1982 Annual Report on Almond Pollination Research
Sponsored by the Almond Board of California

Title: Tree Research: Pollination (Project No. 82-K7)

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

Personnel: Dr. G. M. Loper (Associate Project Leader); D. L. Briggs, T. Battersby, R. Daggs, L. Guimond, M. Klungness, S. Nicosia, T. Parisian, J. Skinner, E. Sugden, T. Webster

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

Interpretive summary:

Numbers and proportions of pollen collecting honey bees can be increased by the addition of a pollen trap which causes pollen stress in the colony. Such traps can lessen the normal increases in amounts of worker bees and brood with prolonged (48 days) use. Since we previously established that pollen foragers are better than nectar collecting bees as pollinators of almonds, the addition of pollen traps can be useful in improving pollination efficiency of most colonies used in almonds.

Cluster counts of worker bee populations can be a useful tool for rapid evaluation of colony strength. A preliminary table to convert cluster counts to estimates of frames of bees has been worked out for colonies with less than 8 frames of bees. Other methods for estimating bee populations (e.g. pollen versus nectar foragers returning to the colony or foraging in almond trees under specified conditions) need to be related to colony quality and distribution so that growers can easily and accurately assess their pollinator needs.

The relation between honey bee colony strength and density versus fruit set was not as clear in 1982 as in previous years. The amount and pattern of rainfall and lack of disease control may have masked our results.

A survey of grower production problems showed bee colony strength or strength times numbers gave the best correlation with yield. Other grower perceived problems included weather as number one, also foragers leaving the orchard; bee hive distribution; and poor overlap of bloom among cultivars.

Studies conducted in South Australia during the wettest winter on record, confirmed our previous studies. Bees tend to forage nearest their colonies, especially under marginal conditions, and fruit set drops off accordingly away from colony locations. Bees fly the shortest distance between trees, and thus tend to forage along rows of the same cultivar.

Effects of Pollen Traps on Honey Bee Foraging and Brood Rearing During Almond Bloom

We have previously demonstrated that honey bees foraging for pollen are more effective in vectoring pollen of almonds than are nectar gatherers. Thus, we wanted to determine if we could increase pollen collecting activity from colonies used in almond pollination by applying traps to remove pollen from returning foragers and inducing pollen stress. This study was also supported by the California State Beekeepers Association.

Experimental procedure: During the third week in February, bottom-type OAC pollen traps were fitted to 21 hives. Activated traps had removable double 5-mesh wire grids which knocked the pollen loads from the legs of returning pollen foragers into a collecting tray where it was inaccessible to the bees. Traps were inactivated by removing the grids. Three groups of seven test colonies were placed in an almond orchard in mid-February and moved to the border of a prune orchard in mid-March. The first, group A, had trap grids for the entire period of study. Group B had grids only for the last part of observations in almonds, March 4-11. Group C did not have grids at any time.

Adult bee and brood populations were adjusted so that all 21 colonies were of similar strength (8-9 frames of bees and 1850-2800 cm^2 brood) at the beginning of observations. The strength of each colony was assessed before observations began in the almonds (February 24), at the time they were moved to the prune orchard (March 12), and after observations were completed (April 13). The total frames of adult bees was obtained by adding estimates of coverage for each frame in the hive. Partial coverage was converted to full-frame equivalents, (i.e. a standard full-depth frame covered on both sides with bees). The total area of capped brood was estimated by comparing each frame to a standard pattern of known areas.

Returning bees were measured by placing an 8-mesh hardware cloth completely across the hive entrance and allowing bees to land on it for 30 seconds. Immediately afterwards, bees with and without pollen on the screen were quickly counted. Returning bees for all 21 hives were counted within each one-hour observation period. In some case, two 30-second observations were made for each hive in one observation period. Data were gathered over three intervals:

I. Feb. 24 - Mar. 3 (almonds; trap grids in Group A only).

II. Mar. 4 - 11 (almonds; grids in Groups A and B).

III. Mar. 24 - 27 (prunes; grids in Group A only).

Pollen was removed from traps every three days. Since weather affected moisture content, volume rather than weight of trapped pollen was measured. Trap samples were examined by light microscope to estimate the percentage of grains from almonds versus other sources.

Results: Colonies with traps had more pollen foragers ($p < .10$) in 20 of 35 observation periods (Table 1). In only one period the reverse effect was seen. Furthermore, the percentage of observation periods for which traps were effective ($p < .05$) increased from Interval I to Interval III.

The proportion of returning bees with pollen was also higher for colonies with traps than for those without them. A log-linear model for each observation interval was constructed. The effects of traps were highly significant for Intervals II and III.

Pollen traps had their greatest effect before late afternoon (Table 2). Of six observation periods in which hives with traps did not have more pollen foragers than those without traps, five such periods had midpoints after approximately 3:00 p.m.

To estimate the reliability of our method of observing returning bees, trapped pollen collected for three 3-day periods (Mar. 4-6, 7-9, 25-27) was measured. The relationship between observed numbers of pollen foragers and volume of pollen trapped at individual colonies was strong (R^2 = 57.1%, 43.8%, 50.2% respectively) for each of the time periods selected, suggesting that our observational technique was effective.

Microscopic analysis of trapped pollen samples indicated the proportion of pollen gathered from almonds (Table 3). Scattered ground cover was the only other available flora. The decline in almond bloom in early March is clearly reflected in the bees' transition to other pollen sources. Group A colonies foraged mainly on almonds but took a lower proportion of pollen from almonds during almond decline than did Group B.

Assessments of colony strength (Table 4) showed that Group A colonies had significantly fewer adult bees and less brood by the time of the final strength assessment, compared to Group C. Group B reared significantly less brood but had similar adult populations compared to Group C at the final assessment.

Discussion: The results of this study indicate that the ratio of pollen foragers can be increased with pollen traps at least under the conditions found in almonds and prunes in 1982. Previous studies have shown that pollen collectors are more efficient pollinators of almonds than nectar collectors so possibly the use of pollen traps could increase yield. However, controlled studies should be done correlating the use of pollen traps to fruit set and yield in cage tests and/or isolated orchards before definite recommendations are made. Studies also need to be done earlier in almond bloom, and with traps in place well in advance. The fact that the flight periods that did not show an increase in pollen forager ratio tended to occur in the late afternoon, may be due to a depletion of pollen in the trees late in the day and warrants further study. The fact that the total numbers of foragers increased as the number of pollen foragers increased in trapped hives, may indicate that non-foragers (naive bees, nurse bees, "idle" bees) are being converted to pollen collectors.

At least during the period of almond bloom when traps were used during this study, there was no significant reduction in brood or adult bee strength. There was a significant reduction in brood and bees in the hives that had the traps on for two months through almond and prune bloom. There was also a significant reduction in brood in the colonies that had traps on for 8 days as shown by the count at the end of two months. More work needs to be done with weaker and stronger hives and with hives with pollen traps on for varying time periods. Some reduction in adult bees may result from drift of bees away from colonies with activated traps.

Analyses of the pollen samples confirmed previous studies that have shown that honey bees collect very high percentages of almond pollen. There were some ground cover plants in bloom in the almonds, and a large number in prunes. More work needs to be done to determine the overall influence of ground covers on almond pollination, the general almond ecosystem, and the welfare of the honey bee.

Samples of the almond pollen have been sent to a U.S.D.A. researcher who is studying the attractiveness of various pollens to bees.

Table 1. Effects of pollen traps according to date on number of pollen foragers: numbers of observation periods for which the effect was positive, negative or not significant.

			No. of Obs. Periods			
		Observation Periods	Positive Effect (p < .05)	Positive Effect (.05 < p < .10)	Effect Not Signficant	Negative Effect (p < .10)
I	Feb. 24 - Mar. 3 (Almonds)	4	1 (25%)	0	2	1
II	Mar. 4 - Mar. 11 (Almonds)	25	11 (44%)	3	11	0
III	Mar. 2 - Mar. 27 (Prunes)	6	4 (67%)	1	1	0
	Total	35	16	4	14	1

Table 2. Effect of pollen traps according to time of day on numbers of pollen foragers: numbers of observation periods for which the effect was positive, negative or not significant.

		No. of Obs. Periods			
Observation Midpoint	Observation Periods	Positive Effect (p < .05)	Positive Effect (.05 < p < .10)	Effect Not Signficant	Negative Effect (p < .10)
10 AM - Noon	8	6 (75%)	0	2	0
Noon - 2 PM	7	4 (57%)	0	3	0
2 PM - 5 PM	20	6 (30%)	4	9	1

Table 3. Percent almond pollen in pollen trap samples.

	Mar. 1 - 3	Mar. 4 - 6	Mar. 7 - 9
Group A Hives (with traps Feb. 24 - Apr. 13)	92.2 ± 1.8	84.1 ± 4.4	75.4 ± 13.1
Group B Hives (with traps Mar. 4-12)	No traps	90.2 ± 2.2	89.3 ± 0.8

Table 4. Effects of pollen traps on adult bee and capped brood population.

Adult bees (full frames)*

	Feb. 24	Mar. 12	Apr. 13
Group A	8.54^{A}	10.66^{A}	14.80^{B}
Group B	9.14^{A}	10.72^{A}	17.75^{A}
Group C	7.89^{A}	11.67^{A}	18.42^{A}

Capped brood area (cm^2)*

	Feb. 24	Mar. 12	Apr. 13
Group A	1858^{A}	5716^{A}	3935^{B}
Group B	2342^{A}	5013^{A}	5110^{B}
Group C	2800^{A}	5155^{A}	6471^{A}

* Figures in any particular column followed by different letters are significantly different from each other ($p < .05$).

Relationship Between Cluster Size and Frames of Bees

Detailed counts of colony strength (frames of bees and brood area) are time consuming. In order to increase our strength data we supplement our detailed counts with quicker cluster counts. These cluster counts are compared with more detailed measures to develop a more accurate conversion table which might also be useful to growers in estimating colony strength in their orchards.

Experimental procedure: In 21 orchards in the Dixon area with 1,444 colonies, we made cluster and detailed strength counts on 205 colonies and cluster counts on an additional 329 colonies. Cluster counts consist of splitting the hive between the hive body and super and quickly determining the numbers of top and bottom bars of frames covered by the cluster. This should be done before bees begin foraging and must be recorded quickly once the colony is split before clusters expand and consistent counts become difficult to obtain. Detailed counts consist of removing each frame, estimating the area of the frame covered by bees on both sides to the nearest 1/4 frame, and converting these to full-frame equivalents. Area, in square inches of brood, is recorded for each frame.

Colonies measured were grouped by observed cluster size and related to mean ($\bar{x}$) and standard deviation (S.D.) of detailed measures. This allowed us to derive an estimate of number of frames bees relative to observed cluster size. An equation to relate cluster size to frames of bees was also derived.

Results: The relationships found between cluster size and frames of bees lead to derivation of appropriate estimates of frames of bees from observed cluster sizes (Table 5). The confidence intervals are reasonably small, so this appears to be a valid estimate, especially when more than 25 colonies are examined. If 30-60 colonies are estimated, a grower will arrive at the correct cumulative estimate within 0.5 frame 95% of the time. The equation derived, $Y = 0.602 + 0.727 X 1$ also relates cluster size (X 1) to frames of bees. However, the table is easier to use and understand and more accurate in converting cluster size to frames of bees. Cluster sizes of less than 9 bars show a clearly increasing relationship with frames of bees, however, for cluster sizes of more than 8 bars, data show no increase (Table 5). This may be due to the small numbers of colonies involved.

Discussion: Our initial correlations suggest that frames of bees can be fairly accurately estimated from quickly observing cluster sizes, at least for colonies of 8 frames or less. Several cautions need to be kept in mind in using such an approach. Cluster size is temperature dependent, it expands once flight activity begins and it expands quickly after the colony is split. Cluster counts also provide no information on whether or not brood is present or its quantity, pattern or quality which reflect the presence and viability of the queen. Another potential approach which could provide more information is to count the proportions and numbers of foragers returning with and without pollen during a 30-second period under specificed conditions. Both methods merit further testing.

Table 5. Relationship between cluster size and actual frames of bees.

Cluster size	Number Observed	$\bar{x}$	S.D.	Estimated frames of bees based on cluster size
0-2	52	1.41	0.91	1.4 ± 0.5
3-4	36	2.43	0.76	2.4 ± 0.5
5-6	28	4.42	2.01	4.4 ± 0.5
7-8	36	7.73	2.67	7.7 ± 0.5
9-10	12	7.24	1.60	--
11-12	6	7.32	2.49	--

Relations between Colony Strength and Density Versus Fruit Fly

As part of our continuing intensive study of orchards in the Dixon area, we continue to search for any relationships between numbers and strengths of honey bee colonies with fruit set in almond cultivars.

Experimental procedure: In the 21 orchards intensively studied in the Dixon area, we made flower, bud and fruit counts on limbs of trees of various cultivars to determine fruit sets. For orchards where we have colony strength data as well as numbers of colonies per acre we regressed these data separately and in combination with fruit sets.

Results: Percent fruit sets for 4 cultivars were low for 1982, especially for early blooming cultivars (Table 6). Orchards with less than one colony per acre obtained the lowest fruit sets in all cultivars (Table 6). Percent fruit set was highest for mid- and late-blooming cultivars in orchards with the greatest numbers of colonies, but only slightly so (Table 6).

Regression analyses gave low correlations using hives per acre or strength versus percent fruit set. The highest correlations were colony strength and fruit set for Mission (0.291) and Nonpareil (0.287). Hives per acre versus fruit set was highest for Mission (0.237). All others were less than 0.16 and two were negative (Table 7).

In two adjacent orchards with similar age trees and similar numbers of hives per acre, but different colony strengths, considerably higher fruit sets were obtained in early blooming cultivars where the greatest concentration of bees occurred. This difference was not apparent in late-blooming cultivars even with the addition of colonies to orchard B on 5 March.

Discussion: Low fruit sets in orchards with less than one colony per acre is consistant with our previous studies. Low fruit set for early blooming varieties is also consistant and may have been enhanced. This year by the amount and pattern of rainfall and the degree to which subsequent fungal diseases were not controlled. Orchards with a mean of 1.8 hives per acre had better fruit sets in early-blooming cultivars than did orchards with means of 2.7 - 2.8 hives per acre. This may in part be related to differences in tree ages, since orchards with 1.8 hives per acre tended to have younger more vigorous trees.

In the two adjacent orchards with similar hive densities, but different colony strengths, the lack of difference in fruit set in late-blooming cultivars was probably due to better flight weather and more uniform dispersion of bees in trees. The latter is supported by our counts on 4 March (Orhcard A:B = 5.2:9.1 bees/tree) and 6 March (Orchard A:B = 18.4:19.7 bees/tree) just before and after the new colonies were added.

Table 6. Percent fruit set for almond cultivars in the Dixon area in relation to the mean number of colonies per acre.

	Mean colonies per acre		
Cultivars	0.3 - 0.6	1.8	2.7 - 28
Ne Plus Ultra	10.7%	19.1%	14.2%
Peerless	8.4%	22.9%	14.7%
Nonpareil	10.8%	22.0%	23.5%
Mission	14.1%	23.4%	26.0%

Table 7. Percent fruit set for almond cultivars in two adjacent orchards in the Dixon area in relation to mean hive number times colony strength.

	Mean hives/acre x colony strength		
	Orchard A	Orchard B	
Cultivar	5.5[1/]	15.8[2/]	18.9[3/]
Peerless	21.2%	33.3%	--
Nonpareil	25.2%	31.3%	--
Mission	28.0%	--	25.2%
Thompson	36.1%	--	38.7%

1/ 2.4 hives/acre x 2.3 strength

2/ 1.9 hives/acre x 8.3 strength

3/ 2.2 hives/acre x 8.3 strength; additional colonies moved in late bloom.

Wind Measurements Inside and Outside Almond Orchards

Wind velocity is known to have some direct effects on bee flight activities. Velocities over 15 m.p.h. prohibit flight. Bees tend to cling to flowers more on windy days, but may be dislodged by strong sudden gusts. We undertook some preliminary wind speeds inside (about 20 rows in) and just outside the edge of almond orchards to determine the amount of modification affected by trees.

Experimental procedure: Data were gathered from a hand-held anemometer at 4-6 feet above the ground. Wind gust, which is an estimate of maximum wind velocity bees may be expected to encounter was measured in 3 orchards over 3 days. Instantaneous wind readings, which are an estimate of average wind velocities bees may encounter, were taken in 2 orchards on one day.

Results: Although instantaneous readings outside the 2 orchards were at least double those inside, the readings were too few to establish statistical significance. None of the readings exceeded 7 m.p.h. A paired t test with $\alpha = 0.05$, $N = 3$ showed no signficant difference between inside versus outside readings, but at $\alpha = 0.1$, differences were apparent.

Wind gusts did not appear to differ between positions inside or outside orchards observed. A paired t test with $\alpha = 0.05$, $N = 10$ showed no significant difference between inside versus outside the orchards. None of the wind gusts exceeded 12 m.p.h.

Discussion: None of the wind speeds encountered were strong enough to prohibit flight, although some of the gust speeds may have been strong enough to influence flight behavior. Additional paired measures combined with observations on bee flight behavior would be useful. It also would be important to compare wind velocities at different levels from bottom to top of the canopy, especially for days with instantaneous and gust wind speeds between 10-20 m.p.h.

Survey of Grower Perceived Pollination and Production Problems - 1981 Crop

Our survey of grower opinion was continued to determine the relative importance of orchard age, size and planting scheme; bee colony strength, number and distribution; and competing bloom on yield.

Experimental procedure: Survey forms and cover letters (see Appendix A) were distributed at the Annual Research Conference and at a growers school in Davis.

Results: Responses were received on 42 orchards. To these were added data from 22 orchards in the Dixon area which were part of our intensive field studies. When size and age of orchards and strength and density of bee colonies were correlated with yield from Mission almonds, colony strength gave the highest correlation (0.428). For Nonpareil almonds, the highest correlation (0.349) occurred between yield and factor obtained by multiplying colony strength times density. Colony strength gave the highest single factor correlation (0.272). Strength X density regressed against yield explained 10.7% of the variation in Nonpareil and 13.0% in Mission. Most of the responses listed weather as the most important problem effecting pollination and yield. Other principal concerns included: movements of foraging bees out of the orchard; distribution of bee hives; and poor overlap of bloom between cultivars.

Discussion: This survey tends to confirm the importance of honey bees colony strength and density in relation to yield in almonds. This survey should be repeated for 1982 with larger numbers and greater diversity of orchards included (the growers responding averaged 2.1 colonies and over 1,000 pounds of meats per acre). Forms for 1982 were made available at the Annual Research Conference (14 December 1982) and are still obtainable from Dr. Robbin Thorp.

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COLLEGE OF AGRICULTURAL AND
ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF ENTOMOLOGY

DAVIS, CALIFORNIA 95616

October 20, 1982

Dear Almond Grower:

The enclosed survey form is an important element in our attempt to provide you with answers to the most perplexing questions about pollination by honey bees: How many colonies per acre are needed and how should they be distributed? Bees often forage up to 2 miles or more from their hive and some individuals forage on flowers other than those of the crop adjacent to the colony. Thus, the foraging behavior of bees prohibits obtaining easy direct answers to these questions since application of pollinators cannot be controlled and localized in single orchards as can fertilizers or pesticides.

Our approach to answering these questions consists of two phases. First our survey should provide a data base from which we can draw some preliminary inferences and identify additional areas of concern on pollination problems. Second, we plan to conduct field studies in selected areas encompassing several orchards to determine whether distribution and density of foraging bees can be better explained by examining these large areas rather than single orchard plots.

We feel that the time spent in answering the survey questions will be more than compensated by the information growers will receive concerning pollination problems. The results of the survey will be made available to cooperating growers. Names of specific growers will be kept confidential. Thank you for your cooperation.

If you have more than one orchard, please use a separate form for each. If additional forms are needed please let me know.

If you have any questions, please write or call (916) 752-0482, if no answer leave a message with my secretary (916) 752-0475.

Sincerely,

Robbin W. Thorp

Robbin W. Thorp
Professor of Entomology

RWT:cms

ALMOND POLLINATION SURVEY - 1982 CROP

GROWER____________________ AGE OF ORCHARD________________

MAIL ADDRESS____________________ NUMBER OF ACRES________________

____________________ LOCATION OF ORCHARD________________

PHONE____________________ ________________

VARIETIES	RATIO OF ROWS OF EACH VARIETY	YIELD (lb/ACRE)

Competing bloom bordering orchard (e.g. other almonds, blooming crops or wild flowers

If no competing bloom adjacent to orchard, how far away and of what type was the nearest competing bloom?

North________________ ________________

East________________ ________________

South________________ ________________

West________________ ________________

Any competing bloom within orchard?________________

Strength of colonies (number of frames of bees and/or brood, if not known rate as excellent, good, fair, poor)________________

Distribution of colonies:

Number of colonies: per acre________; per drop (group)________

No. of drops: within orchard________; outside orchard________

Please note any other orchard or bee conditions that may have affected pollination and yield________________

____

____

What do you feel is your biggest pollination problem?________________

____

Almond Pollination Studies in Australia 1981-82

Dr. Thorp spent a sabbatic leave in Australia, July 1981 to April 1982, and had an opportunity to become acquainted with the almond industry in South Australia and Victoria, and to conduct some research in orchards in two areas of South Australia in cooperation with Dr. Dudley Pinnock, Waite Agricultural Research Institute, University of Adelaide. Financial support was provided primarily by grants from the Co-operative Almond Producers Ltd., Unilever Australia Ltd., Federal Council of Australian Apiarists Associations, the Sunraysia Apiarists Association, and the Minister of Agriculture of South Australia.

Experimental procedure: Studies were conducted in orchards in the plains just north of Adelaide (Angle Vale) and along the Murray River northeast of Loxton (Lyrup) during the wettest winter on record.

Bee Hive distribution and density: Hives at Angle Vale were distributed normally in groups of 11 or 12 at intervals of about 60 m in the younger half of a 16.7 Hectare orchard, but clumped in 4 groups of 21 to 27 in rows 41 and 48 at the east end of the older half of the orchard and nearest the younger half. At Lyrup, hives were distributed singly at every third tree in every third row in two treatment blocks T1 (3.5 Ha.) and T2 (3 Ha.) each with a different tree spacing (T1, 5 X 7 m and T2, 7 X 7 m). A third block (7.2 Ha.) was selected as a check and hives were distributed normally in groups of 6 at intervals of about 140 m. Bee activity, percent fruit set, and harvest yields were taken in trees near and away from the hive placement.

Bee foraging activity: Foraging density near to (within 37 m), and away from (beyond 168 m) hives was measured for several almond varieties at Angle Vale to determine the effects of adverse (marginal) flight weather on foraging range. Similar measures were made at Lyrup except that hive distributions prohibited foraging distances greater than 75 m from the nearest hives. Each observer counted all bees seen in a visual sweep of 15 seconds per tree for 10 trees in a row of each almond variety. Two or three varieties were counted at one time. Observers switched rows at the end of each 10 trees so that each row was counted by each observer, giving two or three replicates and reducing any observer bias. Each row count took about 5 minutes. Near and away rows usually were counted within the same 30-minute period. Counts were made under as many different conditions (a.m., p.m., dates, weather) as possible. Percent bloom was estimated each time bee flights were counted to determine its relationship with bee density.

Intertree flights: The effect of distance on intertree flights was measured at Lyrup in 3 adjacent rows of variety Mission. There were occasional one tree gaps due to missing trees. Each observer counted bees flying between two pairs of trees separated by different distances for 3 minutes. Tree canopies separated by distances of 0.1 m to 4.0 m were compared.

The combined effect of almond variety (bloom stage) and distance between tree canopies (within and between rows) were compared at both locations. Each observer simultaneously counted bees flying between a pair of trees within a row and a pair in adjacent rows. In all cases % bloom for each variety was noted.

Bloom and fruit set counts: Four limbs on each of 5 trees per variety near to and away from bee hives were used. Approximately 50 floral units per limb were counted and segregated into buds, flowers, or senescent. A piece of PVC tape with the data recorded was tied just below the basal-most floral unit counted. These data were used to determine % bloom (flowers/total X 100) for that date, and provided the basis for % fruit set (fruit/total floral units X 100) from counts of developing fruits on tagged limbs in October 1981 and the harvest of these fruits in February 1982. Additional limbs (1 per tree, per date) were counted, recorded and tagged with a different color tape for each date in the same manner as above on one or two subsequent dates to provide data on seasonal changes in % bloom and broader base for fruit set. Kernel weights were obtained from the nuts which were hand harvested for fruit set counts.

Results: Bee foraging activity: Data on bee in tree activities are summarized in Table 8-9. Bee activity was directly related to percent bloom of almond varieties at both localities and at all distances, except for Baxendale at Angle Vale which had higher than expected flight away from and lower than expected flight near to the colonies on 5 Aug. compared to Nonpareil and Mission (Table 8). Foraging activity within each variety was about twice or more at distances near the hives (29-37 m) compared to that away from the hives (168-205 m) at Angle Vale, except as noted for Baxendale on 5 Aug. (Table 8). At Lyrup, maximum distance from nearest hives was 75 m. Some drop in activity within varieties was noted on cool, overcast days at distances beyond 59 m when compared to measures taken within 25 m of hives (10 Aug., 11 Aug., Table 9). On a sunny day (24 Aug.) no drop in activity was noted up to 75 m (Table 9). Additional data supporting an inverse relation between distance from colonies with bee flight and a direct relation with % bloom and bee activity are shown in Tables 10-12. Although colony strength was greater in the treatment blocks than in the control, bee activity in trees in the control at less than 25 m was as high as in the treatments (Table 11-12).

Intertree flights. - An inverse relationship between distance between trees and numbers of intertree flights within a single variety at Lyrup (Table 10). The same relationship was found at Angle Vale in Nonpareil (Table 11), along with a direct relation between % bloom and flight activity as noted in "Bee in tree activity" (Tables 8-9).

All intervarietal flight observations at Angle Vale included Nonpareil as one of the pair. Again there appeared to be a direct relationship of the % bloom of the pollinator of Nonpareil with intervarietal flight, but in all cases flight was less than the within-row flights in the pollinator variety (Table 11). At Lyrup, smaller samples followed similar patterns with intervarietal flights (greater distance) being less than within-row flights. A direct relationship was found between % bloom and flight activity at each comparable distance from bee hives and a decrease in activity with distance from hives (Table 12). The apparent anomolies in orchard T-2 may be due to small sample size, the latest observation made during poor flight weather, the equidistant spacing of trees within and between rows (7 X 7 m) and similar % bloom for each almond variety.

Bloom and fruit set counts. - Fruit set in the older orchard (A, W) at Angle Vale showed no difference between rows near to (A) vs. away from (W) bee hives for NePlus and Davey original limbs (Table 13). Baxendale showed an unexplained increase in fruit set away from the bee hives, however the standard deviation of this mean was high. All varieties in the orchard with uniform colony distribution showed higher fruit set, but this may in part be due to the younger age of these trees. At Lyrup fruit set was generally lowest for all varieties in the control block and highest in T1 Block (5 X 7 m planting). This increase corresponds with higher density of colonies, highest initial colony strength, and shortest distance between colonies and trees.

Discussion: Foraging activity (density) of Honey bees in an almond variety increased with increasing percent bloom relative to other varieties in the same orchard. When a bee leaves a tree, it most often flies to the next nearest tree and to one in the same stage of bloom as the one it left. These behavior patterns tend to channel most intertree flights along rows of the same variety and so reduce pollination efficiency. These results argue for tree spacing closer between than within varieties, and for synchrony of bloom between cross compatible varieties.

Within an almond variety, distance from the nearest bee hives also effects the amount of bee activity, especially when conditions for bee flight are marginal. Significant drops in bee activity were noted in most varieties at distances more than 168 m compared to less than 37 m from nearest bee hives in the older orchard at Angle Vale where all hives were grouped at one end. No drop in activity was found up to 75 m at Lyrup with good flight conditions, but with marginal flight conditions some drop in activity was noted at 59-69 m as compared to activity at less than 32 m from nearest bee hives. These data argue for a more even distribution of colonies throughout larger orchards. Groups of hives placed at intervals of approximately 150 m should produce overlapping areas of maximum foraging activity in good flight conditions.

Fruit and nut set related closely to bee activity at Angle Vale, and showed a decrease with distance from the hives. The fact that the check block at Lyrup had consistantly lower set than the two treatment blocks where hives were excessively dispersed may be a complex relationship involving greater distance (43-61 m versus 3.5-5.1 m) and lower colony strength.

Table 8. Bee foraging activity at Angle Vale near to and away from bee hives. Means based on 15-second visual sweeps per tree, 10 trees per row.

Date	Variety	Trees Counted	Bees/15 sec. $\bar{x}$ (s)	Total Bees	Distance from Hives
5/VIII	Nonpareil	60	13.2 (± 5.5) 5.6 (± 2.8)	810 336	29.3 m 175.6 m
	NePlus	60	20.09 (± 8.3) 9.37 (± 4.61)	1209 585	21.9 m 168.2 m
	Davey	60	5.7 (± 3.0) 2.8 (± 1.54)	342 138	36.6 m 183.0 m
	Baxendale	30	8.6 (± 4.0) 7.1 (± 2.9)	258 213	29.3 m 204.8 m
18/VIII	Nonpareil	30	0.4 (± 0.63) 0.2 (± 0.48)	12 6	29.3 m 175.6 m
	Davey	30	0.4 (± 0.67) 0.13 (± 0.35)	12 4	36.6 m 183.0 m
	Baxendale	30	0.33 (± 0.82) 0.33 (± 0.61)	22 10	29.3 m 204.8 m
	Mission	30	6.28 (± 3.12)	188	7.3 m

Table 9. Bee foraging activity at Lyrup near to and away from bee hives. Means based on 15-second visual sweeps per tree, 10 trees per row (C = Control; T-1 = 5 x 7 m, T-2 = 7 x 7 m tree spacing). Data for distances less than 35 m pooled.

Date	Variety	Trees Counted (N)	Bees/15 sec. $\bar{x}$ (s)	Total Bees	Distance from Hives	Orchard
4/VIII	Nonpareil	38	4.19 (± 2.62)	158	4.6-24.1 m	T-2, C
	NePlus	45	19.7 (± 8.6)	887	4.6-24.6 m	T-2, C
10/VIII	Nonpareil	80	3.5 (± 2.43)	280	4.5-15.5 m	T-1, T-2, C
		40	2.6 (± 1.9)	104	59.0 m	C
	NePlus	80	4.85 (± 3.09)	388	5.6-16.9 m	T-1, T-2, C
		40	2.8 (± 1.9)	112	65.8 m	C
11/VIII	Nonpareil	40	3.3 (± 2.6)	132	17.9 m	C
		40	2.1 (± 1.6)	84	59.0 m	C
	NePlus	40	5.8 (± 3.4)	232	16.9 m	C
		40	3.6 (± 3.0)	144	65.8 m	C
19/VIII	Nonpareil	80	1.29 (± 2.0)	102	6.1-25.3 m	T-1, Scope
		40	0.93 (± 0.94)	37	68.4 m	Scope 4
	Mission	80	2.63 (± 1.7)	210	4.5-31.4 m	T-1, Scope
		40	2.36 (± 1.5)	94	74.4 m	Scope 4
24/VIII	Nonpareil	80	0.5 (± 0.7)	50	6.1-25.3 m	T-1, Scope
		40	0.97 (± 1.0)	39	68.4 m	Scope 4
	Mission	80	2.7 (± 2.2)	216	4.5-31.4 m	T-1, Scope
		40	3.2 (± 2.0)	128	74.4 m	Scope 4

Table 10. Intertree bee flights in three adjacent rows of Mission at Lyrup. Distances from shortest to greatest measured: within rows, between rows and across a gap of a missing tree.

Distance	flights $\bar{x}$ (s)	Total Bees	Number of Observations
0.1-0.35 m	15 (± 11.4)	240	16
0.7-0.8 m	10.9 (± 3.1)	87	8
1.4-1.6 m	6.9 (± 5.4)	166	24
3.5-4.0 m	5.8 (± 3.8)	92	16

Table 11. Intertree flights within and between varieties at Angle Vale 5/VIII/81. Means based on 15-min. counts of bees flying between pairs of trees.

	Varieties	% bloom	Bees/15 min. $\bar{x}$ (s)	Total Bees	Distance Between Trees
Within	CPS-CPS[2/]	21%	36.25 (± 16.1) 6.0	145[1/] 6	0.3 m 2.7 m
	Davey-Davey	16%	15	15	0.3 m
	Baxen.-Baxen.	±50%	52	52	0.3 m
	NePlus-NePlus	84%	61	61	0.3 m
Between	Davey-CPS	16-21%	12	12	2.7 m
	Baxen.-CPS	±50-21%		30	2.7 m
	NePlus-CPS	84-21%	58	58	2.7 m

[1/] N = 4; all others N = 1

[2/] CPS = Nonpareil (California Paper Shell)

Table 12. Intertree flights within and between varieties at Lyrup 10/VIII/81.

Means based on 5-min. counts of bee flying between pairs of trees.

	Varieties	% bloom	Orchard and dist. from hives	Bees/5 min. $\bar{x}$ (s)	Total Bees	N	Approx. distance between trees
Within	Nonpareil-Nonpareil	55%	T-1 4.5 m	27.3 (± 10.7)	82	3	0.3 m
		52%	C 40.0 m	14 (± 1.4)	28	2	0.3 m
		52%	C 66.0 m	12 (0)	24	2	0.3 m
		65%	T-2 4.6 m	12	12	1	2.0 m
	NePlus-NePlus	56%	T-1 8.4 m	61.0 (± 2.8)	122	2	0.3 m
		72%	C 40.6 m	36.5 (± 36)	73	2	0.3 m
		72%	C 63.0 m	6.5 (± 0.7)	13	2	0.3 m
		65%	T-2 3.5 m	3.0	3	1	2.0 m
Between	Nonpareil-NePlus	55-56%	T-1 3.5 m	50.7 (± 10.3)	152	3	2.0 m
		52-72%	C 40.3 m	12.8 (± 8.7)	38	3	2.0 m
		52-72%	C 65.0 m	3.8 (± 1.7)	11	3	2.0 m
		65-65%	T-2 4.0 m	5.0 (0)	15	3	2.0 m

Table 13. Percent fruit set (October, visual), percent nut set (February, picked), and kernel weights (grams) for Angle Vale. Counts based on 4 limbs per tree and 5 trees for each distance from the hives on 3/VIII/81. (A & W = older half of orchard; A = near colonies; W = away from colonies; B = younger half of orchard).

Variety	% Fruit set $\bar{x}$ (s)	% Nut set $\bar{x}$ (s)	Kernel Wt. (g) $\bar{x}$ (s)	Distance from hive
Nonpareil	25.8 (11.6) 16.2 (7.6)	23.9 (11.4) 15.7 (5.9)	1.20 g (0.15) 1.24 g (0.12)	29.3 m (A) 175.6 m (W)
NePlus	25.0 (11.0) 26.6 (9.1)	27.2 (17.8) 23.3 (9.9)	1.10 g (0.08) 1.29 g (0.17)	21.9 m (A) 168.2 m (W)
Davey	22.0 (12.2) 24.4 (11.3)	23.1 (10.6) 22.4 (12.9)	1.14 g (0.15) 1.05 g (0.11)	36.6 m (A) 183.0 m (W)
Baxendale	18.4 (12.5) 34.1 (20.9)	15.9 (12.9) 35.9 (20.8)	1.28 g (0.13) 1.29 g (0.16)	29.3 m (A) 204.8 m (W)
Mission	35.7 (10.7)	37.9 (11.2)	1.11 g (0.10)	7.3 m (A)
Nonpareil	35.6 (13.1)	29.2 (14.9)	1.32 g (0.16)	41.7 m (B)
NePlus	35.4 (12.1)	34.6 (12.6)	1.33 g (0.13)	41.7 m (B)
Mission	44.9 (14.6)	40.8 (14.6)	1.12 g (0.07)	42.5 m (B)

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ALMOND BOARD

G. M. Loper - 1982 Annual Report

Project No. 81-L6 - 82-K7
Pollination

R. W. Thorp (Davis)
G. M. Loper (USDA-Tuson, AZ)

1. Objectives of 1982 Research

   A. To continue testing a modified drop pattern of colonies placed around a 70 acre orchard to obtain uniform honey bee foraging and nut yields.

   B. To determine the diurnal rhythm and rate of pollen gathering by honey bees near almond orchards.

   C. To determine the viability of bee-gathered almond pollen.

2. Interpretive Summary

Over the 2-year period, 1981-82, essentially 3 experiments were conducted: 1) effect of a modified drop-pattern around 70 acre orchards, 2) effect of time-of-day on bee-gathered pollen viability, 3) effect of pollen traps on rate-of-flight from colonies of several strengths. In summary, the results of a modified drop pattern around the 8-9 year-old, 1/2 x 1/4 mile orchards reduced or even eliminated the low forager density and nut yields in the center of the orchards. The suggested drop pattern places 65% of the colonies at the ends (by the perimeter road) of rows 40-60 (a 70 acre, 1/2 x 1/4 mile orchard usually has 100 rows). The results of the pollen trapping-germination study showed that a strong colony (16 frames of bees) brought in approximately 0.81 lbs of pollen per day (fresh weight; dry weight would be approximately 0.7 lbs). This is in addition to pollen getting past the trap, probably 40-50% of the pollen gets through into the combs. Tests of the germinability of this pollen show that it would be unsuitable for commercial collection to be processed for later hand- or

machine-dispersal for pollination. Lastly, weak colonies (4-5 frames of bees) were unsuitable for pollen trapping (bees drifted away from these colonies) but the 8-9 frame colonies increased flight by 63 and 153% (Feb. 23 and 26) and the 12-14 frame colonies increased flight by 54 and 26% (Feb. 23 and 26).

3. Experimental Procedure

A. Modified drop pattern around 70 acre, 1/2 x 1/4 mile orchards. Generally, the grower normally placed groups of colonies around the perimeter by dropping 2 groups of 18 along each short side and 5 groups of 9 along each long side (100 rows of trees). Each year, (1981-82) a second similar orchard was selected with a modified placement taking into account that the average flight distance of a honey bee in an almond orchard is approximately 300 meters and that when bees compete in an area, they will "spread out" (Gary et al., J. Apic. Res. 15:43(1976) and 17:188(1978). This modified placement puts 58% (1981) and 67% (1982) in 3 drops (near row #'s 40, 50 and 60) essentially in the middle of each long side of the orchard. No colonies were actually placed in the middle of the orchard. The "control" orchard with normal placement was always separated from the "test" orchard by at least one "buffer" orchard between them, also with normal placement of bees. Honey bee foragers were counted on all trees across the diagonal when air temperatures exceeded 60°F. Bees per tree were estimated by observing the tree for approximately 30 seconds, standing on the south side of the tree (more bees orient and forage on the "sunny" side of the tree). Each orchard was counted twice each day, once each by 2 technicians. Their values were corrected for any consistent counting differences and averaged for each day and the season. Only data from the Non-pareil trees was used. Similarly, the Non-pareil trees were harvested in August across the same diagonal from both "test" and "control" orchards. Data was analyzed comparing bees/tree and nuts/tree across the diagonal in both orchards in both years.

B. For the diurnal pollen trapping and pollen viability study, an automatic, electric (12v) driven device with 24 trays was placed beneath a conventional O.A.C. type pollen trap placed below a strong colony (16 frames of bees). Each hour, a new tray automaticaly moved in place beneath the trap to collect pollen. At 3 PM, pollen collected the previous 6 hours plus the hourly pollen collected the previous day was removed for pollen viability studies using an agar medium. The total collections were also weighed, dried at 60°C and reweighed to obtain percent moisture. On another day, bee-gathered pollen was also used to hand-pollinate flowers of the Merced variety (short branches had been bagged to eliminate bee visitation). The agar plates were cultured at 30°C and later examined for percent germination under a microscope. Percent nut set on the branches was determined 3 weeks after pollination.

C. The study of the effect of pollen trapping on the rate-of-flight from colonies of 3 different strengths was a serendipitous one. One beekeeper had put pollen traps on about 200 of his colonies but not on others (of another beekeeper) that he had contracted. We examined the colonies and selected 3 from each group (all on the same ranch) that had either 4-5, 8-9 or 12-14 frames of bees plus some brood. It is important to note that the traps were in place at least 1 week before the beginning of almond bloom, so the colonies had "adapted" to the traps before bloom. On the third and sixth days after 1/2 bloom (on the Non-pareil), we used the Gary flight cone for 30 seconds on each colony to estimate rate-of-flight. The schedule began at 12:46 PM and went to 4:15 PM (3 rotations among the colonies) on Feb. 23 and from 9:33 AM to 4:27 PM (4 rotations) on Feb. 26, 1982.

The observation schedule ("rotation") was randomly set up across all colony strenghts and treatments to remove as much bias as possible.

Results:

A. Colony placement. The results of 1982 are shown in Fig. 1a and 1b. The results of the 1981 experiment are similar and provided data for the improved results of 1982. In 1980, we first observed the problem (a "dip" in the center of the orchard with low numbers of foragers per tree) but no nut yields were taken. The result (1982) of placing 67% of the colonies (of each long side) between rows 40-60 in 3 groups, was nearly uniform bee distribution across the orchard and nut yields were also nearly level across the orchard. From these results, plus what we expect to get in 1983, we can finalize a mathematical model describing bee distribution on the basis of colony numbers and strength, average foraging distance and location of each apiary in relation to tree location.

B. Diurnal rhythm of pollen collection and pollen viability. Table 1 gives the data for 3 days when maximum temperatures were between 64.5 and 66.5°F and flying conditions were excellent. Reflecting the continued dehiscence of anthers during the day and the large quantities of pollen available, pollen collection is spread out with large amounts coming in from 10 AM to 4 PM. For this strong colony, the individual hourly pollen trays were not quite large enough to contain the hourly flow at 12 - 1 PM, so the data of 2/26 is probably the best, with a maximum (21.5%) coming in between 1 and 2 PM. On the average, a strong colony can bring in 0.7 lbs of dry pollen per day.

Table 2 presents the results of germinability tests on bee-gathered pollen ranging from "fresh" (0 hr) to 25 hr-old pollen. Three pollen pellets were dispersed in water (approx. 2 ml) and smeared on Agar plates. Under the microscope, any pollen grain that had germinated and the tube had grown equal to the diameter of the pollen grain was counted as germinated. By this test, freshly collected pollen was 72.6% viable and viability dropped slowly down to 59.3% after 24 hours. A "25 hr" sample collected by bees at 8-9 AM 25 hours before testing was actually pollen from flowers that had dehisced the day before and would have been at least 40 hrs old and had been exposed on the flowers overnight. When similar bee-gathered pollen fron 0 to 5 hours old was used to hand pollinate bagged Merced flowers, nut set was poor ranging from 0 to 13.5%. Evidently, even though bee-gathered pollen can germinate on Agar, it cannot satisfactorily fertilize the flower.

C. Effect of pollen trapping on rate-of-flight from colonies. Data from 3 colony strengths was gathered on 2 days - 3 and 6 days after 1/2 bloom. First, it was observed that with many of the weaker (4-5 frame) colonies the bees drifted away and these colonies became weaker. This may be the reason why, on 2/23, there was less flight from the weaker trapped colonies vs. untrapped colonies (Table 3). Secondly, however, in all cases with the stronger colonies on 2/23 and all colonies on 2/26 there was increased flight from trapped colonies relative to untrapped colonies. The percentage increase was greatest for 8-9 frame colonies but all the increases were significant.

Discussion:

The results of the modified placement of colonies appear to be conclusive and valid for 70 acre orchards. Whereas best placement would be achieved by actually placing colonies in the very middle of the orchards, this method of placing more near the middle rows but on the perimeter overcomes the low-forager density problem we first observed in 1980. The additional data expected in 1983 should finish this project, although I'm not sure how to apply it to even larger orchards.

Some beekeeping industry representatives had proposed using bee-gathered pollen as a source of pollen for mechanical pollination the following year. Due to the loss of ability to fertilize flowers, this plan appears to be unfeasible.

There is great interest in, and considerable controversy over, the use of pollen traps and their effect on colony populations and management. Any positive benefits (pollen for sale and possibly increased pollen foraging) must be balanced against the costs (traps, manipulation and possibly reduced brood-rearing). At present, there is insufficient data, but the almond pollination situation is an excellent one for researching. The serendipitous study of 1982 was not complete enough to answer many of these questions for the beekeeper, but indicated that a trapped colony may be a more efficient almond pollination unit.

Publications. None yet, but at least 2 expected during 1983-84. One dealing with modified drop locations and one dealing with the effect of pollen trapping on bee flight, pollen collection and colony management.

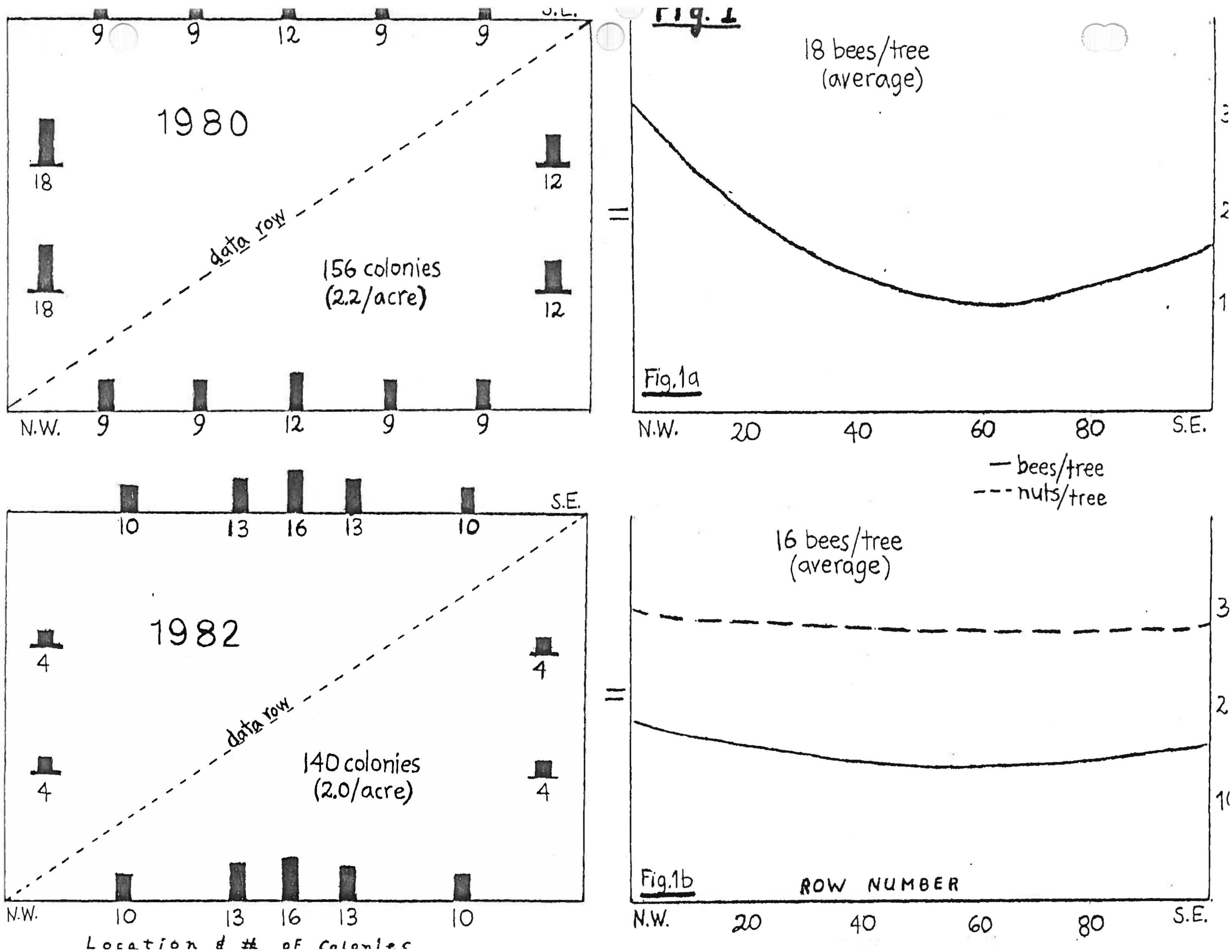
Fig. 1
1980
data row
156 colonies
(2.2/acre)
S.E.
9 9 12 9 9
18
18
12
12
N.W. 9 9 12 9 9
18 bees/tree
(average)
Fig. 1a
N.W. 20 40 60 80 S.E.
— bees/tree
--- nuts/tree
1982
data row
140 colonies
(2.0/acre)
S.E.
10 13 16 13 10
4
4
4
4
N.W. 10 13 16 13 10
Location & # of Colonies
16 bees/tree
(average)
Fig. 1b
ROW NUMBER
N.W. 20 40 60 80 S.E.

Ta[illegible] 1. Hourly pollen collection of almond pollen from a strong (16 frames of bees) colony fitted with an O.A.C. type bottom trap.

Hour	Feb. 25*		Feb. 26*		Feb. 27*		3-day Av.	
	Fr. wt. (g)	% of Daily Total	Fr. wt. (g)	% of Daily Total	Fr. wt. (g)	% of Daily Total	Fr. wt. (g)	% of Daily Total
8 AM	--	·	0.58	0.2	-		0.19	.05
9	6.13	1.5	14.94	5.5	1.21	0.3	7.43	2.0
.0	68.12	16.2	24.18	8.9	38.96	9.6	43.75	11.9
.1	75.12	17.9	35.55	13.0	81.75	20.1	64.14	17.5
.2	58.39	13.9	53.67	19.7	78.11	19.2	63.39	17.3
1 PM	60.48	14.4	58.63	21.5	72.49	17.8	63.87	17.4
2	53.07	12.6	43.50	16.0	59.40	14.6	51.99	14.2
3	46.34	11.0	23.83	8.7	44.17	10.8	38.11	10.4
4	25.90	6.2	11.91	4.4	21.46	5.3	19.76	5.4
5	1.54	0.4	0.17	0.1	1.29	0.3	1.00	0.3
RUNOVER"**	25.44		5.62		8.35		13.14	
OTAL	420.53***		272.58		407.19		366.77	

* Maximum temp. was 66.5°, 64.5°, and 65.0°F, respectively.

** Pollen which fell out of tray when tray over-flowed in mid-day.

** 420.53 g @ 25% H_2O = 315.4 g dry wgt = 0.69 lbs.

Table 2. Percent viability of bee-gathered almond pollen - 1982 (on Agar medium).

Age of Pollen	% Germination, ± S.D.*			
Hours	Rep 1	Rep 2	Rep 3	Av.
0	73.8 ± 4.1	73.1 ± 2.7	70.9 ± 4.2	72.6
1	69.8 ± 5.2	67.8 ± 2.7	67.0 ± 4.6	68.2
2	71.7 ± 4.2	68.9 ± 4.4	61.8 ± 7.4	67.5
3	64.7 ± 4.0	66.4 ± 6.0	71.6 ± 4.4	67.6
4	51.9 ± 4.6	57.9 ± 5.5	65.2 ± 3.9	58.3
5	54.5 ± 5.2	62.4 ± 4.8	70.6 ± 4.3	62.5
17	56.6 ± 4.7	52.6 ± 7.0	58.1 ± 3.8	55.8
18	49.7 ± 5.1	60.9 ± 5.1	65.6 ± 4.3	58.7
19	60.8 ± 3.5	58.6 ± 3.4	-----	59.7
20	46.9 ± 4.0	51.8 ± 4.4	59.6 ± 3.0	52.8
21	53.9 ± 4.2	57.1 ± 4.5	59.3 ± 3.3	56.8
22	62.0 ± 4.4	63.6 ± 3.7	67.3 ± 4.7	62.8
23	53.0 ± 4.0	52.5 ± 4.2	45.2 ± 4.5	50.2
24	58.0 ± 4.2	60.5 ± 3.4		59.3
25**	26.8 ± 6.8	21.6 ± 3.0	25.4 ± 4.4	24.6

* Each replication is the average of 10 microscopic "fields" viewed on the petri plate.

** The 25-hr old sample represents pollen collected by bees between 8 and 9 AM - before that days' anther dehiscence and probably is pollen dehisced the day before.

Table 3

Summary of Flight Cone vs. Colony Strength Evaluations

1982 Almonds

Date: 2/23/82

#Frames	Trap	Count #1* Av. #Bees ± S.D.	#2 Av. #Bees	#3 Av. #Bees	Av. of Ct. # 1-2***
4-5	yes	29.7 ± 31.5	21.0 ± 21.5	18.0 ± 12.8	25.3 ± 23.3
4-5	no	39.0 ± 26.2	36.7 ± 16.2	19.3 ± 8.4	37.8 ± 19.5
	% Decrease	31.3	74.8	7.2	49.4
8-9	yes	101.7 ±102.5	78.3 ± 57.9	63.3 ± 43.8	90.0 ± 75.5
8-9	no	57.3 ± 9.5	53.3 ± 38.8	34.3 ± 14.6	55.3 ± 25.4
	% Increase	77.5	46.9	84.5	62.7
12-14	yes	145.3 ± 34.3	84.3 ± 16.9	74.3 ± 73.4	114.8 ± 41.2
12-14	no	90.7 ± 37.0	58.0 ± 21.4	86.7 ± 42.7	74.4 ± 32.5
	% Increase	60.2	45.3	85.7	54.3

Date: 2/26/82

#Frames	Trap	Count #1** Av. #Bees ± S.D.	#2 Av. #Bees	#3 Av. #Bees	#4 Av. #Bees	Av. of Ct. # 1-3***
4-5	yes	63.6 ± 20.0	68.3 ± 4.7	68.3 ± 14.0	44.0 ± 34.8	66.7 ± 12.7
4-5	no	52.7 ± 41.8	45.3 ± 33.1	53.0 ± 30.5	23 ± 19.1	50.3 ± 30.9
	% Increase	20.7	50.8	28.9	91.3	32.6
8-9	yes	122 ± 64.6	121.7 ± 23.4	146.3 ± 74.8	111.7 ± 57.4	130.0 ± 52.2
8-9	no	54.7 ± 9.3	48.7 ± 43.5	50.7 ± 29.0	41.0 ± 27.5	51.4 ± 20.9
	% Increase	123.0	150.0	189.0	172.0	153.0
12-14	yes	158.0 ± 64.8	207.0 ± 74.5	170.0 ± 34.8	149.7 ± 33.7	178.6 ± 56.8
12-14	no	117.0 ± 55.5	154.0 ± 67.1	155.3 ± 80.8	91.3 ± 31.8	142.1 ± 64.9
	% Increase	35.0	34.0	9.9	64.0	25.7

*Each number for each count is the average of 3 colonies ± standard deviation. Count #1 taken from 12:46-2:03, #2 from 2:08-3:09, #3 from 3:16-4:15.

**Each number for each count is the average of 3 colonies ± standard deviation. Count #1 taken from 9:30-11:21, #2 from 11:27-1:16, #3 from 1:18-2:54, #4 from 2:57-4:27.

***Since data from 2/26 shows a distinct drop in flight after 3:00 p.m., only data prior to 3:00 is averaged.