California Cling Peach Advisory Board

2014 Annual Report

Project Titles:	Regional Testing of New Cling Peach Selections
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Objectives:

A. Release *Extra-Early#1* as a processing peach variety in the *Carson-Andross* gap. Determine appropriate disposition of *Ultra-Early #1, Early#5, Early#6* and *Extra-Late#1.* Finalize virus-free and verified true-to-type foundation nursery stock for these items for use by California nurseries for establishing propagation blocks and grower test blocks.

B. Continue the evaluation of UCD Experimentals currently in regional trials, particularly those in the *Dixon-Andross* and *Halford-Corona* season. Work with processors and growers in defining and testing fruit and tree characteristics required for effective mechanical and once-over harvesting.

C. Continue to promote the low-volume high-throughput fruit-sample processing at the new UCD Pilot Plant. Expand grower/processor opportunities to evaluate raw & processed UCD Experimentals

2014 Summary
UCD advanced selection *Extra-Early#*1 was released as the variety *Kader*. The main attributes of this new variety include the sought after harvest time between *Carson* and *Andross*, high yields of good-quality and disease-resistant fruit, and the ability of the fruit to hold on the tree for one week or more after development to the full ripe stage. Over 400 breeding selections were advanced to fruit quality evaluations at the UCD Mondavi pilot plant in 2014 with approximately half of the samples further evaluated for processing quality. The most promising of these selections are being considered for the next round of regional grower testing with both data and cutout samples being presented at the annual conference as well as regional workshops. Harvest dates for these items ranged from the end of June to early September, indicating good opportunity for harvest season extension if desired by the industry. Many advanced selections also demonstrated the capacity to maintain fruit integrity on the tree for a week or more after maturing to the full-ripe stage, thus allowing once-over and possibly mechanical harvesting. The high genetic diversity maintained in these breeding lines also offer the opportunity to further improve final performance by combining traits from different sources. The most promising Advanced Selections in regional grower trials, including Ultra-Early#1 Early#5, Early#6 and Compacts# 2& 3, continued to show good performance in 2014.

Project Summary: 2014

Because of the requirements for longer orchard productivity and production efficiency for processed compared to fresh-market fruit, new varieties need to be thoroughly tested in the different production regions and under the range of environment/cultural conditions anticipated for commercial production. This is necessary to identify the most promising selections for release to growers as well as to detect any deficiencies prior to large-scale commercial plantings. During the last several years, over 5,500 trees of UCD processing peach selections have been planted in regional evaluation blocks to accelerate the evaluation and release of improved varieties to the California industry. Regional testing data has expedited the release of *Extra-Early #1* in 2014 as the variety *Kader* which provides California growers with a productive, high processing-quality and improved brown rot resistant variety with the desired harvest time between Carson and Andross. Other UCD Experimentals currently in extended regional trials include *Extra-Early #2, Early#4, Early#5, Late#2, Extra-Late#1, Extra-Late#2 and Extra-Late#3, with* a smaller number of trees of *Ultra-Early #2, Ultra-Early #3, Ultra-Early #4, Late#3, Late#4,* and *Extra-Late#3*. [Regional selection designations are based on the *Maturity period* -followed by a number indicating sequence of release for grower testing]. More recently, we initiated regional test plantings of *Ultra-Early #1*, *Early*#6, *Extra-Late#4*, *Extra-Late#5*, *Extra-Late#6*, and *Extra-Late#7* which represent genetically novel selections developed to facilitate mechanical harvest. A genetically controlled more compact tree architecture (resulting in final tree sizes of ½ to 2/3 of standard) for facilitating mechanical orchard management (thin/prune/harvest) is also now in production at Sacramento and San Joaquin Valley grower trials. Over 1,200 additional *Early* to *Extra-Late* selections have been planted since 2010-14, including *Early#5 & Early#6* which show promise as high processing quality, firm and productive cultivars in the *Dixon-Andross* time period, *Late#4* which shows promise as a mid-season mechanically harvestable cultivar and *Ultra-Early #1* which, because of its very early harvest and improved fruit brown rot resistance, is being tested under both organic and commercial conditions. A large number of the earlier UCD experimental plantings were lost when growers removed their cling peach orchards with the recent economic downturn. While performance data was often collected prior to orchard removal, the loss puts greater importance on evaluations of remaining test plantings. In addition, the next generation of advanced processing peach breeding selections combining high productivity, improve disease resistance and improved harvest ability from multiple genetic sources is now being selected for a new round of regional testing.

Release of the Kader processing peach variety.

UCD advanced selection *Extra-Early#*1 was released as the variety *Kader* (Figure 1 And Table 1) in the summer of 2014 following approximately one year of Plant Science Department appraisal and patenting review and processing through the Office of Technology Transfer. The variety was named after Adell Kader, a recently deceased UCD Department of Pomology Post-harvest Biologist who had dedicated his career to improving California processed and fresh fruit quality. The main desirable attributes of the new variety *Kader* include a harvest time just prior to *Andross*, high yields of good-quality and disease-resistant fruit, and the ability of the fruit to hold on the tree for one week or more after developing to the full ripe stage. (The ability of the fruit to hold on the tree after the full- ripe stage is also associated with longer post-harvest cold storage potential, though this needs further research). The following material updates information provided for department review and initially presented in the 2013 Annual Report. In addition, virus-free and true-to-type vegetative

Table 1. Fruit characteristics of the Kader peach relative to commercial standards. (Average of 3 years from fruit randomly collected from 8 6-year-old trees planted at Davis, CA research plots which were heavily thinned to less than 1 fruit per 50cm bearing shoot to minimize competition effect).

Item	CIELAB color a*	CIELAB color b*	CIELAB color L*	Brix	TA	Brix/TA	pH	Fruit weight (g)	Fruit flesh firmness (lbs)	Maturity (d after Loadel)	Red in pit
Loadel	5.7 a	48.6 ab	70.8 a	8.0 a	0.5 ab	16.8	3.8 a	183.7 a	6.1 ab	0	(-)
Carson	5.0 a	50.8 b	71.5 a	7.5 a	0.4 a	17.0	4.0 a	219.5 ab	5.2 ab	5.3	(-)
Kader	7.0 ab	45.0 ab	77.2 ab	12.5 c	0.5 ab	25.7	4.0 a	332.7 bc	6.9 b	7.2	(-)
Dixon	6.1 ab	41.4 a	76.4 ab	12.3 c	0.4 a	30.2	4.1 a	226.4 ab	4.4 a	10.6	(+)
Goodwin	9.1 b	44 a	75.5 ab	12.7 c	0.6 b	22.6	3.9 a	236.2 ab	7.8 bc	15.9	(-)
Andross	6.9 ab	45.9 ab	78.1 ab	12.4 c	0.4 a	30.5	4.1 a	332.2 bc	7.5 bc	17.7	(+)
Klampt	5.4 a	46 ab	78.7 ab	10.7 ab	0.5 ab	21.6	3.9 a	353.1 c	5.4 ab	20.3	(-)
Ross	5.3 a	43.3 a	79.7 b	10.8 ab	0.5 ab	22.5	3.8 a	236.1 ab	8.2 c	23.8	(-)
DrDavis	7.2 ab	45.5 ab	78.8 ab	11.8 abc	0.5 ab	22.3	3.9 a	320.1 ab	5.8 ab	28.4	(-)

Table 2. Fruit Brown-rot disease scores following controlled lab inoculations and incubations. (3 year average).

Genotype	Lesion Diameter (mm)	Proportion Infected	Disease Severity
Carson	16.25	0.90	9.5
Kader	8.60	0.60	5.2
Goodwin	11.22	0.83	5.8
Andross	14.0	0.67	9.3
Ross	21.53	0.90	16.9
Dr.Davis	14.6	0.44	6.1

Table 3. Polyphenol oxidase (PPO) and associated fruit flesh bruising/browning following controlled lab incubations. (from 2013 Techakanon Thesis data).

Genotype	Flesh browning (CIE L* value - % loss over 12h)	PPO activity (mAbs/mi
Carson	0.04	156
Kader	0.03	178
Dixon	0.41	242
Goodwin	0.22	20
Andross	0.40	383
Ross	0.35	193

Table 1

sources of this cultivar had been established over the previous three years and is presently being maintained at the Foundation Plant Services quarantine orchards at Davis, California. Foundation budwood had been made available to interested nurseries in the spring of 2013 so that mother blocks could be established for subsequent commercial propagations. A limited amount of foundation budwood is also available directly from FPS for commercial propagation. The release of the processing peach cultivar *Kader* addresses major objectives of the UCD processing peach breeding program which are development of replacements for the 'Early' maturity season varieties '*Dixon'* and '*Andross'*, and the 'Late' season varieties *Halford*, *Starn* and *Corona*. The variety *Dixon*, which was introduced in 1956, produced very high yields which made it a popular variety for growers.

While fruit flesh displayed a desirable yellow color, the pit often showed a pink to red color from the formation of anthocyanins. This anthocyanin-based red color oxidizes to during processing, resulting in an undesirable bruised-brown canned fruit color as well as an undesirable brown staining of canned syrup. (Rather than a uniform syrup staining, the oxidized, brown anthocyanin pigments sometimes remained somewhat congealed giving the further undesirable appearance of bacterial ooze). The red staining often also extended to the fruit stone or endocarp in addition to adjacent flesh. While the red anthocyanin staining of the pit flesh is undesirable because of later pigment oxidation, read pigmentation of the endocarp appears to make it more susceptible to fragmentation and breakage and maturity. (Physiologically, anthocyanin production is in the same biochemical pathway as the production of lignin which is the very dense woody substance giving the pit it stone-like texture and durability. (This is the main reason that red pit staining is one of the targets for molecular markers in our RosBreed project). The red pit staining in the *Dixon* endocarp is strongly associated with increased susceptibility to breakage resulting in pit fragments being left with the fruit flesh at processing. Because of these problems, processors have for many years refused to buy ‘Dixon’ fruit from growers. The variety is no longer commercially planted, though no replacement variety presently exists (Fig. 2). Since the early 1990s, many thousands of seedlings of processing peach have been developed and evaluated at UCD and *Extra-Early#*1’and the recently released ‘Andross’ replacement ‘cv. ‘*Goodwin’*, as well as the ‘Halford’ replacement cv. *Lilleland* are products of this breeding effort. Originally having the breeding designation of 90,9-116 and the later designation of and *Extra-Early#1* when placed in regional testing, the cultivar *Kader* is the result of a controlled cross with the UC processing peach variety ‘*Ross’* as the female (seed) parent and the UC processing peach breeding line ‘R1-1'as the male (pollen) parent (Fig. 2).

Fig. 1. *Kader* tree (top-left from a commercial orchard in Marysville) and fruit (right) following mechanical pitting and prior to lye- peeling and canning. Top-right image shows 2012 fruit harvested at 10d passed tree-ripe stage while images at bottom are from tree-ripe 2014 harvest.

UCD 90,9-116was first selected in the mid-1990s based on its good fruit and tree qualities, its freedom from red staining of the pit in processed flesh, and the desirable *'Dixon'* ripening time and was propagated to regional test plantings at Winters (Wolfskill Experimental Orchards) and Davis, California, as well as at the Kearney Agricultural Center at Parlier, California. Based on promising results, additional, grower evaluation plots were established in 2004 for this selection in the Sacramento and San Joaquin Valleys of California under the designation of *'Extra-Early #1'*. Field evaluations through 2013 confirm earlier established desirable characteristics and indicate substantial commercial potential for the new variety. Tree-ripe fruit of this selection also demonstrate capacity to maintain good quality for over 1 week on-the-tree (see 2013 Annual Report) allowing delayed harvest and economically efficient once-over harvest including mechanical-harvest rather than multiple hand-harvests practiced for current varieties. Improved resistance to Monilinia fruit brown rot (Table 2) and resistance to flesh browning/bruising (Table 3) also contribute to very good delayed-harvest and post-harvest quality. The exceptional fruit-sizing capacity of 'Extra-Early #1''combined with good fruit eating quality and firmness (Table 1) allow interior and otherwise slower-growing fruit to continue to size with delayed harvest, further contributing to a high yield potential. Fruit weight under conditions of heavy flower thinning is among the largest of the *Extra-Early* and *Early* selections tested (Table 1, see also 2013 Annual Report). This indicates an aggressive compensatory-sizing (very similar to *Andross*) which should facilitate consistently high grower yields. Fruit Brix (averaging 12.9) is also amongst the highest for these maturity seasons) and Brix/TA ratio is above the desired level of 20. *Kader* has consistently shown good levels of fruit brown rot resistance (Table 2) and is being used as a breeding parent for this trait. Fruit are generally symmetrical; though occasionally show some cheek asymmetry similar to *Goodwin* with which it shares some lineage (though *Kader* does not show a similar tendency for split-pits). Flesh color is golden-yellow, also similar to *Goodwin* and also occasionally showing traces of green on shoulders. Flesh shows good firmness as well as low bruising/browning potential (Fig. 3, Table 3). Skin is yellow-gold with up to 80% showing stippled red blush (Figure 2). Fruit drop, split pits, and pit fragments were low in 2006- 2014.

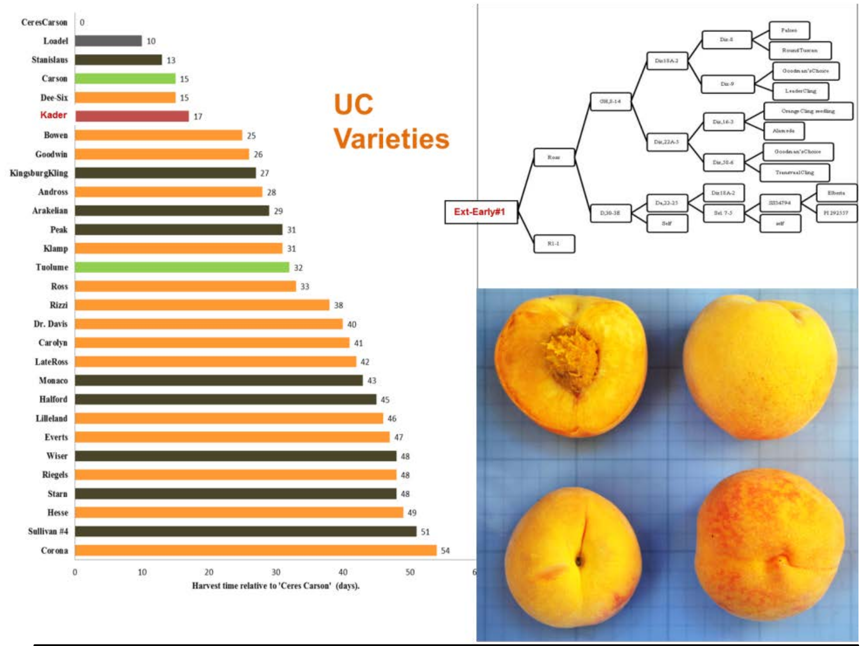

Figure 2. Harvest season of Kader relative to other commercial processing peach varieties (left) showing its location in the desirable Dixon-Andros gap. (Because fruit of Kader hold well on the tree after full ripe, harvest may be delayed until *Andros* season allowing growers and processes more consistent food supplies for the cannery). [Gold bars designate other varieties released by the UC program, black bars represent chance grower selections and green bars are varieties released by private breeders]. Pedigree of Kader showing its regional variety testing designation of Extra-Early#1 (top-right). Raw fruit of the variety Kader at the tree ripe stage (bottom-right).

Evaluations of new and advanced UCD breeding selections.

Table 4. Summary data for selections chosen for cutout display at the 2015 Annual Cling Peach conference, including advanced selections currently in regional testing as well as new breeding selections identified as candidates for future regional testing.

Can# 2014	Selection	Ripe date	Days after Ripe dtae when harvested	Color (RGB scores)	Red in Pit (0=none, 9=color bleed.)	Fragments (0=none, 9=1+ per fruit)	Fresh Fruit firmness (lbs)	Firmness Stand. Dev.	Germplasm donor source	Seed	Pollen
55	2011,14-14	6/26	15	224, 154, 32	0	0	5.5	1.4	*Almond*	07,6-135	Self-pollination
56	2011,4-60	6/26	15	201, 130, 1	2	0	8.9	1.9	*P. scoparia*	05,20-116xx	Self-pollination
62	2011,4-83	7/4	12	224, 145, 16	0	0	7.5	1.4	*P. scoparia*	05,20-118xx	Self-pollination
63	2011,7-264	7/4	12	215, 142, 3	2	0	8.0	1.7	*P. argentea*	05,19-56xx	Self-pollination
66	*ExtraEarly#2*	7/7	0	224, 150, 1	0	0	4.2	2.5	*Standard*	Ross	R,1-1
72	*UltraEarly#1*	7/7	0		0	0	7.0	1.0	*Brazil*	PG8-6	
73	*UltraEarly#1*	7/7	9		0	0	3.9	1.0	*Brazil*	PG8-6	
95	2011,6-242	7/7	17	211, 147, 41	1	0	7.2	0.9	*Mutation*	07,21-70	Self-pollination
100	2011,12-160	7/7	16	230, 155, 1	0	0	7.7	1.5	*S. Africa*	05,4-237	Self-pollination
110	*Compact23-4*	7/7	16	227, 159, 48	1	0	5.6	0.8	*Mutation*	00,9-79	clone compact
112	2011,23-61	7/7	16	219, 142, 1	0	0	8.4	1.2	*Standard*	03,5-209	clone
115	*Goodwin*	7/14	2	212, 146, 1	0	0	6.7	0.8	*Standard*	Dr. Davis	11,11-37
57	2001,2-85	7/15	0	203, 137, 1	0	0	5.3	1.3	*Almond*	Loadel	97A,10-289
71	*Compact#2*	7/15	0	211, 143, 46	2	0	4.8	1.8	*Mutation*	F10E22-59	Self-pollination
121	***Kader***	7/16	7	185, 130, 37	0	0	7.2	1.5	*Standard*	Ross	R1-1
183	***Kader***	7/16	12	222, 147, 1	0	0	7.0	2.1	*Standard*	Ross	R1-1
165	2011,23-27	7/22	13	207, 135, 1	0	0	6.1	1.7	*Standard*	02,6-217	clone
184	2010,1-80	7/22	13	228, 163, 1	1	0	7.3	0.7	*S. Africa*	Loadel	99,12-155
173	*DRDAVIS*	8/5	0	217, 148, 34	0	0	6.5	1.1	*Standard*	D25-9E	G40-5E
175	*Early#5*	8/5	0	205, 147, 1	0	0	5.0	1.1	*Standard*	Loadel	F10E,6-27
181	*Early#6*	8/5	0	238, 177, 14	0	0	5.6	1.3	*S. Africa*	Woltemade	91,17-195
255	2010,1-149	8/7	12	213, 153, 30	1	0	5.1	1.5	*S. Africa*	Loadel	99,12-155
262	2010,4-208	8/7	12	218, 151, 46	0	0	5.7	0.9	*Standard*	Koska	04,4-155
274	2011,6-57	8/7	12	204, 134, 1	2	0	6.1	1.4	*Almond*	05,11-134	Self-pollination
277	2011,6-94	8/7	12	211, 139, 28	0	0	7.0	1.0	*Almond*	05,11-134	Self-pollination
290	*Compact#3*	8/7	13	217, 147, 1	0	1	7.8	1.6	*Mutation*		
302	*Late#2*	8/11	7		0	0	6.3	0.9	*Standard*		
372	*Late#2*	8/11	12	202, 135, 1	1	0	6.1	1.4	*Standard*		
294	99,20-134	8/20	0	219, 144, 50	2	0	4.4	0.4	*Mutation*	F10E, 22-59	Self-pollination
296	2004,4-155	8/20	0	213, 132, 1	1	0	9.0	0.7	*Standard*	97,12-127	Self-pollination
324	2010,18-214	8/20	12	211, 133, 1	1	1	6.3	0.9	*P. argentea*	05,19-51	Self-pollination
328	2010,1-472	8/20	12	232, 160, 78	0	0	5.7	0.9	*S. Africa*	Loadel	99,12-155
332	2010,5-198/6	8/20	12	207, 146, 4	0	0	4.6	1.9	*Standard*	Dr.Davis	97,7-79
378	2011,23-18	8/20	9	208, 125, 1	0	0	7.0	0.5	*Exotic*	00,16-92	clone
390	2011,16-94	8/20	12	224, 154, 46	0	0	6.2	1.5	*Exotic*	05,29-107	Self-pollination
404	*Compact#3*	8/20	12	214, 133, 1	0	0	7.5	1.6	*Mutation*		
369	2011,23-71	8/29	0	204, 123, 1	0	0	8.5	0.8	*Standard*	04,4-104	clone
380	2011,22-152	8/29	0	219, 145, 49	0	0	7.4	0.9	*Almond*	07,17-19	Self-pollination
354	99,19-231	9/1	0	229, 152, 39	0	0	7.9	1.9	*Standard*	F10E, 22-59	Self-pollination

Figure 3. Processed samples of new breeding selections presented in Table 3. Samples were canned at the Mondavi pilot plant in the summer of 2014 and evaluated in January 2015. Image number refers to the 2014 canning number provided in Table 3. (Images of promising items currently in regional testing are provided with their descriptions in the following sections).

Over 400 selections were evaluated for harvest and postharvest fruit quality at the UCD Mondavi pilot plant in 2014 with approximately half of the samples further evaluated for processing quality. A summary of the most promising of these selections is provided in Table 4 with sample images from January 2015 cut-out evaluations provided in Figure 3. Harvest dates for items ranged from the end of June to early September, indicating good opportunity for harvest season extension if/when desired by the industry. To facilitate a greater grower capability for uniform, even once-over harvest, strong breeding pressure has been directed towards this trait. Despite delays of harvest of up to 17 days after the initial fruit full-ripe development, fruit of good color and firmness (Table 4) as well as good processed appearance, including freedom from pit fragments and red pit staining (Figure 3 and Table 4) were obtained. As previously discussed, genotypes having the capacity to hold from one to several weeks on the tree without serious deterioration of fruit quality, also tend to show good post-harvest cold storage life as both appear to be associated with resistance to fruit flesh deterioration, including mealiness, tissue browning and biochemical changes such as aldehyde breakdown. A wide diversity of germplasm donor sources is also documented with breeding lines including Brazilian and South African germplasm, peach relatives (exotics), cultivated almond and the related almond species *Prunus scoparia* and *P. argentea*. The capacity of fruit to hold on the tree after the full ripe stage without appreciable deterioration was usually associated with germplasm derived from other sources with a few exceptions which appeared to be the result from beneficial mutations in commercial lines. Higher fresh fruit firmness was usually associated with higher firmness for processed fruit as measured at the cutout, though some interesting exceptions occurred where improved process firmness appears to be associated with differences in the fruit flesh matrix. Recent selections identified as candidates for future regional testing come primarily from the 2010 block and 2011 Block reflecting the large

	DAF	FD	FW	pH	RD	RP	SSC	TA
DAF	1	0.71	0.87	0.74	0.92	0.31	0.76	0.68
FD	0.71	1	0.94	0.67	0.84	0.41	0.62	0.61
FW	0.87	0.94	1	0.69	0.93	0.47	0.67	0.71
pH	0.74	0.67	0.69	1	0.63	0.52	0.73	0.74
RD	0.92	0.84	0.93	0.63	1	0.27	0.79	0.76
RP	0.31	0.41	0.47	0.52	0.27	1	0.19	0.36
SSC	0.76	0.62	0.67	0.73	0.79	0.19	1	0.87
TA	0.68	0.61	0.71	0.74	0.76	0.36	0.87	1

Trait	TCSA	YE	FW	SSC	FF	TA	RI	Sucrose	Glucose	Fructose	Sorbitol	TS	Vitamin C	Phenolics	Flavonoids	RAC
Yield	0.22*	0.82*	0.28**	ns	ns	-0.21*	ns	ns	ns	-0.29*	-0.27*	ns	ns	ns	ns	ns
HD	ns	ns	0.63**	0.63**	-0.52*	ns	ns	0.62**	ns	0.21*	0.78**	0.66**	ns	0.65**	0.79**	0.72**
YE		-	0.30**	ns	ns	ns	ns	ns	ns	-0.24**	ns	ns	ns	ns	ns	ns
FW			-	0.56**	ns	0.15*	ns	ns	0.36**	0.39*	ns	0.25*	ns	0.53**	0.21*	0.34*
SSC				-	0.49**	0.26**	ns	0.29**	0.27**	0.36*	0.77**	0.49**	ns	0.56**	0.60**	0.61**
FF					-	0.40**	-0.57*	-0.50**	-0.64**	-0.49**	-0.42*	-0.59*	ns	-0.52**	-0.26*	ns
TA						-	ns	ns	0.41**	ns	0.40**	ns	0.46**	ns	0.35**	ns
RI							-	0.42**	0.24*	0.35*	0.41**	0.27**	-0.21*	ns	ns	ns
Sucrose								-	0.57**	0.63**	0.48**	0.95**	ns	0.43**	0.47**	ns
Glucose									-	0.83**	0.44**	0.81**	ns	0.42**	0.44**	0.52**
Fructose										-	0.49**	0.83**	ns	ns	0.24**	ns
Sorbitol											-	0.56**	0.37**	0.52**	0.47**	0.64**
TS												-	0.42**	0.58**	0.61**	0.64**
Vitamin C													-	ns	ns	0.25*
Phenolics														-	0.68**	0.79**
Flavonoids															-	0.87**
RAC																-

Figure 4. Correlations between the fruit quality characteristics for second-generation UCD selections evaluated as part of the RosBreed project (top) in the recently completed study for commercial peach germplasm generally available to North American and European breeding programs. [DAF-ripening time in days after flower, FD-fruit diameter, FW-fruit weight, RD-ripe date, RP-red pigmentation in pit, SSC-soluble solids, TA-two tradable acidity, HD-harvest date).

sizes of these blocks (approximately 10,000 seedlings in each) as well as the general high-quality of the parents and parent combining ability in these breeding progeny. The availability of large populations of breeding progeny from diverse and even intraspecific germplasm sources, yet at advanced stages of selection for commercial fruit and tree quality demonstrated by these populations, was crucial to their selection is the dominant peach germplasm for the next round of the RosBreed molecular marker development project. The primary objectives of the next round of RosBreed testing will also focus on parameters crucial to the processing peach industry including fruit quality and firmness and disease resistance (particularly to fruit brown rot disease). The germplasm diversity contained within the current UCD breeding populations represents a more extensive genetic variability and so greater opportunity to identify genetic solutions to current and evolving production problems (as described in more detail in earlier annual reports). A greater general or overall trait diversity, however, would be detrimental to breeding program efficiency as it would entail diversity both for the presence of desired and undesired traits as well as their interactions. Intensive selection for high levels of locally-adapted commercial fruit quality has concentrated desired processing quality in current advanced UCD processing peach breeding lines while maintaining a diverse germplasm base. Diverse origins can often indicate different mechanisms towards the same goal and so opportunities for even higher expression of desired traits may be achieved when the different sources are combined or pyramided. For example, data in Table 4 identify geographically independent sources for the ability of fruit to maintain integrity following the full-ripe stage, and our preliminary studies indicate independent mechanisms may be involved (different tissue matrix structure from almond and different structural integrity (endoPG softening) from the Brazilian (Conserva) germplasm. Similar results have also been found for fruit brown rot resistance. The quality of UCD germplasm is also indicated by the high levels of correlations identified between desired traits such as soluble solids (SSC) and titratable acidity (TA) (top of Figure 4 from 2003 data) as well as the lack of correlation or linkage between undesired traits (such as an association of high soluble solids with small fruit size). We have just completed a similar analysis of breeding germplasm used by North American and European peach (primarily fresh market) improvement programs (bottom of Figure 4). Although containing greater trait diversity, this general European/North American breeding germplasm actually contains less genetic diversity than UCD populations since peach is genetically highly inbred and unlike most of the programs, we have supplemented that genetic limitation by incorporating material from a range of related species. The high selection pressures which we have applied to that material over the last 15 years also appears to have maintained the breeding potential (i.e. opportunities for continued trait improvement as documented in Table 4) without diluting the breeding quality with new undesirable traits (as documented with the European/North American germplasm in such interactions as the poor correlation between soluble solids and titratable acidity and even the negative correlation between yield and titratable acidity (Figure 4, bottom)). The complexities of these interactions make their study difficult using traditional genetic methods, but make them ideal candidates for molecular marker analysis and both fruit texture integrity and fruit brown rot resistance will be major traits in the next RosBreed analysis of UCD processing peach breeding material.

Promising advanced selections currently in regional trials.

Ultra-Early#1

[UCD breeding designation D,62-193]. *Ultra-Early#1* is derived from a combination of Brazilian (*Conserva485*) and Eastern European (*NJC5102893*) peach germplasm from the Rutgers University breeding program of Dr. Fred Hough which was terminated in the late 1980's. The initial New Jersey selection expressed unusual sections of stem necrosis which we determined to be genetic rather than disease in origin. A series of clonal-source selections since the 1990's (based on the noninfectious-bud-failure elimination strategies developed in almond) has eliminated all trace of this condition in UCD and regional trial trees. *Ultra-Early#1* combines very good size and cropping potential with a very early maturity of approximately 8-12 d before *Loadel*. Despite its early maturity, this selection demonstrates exceptional compensatory-sizing capacity (i.e. the ability to aggressively size fruit

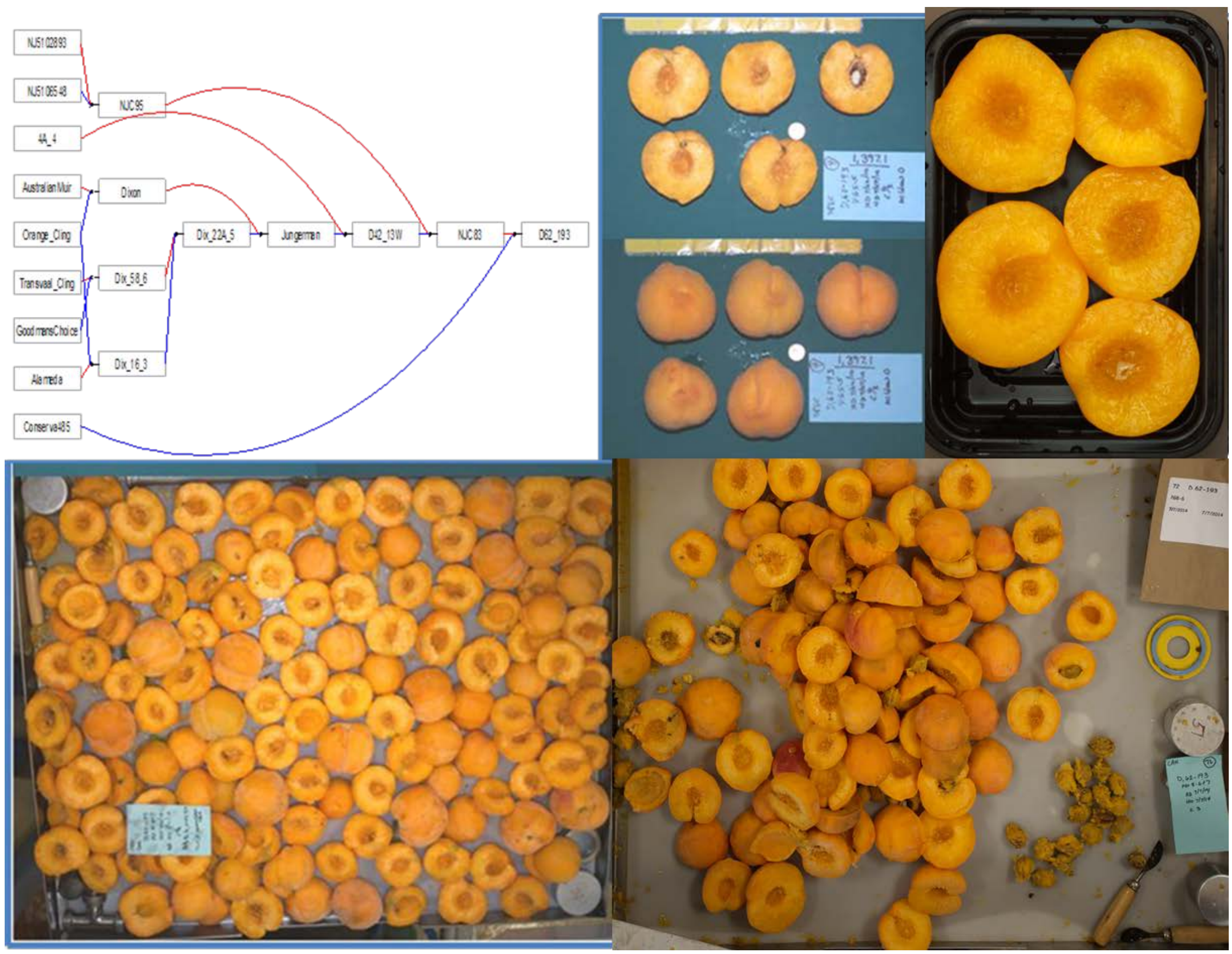

Fig. 6. *Ultra-Early#1*: lineage (top-left); heavily thinned fruit (top-center); 2014 processed fruit (top-right); bottom-left: 2012 fruit at 10d passed tree-ripe, and bottom right are 2014 fruit from tree-ripe harvest. Note a tendency for irregular fruit shape and some beaks at fruit tip.

when more resources become available as would occur when the crop is over- thinned or early fruit loss from weather, disease, etc). The aggressive fruit sizing compensates by making remaining fruit and so yield appreciably larger. Ultra-Early#1 has also shown improved resistance to fruit brown rot and has been an important parent for both early maturity good fruit size and firmness and fruit brown rot. (More data presented in 2012 and 2013 annual Variety Development reports). However, because it is so early, it matures before most processing plants open. The exception was the Kingsburg Del Monte plant, which when closed may have orphaned this variety which has potential for early season extension. However it's exceptional size and yield potential for such an early season combined with its high level of brown rot resistance have made this a particularly attractive variety for organic production of processed product as it allows the product to be processed and the plant before contamination by non-organic fruit. The high orange gold flesh color of this selection would also result in a more desirable processed product without the undesirable risk of mixing with lighter colored fruit resulting in an inconsistent canned product. Fruit in 2014 continued to show good fresh to and process quality (Figure 6).

Early#5.

[UCD breeding designation 90,9-161]. Early#5 is an older selection dating from the mid-1990s. Derived primarily from more traditional California breeding lineages, E*arly5* represented one of the few traditional seedling progeny which matured during the *Dixon-Andross* gap. Fruit ripens with to just after *Andross*. Fruit are medium large, being somewhat larger than *Early#6* or *Goodwin*. The pit cavity is larger with a somewhat ragged appearance. Some pit fragments and split pits have been observed (~3%) but consistently less than Andross. Flesh color is a golden yellow, similar to Andross with a golden yellow skin with up to 30% red blush. Fruit are firmer than Andross with some softening occurring on shoulders and at the suture as the fruit become overripe. Fruit tend to hang well on tree without significant loss in quality (Fig. 7) though pit cavities will gain a some reddening by 10 – 14 days after full-ripe. In hotter regions such as the southern San Joaquin, some fruit flesh may develop a reddish stain when 5+ d overripe. Some fruit drop and brown rot

Fig.7. Early#5 2013 harvest at one week (top-left) and two weeks after tree ripe(bottom left). Harvest at tree ripe in 2014 (top-right) and following processing (bottom-right)

have been observed at regional trials. Flesh has also shown low bruising/browning potential in recent tests, a characteristic which has been verified recently in work and Dr. Barrett's lab. Regional test plots for this selection have been particularly promising with several growers indicating a desire for more extensive plantings in 2014/2015.

Early #6

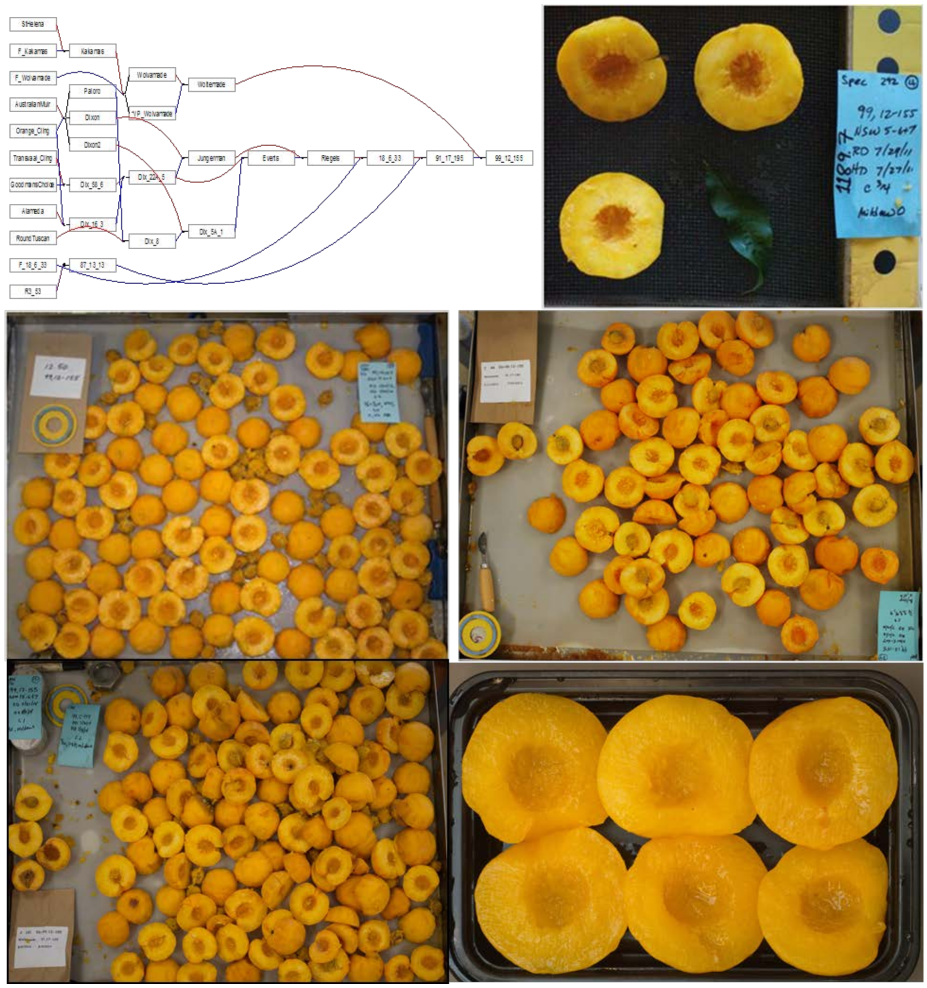

Fig. 8. *Early#6* lineage (top-left), heavily thinned 2012 fruit (top-right) middle shows standard thinned-fruit from 2012 harvested at tree ripe stage (left image) and 2013 harvested at 2 weeks after tree ripe stage (right image). Bottom: 2014 fruit harvested at 2 weeks after tree ripe stage left and processed, right.

[UCD breeding designation 99,12-155]. *Early #6* is an advanced fourth-generation selection derived from South African germplasm combining the long-keeper potential of *Late#4* with a more traditional golden-yellow flesh color, and a maturity time within the crucial *Dixon-Andross* season. This selection has consistently shown superior fruit color as well as harvest- and post-harvest firmness and cropping potential over a multi-year test period. Fruit maintain integrity and quality 14 days or more after tree-ripe (*Long-Keeper* trait) allowing delayed or once-over harvest. Good levels of fruit brown rot resistance **have** also been achieved both in the lab and field, as well as moderate levels of resistance to Monilinia flower blight. Fruit is medium large, uniformly round and firm even when overripe. Fruit remain totally free of red blush on the skin and, more importantly, no red stain development in the fruit pit-cavity even up to two weeks beyond the full-ripe date. (This genotype may be a carrier for a gene that is thought to shut down red pigmentation during fruit development but appears distinct from the standard gene with this expression known as the 'highlighter' gene in that, unlike 'highlighter', the *Early6* maintains good raw and flesh color with processing, (Figure 8). Pit-cavity is medium to large and somewhat ragged. Fruit weight following heavy thinning was moderately large (238g) being similar to *Ross* but significantly smaller than *ExtraEarly-1*. This suggests it may be at a compensatory-sizing yield disadvantage relative to *ExtraEarly-1* when trees are over thinned (or early crop loss from frost, disease, etc.). However, because *Early-6* harvest between *ExtraEarly-1* and *Andross* it may complement these varieties as the fruit, while medium in shape, tend to be uniform and above the minimum required size. Because of its good color, freedom from red pit and pit fragments, and good fruit integrity even after fruit developed to the full-ripe stage, this breeding line will be extensively studied in the RosBreed molecular marker project which began in 2014 and is expected to continue until 2019.

Fig. 8. *Compact #2* tree (left) and 2014 processed fruit (top-right). *Compact #3* 2014 processed fruit (bottom-right).

Compact#2 and Compact#3.

The compact trait results in a tree which is ½ to 2/3 standard size. It is controlled by a single and completely dominant gene and so can be routinely transferred using traditional breeding methods. The short tree size results from reduced internode sizes so that the number of nodes and so the number of potential flowers and fruit remains unchanged. The short internode length, however, results in a higher degree of shoot shading, reducing lateral branches with an increased risk of developing blind would developing blind wood. The trait, which appears to be a bud sport mutation in origin, also confers better fruit flesh integrity and suppression of epicormic or water sprout shoot growth. Both have potential value for processing peach improvement.

Compact#2
[UCD breeding designations 99,6-292]. The trees are productive and compact, being approximately 1/2 to 2/3 standard height (see 2010-11 Annual Reports for detailed data on tree architectures for the Compact series). Thus, while expressing high levels of fruit quality, a long-keeper type on-tree holding ability, and disease resistance, the selections will require novel management strategies to be commercially viable. *Compact#2* fruit ripen with *Dixon* and will hold on the tree until *Andross* time (see Figure 9). Fruit are medium size, of very good quality with a good (on-tree) holding ability allowing a 1 to 2 week delay in harvest if necessary. Fruit can be only moderately firm but with high Brix, low bruising and moderate resistance to fruit brown rot. Fruit flesh is uniform gold to yellow-gold and is usually free of red pigmentation even when overripe (some pink in flesh was observed in pit cavities in 2008 and 2011, all of which cooked-out with processing). Skin is yellow-

gold with up to 40% red blush. Trees are productive with relatively little blind-wood and low preharvest drop making them amenable to mechanical harvest. Some flesh bruising/browning was observed in overripe 2009-11 fruit and ~6% splits observed in 2010-11, though splitting was much lower as trees matured.

Compact#3

[UCD breeding designations 2001,18-215]. Compact#3 tree is productive and compact, being approximately 2/3 standard height (slightly higher than Compact-2, see 2010-11 annual Variety Development report. Fruit are of very good quality with a good (on-tree) holding ability allowing in one to two week delay in harvest if necessary. Fruit ripen with *Monaco* to *Halford* but will hold on the tree until *Corona*. Fruit flesh and skin is uniform yellow and free of red pigmentation. The fruit pit cavity is free of red-staining, though over-ripe fruit will often show a slight brown pit- imprinting, which after canning can appear as a slight pink imprinting in the pit. Trees are very productive with relatively little blind wood (which is often a problem with compact types), low fruit brown rot and low-bruising, making them amenable to once-over or mechanical harvest.

Fig. 9. *Compact#2* –Top Row, left to right: 2014 and 2013 harvested at 1 week after tree-ripe, 2013 harvest at 2 weeks after tree-ripe. *Compact#3*: –Bottom Row, left to right: 2014 harvested 1 week after tree-ripe, 2013 harvest at tree-ripe and 1 week after tree-ripe from a Modesto area grower test plot.

The Compact series (several additional compact genotypes maturing at differing time periods are in the early to mid- stages of selection) consequently offers unique opportunities for increasing both grower and processing efficiency of cling peach in California. As detailed in the 2010-11 annual reports, the trait is incompletely dominant in its genetic control and so relatively easily manipulated (placed in different maturity backgrounds). The major challenge to the Compact series is that it will require new horticultural practices (training, pruning, thinning, harvest-including the mechanization of all of these practices) to fully optimize its potential for decreasing California production costs. The good fruit quality in terms of firmness, color, freedom from red pit and splitting, and good size and color will also contribute to improved processing efficiencies. Commercialization would thus require considerable grower contributions in the area of field production. To encourage such grower innovation we are considering the development the special arrangements with interested growers to provide the incentives they would require to invest in the long-term field research necessary. (Similar arrangements have been suggested for *Ultra-Early#1*). Regional test plots for these selection have also been promising with several growers indicating a desire for more extensive plantings in 2014/2015.

Recent Relevant Publications

Martínez-García P. Fresnedo-Ramírez J. Parfitt D. Gradziel T. Crisosto C. 2013. Effect prediction of identified SNPs linked to fruit quality and chilling injury in peach [Prunus persica (L.) Batsch]. Plant Molecular Biology: 81:161–174. DOI 10.1007/s11103-012-9989-8.

Martínez-García, P.J. D.E. Parfitt, E.A. Ogundiwin, J. Fass, H.M. Chan, R. Ahmad, S. Lurie, A. Dandekar,T.M. Gradziel, and C. H. Crisosto. 2013. High Density SNP Mapping and QTL analysis for fruit quality characteristics in peach (Prunus persica L.) Tree Genetics and Genomes. 9:19-36 DOI 10.1007/s11295-012-0522-7.

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Limane, A. S. Noria and T. Gradziel. Root architecture of Atlas pistachio in relation to underlying soil properties under arid conditions. 2014. African Journal of Agricultural Research. DOI: 10.5897/AJAR20, ISSN 1991-637X

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Martínez-García P. Fresnedo-Ramírez J. Parfitt D. Gradziel T. Crisosto C. (2013) Effect prediction of identified SNPs linked to fruit quality and chilling injury in peach [Prunus persica (L.) Batsch]. Plant Molecular Biology: 81:161–174. DOI 10.1007/s11103-012-9989-8.

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