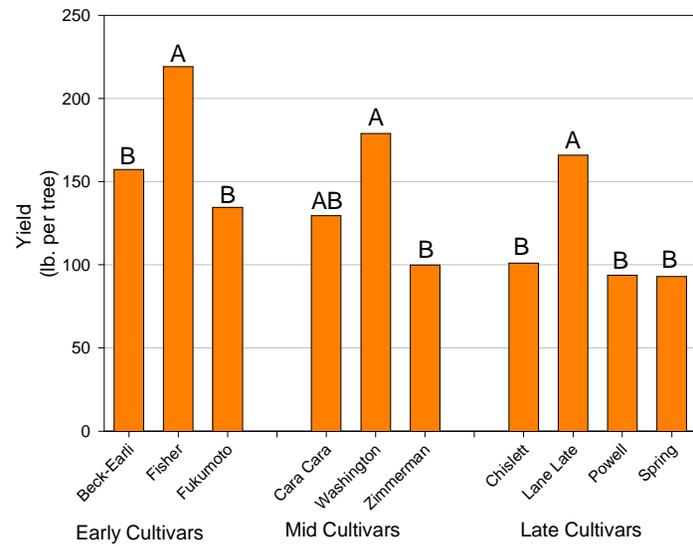


Figure 1. 2007-08 yield of ten navel orange cultivars budded to Carrizo rootstock. Letters indicate significant differences between selections, within the same group, at a 5% level.

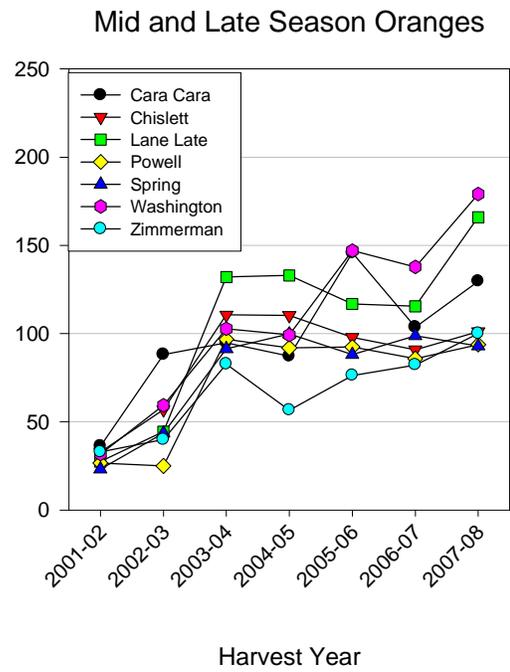
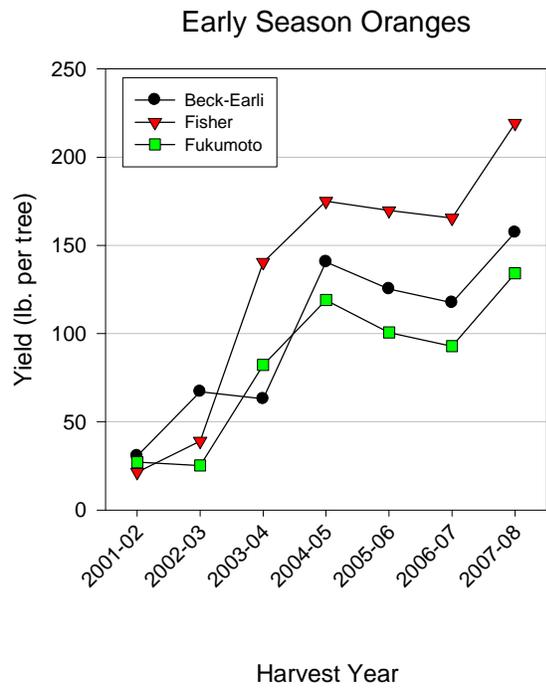


Figure 2. 2001-02 through 2007-08 yields of ten navel orange cultivars budded to Carrizo rootstock.

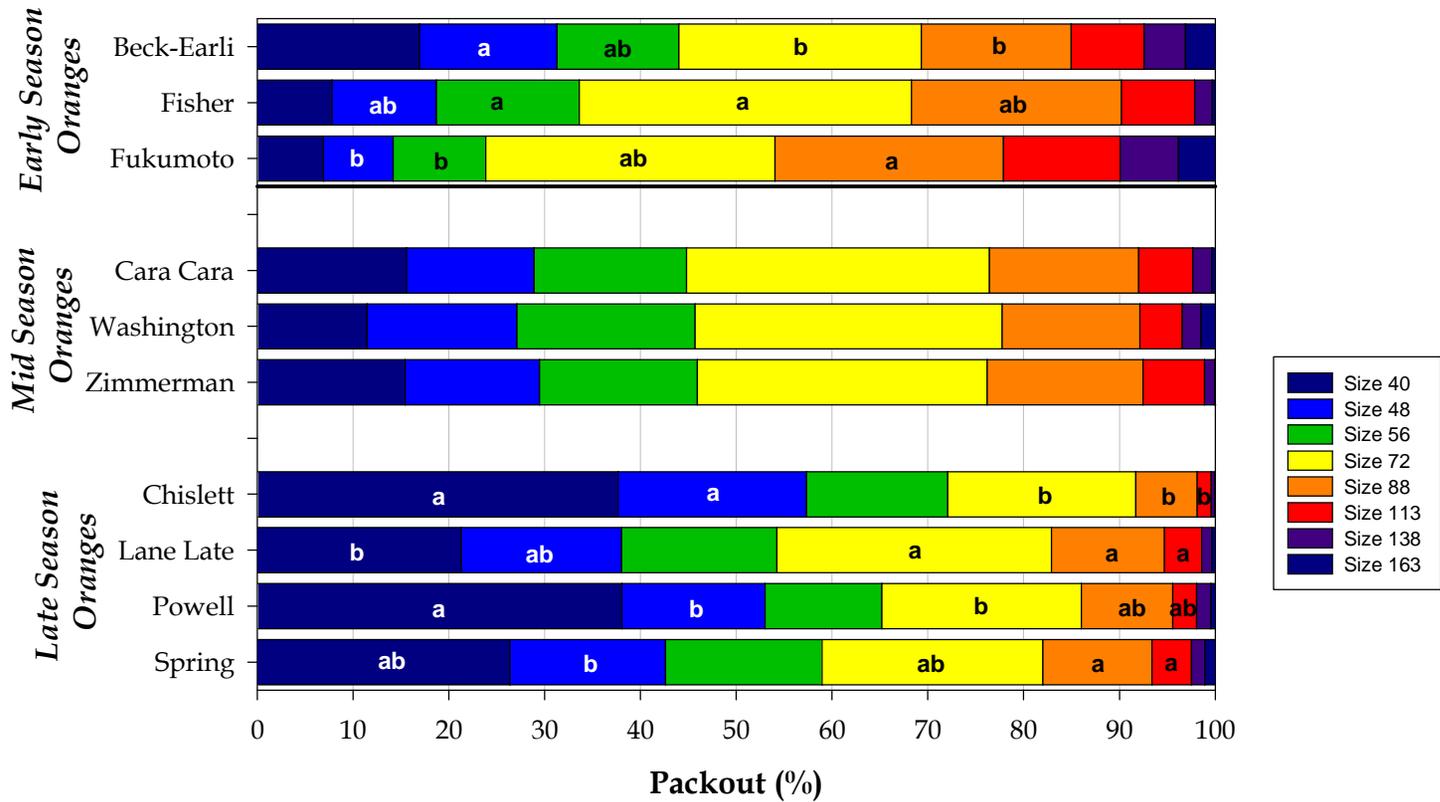


Figure 3. Packout of ten navel orange selections harvested in the 2007-08 season. Letters indicate significant differences between selections, for the same fruit groupings, at a 5% level.

Table 1. 2007-08 fruit quality of ten navel orange cultivars budded to Carrizo rootstock.

Selection	Juice Content (%)	Juice pH	TSS (%)	Total Acids (%)	TSS:TA	Fruit Shape ^y	R/G ^x	Peel Thickness (mm)
Beck-Earli	38.76	3.82	14.25	0.45	31.39	0.88 b	1.83 a	5.25 a
Fisher	43.43	3.65	13.43	0.47	28.87	0.93 a	1.60 b	4.99 a
Fukumoto	42.31	3.65	14.44	0.48	30.21	0.93 a	1.83 a	4.26 b

Cara Cara	40.00	3.58	15.13	0.53 a	29.55 ab	0.94	1.99 a	4.98 a
Washington	45.24	3.63	12.91	0.50 ab	26.17 b	0.93	1.96 a	5.44 a
Zimmerman	38.58	3.68	14.45	0.45 b	32.65 a	0.93	1.60 b	3.97 b

Chislett	41.97	3.82	15.03	0.43	34.99	0.93 ab	1.77 c	5.03
Lane Late	42.65	3.79	14.38	0.47	31.35	0.93 ab	1.94 b	4.72
Powell	44.60	3.66	14.98	0.50	29.99	0.94 a	1.81 bc	4.70
Spring	40.45	3.81	14.69	0.47	31.71	0.92 b	2.31 a	4.70

^z Means separation in columns by Duncan's Multiple Range Test, 5% level. Lack of means separation indicates no significant difference.

^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.

Table 2. 2007-08 fruit grade of ten navel orange cultivars budded to Carrizo rootstock.

Selection	Fancy (%)	Choice (%)	Juice (%)
Beck-Earli	83.67 b	10.85 a	5.48 a
Fisher	93.79 a	5.27 b	0.94 b
Fukumoto	90.63 ab	7.20 ab	2.17 ab

Cara Cara	66.00 c	22.30 a	10.70 a
Washington	76.70 b	18.01 a	5.29 b
Zimmerman	87.12 a	11.21 b	1.67 b

Chislett	79.79 ab	14.17 ab	6.04
Lane Late	88.19 a	9.72 b	2.09
Powell	81.16 ab	12.25 ab	6.59
Spring	73.54 b	18.11 a	8.35

^z Means separation in columns by Duncan's Multiple Range Test, 5% level. Lack of means separation indicates no significant difference.