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ANNUAL REPORT - 1981

INTEGRATED PEST MANAGEMENT FOR ALMONDS

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The goals of the 1981 Integrated Pest Management Project for Almonds were fourfold. First, the information obtained by Dr. Clarence Davis and Wilbur Reil was to be summarized and made public. Second, project personnel were to conduct demonstration and educational programs with Farm Advisors in major almond producing counties to promote monitoring and sound management for the Navel Orangeworm, the Peach Twig Borer, the San Jose Scale, and spider mites. These efforts were to be coordinated with ongoing research in those areas. Third, work on the importance and control of ants in almond orchards initiated by Wilbur Reil was to be continued. Finally, cooperative efforts involving management of spider mites in almond orchards was to be initiated.

Extensive efforts were undertaken in each of the four categories. The remainder of this report will address each issue in more detail.

Summary of Prior Work -

During 1981, data relative to the navel orangeworm and the peach twig borer were assembled and put into manuscript form by Wilbur Reil. Three manuscripts were produced (see Appendices I, II, and III):

Reil, W.O., T.W. Johnson, J.C. Profita, C.S. Davis, L.C. Hendricks, and D. Rough. 1981. Monitoring peach twig borer in almonds with sex pheromone traps. California Agric. Sept-Oct. pp. 19-20.

Reil, W.O., T.W. Johnson, C.S. Davis, L.C. Hendricks, M.Viveros. 1981. The effect of overwintering mummies on the infestation of almonds by navel orangeworm. Submitted to Calif. Agric.

Reil, W.O., T.W. Johnson, C.S. Davis, D. Rough, J.C. Profita, and C.K. Moriuchi. 1981. Timing control measures properly for control of navel orangeworm in almonds. Submitted to Calif. Agric.

Data collected by Dr. Davis and Mr. Reil relative to early harvest in the management of the navel orangeworm was summarized in a publication of the principal investigator (see APPENDIX IV):

Zalom, F., C. Weakley, and J. Connell. 1981. Sanitation and early harvest for the management of navel orangeworm. Almond Facts. 46(6): 44-5.

Demonstration and Educational Programs -

The primary emphasis of the California Almond IPM program is control of its key pest, the navel orangeworm, which annually costs the almond industry 30 million dollars in damage. Orchard sanitation and early harvest are emphasized, with properly timed chemical treatments based on the use of egg traps being recommended in situations where cultural controls cannot be carried out.

There has been marked increased in the awareness of fieldmen and consultants to the advantages of utilizing cultural controls for control of NOW. New methods introduced included using day degrees to forecast PTB and San Jose Scale emergence and the introduction of insecticide resistant mites.

Both mass media and individual meetings with growers and PCAs were utilized in 1981. The Kern County office installed an automatic phone service where growers could call for IPM information. Weekly newsletters containing almond IPM information was mailed to PCAs and growers during the growing season (see examples in Appendix V). Tips on pest management techniques and principles were broadcast over NOAA weather system in Fresno and Merced. These broadcasts were updated twice weekly and contained information on trapping, indentification, phenology and principles and techniques of IPM. Almond IPM information was presented at approximately 17 grower and PCA training sessions. Over 2000 fieldmen and producers attended these sessions. An almond narrative was prepared and installed on the UC/IPM computer system (see APPENDIX VI).

The amount of acreage monitored by CES personnel almost doubled to 1880 acres in 1981 in Butte, Colusa, Fresno, Glenn, Kern, Kings, Madera, Merced, Sutter, Tulare, Yolo, and Yuba counties.

The results of the demonstration program confirmed sanitation and early harvest as suitable measures for the management of the navel orangeworm. Growers who practiced good orchard sanitation and early harvest were able to save the cost of one insecticide plus application costs which amounts to about $40.00 per acre. This saving was offset by the cost of cleaning the orchard. Net profits to these growers were greater since sanitation and early harvest provided better control of navel orangeworm than following the chemical control approach which only provides approximately 50% control. In addition, materials for control of mites were applied once or twice in orchards receiving insecticide application which added an additional $50 to $75 per acre to the costs. Growers who followed all IPM practices generally received a 2% bonus which can amount to $30 to $40 per acre. Pesticide useage was reduced in cleaned orchards by at least 50%. In orchards receiving at least one in season spray one and two acaracide applications were needed to provide control of mites. The use of disruptive materials such as Sevin and Synthetic pythroids was discouraged since the use of these materials lead to mite outbreaks which in turn will hasten resistance to acaracides currently available.

Examples of demonstration activities are provided in Appendices IV and VII.

One grower practicing good sanitation in Sutter County used no in-season insecticide treatments, yet had only 2.2% damage at harvest (see Appendix VIII). Another grower practicing good sanitation in Glenn County treated half his orchard with one in-season NOW spray and the other half with two in-season sprays. The result was that the grower only had a 0.45% reduction in total damage at harvest by treating his clean orchard with a second spray (see Appendix IX). The second application was not economically justified in this case.

The importance of early harvest was demonstrated in two Kern County orchards (Appendix 10). These orchards had in excess of 24 mummies/tree in February which resulted in fairly high navel orangeworm damage. The damage potential was shown to be reduced by prudent harvest.

A survey was conducted in cooperation with Dr. J.C. Headley to provide statistically valid estimates of the number of growers who have adopted practices which are part of the integrated pest management program for almonds in California. This survey provided baseline information on current management practices, and identified areas for increased educational efforts. The results of the survey (see Appendix XI) indicate that there is still room for education on insect pest management. While 70 percent said they were removing mummies in winter, only about 56 percent destroying those mummies which are a source of NOW infestation. About twice as many growers were using in-season sprays as are using egg traps and pheromone traps to time them. Finally there are still between five and six percent of the delivered meats that are rejects, not to mention perhaps an equal amount that were damaged and blew out in hulling.

Several growers indicated on their survey forms that they did not believe sanitation and early harvest to be cost effective. This suggests an additional need for education based on the survey results.

The survey also showed that growers utilizing both sanitation and early harvest had fewer rejected meats than growers not practicing good sanitation. The results are shown in Appendices IV and XI.

The phenology model for the peach twig borer was used to time an in-season _Bacillus thuringiensis_ treatment in cooperation with an organic almond grower in Winters. Damage due to both the navel orangeworm and the peach twig borer was lower in the treated plots (Appendix XII), but the abundance of the peach twig borer was too low to provide an adequate test.

Ants -

Several species of ants were identified that may damage almonds. Field trials showed that damage increases proportionally to the length of time nuts remain on the ground, making rapid harvest and removal from the orchard floor important in areas where ants can be a problem (Appendix XIII). Experimental work has shown that applications of either Diazinon 14G or Lorsban 15G will reduce the number of ant colonies. These materials are not currently registered for use in almond orchards, but Diazinon 14G may be registered by the 1982 season.

Mites -

The influence of water stress on mite abundance was studied in cooperation with Dr. John Labavitch in Butte County during 1981. Weekly samples were taken from plots in which water was withheld beginning in late June, in which water was withheld beginning in late July, and in normally-watered plots. As indicated by the pressure bomb readings in Appendix XIV, the trees were never put under stress. No differences were observed in the abundance of European red mites, spider mites, or predaceous mites between any of the treatments.

Field releases of genetically-improved _Metaseiulus occidentalis_ were conducted by Dr. Marjorie Hoy in 1980 and 1981. Integrated pest management project participants participated where they could be of service (Appendix XV).

APPENDIX I (a)

The peach twig borer, *Anarsia lineatella* Zell., causes two types of injury to the tree and crop of almonds as well as other stone fruits: it damages and kills new shoots by feeding on newly emerged leaves and shoots, and it feeds on new crop nuts. Peach twig borer (PTB) also indirectly causes greater distribution of nut damage by navel orangeworm, *Amyelois transitella* Walker: navel orangeworm is often attracted to PTB-damaged hulls, where it lays its eggs.

PTB larvae may visit several new leaf clusters before settling down to feed on a newly formed terminal. Summer-brood larvae feed on shoot tips or on nuts, or may form a temporary hibernaculum (chamber within the bark).

At the time of hullsplit, PTB larvae begin feeding between the hull and shell. Later, some, but not all, larvae move into the kernels. What causes movement from hull to kernel is not known, but it is thought to be related to the moisture content of the hull and kernel at the time of infestation.

Peach twig borer populations can be monitored in orchards by using sex pheromone traps during the spring and summer. Traps should be placed in the orchard in early April. Several traps are required to monitor the population adequately within an orchard, but no trap should be closer than 300 feet to another trap. Traps are hung 6 to 7 feet high in the northeast quadrant of the tree, 1 to 3 feet from the outside of the canopy. Male moths are attracted and caught in the sticky liner. Moths should be counted and removed at least twice weekly during major flight activity. Pheromone caps should be replaced every four to six weeks and sticky liners should be replaced after 200 moths are caught, when soiled or dirty, or every six weeks, whichever comes first.

Peach twig borer data have been collected during the past three years from joint U.C.-grower integrated pest management demonstration almond orchards throughout California's Central Valley from Kern County in the south to Butte County in the north. Pheromone trap catches and damage to the nuts were monitored in seven orchards in 1978 and six in 1979. The untreated check area in each orchard consisted of two blocks of approximately 10 to 12.5 acres each.

Three pheromone traps were hung 180 feet or more apart in each 10- to 12.5-acre block in 1978. The number of traps used in 1979 was reduced to two per block, more than 300 feet apart, because catches were reasonably consistent within each block, and some interaction between traps in the 10-acre blocks was suspected.

Traps were placed and serviced as indicated. Peak moth catches are reported as moths per trap per day and were computed by dividing the trap catch by the number of days between observations.

The first and second flight periods were determined by field data and also by using a day-degree formula suggesting about 1060 D° per generation for peach twig borer. Temperatures were collected within each orchard by a continuous recording thermograph.

Percentage of damage at harvest was derived from four to twelve 100-nut samples per block, which were hand cracked; the damage percentage was then multiplied by the total yield per acre. These harvest samples were evaluated in late August when the type of feeding damage could be identified. Peach twig borer damage is a typical pattern of surface feeding with very

Monitoring peach twig borer in almonds with sex pheromone traps

A total first-flight trap catch of 155 moths is suggested as the economic threshold of nut damage at harvest.

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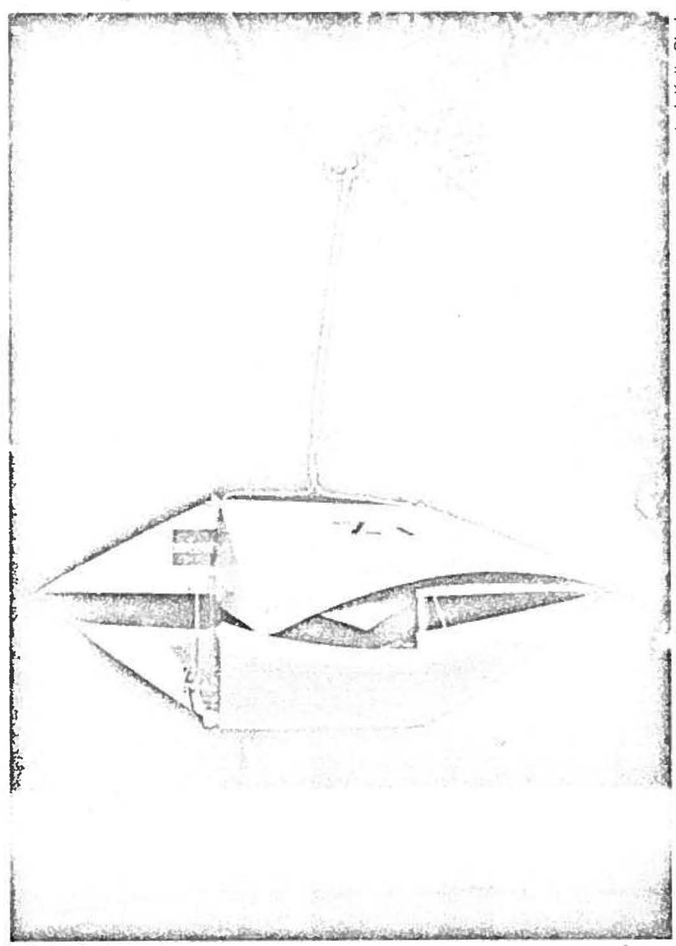

Jack Kelly Clark

APPENDIX I (p. 2)

shallow channels, little frass (dark red in color), and no webbing. Many times the damage rated as being caused by PTB decreased during September because of the masking effect caused by navel orangeworm. Therefore, the damage reported is the amount that would result from peach twig borer if no navel orangeworm damage occurred in the orchard.

The relationship between pounds of damaged nuts and number of moths trapped (fig. 1), as described by the regression equation, $y = 2.05 + 0.16X$ (black line), where y is the pounds of nuts damaged and X is the male moth catch, is highly significant as indicated by the coefficient of correlation (r) value of 0.78. Therefore, each moth caught in the spring flight represents approximately 0.16 pound of nut meat damage at harvest (technically, 2.05 pounds of damage would be observed before any moths are caught in the traps and is a constant that should be added to X).

The r value of 0.81 calculated for the second flight (fig. 2) is also highly significant. The regression equation, as defined by $y = 4.85 + 0.11X$, shows a slightly different slope than in figure 1.

The two orchards in 1978 where traps were only 180 feet apart caused considerable change in the data (broken line in fig. 1 and 3). If the data from these traps were dropped and the other 11 sites analyzed, the values of r would be 0.84 and 0.92 for figures 1 and 3 respectively. The regression equations for figures 1 and 3 (broken lines) are represented by the formulae $y = 4.76 + 0.16X$ and $y = 7.33 + 2.90X$, respectively. From these data the sphere of influence from each trap appears to be greater than 90 feet, and it is quite possible that the traps were competing with each other when only 180 feet apart. The 1978 traps in the other orchards were spaced farther apart with most traps between 250 and 300 feet apart. Further work on trap spacing and placement within an orchard appears to be warranted.

Figure 3 shows first flight collections in 1978 and 1979 in relation to harvest damage with an r value of 0.77 and a regression equation of $y = 1.46 + 2.73X$. Figure 4 shows the second flight peak in 1978 and 1979 in relation to harvest damage with an r value of 0.69 and a regression equation of $y = 4.76 + 1.65X$. The peak catch represents the highest daily count during the flight period.

The most useful trapping information is from the total moth catch and the peak of the first flight. Appropriate control measures could still be implemented after the first flight threshold levels occurred to prevent economically significant loss to the crop.

Coefficient of correlation values of 0.78 and 0.77 (fig. 1 and 3 respectively) are highly significant, indicating that anticipated PTB damage can be predicted from the first flight. If the adjusted data are used with r = 0.84 and 0.92, an even better correlation is suggested.

If the two orchards in question actually had competition between traps and the data were deleted, the following tentative economic threshold levels could be established to recommend when treatment for peach twig borer is warranted during the spring flight. Assuming an average price of $1.50 per pound for almonds, approximately 20 pounds of kernel damage would be the economic threshold warranting a chemical treatment (chemical and application = $30.00). Therefore, the tentative economic threshold for PTB could be established at either a peak of 9.4 moths per trap per day or an accumulation of 155 moths during the first flight.

In the orchards discussed here plus four orchards observed in 1980, excellent control of peach twig borer was achieved by a spray directed at navel orangeworm in May. PTB damage in all orchards was less than 1 percent: in most cases, the insect caused no damage.

Sprays applied at hullsplit (July) have not prevented damage caused by peach twig borer, and only those applied at very early hullsplit have achieved some control. Observations in orchards showed poor control when chemicals were applied at 5 to 10 percent hullsplit and no control when applied later.

Pheromone traps can be used to determine the effectiveness of a previous dormant treatment, identify problem areas ("hot spots"), time sprays, forecast the need for additional control measures, and predict the amount of damage at harvest if no chemical sprays are applied during the spring. These data suggest that correlations exist between peach twig borer peak flight or total moth catches and pounds of kernel damage occurring at harvest. These correlations exist for both the first and second flights. Data from the first flight can be used to initiate control measures. A tentative economic threshold of 9.4 moths per trap per day or 155 total moths for the first flight is suggested.

Peach twig borer total male moth catch in relation to almond harvest damage.

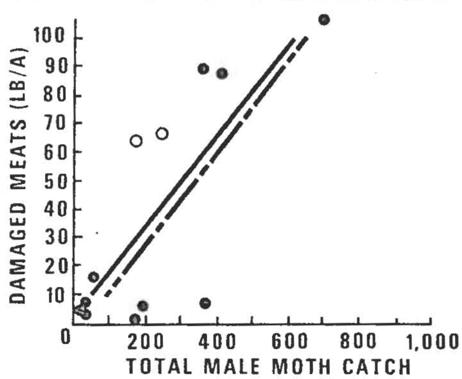

Fig. 1. First flight period April 15 to June 15, 1978 and 1979.

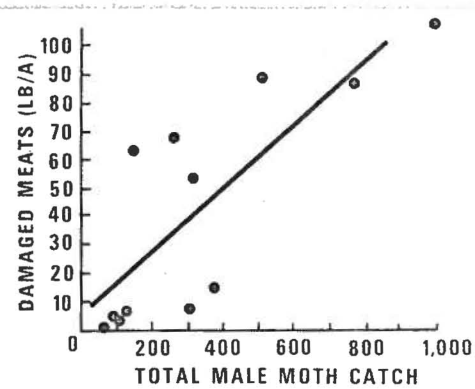

Fig. 2. Second flight period, June 15 to August 1, 1978 and 1979.

Peach twig borer peak daily catch of male moths in relation to almond damage.

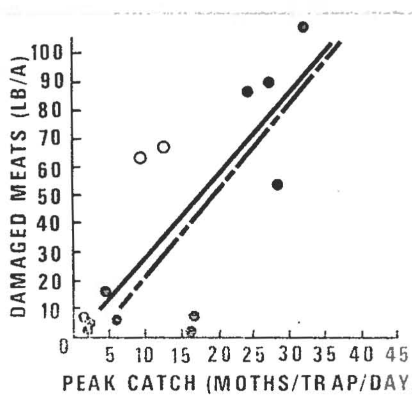

Fig. 3. First flight period, April 15 to June 15, 1978 and 1979.

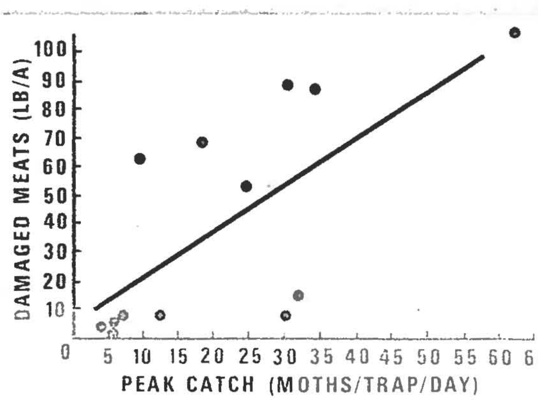

Fig. 4. Second flight period, June 15 to August 1, 1978 and 1979.

APPENDIX II (a)

#4??

The Effect of Overwintering Mummies on the Infestation of Almonds by Navel Orangeworm

W. O. Reil, T. W. Johnson, C. S. Davis, L. C. Hendricks, M. Viveros

The navel orangeworm, Amyelois transitella (Walker), damages the almond crop of California severely during most years. Several attempts have been made to relate the damage experienced at harvest to various measurements or observations throughout the year. One of the assessments that can be used is mummy nuts that are left on the trees after harvest from the preceding year's crop. These mummy nuts are the source of overwintering stages (mostly larvae) of navel orangeworm for the following year. In late December to February, the developing larvae pupate. Adults emerge in late March and April, and lay eggs on mummies still remaining in the orchard. Removal of the mummies during the winter, therefore, will eliminate developmental sites for both the overwintering and first generation (spring NOW larvae). Theoretically, a clean orchard with no mummies will not have any damage from navel orangeworm unless it is contaminated from a surrounding orchard.

Mummies left on trees can be removed at harvest by poling crews after shaking but before pick-up. The nuts removed can be salvaged as part of the harvest. In a few instances, where many nuts are left after the first harvest, a second harvest might be feasible. The trees can also be shaken or poled during the winter, often in conjunction with pruning operations. Wet weather loosens the connective tissue between the nut and peduncle and improves the percentage of mummies removed.

In orchards where considerable mummies still remain following winter shaking, hand polling is also advisable. After shaking, the nuts can be blown off the berm area and destroyed by either flailing, chopping, discing or removal from the orchard.

During the 1978 and 1979 seasons, University of California Cooperative Extension personnel conducted trials in grower orchards throughout the state of California, working on the effect of navel orangeworm on the crop. These orchards were located from Chico to Bakersfield throughout the central valleys of California. In each orchard, mummies were counted on representative trees during the winter. The navel orangeworm population throughout the spring and summer was monitored by the use of egg traps, and samples of nuts were taken during the harvest period in each orchard from early August until September. Each orchard was divided into 8 treatment areas where various chemicals were applied. Each treatment area was approximately 10 to 12-1/2 acres in size. Harvest samples were collected from each treatment weekly during August and September. Four trees within the middle of each treatment area were polled at each harvest date and 200 nuts were sampled from each of the 4 trees. The following week, 4 trees adjacent to those previously sampled were then polled and sampled. This procedure was continued each week until the final harvest when the grower harvested the entire orchard. These samples were then cracked-out by hand and examined for damage by navel orangeworm. At harvest, 12-100 nut samples were randomly taken from each block. These samples were also hand-cracked and examined. The entire 8 treatment area was averaged together to give percent infestation for each date sampled. These data are plotted in Figure 1 to give a weekly change due to navel orangeworm damage. In 5 of the 6 orchards sampled in 1979, the damage caused by navel orangeworm increased dramatically throughout the season from August until late September. The exception was the McFarland orchard which was harvested very early and had a low infestation history of navel orangeworm. This dramatic increase is shown in Figure 1, where damage as high as 30% was experienced in 1 orchard on September 28. If that orchard could have been harvested on August 24, it would have sustained only 5% damage. Data from navel orangeworm egg traps also indicated an increase in egg deposition starting about August 20 and continuing through September.

In January and February, 1980, approximately 11,000 acres of almonds were inspected with representative trees counted in each orchard for mummies remaining during the winter. These blocks varied from 10 acres to approximately 320 acres in size. In each orchard, individual trees were counted visually from the ground before any leaves or blossoms occurred. Only one tree in each row was counted. A minimum of 20 Nonpareil trees were counted in each block along with a minimum of 10 trees from each pollenizer variety. In the larger blocks, 40 Nonpareil trees were counted and 20 of the pollenizer trees were counted. The total mummies per acre was computed by multiplying the mummy counts per variety by the number of trees in each variety per acre. The mission variety was not counted or calculated into mummy counts because of the low incidence of NOW damage experienced with this variety.

Percent infestation in each of these monitored orchards was then obtained from the grower's grade sheets that were returned from the processor. Therefore, the level of navel orangeworm infestation that is reported is the actual grade received by the grower from his returns.

Blocks monitored received one in-season spray either of Guthion or Sevin.

The 1980 data were then divided in 3 sections: Orchards harvested before August 29, orchards harvested August 30 to September 8, and orchards harvested after September 8 (early, mid, and late harvest, respectively). The data were then analyzed to see if there were any correlations between the mummies per acre during the preceding winter, and the percent kernel damage that occurred at harvest time.

Figure 2 shows a relationship between percent damage occurring before August 29 and the mummies per acre for those orchards harvested by this date. An r value of .94 is highly significant. The regression equation is $y = .01 + .00408\ x$.

Figure 3 shows a relationship between the percent damage occurring between August 30 and September 8, and mummies per acre. An r value of .62 is also significant. The regression equation as defined by $y = .4 + .0113\ x$ shows a considerably steeper slope than in Figure 2.

Data collected in 1978 and 1979 from the IPM plots agree very closely with the percent damage before August 29 as indicated by the ☐ on Figure 2. The three data points (☐) on Figure 3 represent the samples taken in 1978 and 1979 from the IPM trials and agree reasonably well with the formula although they represent orchards with more mummies per tree than most of the data presented. Projection of the regression line beyond the data presented could lead to misinterpretation or considerable error in the analysis.

The relationship between percent damage occurring after September 8 and mummies per acre had an r value of .30 which was not significant. Considerable variation exists between the various data especially at the higher mummy counts. This is the main reason for the lower correlation value than was observed in the earlier analysis. It also indicates that mummy counts are much less accurate in predicting the infestation level at harvest on late harvested nuts.

From these data, it appears that one could predict the potential infestation that could be expected from a given mummy level during the preceding winter. The accuracy of such predictions is the highest during early harvest, high during mid-season harvest, but might be considerably in error for late-season harvested almonds.

In a standard planting with 70 trees per acre and an average count of 2 mummies per tree, one could expect an infestation of 0.6% navel orangeworm damage on early harvested nuts, as compared with approximately 2% damage on mid-season harvested nuts. This is in orchards which have received one in-season chemical spray for control of navel orangeworm. In orchards receiving no spray, the damage would be approximately double this figure. Some variations should be expected between orchards or blocks and between locations because of the different mortality and developmental rates of the navel orangeworm due to many other factors besides mummies. These data should be used as an indication of what the average potential might be under different sanitation programs.

Figure 4 shows the relationship between good orchard sanitation practices and no sanitation. This figure shows the 3 ranches of Chowchilla, Chico and Blackwell, giving 32%, 21%, and 37% improvement, respectively, of NOW control from mummy nut removal in the winter. This 30% improvement occurred even though the plots were only about 10 acres in size and randomized with uncleaned plots, and in spite of the NOW being quite

APPENDIX II (p.6)

These trials show that orchard sanitation will ...geworm damage in orchards as small as 10 acres. Had ...a or block been cleaned, kernel damage from navel ...ave been reduced even more. One block at Chowchilla ...aned during the winter had 5.3% NOW damage at harvest ... to a block that had not been cleaned, and progressively ...ge as samples were taken further away from the uncleaned ...area of this orchard sampled was 1/2 mile from the ...nd showed a 0.3% infestation. Therefore, the true ...d sanitation are much greater where larger areas are ...re a single 10 acre block is cleaned.

...s indicate a correlation exists between mummies during ...amage to the nuts from navel orangeworm the following ...ler coefficient of correlation value for the earliest ...s indicates a closer relationship between mummies per ...damage compared to the late harvested almonds. Early ...rease the percent damage. Sanitation alone (winter ...in orchards as small as 10 acres, provided an average of ...navel orangeworm damage.

APPENDIX II (p 7)

W. O. Reil and T. W. Johnson are Staff Research Associates, C. S. Davis is Entomologist Emeritus, L. C. Hendricks and M. Viveros are Farm Advisors in Merced and Kern Counties respectively, University of California Cooperative Extension. The authors gratefully acknowledge the assistance of Walter J. Bentley, Lynette B. Beurmann, and Carol K. Moriuchi.

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APPENDIX II (p. 8)

Figure 2. Percent damage occurring before August 29, 1980
Nonpareil almonds

Y=.0109+.0041 X
r=.94

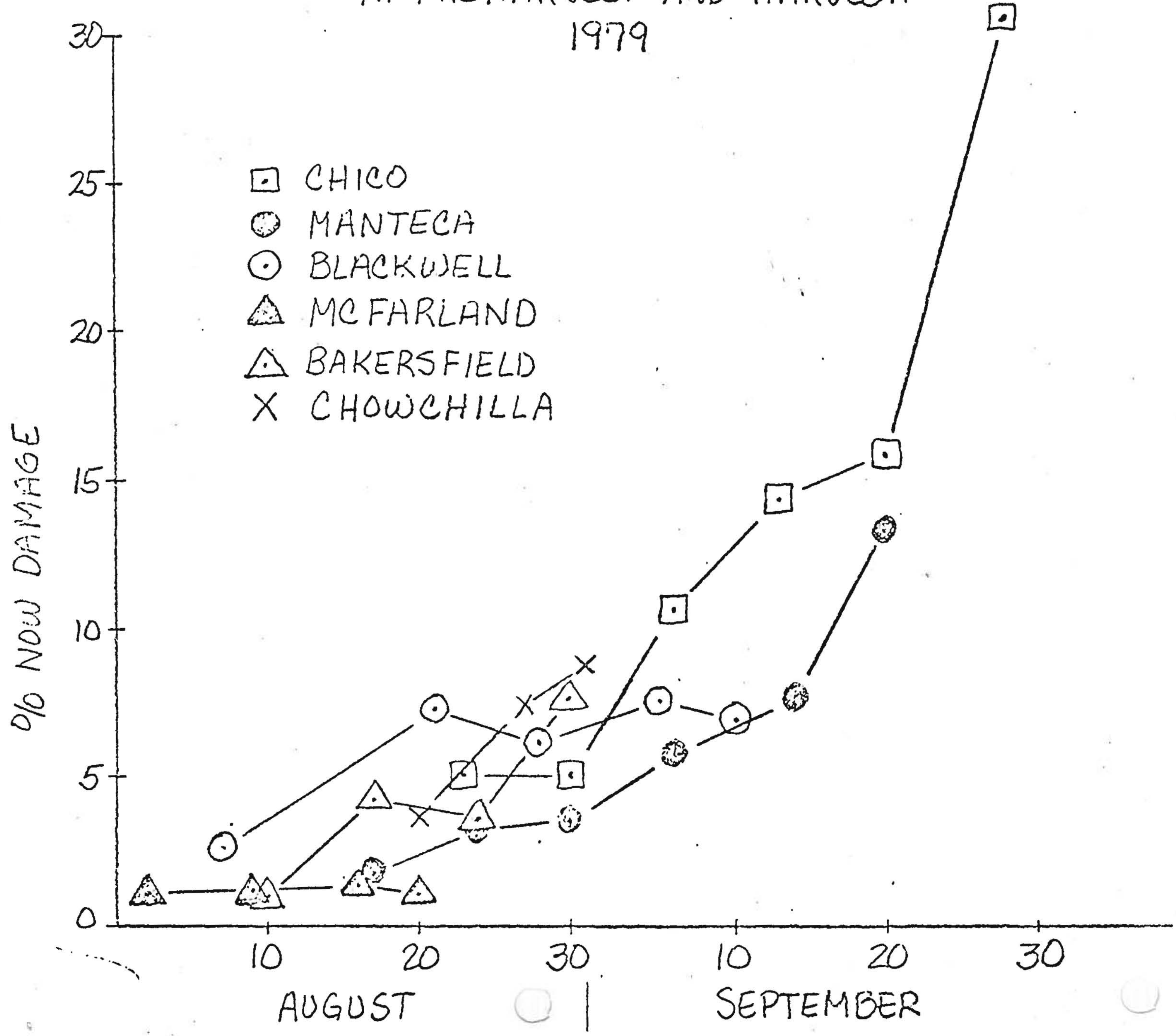
Figure 3. Percent damage occurring between August 30 and September 8, 1980
Nonpareil almonds

Y=.401+.0113 X
r=.62

APPENDIX II (p.3)

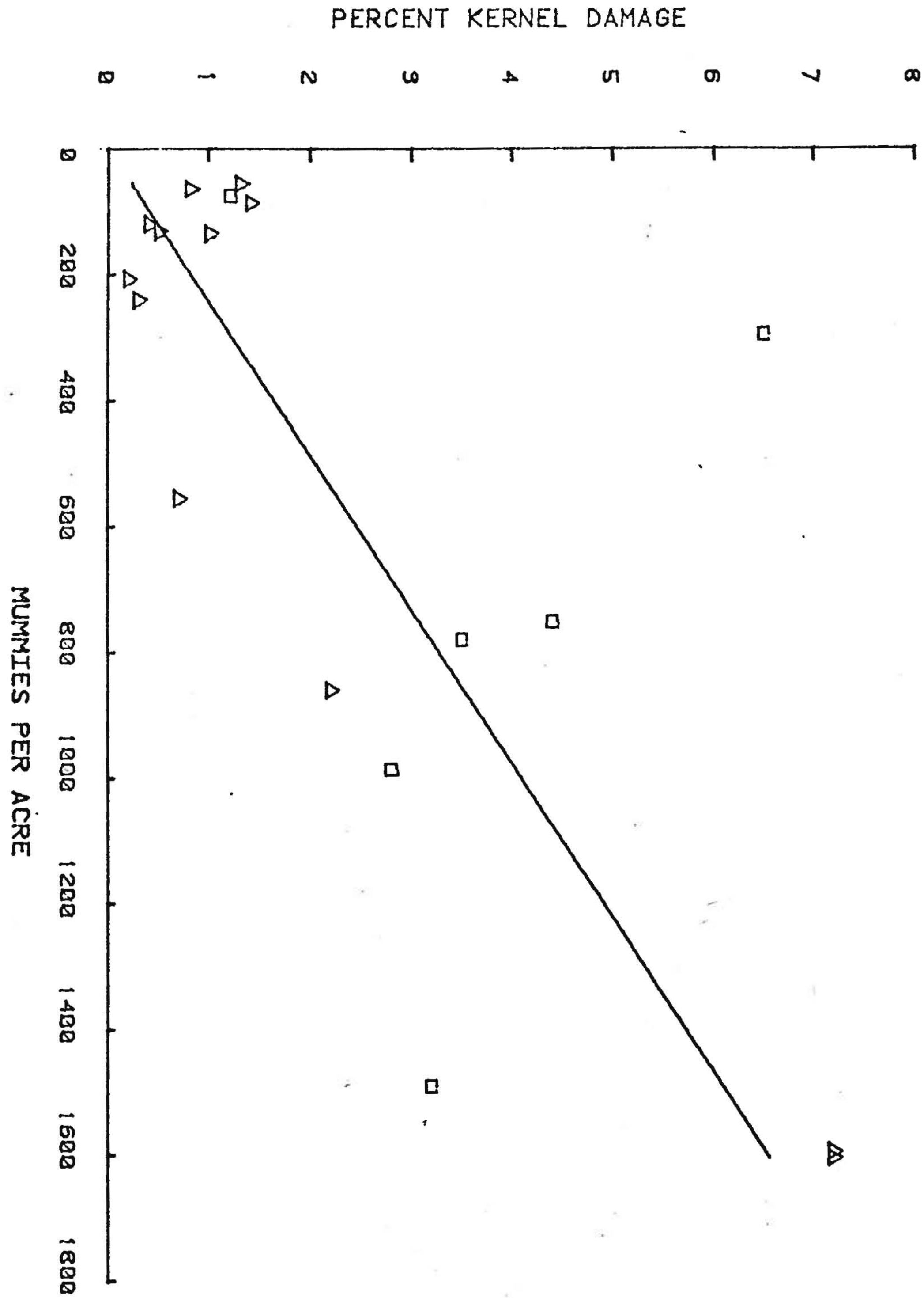
Figure 1

NONPAREIL NUTS INFESTED WITH NAVEL ORANGEWORM AT PREHARVEST AND HARVEST. 1979



APPENDIX II (p.10)

Figure 2



Figure

APPENDIX II (p 11)

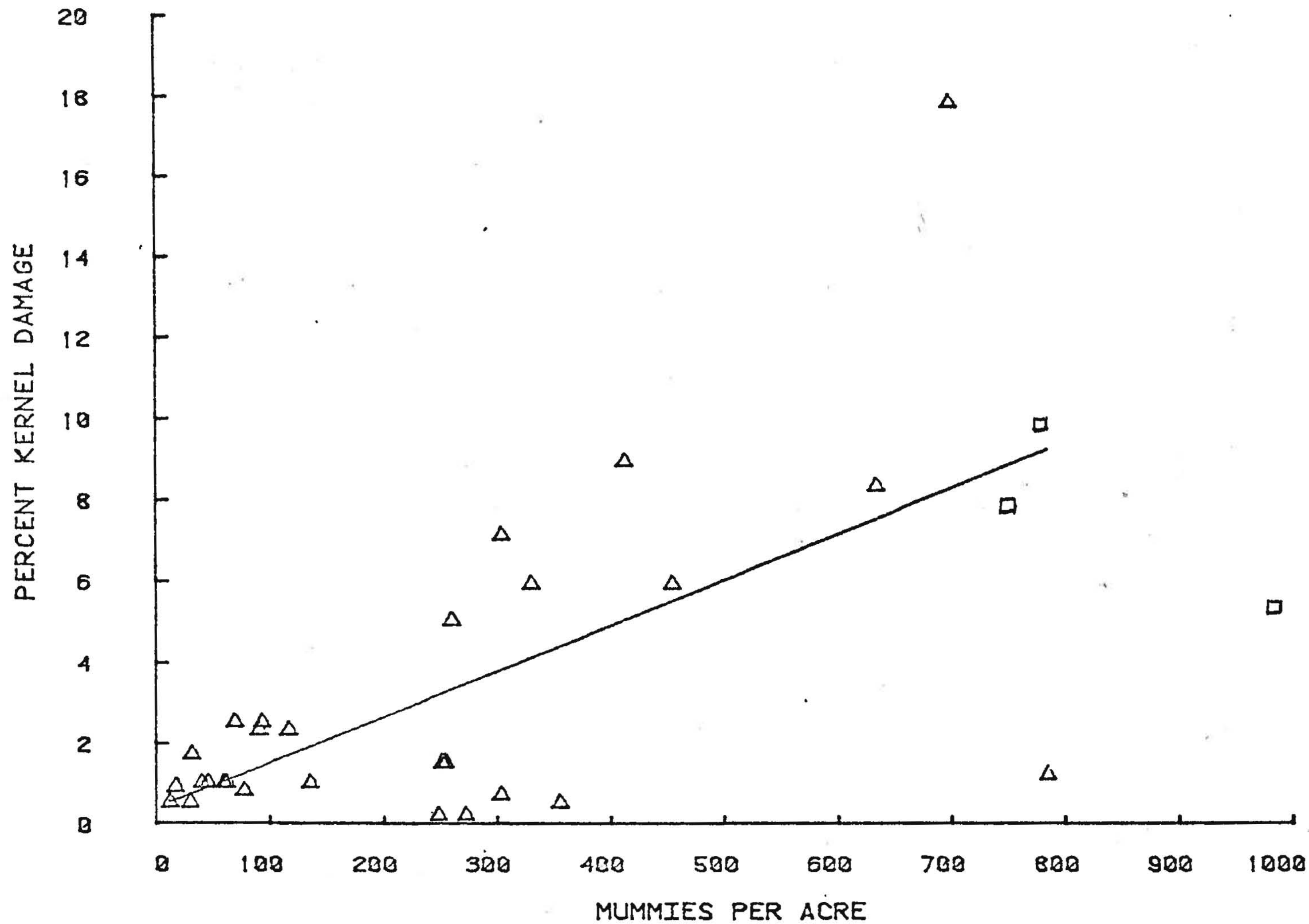
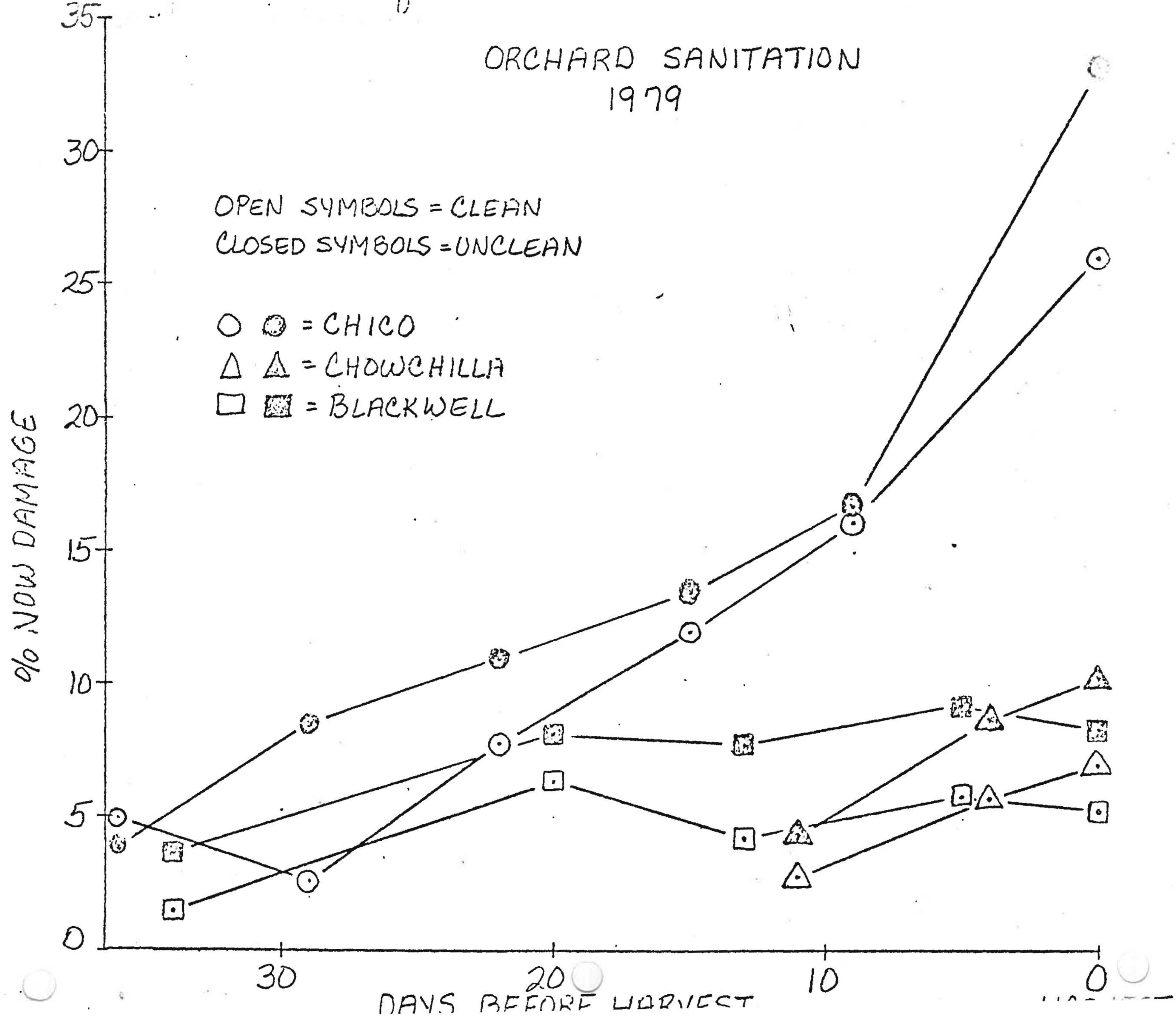


Figure 4



APPENDIX II (p.12)

APPENDIX III (a)

#454

Timing Control Measures Properly for Control of Navel Orangeworm in Almonds

W. O. Reil, T. W. Johnson, C. S. Davis, D. Rough,

J. C. Profita, and C. K. Moriuchi

This is a progress report on 3 years' work in almond orchards throughout California demonstrating egg trap use, chemical control and timely harvest. Only those trials which most effectively showed important concepts are presented. Proper timing of control measures is critical for effective control of Navel orangeworm.

The Almond Integrated Pest Management Project was started in 1978 to develop and demonstrate guidelines for improved orchard management of pests. These trials were conducted throughout the Sacramento and San Joaquin Valleys in cooperation with several growers who provided orchards for trapping and chemical control studies. This article summarizes some of the important concepts demonstrated in these trials. Four trials with the orchards located at Chico (1979), Manteca (1979), Blackwell Corners (1978) and Bakersfield (1979) are described as examples to illustrate the effective use of egg traps, the proper use of chemicals and timely harvest for control of Navel orangeworm.

The Navel orangeworm egg trap developed by Richard Rice has been accepted by some people as a useful tool, but because of misuse it has not

APPENDIX III (p 2)

proven effective under other circumstances. The trap needs to be serviced and read twice weekly to be effective. If used properly, it can demonstrate the flight periods that are occurring in the orchard. It also has been demonstrated that it can be used to time chemicals for proper control of Navel orangeworm.

There are 3 definite peaks that occurred during the season in the Chico IPM orchard during 1979, as seen from average egg deposition on the Navel orangeworm egg traps (Figure 1). The first peak occurred during May, the second occurred in July, and the final occurred in late August and September. During the first egg deposition period the Navel orangeworm female lays eggs on the mummy nuts remaining in the orchard in the spring. The second flight occurs in early July at the time of hullsplit when the new crop nuts are splitting. Most eggs are generally laid on the new crop nuts. The final flight occurs at harvest time or slightly preceding harvest. Emphasis has been placed in recent years on early harvest to avoid this third peak. If harvest is advanced 1 to 3 weeks, part of the third egg deposition and egg hatch period would be avoided. The Navel orangeworm eggs hatch into larvae approximately 5 to 14 days from the time eggs are laid depending on the temperature. These larvae cause the damage to the nuts and therefore damage would occur approximately 1 to 2 weeks following egg deposition.

The percent Navel orangeworm damage that occurred in the Chico orchard each week starting 35 days before the orchard was harvested is presented in Figure 2. The orchard was divided into 10 acre blocks that received different treatments. The treatments were Guthion, timed to the first generation egg deposition (May treatment); Sevin, applied at 1% hullsplit (early July treatment); the first 2 materials, applied to the same block at respective times; and an untreated check. Damage in each treatment increased considerably throughout the entire harvest period (Figure 2). The final egg deposition period occurred in late August to September (Figure 1) which caused the increase in damage shown in Figure 2. Final harvest in this block occurred on September 28. Guthion and Sevin provided 40.6% and 30.8% control, respectively, in the 10 acre blocks. When both materials were applied, better control (49.8%) was obtained. This shows that if the chemicals are properly timed, some control can be obtained from applications of either Guthion or Sevin. If the entire orchard had been treated at any of the treatment dates, the control would have probably been more effective than demonstrated.

The Navel orangeworm egg trap counts occurring in the Manteca IPM orchard in 1979 are shown in Figure 3. The egg trap counts indicated that the initial May flight covered an extended period of time starting April 13 and ending in early June. This long flight period extended egg laying beyond the effective control period of a single spray causing the poor control achieved with Guthion. The July peak was much shorter in length and therefore the Sevin spray applied at that time was quite effective in controlling Navel orangeworm as shown in Figure 4. Again, damage increased dramatically over the final 30 days from late August to September 20 when harvest occurred.

The egg deposition in the Blackwell Corners orchard during 1978 is shown in Figure 5. The line shows the eggs present on the traps. The shaded areas show the most probable time when the sprays controlled larvae hatching from the eggs. This area represents a very small percentage of the total egg deposition period. Because of this very few larvae were controlled by either of the sprays applied in 1978 (Table 1). Sprays must be properly timed to correspond with the egg deposition period to be effective. Consistent egg deposition occurred on April 26. These eggs hatched 12 days later. Sprays applied at this date would have been much more effective. The Sevin application in 1978 was applied at approximately 20% hullsplit. Information collected from egg traps during the past 3 years indicate that the July flight occurs at the beginning of hullsplit. Therefore, sprays applied either at 1% hullsplit or timed to egg hatch are most effective.

The egg deposition of Navel orangeworm that occurred in the Bakersfield IPM orchard in 1979 again shows 3 distinct flights (Figure 6). The first flight started April 10 and continued until June 8. Consistent egg deposition was reached on April 23. Sprays timed to when these eggs hatched were applied on May 1. Hullsplit occurred on July 9. Because of interference with irrigation, the Sevin treatment was not applied until July 18. The damage experienced at harvest was least in the plots receiving Guthion. No control was achieved where Sevin was the only chemical used or where it was applied following Guthion (Table 1).

The shaded areas in Figure 6 indicate the optimum larval control period. The Guthion spray appears to have been applied at the optimum time to achieve control, whereas the Sevin treatment was applied too late and gave very little control. If the Sevin treatment had been applied at very early hullsplit (approximately July 9 instead of 9 days later), the control would have been much better. Harvest occurred on August 30 in this orchard. This occurred approximately 20 days following the start of the third egg deposition period. Samples taken on August 24, 6 days before the actual harvest, showed an average infestation of 3.7% from Navel orangeworm. Infestation averaged 7.6% on August 30. This was a 51% reduction in the amount of damage. Early harvest could have saved over 50% of the damage actually experienced.

In the data presented there are 3 distinct periods of egg deposition for Navel orangeworm. These egg deposition periods occur in late April through the end of May, from mid-June through mid-July and from mid-August through September. NOW egg traps can be used to more precisely define these flight periods. Once the flight periods are determined, sprays can be more effectively timed to better coincide with the larval activity present in the orchard. As shown in Figure 5 and 6 and Table 1, sprays need to be applied when larvae begin emerging from eggs. Sprays that are improperly timed when there are few larvae present will not provide control. If sprays are properly timed, 40 to 50% control can be expected.

Early harvest avoids the third flight period of Navel orangeworm. The earlier harvest occurs, the less pressure the crop will receive from Navel orangeworm. To achieve maximum control of Navel orangeworm a grower needs to precisely time sprays to Navel orangeworm activity by monitoring egg deposition in the orchard. Harvest must also be advanced to avoid, as much as possible, the third brood of Navel orangeworm.

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Wilbur O. Reil and Toynette W. Johnson are Staff Research Associates, Clarence S. Davis is Entomologist Emeritus, Don Rough is San Joaquin County Farm Advisor, and Joe C. Profita and Carol K. Moriuchi were formerly employed on the IPM project for the University of California-Cooperative Extension

This integrated Pest Management Program was partially funded by USDA:SEA, Smith Lever Integrated Pest Management Funds and by the Almond Board of California. The authors wish to thank Bidart Farms, Blackwell Management Co., Boersma Orchards and Mead Orchards for their cooperation. The assistance of Lesley W. Barclay, Walter J. Bentley, Lynette B. Beurmann, Lonnie C. Hendricks, Clem H. Meith and Eileen L. Paine is gratefully acknowledged.

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Figure 1. Chico - 1979

Figure 3. Manteca - 1979

Figure 5. Blackwell Corner - 1978

Figure 6. Bakersfield - 1979

Navel orangeworm eggs deposited on traps in the almond orchards shown.

Indicates dates when insecticides were applied.

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Figure 2. Chico - 1979

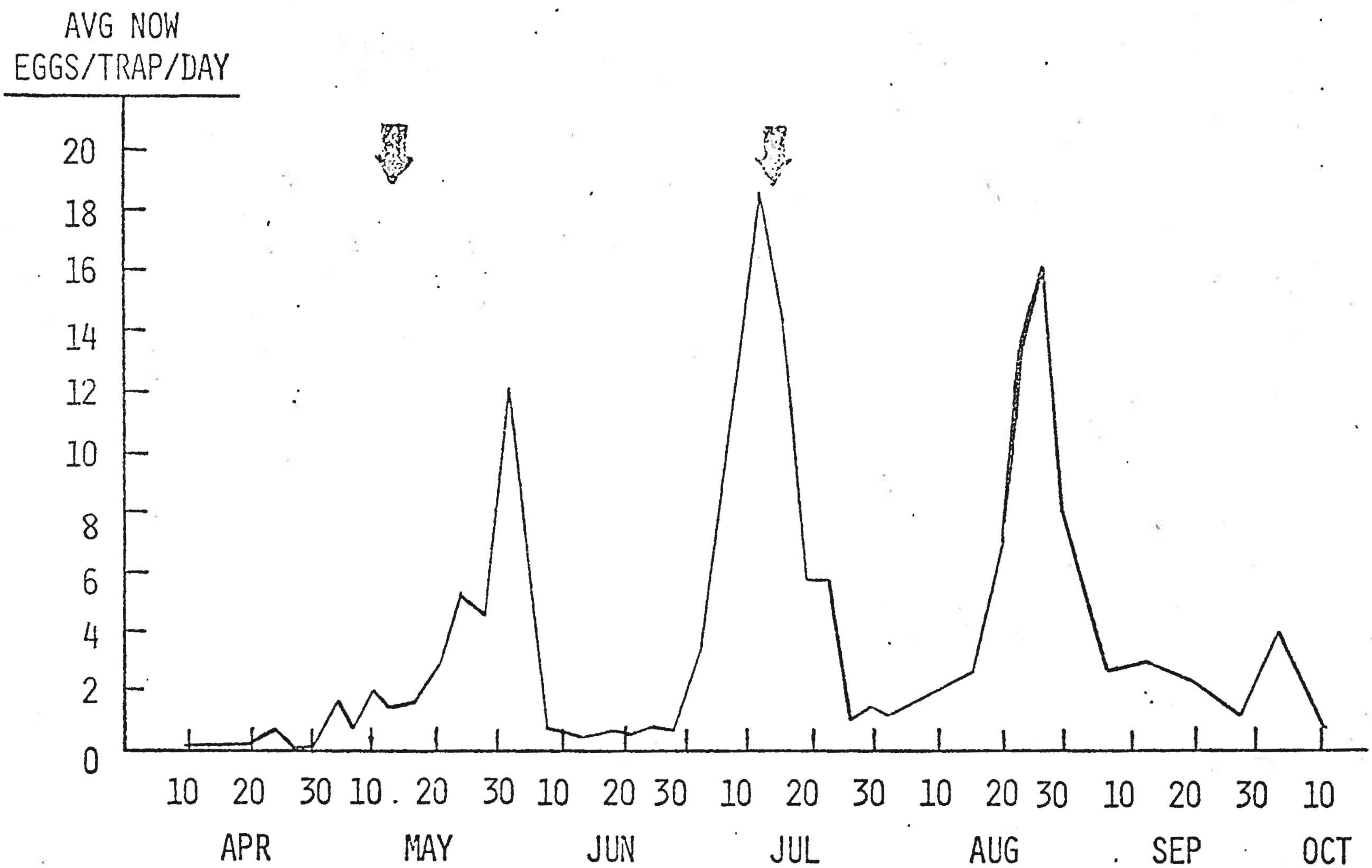
Figure 4. Manteca - 1979

Nut damage caused by Navel orangeworm. Each point represents samples harvested on date shown. Four different control measures are represented.

Table 1. The percent nut meat damage to almonds caused by navel orangeworm.

	Blackwell Corner 1978		Bakersfield 1979	
Treatment	Date Applied	% Damage	Date Applied	% Damage
Guthion	5/30	10.5	5/1	6.4
Sevin	7/23	12.4	7/18	8.5
Guthion & Sevin	5/30 & 7/23	11.8	5/1 & 7/18	6.5
check	---	12.6	---	9.0

Figure 1. Chico - 1979



APPENDIX III (sic)

APPENDIX III (p. ii)

Figure 2. Chico - 1979

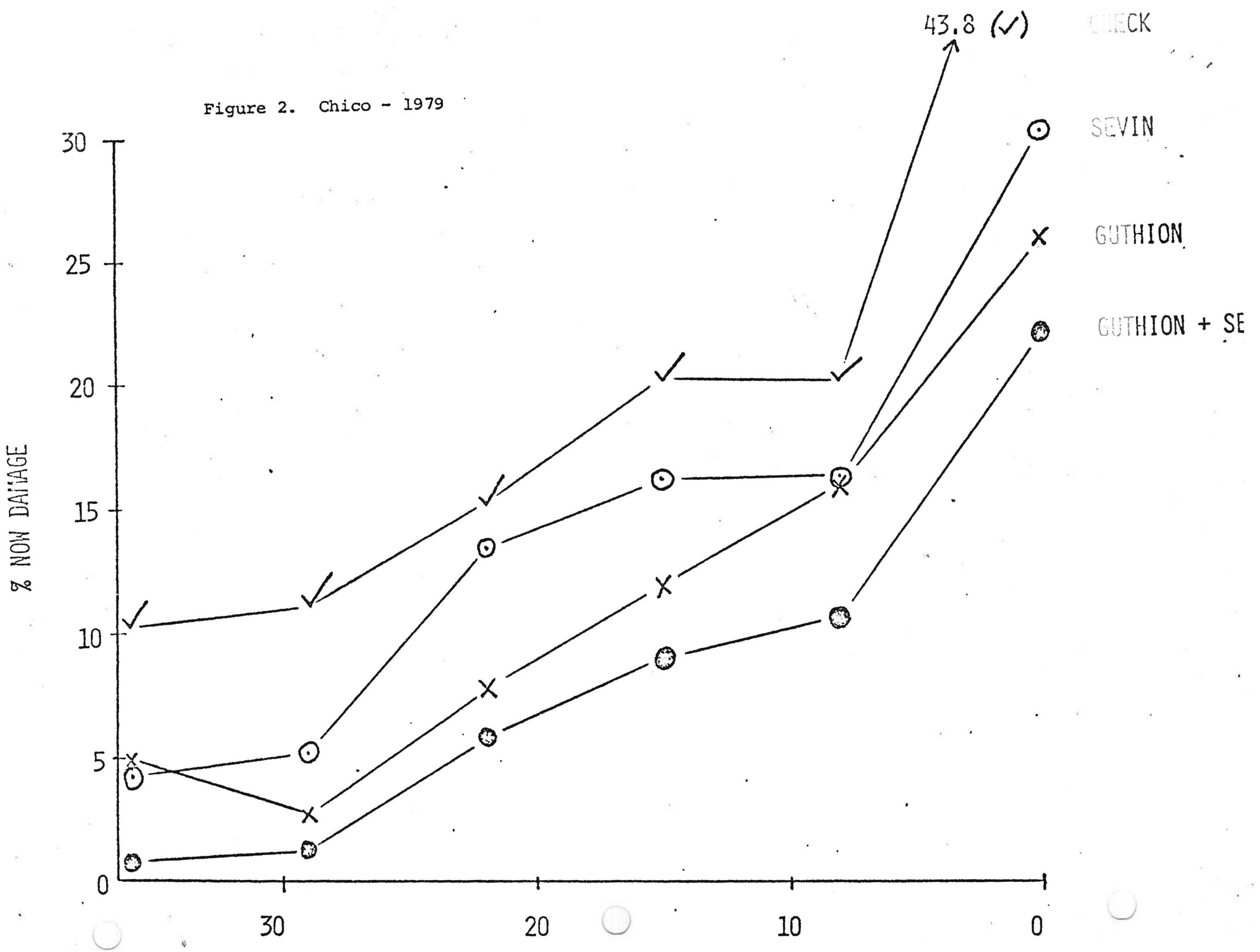
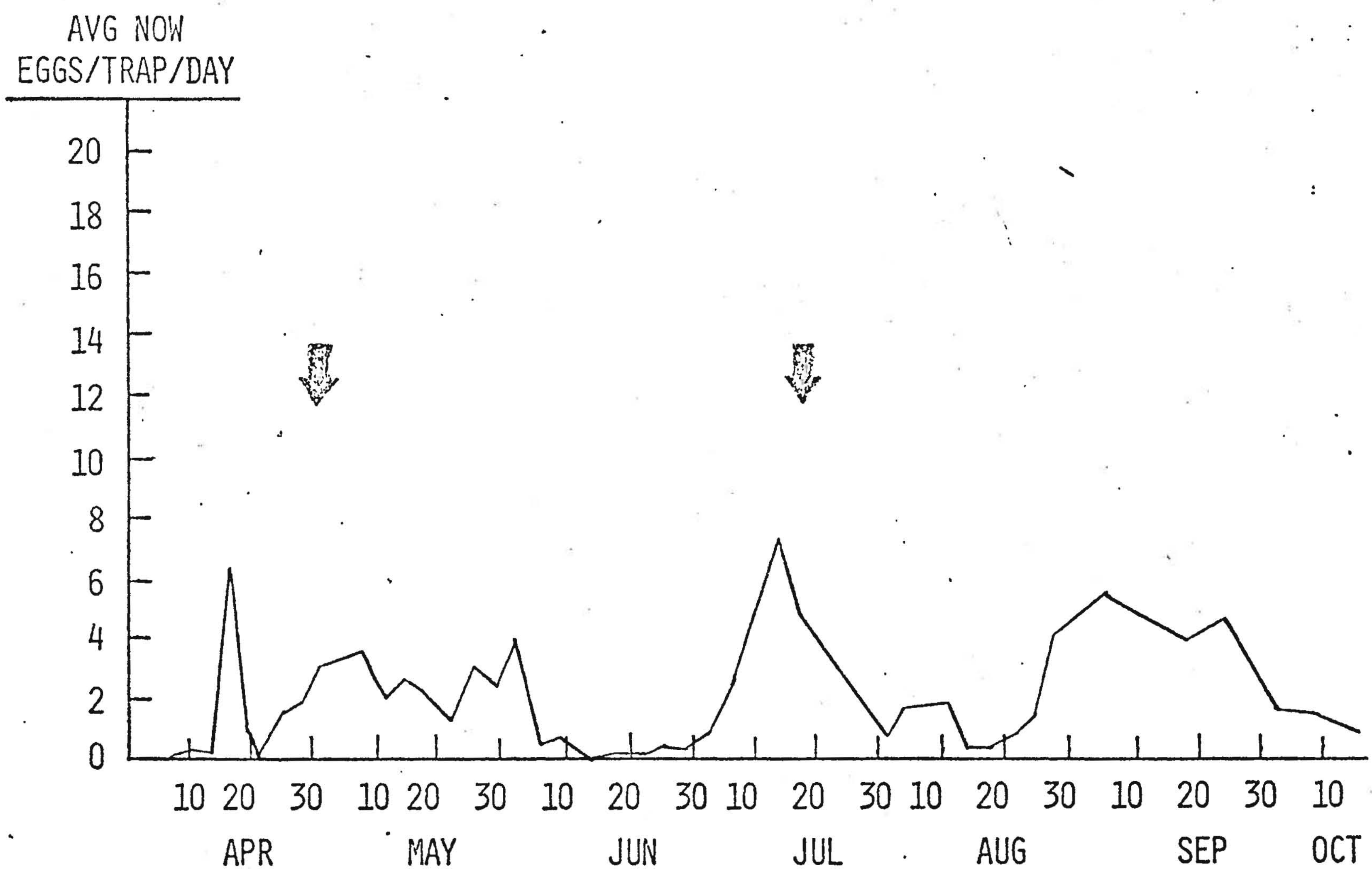
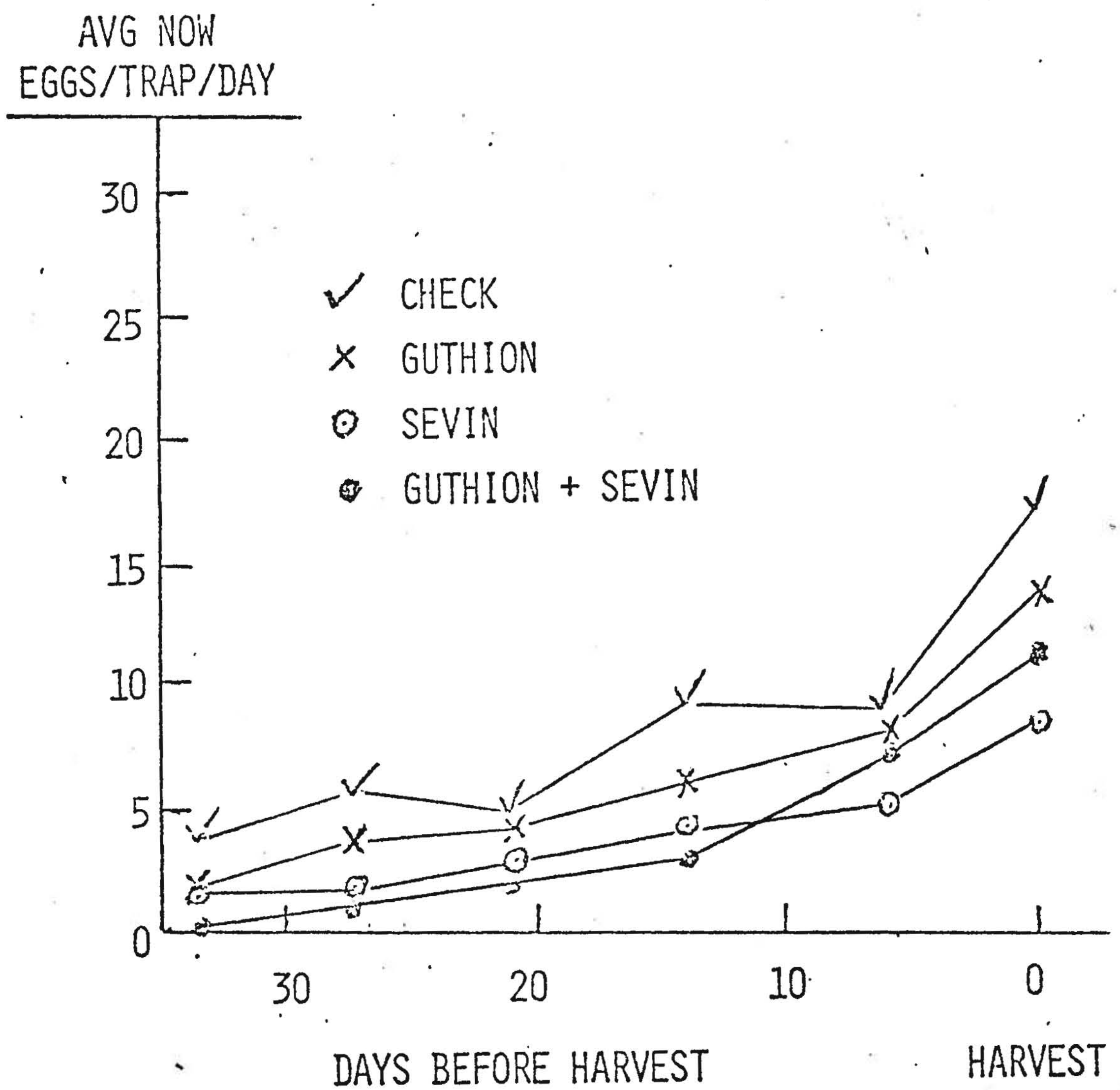


Figure 3. Manteca - 1979



APPENDIX III (P12)

Figure 4. Manteca - 1979



APPENDIX III (P.13)

Figure 5. Blackwell Corner - 1978

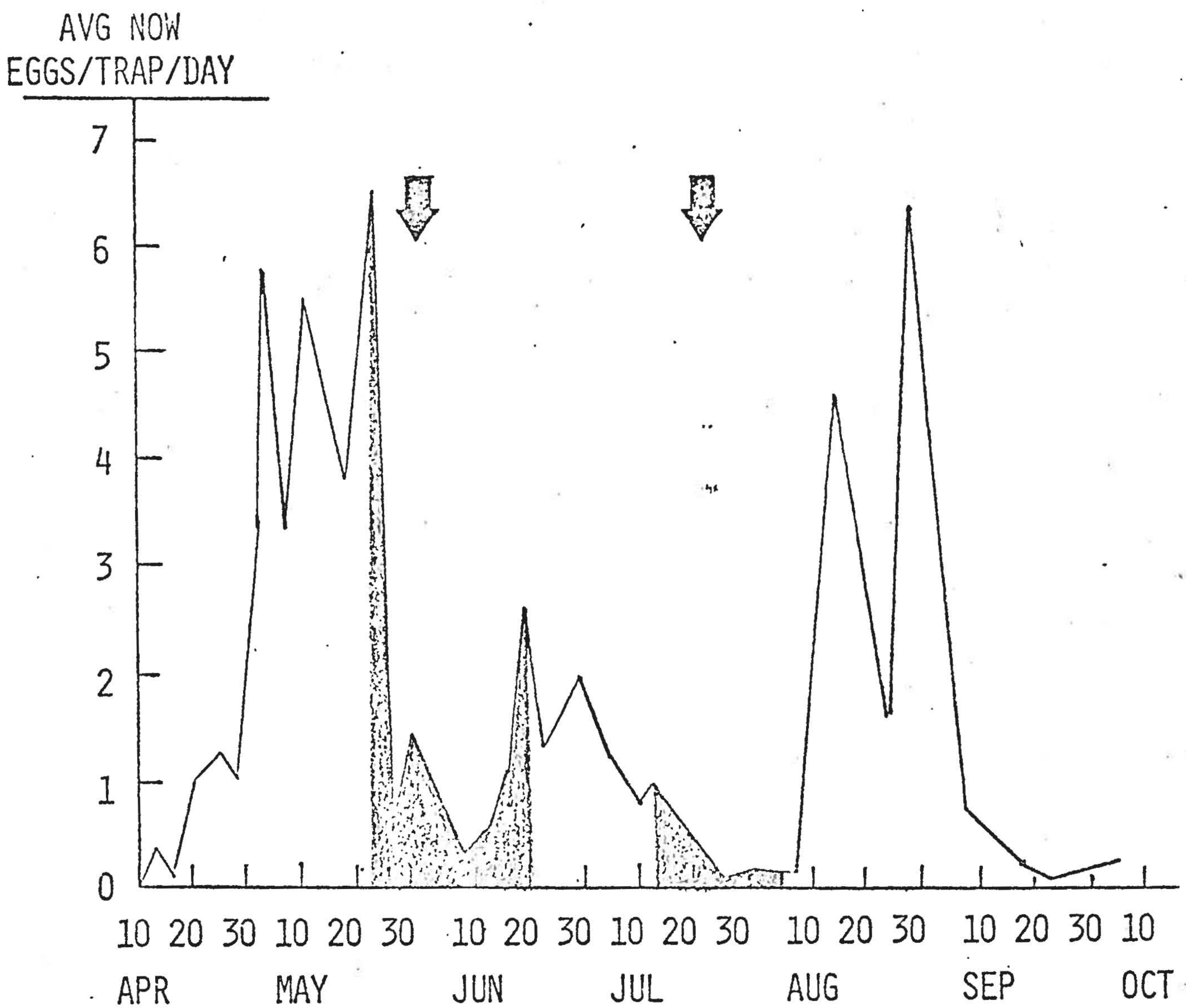


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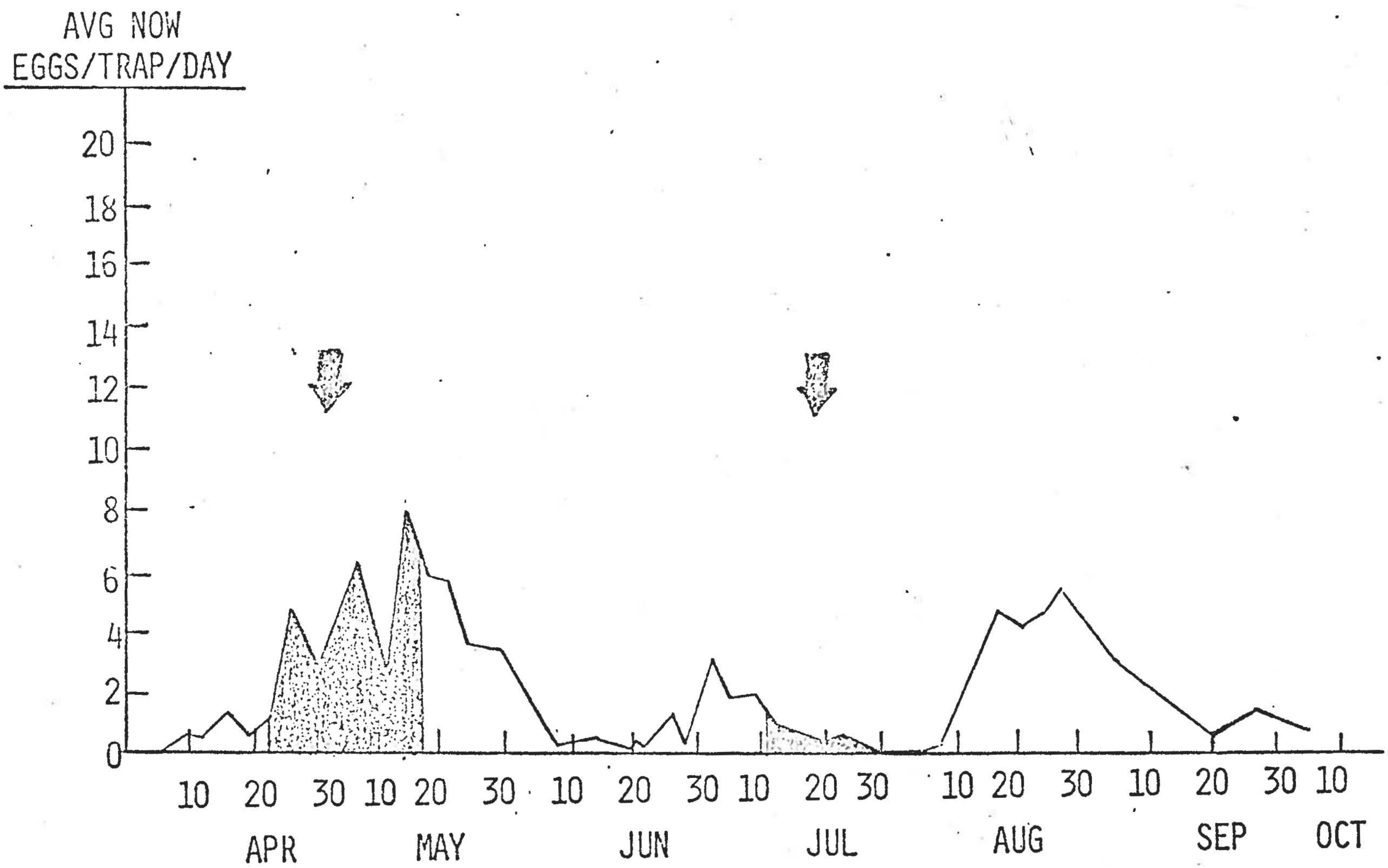
Figure 6. Bakersfield - 1979



APPENDIX IV (p.1)

Sanitation and Early Harvest for the Management of Navel Orangeworm

by

Frank Zalom,
UC Cooperative Extension, Davis Campus

Craig Weakley
UC Cooperative Extension, Yuba City

and

Joseph Connell
UC Cooperative Extension, Oroville

APPENDIX IV (p. 2)

The application of certain cultural procedures at critical stages of the navel orangeworm life cycle will reduce nut damage at harvest. These practices include nut removal to eliminate overwintering sites, and early harvest corresponding to the period when navel orangeworm populations are at low levels prior to emergence of second generation moths (those developing from egg laying at hullsplit). The success of these procedures has been documented by several researchers, and has been proven to be effective by many growers.

In cooperation with Dr. J.C. Headley, a survey of almond growers cultural practices and worm damage was conducted following the 1980 season. Those growers utilizing both sanitation and early harvest or sanitation alone sustained 56% and 40% fewer rejected meats respectively than those growers utilizing neither technique (Table 1). Of the growers who utilized both cultural practices, 22.0% did not apply in-season insecticide treatments. These growers had a reject rate of only 2.1%. Growers asked to participate in the survey were selected at random by the Almond Board of California and the California Almond Growers Exchange. Only responding almond growers with 20 acres or more were included in the previous sample data.

The navel orangeworm feeds for much of the year in mummy nuts left on the tree. Removal and destruction of those mummy nuts lower the navel orangeworm population by killing the overwintering larvae and by limiting the habitat available for population buildup in April and May. It has been stated that an orchard cleaned to 5 mummies/tree would result in a 50% reduction in the amount of navel orangeworm damage at harvest. Recent studies indicate that orchards cleaned to less than 2 mummies/tree in February may not require in-season insecticide applications if they are more than 1/4 mile from a navel orangeworm source and are harvested early. Dr. Martin Barnes and his students are attempting to further define mummy thresholds.

Migration from neighboring uncleaned orchards and high cost are often cited as reasons for not practicing good orchard sanitation. Studies by Dr. Clarence Davis and others have shown that cleaning blocks as small as 10 acres can result in a significant reduction in damage at harvest. Further reduction could be achieved if the mummy sources were eliminated on an area-wide or district basis.

Mummy removal can occur either post-harvest or during the winter by shaking the tree or by hand poling. When sanitation is achieved immediately following the initial harvest, returns from recovered nuts may offset the cost of cleaning. Winter mummy removal is most complete during extended foggy periods or after a rain. Once on the ground it is important to destroy mummies by discing, flailing, or otherwise removing them in the case of clean culture. In a recent study, Dr. Headley has shown that the cost of winter mummy removal by poling and subsequent mummy destruction is comparable in per acre cost to a single navel orangeworm insecticide application. Sanitation costs are even more favorable when compared to an insecticide plus miticide application.

One grower in Sutter County who uses post-harvest poling has a history of no in-season navel orangeworm sprays. His 15 year old, 47 acre orchard is well isolated and has 86 trees/acre (2/3 Nonpareil, 1/6 NePlus, 1/6 Mission). Mummy counts in February, 1981, averaged only 0.45 mummies/tree. Navel orangeworm damage following the 1981 harvest was 1.8%. The orchard was gleaned by a poling crew paid $4.00/man-hour at a cost of $5.11/acre. The nuts recovered were worth $14.24/acre at $1.00/lb. yielding an additional return of $9.13/acre to the grower.

The benefit of orchard sanitation or sanitation in combination with insecticide treatment will be substantially reduced if either program is practiced without early harvest, rapid nut removal from the orchard, and immediate hulling or stockpile fumigation. Moth activity increases dramatically in the period beginning about 30 days after the initiation of hullsplit. These moths are responsible for the third generation larvae which cause the most nut damage (Figure 1). In order to avoid the adverse effects of this third generation, harvest should begin when 95 to 100% of the almonds at head height show hull crack when squeezed. Often it is impossible to harvest an entire orchard as early as desired. In such cases it is best to begin the harvest in blocks that have a higher mummy load or are near external sources of the navel orangeworm.

Inadequate nut removal is often cited as the reason for delaying harvest. A recent study in Butte County has shown that nut removal was 93% when trees were harvested the 1st week in August. Further nut removal was obtained with a second shake. The second shake was less costly than the additional insecticide treatment that would have been needed had harvest been delayed (Table 2). This method of early harvest provided the most cost effective control of third generation navel orangeworm larvae.

Information currently available overwhelmingly supports sanitation, early and rapid harvest, and rapid hulling or on-farm fumigation as good management strategies for the navel orangeworm. When chemical control is warranted, timing should be based on the use of egg traps with almond press-cake attractant. Furthermore, judicious chemical use is critical to maintaining natural enemies of other pests of almonds including predators of spider mites.

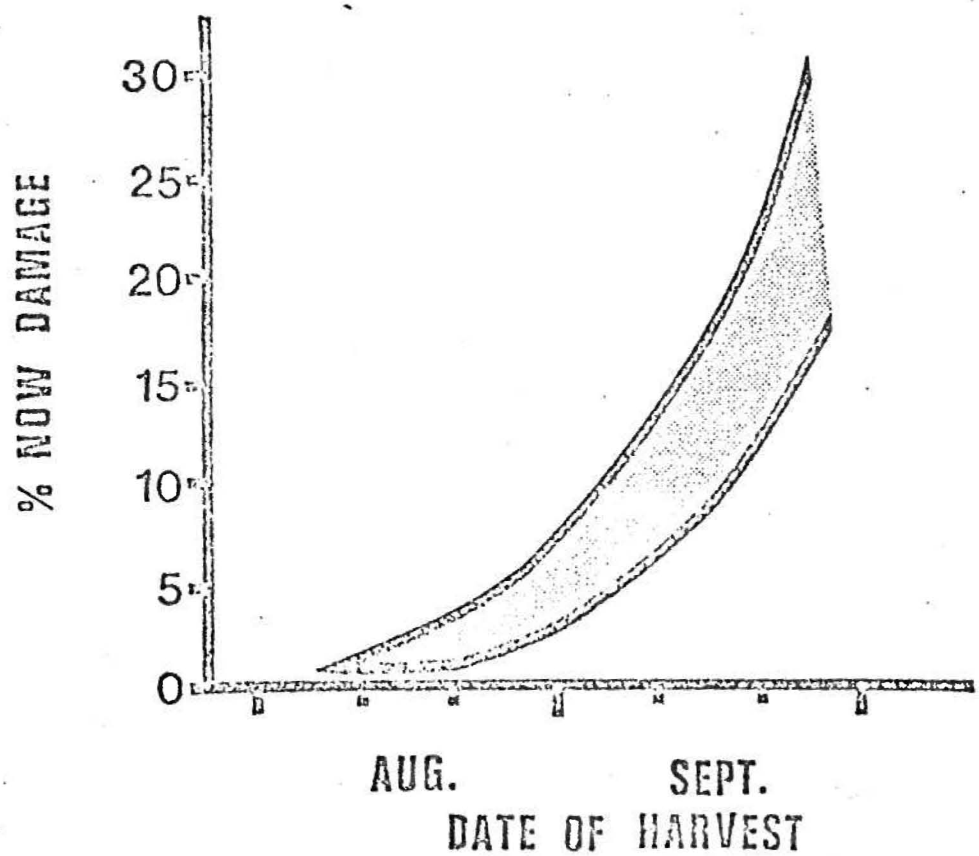


Figure 1. Navel orangeworm damage increasing 1/2 to 1% per day as the season progresses will likely fall within the shaded area on a given harvest date depending on latitude and other external factors.

APPENDIX IV (p.6)

TABLE 1. Influence of Recommended Cultural Practices on Percentage of Reject Almonds, 1980

Cultural Practice NOW Management	Rejects	Avg. Size/ Orchard (Acres)	Avg. Yield Good Meats (lbs/acre)	Orchards Using >1 In-season Insecticide Apps.	Number of Orchards
None	6.2%	149	756	42.1%	19
Post-harvest or Winter Sanitation	3.7%	328	1104	59.6%	47
Sanitation and Early Harvest	2.7%	140	862	51.2%	41

APPENDIX III

Table 2. Per Acre Costs of Harvest Practices for Navel Orangeworm Management in a 7 Year Old, Butte County Orchard, var. Nonpareil, 1981.

Practice	% Removal	Addt'l Harvesting Costs	Cost of nuts Remaining on tree @ $1.00/lb	Addt'l Pesticide Costs[1]	Net Cost
Early Harvest - 1 Shake	93.2	$ 0.00	$90.75	$ 0.00	$90.75
Early Harvest - 2 Shakes	98.2	13.70	23.25	0.00	36.95
Standard Harvest - 1 Shake	98.5	0.00	16.46	58.04	74.50

[1] Sevin & Plictran

COOPERATIVE EXTENSION

UNIVERSITY OF CALIFORNIA

COUNTY OF KERN

FARM AND HOME ADVISORS OFFICE

P.O. Box 2509 2610 M Street
Phone (805) 861-2631
BAKERSFIELD, CALIFORNIA 933[illegible]

June 15, 1981

ALMOND PEST UPDATE

Weeks of:

May 29 - June 5
June 5 - June 11

Navel Orangeworm

	#/Trap/Week	#/Trap/Night	% Traps Infested
May 29 - June 5			
Wasco Orchard #1	22	3	80
Wasco Orchard #2	33	5	80
June 5 - June 11			
Wasco Orchard #1	13	2	80
Wasco Orchard #2	17	3	80

Peach Twig Borer

May 29 - June 5		
Wasco Orchard #1	1	.10
June 5 - June 11		
Wasco Orchard #1	3	.50

Comments:

Twospotted spider mites are being reported in a number of areas. Due to heavy buildup of predacious mites in the Wasco orchard, twospotted mite is being held in check. For those applying a miticide now, I would not include a material for Navel orangeworm control. We are between generations of N.O.W. and the timing of the spray would be poor. First generation eggs are very low in number while the moths laying second generation eggs have not started flight yet. If a spray for N.O.W. is to be made, wait until initiation of hullsplit or when egg deposition increases and hatch occurs. This should not occur until late June or early July.

San Jose scale males are flying in low numbers.

Sincerely,

Walter J. Bentley
Farm Advisor

Mario Viveros
Farm Advisor

APPENDIX [illegible] (p2)

[illegible]

[illegible] 11 - [illegible] 18, 1981

[illegible]

[illegible]

	Moths/T/D[1]	Total[2]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3.7	[illegible]	[illegible]

[illegible]

	Moths/T/D	Total			Moths/T/D	Total Flight
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Kennedy	[illegible]	[illegible]	[illegible]		1.5	401.9

[illegible]

	Moths/T/D	Total	[illegible]		Moths/T/D	Total Flight	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.5	60.9	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52.1	[illegible]
[illegible]	[illegible]	[illegible]	88	Livingston	11.2	721.0	[illegible]
				[illegible]	1.5	18.6	[illegible]

[illegible]

	Moths/T/D	Total Flight	[illegible]		Moths/T/D	Total Flight	[illegible]
Kings	7.5	[illegible]	-	[illegible]	[illegible]	[illegible]	-
Crutchers-1	7.7	[illegible]	-	Livingston	5.17	80.5	-
Norman	1.15	[illegible]	-	[illegible]	[illegible]	37.7	-
LeGrand	7.5	35.5	-	[illegible]	[illegible]	154.5	-

1) Average moths per trap per day this week. 2) Total per trap this flight.
[3] Populations too low for accurate analyses.

APPENDIX II (p.3)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

ALMONDS Integrated Pest Management Programs

I. Management Program

   A. Orchard Sanitation

   B. Timely Harvest

II. Monitoring Program

   A. Navel Orangeworm

   B. Peach Twig Borer

   C. San Jose Scale

   D. Use of Day Degrees

I. Management Program.

The following are summaries of important integrated control procedures in the management of Peach Twig Borer (PTB) and navel orangeworm (NOW) in almonds. More information is available....

A. Orchard sanitation. Orchard sanitation, aimed at overwintering navel orangeworm populations in mummy nuts, is quite important. Thorough sanitation in winter will reduce kernal damage by substantial amounts. If possible, all acreage should be cleaned every year.

1. Removing Nuts. Hand poling or mechanical shaking is normally done during December or January. Mummies are most easily removed during foggy weather or after a rain that has kept the trees dripping wet for several hours. The moisture soaks into the gums, making them gelatinous, and adds weight to the almonds. Mechanical shaking is recommended for trees taller than 12 feet, as it is cheaper and the shaker damages the trees less than does hand poling. However, hand poling may be efficient for trees less than 20 feet tall and when mummies are less than 50 per tree.

2. Destroying Mummies. Once the nuts are on the ground, it is important that they are destroyed or removed before moth emergence begins in March and April. This should be as soon as orchard floors are dry and danger of frost has passed. Discing or flail mowing between rows, a normal operation in many orchards, along with factors conducive to rotting, will kill any NOW present.

B. Timely Harvest. Timely harvest is essential for NOW control. Even in orchards which are cleaned and receive orangeworm sprays, damage can be quite high if harvest is not done early.

1. Insect Control. Efficient harvest halts the rapid increase in damage caused by navel orangeworm starting in mid-August and continuing into

October. In this period, infestation has been observed to increase at a rate of one-half to over two percent per day.

2. Timely Knocking and Pick-up. Even though infestation can be restrained by knocking early, it is still important to pick up almonds as soon as possible after they have dried on the ground. Navel orangeworm populations (eggs, larvae and pupae) already present in these nuts can continue to develop and cause more damage.

II. Monitoring Program.

The following procedures have been developed for use by county farm advisors and cooperating growers. They will provide needed information for pest phenology models which are used to assess treatment needs. More information on these programs is available....

A. Naval Orangeworm. It is well known that NOW overwinters in almond mummies within the orchard and the number of mummies has an effect on the amount of NOW damage at harvest. In the past it was said that if the trees could be cleaned to five mummies per tree a 50% reduction in the amount of NOW damage experienced at harvest could be expected. Recent data indicates that if an orchard is cleaned to one mummy or less per tree during the dormant period, and harvest occurs as early as possible, summer treatments are not needed to prevent economic damage by NOW at harvest.

1. Mummy Counting in January. It is necessary to count the mummies on 20 trees at random in each 10 acre block. Mummy counts should be done after pruning.

2. NOW Trapping. The standard egg trap utilizing almond press cake for bait (15 grams/trap) will be utilized for monitoring NOW during the season. At least five, but preferably 10 traps per block should be used. Traps should

be hung high in softshell trees on the north side of the trees. Bait should be changed weekly. Care should be taken to keep the bait dry as it molds easily if wet. In sprinkled orchards one might want to install low angle heads to avoid getting traps wet. Traps should be checked two times per week throughout first flight (mid-March to June) in the spring, and then once per week until just before hull split (about July 1) when they should again be checked twice weekly to detect the second generation. Eggs should be removed by using a toothbrush and the number of eggs per night should be recorded and graphed.

B. Peach Twig Borer. A phenology model has been developed for Peach Twig Borer. The lower threshold is 50^{0} and approximately 1000 day degrees are required for a generation to develop. About 200-225 degree days are required from emergence of first moth to egg hatch. This information can aid in timing the "May Spray" if a treatment is needed at that time. A dormant phosphate and oil treatment has been the standard for PTB control for many years and is still effective in most cases. However, in certain cases dormant sprays have not provided season-long control and nut infestations of 10% or more by PTB have been experienced even with dormant treatments. The reasons for this are not well understood, but poor coverage and the choice of materials are probably involved in most cases. Diazinon plus oil, Parathion plus oil and Supracide with or without oil have all provided season long control in most cases. Control with other materials have been somewhat erratic.

At least one trap per ten acres should be used with a minimum of four traps per orchard.

1. PTB Trapping. Traps should be installed in orchards about March 15 and monitored on the same schedule as NOW egg traps. Traps should be hung on the north side of the trees at head height. For convenience these traps can beplaced in trees adjacent to NOW traps. Pheromone caps and bottoms should be

changed at least on a monthly basis. If large numbers (200 moths) are caught, or unusually dusty conditions persist, bottoms should be changed more frequently. Numbers should also be recorded as average number per trap per day in order to compensate for any variation in the number of days between readings. Begin accumulation of D^o when the first male is trapped. After 200 D^o have accumulated a search should begin for newly hatched larvae in a young orchard. in order to verify the number of D^o. When newly hatched larvae are found, treatments for PTB control in those orchards requiring control should be applied within 10 days. At present only very rough estimates exist whether a treatment is needed or not. If less than 20 adults per night are trapped a treatment is not needed. If more than 60 per night are caught during either the spring or late June-early July flight a treatment is indicated and should be applied when 200-225 D^o have accumulated after trapping the first moth from that generation.

If both NOW and PTB are to be treated with a May spray, time this application to optimum NOW criteria. This timing will normally also control PTB quite effectively; separate May sprays for NOW and PTB should not be needed.

C. San Jose Scale. Phenology models and pheromone traps are available for monitoring and predicting biological events for SJS. No treatment thresholds exist at this time, but orchard prunings can be examined during the dormant period to determine the presence of heavy scale populations. If high populations are found, and a May or June treatment is necessary, the phenology models can be used to predict when crawler emergence should occur. This happens when 550 D^o have accumulated after first males are trapped in March.

The lower D^o threshold for SJS has been determined to be 51°. Four or five scale traps should be maintained in each monitored orchard in order to develop information on how traps can be utilized for determining treatment levels.

D. Use of Day Degrees. There are several ways to calculate day degrees. In order to standardize D^{o} data in this program we recommend using either of the following two procedures.

The UC/IPM Computer network will include programs to calculate day degrees from weather reporting stations throughout the state. The programs will also be able to calculate day degrees from weather data recorded and inputted by a farm advisor or cooperator.

Alternatively, day degrees can be calculated from charts which will be furnished to the farm advisors. To use these charts, select the appropriate chart for proper lower threshold (for NOW 55^{o}, PTB 50^{o}, SJS 51^{o}). Locate the days minimum along the top and maximum along the left hand column. The D^{o} value for that day is the number where the two lines intersect. Record daily D^{o} and accumulation at least two times per week. During critical periods the D^{o} may need to be updated almost on a daily basis, as 20-25 D^{o} can accumulate per day during warmer spring weather.

[E. Environmental Monitoring. In order to use phenology models for PTB and SJS, a weather monitoring station should be located as near as possible to trapped orchards. Daily weather information from a network of reporting stations throughout the state will be put into the UC/IPM Computer data base and will be available to users in the county offices.

Advisors or cooperators may prefer to collect weather information directly from trapped orchards. The minimum weather data needed is daily high and lows from a simple high-low thermometer. To be worthwhile, orchard-specific information must be continuous over the critical part of the season.

From Navel Orangeworm

By Ron Goble
Fresno Bee staff writer

THE NAVEL ORANGEWORM doesn't have as much of a taste for citrus as his name would lead you to believe. However, give him a few meaty almonds to nibble on and he goes wild.

This dinky white worm with the disproportionate appetite has been known to gnaw the profits right out of the pockets of many a California almond grower — even before the nuts could be shaken off the trees. In 1980 the almond industry reported more than $38 million in losses because of the worm.

Some growers' orchards are hit harder than others. Some farmers turn to a spray program to try and control the pest. Others rely on cultural practices that forestall the voracious little larva by preventive measures.

Both procedures are effective to a point,but both pose special problems for the grower to wrestle with at different times of the year.

Otis Freeman, a longtime Fresno area almond grower, in recent years has established a good record for shipments of almonds with only a small percentage of navel orangeworm damage. This 63-year- old Fresno man has a reputation for maintaining a clean orchard operation and it has meant a financial bonus for him at harvest.

He doesn't rely on luck. He has a system.

Freeman planted his first almond trees in 1964, after deciding to get out of the dairy business and growing cotton, alfalfa and corn.

"My father thought I'd taken leave of my senses," he says today.

He says he's learned a lot since planting that first orchard. And one of the biggest lessons started in 1973.

Since that year Freeman has taken the time and expense to shake all of his almond trees after the fall harvest and pruning activities are complete. Before the dormant season settles in, Freman sends his hired hands into the orchard one more time to shake the last of the nuts — often called "mummies" — from the trees.

THE IDEA is to get all the nuts and hulls out of the trees so they won't be used for shelter by overwintering navel orangeworms. Then, once the final collection of leaves, nuts and hulls has been brought to the ground, they are swept into a windrow and destroyed by a flail machine.

"It is best if the post-harvest shaking operation can be put into action when weather conditions are right," Freeman said. "A dense fog is the best. That way the nuts become heavy with moisture and fall off the tree more easily."

Freeman said the weather doesn't always cooperate, but generally there are enough foggy, wet days to get the job done.

"Rain makes for good shaking too, although the nuts can dry quickly if the sun comes out or a breeze comes up," he said. "Fog lasts lo[illegible] into the day."

Freeman isn't opposed to using chemicals to control pests, but thus far he has never had to spray to control the worm.

Bill Barnett, the integrated pest management specialist for the University of California Cooperative Extension, said chemical sprays used to control the navel orangeworm are usually [illegible]

late April or early May and the only thing they have to eat is old almonds that are still in the tree, according to Barnett. Therefore, if there are no mummies left, there will be no worm problem.

The second generation will emerge in early July and may or may not correspond to hull split. If the emergence occurs before hull split there isn't too much reason for concern. However, if the worms emerge after hull split they could have a big impact on the new crop.

A third generation usually appears in early September. However, this year the extremely hot summer moved it up into August and brought on a fourth generation, which, Barnett said, was unusual.

"In addition to good orchard sanitation, it is important that growers get an early harvest," Barnett said. "Most almond growers try to get the crop on the ground before the third navel orangeworm generation."

ONE GROWER Barnett worked with applied two chemical treatments and still sustained 12 percent rejects because of worm damage at harvest.

Each well-timed and thoroughly applied in-season spray will reduce kernel damage about 50 percent, according to Barnett, provided harvest is timely. May sprays are aimed at worm larvae infesting mummie almonds. July sprays are directed at larvae infesting the new crop, he said.

In-season sprays can lead to spider mite build-up in the orchard, so a miticide should be included in the treatments, according to Barnett, who estimates that one treatment for navel orangeworm with a miticide will cost around $75 per acre.

On the other hand, Freeman estimates his cost for shaking, sweeping and flailing the nuts is about $20 per acre (including depreciation and maintenance costs). He said he could shake about eight-tenths of an acre per hour under ideal conditions with actual out- of-pocket costs between $12 and $13 per acre.

The overall cost and the potential mite problem are two reasons Freeman decided against spraying.

"The mite can build up quickly and defoliate your trees before you know what is happening. Then you have real problems," he said. "I get by with one chemical treatment at the proper time to keep the mite populations down."

Since Freeman started his orchard sanitation program and pressed for early harvest, his percentage of rejects has declined sharply. There were times when 10 to 15 percent rejection rates were not uncommon.

He recorded an alarming 7 percent rejects in 1972 when his almonds were delivered. But by 1976 that figure had dropped to 3.8 percent and in '79 and '80 it was less than 1 percent.

This year only 1.3 percent of his 100-acre crop was rejected. Most of his acreage is planted to [illegible]

[illegible] percentages on an industry-wide basis as provided by the California Almond Board have been: 3.8 percent in 1972; 3.1 percent in 1973; 3.9 percent in 1974; 3.8 percent in 1975; 6.1 percent in 1976; 6 percent in 1977; 8.8 percent in 1978; 3.3 percent in 1979; 3.9 percent in 1980; and 4.2 percent in 1981.

This year the almond crop is expected to be [illegible]

Efficacy of Almond Orchard Sanitation for NOW Control
Sutter County (Weakley)

% Damaged Nuts

Tree	PTB	NOW	Total
1	1	0	1
2	1	0	1
3	0	0	0
4	0	1.5	1.5
5	0	0.5	0.5
6	0	0.5	0.5
7	0	2	2
8	0	2	2
9	0	1	1
10	0	1.5	1.5
Average:	0.4%	1.8%	2.2%

Sample size: 100 nuts/tree

Trees 1-5 sampled 8/20/81

Trees 6-10sampled 8/25/81

Mummies/tree 2/16/81 = 0.45

No in-season treatment

Efficacy of Almond Orchard Sanitation for NOW Control

Glenn County (Kreuger)

Second Sample

% Damaged Nuts

Tree	PTB	NOW	Total
1	0	2.5	2.5
2	0	1	1
3	0	2	2
4	0.5	1	1.5
5	0	1.5	1.5
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	1	0	1
Average:	0.15%	0.8%	0.95%
11	0	2	2
12	0	1	1
13	0	0.5	0.5
14	0	0	0
15	0	0.5	0.5
16	0	0.5	0.5
17	0	0	0
18	0	0	0
19	0	0.5	0.5
20	0	0	0
Average:	0%	0.5%	0.5%

Sample size: 100 nuts

Samples taken 9/3/81

Trees 1 - 10 treated with Guthion 5/15/81

Trees 11 - 20 treated with Guthion 5/15/81 and 7/9/81

Mummies / tree 2/20/81 ~1.0

Orchard I - Kern Co. (Bentley & Viveros).

Mummies / Tree 2/11/81 - 24.7
3/31/81 - 7.7

% Damage 7/21/81 - 4.0
8/4/81 - 11.0
8/11/81 - 11.7
8/17/81 - 13.3

Orchard II - Kern Co. (Bentley & Viveros)

Mummies / Tree 2/11/81 - 27.6
3/31/81 - 13.8

% Damage 7/21/81 - 6.3
8/4/81 - 8.8
8/11/81 - 13.3
8/17/81 16.6

APPENDIX XI (?)

ITEM	MEAN	N
Total Acres of Trees	125.81	210
Acres of Bearing Trees	124.46	213
No. of Yrs. Producing Almonds	14.54	215
Percent Having Heard of 4 Point IPM Program	63.0	191
Percent Poling Mummies in Winter	48.3	213
Percent Shaking Mummies in Winter	21.7	212
Percent Practicing Winter Cleanup	70.0	---
Percent Destroying Mummies	56.3	213
Percent Using Dormant Spray	83.3	215
Percent Using Egg Traps	35.5	214
Percent Using Pheromone Traps	25.8	213
Percent Using May Spray	59.8	214
Percent Using July Sprays	58.1	215
Percent Harvesting Early	53.5	213
Percent Poling After Shaking	77.2	215
Percent Practicing Timely Pickup	88.3	214
Percent Using Artificial Drying	11.3	213
Meat Yield Per Acre (lbs.)	809.48	187
Percent Meats Nonpareil	53.0	181
Percent Meats Merced	12.3	159
Percent Rejects	5.5	151
Percent Nonpareil Rejects	6.6	172
Percent Merced Rejects	6.2	72

APPENDIX XI (p. 2)

INFLUENCE OF RECOMMENDED CULTURAL PRACTICES ON PERCENTAGE OF REJECT ALMONDS 1980

MANAGEMENT PRACTICE FOR NOW (IN-SEASON SPRAYS)	% REJECTED MEATS	AVG. SIZE OF ORCHARD (ACRES)	AVG. YIELD PER ACRE (LBS. GOOD MEATS)	# OF ORCHARDS
NONE	6.2	149	756	19
(0 SPRAYS)	7.8			8
(1 SPRAY)	4.3			3
(>1 SPRAY)	6.3			8
SANITATION ALONE	3.7	328	1104	47
(0 SPRAYS)	1.0			1
(1 SPRAY)	3.3			18
(>1 SPRAY)	4.1			28
SANITATION AND EARLY HARVEST	2.7	140	862	41
(0 SPRAYS)	2.1			9
(1 SPRAY)	4.0			11
(>1 SPRAY)	2.7			21

APPENDIX XII

Bacillus thuringiensis treatment for the peach twig borer, timed with the peach twig borer phenology model.

CONTROL –

TOTAL NUTS COUNTED	1075
TOTAL DAMAGE	6.98%
DAMAGE BY NOW	6.79%
DAMAGE BY PTB	0.19%

TREATED –

TOTAL NUTS COUNTED	1008
TOTAL DAMAGE	5.16%
DAMAGE BY NOW	5.06%
DAMAGE BY PTB	0.10%

APPENDIX XIII (a1)

ANTS IN CALIFORNIA ALMOND ORCHARDS

W. O. Reil and W. J. Bentley

University of California - Cooperative Extension

Although ant damage has been identified in the past on nut crops and some control measures were applied to the soil in the 1950's and 1960's, the damage was generally considered minor until recently. Factors which may have contributed to the apparent increased damage are: (a) increased planting of nut crops, especially almonds, in the southern San Joaquin Valley on previously unirrigated soils; (b) conversion to mechanical harvesting and change in management practices where the nuts remain on the orchard floor for longer periods of time; (c) change in orchard management to non-tillage; and (d) use of drip and sprinkler irrigation instead of flood.

Two species of ants have been identified as causing major damage to almonds, although other species have been found in orchards and have caused occasional damage. The ants presently known to be a problem in almonds are the pavement ant and the southern fire ant. The pavement ant, Tetramorium caespitum (Linne), ranges in color from blackish-brown to yellowish-brown with the body covered by course hairs. The workers are 2-4-1/2 mm (1/12 - 1/7") in length. The antennae have 12 segments with a 3 segmented antennal club. This ant will travel in a single file in search of food. The southern fire ant, Solenopsis xyloni (MacCook), has a reddish-yellow head and thorax with a black abdomen. The workers range widely in size from 1.6 to 6 mm (1/16 - 1/4"). This ant has a painful sting (thus the name fire ant). An identifying characteristic is a 10 segmented antenna with a 2 segmented antennal club.

The southern fire ant has the widest distribution and is causing the most damage in almond orchards in California. The type of damage caused by both species of ants appears first as a scraping or peeling of the pellicle (skin of kernel). Feeding usually starts on the nut at the base opposite the apex (tip). The ant then proceeds to chew into the inner kernel. Mandible marks can be seen with a hand lens, appearing as roughened contours in the kernel. No frass or webbing is present although considerable chewings (white, sawdust-like material) might be present. Eventually, the entire inner kernel (meat) is completely hollowed out leaving only parts of the pellicle.

Early harvest trials conducted in 1980 where nuts remained on the ground for extended periods indicates that most damage occurs to the nuts after shaking. Percent damage increases proportionally to the length of time nuts remain on the ground. Damage caused by the southern fire ant increased to 8.5% at Tejon over 4 weeks (Table 1). The pavement ant caused an increase of 5.7% damage in the same 4 week period (Dayton - Table 1).

TABLE 1. Percent nut damage caused by the southern fire ant (Tejon) and the pavement ant (Dayton). 1981.

Date Sampled	Tejon	Dayton
Aug. 20*	0	0
Aug. 27	3.5	0.4
Sept. 3	6.5	2.0
Sept. 10	5.5	4.6
Sept. 15	8.5	5.7

*Almonds shook from trees and remained on orchard floor for the duration of trial.

No chemicals are currently registered for ant control in almond orchards; therefore, no specific recommendations can be made. Summer sprays of Guthion, Sevin or Imidan applied at hullsplit for Navel orangeworm control have also provided suppression and reasonable control of southern fire ants. Trials in 1978 and 1979 showed that chemical (foliar application) control for Navel orangeworm gave approximately 83% ant control when applied in late June and July.

Experimental work conducted the past three years has shown that applications of either Diazinon 14G or Lorsban 15G have reduced the number of ant colonies present in the orchard. These materials currently are not registered for use in almond orchards. Diazinon 14G was recently registered for ant control in citrus orchards and hopefully will also be registered on almonds before the 1982 season.

APPENDIX ALL (P.6)

Table 4

McFarland Ant Trial - 1981

Chemicals Applied to The Ground on Dates Shown

Material	Amt./Ac.	Date Applied	Visual Rating 2/8	Visual Rating 8/5	% Nut Damag
Lorsban 15G	20 lbs.	5/13	0.13	0.13	5.9
Lorsban 15G	20 lbs.	7/8		0.50	5.5
Diazinon 14G	20 lbs.	5/13	0.38	0.38	6.8
Diazinon 14G	20 lbs.	7/8		0.63	7.1
Lorsban 4EC	3 Qts.	5/13	1.13	1.50	11.6
Lorsban 4EC	3 Qts.	7/8		1.13	7.3
Diazinon 40W	3.5 lbs.	5/13	1.25	0.88	13.7
Diazinon 40W	3.5 lbs.	7/8		1.00	11.3
Diazinon 40W + Coax	3.5 lbs. + 2 lbs.	5/13	0.88	1.00	11.8
Check			4.0	3.69	14.3
$LSD_{.05}$			1.04	1.22	4.1

APPENDIX XIV

Influence of Water Stress on Mite Abundance - Butte Co.

Date	Control				June Drying				Early Preharvest Drying			
	Pressure (PSI)	ERM $\bar{x}$/10 leaves	TSM —	PRED —	Pressure (PSI)	ERM $\bar{x}$/10 leaves	TSM —	PRED —	Pressure (PSI)	ERM $\bar{x}$/10 leaves	TSM —	PRED —
6-12-81	50.0	—	—	—	54.2	—	—	—	47.5	—	—	—
6-17-81	61.0	—	—	—	66.3	—	—	—	55.6	—	—	—
6-26-81	53.7	740.8	16.8	13.2	65.0	776.0	62.4	7.2	61.8	1039.2	34.8	10.8
7-2-81	48.1	174.0	0.0	0.0	81.3	264.0	0.0	9.6	55.0	220.8	7.2	7.2
7-10-81	65.0	15.6	0.0	0.0	75.0	39.6	1.2	0.0	68.1	42.0	0.0	2.4
7-15-81	46.9	15.6	0.0	0.0	52.1	16.8	0.0	0.0	66.9	22.8	0.0	1.2
7-24-81	53.0	1.2	0.0	0.0	65.0	1.2	0.0	0.0	78.0	3.6	0.0	0.0
7-30-81	59.0	7.2	0.0	0.0	59.0	7.2	0.0	0.0	91.0	8.4	0.0	0.0
8-6-81	63.8	1.2	0.0	0.0	63.8	3.6	0.0	0.0	90.0	1.2	0.0	0.0
8-14-81	75.6	1.2	0.0	0.0	73.1	1.2	0.0	0.0	101.0	4.8	0.0	0.0
8-25-81	72.5	4.8	0.0	0.0	76.3	2.4	3.6	0.0	93.1	4.8	3.6	0.0

Large Scale Releases of a Genetically-Improved Biological Control Agent

Aerial Dispersal of Metaseiulus occidentalis documented for the first time.

Marjorie A. Hoy, William W. Barnett, Wilbur O. Reil, Darryl Castro, Daniel Cahn, Lonnie C. Hendricks, Richard Coviello and Walter J. Bentley

APPENDIX XV (p 2)

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Spider mites can be serious pests in California almond orchards. In some orchards, the mite Metaseiulus (=Typhlodromus) occidentalis (Nesbitt) is an effective predator of the Pacific and two-spotted spider mites, Tetranychus pacificus McGregor and T. urticae Koch, respectively. Pesticides used to control the navel orangeworm, Amyelois transitella (Walker), and the peach twig borer, Anarsia lineatella Zell., can disrupt this biological control, however. Carbaryl (Sevin) and the new pyrethroid permethrin (Ambush or Pounce) can cause serious spider mite outbreaks, by killing spider mite predators, including M.occidentalis, by stimulating spider mite reproduction, or by causing dispersal of spider mites, which also can enhance their reproduction.

M.occidentalis has been selected in the laboratory for resistance to carbaryl and to permethrin (California Agriculture, January 1980 and November-December 1980) as part of a genetic improvement project. The two strains, which are also resistant to organophosphorus insecticides, such as Guthion (azinphosmethyl), diazinon, and Imidan (phosmet), are called carbaryl-OP and permethrin-OP resistant. These strains have been evaluated in the laboratory, greenhouse, and small field plots to determine their ability to become established, control spider mites, overwinter in orchards, and survive commercial pesticide applications.

The concept of genetic improvement of biological control agents previously received little support because of concerns that laboratory-selected natural enemies might not be as effective as unselected "wild" strains. Because our previous field plots were small and not always managed "normally" by the grower, we conducted research on the

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The concept of genetic improvement of biological control agents previously received little support because of concerns that laboratory-selected natural enemies might not be as effective as unselected "wild" strains. Because our previous field plots were small and not always managed "normally" by the grower, we conducted research on the feasibility of large-scale field releases of pesticide-resistant strains of predators for spider mite control. Goals were to rear resistant M. occidentalis and release them in San Joaquin Valley commercial almond orchards; document their establishment during the first season; document their ability to overwinter; and determine if pesticide rates can be reduced to manage spider mites and predators. This report describes our progress in rearing large numbers of the resistant predators, their establishment, and a previously unknown phenomenon--large-scale aerial dispersal of M. occidentalis from an almond orchard.

Predator rearing

Two systems were developed to produce predators. Most of the 1.5 million _M. occidentalis_ females released in almond orchards during 1981 were reared on pinto beans, _Phaseolus vulgaris_ (L), in a University of California, Berkeley, greenhouse. Plants were grown in flats containing one-half U.C. soil mix and one-half vermiculite. In the initial phase of greenhouse production (February to May) _T. urticae_ were added to the bean plants as soon as dicotyledon leaves appeared. About one week later, resistant _M.occidentalis_ were added. Plants were treated with carbaryl or permethrin periodically to ensure that the predator colonies remained resistant and that non-resistant predators were removed. Each strain was maintained on separate benches in the greenhouse.

Low rates of acaricide (Omite 30 WP, 1/3 to 1/2 pounds /100 gallons water) were applied when predator-prey densities became imbalanced (usually more than 40 to 50 spider mites of all stages to 1 predator). After the predator-prey system stablized in May, predators were multiplied by cutting old plants containing both spider mites and _M.occidentalis_ and placing them on clean young bean flats. These divisions yielded three new flats every two to three weeks during the summer.Continuous production of predators from June to September was possible, and about one million carbaryl-OP-resistant predator females and 227,000 permethrin-OP-resistant females were released.

Predators also were reared outdoors in a half-acre soybean plot in the San Joaquin Valley. This method required less labor than the greenhouse system, but large numbers of predators were not available for release until early August. The soybeans were planted April 27, amd 31 flats of spider mites and carbaryl-OP-resistant predators were added on four occasions in June. Total input of M.occidentalis was estimated to be 180,000 females. By August, the plants were about 4 feet tall and could be harvested. Leaf samples taken on August 6 indicated that the half-acre plot contained approximately 32 MILLION M.occidentalis females, plus at least another 30 million immatures and males. Each soybean plant contained an average of 300 predator females.

This method was the least expensive in producing large quantities of predators in inoculative releases during August or September for large acreages. Control of spider mites can not be expected during the field season of release with these late releases. However, this procedure should be helpful in establishing a population that will be effective the following year.

Predator releases

In all cases, both predator strains were released in the orchard after the relevant insecticide had been applied so that native (susceptible) predators were largely eliminated. Pinto bean plants were cut and placed in the crotch of the tree. Release patterns and numbers released varied from orchard to orchard (see table), but most often 350 females were placed in every third tree, in every third row. Unknown numbers of males and immatures were released as well.

We expected establishment in the tree and spread from release trees to adjacent nonrelease trees sometime during the 1981 field season. Releases were made thoughout the summer when adequate prey were available to support the predators; that is, a minimal prey level of one-half to one spider mite of any stage per leaf. Black cotton cloth bands were stapled to major scaffolding limbs of release and nonrelease trees in all orchards during September. Overwintering female predators recovered from the bands during December and January will be tested in the laboratory to determine if they are resistant and well distributed in the release orchards.

Spider mite populations were managed by using low rates of Omite ($\frac{1}{2}$, 1, or 2 pounds 30 WP per acre) or Plictran ($\frac{1}{2}$ or l pound per acre) both before and after predators were released. Use of these low rates sometimes gave poorer spider mite control than desirable if populations of M.occidentalis were not adequate or well distributed in the orchard. Weather, population densities, and irrigation schedules are also important in determining if these low rates give satisfactory control. If the weather is extremely hot, spider mite webbing has built up, or the orchard is water stressed, low rates of Omite or Plictran may not control spider mites sufficiently to prevent foliage damage. Thus, although low rates of these selective acaricides are potentially useful in spider mite management, considerable experience and monitoring are required to prevent excessive damage from spider mites. We will continue to evaluate such use of acaricides during 1982, because low rates can prevent predator-prey imbalances resulting from temporary loss of food, reduce grower costs, and retard development of resistance to these chemicals. Dominant resistance genes will be selected for more slowly in native spider mite populations if acaricides are used infrequently and at low rates. Plictran resistance has been found in spider mites in Oregon pear orchards recently (P.H. Westigard, personal communication), and serves as a warning of the potentially limited life span of these acaricides in California.

Aerial dispersal

We suspected that carbaryl-OP-resistant M.occidentalis dispersed aerially in the Bidart almond orchard near Bakersfield during 1979-80. A few predators had been released in August 1979 at one end of the block, and by August 1980 the carbaryl-OP-resistant predators were present thoughout the block in large numbers (Fig. 1), which indicated they had established, spread, and survived a carbaryl application in July 1980. An additional sample and laboratory test with carbaryl in April 1981 showed that the resistant strain had survived a second winter. Because the predators were so widely distributed over at least 50 acres, aerial dispersal was suspected.

In 1981, we conducted an experiment to determine if our suspicion was justified. Carbaryl-OP-resistant M.occidentalis were released on June 9 into every third tree, in every third row in an almond orchard (Livingston-I in table). Carbaryl had been applied in May and again on July 3. Despite applications of 2 pounds 30 WP Omite per acre on July 3 and 21, spider mites increased and caused substantial foliage damage and some defoliation because populations were high when the acaricide was applied. The abundant spider mites also provided unlimited food for the predators, which multiplied extensively.

As foliage quality declined, spider mites (predominantly T.urticae and T.pacificus females) began to disperse from the orchard in July. Dispersal was detected by trapping the mites on sticky panels situated on two towers placed at the east end (downwind of prevailing winds) of the orchard on July 31. The 11-foot-high towers were about 25 feet from the edge of the orchard on a 2-foot levee. Six plastic panels 9 by 12 inches, were coated with high vacuum grease (Dow Corning) and attached at three levels on the tower. After removal from the orchard, the panels were scanned with a dissecting microscope, and spider mite and predator numbers were estimated by counting one-ninth of the panel area. Predators from the panels were slide-mounted and identified to species; all were M.occidentalis females. No immatures or males were recovered on the panels.

Aerial dispersal of M.occidentalis in the field has not been documented previously. The dispersal raises interesting questions about the fate of the resistant strains we have released. We know how to establish resistant predators in specific orchards after the relevant pesticide has been applied. However, we don't know how rapidly or how far these resistant predators will disperse from the release sites, or how to manage the resistance in the orchards or vineyards to which the resistant M.occidentalis disperse.

During 1980 and 1981, we inoculated 210 and 86 acres of almonds in the San Joaquin Valley with the carbaryl-OP- and permethrin-OP-resistant strains, respectively (fig. 2). It will be interesting to learn whether these orchards will serve as foci for the spread of carbaryl resistance (determined by a single major semidominant gene) into other orchards or vineyards. (Spread of the permethrin-OP resistant strain is not expected because the permethrin resistance is determined by several genes. If this strain interbreeds extensively with permethrin-susceptible wild predators, the resistance is lost.) Only careful monitoring of the area around these release sites can resolve our questions. It is clear for the first time, however, that M.occidentalis can disperse through the air. The relative importance of this method of dispersal remains to be resolved.

Table 1. Resistant *M. occidentalis* Releases in Almonds during 1981

Orchard location	Acreage	Strain released	Release date	Release pattern	No. ♀♀ Released/ tree[1/]	Total ♀♀ released	No. bands[2/]
N. Palm & North Ave. Turlock - I	3	Carbaryl-OP	July 31	2nd tree 3rd row	500	50,000	40
N. Palm & North Ave. Turlock - II	6	Permethrin-OP	July 31	3rd tree 3rd row	1000	34,300	80
Washington & Westside Rd. Livingston - I	14	Carbaryl-OP	June 9	3rd tree 3rd row	350	61,600	100
Washington & Westside Rd. Livingston - II	10	Carbaryl-OP	Aug. 15	3rd tree 3rd row	350	60,000	40
Ave. 18 & Rd. 20 Madera	6	Carbaryl-OP	July 21	every tree	300	180,000	74
Hwy 33 & Mountain View Three Rocks	80	Carbaryl-OP	July 10	3rd tree 3rd row	350	555,400	240
Merced & Palm Ave. Wasco	20	Permethrin-OP	Sept. 15	3rd tree edges only	200	8,600	30
Hwy. 46 & Palm Ave. Wasco	15	Carbaryl-OP	May 28	5th tree 5th row	2900	175,000	40
Hwy. 46 & 43, Block 32-4 Blackwell Corners	60	Permethrin-OP	Aug. 5	3rd tree 3rd row	350	165,000	100

1/ Based on prerelease counts of bean plants.
2/ Trees were banded on Sept. 15, 16, or 17 to monitor overwintering success and resistance levels of *M. occidentalis*.

Fig. 1. Greenhouse mass rearing of M.occidentalis using pinto beans infested with two spotted spider mites. One predator-infested flat can be cut and distributed on 4 new flats for multiplication of predators. Over 1 ½ million resistant predators were produced during June-August by this method.

Fig. 2. Mass rearing of resistant M.occidentalis in a ½ acre soybean plot in the San Joaquin Valley. Soybean plants contained about 300 predator females each in late July. Cut plants are placed into the crotch of almond trees and predators move into the tree from the wilting bean plants. Approximately 32 million predator females were present in this ½ acre plot on August 6.

APPENDIX XV (p.13)

Fig. 3. Diagram of the Bidart almond orchard where carbaryl-OP resistant M.occidentalis were released in August 1979. Predators recovered in 1980 and 1981 were resistant to carbaryl, indicating extensive movements had occurred in this 80 acre orchard.

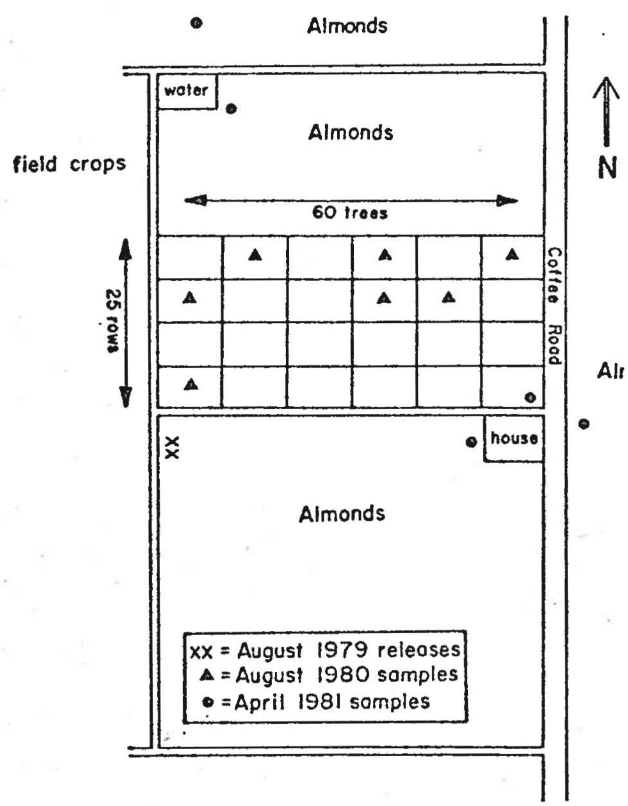

Fig. 4. Dispersal of carbaryl-OP and permethrin-OP resistant M.occidentalis from almond orchards where releases were made in 1980 and 1981.