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ALMOND BOARD OF CALIFORNIA

REPORT TO THE ALMOND BOARD OF CALIFORNIA -- 1996

Walt Bentley[1], Cressida Silvers[2], Anne Marie Ridgely[3], Lonnie Hendricks[4], and Roger Duncan[4]

[1]*IPM Entomologist, Statewide IPM Project, UC Kearney Agricultural Center;* [2]*SRA, UC Kearney Agricultural Center;* [3]*Community Alliance for Family Farmers;* [4] *Farm Advisors, UCCE Merced and Stanislaus counties*

Project: 96-BIOS
Specialized Monitoring of Almond BIOS Orchards in Merced and Stanislaus Counties

Problem and its Significance:

The goal of this project was to compare pest infestation as well as pest and beneficial arthropod population dynamics in orchards managed under two different approaches. A Biologically Integrated Orchard System (BIOS) approach, not using disruptive sprays, was compared to that of a more conventional pest management system where sprays are used. Also, the BIOS orchards had cover crops planted while only two of the Conventional orchard comparisons used planted cover crops (low grow mixture). In addition to the comparisons on arthropod abundance and damage between the two different management approaches, descriptive information on most of the 52 BIOS participants enrolled in the Merced and Stanislaus County program were conducted. Information on winter sanitation, pest monitoring, navel orangeworm parasitism, insecticide use, and crop damage was collected from these BIOS participants.

Objectives:

1. Compare the influence of winter mummy load on subsequent navel orangeworm (NOW) infestation and the relationship between mummy load and parasitism of NOW.

2. Evaluate the abundance of San Jose scale and its associated parasites in BIOS and conventional blocks.

3. Monitor NOW and peach twig borer (PTB) throughout the growing season in BIOS and conventional orchards.

4. Assess damage due to ants, NOW, and PTB at harvest in BIOS and conventional orchards.

5. Evaluate pest and beneficial mite presence in BIOS and conventional orchards during the mid summer.

Procedures:

Nine BIOS and nine Comparison orchards were monitored throughout the season. Due to hullsplit or May insecticide treatments in two BIOS locations only information from the remaining seven Comparison orchards is included. Six of the conventional orchard sites used at least one growing season organophosphate or pyrethroid insecticide application and all used dormant sprays (See Table 1). At the seventh site neither the BIOS or Comparison orchard received a disruptive spray but the comparison did not have a seeded cover crop, as did the BIOS site. None of the seven BIOS orchards used disruptive insecticides during the winter or growing season, except spot insecticide treatments for ants. All BIOS orchards used *Bacillus thuringiensis* (Bt) sprays during bloom and five received releases of *Goniozus legneri*. Forty-four of 52 BIOS orchards in Stanislaus and Merced county were also evaluated for winter mummy load, presence of NOW parasites, and harvest infestation.

The seven Comparison orchards which could be used for evaluation are shown in Table 1 (orchards 8 and 9 were excluded because of spray). There were three in Stanislaus county and four in Merced county. Four of the comparisons involved dividing the cooperator's orchard in half with one half managed using BIOS techniques and the other half using broad spectrum sprays to reduce insect damage. These included The Boone, Madsen, Lambrix, and Segers orchards. In each of the seven comparisons, infestation evaluation was based on the Nonpareil variety. Each of the site comparisons were to be considered as replicates with the treatments being the management system of BIOS (nonsprayed with disruptive materials, *Goniozus legneri* and *Galandromous occidentalis* releases, a planted cover crop) with the Conventional pest management (a dormant and hullsplit spray with an organophosphate, no parasitoid or predator release). Two of the conventional orchards had cover crops planted (Boone and Lambrix). In the remaining orchards either no cover weeds were present or resident vegetation was the cover. Analysis of differences were compared using a standard analysis of variance program.

Objective 1: Winter Sanitation And Its Influence on NOW Infestation and Parasitoid Abundance

Three of the Comparison growers were not selected until after almond trees had bloomed and leafed. Therefore it was impossible to make valid mummy counts in these blocks. However, mummy counts were taken at 52 sites involving BIOS almond growers. Unharvested almonds from a minimum of ten randomly selected trees were taken from each of 52 sites. The results of these counts are shown in Table 2.

Winter mummy load in the 52 locations ranged from 0 to 177 per tree with an average of 18 per tree. Current recommendations that almond growers achieve a level of two or fewer mummies per tree by the time NOW begins emergence in the spring. Nineteen of the 52 sites sampled reached this level. Average NOW infestation in the winter mummy nuts was only 12.1% and ranged from 0 to 36%. This is a relatively low average given the number of mummies per tree. Of the 52 grower participants involved in BIOS 62% (32 almond growers) actively shake or pole trees during the winter

Thirteen of the 19 Nonpareil cultivar sites which had fewer than two mummies per tree had harvest samples collected and evaluated for infestation. Five hundred nuts were collected and examined from each site. Navel orangeworm infestation averaged 1.63% in the Nonpareil cultivar (infestation ranged from 0 to 5%) for these growers. Twenty-two sites, with Nonpareil cultivar, which averaged more than two mummies per tree were also sampled for infestation at harvest. Navel orangeworm infestation averaged 3.48% in the Nonpareil cultivar (infestation ranged from 0.2% to 14% at these sites). Clearly the recommendation for removing unharvested mummies, which harbor NOW during the winter, is important in reducing harvest infestation of Nonpareils.

Many BIOS growers feel that infested winter mummies are important in maintaining parasitoids of NOW from one season to the next. Mummy samples were taken from each site and examined for either adult or larval parasitism. Larvae were also held for emergence of parasites. The number of mummies collected from 25 to 100 per orchard. Of the 44 BIOS orchards where NOW were collected two adult *Goniozus* were found and no parasitoid larvae were recovered. A single adult was found at each of two sites. Two sites were found with the parasitoid *Pentalitomastix plethorica* present. Again a single parasitized larvae was found at each of two sites. There was no relationship between the abundance of winter mummies in the orchard and the abundance of either parasitoid. No parasitoids were found at the sites with mummy loads of more than 100 per tree and receiving no sprays. No parasitoids were found at the five sites where mummy load ranged from 30 to 57 mummies per a tree. Clearly, leaving unharvested mummies on trees is not advantageous. The practice of collecting mummies after removal and placing them in containers for emergence of any parasitoids may still be of value, if the parasitoids are able to survive the winter.

Objective 2: Evaluation of San Jose Scale and Associated Parasitoid Abundance

Of 55 almond growers surveyed by the Community Alliance of Family Farmers in 1996 only 17 were applying a dormant spray. Of these 17, only four used an organophosphate or pyrethroid in addition to the standard inclusion of a horticultural oil. Because of this reduced reliance on dormant insecticide applications there is concern with increased San Jose Scale abundance and damage. Beginning in April 1996, two San Jose scale pheromone traps were placed in each of the nine sites. Every two weeks these traps were counted for the presence of male San Jose scale and two parasitoids, *Prospaltella perniciosi* and *Aphytis* spp. Pheromone caps were changed on a monthly basis. The seasonal dynamics of male San Jose scale flight and its most abundant parasitoid, *Prospaltella*, is shown for each of seven Comparison orchard sites (Figs. 1-7). In each of the comparisons between the BIOS grower and the Conventional approach, the patterns of activity were virtually identical. That is flight initiation, peak flight and valleys in flight activity were no different based on management approach. Even of more interest is the low abundance of San Jose scale in each of the BIOS orchards. The highest population was found at the Hopeton location with a peak of 140 male scale per trap over a two week period. This is an extremely low level of male scale. The level of scale was also low in the sprayed orchards, but this was expected to occur with an effective dormant spray. Even more surprising was the extremely high population of *Prospaltella* with peak levels in two of the orchards of over 5,000 parasitoids during a two week period. Also of surprise was the relative high level of *Prospaltella* in the sprayed comparisons, although there abundance was much more variable late in the season. There is evidence to indicate the summer sprays are reducing *Prospaltella* and resulting in higher resurgence of San Jose scale (Fig. 1). Table 3 presents the seasonal trap San Jose scale trap catch averages from the six comparisons.

Objective 3: Monitor Seasonal Ovipositional Dynamics of NOW and Flight Activity of PTB in BIOS and Conventionally Sprayed Comparison Orchards.

The purpose of objective 3 was two fold. To detect differences in the dynamics of NOW egg laying and PTB flight activity as measured by egg traps (NOW) and pheromone traps (PTB) between the two orchard management systems and to detect differences in the number of NOW eggs and PTB male moths between the two systems. Figures 1 through 7 present the seasonal egg laying activity for NOW and the seasonal flight activity for PTB in the Comparison orchards. Two black NOW egg traps and two Consep® wing traps were placed in each of the Comparison orchards and monitored once per week.. The NOW egg traps were baited with almond press cake mixed with crude almond oil (1 part of oil to 10 parts of almond press cake). These traps were set out on April 1. The bait was changed monthly or if the bait became wet. Consep® PTB pheromone dispensers were placed in each of the PTB wing sticky traps and these were changed on a monthly basis. The trap bottoms were changed monthly or when bottoms became dirty. The objective here was to determine the presence of these two key pests as measured by traps and the relative period of activity, either by egg laying, or by male flight, in the BIOS and sprayed conventional orchards.

In four of the orchard comparisons oviposition by NOW was relatively low. Orchard Comparisons 1, 3, and 4 present higher egg abundance. Three periods of NOW egg laying are clearly shown. The first generation became active in early April and egg laying extended through the end of May. Second generation eggs were laid in late June through mid July and third generation eggs were laid in early August and this continued through September. The greatest abundance of eggs were those of the first generation. This is typical because of the lack of competition from new crop nuts with the egg traps, which occurs during July and also in August. Often, after the nuts are removed from the orchard in August trap egg trap counts will again increase. This is clearly seen in Comparison 3. Although there are some variations in activity between Comparison orchards, such as seen in the last NOW egg laying period in Comparison 2, the dynamics of NOW oviposition is quite similar between the two comparison sites at each of the seven locations. The orchard comparisons at the Hopeton location (Comparison 5) showed virtually no egg laying activity. The winter survey of mummies resulted in a zero count in the sampled trees at this site.

Peach twig borer monitoring was also initiated on April 1 and continued into September. The dynamics of moth flight was virtually identical between BIOS and the sprayed Comparison orchards at each of the 6 sites, as well as the seventh nonsprayed comparison in Winton (Fig. 7). Overwintering flight was recorded on April 8 and continued through June 10. The first summer generation began during the first week of July and ended during the last week of July. The second generation is less discernible but flight appears to have begun in early August. The only comparison where an effect from the hullsplit spray could be interpreted to influence male moth activity was Comparison 6, at the Hilmar location, with a decrease between the readings shown on July 8. The spray was applied on July 1 and again on July 10

Navel orangeworm eggs and PTB male moth average trap catches are shown in Table 4. Navel orangeworm egg deposition during the season was quite low with the BIOS orchards averaging

91 eggs per trap per season and the Conventional spray orchards averaging slightly more than twice that number with 184 eggs per trap per season. There was no statistical difference between the two numbers due to the wide variation in egg deposition between orchard locations. However this difference in egg numbers needs to be evaluated more closely, particularly in orchards such as those in Comparison 3 and the non sprayed Comparison, where NOW egg laying drops dramatically toward the end of the season.

The seasonal per trap average of male PTB was also not different between the two farming practices (table 4). There were 2151 males per trap in the BIOS system while there were 2225 per trap in the Conventional system.

Objective 4: Assess the Damage to Nuts by NOW, PTB and Ants.

At harvest 1000 nuts were collected from each of the Comparison orchards and brought into the lab. Collections were made at random by picking nuts in groups of 5 to 10 throughout the orchard. These samples were held at 35° Fahrenheit until they could be hand cracked and damage identified. A sub sample of 500 nuts were cracked from the 1000 collected. In addition to the samples collected from the original nine Comparison orchards, 36 additional Nonpareil nut samples were collected and cracked from other BIOS participants to further evaluate the damage due to the three key pests of almonds. Table 5 presents the infestation and parasitism found in each of the 6 orchard comparisons, Orchard 7 where neither comparison was sprayed, and the average infestation in the six orchards. Also evaluated was the presence of the two parasites *Goniozus legneri* and *Pentalitomastix plethorica*. The infestation data was analyzed using an analysis of variance for randomized complete block design. There was no statistical difference between any of the parameters measured.

Navel orangeworm infestation was the most severe problem found in both management practices. The BIOS NOW infestation ranged from a low of 0.2% (found in the Segers Comparison 5) to a high of 14% (found in Comparison 1). The average infestation for all six BIOS orchards was 4.4%. The conventionally managed and sprayed orchard NOW infestation ranged from 0 (Segers, Comparison 5) to 6.2% (Comparison 3). The average infestation for all six of the standard sprayed orchards averaged 2.2%. In Comparison 7 (Madsen orchard), which was not replicated, NOW infestation in the BIOS Cover Crop (low grow) orchard averaged 5.4% while in the BIOS Resident Vegetation orchard infestation averaged 1.2%. The relatively low level of NOW infestations in Comparisons 2, 4, and 5 would not justify the inclusion of a spray.

Peach twig borer infestation was not severe in 1996. Infestation in the BIOS orchards ranged from 0 (Comparison 6) to 3.2% (Comparison 2) and averaged 0.8%. Infestation in the Conventionally managed and sprayed locations ranged from 0 (Comparisons 3, 5, and 6) to 4.4% (Comparison 2) and averaged 0.8%. There was no statistical difference found between the two management systems. Peach twig borer infestation in the Madsen orchards (Comparison 7) both averaged 0.4%.

Two of the BIOS Comparison orchards did treat individual colonies of ants with chlorpyrifos applied to the orchard floor. This was done in Comparisons 1 and Comparison 6. Ant damage in the BIOS orchards ranged from 0 (Comparison 3) to 5.4% (Comparison 6 which treated localized colonies) and averaged 1.6% for all 6 BIOS locations. Ant damage in the Conventionally managed and sprayed comparisons ranged from 0.2% (Comparisons 1 and 3) to 2% (Comparison 6). As in the previous analyses there was no statistical difference in management practices.

No *Goniozus legneri* were found in any of the sprayed orchards and only two of the BIOS orchards, both of which received releases during the growing season. The rates of parasitism were low, being 2% and 4% in Comparisons 3 and 6 respectively. Low levels of ant damage were found in the unsprayed Comparison 7.

Almond growers are interested in total reject levels. When the totals of all three primary pests are compared, the BIOS orchards averaged 6.8% insect damage while the Sprayed comparisons averaged 3.8%, a difference of 3%.

Objective 5: Compare Abundance of Webspinning Spider Mites and The Western Orchard Predator Mite Between BIOS and Conventionally Managed Orchards.

The abundance of webspinning spider mites (Pacific mite and two-spotted spider mite) and the predominant mite predator, the western predator mite were sampled in seven of the orchard comparisons. These samples were first collected July. Additional samples in only three of the orchards were made in August. Sampling consisted of selecting ten leaves from each of five randomly selected trees in each of the BIOS and Conventionally managed orchards. The leaves from each tree were placed in a paper bag which was then placed in a cooler. The samples were carried back to the lab where the leaves were counted for mites.

Table 6 presents the results of the July and August sampling. Mite sampling was delayed into the summer because of the observed low levels of webspinning mites made during periodic field checks. As can be seen in Table 6, low levels of mites were found during the initial samplings from each of the locations. Unfortunately, just as the trees and spider mites responded to the extreme heat stress in early August, sampling had to be curtailed due to the need to collect harvest samples for infestation. The greatest abundance of Pacific mite was found in the Denair area in Orchard Comparison 2, on August 12. At that time the BIOS orchard, which had not been treated with a miticide reached a level of 12 mites per leaf while the comparison orchard which had a miticide applied with the hullsplit application of Guthion® reached a level of 0.2 mites per leaf. The western predator mite was virtually absent (Table 6 shows zero due to rounding) in all of the orchards. This was most likely a predator response to the absence of prey early in the season. These late season mite outbreaks often result in abundance of the western predator mite the following year.

Unfortunately few management conclusions can be drawn from the information collect in 1996. Most of the orchards, whether sprayed or unsprayed during the growing season, had severe mite problems in late August and early September.

Discussion

Information gained from the 1996 Specialized Monitoring Program can be applied to growers using either of the two generalized management programs compared in this project. However this study needs to be followed for a period of years whereby the information can continue to be incorporated into an overall pest management approach, an approach that growers can have confidence in utilizing.

One of the major finds in the 1996 study was the influence that winter sanitation has in reducing the subsequent harvest infestation. Those growers following recommended guidelines of fewer than two mummies per tree in February reduced NOW infestation by 48% over those that did not achieve this level. Interestingly, many of those almond growers with low numbers of wintering mummies indicated they do not do winter sanitation. From this it can be concluded that many orchards have a substantial amount of natural nut removal, either due to weather or possibly birds. Another possible explanation is a more effective removal of nuts at harvest. The influence of cover crops on the efficiency of nut removal at harvest should be examined.

Unfortunately, in the 1996 study, the survival of the key NOW parasitoid, *Goniozus legneri*, was quite low. Winter surveys resulted in virtually no finds (two from sites were single individuals were found). Similar results were also found in a separate, more in depth study, by Dr. Kent Daane. Based on the release methods used by participants (primarily placing parasitoid pupa in trees) and the conditions of 1995-1996 winter, the survival of this parasitoid was not adequate. Many factors could come into play concerning this parasitoid. It is not clear whether the release method allowed for greater predation of the parasitoid. Certainly, in BIOS orchards, generalist predators are abundant and they make no distinction between prey. One key predator may be the gray field ant *Formica aerata*, commonly found in trees and also attacking peach twig borer.

In addition to the poor wintering survival of *Goniozus*, there was relatively low parasitism found at harvest. This parasitoid was found at six of the 41 sites where harvest samples were evaluated (500 nuts per site). Percent parasitism at these six sites was 56%, 4%, 9%, 2%, 3.5%, and 6%. It has been demonstrated that *Goniozus* can provide 50% or more parasitism in many locations. The reason for this occurring at only one site in 1996 needs to be more thoroughly studied.

Because of the low level of winter survival of *Goniozus*, even in orchards where mummy nuts were abundant, almond growers should emphasize winter sanitation. This practice was demonstrated in this study, and in others, to consistently provide 50% reduction in infestation when compared to those orchards where mummies remained on trees. There are methods which can incorporate both winter sanitation and unharvested mummies (placed in screened buckets after removal from trees) so as to encourage *Goniozus* survival.

The results from monitoring San Jose scale and its two key parasitoids, *Prospaltella*, and *Aphytis*, are encouraging. The pheromone used to monitor SJS also attracts these parasitoids. This years work has substantiated field observations which show SJS to be a relatively minor problem in the BIOS orchards. There were no differences in the number of scale trapped between the Comparison orchards, all of which were extremely low (an average of

97/trap/season in BIOS and 108/trap/season in Sprayed). What was unexpected, was the abundance of *Prospaltella* (1618/trap/season in the BIOS and 1134/trap/season in the sprayed). *Aphytis* numbers were lower, averaging 172/trap/season in the BIOS orchards and 125/trap/season in the sprayed orchards. Work on San Jose scale and parasitoids associated with it will be followed more closely in 1997. It does appear that *Prospaltella* is having a dramatic impact on SJS populations in almond orchards.

Navel orangeworm egg abundance, as measured by black egg traps, was extremely low in both the BIOS and Conventional Spray blocks. Although there was no statistical difference between the two comparisons the BIOS blocks averaged half the number found in the conventionally sprayed orchards. It would be expected that the sprayed orchards would record fewer eggs than the unsprayed orchards, but this was not the case. The possible influence from predation in these unsprayed blocks needs further study. Despite the small numbers found, the occurrence of egg deposition during the season is quite similar between the two blocks. From this, no shift in population activity, which might influence infestation as the nuts become susceptible, could be detected between comparisons.

Peach twig borer numbers and seasonal flight activity as measured by the egg traps were almost identical between the comparison orchards. As with NOW this would indicate that this would indicate little benefit from the sprays used in this program, if pheromone trap measurement of males can be used to judge populations.

Although average infestation for the three primary pests of almonds, NOW, PTB, and ants, was greater in the BIOS locations, the cost of this difference must be weighed in comparison to the cost of the sprays used to lower infestation. Additionally, the cost of miticides, invariably needed when disruptive sprays are applied during the growing season, should also be included. It does appear that sanitation can be used to keep NOW infestation within acceptable levels. Also, further work with *Goniozus* releases may lead to a technique which better allow survival of this beneficial during the season. Currently the major pest problem is with the management of ants. The development of newer and effective baiting programs may allow for better ant management in the future, but currently a chemical control is necessary to manage orchards with a high abundance of either pavement ant or southern fire ant. Management of PTB can be accomplished with an aggressive program of *Bacillus thuringiensis* (Bt) at bloom. Also, the possibility exists for the use of mating disruption to manage this pest.

Little information can be drawn from the work done with webspinning spider mites in 1996. The extreme heat during August caused problems with mites in both the BIOS and standard sprayed orchard comparisons. The lack of predators was a major draw back in all the orchards sampled. Early season sampling for mites needs to be incorporated into the decision process for predator releases. The scenario which developed in 1996, low mite and predator abundance early in the season followed by extreme heat stress late in the season, is one that is the most difficult to manage. It requires intensive mite sampling during the season and management decisions just as harvest is getting underway.

Intensive monitoring will be accomplished in 1997 to provide both a greater data base to develop management approaches to almond pests which rely on fewer insecticide inputs and to extend timely information to growers in the Merced and Stanislaus County area.

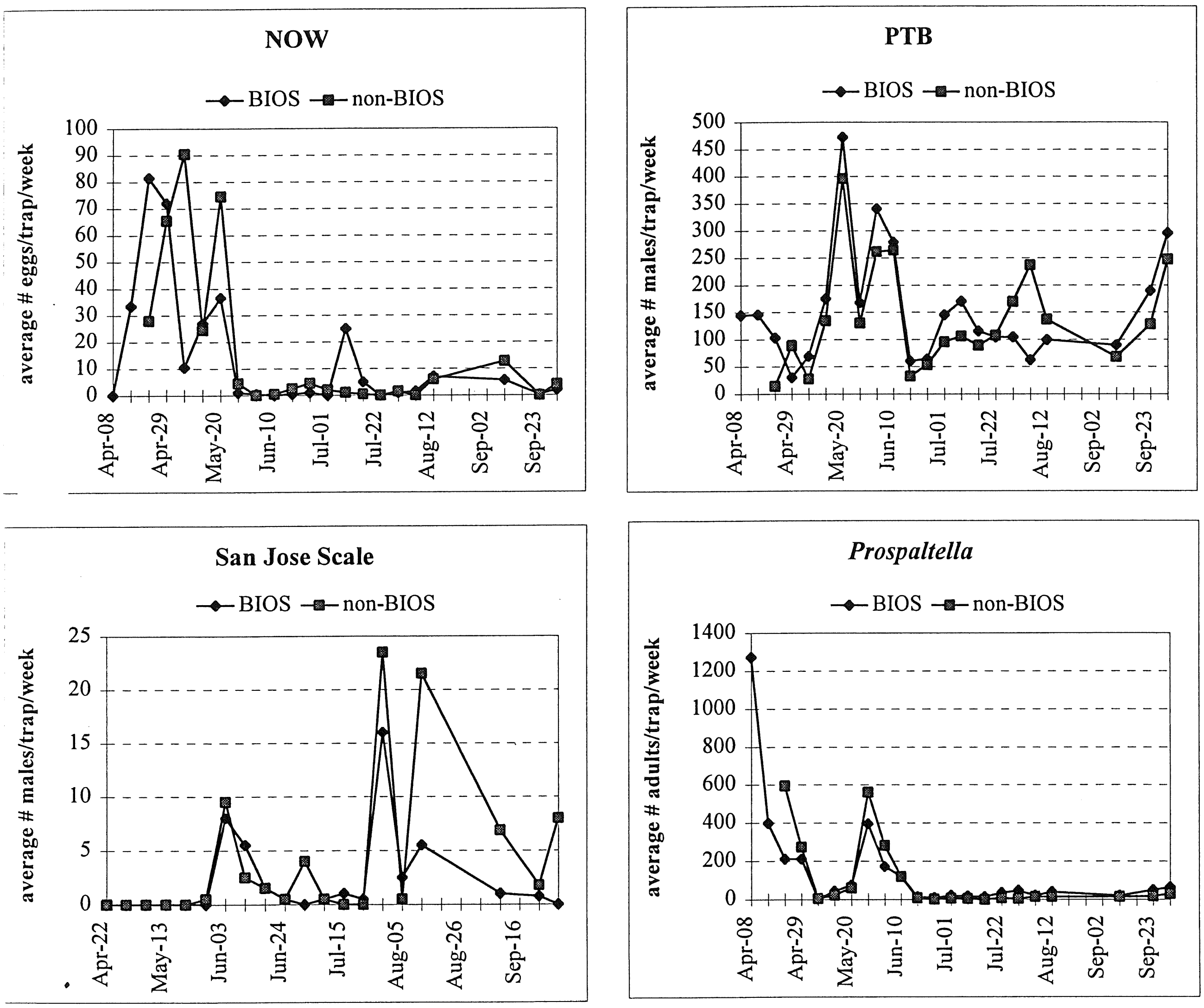

Figure 1. Seasonal population dynamics of four insects associated with almonds. Orchard comparison set 1, Hughson, Stanislaus County.

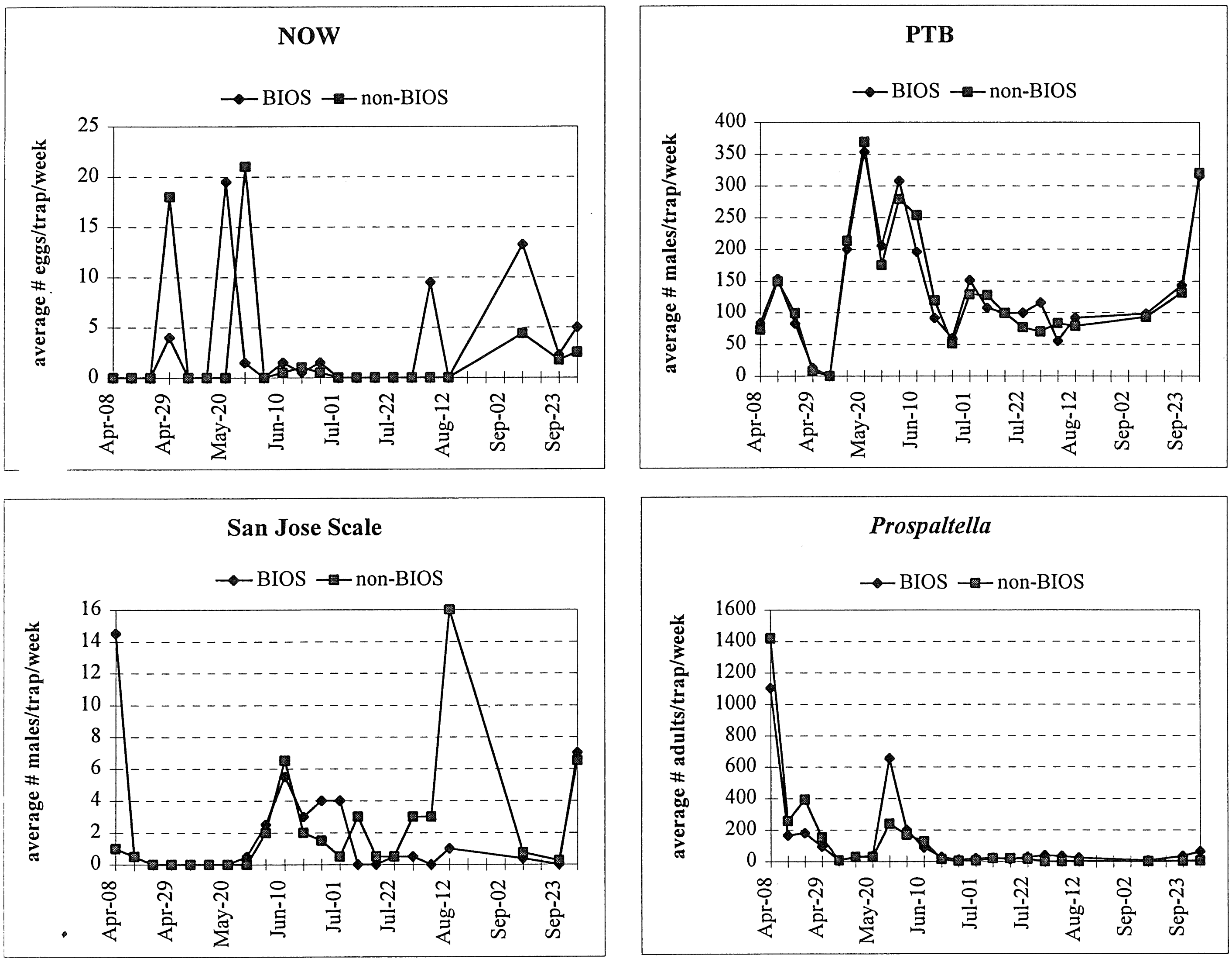

Figure 2. Seasonal population dynamics of four insects associated with almonds. Orchard comparison set 2, Denair, Stanislaus County.

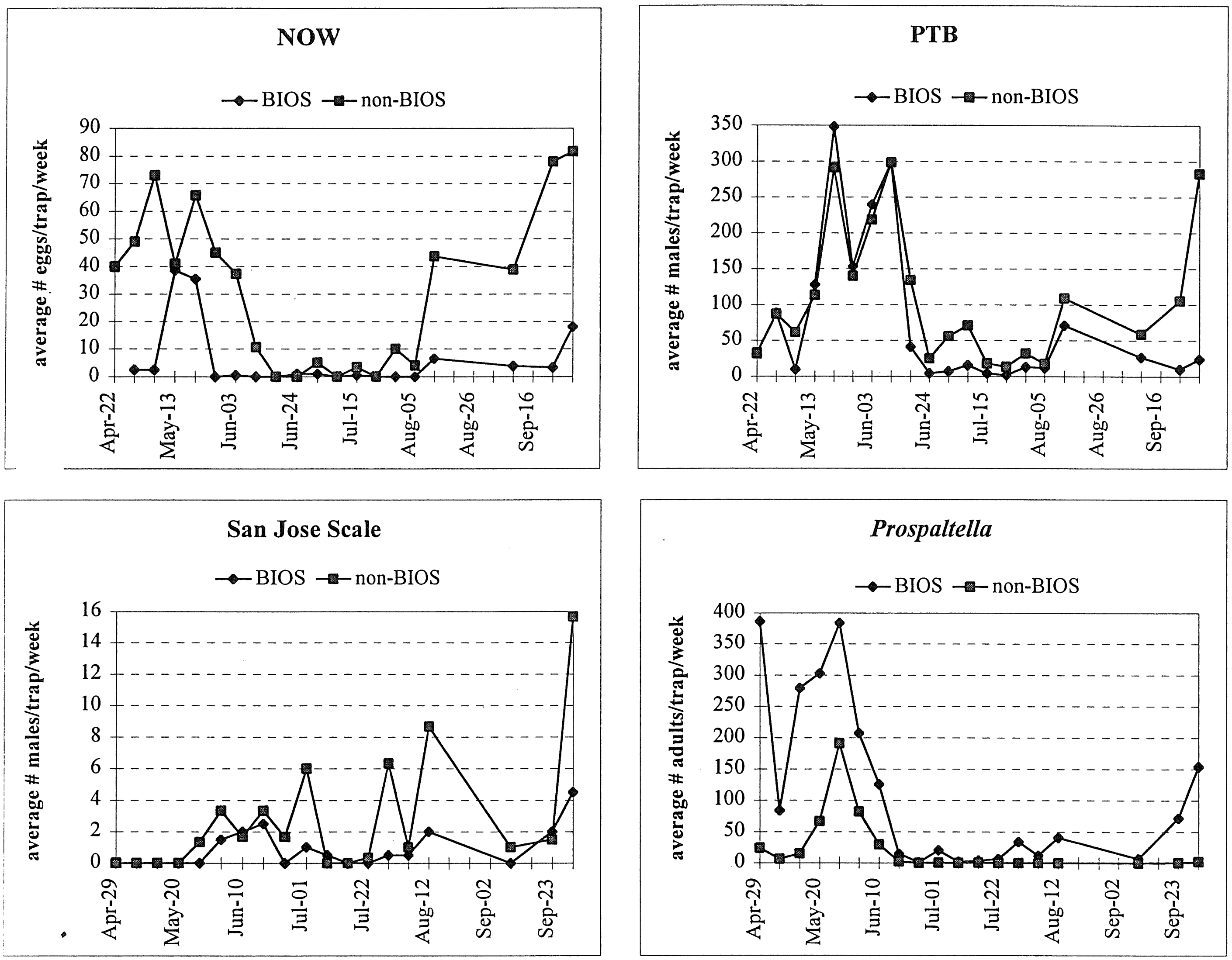

Figure 3. Seasonal population dynamics of four insects associated with almonds. Comparison orchard set 3, Winton, Merced County.

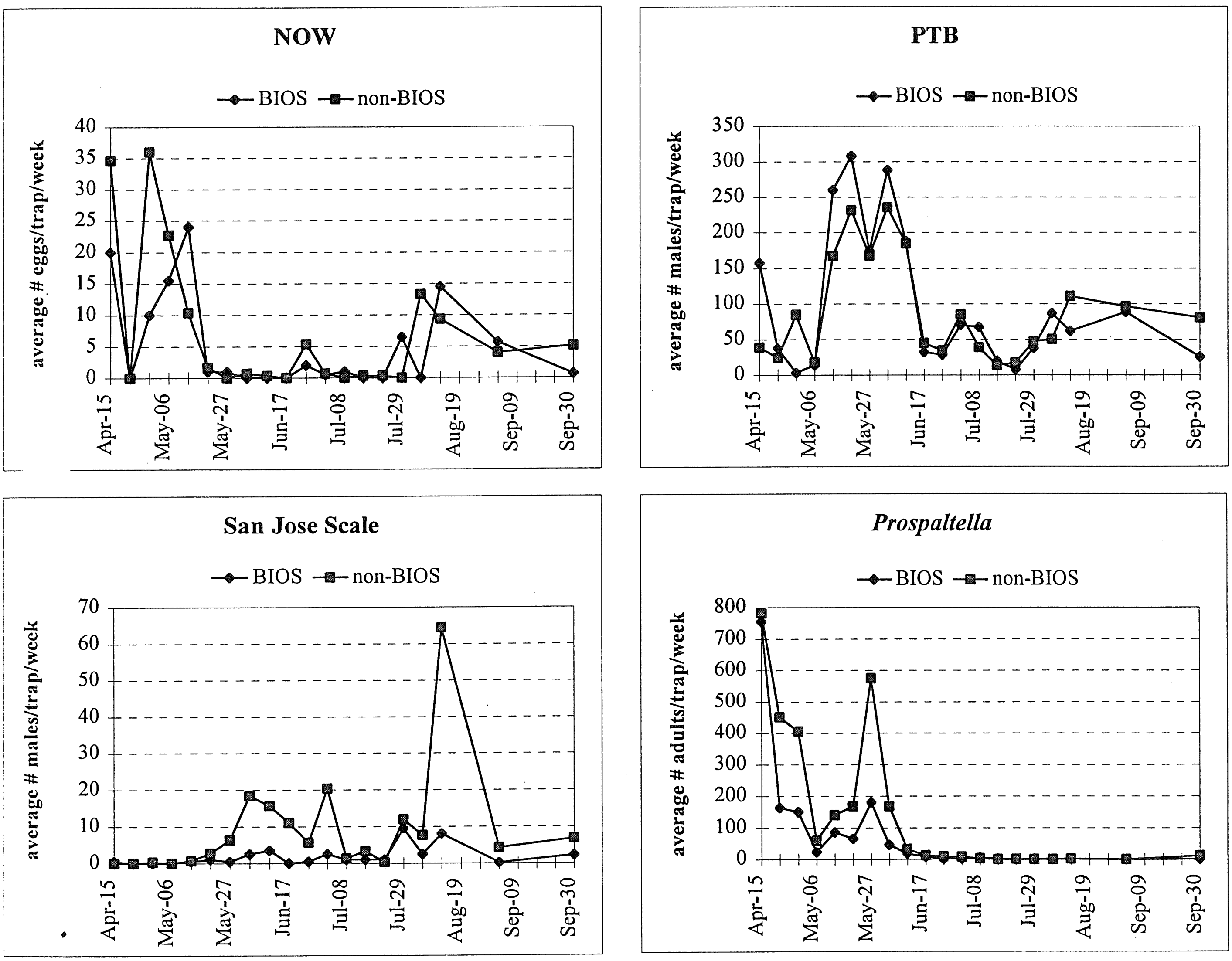

Figure 4. Seasonal population dynamics of four insects associated with almonds. Comparison orchard set 4, Merced, Merced County

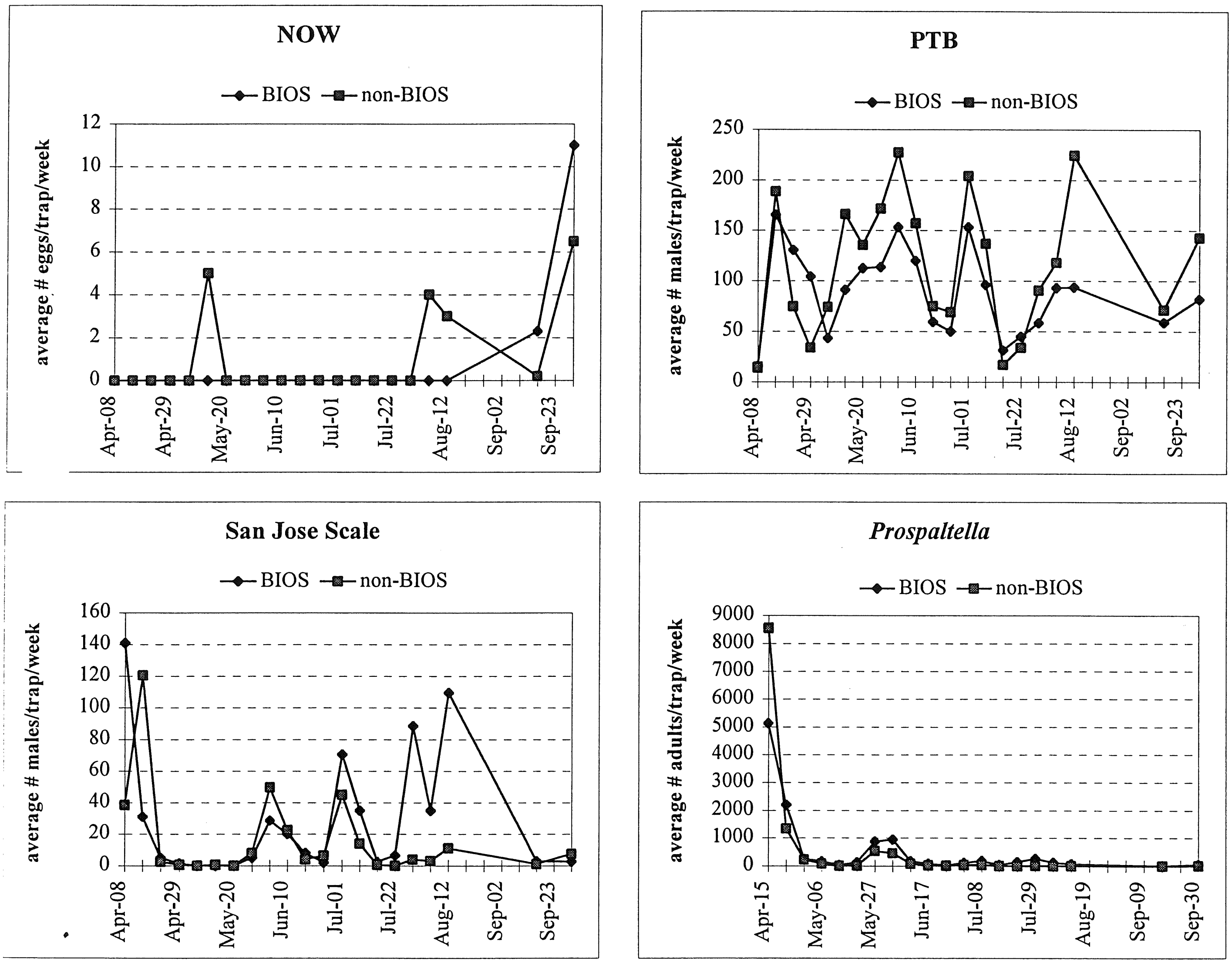

Figure 5. Seasonal population dynamics of four insects associated with almonds. Comparison orchard set 5, Hopeton, Merced County.

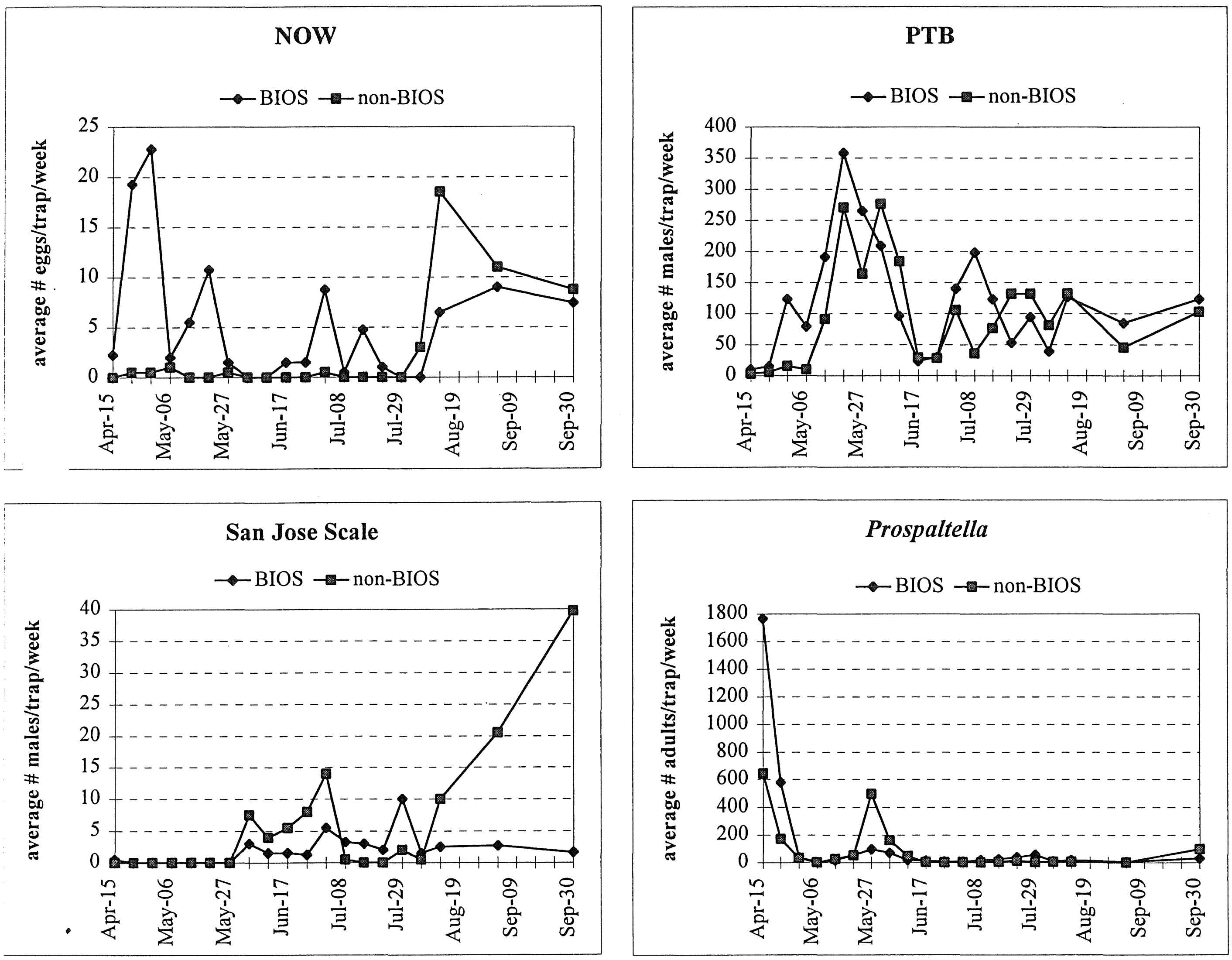

Figure 6. Seasonal population dynamics of four insects associated with almonds. Comparison orchard set 6, Hilmar, Merced County.

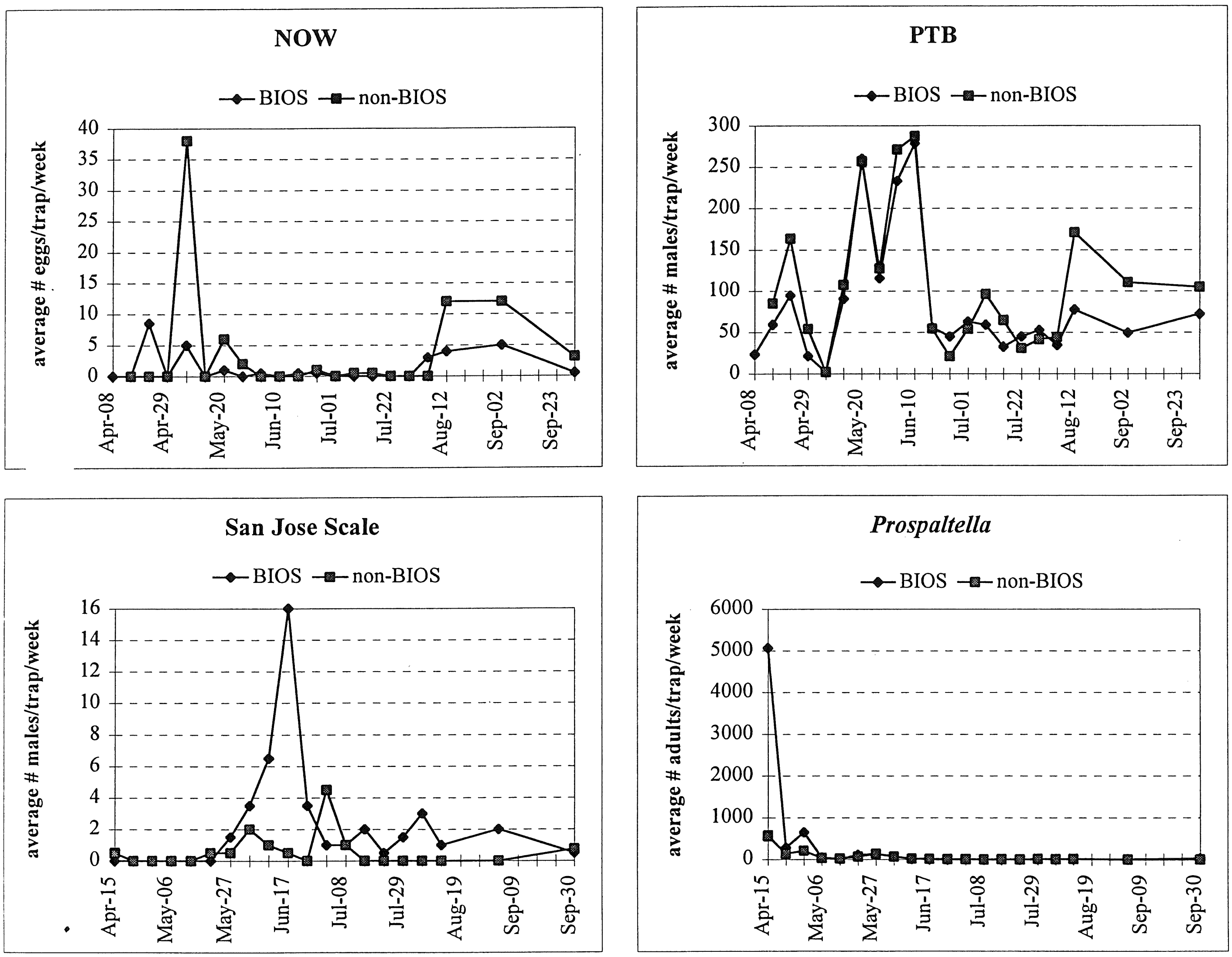

Figure 7. Seasonal population dynamics of four insects associated with almonds. Cover crop comparison, Winton, Merced County.

Table 1. BIOS vs. sprayed comparison orchard descriptions, 1997 specialized monitoring program.

Grower/Location	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 1							
Beekman BIOS Hughson, Stanislaus Co.	19	2 Nonpareil; 1 Merced	23	Rich mix Low Grow Insectiary (every 10th row)	No	*Goniozus* & *Trichograma*	Bloom: Bt, spot Lorsban for ants
Baptista, Comparison Hughson, Stanislaus Co.	5	Nonpareil and Price	14	None (some weeds)	Yes Knocking, disking	No	Dormant: Diazonon-Supreme oil Hullsplit (7/15): 1 gal/acre Lorsban
Comparison 2							
Boone BIOS Denair, Stanislaus Co.	10	50% Nonpareil; 36% Price	10-11	Rich Mix with grains, cereals	No	4 *Trichograma, Goniozus, Galandromous*	Bloom: Bt
Boone, Comparison Denair, Stanislaus Co.	5	14% Neplus	10-11	1/2 Rich Mix with vetch	No	2 *Trichograma, Goniozus, Galandromous*	Bloom: Bt Hullsplit (7/19): 1 lb and Guthion; Vendex
Comparison 3							
Kinoshita, BIOS Winton, Merced Co.	8	2 Nonpareil; 1 Merced	29	Low Grow (?)	Yes, poling	3 *Goniozus*; 3 predatory mite; and 1 *Trichogramma*	Dormant: Bt bloom 6/20 Bt: Consep PTB disrupt
Miyamoto, Comparison Winton, Merced Co.	20	2 Nonpareil; 1 Merced	20+	None	Yes	No	Dormant (1/24): 6.4 oz/acre Asana & 2 gal/acre Superior oil Hullsplit (7/14): 2 lb/acre Guthion & Omite

Grower/Location	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 4							
Lambrix, BIOS Merced, Merced Co.	12	1 Nonpareil; 1 Carmel	12	Low Grow	Yes	No	Bloom: Bt 3/7-3/13
Lambrix, Comparison Merced, Merced Co.	25	1 Nonpareil; 1 Carmel	12	Weeds, mowed	Yes	No	Bloom: Bt 3/7-3/13 Hullsplit (7/5 & 12): 4 lb/acre Imidan, Nonpareil only
Comparison 5							
Segers, BIOS (Block 7) Hopeton, Merced Co.	28	Butte; Ruby; Mission	8	Rich Mix; Low Grow	Yes	No	Bloom: Bt 4/1
Segers, Comparison (Block 4) Hopeton, Merced Co.	28	Butter; Ruby; Mission	8	Rich Mix; Low Grow	Yes	No	Bloom: Bt 4/1
Comparison 6							
Stinson, BIOS Hilmar, Stanislaus Co.	40	55% Nonpareil; Merced, Mission, Fritz, Price	35	Self-seeded, Rich Mix	Yes	1 *Goniozus*; 1 *Trichogramma*; predatory mites	Hullsplit(mid-June): west half Omite Ground: 1 pt/acre Lorsban for ants
Balvert, Comparison Hilmar, Stanislaus Co.	20	50% Nonpareil; 25% Neplus; 25% Mission	25	None	No	No	Dormant: 4 oz/acres Asana & 1 gal/20 gal H2O oil Hullsplit (7/1 & 7/10): 2 pt Lorsban, 4 oz Vendex & Supreme oil

Grower	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 7							
Madsen, BIOS Winton, Merced Co.	5	50% Nonpareil; Mission Merced, NePlus	1972	Low Grow	No	4 *Goniozus*; 2 *Trichogramma*	Bloom: Bt 2/15-3/1
Madsen, Comparison Winton, Merced Co.	6	50% Nonpareil; Price, Mission, Merced	1977	Weeds	No	4 *Goniozus*; 2 *Trichogramma*	Bloom: Bt 2/15-3/3
Comparison 8							
Parker, BIOS (Block F) Waterford, Stanislaus Co.	120 (out of 240)	Nonpareil; Monterey; Carmel	8 or 9th leaf	Low Grow	Yes	No	May: 3 pt/acre Lorsban
Parker, Comparison (Block D) Waterford, Stanislaus Co.	120 (out of 240)	Monterey; Carmel	6th leaf	weeds	Yes	No	May: 3 pts/acre Lorsban and (Aug): 2 pts/acre Omite
Comparison 9							
Segers, BIOS (Block 9) Hopeton, Merced Co.	20 (out of 91)	Nonpareil; Carmel	17	Low Grow	Yes	No	Delayed dormant: liquid lime sulfur Hullsplit (7/8): Bt
Segers, Comparison (Block 8) Hopeton, Merced Co.	20 or of 83)	Nonpareil; Price	17	Low Grow	Yes	No	Hullsplit (7/8): 2 pts/acre Lorsban & Asana, Nonpareil only

Table 2. Winter mummy count survey from Merced and Stanislaus County BIOS Growers, 1996.

Avg. no. mummies per tree (52 sites)	Average % infested by NOW (44 sites)	No. of species found at 44 sites	
		Goniozus	*Pentalitomasix*
18.0	12.1	2	2

Table 3. Average seasonal trap catches of San Jose scale, *Prospaltella perniciosi*, and *Aphytis* spp. from 6 BIOS and 6 conventionally sprayed orchards, Merced and Stanislaus Co., 1996.

Farming practice	San Jose scale	*Prospaltella*	*Aphytis*
BIOS	97	1618	172
Sprayed	08	1134	125

Table 4. Average seasonal trap catches of navel orangeworm eggs and male peach twig borer from 6 BIOS and 6 conventionally sprayed orchards, Merced and Stanislaus Co., 1996.

Farming practice	NOW eggs	PTB males
BIOS	91	2151
Conventional Spray	184	2225

Table 5. Infestation comparisons BIOS vs. Spray*, Merced and Stanislaus counties, 1996.

Comparison 1. Beekman vs. Baptista

Harvest infestation levels		
	BIOS	Spray
NOW	14.0%	4.6%
NOW parasitism	0.0%	0.0%
PTB	0.2%	0.6%
Ant	1.0%	0.2%

Comparison 2. Boone vs. Boone

Harvest infestation levels		
	BIOS	Spray
NOW	2.4%	1.8%
NOW parasitism	0.0%	0.0%
PTB	3.2%	4.4%
Ant	3.4%	1.4%

Comparison 3. Kinoshita vs. Miyamoto

Harvest infestation levels		
	BIOS	Spray
NOW	4.8%	6.2%
NOW parasitism	2.0%	0.0%
PTB	0.8%	0.0%
Ant	0.0%	0.2%

Comparison 4. Lambrix vs. Lambrix

Harvest infestation levels		
	BIOS	Spray
NOW	0.6%	0.2%
NOW parasitism	0.0%	0.0%
PTB	0.2%	0.0%
Ant	1.0%	0.8%

Comparison 5. Segers B vs. Segers B

Harvest infestation levels		
	BIOS	Spray
NOW	0.2%	0.0%
NOW parasitism	0.0%	0.0%
PTB	0.2%	0.0%
Ant	0.6%	0.4%

Comparison 6. Stinson vs. Balvert

Harvest infestation levels		
	BIOS	Spray
NOW	4.4%	0.6%
NOW parasitism	4.0%	0.0%
PTB	0.0%	0.0%
Ant	5.4%	2.0%

Comparison 7. Madsen vs. Madsen

Harvest infestation levels		
	BIOS Cover	BIOS Resident
NOW	5.4%	1.2%
NOW parasitism	0.0%	0.0%
PTB	0.4%	0.4%
Ant	0.4%	0.2%

Average of 6 BIOS vs. Spray

Harvest infestation levels		
	BIOS	Spray
NOW	4.4%	2.2%
NOW parasitism	1.0%	0.0%
PtB	0.8%	0.8%
Ant	1.6%	0.8%
TOTAL	6.8%	3.8%

* Comparison 7: Neither sprayed but comparison with resident cover.

Table 6. Abundance of webspinning spider mites and the western predator mite under two management approaches.

		Spider Mite/Leaf		Western Predator Mite/Leaf	
Orchard comparison	Date	BIOS	Sprayed	BIOS	Sprayed
1 (Hughson)	7/10	0.0	0.0	0.0	0.0
1 (Hughson)	7/18	0.1	0.0	0.0	0.0
1 (Hughson)	8/12	1.28	2.32	0.0	0.0
2 (Denair)	7/10	0.0	0.0	0.0	0.0
2 (Denair)	8/12	12.0	0.2	0.0	0.0
3 (Winton)	7/9	0.0	0.0	0.0	0.0
5 (Hopeton)	7/2	0.1	0.1	0.0	0.0
6 (Hilmar)	7/10	3.2	0.0	0.0	0.0
6 (Hilmar)	7/18	0.3*	0.0	0.0	0.0
6 (Hilmar)	8/1	2.2	0.3	0.0	0.0
8 (Waterford)	7/2	0.0	0.1	0.0	0.0
Cover Crop** (Winton)	7/2	0.1	0.1	0.0	0.0

* Omite® 7/15

** Neither side sprayed

Table 1. BIOS vs. sprayed comparison orchard descriptions, 1997 specialized monitoring program.

Grower/Location	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 1							
Beekman BIOS Hughson, Stanislaus Co.	19	2 Nonpareil; 1 Merced	23	Rich mix Low Grow Insectiary (every 10th row)	No	*Goniozus* & *Trichograma*	Bloom: Bt, spot Lorsban for ants
Baptista, Comparison Hughson, Stanislaus Co.	5	Nonpareil and Price	14	None (some weeds)	Yes Knocking, disking	No	Dormant: Diazonon-Supreme oil Hullsplit (7/15): 1 gal/acre Lorsban
Comparison 2							
Boone BIOS Denair, Stanislaus Co.	10	50% Nonpareil; 36% Price	10-11	Rich Mix with grains, cereals	No	4 *Trichograma, Goniozus, Galandromous*	Bloom: Bt
Boone, Comparison Denair, Stanislaus Co.	5	14% Neplus	10-11	1/2 Rich Mix with vetch	No	2 *Trichograma, Goniozus, Galandromous*	Bloom: Bt Hullsplit (7/19): 1 lb and Guthion; Vendex
Comparison 3							
Kinoshita, BIOS Winton, Merced Co.	8	2 Nonpareil; 1 Merced	29	Low Grow (?)	Yes, poling	3 *Goniozus*; 3 predatory mite; and 1 *Trichogramma*	Dormant: Bt bloom 6/20 Bt: Consep PTB disrupt
Miyamoto, Comparison Winton, Merced Co.	20	2 Nonpareil; 1 Merced	20+	None	Yes	No	Dormant (1/24): 6.4 oz/acre Asana & 2 gal/acre Superior oil Hullsplit (7/14): 2 lb/acre Guthion & Omite

Grower/Location	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 4							
Lambrix, BIOS Merced, Merced Co.	12	1 Nonpareil; 1 Carmel	12	Low Grow	Yes	No	Bloom: Bt 3/7-3/13
Lambrix, Comparison Merced, Merced Co.	25	1 Nonpareil; 1 Carmel	12	Weeds, mowed	Yes	No	Bloom: Bt 3/7-3/13 Hullsplit (7/5 & 12): 4 lb/acre Imidan, Nonpareil only
Comparison 5							
Segers, BIOS (Block 9) Hopeton, Merced Co.	20 (out of 91)	Nonpareil; Carmel	17	Low Grow	Yes	No	Delayed dormant: liquid lime sulfur Hullsplit (7/8): Bt
Segers, Comparison (Block 8) Hopeton, Merced Co.	20 or of 83)	Nonpareil; Price	17	Low Grow	Yes	No	Hullsplit (7/8): 2 pts/acre Lorsban & Asana, Nonpareil only
Comparison 6							
Stinson, BIOS Hilmar, Stanislaus Co.	40	55% Nonpareil; Merced, Mission, Fritz, Price	35	Self-seeded, Rich Mix	Yes	1 *Goniozus*; 1 *Trichogramma*; predatory mites	Hullsplit(mid-June): west half Omite Ground: 1 pt/acre Lorsban for ants
Balvert, Comparison Hilmar, Stanislaus Co.	20	50% Nonpareil; 25% Neplus; 25% Mission	25	None	No	No	Dormant: 4 oz/acres Asana & 1 gal/20 gal H2O oil Hullsplit (7/1 & 7/10): 2 pt Lorsban, 4 oz Vendex & Supreme oil

Grower	Acreage	Varieties	Age (yrs)	Cover crop	Sanitation	Releases	Treatment
Comparison 7							
Madsen, BIOS Winton, Merced Co.	5	50% Nonpareil; Mission Merced, NePlus	1972	Low Grow	No	4 *Goniozus*; 2 *Trichogramma*	Bloom: Bt 2/15-3/1
Madsen, Comparison Winton, Merced Co.	6	50% Nonpareil; Price, Mission, Merced	1977	Weeds	No	4 *Goniozus*; 2 *Trichogramma*	Bloom: Bt 2/15-3/3
Comparison 8							
Parker, BIOS (Block F) Waterford, Stanislaus Co.	120 (out of 240)	Nonpareil; Monterey; Carmel	8 or 9th leaf	Low Grow	Yes	No	May: 3 pt/acre Lorsban
Parker, Comparison (Block D) Waterford, Stanislaus Co.	120 (out of 240)	Monterey; Carmel	6th leaf	weeds	Yes	No	May: 3 pts/acre Lorsban and (Aug): 2 pts/acre Omite
Comparison 9							
Segers, BIOS (Block 7) Hopeton, Merced Co.	28	Butte; Ruby; Mission	8	Rich Mix; Low Grow	Yes	No	Bloom: Bt 4/1
Segers, Comparison (Block 4) Hopeton, Merced Co.	28	Butter; Ruby; Mission	8	Rich Mix; Low Grow	Yes	No	Bloom: Bt 4/1