Inflorescence Bud Retention in 'Kerman' Pistachio: Effects of Defruiting Date and Branch Size

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Abstract. Alternate bearing in pistachio (*Pistacia vera* L.) is correlated with crop load; a heavy crop on 1-year-old wood appears to cause abscission of inflorescence buds on current wood. Defruiting heavily bearing trees before or during the period of nut growth stopped inflorescence bud loss. This relationship between crop and bud loss was affected by the fruiting status of neighboring shoots. Large defruited branches (> 5.5cm diameter), in fruiting trees had bud retention values (50% to 65%) equivalent to fully defruited control trees, but smaller branches showed reduced bud retention levels. Bud retention was increased 2- to 6-fold in small branches when neighboring branches were defruited. Nitrogen concentration of leaves in late August was positively correlated with the final bud retention percentage and inversely correlated with defruiting date.

Alternate bearing in pistachio arises as a result of inflorescence bud abscission during the year in which a heavy crop is borne (Crane and Nelson, 1971). The timing of this bud loss is closely associated with growth of the pistachio nut kernel (Crane and Iwakiri, 1987), beginning in late June or early July [$\approx$ 90 days after full bloom (AFB)] and ceasing about mid-August (Crane and Nelson, 1971; Crane et al., 1971).

Flower bud abscission in 'Koilarati' pistachio in Greece was affected by fruit removal, depending on time of treatment (Porlingis, 1974). If defruiting was done before 78 days AFB, abscission remained at low levels (< 20%) but if done 101 days AFB, bud abscission increased to 100%, leading the author to conclude that "... bud abscission was initiated at a certain bud age irrespective of the presence of fruit." However, no defruiting treatments were imposed in the period between 78 and 101 days AFB, and such information would be useful in identifying the critical period for initiation of bud abscission. The first experiment reported herein was designed to study the effects of closely timed fruit removal treatments on inflorescence bud abscission.

Reduced carbohydrate levels in heavily bearing trees or branches were implicated as a cause for bud loss (Crane and Al-Shalan, 1977; Crane et al., 1976). Data from a ¹⁴CO₂ study (Takeda et al., 1980) led to the suggestion that developing fruits induce a change in photosynthate partitioning, depleting bud

carbohydrates and resulting in bud abscission. Further evidence for this argument comes from studies in which bud loss was affected by manually adjusting leaf area and/or fruit load on individual shoots (Crane and Nelson, 1972; Crane et al., 1973; Porlingis, 1974). An implicit but untested assumption in many of these studies was that treatment response was unaffected by the fruiting status of nearby tree branches. The second experiment reported herein was designed to determine if bud loss on fruiting shoots is influenced by neighboring branches.

Experiments were conducted in commercial orchards. The one used in 1983, near Lost Hills, Calif., was an 11-year-old planting of 'Kerman' on *P. integerrima* Stewart seedling rootstock. The one used in 1984 and

1986, near Madera, Calif., was a 12-year-old planting of 'Kerman' on *P. atlantica* Desf. seedling rootstock. Significant changes in cultural practices in the orchard used in 1983 precluded its use thereafter.

Timed fruit removal. In the first experiment, four whole trees were completely defruited at weekly intervals beginning in mid-June 1983 and in late May 1984 and continuing through early August. In 1983 and 1984, respectively, five and 10 randomly selected fruiting shoots per tree were tagged and observed weekly for the loss of inflorescence buds. On each date of observation, buds were touched lightly with a fingertip to distinguish those that had formed an abscission layer but remained lodged between the leaf petiole and the shoot. Trees were visually selected for uniformly heavy crop load, and treatments were randomly assigned in a complete-block design with four single-tree replicates.

Neighboring branch defruiting. In the second experiment, branch units of varying sizes were defruited in mid-June 1983 and in late May 1984 and 1986. Defruited branch units were of four sizes: 1) primary scaffold, comprising about one-fourth to one-third of the tree canopy; 2) secondary scaffold, about one-half the size of a primary; 3) tertiary scaffold, about one-half to one-third the size of a secondary; and 4) small branch, comprising about four to eight growing points. Only one defruited branch treatment was imposed per tree, except in 1984, when two small-branch defruiting treatments were imposed per tree. Remaining fruiting portions of trees were undisturbed. An additional treatment in 1984 and 1986 consisted of two defruited secondary scaffolds per tree, and within each secondary scaffold one small branch unit was left fruiting. Whole fruiting and defruited trees were used as controls. The experimental design was a randomized complete block with

Fig. 1. Effect of defruiting date on retention of inflorescence buds of 'Kerman' pistachio, 1984.

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Table 1. Effect of defruited branch size on retention of inflorescence buds in 'Kerman' pistachio.

Defruited portion of tree	1983			1984			1986		
	Branch diameter (cm)	Bud retention(%)		Branch diameter (cm)	Bud retention (%)		Branch diameter (cm)	Bud retention (%)	
		Fruiting portion	Defruited portion		Fruiting portion	Defruited portion		Fruiting portion	Defruited portion
Primary scaffold	9.1	2 a	52 a	8.9	2 b	62 a	9.3	3 a	57 a
Secondary scaffold	5.7	8 a	53 a	5.7	13 a	65 a	6.1	11 a	60 a
Tertiary scaffold	3.2	10 a	40 b	3.7	6 ab	53 b	3.4	10 a	47 a
Small branch	1.6	8 a	26 c	1.7	3 b	50 b	1.5	7 a	51 a
Controls									
Whole tree, fruiting	---	3 a	---	---	1 b	---	---	3 a	---
Whole tree, defruited	---	---	56 a	---	---	63 a	---	---	65 a

Table 2. Retention of inflorescence buds on a small fruiting branch within a defruited secondary scaffold in 'Kerman' pistachio, 1984 and 1986.

Bearing unit	Fruiting status	Diameter (cm)		Bud retention (%) ^a	
		1984	1986	1984	1986
Tree	Fruiting	14.9	13.1	7 c	3 c
Secondary scaffold	Defruited	5.4	6.3	65 a	82 a
Small branch	Fruiting	1.8	1.6	16 b	19 b

^aAverages of eight to 10 shoots on each of six single-tree replicates. Separated by Duncan's multiple range test, at $P = 0.05$.

Fig. 2. Correlation of final percent bud retention with leaf N content in 'Kerman' pistachio, 1984. Numbers in parentheses indicate dates of defruiting.

six single-tree replicates. In the fruiting and defruited parts of each tree, five shoots in 1983 and 10 shoots in 1984 and 1986 were observed once, in late August, for cumulative inflorescence bud loss. Small branches did not always have the desired number of uniform shoots for observation and averaged only 4.2 observed shoots in 1983, 8.8 in 1984, and 7.6 in 1986.

Leaf samples, consisting of 20 to 25 terminal leaflets from 'the middle portion of randomly selected shoots (Uriu and Crane, 1977), were collected in late August in 1983 and 1984 and analyzed for total N by the method of Carlson (1978).

Data are expressed as percent bud reten-

tion to conform to previous studies (Crane and Nelson, 1971; Crane et al., 1973). In both years, if defruiting was done before the end of June, bud retention remained at 55% to 65% throughout the summer. (Fig. 1; 1983 data not shown). When fruit remained on trees past the first of July, bud retention began to decrease until, in control trees, only 2% to 5% of inflorescence buds remained by late August. If fruits were removed in the intervening period (5 to 19 or 26 July), bud retention was at intermediate levels. The longer the fruits remained on the tree, the lower the ultimate level of bud retention. We cannot explain the apparent superiority of defruiting on 30 May, 1984 (Fig. 1) which

was absent in 1983.

The period from about 1 to 26 July was critical to the loss of inflorescence buds (Fig. 1). When developing nuts were removed before that time, 60% of inflorescence buds were retained, but if nuts were left on shoots past that time, bud retention fell to <10%. The close association of fruit removal with a cessation of bud abscission contradicts a previous hypothesis that abscission occurs due to bud age, without respect to the presence of fruits (Porlingis, 1974). Alternatively, cultivars may account for the different responses; Crane and Nelson (1971) reported striking differences in the extent of bud abscission between 'Kerman' and 'Red Aleppo.'

The 30% to 40% bud abscission that occurred in both years before the imposition of treatments is common to 'Kerman,' regardless of the presence of fruit, and may reflect the natural loss of poorly formed buds in the axils of the basal two to four leaves or may be evidence for a two-phase abscission process (Crane and Iwakiri, 1987).

The concentration of N in leaves was highly correlated with percent bud retention in 1983 and 1984, $r = 0.91$ and 0.96 , respectively (Fig. 2; 1983 data not shown). The defruiting date is given for each representative point and indicates that the longer the crop remained on the tree the lower the leaf N and final percent bud retention.

These data support the idea that lower leaf N levels in bearing trees (Uriu and Crane, 1977) are likely the result of N accumulation in developing nuts (Porlingis, 1974). The high correlation of late summer leaf N with level of bud retention (Fig. 2) does not imply causation in light of data showing that increasing leaf N by foliar N sprays does not alter bud abscission (L. Ferguson, unpublished data).

When branches were defruited within a heavily fruiting tree, bud retention response depended on branch diameter (Table 1). Large branch units had bud retention levels equivalent to completely defruited trees (50% to 65%), while in small branches bud retention decreased by 26% and 12% in 1983 and 1984, respectively. However, defruited small branches had three to 12 times better bud retention than shoots in the fruiting portions (Table 1). This result indicates fruit influence on bud abscission is primarily, but not entirely, a local phenomenon. The year-to-year difference in magnitude of the branch size response may have resulted from use of different orchards.

small fruiting branch that arose from a defruited secondary scaffold within a fruiting tree retained 16% and 19% of its buds in 1984 and 1986, respectively. These values, while low, were still significantly higher than those of fully fruiting trees (Table 2). Bud retention values for the defruited scaffold remained at levels comparable to previous treatments (Table 1). These relationships again indicate that abscission response to fruit is not entirely local. Therefore, caution must be exercised when experimenting with single-shoot treatments in pistachio, because inflorescence bud abscission can be influenced by neighboring branches.

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