Project No. 80-L5
(Continuation of Project No. 79-04)

Cooperator:
University of California
Department of Entomology
Davis, California 95616

Project Leader: Dr. Robbin W. Thorp   Phone (916) 752-0482 or 752-2802

Personnel: Dennis L. Briggs, Evan Sugden, Tom Parisian, John Skinner

Project: Tree and Crop Research
Pollination

Objectives: To develop information on pollination by bees which will result in increased production and greater grower returns.

Progress: Research on artificial pollination showed no increase in set in 1979 although some increase was noted in 1978 in the same orchard. This suggests the test needs repeating. Increases in fruit set were obtained using bouquets, especially when placed in trees. Our research continues to strengthen our hypotheses that pollen foraging honey bees visit younger flowers and are more efficient in transferring pollen in almonds than nectar gatherers. This year we found the frequency of visitation by pollen versus nectar gatherers at different times during the bloom phenology of each variety was correlated with the frequency distribution of floral age classes. Since pollen foragers predominate early, this may help explain why we find the earliest blossoms of each variety produce the highest fruit set. Reciprocal bouquet tests further suggest that similarity in phenological stage overrides varietal differences in relation to floral preferences of foraging bees. Experimental modifications of flowers with fluorescent nectar confirmed our hypothesis that bees may perceive and use visual characteristics of nectar in determining their visitation behavior to flowers such as almonds which have fluorescent nectar. Attempts to find quick, reliable methods for early determination of effective pollination in almonds suggest that visible post-pollination changes and electrophotography may be promising as replacements to the time consuming pollen tube growth analyses and as a supplement to subsequent fruit set counts.

Plans:

1. To compare measures of colony strength (frames of bees and of developing brood) per hive, per acre and per orchard in a large area involving several orchards and cooperators to study:

   A. Foraging activities at the colonies (flight profiles);
   B. Bee density and activities at the flowers;
   C. Fruit set and yields of orchards involved.

2. To extend comparisons of effects of floral phenology vs. varietal differences on bee foraging behavior to include effects on intertree and intervarietal flight behavior.

3. To explore methods for early determination of effective pollination of almond flowers.

4. To cooperate with USDA personnel in establishing the value of *Osmia lignaria*, the blue orchard bee, as a pollinator of almonds and determining appropriate population levels needed and how best to manage them.

Almond Industry Participation $10,305

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DEPARTMENT OF ENTOMOLOGY

DAVIS, CALIFORNIA 95616

I HAVE COPY

December 31, 1980

Mr. Dale Morrison
Almond Board of California
P.O. Box 15920
Sacremento, CA 95813

Dear Dale,

Enclosed are 2 copies of our annual report on almond pollination for 1980.

Happy New Year.

Sincerely,

Robbin W. Thorp
Professor of Entomology

RWT:cms
enclosures

1980 Annual Report on Almond Pollination Research

Sponsored by the Almond Board of California

Title: Tree Research: Pollination (Project No. 80-L5)

Prepared by: Dr. Robbin W. Thorp, Project Leader, Department of Entomology, University of California, Davis

Personnel: Dennis L. Briggs, Tom Parisian, Evan Sugden, John Skinner, Mike Klungness, Kelly Havelock, Joel Groberg

Objectives: To develop information on pollination by bees which will result in increased production and greater grower returns.

Interpretive summary:

Reduced fruit sets occurred on varieties with flowers open just before and during rains from 14-21 Feb. 1980 while Flowers open after the rains showed better fruit set. Fruit set was highest near bouquets of compatible flowers placed in the crotch of a tree and dropped rapidly with distance even within the same tree. A method for consistent, optimum, in vitro (laboratory) pollen germination was developed. Pollen viability is highest in early stages of anther dehiscence and drops off sharply in the last anthers to dehisce. Pollen viability of bouquet flowers opening after the first day decreased markedly in comparison to that for uncut flowers. Pollen viability decreases with high moisture and probably with late blossoms on many varieties. A Benlate plus Ziram application significantly lowered percent pollen viability. Bees tend to select the next tree to fly to on the basis of shortest distance and most similarity in stage of bloom. Pollen collecting bees carry more viable pollen and produce more fruit set than nectar collectors. We obtained further confirmation for our hypothesis that bees can detect and use the fluorescent/UV

absorbing quality of almond nectar in their foraging behavior. Nectar production and availability tends to coincide closely with that of pollen. A survey of the 1980 crop was initiated and will be analyzed (when sufficient responses arrive) to determine correlations among current practices (orchard planting schemes, bee colony numbers, distributions and strength) in relation to crop yields. These data will be followed up by field research in clusters of orchards in 1981.

<u>Meteroligical Effects On Fruit Set</u>

Effects of the exceptionally rainy period from 14 to 21 February 1980 were studied through fruit set counts from flowers in bloom before, during and after this period. Also, fruit set counts were made of hand pollinated, open pollinated, and non-pollinated flowers to determine how sets from potential and actual pollination differed from non-pollination treatments during the damp weather conditions.

<u>Experimental procedure</u>: On February 20, flowers on three branches on each of ten NePlus trees were selectively removed to leave specific age categories as follows:

Branch 1 - all except senescent (leaving early bloom)

Branch 2 - all except receptive (leaving mid-bloom)

Branch 3 - all except buds and flowers with nondehisced anthers (leaving late bloom)

The remaining flowers were counted for later fruit set counts. Overall bloom stage and counts for fruit set were made the following day on Nonpareil trees in the four quadrants of the same orchard.

In another orchard, counts for fruit set were made on bagged (non-pollinated and hand pollinated) branches and on non-bagged (open pollinated) branches of Thompson and Mission.

Results: Fruit set counts on NePlus of the early, middle, and late bloom (before, during and after the week of rains) gave 7.4%, 7.2% and 17.6% respectively. These percentages correspond closely with the weather. The middle bloom came at the time of the poorest pollination weather, and early bloom apparently had not matured enough to avoid detrimental effects of the rain.

The counts made on the Nonpareil supported the findings on the NePlus. Since these trees were at less than 1% bloom at the start of the rainy period, a higher percent bloom on 21 February, the end of the rains, means more flowers opened during the rain. Thus the amount of flowers opening during the rain was inversely correlated with percent fruit set (Table 1).

Even late varieties such as Thompson and Mission may have suffered from poor pollination due to poor weather in their early bloom. Assuming that the hand pollinated flowers produce somewhere near the maximum potential fruit set and the open pollinated flowers produce about the actual number set, only about half of the potential was reached in Thompsons and only one-third in Missions in this orchard near Winters, California.

Bouquet Pollination

Bouquets of compatible varieties were placed in three orchards with different planting schemes to see if fruit set could be improved.

Experimental procedure: In orchards 1 and 2, bouquets were placed in buckets in the crotches of trees. In orchard 3, large limbs from an orchard that was being pulled out were placed directly in the crotches of trees with no water hoping that flowers would survive adequately on large branches in the damp cool season. Orchard 1 was a solid block planting with the east half of each row planted with Mission and the west half of each row with NePlus (Fig. 1A). Orchard 2 contained NePlus:Nonpareil:Mission (1:4:1) with a gap of one row on the south side of every fourth Nonpareil row (Fig 1B). Orchard 3 was planted with two rows of Mission for every two rows of Nonpareil (Fig. 1C). Fruit set counts were made in trees with bouquets and in nearby trees without bouquets. In orchard 2, counts were also made within test trees at various distances from bouquets.

Results: Data from 1980 (Table 3) confirm results of bouquet studies last year which showed significant increases in percent fruit set through the use of bouquets. Fruit sets within trees with bouquets also decreased with distance from the bouquet with 12.5% at < 2.1 m and 9.5% at 2.4-3.7 m. There was much variability between sets in different trees of the same treatment which made it difficult to establish just how far the effects of bouquets reach, but the main effects seem to be within the treated tree.

Pollen Viability

A method for consistent, optimum in vitro pollen germination was developed. It was used to compare viability of pollen of bouquet flowers with that of uncut flowers, and to determine effects of age of flowers and fungicide sprays on pollen viability.

Experimental procedure: Pollen germination was tested in hanging droplets with 0, 1 or 2% agar and 0, 10, 20 or 40% sucrose. Petri plate cultures with 2% agar and 10% sucrose incubated in a verticle position to avoid water condensation from contacting pollen were used for all subsequent analyses. Pollen was plated and read out within 24 hours. Plates were put on a microprojector and permanent record drawings of the condition of each grain (non-germinated, germinated and length of pollen tube) were made along with records of the incubation time and experiment notes for subsequent analyses of percent germination and pollen tube growth. Pollen germination was tested from Mission and Thompson flowers of different ages from inital dehiscence through all anthers dehisced to determine effects of aging on viability. Viability of new flowers on one day old bouquet limbs was compared with that from fresh flowers of uncut limbs on trees of the same variety. Comparisons also were made of pollen from different aged flowers, and bouquets with different treatments (in water, in water with "floralife"). Varietal differences were tested at the end of the rainy period. Pollen collected on clear versus damp days also were compared. Pollen from flowers treated with a benlate and ziram spray and from untreated flowers of the same varieties were compared in tests for effects on viability. Pollen from pollen versus nectar collecting bees also was compared. Analysis of variance used on all data in this section.

Results: Differences between media used in hanging droplet trials produced highly significant differences in mean germination (Table 4) (Pr. = 99.91%). Sucrose at 20 and 40% prohibited germination. Since there is no significant difference in the percent of pollen germinated plus lysed (Pr. = 11.5%) it would appear that 10% sucrose is an optimum osmoticum to prevent lysis. The difference between 10% sucrose with or without agar is just bordering on significance (Pr. = 89.5%), but the lower germination in agar is probably due to the presence of condensed moisture which lowers the osmotic gradient and causes lysis of germinable pollen. When petri plate cultures were incubated vertically to prevent condensed moisture from contacting pollen, 100% germination of fresh pollen could be achieved in 10% sucrose plus 2% agar.

Phenological stage (age) of flowers in relation to amount of anther dehiscence is an important source of variation (Pr. = 97.6%) in late blooming varieties (Mission and Thompson) (Table 5A). Variety was another important source of variation (Pr. = 99.9%) with mean viability for Mission and Thompson being 55.5% and 84.4% respectively. Phenological effects showing decreasing viability of pollen from flowers in early stages of anther dehiscence through late stages of dehiscence also were noted on Mission trees and Drake bouquets placed in them (Table 5 B-E) with all significant above 91.1% probability. Pollen viability from anthers dehiscing on bouquet flowers five days after being placed in the orchard showed no significant differences between dehiscence stages, perhaps because viability was so low (Table 5 F & G).

Comparisons between fresh flowers on bouquets only one day old with flowers of the same stage on uncut limbs were not significantly different (Table 6, 7), except for NePlus on 22 Feb. 1980. Although generally low, the greater pollen viability for uncut versus bouquet flowers was significant by the fifth day with bouquets in water with floral preservative producing the least viable pollen.

Effect of variety on pollen viability was significant (Table 8). Since mean percent germination decreased with earliness of varietal bloom, it appears that later flowers may produce less viable pollen than earlier flowers of the same variety.

A detrimental effect of moisture on pollen also was noted. A comparison of mean germination of pollen collected on clear days (82.6%) versus that on damp days (57.8%) was highly significant at a 99.9% probability.

A reduction in viability of pollen from trees treated with a fungicide (Benlate and Ziram) application was noted (Table 9). Only pollen exposed to the treatment showed significant reductions in viability. Pollen from anthers dehisced after the application did not exhibit any reduction in viability.

Viability of pollen on bees was significantly different according to activity (Pr. = 98.7%) with pollen collectors bearing the most viable pollen,

(Table 10). There was no significant difference (Pr. = 35.4%) in viability of loose pollen from the venter of all bees versus the corbicula (tibal pollen transport apparatus) pollen loads of pollen collectors (Table 10). However, the greatest differences in mean pollen germination in these samples were associated with groupings of data by days of collection.

Early Determination of Effective Pollination

Methods such as electrophotography, heat sensing, and examination of clipped styles were tested as means of early detection of fertilization of almonds.

Experimental procedure: Pollinated and non-pollinated almond styles and pistils were electrophotographed 4-11 days after pollination. These were preserved and examined with fluorescence microscopy for pollen tube growth and possible pollination. In some of the tests above, the style was clipped for examination while the ovary was left on the plant to continue to develop. Fruit set counts were taken on these ovaries and on a number of unclipped controls.

Results: No significant differences were detected between pollinated and non-pollinated pistils and styles using electrophotography contrary to what the results of a small sample in 1979 suggested. No decrease in percentage fruit set resulted from clipping the styles 4 and 11 days post-pollination (clipped - 21.4%, not clipped - 17.5%). Pollen tube growth to the bottom of the style does not guarantee fertilization. However by clipping the styles, counting the number of pollen tubes down the style, and relating these to fruit set, it may be possible to develop a formula for deriving probable % fruit set from pollen tube growth.

Work was initiated on a technique to use a thermocouple to detect possible temperature differences between pollinated and non-pollinated pistils. More work has to be done in refining the technique before data can be collected.

Intertree Flights

Observations were made along and across rows of the same and different varieties to determine the factor or factors (e.g. distance, variety, stage of bloom) controlling bee flights between trees.

Experimental procedure: In two orchards with different planting designs (figures 1 B and 1 D), 5 minute counts were made of honey bee flight going across 2 or 3 possible intertree flight coordinants. After 5 minutes observers rotated to another set of intertree flight coordinants. No distinction was made in the counts as to which direction the bees were flying between any two trees. In orchard 4 (Fig. 1D) the shorter distance between trees of the same variety was 9.1 meters, the intervarietal nearest neighbor distance was 6.1 meters, trunk to trunk. In orchard 2 (Fig. 1B), trees within rows were 9.1 m apart while the diagonal nearest neighbor was 6.1 m away trunk to trunk. Orchard 2 was further complicated in that there was a gap of 9.1 m between every 4th Nonpareil and its pollinizer due to the removal of a pollinizer row. Analysis of variance used on all data in this section.

Results: In orchard 4 (Table 11), the highest correlation between distance and bee flight was achieved using a regression of all distances within rows. Almost half of the variation in flight (48.8%, P = 99.95%) within rows is explained by distance. Within the diagonals, which were the shortest flight distances, only 1.6% of the flight variation was explained by distance. Overall in orchard 4, 23% of flight variation is due to distance.

In orchard 2 (Table 11), possibly because of the more complex planting scheme, the results are more difficult to interpret. Overall distance appears to explain about 10% (9.7%, P = 99.95%) of the variation. Within transects, only the "within rows" observations had sufficient data to obtain a correlation of 3.6% (P = 95.0%) between distance bee flight. Between transects, there was a significant difference in bee flights (P = 99.99%). However, because of interaction between variety, transect and canopy distance the influence of variety is difficult to determine.

Differences in the diameters of the canopies were noted. Mission canopies tend to be further apart than Nonpariel canopies because of the upright growth structure of Mission. NePlus trees are smaller in general than Nonpareil trees and thus at the canopy are also farther apart than Nonpareil trees. In orchard 2 the mean distances between canopies were:

Mission	γ	Mission	3.3 m
NePlus	γ	NePlus	3.5 m
Nonpareil	γ	Nonpareil	2.1 m

These greater distances between canopies in pollinator rows may increase flight between cross-pollinating varieties especially in a diamond shape planting where the trees in one row are offset from those in the adjacent row.

Differences of stage of bloom did not appear to affect monement between varieties as evidenced by comparing adjusted counts of Mission and Nonpareil intertree flights in Orchard 2 (Table 12). The movement of bees between Mission and Nonpareil was virtually the same over the two days where as the movement in Nonpareil rows and diagonals decreased while the movement in Mission rows increased indicating shifts in activity corresponding to shifts in bloom stage.

Pollen Transfer Efficiency

A pilot experiment in 1979 indicated a difference in the percent fruit set between flower stigmas contacted by pollen collecting honey bees versus nectar collecting honey bees. A more intensive study was set up to test this hypothesis.

Experimental procedure: Pollen and nectar foraging bees were collected on compatible almond flowers, anesthesized with carbon dioxide, and the venter pressed 9 times each against almond stigmas from which other pollinators were excluded. Other pollen and nectar foragers were collected for counts of the number of pollen grains available on their bodies for pollination and for viability (*in vitro* germination) tests.

Results: Table 13 shows the results of 4 days of daubing pollen and nectar collectors on almond stigmas. There are variations in set between the dates because of the different varieties used, the different weather conditions, and the different proportions of pollen to nectar collectors on the different days. Also, the time consuming nature of this technique made it difficult to get significantly large samples. On all dates the pollen collectors induced a higher percent set than the nectar collectors. Treating each day equally, the pollen collectors produced 1/3 more fruit set than the nectar collectors over the four days.

Hand pollinated flowers on February 23 and 26 produced fruit sets that were similar to those from the 9 stigma contacts that were given each flower in the bee daubing. This may mean that nine stigma contacts by pollen collectors produces about the maximum fruit set possible. The fact that on February 12, the pollen daubing gave so much higher set than the open pollinated may indicate that because of the weather or other factors the bees weren't able to fully pollinate the flowers.

Fluorescent Nectar

Tests have indicated that foraging bees can percieve fluorescence in artificial flower models (1976-1978). Preliminary tests last year indicated that bees can perceive fluorescence in experimentally modified flowers. Further tests were conducted this year to try to confirm these preliminary results, and to exclude the possibility that nectar odor serves as a cue.

Experimental procedure: To minimize interference of these tests with gathering of other data during almond bloom, we selected flowers of *Fremontodendron californica*, flannel bush, as our test system. Their nectar fluoresces blue like that of almonds and they bloom April through June. Anthers were removed from flowers of the same age. Nectaries were flushed with distilled water and dried by absorbing all liquid with tissue paper. The nectaries were refilled with previously extracted nectar, sucrose solution, and a third solution. This third solution varied from trial to trial and consisted of the following solutions:

(1) deionized water

(2) volatiles (odors) extracted from nectar

(3) lyophilized (vacuum freeze dried) and rehydrated nectar

(4) other fluorescent compounds (Coumarin and Tinopal)

Two or three sets of the three treatments were monitored on the host shrub for bee visitation by each observer. Treatments were rotated among the three flowers of each set every 15 minutes to avoid any possible bias due to the contamination by previous bee visits and position effects. In most of the tests, the experimental flowers were filled with solutions by a person other than the observer to avoid possible observer bias. All data analysed by Chi Square.

Samples of the nectars, lyophilized nectar, and volatiles have been sent to Dr. Stephen Buchmann at the U.S.D.A. Laboratories in Tucson for possible analyses of the compounds in the nectar and volatiles.

Results: The bee visitation based on landings and probings at flowers with water as the third solution differ significantly ($P < 0.001$) for the dates

April 14-21 from that expected if the bees perceive all treated flowers the same, (Table 14). The preferences for water and sucrose were almost the same indicating that the bees could not distinguish between the two, but could distinguish between them and the fluorescent nectar.

In order to eliminate the possibility that the bees were using odor partly or totally to determine the presence of nectar, fluorescent compounds with no detectable odor, nectar volatiles collected by distillation, and lyophylized or cooked nectar (presumably with any volatiles driven off) were used as comparisons (table 14). From 24-30 April artificial fluorescing nectars were made up by adding Coumarin or Tinopal to sugar syrup. The bees clearly and significantly picked out the natural nectar and exhibited little difference in visitation behavior to syrup versus our artificial nectars. On 2 May honey bees again selectively responded to natural nectar over syrup or cooked nectar. However, the latter was carmelized and assumed a "burnt" odor which may have adversely affected bee visitation behavior. None of the trials from 6 - 15 May gave significant differences in visitation response, but the numbers of observations were very low. Also these were conducted as the plants were going out of bloom. With so little bloom the few bees available may not have been adequately trained to the natural nectar.

At a site in Kern County, CA. with a native population of plants and mostly native pollinators (*Xylocopa* 79; *Apis* 23; *Hylaeus* 21; halictids 8), we found a significant difference between natural nectar and the other test solutions.

Nectar and Pollen Production and Availability

The production and availability patterns of rewards (nectar and pollen) sought by bees help determine visitation behavior of bees.

Experimental procedure: Nectar was extracted from flowers of various age categories. Flowers of many varieties were collected just before anthesis for counts of total anthers, and amounts of pollen per anther or flower. Pollen grain counts are being done by particle counter and haemocytometer.

Results: Maximum nectar availability coincides closely with maximum pollen availability, *i.e.*, the period of anther dehiscence (Table 15). The amounts of nectar available before dehiscence and during senescence is about equal to that produced during dehiscence. Preliminary data indicate that pollinated flowers produce more nectar than non-pollinated ones.

Anthers per flower run about 32 ± 2 depending on variety and location. Pollen grain counts are underway, but not completed.

Discussion:

Rain extending from 14-21 February was one of the most severe factors leading to low fruit sets and yields in the varieties with most flowers opening during the period. In the Davis-Winters area this affected the middle NePlus and early-middle Nonpareil bloom most severely.

Bouquets increase fruit set in the trees in which they are placed. More research is needed to determine the intertree effects of bouquets. Even large branch bouquets not placed in water to keep them fresh, caused improved set, perhaps because of the damp cool weather. This suggests that innovative methods may be developed in the make up and placement of bouquets. Light weight bouquets could be placed higher in the canopy.

Pollen viability of bouquet flowers is usually comparable to that of uncut flowers initially. The only exception (NePlus, 22 Feb., Table 6) may have been due to generally lower viability in older flowers (Table 8) coupled with the trauma of cutting for bouquets. Preservatives (e.g. "Floralife") used in the cut-flower industry lengthen flower life, but tend to inhibit normal ontogenetic development. Our tests showed lowered viability of pollen when bouquets were kept in preservative solutions beyond the first day.

Bouquets probably are most applicable for orchards with inadequate planting of cross-compatible varieties, years with marginal weather for bee flight, and where the grower has a ready supply of limbs (e.g. non-diseased prunings or cull trees).

Pollen viability decreases in later dehiscing anthers of a flower (Table 5) and probably also in later opening flowers on a tree (Table 8). These help explain why nectar gatherers, which tend to visit flowers of later developmental stages than do pollen collectors, bear less viable pollen and induce lower fruit set.

When a bee leaves a tree, the choice of the next tree it will fly to is based on the shortest distance and the greatest similarity in stage of bloom. Thus cross-compatible varieties with coincident bloom and planted on a diagonal should have the greatest potential for cross-pollination.

Table 1. Percent fruit set on Nonpareils near Winters, CA. in relation to percent flowers opened during the rains from 14 - 21 February 1980.

% bloom on 21 Feb.	86.5	70.3	56.1	53.4
% fruit set	1.9	5.2	10.2	10.9

Table 2. Percent fruit set on Thompson and Mission near Winters, CA. in relation to different pollination treatments.

	Thompson	Mission
No Pollination (Bagged)	0.0	0.0
Open Pollination	17.8	5.0
Hand Pollination (Bagged)	33.9	15.0

Table 3. Percent fruit set in bouquet pollination studies of orchards depicted in Fig. 1. Near = < 3.7 m in tree with bouquet; Away = > 3.7 m in trees without bouquets.

	Orchard 1	Orchard 2	Orchard 3
Near	5.6%	10.6%	5.1%
Away	2.0	7.0	1.9

Table 4. Effects of medium on percent pollen germination in vitro. All numbers are percentages.

Medium		Pollen	
Agar	Sucrose	Germination	Germination + Lysed
0	0	15.15	75.55
0	10	57.97	79.87
1	0	15.15	80.01
2	10	40.28	81.25

Table 5. Effects of flower phenology (dehiscence stage) on pollen viability (percent germination) in: Mission and Thompson (7-11 March 1980) = A; Mission (28 Feb.) = B, (3 March) = C; Drake bouquets (28 Feb.) in water = D, in Floralife = E; Drake bouquets (3 March) in water = F, in Floralife = G.

	Anthers Dehisced					Significance	
	None	Few	Several	Many	All	Pr%	
Trial A	58.6	61.2	80.1	78.9	57.2	97.6	*
B	---	89.8	95.4	53.6	16.8	99.9	*
C	---	44.1	21.1	22.9	3.8	93.6	*
D	---	90.9	58.4	58.2	24.0	99.8	*
E	---	62.6	66.7	54.0	11.5	91.1	*
F	---	13.1	24.1	6.4	9.3	59.1	(N.S.)
G	---	13.1	2.6	15.5	2.6	81.9	(N.S.)

Table 6. Effects of bouquet versus uncut flowers on tree in pollen viability within one day after bouquets set out.

	NePlus (21 Feb.)	NePlus (22 Feb.)	Mission (25 Feb.)
Tree	69.9	64.4	80.6
Bouquet	57.7	35.3	67.3
Significance Pr%	86.3 (N.S.)	99.3 *	73.4 (N.S.)

Table 7. Effects of bouquets age on pollen viability (percent germination) compared with uncut flowers on tree. Drake bouquets sets in Mission trees on 27 Feb. 1980.

		Bouquets		Significance
	Tree	in Water	in "Floralife"	Pr %
28 Feb.	63.9	57.9	50.5	43.6 (N.S.)
3 March	24.2	13.2	8.9	94.5 *

Table 8. Effects of variety on pollen viability from fresh flowers at the end of the rainy period (20 Feb. 1980)

	Jordanolo	NePlus	Nonpareil	Significance
Mean % germination	46.4	63.7	76.1	Pr = 98.7%

Table 9. Effects of a fungicide (Benlate + Ziram) spray on viability (percent germination) of pollen collected from flowers two days after the application (26 Feb. 1980).

Exposed pollen	Untreated	Sprayed	Significance
Early dehiscence	92.9	74.2	99.8 *
Late dehiscence	80.4	47.7	99.5 *
Unexposed pollen	92.7	96.5	N.S.

Table 10. Viability of pollen on bees by foraging behavior, and location on bee.

	Location on bee		
Collecting	Venter	Corbiculae	Mean All
Pollen	62.1	73.6	65.1
Pollen + Nectar	43.2	44.8	47.5
Nectar	38.0	---	38.0
Total All Bees	51.2	54.5	---

Table 11. Intertree flights by honey bees in relation to distance between canopies and variety. Mean number of bee flights per 5 minutes of observation.

M = Mission; N+ = NePlus; N = Nonpareil; T = Thompson.

	Transect	Varieties	Distance (m)	Flights
Orchard 4	In row	T - T	5.3 m	0.0
	Across row	T - T	5.1	0.7
	In row	M - M	1.7	4.5
	Across row	M - M	1.5	4.2
	Diagonal	M - T	1.3	4.9
Means:	Across row		3.5	2.2
	In row		3.3	2.5
	Diagonal		1.3	4.9
Orchard 2	In row	N+ - N+	3.5	0.8
	In row	M - M	3.3	1.1
	Across gap	N+ - N	2.25	1.1
	Across gap	M - N	2.2	1.0
	In row	N - N	2.1	1.5
	Diagonal	N - N	1.1	2.5
	Diagonal	N+ - N	0.5	3.4
	Diagonal	N - N	0.45	2.9
Means:	In row		2.7	1.3
	Across gap		2.2	1.0
	Diagonal		0.65	2.8

Table 12. Intertree flights by honey bees in relation to distance between canopies, variety and percent bloom in orchard 2.

			25 Feb.[a]	28 Feb. [b]
Transect	Varieties	Distance (m)	Flights	Flights
In row	M - M	3.3 m	0.7	2.9
Across gap	M - N	2.2	1.3	1.3
In row	N - N	2.1	1.6	0.2
Diagonal	M - N	1.1	2.9	3.0
Diagonal	N - N	0.45	2.8	2.0

a = Nonpareil 91%, Mission 49% bloom.

b = Nonpareil 97%, Mission 94% bloom.

Table 13. Percent fruit set of pollen transfer efficiency tests in which honey bees foraging for pollen or nectar on compatible almond varieties were daubed 9 times each on stigmas from which pollinators were excluded.

Date	Pollen	(n)	Nectar	(n)	Open pollinated	(n)	Hand pollinated	(n)
Feb. 12	46.4	(28)	12.5	(16)	26.9	(26)		
13	48.0	(25)	26.1	(23)				
23	32.1	(28)	27.8	(18)			28.9	(38)
26	57.1	(14)	53.0	(66)	____	____	51.0	(49)
Mean	40.9	(95)	29.9	(123)				

Table 14. Fluorescent nectar. Honey bee visitation (landing and probing) behavior to experimentally modified Fremontodendron flower nectaroes. Tests from 14 April through 15 May at UC Davis Arboretum. Tests 18-19 June in Kern County, CA.

Dates	Nectar	Syrup	Other	Totals	Expected	X^2 (df^2)	P <	Signif.
April 14-21	377	166	151[b/]	694	231.3	138.2	0.001	*
April 24-28	79	37	42[c/]	138	52.7	19.87	0.001	*
April 30	85	22	31[d/]	138	46	50.49	0.0005	*
May 2	53	32	22[e/]	107	35.7	14.0	0.001	*
May 6-7	95	72	86[f/]	253	84.3	3.2	0.2	N.S.
May 12	21[a/]	17	33[f/]	71	23.7	5.7	0.1	N.S.
May 14	8[a/]	11	13[g/]	32	10.7	1.1	0.7	N.S.
May 15	26	36	23[g/]	85	28.3	3.4	0.1	N.S.
June 18-19[h/]	131[a/]	83	90[g/]	304	101.3	13.4	0.005	*

a/ Nectar with volatiles removed.

b/ Water.

c/ Coumarin in syrup.

d/ Tinopal in syrup.

e/ Cooked nectar to drive off volatiles.

f/ Lyophilized nectar (less volatiles) rehydrated.

g/ Volatiles in syrup.

h/ All bees (Xylocopa, Apis, Hylaeus, halictids).

Table 15. Nectar production (lambdas per flower) by floral stage in three collections.

	Non-dehisced	Dehiscing	Scenescent
Winters (3 Mar.)	13.8	14.5	5.7
Winters (3 Mar.)	4.0	21.0	8.1
U.C. Davis (4 Mar.)	4.8	12.1	4.5
Total nectar/flower	8.8	15.4	6.1

Fig. 1. Planting schemes of orchards where 1980 pollination studies were conducted.

M = Mission; N = Nonpareil; N+ = NePlus Ultra; T = Thompson.

A. Orchard 1.

N+ N+ N+ N+ M M M M
N+ N+ N+ N+ M M M M
N+ N+ N+ N+ M M M M
N+ N+ N+ N+ M M M M

B. Orchard 2.

N+ N+ N+ N+ N+ N+ N+ N+
N N N N N N N
N N N N N N N N
N N N N N N N
N N N N N N N N
[Gap. Row removed]
M M M M M M M M
N N N N N N N
N N N N N N N N
N N N N N N N
N N N N N N N N
[Gap. Row removed]
N+ N+ N+ N+ N+ N+ N+ N+
N N N N N N N

C. Orchard 3.

M M M M M M M M
M M M M M M M M
N N N N N N N N
N N N N N N N N

D. Orchard 4.

M M M M M M M M
T T T T T T T
M M M M M M M M
T T T T T T T