Table 2. Defoliation of black locust seedlings 2 weeks after treatment with ethephon and shoot damage after 1 month.

Ethephon (ppm)	Defoliation[z] (%)	Damage[y] rating
0	0 d	0
300	24 c	0
600	53 b	0
1,200	79 ab	0
2,400	94 a	0

[z]Mean separation by Duncan's multiple range test, 1% level.

[y]Rating (0 = no damage; 10 = 100% damage).

was to the succulent tips from the high levels of endothall/ethephon. Refoliation of the undamaged shoots of Chinese elm, white ash, live oak, and black locust took place within 1 month after treatment and white oak and pin oak refoliated within 2 months. As was noted by Davis et al. (1) on bean, it appeared that levels of endothall and ethephon which caused slight leaf injury were more effective chemical abscissors. This mild injury to the leaf probably facilitated the penetration of sublethal quantities of both chemicals (3).

Research is in progress on ornamental nursery stock in the field to determine defoliation responses during different stages of growth including the period prior to natural abscission.

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Parthenocarpy—A Factor Contributing to the Production of Blank Pistachios[1]

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Abstract. **During a 4-year period, 'Kerman' pistachio trees (*Pistacia vera*) produced an average of 26% blank nuts. Production of blanks by individual trees remained relatively constant from year to year and was not associated with yield or position of the trees in relation to pollinators. Blank production was also found to be a characteristic of *P. atlantica* Desf. and *P. chinensis* Bunge. Results demonstrated that production of blanks, at least in 'Kerman', is partly the result of parthenocarpy.**

The production of blank (empty, except for the funiculus) pistachio nuts is an important problem wherever the crop is produced (4). The scant literature on the subject, however, contains little more than vague speculation as to the underlying cause of this phenomenon. Grundwag and Fahn (3) in Israel tried to clarify the situation through an embryological study; but they merely described instances of degeneration of megaspore mother cells, megaspores, and embryo sacs, all of which normally result in flower abscission. In addition, they found a few flowers on some trees, and all flowers on other trees, to be devoid of megaspore mother cells and embryo sacs. However, they did not indicate whether blank pistachios were produced on trees in which all flowers lacked embryo sacs, nor did they imply that parthenocarpy might be involved in the production of blanks.

In the study described here, blank production in 'Kerman' (1), currently the only female pistachio being planted commercially in California, was compared to that in other cultivars and species. Also, the possible involvement of parthenocarpy in blank production was studied.

In 1961, seedling rootstocks of *P. atlantica* at the Wolfskill Experimental Orchards, Winters, California were budded to 'Peters' (staminate) and 'Kerman' (pistillate) cultivars in a ratio of 1:6 trees, respectively. Individual yield records of 24 'Kerman' trees have been maintained since they began bearing in 1969. The average percentage of blank nuts was determined from three 100-nut samples per tree. The variation among samples from individual trees generally did not exceed 4%.

The 4-year average blank production per individual tree varied from a low of 14.7% to a high of 38.7% (Table 1). With the exception of tree 1-11 in 1972, the individual trees consistently produced relatively high or relatively low percentages of blanks each year. Average blank production varied from a low of 20.3% in 1970 to a high of 31.7% in 1972. The seriousness of the problem is indicated by the fact that blank production of all trees averaged 26.2% for the 4-year period.

The degree of blank production was not associated with yield of the individual tree (Table 1). For example, average yield of tree 2-8 was almost twice that of 1-11; yet there was a difference of only 1% in blank production between the trees. Likewise, tree 3-5 yielded 3 times more than 1-9, with only 0.5% difference in blank production. Although similar average yields of all trees occurred in 1970 and 1972, the greatest extremes in blank production also occurred, 20.3 and 31.7%, respectively.

Position with respect to the prevailing wind and proximity to staminate trees, both of which would have an effect on degree of pollination, are factors that might also be related to the production of blanks. However, neither seems to be operative in this instance. For example, tree 2-6 was more favorably situated for pollination than was 2-8. Yet, 2-6 produced the highest average percentage of blanks of all trees in the orchard, whereas 2-8 was third lowest in this respect. Because of these findings, and because yield and blank production do not seem to be related, it is tentatively concluded that variation in blank production from tree to tree is a rootstock effect.

Table 1. Blank production, by count, and yield of in-shell 'Kerman' pistachios. The data are for the 5 out of 24 trees that produced the least, and for the 5 that produced the greatest, percentages of blanks during the 4-year period.

Row and tree	Blanks (%)					Yield (kg)				
number	1969	1970	1971	1972	Avg	1969	1970	1971	1972	Avg
4–13	19	10	10	20	14.7	6.3	3.1	14.7	3.4	6.8
4–12	13	18	14	18	15.7	7.5	17.5	12.5	15.8	13.3
2–8	22	13	20	24	19.7	13.2	14.4	23.9	20.8	18.0
1–11	13	19	18	33	20.7	7.9	7.5	15.0	9.1	9.8
2–2	23	19	21	22	21.2	5.0	12.1	6.1	10.7	8.4
2–10	20	23	27	44	28.5	5.8	7.5	8.0	3.7	6.2
3–1	34	29	31	39	33.2	6.8	8.7	10.6	10.3	9.1
3–5	46	25	29	39	34.7	7.1	10.8	8.6	11.7	9.5
1–9	55	24	30	32	35.2	1.0	4.0	3.2	3.4	2.9
2–6	49	23	37	46	38.7	5.5	8.3	13.1	10.2	9.2
Avg	29.4	20.3	23.7	31.7	26.2	6.6	9.3	11.5	9.9	9.3

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To compare blank production by 'Kerman' to that of other cultivars, nut samples were obtained from a commercial orchard at Elk Grove, California and from a cultivar collection at the Wolfskill Experimental Orchards. Trees at both locations were 40-50 years old, and were propagated on *P. atlantica* seedling rootstocks. The data revealed that the production of blanks is common to all cultivars studied and that the degree to which this trait is expressed by a particular cultivar is generally consistent from year to year (Table 2). With the exception of 'Bronte', 'Kerman' consistently produced more blanks than did all other cultivars, including 'Lassen', a sister seedling.

To determine if the production of blanks occurs in species other than *P. vera*, seeds were collected from 10 mature *P. atlantica* seedlings growing in the Elk Grove orchard and from 10 *P. chinensis* trees in a residential area of Davis. The nuts from the *P. atlantica* trees ranged from 23 to 100% blanks, with an average of 58% (Fig. 1). Blank production by *P. chinensis* ranged from 1 to 72%, with an average of 22%. Thus, production of blanks is a characteristic common to at least 3 species in the genus *Pistacia*.

The fact that a few blank 'Kerman' nuts were produced on control branches bagged to exclude pollen in a pollination study in 1971 indicated that parthenocarpy might be involved. Therefore, in 1972, 6 branches, each bearing several inflorescences on each of 3 trees, were enclosed in bags made of tightly woven, white cotton gabardine, material that had proven satisfactory in walnut breeding operations (5). The bags were put in place before the inflorescences had expanded sufficiently to expose the stigmas of the individual flowers. They were removed 2 weeks later after cessation of pollen shedding. Since terminal vagetative bud removal had been shown to increase parthenocarpic fruit set in the fig (2), the terminal vegetative buds were removed at the time of bagging from 3 of the experimental branches on each tree. To estimate the percentage of nut-set per cluster, the individual flowers on each of 25 clusters picked at random were counted. The average number of flowers was 133.

Only 2 of the 18 bagged branches failed to produce some fruits (Table 3), and these were with vegetative buds intact. Furthermore, all fruits on all branches were blanks. The absence of shoot growth resulted in increased percentages of inflorescences, and of flowers, that produced parthenocarpic fruits. The average parthenocarpic fruit set per cluster not in competition with vegetative growth was 7.5% compared to 1.7% for clusters competing with shoot growth (Fig. 2).

Another indication of the potential 'Kerman' has for expressing parthenocarpy was revealed by an unusual phenomenon that occurred in 1972. The tips of at least 5 shoots on as many trees were broken off early in the season, presumably by wind. The terminal-most inflorescence bud on each shoot expanded and bloomed the first part of June, 10 months ahead of the time it normally would have bloomed. Although no pollen was available at that time for pollination, parthenocarpic fruit sets of 9.0 to 37.6% occurred (Fig. 3).

Table 2 Percent blank production, by count, of several pistachio cultivars growing at 2 locations.

Cultivar	1970	1971	1972
		Elk Grove	
Red Aleppo	1.7	--	6.0
Trabonella	11.3	--	12.0
Bronte	20.0	51.3^{z}	26.0
		Wolfskill Experimental Orchards	
Trabonella	7.7	--	8.9
Damghan	13.0	17.0	14.5
Lassen	13.7	13.0	15.3
Kerman	20.3	23.7	31.7

^{z}A severe postbloom frost may have killed some ovules.

Fig. 1. Clusters from a seedling of *Pistacia atlantica* that produced 43% blank nuts. The blank nuts are reddish (black in photo), and the seeded ones are greenish-blue (white in photo).

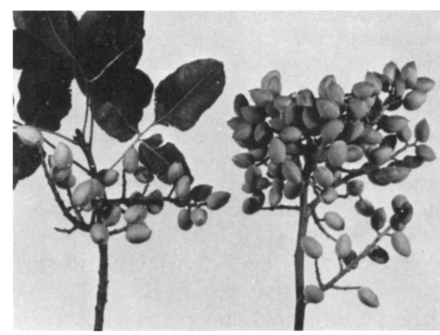

Fig. 2. Parthenocarpic fruit-set on 'Kerman' pistachio branches with and without current-season's shoot growth that were bagged during the pollination period.

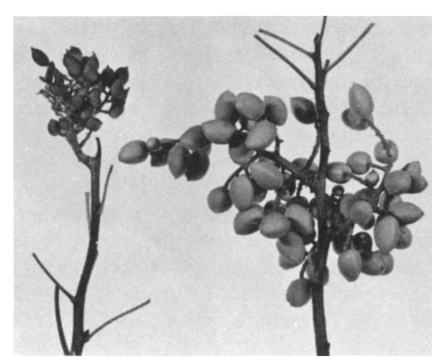

Fig. 3. Parthenocarpic 'Kerman' pistachio nuts produced 1 year ahead of normal time on a current-season's shoot (left), compared with those resulting from fertilization which are produced normally on 1-year-old wood (right). The blades were removed from the leaves to show the position of cluster attachment. Photo June 27, 1972.

Table 3. Parthenocarpic fruit–set in the 'Kerman' pistachio as affected by the presence and absence of current-season's shoot growth.

Tree and branch	Inflorescences Number bagged	Fruitful No.	Fruitful %	Range in fruit set among clusters (%)	Avg fruit set/cluster (%)
		No current growth – vegetative buds removed			
A–1	8	8	100	7.5 – 17.2	12.4
A–2	7	7	100	9.0 – 21.0	13.3
A–3	8	6	75	0 – 13.5	5.2
B–1	8	8	100	6.4 – 14.2	7.8
B–2	7	6	85.7	0 – 16.9	10.0
B–3	5	5	100	1.5 – 9.0	6.2
C–1	8	8	100	1.3 – 7.4	4.8
C–2	6	5	83.3	0 – 7.4	4.3
C–3	4	4	100	3.2 – 6.7	3.9
		Current growth – vegetative buds intact			
A–4	7	7	100	4.5 – 8.2	6.2
A–5	7	2	28.5	0 – 3.7	0.9
A–6	4	0	0	0	0
B–4	8	4	50	0 – 1.3	0.9
B–5	6	5	83.3	0 – 4.3	3.1
B–6	8	2	25	0 – 3.0	2.4
C–4	5	2	40	0 – 3.7	0.9
C–5	5	1	20	0 – 2.9	0.6
C–6	4	0	0	0	0

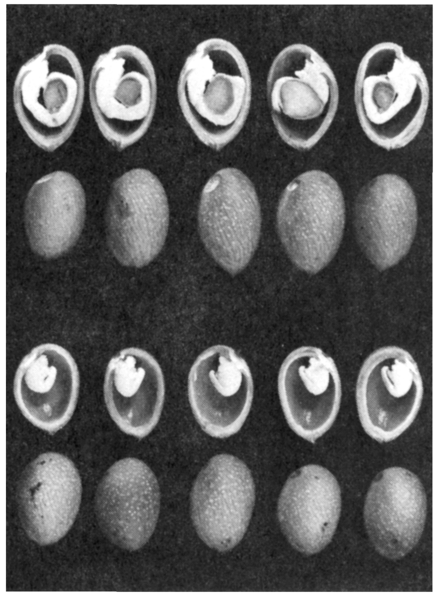

Fig. 4. Comparative development of 'Kerman' pistachio nuts resulting from pollination and fertilization (top) and from parthenocarpy (bottom). The pericarp in both instances has reached ultimate size, but expanding seeds are absent in the parthenocarpic nuts. Photo July 10, 1972.

Thus, it is established that parthenocarpy is responsible, at least in some instances, for production of blanks in the 'Kerman' cultivar, and probably in others as well. The external appearance of parthenocarpic pistachios is similar to that of nuts containing seeds (Fig. 4), and their growth patterns are also similar (1). The extent to which parthenocarpy contributes to the total blanks produced is questionable, as M. V. Bradley[3] (unpublished) has recently found that various abnormalities which occur early in the development of the seed unquestionably contribute to the production of blanks.

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A Comparison of Filbert Training to Tree and Bush Forms[1]

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Abstract. **For commercial nut production the filbert (*Corylus avellana* L.) is trained as a tree in the U.S., but is commonly grown as a bush in other countries. In a 12 year conparitive test, growth was similar for both methods of training, but the bush form produced slightly fewer nuts. Suggested causes for the reduced yields are the additional pruning the bush receives to keep traffic lanes open, the location of its bearing wood, the nuts lost within the stem mass, and the effect of shading.**

The European filbert grows naturally into a large multistem bush. In Turkey, Italy, and Spain, the principal areas of commercial production, the filbert is generally grown as a bush. In the United States, it is grown as a tree to facilitate mechanized cultural and harvesting operations. The 2 training systems had never been compared to determine their efficiency in nut production and cultural management.

In 1960, a tree-training trial was established at Wilsonville, Oregon consisting of 16 plots, 8 of which were trained as trees and 8 of which were allowed to grow naturally as bushes. Each plot consisted of 5 trees. Layered plants of 'Barcelona' were headed at 60 cm when planted. The trees were trained with 4 to 5 scaffold branches, while the bush plants had from 5 to 20 stems of varying size. All plants received minimal pruning until 1967, when annual corrective pruning was started. Yield data from 1963 to 1966 were measured as wt of green nuts per plant. Yield data for 1967 are unavailable because of a windstorm. Yields from 1968 to 1971 represent dry-nut wt per 5-tree plot (Table 1).

Height-width measurements were taken annually from 1967 to 1972. All plants were spaced 4.57 m apart and ultimately had an upright, vase-shaped habit. Width was measured in 2 directions and averaged. Measurements shown in Table 2 are the average of 20 representative plants from each training treatment. Volume in m^3 was calculated for a prolate spheroid, a plant taller than wide, by the formula $4/3\ \pi\ ab^2$, where a = ½ the height and b = ½ the width (5). Plant size (Table 2) did not differ significantly as a result of the training system. Yield differed significantly in 1 of the 4 years in which data were available for statistical analysis. While some of these yield differences are relatively small, at a density of about 480 plants/ha, trees yielded more than bushes by 181, 7, 738, and 234 kg/ha for the years 1968, 1969, 1970, and 1971 respectively.

Table 1. Filbert-nut yields from plants trained to tree and bush formes.

	Yield (kg/5-tree plot)	
Year	Tree	Bush
1963	3.06	1.18
1964	5.90	2.95
1965	9.53	7.03
1966	20.19	18.82
1967	N.A.	N.A.
1968	13.44	11.56
1969	16.76	16.69
1970	33.29**	25.61
1971	28.58	26.14

**Significantly greater than bush form at the 1% level, 2-tailed t-test.

Since plant size and calculated volume are nearly equal for both plant forms, other factors must be considered to explain yield differences. The multiple stems of the bush plant are usually long, thin, unbranched at their base, and tapered gradually toward their apex. These stems bend readily with a crop load. Those that become a barrier to orchard traffic must be eliminated in part or whole. Such convenience pruning can remove a relatively large portion of the nut-bearing wood, especially if such stems require removal at the groundline. Renewal stems grow 2 to 3 m per year, are usually crowded, and do not produce bearing wood until they reach light, or their growth rate is reduced. The lower branches of closely spaced bush plants are shaded and have proportionately less bearing wood. Nut production comes primarily from the flat-topped upper branches. The scaffold branches of the tree form expose more vegetation to the light early in the plant's life; but as these trees begin to crowd, nut production on their lower branches is also reduced. The largest filberts and the largest nut clusters are borne on wood with the greatest light exposure, a fact that would place the bush at some disadvantage.

As nuts drop from the bush plant, many lodge among the multiple stems, where they are inaccessible to the mechanical sweeper. This is not a problem in other countries where nuts

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