

EVALUATION OF PISTACHIO BREEDING SELECTIONS 2009-10 ANNUAL FULL REPORT

Craig E. Kallsen, UCCE Farm advisor, Kern County
Dr. Dan Parfitt, Pomologist-AES, Dept. of Pomology, Univ. of Calif./Davis
Dr. Ted DeJong, Professor, Dept. of Pomology, Univ. of Calif./Davis
Joseph Maranto, retired UCCE Farm Advisor, Kern County

SUMMARY

In 2010, the process of evaluating the performance of advanced pistachio selections grafted onto rootstocks in replicated and randomized scientific trials continued. These advanced selections came into existence as the result of tree selections made from a breeding experiment initiated by Dr. Dan Parfitt and Farm Advisor Joseph Maranto in 1989 and 1990. The two oldest trials were planted in northwestern Kern County (identified as Twisselman) and in Madera County (identified as Madera) in 1997 and 1999 respectively. In 2010, in these two trials we continued to compare the cultivars Golden Hills, Lost Hills and Kerman. Golden Hills and Lost Hills were released as cultivars by the University of California in 2005 and continued to appear to be valid options for pistachio growers seeking early maturing varieties with yield and nut characteristics that compare favorably with Kerman, the industry standard.

Three additional advanced selection trials were planted in 2002. Two of these trials contain multiple trees of all the female and male selections that are being evaluated as part of this project. These two trials are located in Kern County near Wasco (identified as Little Creek), and near the Grapevine on Interstate 5 (identified as Tejon). The third 2002-planted trial located and near Madera (identified as Madera and contained within the older trial) contains 20 female selections, including 'Kerman', with the males 'Randy' (early blooming), 'Peters' and a late flowering male selection. Trees in the advanced selection trials planted in 2002 were in their 9th leaf in 2010, and exhibited a range of flowering, yield and nut quality characteristics.

Many of the female entries in these trials, over the past four years of harvest evaluation, have either not demonstrated characteristics superior to existing cultivars or have demonstrated negative characteristics, such as nut gumming, differential nut maturity across the tree, low early yields or just low yields in general, excessive early nut splits, inferior shell hinge strength or rank vegetative growth that make them relatively poor candidates as commercial varieties. Evaluation continues on the few remaining selections that appear to have some attributes that are superior to existing cultivars, or sufficiently different to provide additional market opportunities to the industry.

INTRODUCTION

In 1990, the then California Pistachio Commission supported the creation of a new University of California Pistachio Breeding Program conducted by Mr. J. Maranto, U.C. Cooperative Extension Farm Advisor in Kern County, and Dr. D. Parfitt, Research Pomologist at UC/Davis. The objective of the research was to produce and identify

cultivars with useful cultural or nut quality characteristics different from or superior to Kerman. These characteristics would include such things as increased size, less blanking and less closed shell, or with other valuable characteristics such as varying nut-maturity dates. Adding new cultivars might also buffer the genetic vulnerability that monoculture creates when a new pest or disease attacks a particular cultivar.

The breeding program created a large germplasm base from crosses made by Maranto and Parfitt among available male and female cultivars existing in various locations in California. The seedling families that resulted from the crosses were planted in three locations (Winters, Kearney, and Bakersfield). In 1996, trees with what appeared to be potentially valuable characteristics were selected by Dr. Parfitt from the Bakersfield seedling plot first because of the more rapid development of the trees at this location. Budwood from the selected trees was grafted onto rootstocks and planted in replicated and randomized trials, called “advanced selection trials.” Advanced selection trials were established in 1997, in northwestern Kern County (identified as Twisselman); and in 1999, near Madera in Madera County (identified as Madera). Of the nine female selections placed in the advanced selection plots in 1997 and 1999, two were released by the University of California in 2005 as cultivated varieties. These varieties were called Golden Hills and Lost Hills. The early male, called Randy was also released as a pollenizer for the two female varieties. These two female varieties and Randy continued to be evaluated as part of this current project.

In 2002, three additional advanced selection plots were established based on additional evaluations and selections of trees from Maranto’s and Parfitt’s seedling trials at Bakersfield and Winters. The seedling trees were evaluated initially by Dr. Parfitt, and later by Drs. Weinbaum, and DeJong based on data and notes of Dr. Parfitt and further evaluations of the original seedling test trials at Bakersfield and Winters. The primary goal of these later selections was to identify the female seedlings that possessed consistently large nut size and with a range of bloom and fruit maturity dates. A secondary goal was to identify males which had early and late bloom dates and that were from the same families as the selected females to preserve the germplasm. More recently, two selections from the Kearney trial were placed in a newly established trial (2010) near Highway 65 and Garces Highway in Kern County

PROCEDURES

In 1997, at Twisselman, 40 trees of each advanced female selection were organized in an experimental plot consisting of two replications in a randomized, blocked design. Each replication consists of 10 trees of each female selection on PG1 rootstock. The advanced selection trial in northeastern Kern County was located in an excellent pistachio growing area of the San Joaquin Valley. Soils are well-drained, deep, boris and calcareous clay loams. The climate throughout the year is arid and the summer is characterized by high daytime temperatures with frequent light winds.

The experimental design at the Madera site (planted in 1999) is different to Twisselman in that each of the two replications consists of only 10 trees of each selection (five on UCB-1 and five on PG1 rootstock). Peters males and the selected early (Randy) and late blooming (B6-6) males are present in each of these advanced selection

plot. Madera is located on sandy loam soil with a relatively shallow, mechanically-fractured hardpan.

In 2002, additional advanced evaluation plots were established at the following three locations, east of the I-5 Grapevine in Kern County (identified as Tejon), near Wasco in Kern County (identified as Little Creek) and near Madera (identified as Madera) in Madera County. Tejon is planted on a deep, sandy soil near the extreme southeastern end of the San Joaquin Valley. The climate is arid and the location is relatively warm in the winter, often resulting in insufficient winter chilling for pistachio. Little Creek is also arid and is planted on a deep, loam soil. Winter temperatures are colder than at Tejon and humidity is higher. Madera, like Tejon, is located in the citrus belt, and sufficient winter chilling can be a problem. Madera probably receives, on average, two to three times the annual precipitation of Tejon and Little Creek. The Madera location is adjacent to the San Joaquin River, with higher humidity. Twenty-two new female selections in addition to Kerman, Lost Hills and Golden Hills were grafted onto PG1 rootstocks at Tejon and Little Creek. Twenty-two male selections and ‘Randy’ were grafted at the Tejon and Little Creek plots. In general, at Tejon and Little Creek, the experimental design consists of four replications (i.e. experimental units), one replication per each of four blocks, with four or five trees in each replication. Because its nut size was thought to be similar to Kerman, Golden Hills was planted at Tejon and Little Creek in four replications but each replication consisted of a single tree. Space limitations restricted the female and male selection testing of the new selections at the Madera location. In 2002, 18 of the newly selected females in addition to Kerman and Lost Hills were interplanted into the older trial, described above, in locations where older, poorer performing selections had been removed. Plots with individual selections on the same rootstock are not replicated at Madera. For each selection, one plot consists of five trees on UCB-1 rootstock in one of the blocks, and another on PG1 rootstock in the other block. Randy, Peters and B6-6 were already incorporated in the older trial, meeting the pollination requirements of the test females.

Evaluating time and quantity of bloom

Flowering data was collected in the spring of this year using the scoring system found in Table 1. The data were compiled for each plot by taking the average scores of the trees of a selection and assigning them estimated full-bloom date. The dates were then compared to the standard variety, Kerman. Time of bloom in the older advanced selection trials appears in the text later in the report.

Along with the full bloom date the male trees were scored for the quantity of flowers. Quantity of flowers per tree on the selections were estimated and given the designation of ‘F’ for few flowers (0-5 flowers), ‘L’ for light amount, ‘M’ for medium amount, ‘H’ for heavy amount of flowers, or ‘HD’ standing for heavy dense flower set. ‘NF’ designates that the selection had no flowers. The males Randy, Peters, B6-6, B16-58, and B16-30 have been evaluated for pollen viability and durability.

Evaluating yield and nut quality parameters

The estimates of harvest readiness are not precise. Harvest readiness was determined by visual inspection of the nuts for hull slippage and are an estimate of the

earliest date that harvest could occur without significant loss of yield to nut immaturity. The dates would probably have an error margin of two or three days.

In the trials established in 2002, the decision to harvest or not to harvest a given cultivar in 2010 was based both on past performance of a particular selection during past harvests in 2006 through 2009 with respect to yield and nut quality, and a visual inspection of yield and nut quality present on the tree near harvest in 2010.

Kerman, Lost Hills and Golden Hills, when present in the trial, were always harvested and used as a basis of comparison. In 2010, the nuts of some selections in the 2002- planted trials that were thought to have commercial possibilities were mechanically shaken from the tree and collected on tarps along with the plots containing Golden Hills, Lost Hills and Kerman for comparison. Most of the leaves and twigs were separated from the nuts, and the nuts weighed using calibrated scales. Nut removal is not 100 percent. Yields, as expressed in the results, are typical of those obtained in a typical commercial harvest.

At the Twisselman trial, the nuts were harvested mechanically with a shaker and catching screen which separated the large trash from the nuts and transferred the remaining nuts to a bin or bins. At Madera, the older trial was harvested with an almond shaker and the nuts collected on tarps and transferred to a bin. The bin and nuts were weighed in the field.

In 2010, a single 20-lb green-weight sample was removed from each replicate of all of the plots that were harvested at each experimental site. In past years, two samples were removed from some plots, usually at Twisselman and Madera, however, the results from the two samples were generally very similar. The 20-lb samples were transported to a pistachio processor on the day of harvest to begin the process of nut quality evaluation. Nut quality was determined by technicians trained by the United States Department of Agriculture. In the process of evaluating nut quality, nuts are basically divided into three categories as follows: edible, split inshell nuts, shelling stock, and closed shell nuts. Foreign matter and very small nuts are placed into a fourth category but usually make up a small percentage of the final sample. Nuts in the shelling stock category have shells that are split, but have defects in the shell that require that the shell be removed before sale. Defects include stained shells, shells with adhering hull, split shells in which the kernel has been lost, small nuts, and otherwise damaged shells. Closed shell nuts are nuts, both blanks (i.e. no kernel), and nuts with kernels that are not split. In the analysis, both shelling stock and closed shell nuts are eventually shelled. Edible weight (also called grower-paid weight) is considered the sum of the weight of clean, edible split inshell nuts plus only the edible kernels from shelling stock nuts and closed shell nuts. Total yield (CPC yield) includes the edible weight described above plus the weight of the shells from shelling stock and closed shell kernels. All yields on a per acre basis were adjusted downward by 4.0 % assuming a 1:24 male to female ration in the orchard.

RESULTS AND DISCUSSION

Bloom

Oldest Advanced Selection Trials, Twisselman (planted in 1997) and Madera (planted in 1999)

At Twisselman, average full bloom for Golden Hills and Kerman for the period from 2004-2010, was April 3 and April 9, respectively. For the older Golden Hills and Kerman trees at Madera from 1997 through 2010, the average full bloom date was April 9 and April 13, respectively. The average Lost Hills bloom date is normally about 2 days later than that of Golden Hills. The pollenizer for Golden Hills and Lost Hills is the Randy male. The Randy male has a long bloom period with full bloom closely approximating Golden Hills and Lost Hills.

New Advanced Selection Trials at Tejon and Little Creek planted in 2002

For 2009 and 2010 bloom-time data and flowering quantity are recorded in Tables 2 (females) and Table 3 (males) for the 2002-planted advanced-selection trials. Bloom time is shown as 'numbers of days different' from full bloom dates of Kerman. Usually, as trees age, bloom dates become more stable. Kerman full bloom has been in the later part of the blooming period of the trial selections. In 2009 and 2010 most female selections bloomed earlier than Kerman. B4-41 bloomed so much earlier than Kerman that it would be at substantially increases risk from late winter freeze events at some San Joaquin Valley locations. The yield of B4-41 may be comprised by the absence of a male that blooms similarly early. Bloom for a given selection usually extends for a period of 10 to 15 days. The group of selections that were estimated to flower within a few days of Kerman should be considered to have similar bloom times. When comparing Kerman to the male selections the data shows that the timing of full boom in Kerman falls in the middle of the bloom period. Evaluation of some selections for bloom has been difficult because of lack of flowers or because of an extended bloom period, with flowers of variable age on the same tree at the same time. Selections with very different full bloom ratings among locations and years are attributable to this. Variable bloom timing on a given tree is reflected in the generally undesirable characteristic of differential nut maturity across the tree at harvest time.

Harvest Date, Nut quality and yield

Oldest Advanced Selection Trials, Twisselman (planted in 1997) and Madera (planted in 1999)

Of the original nine female selections selected for further evaluation in 1996, two were selected as cultivated varieties and released to the pistachio industry by the University of California in 2005, as was one of the two male selections as a pollenizer for the female varieties. The female varieties were called Golden Hills, Lost Hills and the male, Randy. Values for total yield, edible yield (i.e. grower-paid weight), selected nut

quality characteristics and harvest readiness date for the older trials at Twisselman (in Kern County) and Madera are presented in Tables 4, 5, 6 and 7.

In 2010, we conducted the final comparative harvest among the cultivars Golden Hills, Lost Hills and Kerman at these oldest trial sites. Golden Hills and Lost Hills were released as cultivars by the University of California in 2005. Beginning next year in 2011, increasing commercial tonnage of these nuts will be arriving at processing facilities, and for these cultivars growers will no longer have to rely solely on data from small research trials for performance evaluation.

In Kern County in 2010, both Kerman and Golden Hills showed reduced yields as a result of the high on-bearing year of 2009 (see Table 4 and Figure 1). Lost Hills continued to demonstrate reduced alternate bearing compared to Kerman and Golden Hills (see Figure 1 at the end of this report). However, at Madera, in 2010, these cultivars were on an on-bearing year. Yield and nut quality results of these older cultivars at Madera, are presented in Tables 6 and 7.

Perhaps the most noteworthy characteristic of Golden Hills and Lost Hills is their earlier harvest-readiness by about two weeks compared to Kerman (see Tables 4 and 6). The nuts of Lost Hills continued to demonstrate weaker shell-hinge strength than Golden Hills and Kerman. How much of a disadvantage this may prove to be will probably have to wait processing of the first large-scale commercial harvests, probably in 2011.

At Madera, the cultivars are on two different rootstocks, PG1 and UCB1. Generally, for cumulative or average characteristics from 2004 through 2010, there have been no differences in performance characteristics between PG1 and UCB1 rootstocks. For the few characteristics where significant differences occurred, the differences in the values were minor (data not shown).

New Advanced Selection Trials at Tejon, Little Creek and Madera planted in 2002

Most selections have already demonstrated sufficiently poor yield, nut quality problems, rank growth or graft-union characteristics during the past four years that probably make them unsuitable for further consideration as commercial cultivars. These selections are no longer being harvested.

Cumulative yield and average nut-quality characteristics are presented from 2007-2010 for trees currently in ninth-leaf. Results from the Tejon trial are presented in Tables 8 and 9, Little Creek in Tables 10 and 11, and from the 2002-planting at Madera in Tables 12 and 13. In general, in 2010, all of the cultivars demonstrated more closed shell, probably as a result of the cooler growing season. Over the four years of harvests shown, B18-68 demonstrated high levels of edible yield, even though the percentage of closed shell was high.

In general, nut maturity was most advanced at Tejon, and latest at Little Creek, which tends to have cooler spring and summer temperatures. Crow depredation that occurred at Tejon in 2008 was not a problem in 2009 and 2010, thanks to the loan of a sonic bird repelling machine to the project by Mr. Rod Stiefvater of RTS Agri Business. A number of selections continued to demonstrate very uneven nut maturity, made worse in a year that uneven nut maturity was the norm even in many commercial Kerman blocks. In these selections, a significant number of nuts reached harvest maturity in late August while an equally significant number of nuts had not yet matured by late

September. Selections like this tend to have an excessive amount of early hull split, adhering hull, shell staining and are difficult to shake. Generally, compared to its performance at Twisselman and the older trial at Madera, Lost Hills has shown a greater incidence of early shell splitting in the younger blocks established in 2002. The reasons for this difference in performance are not known. Kerman, Golden Hills, and B18-68 have demonstrated relatively even nut maturation across the tree for the past four years in all of the younger trials.

The delayed harvest as a result of the cooler spring and summer temperatures in 2010, demonstrated that Lost Hills and Golden Hills are more susceptible to the fungal disease *Alternaria* late blight than is Kerman. The nuts of Golden Hills and Lost Hills mature about 2 weeks earlier than Kerman and after harvest the leaves normally begin to dry, usually before those of Kerman. This season, these early senescent leaves were colonized by *Alternaria* at the Madera trial which is located adjacent to the San Joaquin River and at Little Creek, which is in the Highway 99 corridor of Kern County. In both these areas both almonds and pistachio have had greater problems with *Alternaria* late blight historically. The later harvest this season gave *Alternaria* more time in the fall to develop on leaves and rachises which resulted in more early-split nuts, adhering hull and staining of nuts. *Alternaria* was not a problem at the drier trial locations at Tejon and Twisselman.

CONCLUSIONS

This project continued to evaluate the genetic material in the advanced selection trials for potential new cultivars and/or genetic sources for traits that may be useful in a future breeding program. The advanced selections in the trials established in 2002 exhibited a range of flowering, yield and nut quality characteristics. The qualities of Kerman, Golden Hills and Lost Hills are such that the likelihood of finding selections superior to these without other serious quality flaws are relatively low and not many selections remain under serious consideration. The harvest results for the trials established in 2002 were in 2010, in the ninth-leaf and, thus, are preliminary with respect to surmounting the hurdle necessary for release as cultivars. Based on our experience with the older advanced-selection trials, our current thinking is that the advanced selections that demonstrate early commercial potential should be evaluated for eight years (i.e. four alternate bearing cycles) beginning with the 6th leaf, before and if they are released as new cultivars for general planting. We are currently 38% of the way toward meeting that goal with what appears to be the best of these selections in the trials planted in 2002.

In 2005, Golden Hills, Lost Hills and Randy were released by the University of California to various nurseries, under license, for budwood increase and commercial sales. Harvest results collected from 2006 through 2010 in these younger trials, continue to support Golden Hills and Lost Hills and their pollenizing male Randy, as being useful cultivars for the California pistachio industry. The observation that Lost Hills produced nuts with moderately poorer shell hinge strength compared to Kerman and Golden Hills, and, in the new trials especially, Lost Hills' higher incidence of early shell splitting and more variable rate of nut maturation on the tree remain valid concerns, while is reduced alternate bearing and large nut size remain positive attributes.

The original seedling selection plots created by Mr. Maranto and Dr. Parfitt, as are some of the original parent materials, are now gone. However, germplasm lives on in the new varieties Golden Hills, Lost Hills and Randy, and in at least one advanced selection strain in the three new advanced selection plots established in 2002. Additional trials with advanced selections from new breeding efforts conducted in 2000, and with previously untested existing cultivars obtained from the mid-East in the past, were planted in 2007 and 2010, and contain promising potential cultivars.

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TABLES SECTION

Table 1. Flower emergence scores.	
Scoring number	Degree of flowering
0	Dormant or red bud
1	Green tip
2	Early bloom, some open with pistils or pollen showing
3	Mid bloom, 50% open
4	Full bloom, 80% open
5	Late Bloom, 100% open or finished

(NOTE: Put in Figure of annual yield by year for the three cultivars.

Table 2. Flowering date and flower quantity of the female pistachio selections at each location for 2009 and 2010. Full bloom was estimated as the time of maximum number of open flowers (rating of 4 from Table 1). Full bloom of selections was recorded in numbers of days from the standard industry variety, Kerman.(a '-' sign indicates days bloom before Kerman).

Selection	Tejon full bloom, days from Kerman 2009	Tejon full bloom, days from Kerman 2010	Little Creek full bloom, days from Kerman 2009	Little Creek full bloom, days from Kerman 2010	Madera full bloom, days from Kerman 2009	Madera full bloom, days from Kerman 2010
B4-41	-17	-18	-22	-17	*	*
W21-74	-17	-15	-15	-13	-10	-16
B15-69	-13	-12	-12	-12	-11	-11
B2-21	-16	-15	-12	-15	*	*
B18-68	-12	-11	-12	-13	-7	-13
B20-62	-11	-9	-9	-7	-9	-11
W24-56	-8	-11	-6	-4	-1	-8
B6-21	-10	-8	-5	-1	-6	-11
Golden Hills	-9	-7	-10	-12	*	*
B4-8	-6	-5	-6	-7	*	*
W20-123	0	-7	1	-4	-2	-10
Lost Hills	-6	-9	-8	-8	-6	-11
W19-63	-4	-9	-5	-4	-7	-12
B23-5	-4	-3	-5	-5	-7	-9
B16-32	-13	-8	-13	-8	-6	-7
W21-51	-2	-5	-6	-3	-3	-5
B15-21	-4	-8	-3	-7	*	*
B2-6	1	-3	-2	0	-2	-4
W19-36	-3	-1	-3	-4	-2	-2
B1-69	2	-2	-3	-6	*	*
B22-17	-4	-2	-4	few flowers	-5	-2
W5-48	0	0	-2	1	-2	-2
Kerman	4/21/09	4/21/10	4/19/09	4/16/2010	4/16/09	4/18/10
W20-124	2	-5	6	few flowers	-2	-1
W22-37	3	5	1	few flowers	3	0
W22-92	1	-4	1	few flowers	1	1
* Selection not present in trial as 9th leaf tree.						

Table 3. Flowering date and flower quantity of the male pistachio selections at each location for 2009 and 2010. Quantity of flowers on the selections were estimated and given the designation of ‘F’ for few flowers, ‘M’ for medium amount, ‘H’ for heavy amount of flowers, or ‘VH’ for very heavy flower set. ‘NF’ designates that the selection had no flowers. Full bloom was estimated when maximum numbers of flowers were open (rating of 4 from Table 1). Full bloom of selections was recorded in numbers of days from the standard female variety, Kerman (a ‘-’ sign indicates days bloom before Kerman).

Selection	Tejon Quantity of flowers 2009	Tejon Quantity of flowers 2010	Little Creek quantity of flowers 2009	Little Creek quantity of flowers 2010	Tejon Full bloom, days from Kerman 2009	Tejon Full bloom, days from Kerman 2010	Little Creek full bloom, days from Kerman 2009	Little Creek full bloom, days from Kerman 2010
16-58	VH	H-VH	VH	VH	-13	-8	-12	-9
15-70	VH	H	VH	H-VH	-7	-9	-6	-7
22-20	VH	VH	VH	VH	-4	-7	-6	-6
Randy	VH	VH	VH	VH	-6	-7	-6	-7
15-43	VH	VH	VH	VH	-7	-8	-1	-9
7-10	VH	VH	M	F	-2	-6	1	-7
16-30	H-VH	H-VH	VH	H	-3	-3	-2	-5
19-69	M-H	H	H	VH	-3	-3	0	-2
16-50	M-H	H	F-M	F-M	-4	-3	0	0
16-51	H	M-H	VH	M	-4	1	-1	2
16-61	H	H-VH	M	H-VH	-3	1	0	-4
Kerman ¹					4/21/2009	4/21/10	4/19/2009	4/16/2010
2-42	H	H	H	F-M	1	2	0	2
4-64	H	M-H	H	M-H	-3	1	0	4
19-18	H	M-H	VH	H	2	0	1	4
18-50	M	F-M	F	F	2	2	1	2
22-55	H	F-M	H	H	0	0	2	-2
19-22	H	M	H	M	6	2	6	7
20-36	F	F	NF	F	7	2	NF	7
17-69	HD	M-H	M	F-M	6	12	6	7
2-53	M	F-M	H	F	4	4	0	5
6-6	M	M-H	H	M-H	2	2	2	5
15-20	female ²	female ²	M-H	M	female ²	female ²	1	-2
4-21	female ²	female ²	female ²	female ²	female ²	female ²	female ²	female ²
¹ Standard industry female variety								
² Error in selection or budding.								

Table 4. Yield, cumulative edible yield, insect damage and harvest-readiness date of Kerman, Golden Hills and Lost Hills in northwestern Kern County (Twisselman) in 2010. Cumulative and average values, where reported, is for 6th through 14th leaf.

cultivar	Yield (CPC), 2010, lbs/acre	Edible yield ^z , 2010, lbs/acre	Cumulative edible yield ^z , 2002 – 2010, lbs/acre	Average insect damage, all sources, % ^y , 2002-10	Average harvest readiness date, 2002-10
Kerman	2663 a ^x	2435 a	25,213 a	1.4 b	Sept. 13
Golden Hills	2350 a	2284 a	33,919 a	0.2 a	Aug. 30
Lost Hills	4377 a	4245 a	31,050 a	0.4 a	Sept. 1

^z Includes edible split inshell nuts, and only the kernels from shelling stock and closed shell. Also known as grower paid weight. Total yield, in the previous column, also includes the shells from shelling stock and closed shell. All yields adjusted downward for non-producing males per acre.

^y All percentages expressed as a percentage of a 500 gram nut subsample removed from the hulled and processed 20-lb samples (adjusted to 5% moisture) that were collected from each replicated test plot in the trial at harvest.

^x Different letters in the same column denote significant differences using Fisher's protected LSD test at $P \leq 0.05$

Table 5. Average individual nut weight and other selected nut quality characteristics in 2010 of 14th leaf Kerman, Golden Hills and Lost Hills cultivars in northwestern Kern County (Twisselman). Values are averaged for 6th through 14th leaf (2002-10).

cultivar	Average edible split inshell, %	Average shelling stock, all sources, %	Average closed shell, all sources, %	Average loose kernels and shells ^z , %	Average nuts smaller than 30/64 inch ^z , %	Average individual nut weight, grams
Kerman	71.2 a ^y	4.2 a	23.0 a	0.5 a	1.6 b	1.25 a
Golden Hills	86.1 b	3.9 a	9.3 a	0.6 a	0.5 b	1.28 a
Lost Hills	87.1 b	5.0 a	7.0 b	2.8 b	0.0 a	1.45 b

^z This nut quality factors is a component of shelling stock.

Column 2 + Column 3 + Column 4 + Foreign matter (not shown) = 100% of sample.

^y Different letters in the same column denote significant differences using Fisher's protected LSD test at $P \leq 0.05$

Table 6. Yield, cumulative edible yield, percent insect damage, and harvest readiness date of oldest Kerman, Golden Hills and Lost Hills cultivars in Madera County in 2010. Cumulative yield, where reported, is for 6th through 12th leaf.

cultivar	Total yield (CPC) 2010, lbs/acre	Edible yield, 2010, lbs/acre	Cumulative edible yield 2004 – 2010, lbs/acre	Average insect damage, all sources, % 2004-10	Average harvest readiness date, 2004-10
Kerman	6889 a ^z y	6404 a	17,670 a	0.6 a	Sept. 18
Golden Hills	5914 a ^x	5690 a	17,370 a	0.6 a	Sept. 5
Lost Hills	5953 a	5687 a	20,084 b	0.6 a	Sept. 5

^z Different letters in the same column denote significant differences using Fisher's protected LSD test at $P \leq 0.05$

^y Values for Madera are the average of cultivar performance on PG1 and UCB-1 rootstock.

^x The upper canopy of Golden Hills trees were severely pruned back to 1- inch diameter wood in the winter 2008-09, which reduced yield that year.

Table 7. Average Individual nut weight and other selected nut quality characteristics in 2010 of 12th leaf Kerman, Golden Hills and Lost Hills cultivars in Madera County. Values are averaged for 6th through 12th leaf (2004-10).

cultivar	Average edible split inshell, %	Average shelling stock, all sources, %	Average closed shell, all sources, %	Average loose kernels and shells ^z , %	Average nuts smaller than 30/64 inch ^z , %	Average blanks ^y , %	Average individual nut weight, grams
Kerman	73.5 a ^{xw}	8.7 a	17.6 b	1.5 b	0.2 a	9.7 b	1.4 b
Golden Hills	84.5 c	7.6 a	7.6a	0.6 b	0.4 a	4.8 a	1.3 a
Lost Hills	83.3 b	9.2 a	7.2 a	3.0 c	0.3 a	4.7 a	1.4 b

^z This nut quality factor is a component of shelling stock.

^y This nut quality factor is a component of closed shell.

^x Different letters in the same column denote significant differences using Fisher's protected LSD test at $P \leq 0.05$

^w Values for Madera are the average of cultivar performance on PG1 and UCB-1 rootstock.

Table 8. Edible yield and selected average nut quality characteristics; shelling stock, closed shell from all sources, clean inshell split percentages, nut weight and harvest readiness date from 2007-2010 at Tejon (east of the I-5 Grapevine in Kern County). In 2010 the trees were in 9 th leaf (grafted 2002).							
selection or variety	edible yield ^z , lbs/acre 2010 only	Cumulative edible yield ^z , 2007-2010	Average edible split inshell nuts, % ^x	Average shelling stock, % ^x	Average closed shell all sources ^y , % ^x	Average single nut weight, g	Average harvest readiness date
B18-68	4004 a ^w	8558 a ^v	83.0 ab	2.4 a	13.5 b	1.27 a	Aug. 29
Lost Hills	4220 a	7833 a	87.7 bc	4.2 b	7.1 a	1.36 b	Sept. 1
Golden Hills	5117 b	8847 a	91.0 c	2.0 a	6.5 a	1.27 a	Aug. 30
Kerman	5005 b	8237 a	81.0 a	1.7 a	16.6 b	1.36 b	Sept. 12

^z Includes edible split inshell nuts, and only the kernels from shelling stock and closed shell. Also known as grower paid weight. Adjusted for non-producing males.

^y Includes blanks, insect damaged closed shell, edible closed shell, etc.

^x All percentages expressed as a percentage of a 500 gram nut subsample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest.

^w Different letters in the same column denote significant differences among means using Fisher's protected LSD test at $P \leq 0.05$.

^v B18-68 was the only cultivar of those listed that had harvestable yield in the 5th leaf (average of 339 lbs/acre in 2006).

Table 9. Average percent edible closed shell nuts, loose kernels and shells, total insect damage, small nuts passing through 30/64th inch screen, and dark stain for the years 2007 through 2010 at Tejon (east of the I-5 Grapevine in Kern County). In 2010 trees were in 9th leaf.

selection	Average loose kernels and shells, % ^z	Average total insect damage ^y , % ^z	Average small nuts, diam. less than 30/64 % ^z	dark stain, % ^z
B18-68	0.8 a	0.4 b	0.0 a	0.7 b
Lost Hills	2.6 b	0.2 a	0.1 a	0.4 a
Golden Hills	0.5 a	0.2 a	0.6 b	0.3 a
Kerman	0.7 a	0.1 a	0.2 a	0.2 a

^z All percentages expressed as a percentage of a 500 gram nut sample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest. All of the nut quality factors listed in this table are components of shelling stock.

^y Includes insect damage from edible, split inshell, shelling stock and closed shell.

^x Different letters in the same column denote significant differences among means using Fisher's protected LSD test at $P \leq 0.05$.

Table 10. Edible yield and selected average nut quality characteristics; shelling stock, closed shell from all sources, clean inshell split percentages, nut weight and harvest readiness date from 2007-2010 at Little Creek (east of Wasco in Kern County). In 2010 the trees were in 9th leaf (grafted in 2002).

selection or variety	edible yield ^z , lbs/acre 2010 only	Cumulative edible yield ^z , 2007-2010	Average edible split inshell nuts, % ^x	Average shelling stock, % ^x	Average closed shell all sources ^y % ^x	Average single nut weight, g	Average harvest readiness date
B18-68	3936 b ^w	8603 a	77.5 a	3.6 a	17.8 c	1.35 ab	Sept. 10
Lost Hills	2950 a	7103 a	82.4 b	11.4 c	5.3 a	1.39 b	Sept. 17
Golden Hills	4016 b	7430 a	87.7 c	5.7 b	5.9 a	1.36 b	Sept. 10
Kerman	4719 b	7781 a	81.0 b	5.3 ab	12.5 b	1.29 a	Sept. 21

^z Includes edible split inshell nuts, and only the kernels from shelling stock and closed shell. Also known as grower paid weight. Adjusted for non-producing males.

^y Includes blanks, insect damaged closed shell, edible closed shell, etc.

^x All percentages expressed as a percentage of a 500 gram nut subsample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest.

^w Different letters in the same column denote significant differences among means using Fisher's protected LSD test at $P \leq 0.05$.

Table 11. Average percent edible closed shell nuts, loose kernels and shells, total insect damage, small nuts passing through 30/64th inch screen, adhering hull and dark stain for the years 2007 through 2010 at Little Creek (east of Wasco in Kern County). In 2010 the trees were in 9th leaf (grafted 2002).

selection	Average loose kernels and shells, % ^z	Average total insect damage ^y , % ^z	Average small nuts, diam. less than 30/64 % ^z	Average dark stain, % ^z	Average adhering hull, % ^z
B18-68	0.8 a	0.8 a	0.1 a	1.5 a	0.5 a
Lost Hills	4.4 b	0.7 a	0.2 a	3.0 b	2.8 c
Golden Hills	1.3 a	0.5 a	0.8 b	1.3 a	1.6 b
Kerman	1.2 a	0.8 a	0.5 ab	1.2 a	1.6 b

^z All percentages expressed as a percentage of a 500 gram nut sample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest. All of the nut quality factors listed in this table are components of shelling stock.

^y Includes insect damage from edible, split inshell, shelling stock and closed shell.

^x Different letters in the same column denote significant differences among means using Fisher's protected LSD test at $P \leq 0.05$.

Table 12. Cumulative edible yield in pounds per acre, and average nut quality characteristics; edible split inshell percentage, shelling stock, closed shell from all sources, for 6th -9th leaf- pistachio selections on UCB-1 and PG1 rootstocks in Madera County, from 2007 – 2010.

Selection/rootstock	Cumulative edible yield, lbs/acre	Average, split inshell nuts, % ^y	Average shelling stock, % ^y	Average closed shell all sources ^z , % ^y	Average individual nut weight, grams	Average harvest readiness date
B18-68/UCB-1	7817	76.5	2.2	20.4	1.36	Sept. 4
B18-68/PG1	8381	68.6	3.4	27.1	1.40	Sept. 4
Kerman/UCB-1	8437	77.3	2.0	17.8	1.42	Sept 14
Kerman/PG1	7411	77.3	2.6	21.1	1.31	Sept 14
Lost Hills/UCB-1	9808	87.4	5.5	5.7	1.44	Sept 4
Lost Hills/PG1	8698	86.9	4.4	7.7	1.44	Sept 4

^z Includes blanks

^y All percentages expressed as a percentage of a 500 gram nut sample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest.

Note Golden Hills was not included in the trial established in 2002.

Table 13. Cumulative edible yield in pounds per acre, and average nut quality characteristics; edible split inshell nuts, shelling stock, closed shell from all sources, blank nut and dark stain percentage for 6th-9th leaf- pistachio selections on UCB-1 and PG1 rootstocks in Madera County, from 2007 – 2010 (note: Due to space limitations, these cultivar/rootstock combinations were not replicated in the younger trial so no statistical analysis was done. Without replication in the trial, plot location can overwhelm true cultivar and rootstock differences).

Cultivar/ rootstock	Edible yield, lbs/acre	Average split inshell nuts, % ^z	Average shelling stock, % ^y	Average closed shell all sources ^z , % ^y	Average dark stain, % ^{y, x}	Average blank nut, % ^{y, w}	Average individual nut weight, grams	Average harvest readiness date
B18-68/UCB-1	7817	76.5	2.2	20.4	1.2	8.3	1.36	Sept. 4
B18-68/PG1	8381	68.6	3.4	27.1	1.7	9.8	1.40	Sept. 4
Kerman/UCB-1	8437	77.3	2.0	17.8	0.9	7.4	1.42	Sept 14
Kerman/PG1	7411	77.3	2.6	21.1	0.7	9.8	1.31	Sept 14
Lost Hills/UCB-1	9808	87.4	5.5	5.7	1.5	2.6	1.44	Sept 4
Lost Hills/PG1	8698	86.9	4.4	7.7	1.2	4.4	1.44	Sept 4

^z Includes blanks

^y All percentages expressed as a percentage of a 500 gram nut sample removed from the hulled and processed 20-lb sample (adjusted to 5% moisture) that was collected from each replicated test plot in the field at harvest.

^x This nut quality factor is a component of shelling stock.

^w This nut quality factor is a component of closed shell.

Note Golden Hills was not included in the trial established in 2002.

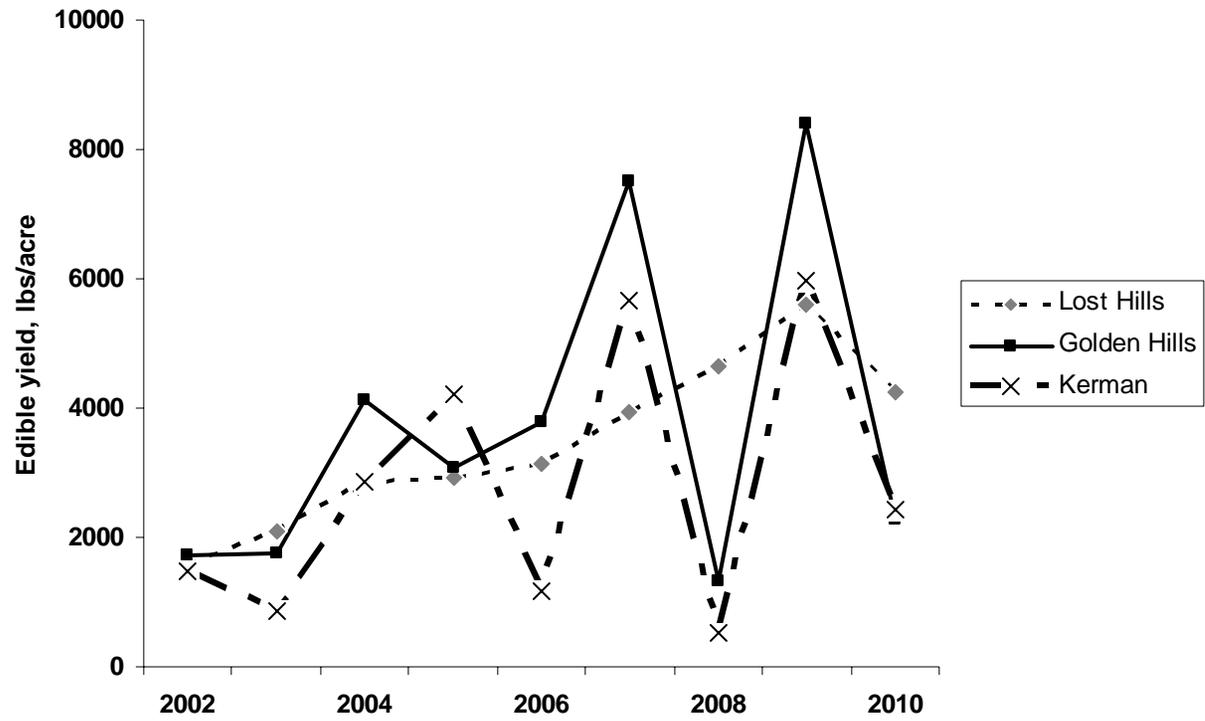


Figure 1. Alternate nut bearing pattern for Lost Hills, Golden Hills and Kerman from 6th through 14th leaf at Twisselman in northwestern Kern County, 2002-2010. Note the reduced alternate bearing Pattern of Lost Hills.