Cultivar Selection Trials of Navel Orange in Arizona for 2008-09[1]

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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 sweet 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 two 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 early in 2008, so early- and mid-maturing selections were harvested on 12-19-08. This includes 'Beck-Earli', 'Fisher', 'Fukumoto', 'Washington', 'Cara Cara' and 'Zimmerman'. Late-season selections 'Chislett', 'Lane Late', 'Powell', and 'Spring' were harvested on 1/14/2009. Yields are expressed as lbs. fruit per tree. Trees were strip-picked for the harvest. Harvested fruit for each tree is collected in plastic boxes and weighed. Each box weighed about 42 lbs. Eighty-five to 100 lbs of fruit from each tree were 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- and mid-maturing selections harvested on 12-19-08

<u>*Beck-Earli*</u>: Yields of 'Beck' were greater than they have ever been in this trial, at about 250 lbs. per tree (Fig. 1). This yield was still significantly less than 'Fisher', and statistically the same as 'Fukumoto'. Yield of 'Beck' for 2008-09 was about 74% 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' had larger fruit than 'Fisher', but about the same as '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 'Fisher' or 'Fukumoto'.

Fisher: Yields of 'Fisher' were the highest for any of the selections tested in this trial, at about 332 lbs. per tree (Fig. 1). This level of yield was significantly higher than either of the other 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 219 lbs. per tree that occurred in 2007-08. Fruit of 'Fisher' was small, peaking on size 88, and was not larger than 'Beck', or '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 least percentage of fancy grade fruit, and considerable choice and juice grade fruit. (Table 2).

Fukumoto: 'Fukumoto' trees produced 165 lbs. of fruit per tree, about 50% 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 126 lb. per tree yield of the 2007-08 season. 'Fukumoto' fruit was similar to 'Beck', peaking on sizes 72 and 88. Juice quality parameters were similar to those of 'Beck' and 'Fisher', the only difference being that juice pH of 'Fukumoto' was significantly greater than that of 'Beck' (Table 1). 'Fukumoto' fruit was round, similar to 'Fisher' and fruit color was more orange/red than 'Fisher'; and the peel thickness was 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' or 'Fisher'.

Cara Cara: Of the mid-season selections, the 211 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 211 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, and much greater than the 133 lbs recorded in 2007-08. There were no significant differences in packout between the three mid-season selections, and 'Cara Cara' peaked on sizes 72 and 88 (Fig. 3). Juice content, juice pH and TSS of 'Cara Cara' were not significantly different than 'Washington' (Table 1), but the selection did have a greater juice content and a lower TSS than did 'Zimmerman', but this did not lead to a lower TSS:TA ratio, due to a similar TA level. Fruit shape was almost round, and the peel color was significantly less green than 'Zimmerman'. Peel thickness was similar to both 'Washington' and 'Zimmerman'. 'Cara Cara' had similar levels of the fancy choice and juice grades compared to 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 245 lbs. per tree (Fig. 1), the second greatest yield in the entire trial; and a quantity that was greater than the yield of 'Zimmerman' and 'Cara Cara'. This yield is 37% greater than the yield from 2007-08 and represents about 74% of the yield of 'Fisher'. 2008-09 is the fourth season in a row that 'Washington' had the greatest yield of the mid-season selections (Fig. 2). 'Washington' navel fruit peaked on sizes 72 and 88 (Fig. 3). Most juice quality parameters were not different than the other two mid-season selections analyzed, except for juice content was significantly greater and TSS:TA was significantly less for 'Washington' as compared with 'Zimmerman'. Fruit was almost round with more color, but with a similarly thick peel compared to 'Cara Cara' and 'Zimmerman fruit.

Zimmerman: 'Zimmerman' had the least yields of all the mid-season navel selections, at about 191 lbs. per tree, about 12% less than the yield of 'Washington', and about 9% less than that of 'Cara Cara' (Fig. 1). Zimmerman' is typically one of the lower-yielding selections under test (Fig. 2), and this season was one of the few in which it was not the lowest. This quantity was about 91% more than its previous maximum production of 100 lbs. per tree recorded for the 2007-08 season. Fruit size was similar to the other mid-season selections tested, peaking on sizes 72 and 88 (Fig. 3). Juice content was low and TSS level was greater than the other mid-season oranges. The other juice quality parameters for 'Zimmerman' were

similar to the other mid-season selections (Table 1). Fruit was round, but significantly more green than either 'Washington' or 'Cara Cara'. Exterior quality was similar to the other two selections tested.

Late-season selections harvested on 1-14-09

Chislett: For 2007-08, 'Chislett' yield, about 150 lbs. per tree, was significantly less than that of 'Lane Late' but similar to 'Powell' and to 'Spring' (Fig 1.). 'Chislett' yields are the least for all the selections under test. Yields had fallen every year from the 2003-04 to 2007-08 harvest season, when they peaked at 110 pounds per tree, so this year's production represents the best ever for this selection and 36% more production than in 2003-04 (Fig. 2). Fruit of this selection was the largest of all the selections, peaking on size 72, significantly larger than 'Lane Late', 'Powell', 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 round shape, but were significantly greener than fruit of 'Spring' or 'Lane Late' (Table 1). Fruit of 'Chislett' had neither the best nor the worst external quality (Table 2).

Lane Late: Yields of 'Lane Late' were similar to that of 'Washington' and 29% less than that of 'Fisher', but were the greatest of all the late-maturing selections, at about 236 lbs. per tree (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 88, when compared to the other three (Fig. 3), and had significantly more fruit of sizes 88 and 113, and less of sizes 40, 48, 56 and 72 than 'Chislett'. Interior fruit quality parameters were similar to the other late-maturing selections, but fruit was also less colored than 'Spring', but more so than 'Chislett' and 'Powell' (Table 1), and similar exterior quality among the four late-maturing selections (Table 2).

Powell: Yields for 'Powell' for 2008-09 of 166 lbs. per tree were about 76% more than the 2006-07 yields of about 94 lbs. per tree (Figs. 1 and 2), but still significantly less than that of 'Lane Late', but not significantly less than 'Chislett' or 'Spring'. Fruit of 'Powell' was similar to that of 'Lane Late' and 'Spring', peaking on sizes 72 and 88 (Fig. 3), but was much smaller than the fruit of 'Chislett'. There was nothing noteworthy about the interior juice quality of 'Powell', but the fruit was significantly less colored than that of 'Spring' and 'Lane Late' (Table 1). 'Powell' fruit had exterior quality typical of the other late-maturing selections tested (Table 2).

Spring: 'Spring' navel orange yields, at about 199 lbs. fruit per tree, were more than twice that of the 92 lbs. recorded last year, and not significantly less than that of 'Lane Late' or more than 'Chislett' or 'Powell' (Fig. 1). After steadying at about 100 lbs of fruit per tree since the 2003-04 season, yields of 'Spring' more than doubled this year. (Fig. 2) Fruit size peaked on sizes 72 and 88(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

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. 'Cara Cara' is performing well enough to warrant recommendation as a suitable cultivar for the Arizona citrus industry.

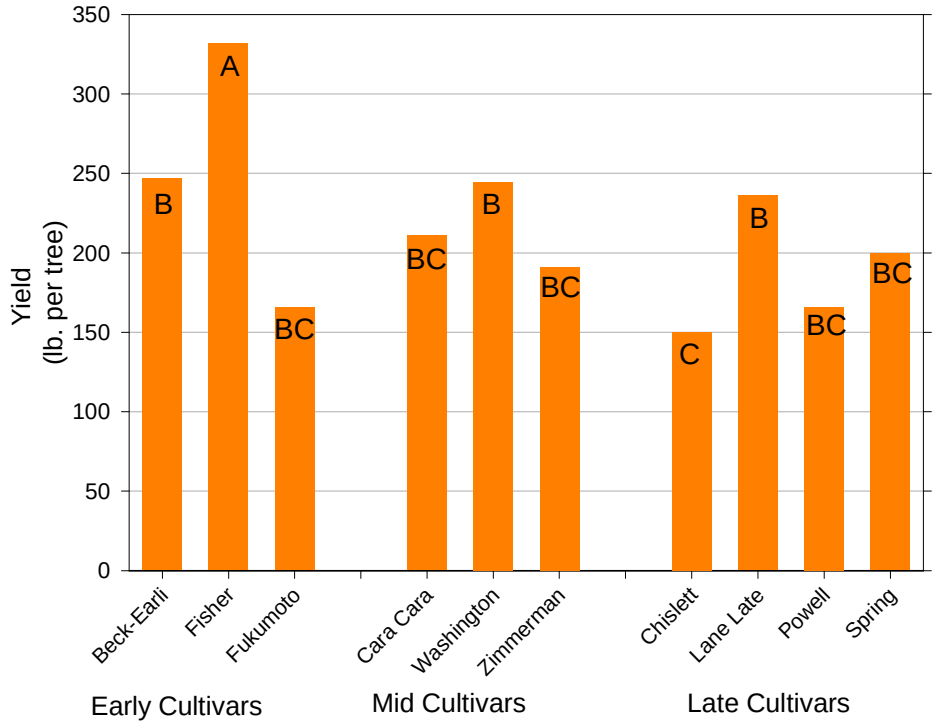

Figure 1. 2008-09 yield of ten navel orange cultivars budded to Carrizo rootstock. Letters indicate significant differences between selections at a 5% level.

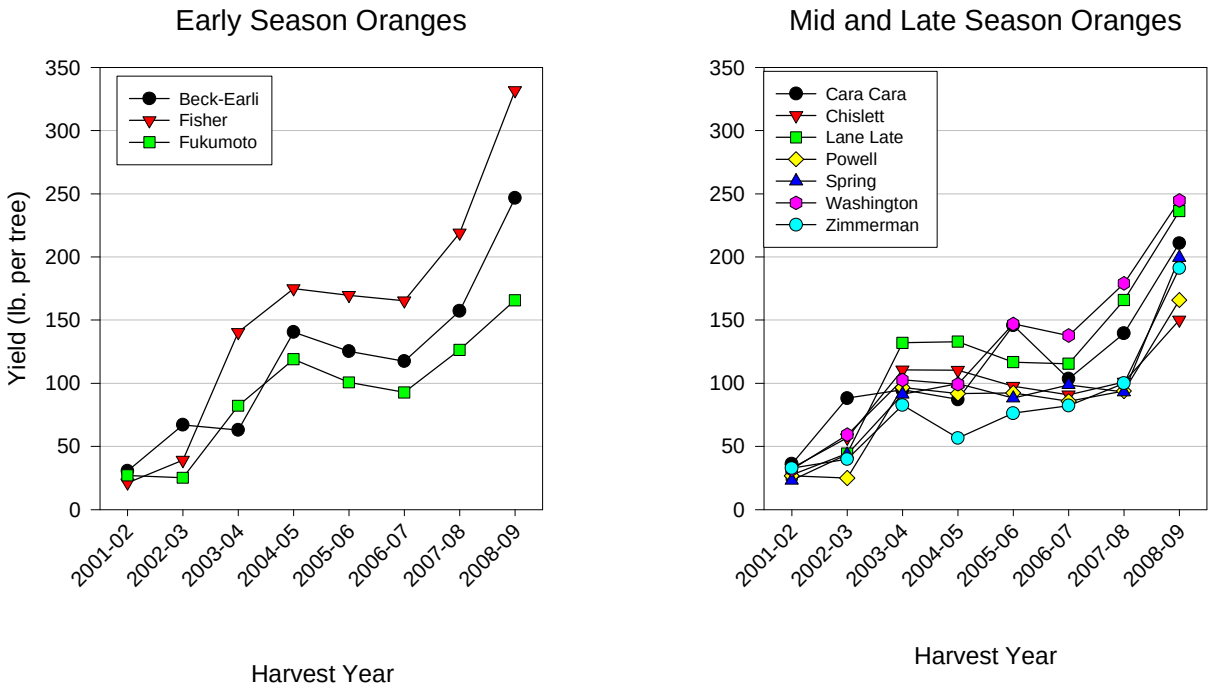

Figure 2. 2001-02 through 2008-09 yields of ten navel orange cultivars budded to Carrizo rootstock.

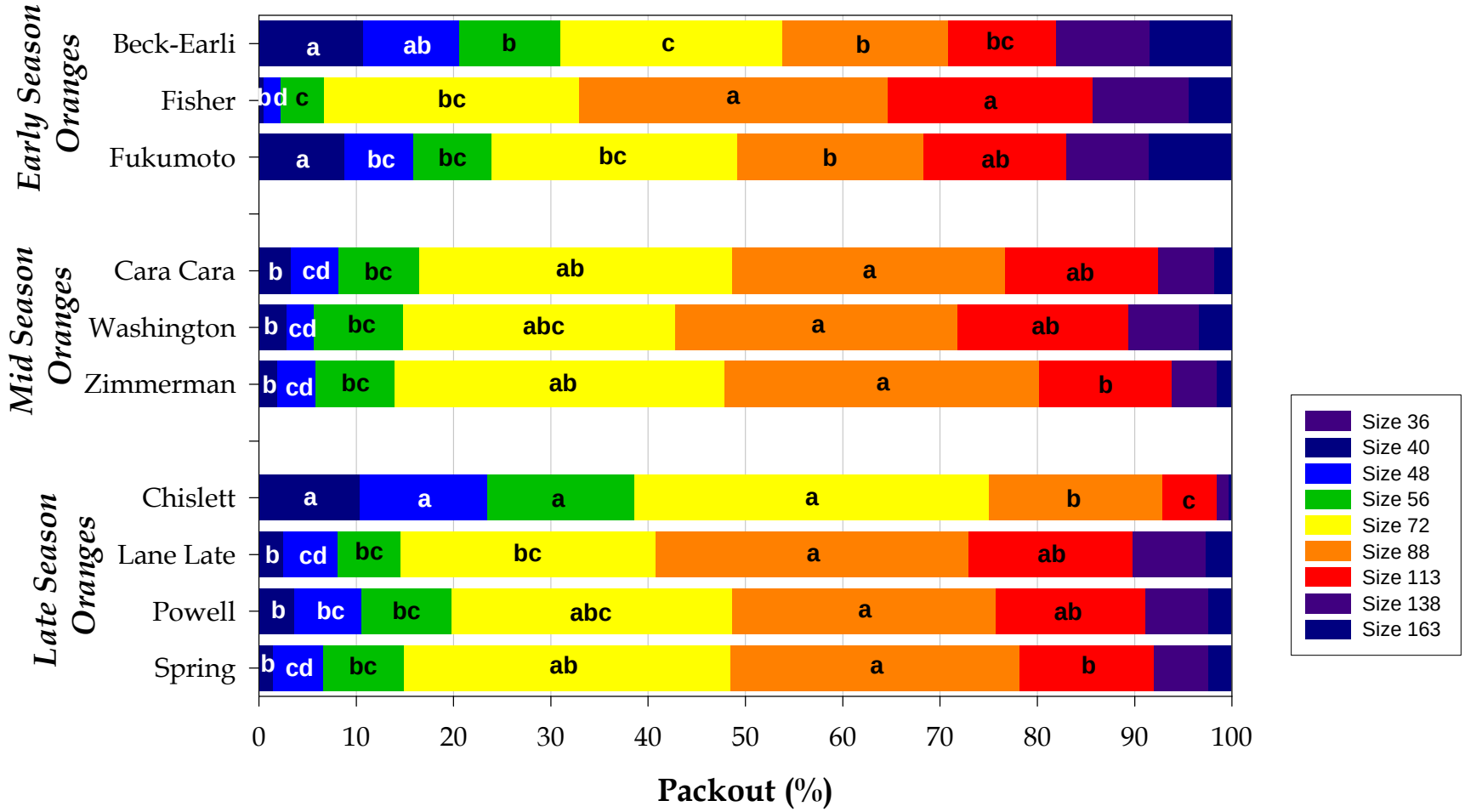

Figure 3. Packout of ten navel orange selections harvested in the 2008-09 season. Letters indicate significant differences between selections, at a 5% level.

Table 1. 2008-09 fruit quality of ten navel orange cultivars budded to Carrizo rootstock.

Selection	Juice Content (%)	Juice pH	TSS (%)	TA (%)	TSS:TA	Fruit Shape[y]	R/G[x]	Peel Thickness (mm)
Beck-Earli	35.65 c[z]	4.01 bc	14.41 a	0.578	25.42 ab	0.854 c	1.62 de	6.26
Fisher	39.60 abc	4.09 ab	13.86 abc	0.547	25.65 ab	0.925 b	1.49 f	5.76
Fukumoto	36.10 c	4.15 a	14.39 a	0.519	28.04 a	0.924 b	1.65 d	5.69
Cara Cara	40.38 ab	4.07 ab	14.16 ab	0.586	24.42 bcd	0.933 ab	1.77 c	5.80
Washington	38.38 abc	4.02 abc	13.22 bcd	0.572	23.15 bcd	0.928 b	1.86 b	5.59
Zimmerman	31.87 d	4.03 abc	14.23 a	0.578	24.89 bc	0.923 b	1.54 ef	5.51
Chislett	36.44 bc	4.03 abc	12.77 d	0.539	23.91 bcd	0.939 a	1.49 f	5.62
Lane Late	40.77 a	3.99 bc	12.54 d	0.575	22.37 cd	0.940 a	1.61 de	5.29
Powell	40.53 ab	3.92 c	12.98 cd	0.603	21.67 d	0.942 a	1.49 f	5.38
Spring	39.10 abc	4.05 abc	13.24 bcd	0.577	23.48 bcd	0.928 b	2.03 a	6.01

[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. 2008-09 exterior fruit grade of ten navel orange cultivars budded to Carrizo rootstock.

Selection	Fancy (%)	Choice (%)	Juice (%)
Beck-Earli	94.76 cd	3.43 a	1.81 ab
Fisher	94.03 d	3.17 ab	2.80 a
Fukumoto	96.24 abcd	2.03 abcd	1.73 ab
Cara Cara	97.13 abc	1.56 abcd	1.32 ab
Washington	99.01 a	0.56 d	0.42 b
Zimmerman	95.40 bcd	3.24 ab	1.37 ab
Chislett	96.60 abc	2.48 abc	0.88 b
Lane Late	97.47 abc	1.01 cd	1.51 ab
Powell	97.70 ab	1.76 abcd	0.57 b
Spring	98.21 a	1.38 bcd	0.41 b

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