Project No. 84-B8

Navel Orangeworm, Mite and Insect Research

Control of Mites on Almonds

Marjorie A. Hoy

Department of Entomology

201 Wellman Hall

University of California

Berkeley, CA 94720

(415) 642-3989

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Control of Mites on Almonds

Project Leader: Dr. Marjorie A. Hoy (415)642-3989
Department of Entomology
University of California
Berkeley CA 94720

Personnel: Janet Conley

Objectives: (1) Maintain the resistant strains of the predator mite M.occidentalis for distribution. (2) Determine carbaryl resistance levels in M.occidentalis released previously. (3) Develop a cost analysis of the proposed mite management program with an economist. (4) Determine organophosphate insecticide resistance levels in native M.occidentalis in the northern Central Valley. (5) Develop baseline data on Omite and Plictran resistance levels of spider mites in release and other orchards to determine if low rates of acaricides delay resistance development.

Interpretive Summary: During 1984 we maintained the Sevin-OP-sulfur resistant strain of M.occidentalis and distributed a total of 1.8 million to individuals requesting them. At least three companies are now producing this strain commercially.

Sevin resistance levels of predator populations released previously into almond orchards remain good to high despite minimal field selections with Sevin. For example, the population in Bakersfield (Bidart orchard) was released in 1979 and received Sevin applications in 1979 and 1980 only, yet this colony has maintained high Sevin resistance levels. Long term establishment (at least 5 years) appears possible with this Sevin-OP-sulfur resistant strain.

Additional native populations of M.occidentalis were screened for their organophosphorus (OP) resistance levels by testing with Guthion. The colonies' survival ranged from 20 to 77 % survival (averaging about 50 %) after treatment with 2 lbs. a.i. Guthion/100 gallon water, or the equivalent of 4 lb. 50 WP/100 gallons. Thus, most native predators are likely to survive Guthion (or Diazinon and Imidan) applied at field rates. These insecticides can be used with minimal disruption of M.occidentalis:spider mite interactions. No native M.occidentalis have been found to be resistant to Ambush/Pounce, however, and these insecticides are disruptive. Most native M.occidentalis populations are susceptible to Sevin. During 1984, however, we discovered several populations in the Chico area which have usable levels of Sevin resistance. We do not know if these populations are descendents of the laboratory-bred Sevin-resistant strain released in the area two years previously or not. Other populations in the Chico area are susceptible to Sevin. Thus, Sevin can't be used unless you have released the Sevin-resistant strain, or you know from past experience that your population tolerates Sevin. No Sevin resistant natives have been found in other almond growing areas.

Laboratory trials were conducted with Lorsban and Supracide.

The Sevin-OP resistant strain had 70 % survival at half the field rate, and 5 % survival at the field rate, suggesting that Lorsban is toxic to these predators. Careful field trials should be conducted to determine if Lorsban can be used selectively, as it may not be as toxic under field conditions where coverage is poorer. Supracide killed all predators at the field rate, and is unlikely to be selective in the field.

Spider mites (both Tetranychus urticae and T.pacificus) were collected from almond orchards from Bakersfield to Chico, colonized, and tested with Plictran and Omite to obtain baseline data (LC_{50} values). The results are disturbing. Several populations of spider mites are becoming resistant to both Omite and Plictran. This means that these materials will have a limited use unless a resistance management program is initiated immediately. This resistance management program employs a) reduced rates and numbers of acaricide applications each season, b) alternation of Omite, Plictran and Vendex, c) use of selective insecticides to prevent disruption of predators so fewer acaricides are needed (Diazinon, Guthion, Imidan are selective; Sevin can be used only if the Sevin-resistant strain is established in the orchard), and d) release of M.occidentalis in orchards lacking effective numbers of predators. The program is outlined in a separate paper: "Managing Mites in Almonds: An Integrated Approach". Adoption of the integrated mite management program will provide better spider mite control, reduce costs, and delay the onset of acaricide resistance.

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I. Introduction

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II. Maintenance and Distribution of Resistant Strains of *M. occidentalis*

The carbaryl-OP-sulfur and carbaryl-OP-permethrin strains were maintained during the past year in laboratory cultures and in the greenhouse. Laboratory cultures were selected with carbaryl and permethrin, as appropriate, to maintain pure cultures. The greenhouse cultures were maintained until August 1984, when they were terminated due to a serious outbreak of disease in the two spotted spider mites reared as prey. We couldn't clean up the cultures without terminating them. Fortunately, we can obtain new starts of the carbaryl-OP-sulfur colony on bean plants from Darryl Castro and Dan Cahn, Richard Katz, or Barry Wilk and Cliff Kitayama. They have ongoing cultures which they will sell to interested people. The carbaryl-OP-permethrin strain will have to be restarted on bean plants when we have a healthy spider mite colony again.

The table shows the number of carbaryl-OP-sulfur resistant *M. occidentalis* provided to people who requested it. As indicated above, these three companies currently sell the carbaryl-OP-sulfur resistant predators for release into almonds and other crops in California. In addition, others may have this colony for sale from previous years; I'm unaware of their status at this time.

We should maintain ongoing laboratory cultures for the forseeable future, but I do not plan to do additional large scale greenhouse rearing in the future since these commercial sources are now available.

Table II-1. Distribution of carbaryl-OP-sulfur resistant *M. occidentalis* during 1984.

Names & addresses of recipients	Date provided	No. provided
Integrated Orchard Management D. Castro & D. Cahn 3524 West Fairvies Ave. Visalia, CA 93277 (209) 625-5199 (209) 594-4267	February	250,000
Wilk, Kitayama and Mead P.O. Box 599 Durham, Calif. 95936 (916) 345-1554	9 March	40,000
Wilk, Kitayama and Mead	23 March	200,000
Wilk, Kitayama and Mead	4 April	150,000
Integrated Orchard Management	13 April	150,000
Wilk, Kitayama and Mead	9 May	750,000
Wilk, Kitayama and Mead	29 May	90,000
Mighty Mites Richard Katz 1513 5th Street Berkeley, Calif. 94710 (415) 525-3292	13 June	170,000
TOTAL:		1,790,000

III. Carbaryl, OP and Permethrin Resistance Levels of *M. occidentalis* Released Previously in California Almond Orchards

During 1984, we collected colonies of *M. occidentalis* from as many former release sites as possible, and screened them with a standard rate of carbaryl (2.4 g. a.i./liter distilled water), of permethrin (2 g. a.i./100 liters distilled water), and of guthion (2 lb. a.i./ 100 gallons of water) to obtain an estimate of the carbaryl, permethrin and OP resistance levels of the *M. occidentalis* in these former release sites. The results are given in Table III-1.

Predators collected from the Bidart orchard are still highly resistant to carbaryl; this orchard received carbaryl-OP resistant predators in 1979; the orchard was treated with carbaryl in 1979 just before the release, and once in 1980. To my knowledge no additional carbaryl has been applied to the orchard in succeeding years. Surrounding orchards have received permethrin applications during one or two years which may have reduced the number of "native" carbaryl-susceptible predators that could migrate into the orchard to dilute this resistance. At any rate, despite the lack of regular selection with carbaryl, the population in the Bidart orchard has maintained a high level of resistance and this suggests that once the resistant strain is well established in the orchard, it should persist for at least 5 years! OP resistance is high (47% survived 2 lb. a.i. azinphosmethyl/ 100 gallons water, and the 22, and 12% survival rates at 2 g. a.i. permethrin/100 liters water is also higher than expected (0-4% survival).

Perhaps the permethrin treatments in surrounding orchards has had an effect on this population, as well.

The Durjava orchard received carbaryl-OP resistant predators that were released by Bill Barnett during August 1982. This orchard, located on Peach Avenue near Livingston, received predators in every third row; it had been treated with Sevin in May prior to the release, but the grower indicated in July 1984 that Sevin had not been used since then. This block had very few spider mites in it in July 1984, and only 16 predators were colonized for testing with Sevin. There seems to be no Sevin resistance in this colony, suggesting several possibilities: 1) the Sevin-resistant strain may never have established in the orchard since it received no Sevin after release and releases were into only one-third of the trees, 2) the colony established but was lost due to lack of prey. This orchard was not monitored after the releases for spider mite interactions, so we can draw no conclusions other than the fact that the resistant strain has not been maintained in the block based on this sample in July 1984.

The Livingston II & III orchard colony, also collected in July 1984, has a moderate level of carbaryl resistance (25% survival); this is probably a useful level of resistance. The carbaryl-OP-sulfur resistant predators were released into Livingston-II in September 1981 in every third tree in every third row. The resistant predators were released into every tree in Livingston-III in May 1982. No carbaryl applications were applied in 1983 or 1984 which would have selected for the carbaryl resistance, although carbaryl was applied in 1982 to much of the block. Considering that the orchard was never completely purified, and that carbaryl has been applied only once, the carbaryl resistance level is good and M. occidentalis provided good control of spider mites in this orchard during 1984 (Mr. C. V. Horton, personal communication). The 75% survival rate with guthion indicates a good OP resistance level exists.

The Livingston-IV colony exhibited a good level of carbaryl resistance (40% survival); this block received the Sevin-resistant strain in August 1982 when Bill Barnett released ca. 360 predator females per tree in every tree. The field notes provided by Bill Barnett suggest that Sevin had been applied twice during 1982 prior to the releases. During 1983, no acaricides or insecticides were applied; in 1984 the same was true (Mr. Horton, personal communication). The high level of carbaryl resistance in this population is possibly due to the fact that few natives were present in the orchard prior to the release into every tree so that a relatively pure colony established.

Two colonies were collected from Pecks orchard near Three Rocks in Fresno County; one from the area where releases were originally made (ca. 80 acres) and the other from adjacent trees where no releases were made (also ca. 80 acres). Collecting predators on June 28, 1984 was difficult. Very few predators could be found as the population had crashed from earlier peaks when the European red mites in this block were controlled by a combination of M. occidentalis and acaricides (Dan Cahn, personal communication). So, the colony from the release area was started with only 2 females, which is a very poor sample size. Survival in both colonies was only 10 and

12% respectively, indicating low levels of carbaryl resistance exist but these are probably sufficiently low that Sevin could disrupt spider mite control temporarily. However, a Sevin application would likely increase the Sevin resistance levels, since there is clearly some Sevin resistance in the predators in this 180 acre block. It is interesting to note that both the release and nonrelease blocks have similar resistance levels, suggesting that the predators have dispersed throughout the orchard.

This orchard was inoculated with the carbaryl-OP resistant colony in July 1981. The orchard received a carbaryl application at hullsplit in 1981 and one in May 1982; no carbaryl was applied in 1983 or 1984.

III - 1. Carbaryl, Permethrin and Azinphosmethyl resistance levels in 1984 of *M. occidentalis* released previously.

Colony source	Date collected 1984	No. colonized	% survival[a/] carbaryl	H_2O	permethrin	H_2O	azinphosmethyl	H_2O
Bidard orchard,	27 June	24 ♀						
Bakersfield		+ 40 imm	87	100	22/12	80/90	47	70
Durjava,Livingston	12 July	16 ♀	0	100	0	80	52	100
Livingston II & III	12 July	28 ♀	25	90	0	100	75	100
Livingston-IV	12 July	40 ♀						
		+ 10 imm	40	90	0	60	57	0
Livingston-V	12 July	2 ♀	47	90	5	80	35	80
Pecks-release area,	28 June	2 ♀	10	90	7	100	75	90
Three Rocks								
Pecks-non-release area,	28 June	19 ♀						
Three Rocks		+ 13 imm	12	90	7	80	65	90
Resistant control	-	-	72	80	70/50	100/60	90	100
Susceptible control	-	-	0	80	0/2	90/70	70	90

a/ 40 to 50 ♀♀ tested on bean leaf discs treated with 2.4 g a.i. carbaryl/liter distilled water, or 2 g a.i. permethrin/100 liters distilled water. Forty females were tested with 2 lb. a.i. azinphosmethyl/100 gallon water by slide dip.

IV. Cost Analysis of Mite Management

Dr. Joseph Headley, Department of Agricultural Economics, University of Missouri, Columbia 65201 (314) 882-4512, is willing to conduct an economic analysis of the mite management program vs. a "standard" acaricidal program. In addition, he has indicated interest in computing the cost of the research compared to benefits in its implementation. We estimate that he will come to Berkeley for several days to a week, perhaps in early May. During this time, he will contact people for information, and compile information.

Funding for travel is necessary; I estimate that $800 will be required to pay mileage to the airport (150 miles), airfare (ca. $400), and expenses.

Attached is a letter from Bill Barnett, which provides one estimate of cost savings from using this mite management program.

COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA

County of Fresno
Farm and Home Advisors Office

1720 South Maple Avenue
Fresno, California 93702

October 5, 1984

Dr. Marjorie Hoy
Department of Entomology
U. C. Berkeley
201 Weilman Hall
Berkeley, CA 94720

Dear Marjorie:

Seeing your recent California Agriculture article reminded me that I have been intending to write you for several weeks to bring you up to date on what we've been doing.

We monitored a total of nine orchards in Fresno and Merced Counties this year. Resistant predators had been released in four of the five orchards in Merced County. As you suggested border treatments were made before mite numbers increased to the point where any appreciable migration took place. This technique worked very well and were the only miticides applied in our monitored orchards in Merced.

In Fresno County all of the orchards required one treatment. However, the most material applied was 1/4 pound Plictran per acre. This amounted to about $4.00 per acre maximum for material.

I am extremely encouraged by these results and feel we have an excellent integrated control program for mites in almonds. I believe that realistically growers can expect to save 75% of the cost of materials for mite control on almonds. This is no small amount when you consider there are 400,000 acres of almonds in the state. In addition, I am sure the techniques will be applicable to other deciduous trees and vines. Your work on resistant predators, spider mite distribution and low rates of acaracides is the basis for this program. Without your research it would not have been possible.

I have enjoyed working with you on this project and want to commend you on an excellent piece of work. This is an outstanding example of the type of research those of us working in the field need if we are going to be successful implementing Integrated Control Program in California.

V. Organophosphate, Carbaryl, and Permethrin Resistance Levels in Native *M. occidentalis* Collected from Almonds during 1984.

During 1984, colonies of *M. occidentalis* collected from Butte, Glenn, and Kern Counties were colonized and tested for their resistance or tolerance to permethrin, carbaryl and azinphosmethyl using "standard" doses, which have been shown in previous years' testing to be definitive as to defining resistant populations. For example, 2.4 g. a.i. carbaryl/ liter distilled water is a discriminating dose; resistant laboratory colonies typically exhibit 70-85% survival; susceptible colonies typically exhibit 0-4% survival. Likewise, 2 grams a.i. permethrin/100 liters distilled water is toxic to susceptible predator females, which exhibit 0-5% survival; resistant laboratory colonies exhibit 70-80% survival. These tests are conducted by placing gravid adult females on bean leaf discs with two-spotted spider mites as prey; five females are placed on each disc to be treated with carbaryl, while ten are placed on discs treated with permethrin. The discs are then sprayed with the pesticide. Survival is scored after 48 hours, and mites that are capable of moving are scored as survivors; dead and runoff mites are scored as dead. Twenty gravid adult females are placed on double sided sticky tape on glass microscope slides (2-3 replicates) and dipped into 2 lbs. a.i. azinphosmethyl/100 gallons distilled water (Guthion 50 WP). Survival is determined after 48 hrs at 25°C; dead are those unable to move when touched gently with a brush. Data are analyzed by probit analysis using a maximum likelihood method (Polo: A User's

Guide to Probit or Logit Analysis, 1980. Robertson, J. L., R.M. Russell, & N. E. Savin. USDA, Forest Service. Pac. SW Forest & Expt. Sta. Tech. Rept. PSW-38, 15 pp.).

Carbaryl Resistance

Results are given in Table V-1. The colonies from Butte County exhibited an interesting pattern of carbaryl and OP resistance: The Almont almonds, Almont II, Dutra, McHann-Decker, McHann-Decker II, Schell Ranch and Vina Gold almond orchards had high carbaryl resistance levels, whereas the Keeney and Nock orchard populations had low carbaryl resistance levels (10-12% survival).

The McGowan prune orchard population in Butte County also had a high carbaryl tolerance. Orchards in Glenn County (Chapla and Hamilton City) are susceptible to carbaryl, as is the Pond Rd. Colony from Kern County (Table V-1). The Lerdo Hwy colony from Kern County also exhibited high carbaryl tolerance as did the safflower colony from Glenn County. Thus, there is a patchwork array of colonies of M. occidentalis that are carbaryl tolerant. Whether these colonies are descendents of the laboratory-bred carbaryl-resistant strain is unknown.

Figure V-1 shows a map of the Chico-Durham area. The circles indicate orchard sites (A-J) with the % survival each colony exhibited when tested with carbaryl as shown in Table 1. The squares show locations of colonies which had low carbaryl survival rates. The circles and squares don't present a clear pattern. Whether carbaryl selection pressure in this area is sufficient to induce carbaryl resistance may never be known; it is possible that the carbaryl-resistant colony, which was released in 1982 in two sites and in 1983 in one site, could have dispersed into these sites within the last two years. These release sites are shown as triangles on the map. Detailed studies of these colonies would have to be conducted to determine whether the mechanisms of resistance and/or mode of inheritance of the resistances are different to resolve the questions.

Table V-2 gives the pesticide histories for the orchards, if known. Orchard A has a high Sevin resistance and has had 4 Sevin applications in the last 3 years. The population from orchard B is Sevin resistant but has had no Sevin; the population from orchard C is Sevin resistant and had 4 Sevin applications in 1981. Predators from orchard D are Sevin resistant and received 3 Sevin applications in the last 3 years. Predators from E are Sevin resistant and have received 8 Sevin applications in the last 3 years. Predators from F are Sevin-susceptible and have never been sprayed with Sevin. Predators from orchard G have been "generally unsprayed" but are resistant to Sevin. Predators from I are susceptible to Sevin and have received 1 Sevin application in the 1979 to 1983 interval. The predators from the safflower field have unknown histories and are Sevin resistant, as are predators from the almond orchard M. Predators from orchard K are susceptible and have received no Sevin. Predators from orchard N are susceptible, and the history is unknown. Overall, there is some relationship between the number of applications of Sevin and the Sevin resistance in *M. occidentalis*. However, this could mean either that the applications selected for a new Sevin resistance, or it could indicate that the resistant strain which was released nearby was selected for by the Sevin applications after they dispersed into the new sites.

No colony shows field-usable levels of survival to permethrin. The Nock orchard and the Safflower colonies from Butte and Glenn Counties, respectively had modest survival rates with 2 g. a.i. permethrin/100 liter water on at least one of two trials, as did the Lerdo Hwy and Pond Road colonies from Kern county. However, the tolerance either did not hold up on a second test, or they were sufficiently low that permethrin is not a selective material. However, the Safflower colony is interesting, and it should be selected with permethrin in the laboratory to determine if we might be able to obtain permethrin resistance determined by a major dominant gene.

Survival after slide dip with azinphosmethyl ranged from 20 to 77% for these colonies, averaging about 50%. This survival rate (at 2 lb. a.i./100 gal) is sufficiently high that most predators should survive Guthion treatments in the field. Some population depression could occur in some orchards, but generally the colonies have usable levels of resistance. Past tests have shown that colonies with these Guthion resistance levels also have high Diazinon and Imidan resistances.

Thus, I would expect that most applications of Guthion, Diazinon, or Imidan would have minimal impact on the native *M. occidentalis* populations. It is unlikely that mortality would be greater than 30-50%, at the highest rates of Guthion, and most likely would be lower due to incomplete coverage. Reports from growers and Farm Advisors support this conclusion; Guthion, Diazinon, and Imidan by themselves seem to be non-disruptive to native M. occidentalis populations. Some apparent disruption is probably due to the fact that excessive acaricide rates are sometimes applied at the same time, which can result in predator dispersal or starvation. Also, in certain orchards, particularly those which have been very rarely treated with OPs, the predators may not be M. occidentalis. Metaseiulus mcgregori is occasionally present in almond orchards that are untreated with insecticides. These predators are not common, but could be decimated if OPs were applied. Because this species is so similar in appearance to M. occidentalis only slide mounting can detect the difference in these two species; hand lens I.D.s won't work.

Table V-1. Organophosphate, Carbaryl, and Permethrin Resistance Levels in Native *M. occidentalis* Collected During 1984.

County & Orchard	Date collected 1984	No. colonized	% survival on[a/] carbaryl	H_2O	permethrin	H_2O	azinphos-methyl	H_2O
<u>Butte Co.</u>								
A) Almont Almonds		54 ♀						
Burdick Rd/Troxel Av.	3,16 April	+30 imm	92/54[b/]	100/95	5	100	72	85
A-2) Almont II		10 ♀						
Burdick Rd/Troxel Av.	31 May	+55 imm	62	95	-	-	-	-
B) Dutra almonds		35 ♀						
River Rd/Hwy 32	16 April	+35 imm	80/26	100/100	4	60	22	100
C-1) Decker almonds								
(McHann) Durham-		21 ♀						
Dayton Hwy/ Fimple Rd.	16 April	+40 imm	80/50	100/95	0	100	20	95
C-2) Decker-II								
Durham-Dayton Hwy/		14 ♀						
Fimple Rd.	31 May	+15 imm	60	95	-	-	-	-
D) Schell Ranch almonds		30 ♀						
Muir Av/Kennedy Av.	16 April	+60 imm	68/42	100/100	4	100	24	90

Table V-1. (cont'd)

County & Orchard	Date collected 1984	No. colonized	% survival on[a] carbaryl	H_2O	permethrin	H_2O	azinphos-methyl	H_2O
Butte Co. (cont'd)								
E) Vina Gold almonds								
(Cana) Broyles Rd./ Hwy 99	16 April	30 ♀ +63 imm	82/82	100/100	2	80	32	100
F) Keeney almonds								
Stanford Rd/Midway Rd.	21 June	1 ♀	12	90	2	70	77	90
G) McGowan's prunes								
Nord Hwy/Carmen Ln.	21 June	18 ♀	60	80	7	100	57	100
H) Nock almonds								
Ord Ferry Rd SW of Dayton	3 July	14 ♀	10	90	22/2	100/90	55	100
Glenn Co.								
I) Hamilton City almonds								
Hwy 32 & 45	7 Aug	+10 imm	10	91	10	90	50	80
J) Safflowers								
Hwy 162 West of Glenn	21 June	2 ♀	45/24	80/100	30/39	100/100	57	70

Table V-1. (cont'd)

County & Orchard	Date collected 1984	No. colonized	% survival on[a/] carbaryl	H_2O	permethrin	H_2O	azinphos-methyl	H_2O
Glenn Co. (cont'd)								
K) Chapla almonds								
County Rd. P & 25	7 Aug	6 imm	6	90	12	90	62	90
L) Old Nottelman almonds		20 ♀						
Fimple Rd, nr. Durham	8 Oct	+30 imm	c/	-	-	-	-	-
Kern Co.								
Lerdo Hwy		2 ♀						
Lerdo Hwy/Hwy 99	28 June	+14 imm	87	100	17/5	100/90	65	80
Pond Road		60 ♀						
Pond Rd/Hwy 99	28 June	+60 imm	10	90	17/7	100/70	55	100
Resistant Control	-	-	44-76	80-100	50-70	60-100	72-90	90-100
Susceptible Control	-	-	0	80-100	0-2	70-100	25-70	90

a/ 40-50 females were tested with 2.4 g a.i. carbaryl/liter spray distilled water, or 2 g a.i. permethrin/100 gal water; using leaf assays or 2 lb a.i. azinphosmethyl/100 gal water using slide dip analysis.

b/ When 2 numbers are given, these are the results of 2 different tests.

c/ This orchard has not yet been screened because it was collected late.

Table V-2. Pesticide histories for orchards with native M. *occidentalis* tested during 1984.

Orchard	Pesticide histories
A) Almonds[a/]	1980 - 3 Guthion applications
	1981 - 3 Guthion, 1 Sevin, 1 Ambush application
	1982 - 1 Guthion, 2 Ambush
	1983 - 2 Guthion, 3 Sevin
B) Almonds	1981 - 2 Guthion, 1 Pounce
	1982 - 2 Pounce
	1983 - 1 Pounce
C) Almonds[a/]	1981 - 2 Guthion, 4 Sevin, 4 Ambush
	1982 - 2 Guthion, 1 Ambush
	1982 - 2 Guthion, 1 Ambush
D) Almonds	1981 - 2 Guthion, 2 Sevin
	1982 - 1 Sevin, 1 Ambush
	1982 - 2 Ambush
E) Almonds[a/]	1981 - 2 Guthion, 4 Sevin
	1982 - 1 Supracide, 1 Guthion
	1982 - 2 Guthion, 4 Sevin
F) Keeney almonds	*Never treated with Sevin
G) McGowan's prune plums	*Generally unsprayed
H) Nock almonds	1983 - 1 Guthion, 1 Sevin
	1984 - none to date (July 3)
I) Hamilton City almonds	1978 - Diazinon
	1979-1983 - 1 Sevin
	1983 - no insecticide

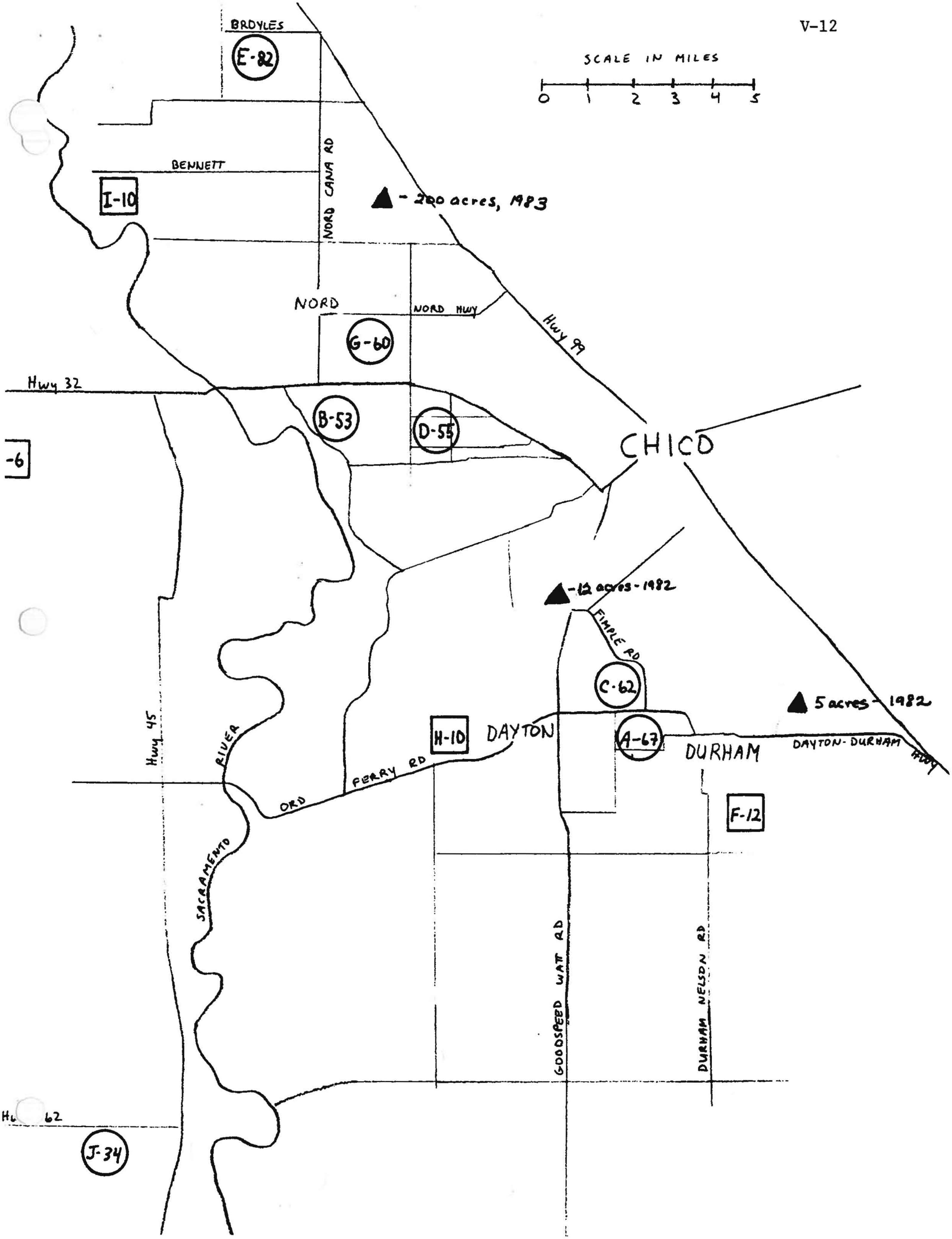
Table V-2. (cont'd)

Orchard	Pesticide histories
J) Safflowers	Unknown
K) Chapla almonds	1980 - 1 Diazinon
	1981 - 1 Guthion
	1982 - 1 Pounce
	1983-1984 - 1 Parathion
L) Old Nottelman almonds	"low to moderate" Guthion applications
	Pounce - once
	no Sevin
M) Lerdo Hwy almonds	unknown
N) Pond Road almonds	unknown

a/ These applications were made to half the trees.

Figure V-1.

Map of Chico-Durham area where colonies of *M. occidentalis* were collected during 1984 and screened for their carbaryl, OP, and permethrin tolerance. Sites A-J (identified in Table 1) are located on the map; circles with numbers inside show the % survival of females tested with 2.4 g. a.I. carbaryl/liter water. Squares with numbers indicate susceptible orchards (with less than 10% survival) are intermixed with orchards having predators with higher survival rates (circles). The 3 triangles indicate the previous release sites for the carbaryl-resistant strain.


SCALE IN MILES
0 1 2 3 4 5
BROYLES
E-82
BENNETT
I-10
NORD CANA RD
▲ - 200 acres, 1983
NORD
NORD HWY
G-60
Hwy 99
Hwy 32
B-53
D-55
CHICO
-6
▲ - 12 acres - 1982
FIMPLE RD
C-62
▲ 5 acres - 1982
H-10
DAYTON
A-67
DURHAM
DAYTON-DURHAM HWY
Hwy 45
RIVER
ORD
FERRY RD
F-12
SACRAMENTO
GOODSPEED WATT RD
DURHAM NELSON RD
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Hoy 1984 Almond Board Annual Report

VI. Baseline Data on Omite and Plictran Resistance Levels of Spider Mites in Release and Other Almond Orchards

Colonies of Tetranychus urticae and T. pacificus were obtained from almond orchards in Butte, Glenn and Kern Counties during 1984. They were colonized on bean plants and tested for their tolerance to both Plictran and Omite. This report provides data completed to date, but additional tests are in progress and these results will be reported as an interim report as soon as possible.

Both Plictran and Omite were tested using the slide dip technique. Adult gravid females are placed, 20 per slide, on sticky tape and dipped into freshly-prepared solutions for 5 seconds. The slides are then placed in a growth chamber at 25°C for 48 hours and scored. Live mites are those that can move when touched lightly with a camel's hair brush. Data are analyzed using probit analysis (Polo: A User's Guide to Probit or Logit Analysis, J. L. Robertson, R. M. Russell, N. E. Savin, 1980, U.S.D.A. Forest Service, Pac. S.W. Expt. Sta. Techn. Rept. PSW-38). Data are analyzed by the likelihood ratio test for equality and likelihood ratio test of parallelism. All tests were conducted with a Greenhouse colony of T. urticae used as a "standard" for comparison. Data in Tables IV-1, 2 and 3 provide LC_{50} and LC_{90} values of both the target and "standard" colony for comparison. The units for the LC_{50} and LC_{90} values are in lbs. formulated acaricide/100 gallons for easy comparison to field rates.

Three of five T. urticae colonies collected from Butte County exhibited measurable levels of Plictran resistance (Table VI-1). LC_{50} values of the Dutra River, McHann-Decker and Mead almond orchard populations were significantly different from the control greenhouse colony. The LC_{90} values are more dramatic: The McHann-Decker and Mead almond colonies would require nearly 5 lbs of formulated Plictran/100 gallons water to kill 90% of the mites! This means that Plictran can't be used economically in these orchards.

The good news is that these populations do not appear to be resistant to Omite (Table VI-2). There were no statistical differences in LC_{50} values among the colonies. However, there was variability, and the LC_{90} values did vary. Thus, there is no room for complacency. It seems likely that Omite resistance could develop rapidly in these populations if it were misused.

T. pacificus populations were collected from Glenn County (Hamilton City, Chapla) and from Kern County (Pond Road, Bidard, and Wasco). Table VI-3 shows the results of slide dip tests with Omite. The Pacific mite colony from the Bidart orchard has a significantly increased LC_{50} value of 0.753 lbs 30WP/100 gallons water. Thus, it appears that Omite resistance is developing in this orchard.

Tests with these same T. pacificus colonies are currently being conducted with Plictran. The detailed results are not yet available. However, it is clear that some of these Kern County populations are highly resistant to Plictran - even more resistant than the Chico populations of T. urticae. Thus, these southern orchards are in danger of losing both Plictran and Omite as selective acaricides.

Additional tests are being conducted now to associate the slide dip test results with leaf spray treatment rates. Also, tests will soon be conducted with Vendex to determine if we have cross resistance. In addition, we plan to conduct a genetic analysis of the Plictran resistance to determine mode of inheritance. It seems critical that we know how stable the resistance is and how rapidly it is likely to appear with selection. Thus, selections will be conducted with several of the partially-resistant *T. pacificus* and *T. urticae* colonies to see how many selections are required to obtain a high level of resistance.

Table VI-1. Dose responses to Plictran of *T. urticae* collected from almond orchards during 1984 as determined by slide dip analysis.

T. urticae colony	Location	Date collected 1984	LC_{50} a/	Greenhouse control LC_{50} a/	95% C.I.	LC_{90} a/	Greenhouse control LC_{90} a/	95% C.I.	Slope
Greenhouse	Shell Corp.								
	Modesto	July	.482	(average)	.343 to .510	1.561	-	1.263 to 2.106	2.28 ± .21
Dutra River	River Rd/Hwy 32								
almonds	Butte Co.	16 April	.508	(.405) b/	.381 to .632	2.199	(1.262)	1.602 to 3.735	2.01 ± .28
McHann-Decker	Durham-Dayton Hwy/								
almonds	Fimple Rd.Butte Co.	16 April	.689	(.447) c/	.456 to 1.052	4.807	(1.474)	2.445 to 23.748	1.52 ± .23
Mead	Burdick Rd/Troxel Rd.								
almonds	Butte Co.	16 April	.972	(.433) b/	.720 to 1.399	4.612	(1.564)	2.534 to 25.454	1.89 ± .39
Bertagna	Hegan Ln/Fimple Rd.								
almonds	Butte Co.	16 April	.402	(.397)	.244 to .550	1.565	(1.272)	1.106 to 2.926	2.17 ± .28
Almont	Burdick Rd/Troxel Rd.	3 April &							
almonds	Butte Co.	16 April	.479	(.447)	.306 to .635	1.897	(1.474)	1.313 to 4.033	2.14 ± .32

a/ lb 50 WP/100 gallons of water

b/ Lines parallel but not the same

c/ Lines not parallel and not the same

Table VI-2. Dose responses to Omite of T. urticae collected from almond orchards during 1984 as determined by slide dip analysis.

T. urticae colony	Location	Date collected 1984	LC_{50}[a]	Greenhouse control LC_{50}[a]	95% C.I.	LC_{90}[a]	Greenhouse control LC_{90}[a]	95% C.I.	Slope
Greenhouse	Shell Corp Modesto	July	.610	(average)	.533 to .674	1.309	-	1.163 to 1.549	3.86 ± .35
Mead almonds	Burdick Rd/Troxel Rd. Butte Co.	16 April	.503	(.508)	.382 to .586	.941	(1.128)	.840 to 1.105	4.71 ± .83
Dutra River almonds	River Rd/Hwy 32 Butte Co.	16 April	.706	(.637)	.552 to .827	1.341	(1.390)	1.092 to 2.161	4.60 ± .76
Bertagna almonds	Hegan Ln/Fimple Rd. Butte Co.	16 April	.645	(.637)	.505 to .750	1.272	(1.390)	1.044 to 1.937	4.34 ± .71
Greenhouse	Chevron Corp. Richmond	Sept	.653	(average)	.527 to .770	1.655		1.325 to 2.407	3.17 ± .32
McHann-Decker almonds	Durham Dayton Hwy/ Fimple Rd.Butte Co.	16 April	.736	(.702)	.567 to .904	1.928	(1.813)	1.449 to 3.402	3.07 ± .38
Almont almonds	Burdick Rd/Troxel Rd. Butte Co.	3 April & 16 April	.756	(.702)	.599 to .915	1.968	(1.813)	1.492 to 3.361	3.08 ± .38

a/ lb 30 WP/100 gallons of water.

Table VI-3. Dose responses to Omite of T. pacificus collected from almond orchards during 1984, as determined by slide dip analysis.

T. pacificus colony	Location	Date collected 1984	LC_{50} a/	Greenhouse control LC_{50} a/	95% C.I.	LC_{90} a/	Greenhouse control LC_{90} a/	95% C.I.	Slope
Greenhouse T. urticae	Chevron Corp. Richmond	Sept.	.653	(average)	.527 to .770	1.655	-	1.325 to 2.407	3.17 ± .32
Hamilton City T. pacificus almonds	Glenn Co.	7 Aug	.509	(.680)	.323 to .660	1.401	(1.582)	1.068 to 2.312	2.91 ± .52
Chapla T. pacificus almonds	Glenn Co.	7 Aug	.543	(.649)	.317 to .698	1.446	(1.474)	1.110 to 2.641	3.01 ± .54
Greenhouse T. urticae	Shell Corp. Modesto	July	.610	(average)	.533 to .674	1.309	-	1.163 to 1.549	3.86 ± .35
Pond Rd. almonds	S.Pond Rd/McFarland Kern Co.	28 June	.594	(.603)	.398 to .717	1.423	(1.315)	1.156 to 2.271	3.37 ± .53
Bidart T. pacificus almonds	Kern Co.	27 June	.753	(.605) b/	.632 to .852	1.582	(1.408)	1.336 to 2.134	3.98 ± .55
Wasco T. pacificus almonds	46th/Palm Kern Co	27 June	.546	(.605)	.333 to .675	1.615	(1.408)	1.267 to 2.958	2.72 ± .54

a/ lb.30 WP/100 gallons. b/ Lines parallel but not the same.

Table VI-4. Dose responses to Plictran of *T. pacificus* collected from almond orchards during 1984 as determined by slide dip analysis.

T. pacificus colony	Location	Date collected 1984	LC_{50}[a/]	Greenhouse control LC_{50}[a/]	95% C.I.	LC_{90}[a/]	Greenhouse control LC_{90}[a/]	95% C.I.	Slope
Greenhouse	Chevron Corp	Sept.	0.336		.165 to .542	2.454		1.290 to 11.123	1.48 ± .21
T. urticae	Richmond								
Chapla almonds		7 Aug.	0.488	(.336)[b/]	.287 to .691	2.251	(2.454)	1.562 to 4.061	1.93 ± .19
T. pacificus	Glenn Co.								
Bidart almonds		27 June	2.669	(.336)[c/]	1.895 to 3.124	3.958	(2.454)	3.346 to 6.774	7.49 ± 1.37
T. pacificus	Kern Co.								
Pond Rd.	S. Pond Rd/McFarland	28 June	1.775	(.336)[c/]	1.085 to 2.203	3.605	(2.454)	2.805 to 7.866	4.17 ± .73
almonds	Kern Co.								
T. pacificus									
Wasco almonds	46th/Palm	27 June	3.05	(.336)[c/]	-	7.09	(2.454)	-	3.50 ± .84
T. pacificus	Kern Co.								

a/ lb. 50 WP/100 gallons of water. b/ Lines parallel but *not* the same. c/ Lines *not* parallel and *not* the same.

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Survey of *Tetranychus urticae* and *T. pacificus* from California Almonds for Omite, Plictran and Vendex Resistance

Marjorie A. Hoy
Department of Entomological Sciences
University of California
Berkeley, California 94720
(415) 642-3989

December 3, 1984

The attached is a excerpt from a report to the Almond Board of California. It reports on a survey of spider mites (Tetranychus urticae and T.pacificus) collected from almond orchards in Butte, Glenn and Kern Counties in California that were screened for Omite, Plictran, and Vendex resistance. Since the report was written, additional data were obtained, and are reported in Tables 4,5, and 6. Table 4 provides Plictran dose response data for T.pacificus using a slide dip analysis. Table 5 reports Plictran dose response data for the same T.pacificus colonies using a leaf spray method. Table 6 reports dose responses for T. pacificus on Vendex using the leaf spray method. The leaf spray method involves placing adult female spider mites on pinto bean leaf discs (Phaseolus vulgaris) and spraying to drip with the formulated pesticide. A water control is treated the same way. Mortality is assessed after 48 hrs and dead and run off mites are counted as dead.

SUMMARY OF THE PROBLEM

1) Plictran resistance was found in 3 of 5 colonies of T.urticae as determined by slide dip analysis (Table 1).

2) Plictran resistance was found in all 4 T.pacificus colonies tested (Table 4).

3) Omite resistance was not found in the 5 T. urticae colonies tested (Table 2).

4) Omite resistance was found in one T.pacificus colony of 5 tested (Table 3).

5) Leaf spray tests were conducted with Plictran to approximate the field situation more closely. The T.pacificus colonies that are Plictran resistant appear even more resistant by this assay (Table 5).

6) Populations that are resistant to Plictran are also resistant to Vendex (Table 6). Thus, cross resistance is present.

These data suggest that Omite, Plictran, and Vendex have a limited time for which they will be effective in controlling spider mites in almonds. In several orchards during 1984, control failures occurred after Plictran applications. Thus, Plictran or Vendex should not be used in these orchards in 1985.

How long can we keep these valuable pest management tools? That depends upon the rate with which we use them up. Plictran is no longer useful in some almond orchards already.

AN ACARICIDE RESISTANCE MANAGEMENT PROPOSAL

It is difficult to give hard and fast rules for managing acaricide resistance in spider mites in California almond orchards. We lack much useful information. We don't have a complete survey of the extent of the resistance, knowledge of the genetic basis of the resistance, information on the stability of the resistance, or the fitness of the resistant strains. It would take at least another year to obtain these data. It is my opinion that we should proceed as though we don't have another year to waste before implementing new tactics in managing acaricide resistance in spider mites in almonds. This seems to me to be the conservative approach in the sense that we desperately need to preserve these valuable pest management tools as long as possible. I am assuming therefore that all almond orchards are at risk with respect to the possibility of developing acaricide resistance. Thus, I propose that we institute the following policy for the 1985 field season in all almond orchards.

I. If growers have predominantly used Plictran or Vendex in past years, switch to Omite in 1985. Conversely, if growers have predominantly used Omite, switch to Plictran or Vendex in 1985. Keep switching each succeeding year.

II. Use LOW DOSES of acaricide rather than high doses. High doses select most rapidly for resistance. LOW DOSES are rates such as 2 lbs 30WP Omite/acre, 0.5 lbs.50WP Plictran/acre, etc. The goal is to kill only 50% of the spider mites and to do so EARLY in the season (May or June). Predators in the orchard should then be able to keep the population under control the rest of the season. (See the Integrated Mite Management Guidelines for details.)

III. Apply ONLY ONE LOW RATE, or less, of acaricide during the growing season. Spot treatments early in the season can help the predators to control mites and the whole orchard need not be treated.

IV. Rely on predators to do the majority of your mite control. Help your native predators by using selective insecticides such as Guthion, Diazinon, or Imidan. If you lack predatory mites such as Metaseiulus occidentalis, release them in your orchard. They are commercially available from a number of sources and can provide substantial mite control even during the first season of release. Predators will eat both resistant and susceptible spider mites and will persist in the orchard for years.

VI. Baseline Data on Omite and Plictran Resistance Levels of Spider Mites in Release and Other Almond Orchards

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T. pacificus populations were collected from Glenn County (Hamilton City, Chapla) and from Kern County (Pond Road, Bidard, and Wasco). Table VI-3 shows the results of slide dip tests with Omite. The Pacific mite colony from the Bidart orchard has a significantly increased LC_{50} value of 0.753 lbs 30WP/100 gallons water. Thus, it appears that Omite resistance is developing in this orchard.

Tests with these same T. pacificus colonies are currently being conducted with Plictran. The detailed results are not yet available. However, it is clear that some of these Kern County populations are highly resistant to Plictran - even more resistant than the Chico populations of T. urticae. Thus, these southern orchards are in danger of losing both Plictran and Omite as selective acaricides.

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able VI-1. Dose responses to Plictran of *T. urticae* collected from almond orchards during 1984 as determined by slide dip analysis.

. *urticae* olony	Location	Date collected 1984	LC_{50} a/	Greenhouse control LC_{50} a/	95% C.I.	LC_{90} a/	Greenhouse control LC_{90} a/	95% C.I.	Slope
reenhouse	Shell Corp. Modesto	July	.482	(average)	.343 to .510	1.561	-	1.263 to 2.106	2.28 ± .21
utra River almonds	River Rd/Hwy 32 Butte Co.	16 April	.508	(.405) b/	.381 to .632	2.199	(1.262)	1.602 to 3.735	2.01 ± .28
cHann-Decker almonds	Durham-Dayton Hwy/ Fimple Rd.Butte Co.	16 April	.689	(.447) c/	.456 to 1.052	4.807	(1.474)	2.445 to 23.748	1.52 ± .23
ead almonds	Burdick Rd/Troxel Rd. Butte Co.	16 April	.972	(.433) b/	.720 to 1.399	4.612	(1.564)	2.534 to 25.454	1.89 ± .39
ertagna almonds	Hegan Ln/Fimple Rd. Butte Co.	16 April	.402	(.397)	.244 to .550	1.565	(1.272)	1.106 to 2.926	2.17 ± .28
lmont almonds	Burdick Rd/Troxel Rd. Butte Co.	3 April & 16 April	.479	(.447)	.306 to .635	1.897	(1.474)	1.313 to 4.033	2.14 ± .32

a/ lb 50 WP/100 gallons of water

b/ Lines parallel but not the same

c/ Lines not parallel and not the same

Table VI-2. Dose responses to Omite of *T. urticae* collected from almond orchards during 1984 as determined by slide dip analysis.

T. urticae colony	Location	Date collected 1984	LC_{50} a/	Greenhouse control LC_{50} a/	95% C.I.	LC_{90} a/	Greenhouse control LC_{90} a/	95% C.I.	Slope
Greenhouse	Shell Corp Modesto	July	.610	(average)	.533 to .674	1.309	-	1.163 to 1.549	3.86 ± .35
Mead almonds	Burdick Rd/Troxel Rd. Butte Co.	16 April	.503	(.508)	.382 to .586	.941	(1.128)	.840 to 1.105	4.71 ± .83
Dutra River almonds	River Rd/Hwy 32 Butte Co.	16 April	.706	(.637)	.552 to .827	1.341	(1.390)	1.092 to 2.161	4.60 ± .76
Bertagna almonds	Hegan Ln/Fimple Rd. Butte Co.	16 April	.645	(.637)	.505 to .750	1.272	(1.390)	1.044 to 1.937	4.34 ± .71
Greenhouse	Chevron Corp. Richmond	Sept	.653	(average)	.527 to .770	1.655		1.325 to 2.407	3.17 ± .32
McHann-Decker almonds	Durham Dayton Hwy/ Fimple Rd.Butte Co.	16 April	.736	(.702)	.567 to .904	1.928	(1.813)	1.449 to 3.402	3.07 ± .38
Almont almonds	Burdick Rd/Troxel Rd. Butte Co.	3 April & 16 April	.756	(.702)	.599 to .915	1.968	(1.813)	1.492 to 3.361	3.08 ± .38

a/ lb 30 WP/100 gallons of water.

T. pacificus colony	Location	Date collected 1984	LC_{50} a/	Greenhouse control LC_{50} a/	95% C.I.	LC_{90} a/	Greenhouse control LC_{90} a/	95% C.I.	Slope
Greenhouse *T. urticae*	Chevron Corp. Richmond	Sept.	.653	(average)	.527 to .770	1.655	-	1.325 to 2.407	3.17 ± .32
Hamilton City *T. pacificus* almonds	Glenn Co.	7 Aug	.509	(.680)	.323 to .660	1.401	(1.582)	1.068 to 2.312	2.91 ± .52
Chapla *T. pacificus* almonds	Glenn Co.	7 Aug	.543	(.649)	.317 to .698	1.446	(1.474)	1.110 to 2.641	3.01 ± .54
Greenhouse *T. urticae*	Shell Corp. Modesto	July	.610	(average)	.533 to .674	1.309	-	1.163 to 1.549	3.86 ± .35
Pond Rd. almonds	S.Pond Rd/McFarland Kern Co.	28 June	.594	(.603)	.398 to .717	1.423	(1.315)	1.156 to 2.271	3.37 ± .53
Bidart *T. pacificus* almonds	Kern Co.	27 June	.753	(.605) b/	.632 to .852	1.582	(1.408)	1.336 to 2.134	3.98 ± .55
Wasco *T. pacificus* almonds	46th/Palm Kern Co	27 June	.546	(.605)	.333 to .675	1.615	(1.408)	1.267 to 2.958	2.72 ± .54

a/ lb.30 WP/100 gallons. b/ Lines parallel but not the same.

Table VI-4. Dose responses to Plictran of *T. pacificus* collected from almond orchards during 1984 as determined by slide dip analysis.

T. pacificus colony	Location	Date collected 1984	LC_{50}[a]	Greenhouse control LC_{50}[a]	95% C.I.	LC_{90}[a]	Greenhouse control LC_{90}[a]	95% C.I.	Slope
Greenhouse	Chevron Corp	Sept.	0.336		.165 to .542	2.454		1.290 to 11.123	1.48 ± .21
T. urticae	Richmond								
Chapla almonds		7 Aug.	0.488	(.336)[b]	.287 to .691	2.251	(2.454)	1.562 to 4.061	1.93 ± .19
T. pacificus	Glenn Co.								
Bidart almonds		27 June	2.669	(.336)[c]	1.895 to 3.124	3.958	(2.454)	3.346 to 6.774	7.49 ± 1.37
T. pacificus	Kern Co.								
Pond Rd.	S. Pond Rd/McFarland	28 June	1.775	(.336)[c]	1.085 to 2.203	3.605	(2.454)	2.805 to 7.866	4.17 ± .73
almonds	Kern Co.								
T. pacificus									
Wasco almonds	46th/Palm	27 June	3.05	(.336)[c]	-	7.09	(2.454)	-	3.50 ± .84
T. pacificus	Kern Co.								

a/ lb. 50 WP/100 gallons of water. b/ Lines parallel but not the same. c/ Lines not parallel and not the same.

Table VI-5. Dose responses to Plictran of *T. urticae* and *T. pacificus* collected from almond orchards during 1984 as determined by leaf spray analysis.

Colony	Location	Date Collected 1984	LC_{50} a/	95% C.I.	LC_{90} a/	95% C.I.	Slope
Bertagna *T. urticae* almonds	Hegan Ln/Fimple Rd Butte Co.	16 April	0.494	.280 to .715	3.973	2.439 to 9.860	1.42 ± .26
Mead *T. urticae* almonds	Burdick Rd/Troyel Rd. Butte Co.	16 April	0.923	.545 to 1.414	6.866	3.599 to 29.653	1.47 ± .26
Chapla *T. pacificus* almonds	Glenn Co.	7 Aug.	2.040	-	5.542	-	2.95 ± .98
Pond Rd. *T. pacificus* almonds	S.Pond Rd/McFarland Kern Co.	28 June	2.353	1.238 to 6.749	34.532	9.941 to 3168.05	1.10 ± .28
Wasco *T. pacificus* almonds	46th/Palm Kern Co.	27 June	3.929	2.040 to 31.517	97.143	17.371 to 192990.74	0.92 ± .26
Bidart *T. pacificus* almonds	Bakersfield Kern Co.	27 June	709.7	-	9 million	-	0.31 ± .35

a/ lbs 50 WP/100 gallons water

Table VI-6. Responses to Vendex by *T. urticae* and *T. pacificus* collected from almonds as determined by leaf spray analysis.

Colony	Location	Date collected 1984	% Survival at 0	% Survival at 4 oz[a]	% Survival at 8 oz[a]	LC_{50}[b] for Plictran
Bertagna *T. urticae* almonds	Hegan Ln/Fimple Rd. Butte Co.	16 April	100	50	30	0.50
Mead *T. urticae* almonds	Burdick Rd/Troxel Rd Butte Co.	16 April	100	70	25	0.92
Chapla *T. pacificus* almonds	Glenn Co.	7 Aug.	100	40	35	2.04
Pond Rd. *T. pacificus* almonds	S.Pond Rd/McFarland Kern Co.	28 June	100	75	70	2.35
Wasco *T. pacificus* almonds	46th/Palm Kern Co.	27 June	100	75	75	3.93
Bidart *T. pacificus* almonds	Bakersfield Kern Co.	27 June	100	95	90	709.7

a/ oz. 4L/100 gallons of water

b/ lbs 50WP/100 gallons of water

VII. Results During 1984 of Using the Mite Management Guidelines

Darryl Castro and Dan Cahn used the mite management guidelines (described in Section VIII) to manage spider mites in almond orchards in the San Joaquin Valley during 1984. These orchards generally had histories of severe spider mite problems in previous years. During 1984, orchards lacking native M. occidentalis received 2,300 to 3,600 carbaryl-OP-sulfur resistant ♀♀/acre early in the growing season. Spider mite-predator interactions then were monitored using 4 to 6 cluster sites within each block where foliage was sampled once a week from marked tree clusters, brushed and counted. Mean mites/leaf, predator:spider mite ratios, and spider mite days were calculated. Acaricides were applied using the guidelines previously established (see guidelines for May, June, July and August in Section VIII).

Below I summarize the data provided by Darryl Castro and Dan Cahn. They very kindly provided these summaries and graphs to show that it is possible to use these guidelines on a commercial scale. I think the results are remarkable. They achieved excellent control of spider mites and "average cost of mite control for our growers this year, not including our fees or costs of predatory mites if used, worked out to be about $9/acre. Large growers with uniform blocks generally spent $5/acre or less" (Darryl Castro, personal communication).

The following data are a partial summary for each orchard of the 1984 season.

EAST ORCHARD

This orchard is about 60 acres in size, received two predator releases, one in late April and one in mid-May of 3600 and 2900 M. occidentalis per acre, respectively. On May 13, about 40 acres were treated with Omite (1.7 lb/acre); on May 31, 60 acres were treated with .68 lb Plictran 50WP acre; on June 27, about 20 acres were treated with 0.57 lb. Plictran 50WP/acre and on July 24, 3 acres were treated with .85 lb. Plictran 50WP/acre. The graph shows the orchard average (some of the acaricides are not shown because they were partial treatments). The predators clearly established and the orchard accumulated only 53 Spider Mite Days over the season. This is well below the 120 SMD we established as our maximum.

WALNUT ORCHARD

This orchard is about 40 acres in size, and received 2900 predator females/acre on May 12. Forty acres were treated with Plictran (0.68 lb/acre) on May 28, and 40 acres on July 3 with 0.42 lb/acre. The graph shows that the orchard accumulated about 61 SMD during the season.

SUMNER PECK #1

This 150 acre orchard received no predators and had no acaricide treatments. European red mite was present and M. occidentalis numbers built up on them. The graph shows that only 21 SMD accumulated in this orchard and measurable spider mites were difficult to find after the end of June.

SUMNER PECK #2

This 150 acre orchard had no predator releases. The entire block was treated with Omite 6E (air) at a rate of 8 oz./acre on May 8. The graph shows that an average of 52 SMD accumulated in this orchard. Again, detectable spider mite densities were hard to find after late June.

SUMNER PECK-NEBRASKA

This orchard consists of 130 acres. No predators were released here and on July 10, 7 acres were treated with Plictran (1 lb 50WP/acre). This spot treatment was certainly effective. By the end of the season, only 3 SMD had accumulated in this orchard.

ZAPATO CREEK 1

This 55 acre block received 2300 *M. occidentalis* females/acre on June 9. On June 11, 8 acres were treated with 12 oz. Omite 6E/acre. On June 27, 55 acres were treated with Guthion (4 lb. 50WP/acre) and 7 acres were also treated with 0.75 lb. Plictran 50WP/acre. Another small Plictran application (0.75 lb. 50WP Plictran/acre on 3 acres) was applied to the border on July 14.

ZAPATO CREEK 2

This 55 acre orchard received a Guthion treatment on June 27. On July 7, 2500 predators/acre were released, and on July 14, 4 acres were treated with 0.75 lb Plictran 50WP/acre on the border of the orchard. This orchard averaged 6 SMD for the season.

ZAPATO CREEK 3

This 80 acre orchard received 2300 predators/acre on June 9. On June 11, 25 acres were treated with 12 oz. Omite 6E/acre. On June 27, 80 acres were treated with Guthion, and on July 14, 6 acres on the border were treated with 0.75 lb. Plictran 50WP/acre. The orchard averaged 23 SMD for the season.

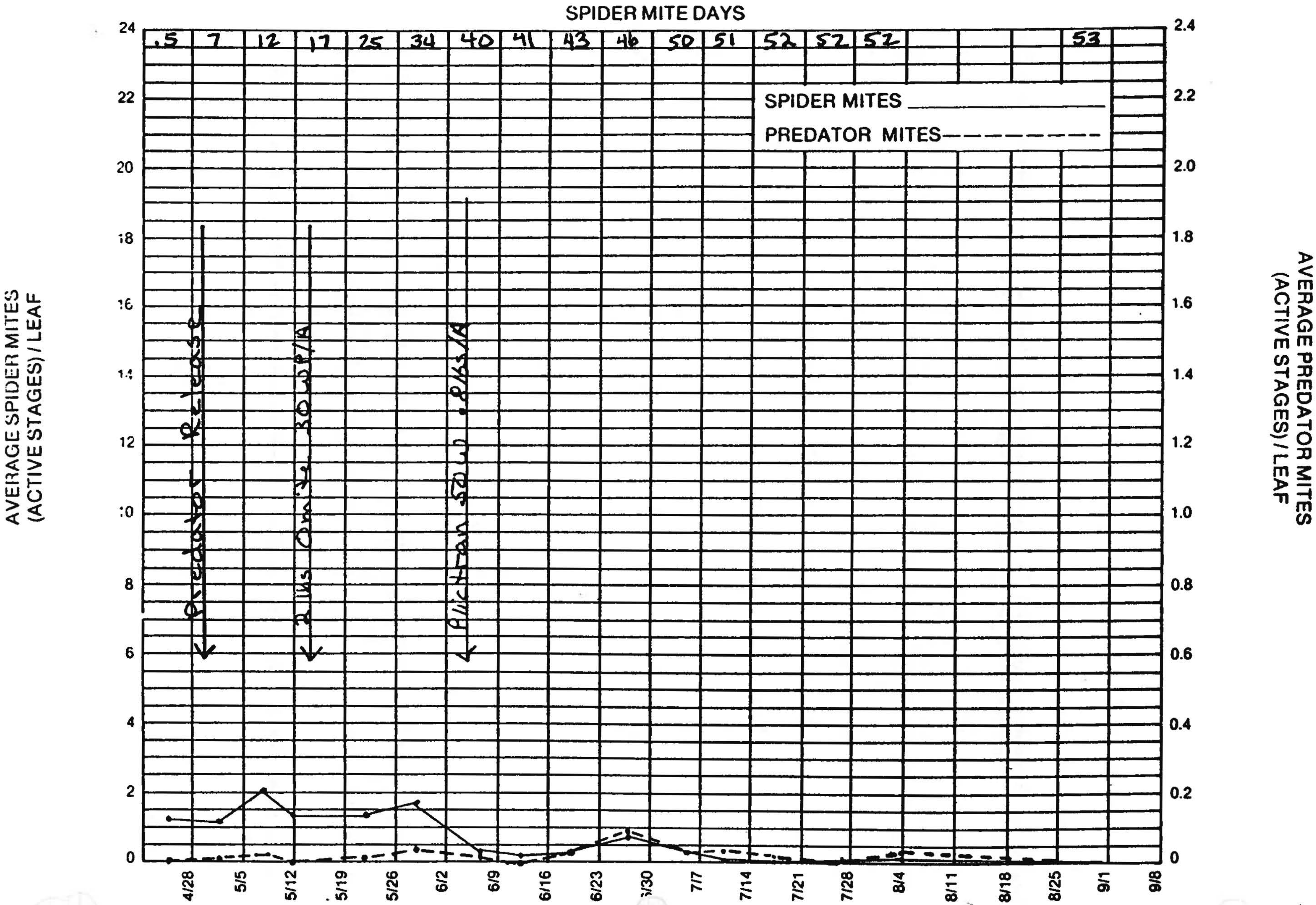
JAYNE AVENUE

This 72 acre almond orchard was treated with Guthion on June 20. On July 7, 7 acres were treated (on the border) with 0.5 lb. Plictran/acre. This orchard averaged 15 SMD for the season.

Integrated Orchard Management

3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower Nielsen
Orchard Field East - Orchard Ave.
Crop
Date



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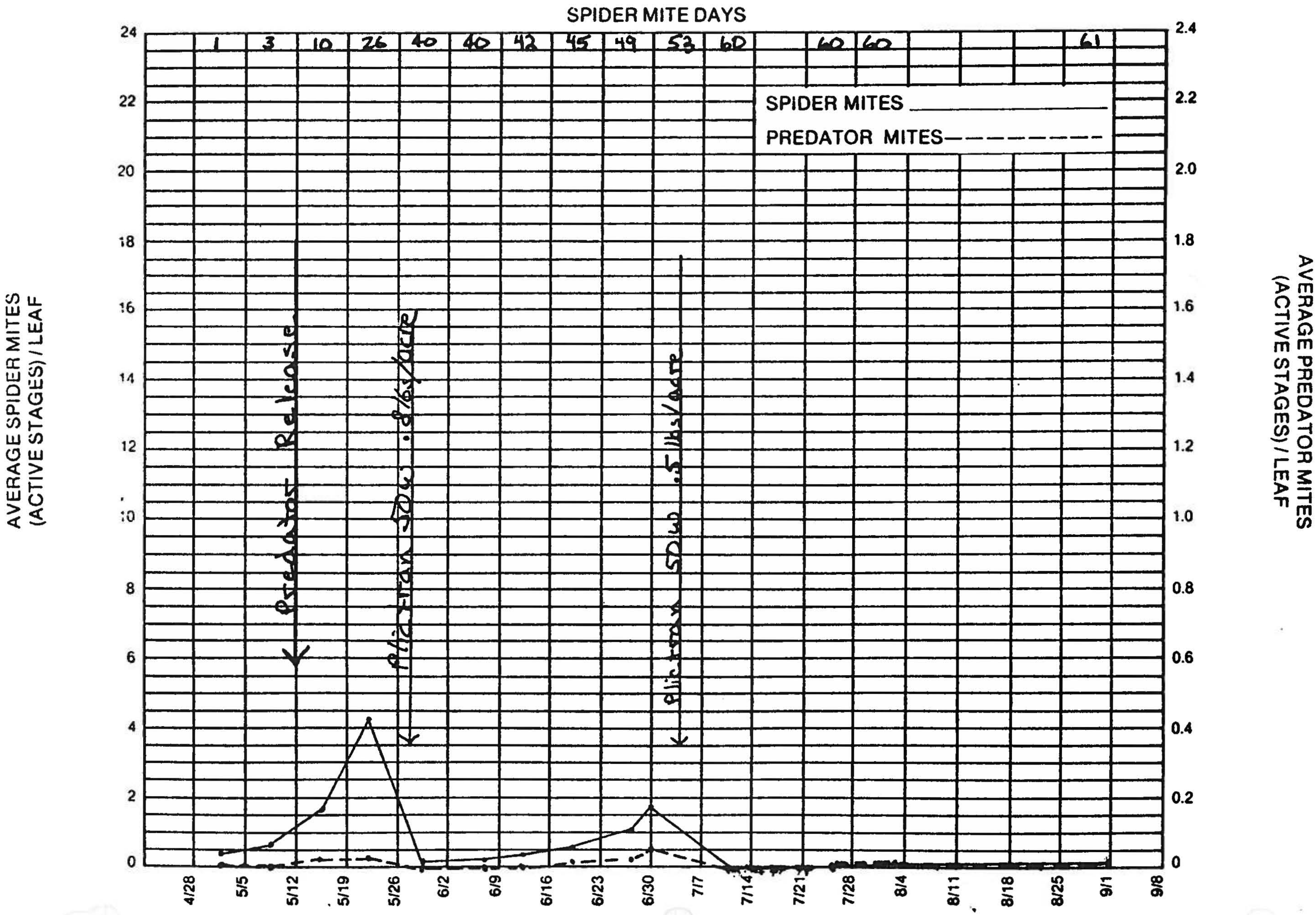
Grower ______________________

Orchard Field Walnut - Average

Crop ______________________

Date ______________________



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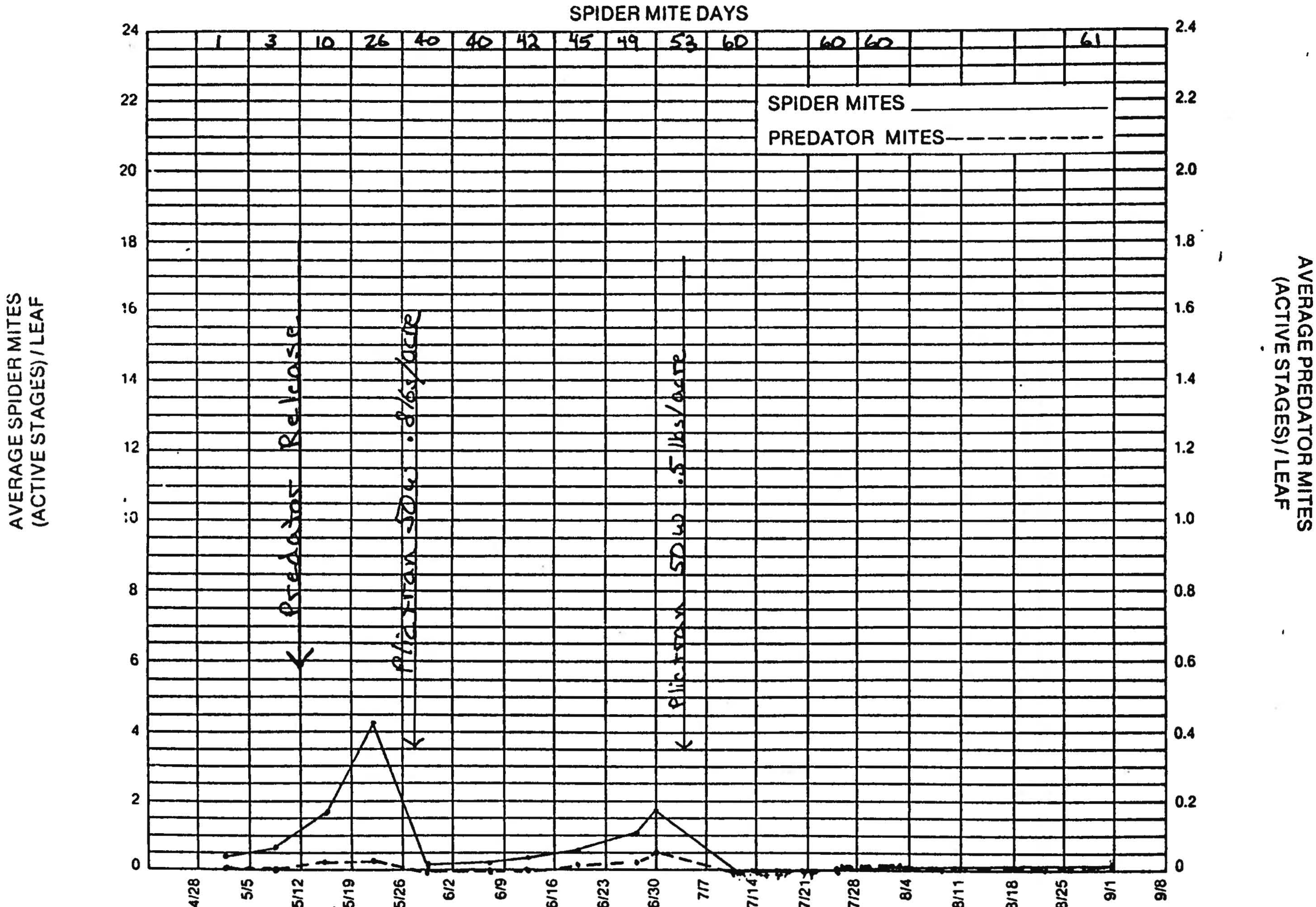
Phone (209) 625-5199

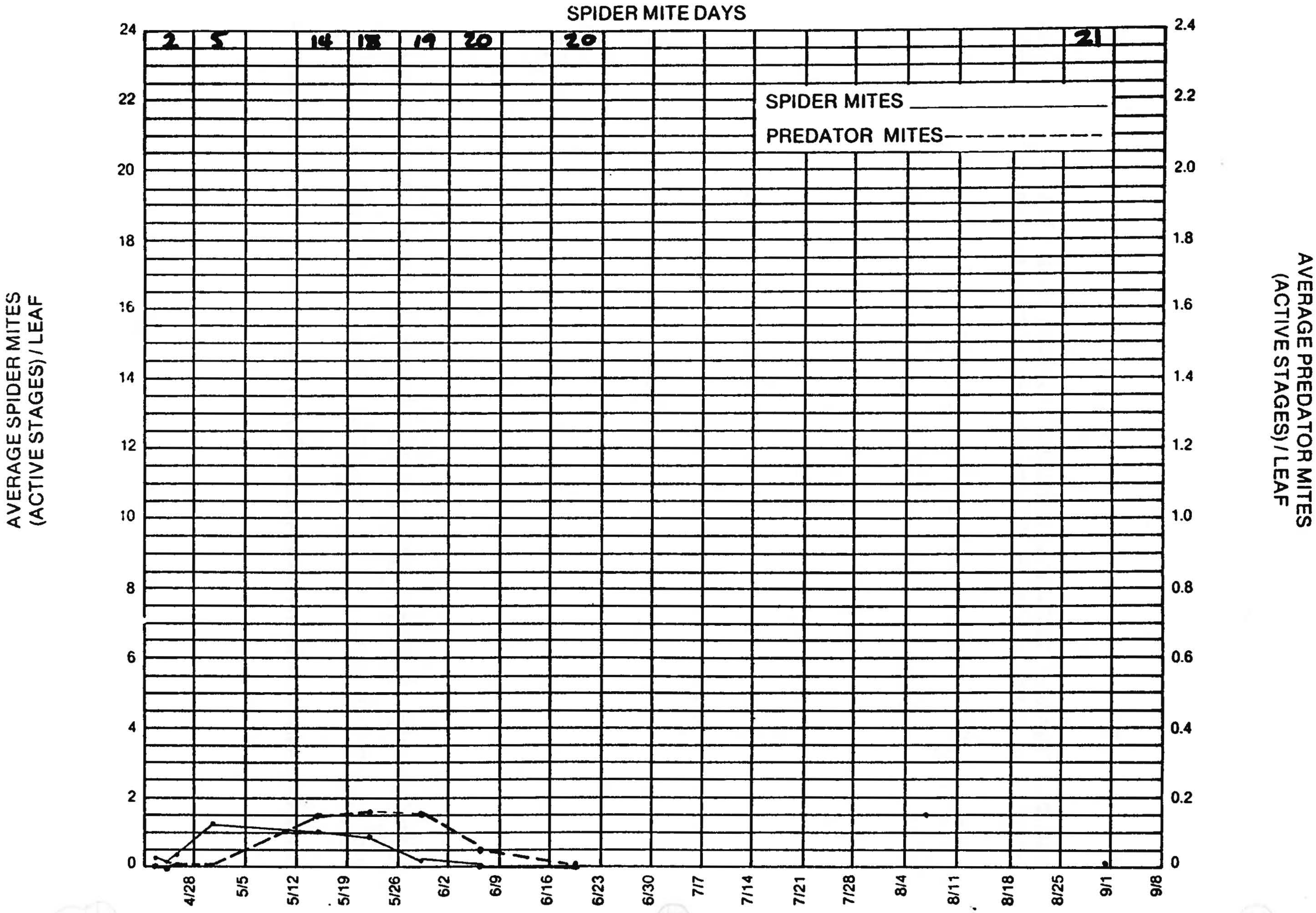
Grower ______
Orchard Field Walnut - Average
Crop ______
Date ______



C

Integrated Orchard Management
3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower Sumner Peck
Orchard Field Block 1 Average
Crop
Date



C

VII-7

Integrated Orchard Management

3524 West Fairview Avenue • Visalia, California 93277
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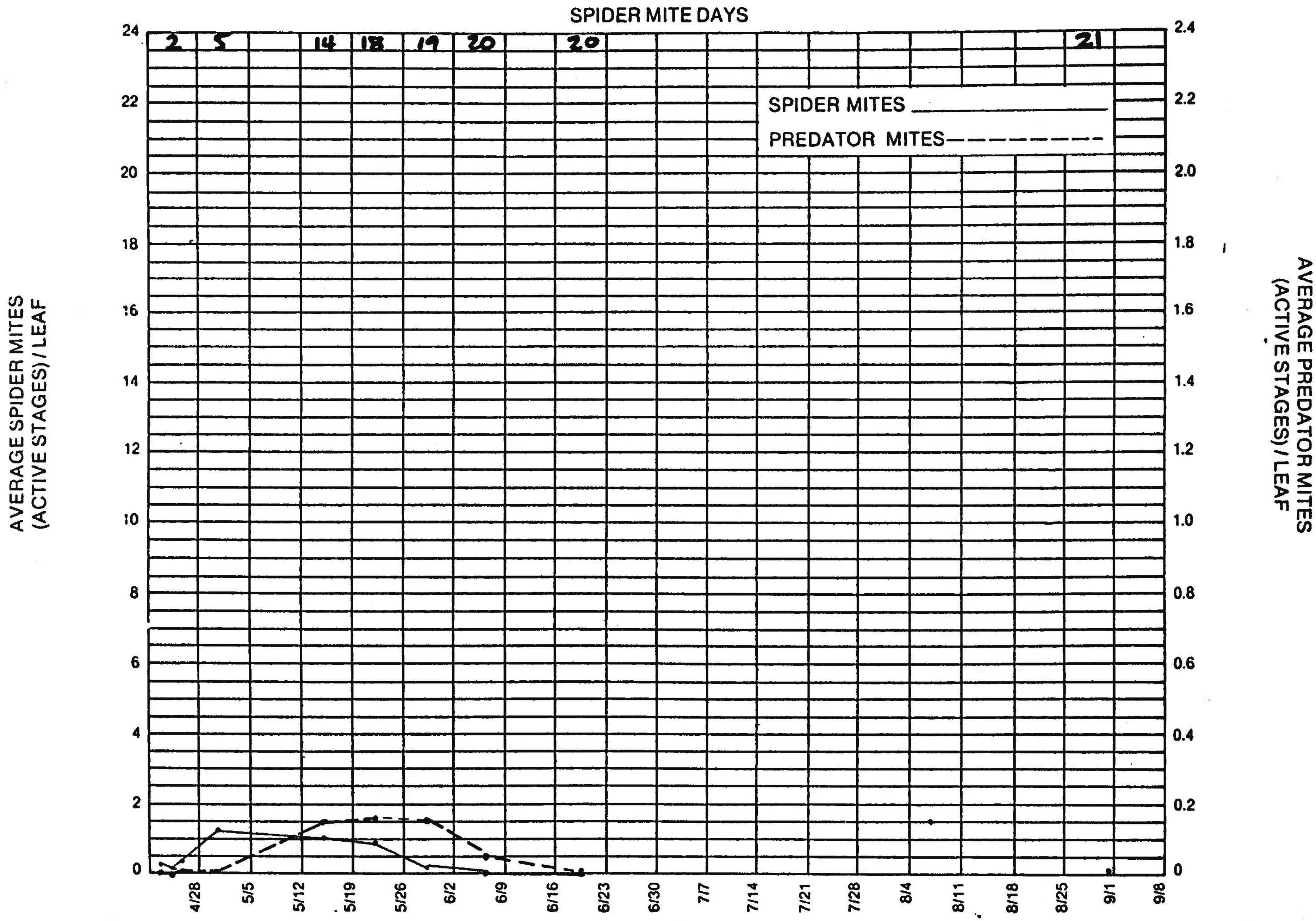
Grower Sumner Peck
Orchard Field Block 1 Average
Crop
Date

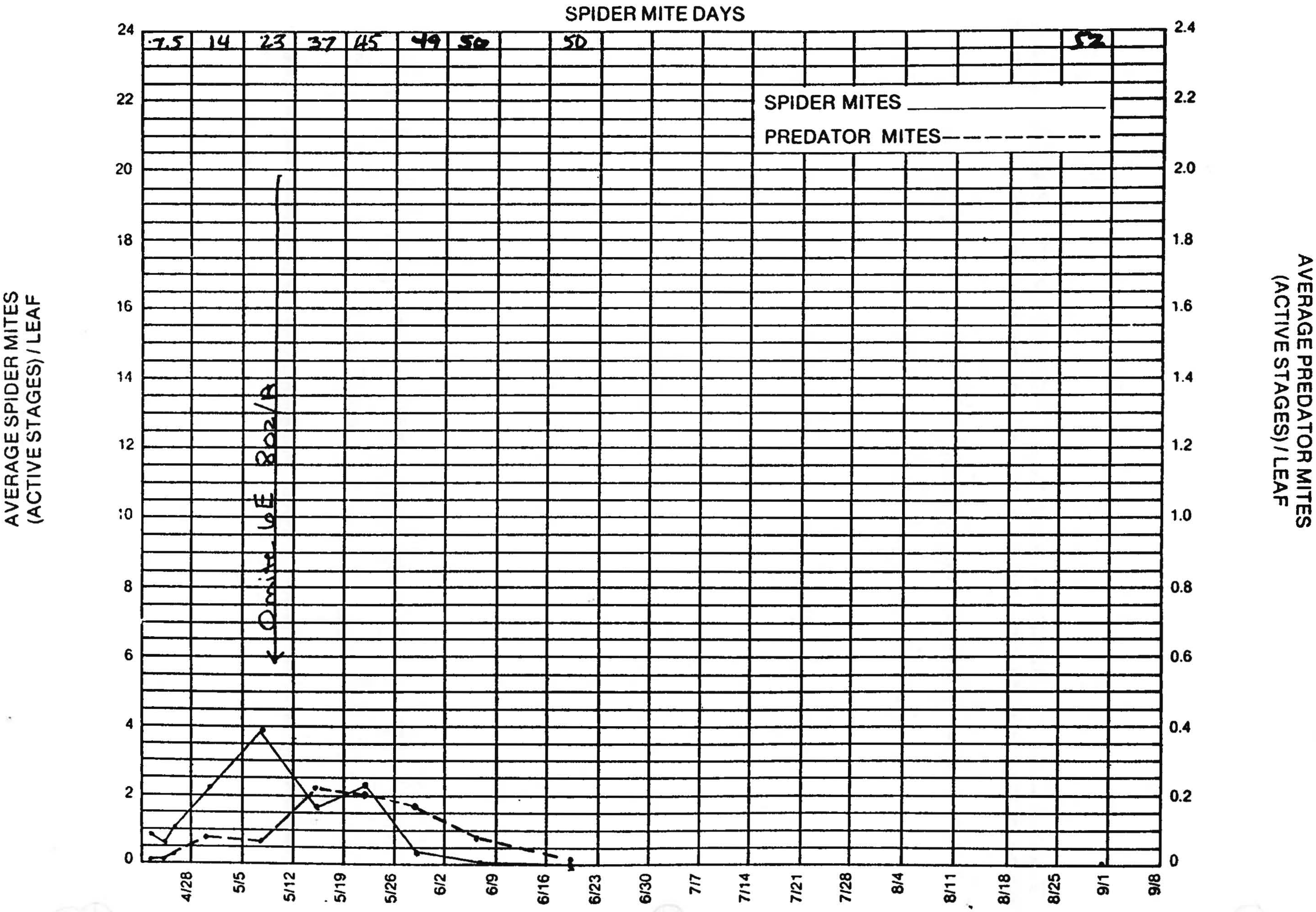


C

VII-8

Integrated Orchard Management
3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower Sumner Peck
Orchard Field Block 2 Average
Crop
Date



Integrated Orchard Management

3524 West Fairview Avenue • Visalia, California 93277
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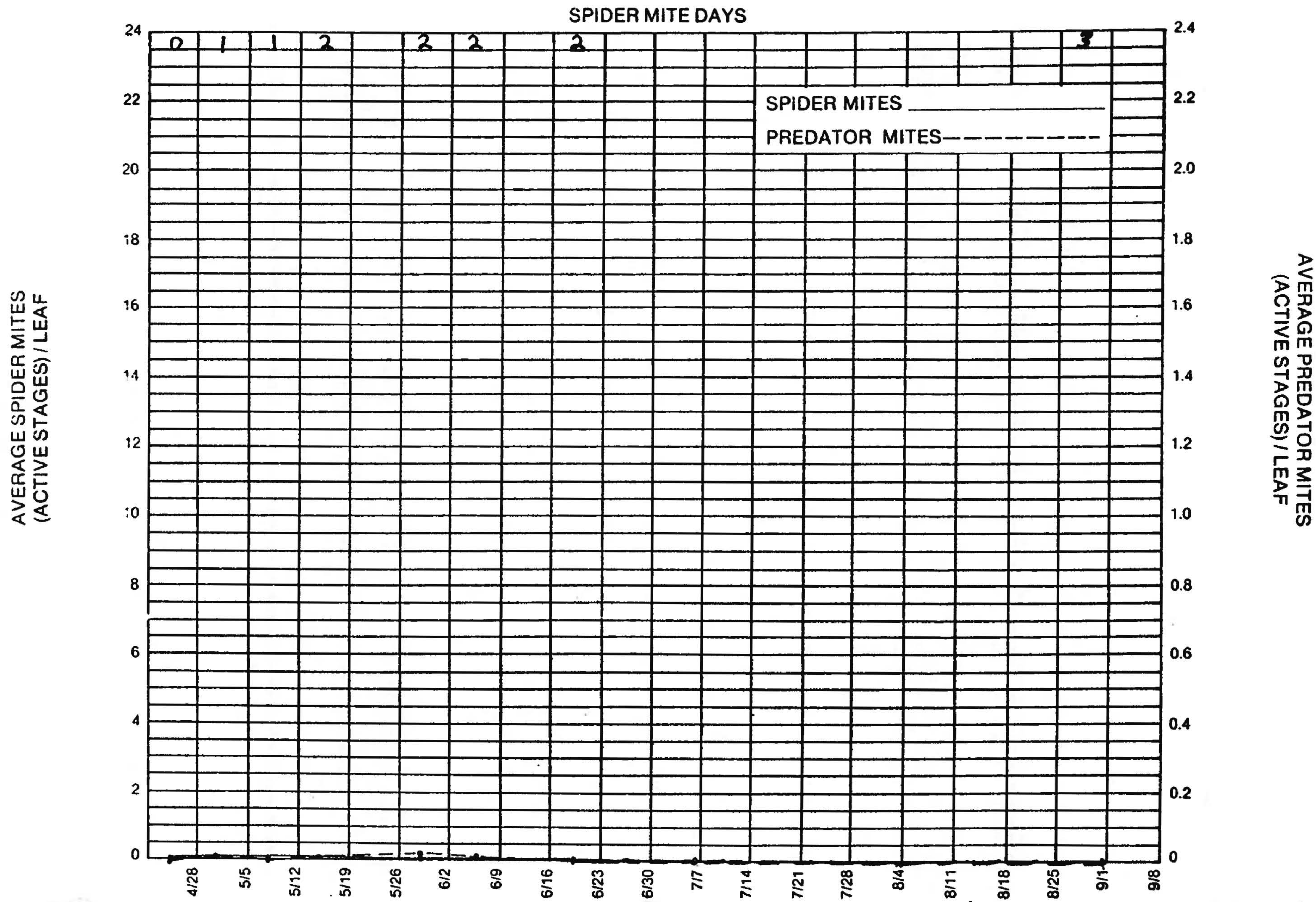
Grower Sumner Peck

Orchard Field Block 3 (Nebraska) Average

Crop ____________

Date ____________



VII-10

Integrated Orchard Management

3524 West Fairview Avenue • Visalia, California 93277
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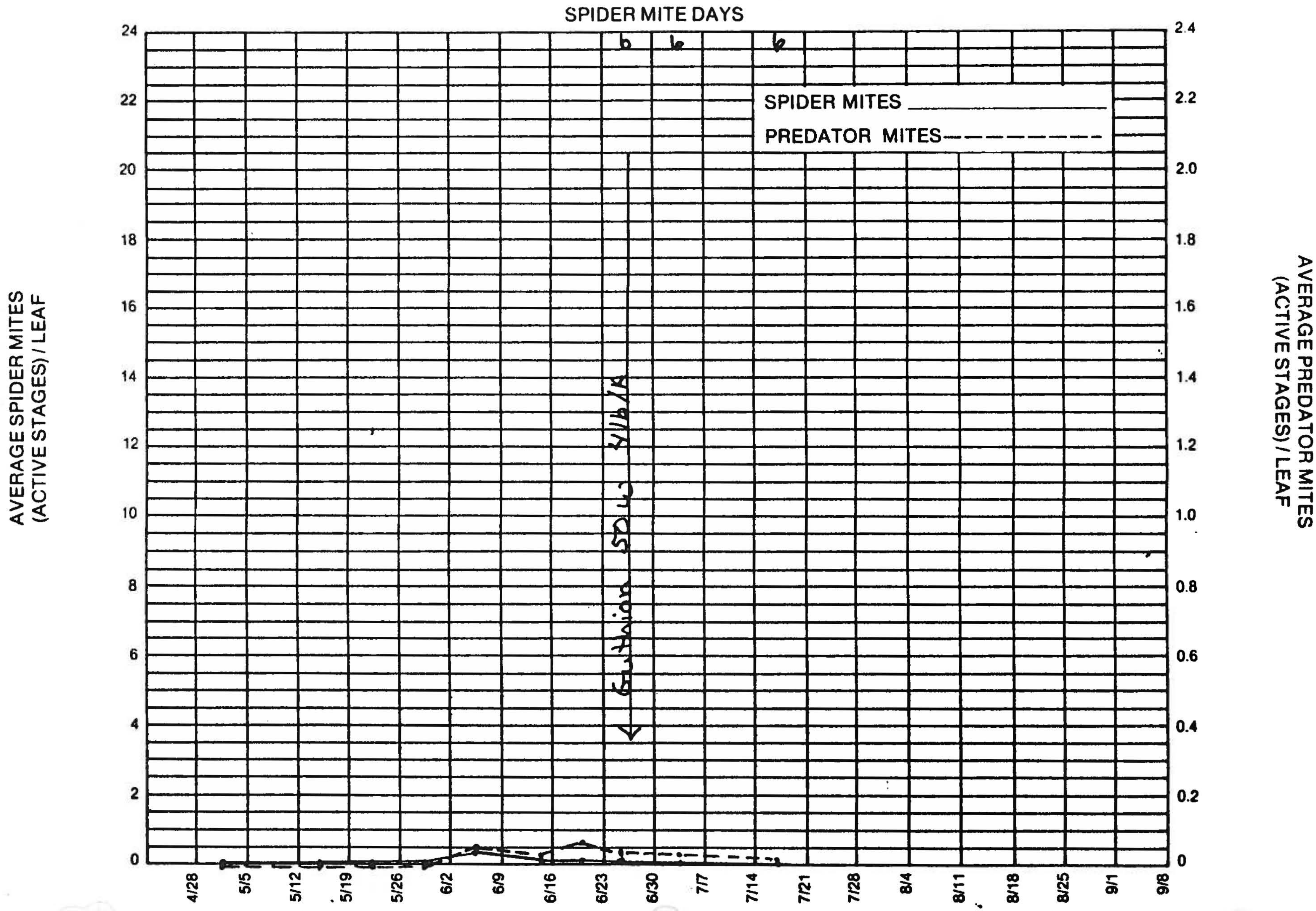
Grower Robinson
Orchard Field Zapato Creek Block1 Average
Crop
Date



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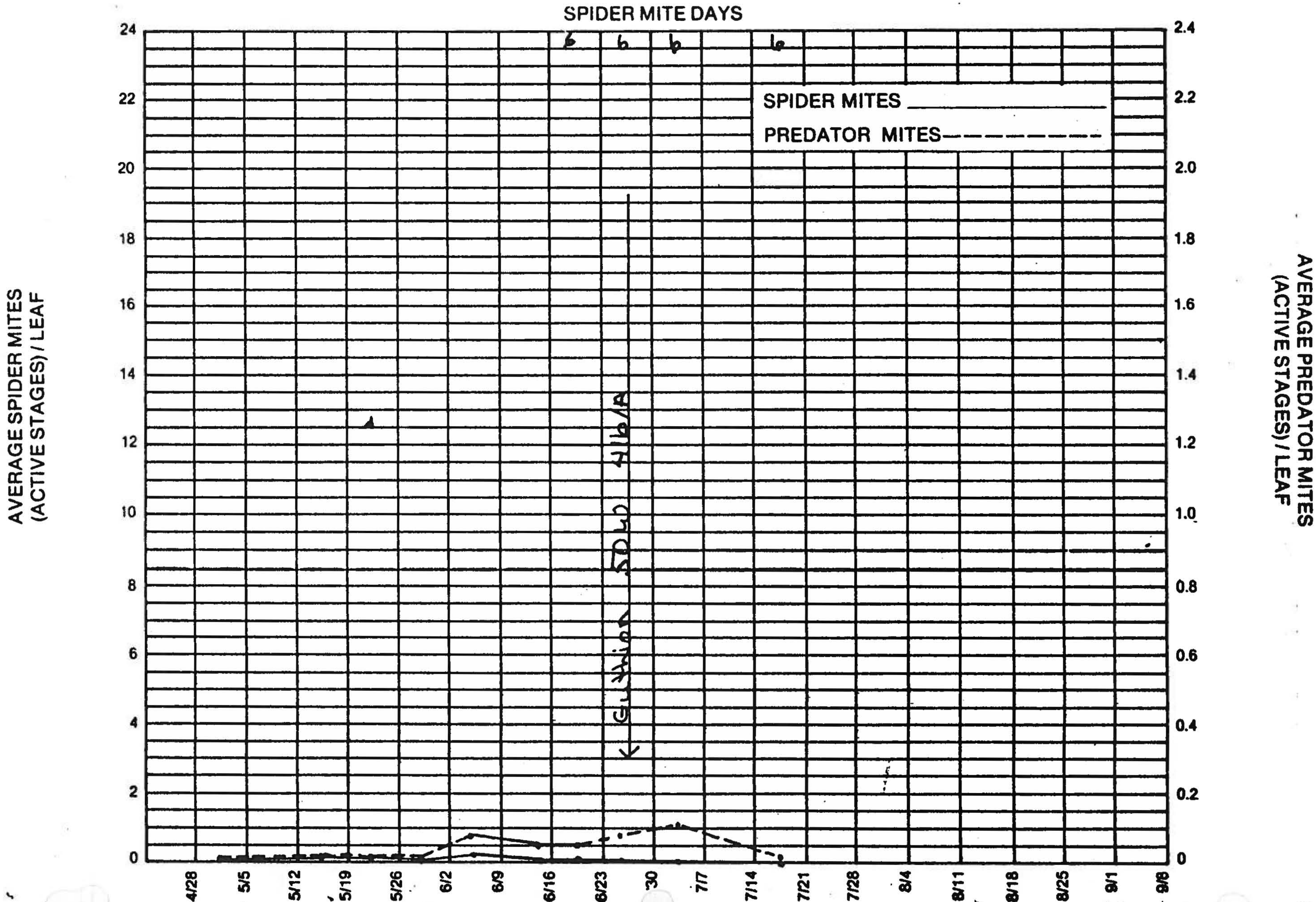
3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower Robinson
Orchard Field Zapato Creek Block 2 Average
Crop Orchard Ave.
Date



Integrated Orchard Management

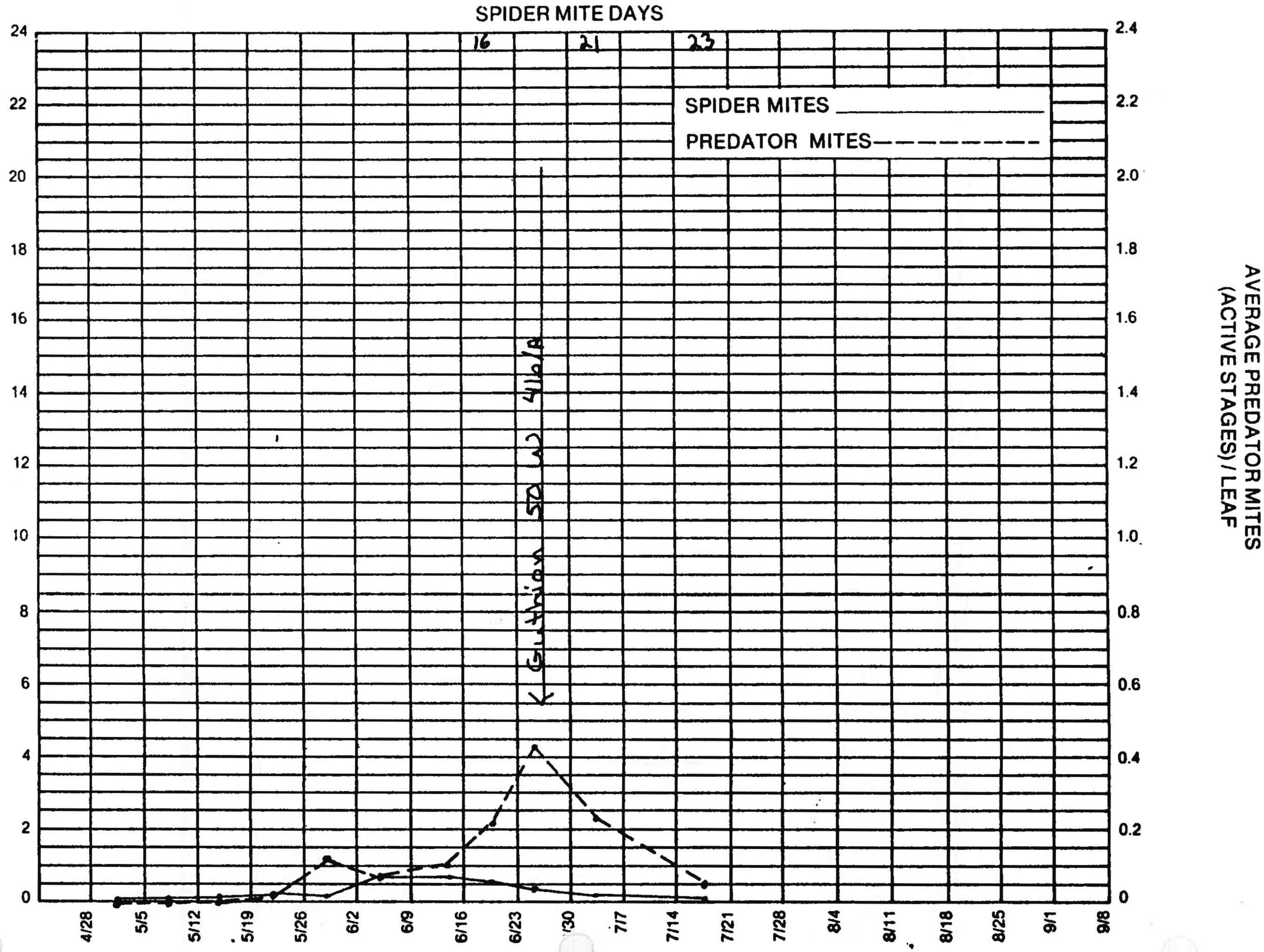
3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower Robinson

Orchard Field Zapato Creek Block 3 Ave.

Crop ______________

Date ______________



Integrated Orchard Management

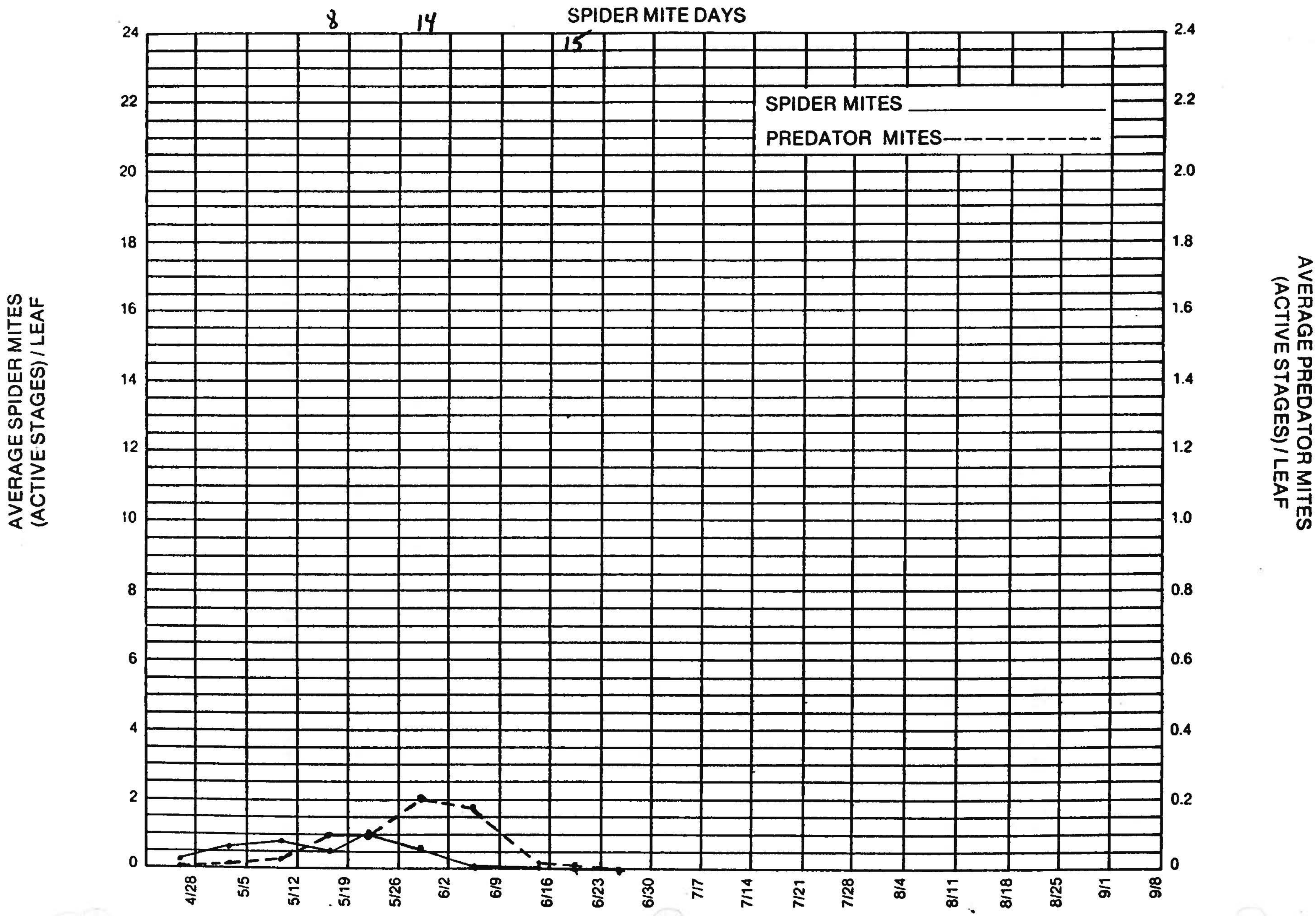
3524 West Fairview Avenue • Visalia, California 93277
Phone (209) 625-5199

Grower ______________________

Orchard Field Jayne Average

Crop ______________________

Date ______________________



D

IX. Survey of *M. occidentalis* for Resistance/Tolerance to Lorsban, Supracide, Dibrom, Maneb, Thiodan, Vendex, Diazinon, Imidan, and Cygon.

Colonies of *M. occidentalis* were screened in the laboratory for their tolerance/resistance levels to the above named pesticides using a leaf spray method. Gravid females were placed on bean leaf discs (5/disc) with two spotted spider mites as prey. Pesticides were then sprayed on the leaf discs to obtain complete coverage. After 48 hours survivors were scored. Dead included both dead and runoff individuals. Controls were treated with water. Rates were a multiple of the "field rate" and formulated pesticides were used. These laboratory assays will provide useful hints about selectivity, or lack thereof, but are not definitive. It is likely that they overestimate field mortality since we give complete coverage. Thus, untreated refuges and photodeterioration of pesticide residues could render these products less toxic.

Results are given in Table IX-1. From these data, it appears that Lorsban is toxic to both *T. urticae* and the carbaryl-OP-sulfur resistant strain of *M. occidentalis*. However, the fact that 71% of the females survived at 0.5 the field rate suggests that field trials are necessary to determine just how toxic this product is to *M. occidentalis*. It is also possible that field use would select for a higher Lorsban resistance.

Supracide is highly toxic to all colonies tested at the "field rate." Dibrom is least toxic to the carbaryl-OP-sulfur resistant strain compared to two vineyard colonies; this product could be selective in the field, again due to partial coverage and residue breakdown.

Maneb appears to have very low toxicity to the three predator colonies tested, and the females appeared to deposit eggs normally, indicating that sterility was not induced.

Thiodan was consistently toxic to all three colonies tested, with the few surviving predators paralyzed. This product also induced high spider mite mortality.

Vendex is shown here to be a selective acaricide, although some predators were paralyzed. Diazinon and Imidan are also clearly selective materials, as the four colonies tested survived field rates well. The two almond colonies did well, indicating that OP resistance in these native populations is probably sufficient so that growers can assume their natives will survive applications of these materials. However, high spider mite mortality was observed with Imidan; this could create problems if this is a widespread phenomenon since the predators could run out of food. No such impact was observed with Diazinon. Cygon was also reasonably selective to the 3 _M. occidentalis_ colonies tested.

Table IX-1. Results of laboratory screening with various pesticides with *M. occidentalis* adult females using a leaf spray technique.

Colony	Pesticide tested	Rates tested (x field rate)	No. tested	% surviving	Notes
Carbaryl-OP-sulfur	Lorsban (field rate = 1 lb 50 WP/ 100 gal. water)	0.5	80	71.3	Most spider mites were dead
		1.0	80	5	
		2.0	60	0	
		water	45	80	
Carbaryl-OP-sulfur, greenhouse	Supracide (field rate = 1 qt. 3.2 EC/ 100 gal. water)	1.0	100	0	
		water	20		
Carbaryl-OP-sulfur, laboratory		1.0	20	0	
		water	20	70	
Wasco almonds		1.0	20	0	
		water	20	90	
Steffan almonds		1.0	20	0	
		water	20	80	

Table IX-1. (cont'd)

Colony	Pesticide tested	Rates tested (x field rate)	No. tested	% surviving	Notes
Raven	Dibrom (naled)	1.0	55	3.6	
	(field rate =	0.5	55	21.0	
	2/3 pt. 8 EC/	water	20	100.0	
	100 gal.water)				
Cecil grapes		1.0	60	21.7	
		0.5	60	55.0	
		water	20	95.0	
Carbaryl-OP-sulfur		1.0	20	45.0	
		0.5	20	70.0	
		water	20	95.0	
	Maneb				
Carbaryl-OP-sulfur, greenhouse	(field rate)	1.0	100	95	Predators deposited eggs
		water	20	95	
Wasco almonds		1.0	20	90	
		water	20	95	
DeFreitas almonds		1.0	20	100	
		water	20	95	

Table IX - 1. (cont'd)

Colony	Pesticide tested	Rates tested (x field rate)	No. tested	% surviving	Notes
Wasco almonds		1.0	20	90	
		water	20	95	
Steffan almonds		1.0	20	90	
		water	20	95	
	<u>Imidan</u>				
Carbaryl-OP-sulfur, greenhouse	(field rate = 0.5 lb a.i./100 gal. water)	1.0	100	85	High spider mite mortality
		water	20	95	
Carbaryl-OP-sulfur, laboratory		1.0	20	95	
		water	20	95	
Wasco almonds		1.0	20	100	
		water	20	95	
Steffan almonds		1.0	20	95	
		water	20	95	
	<u>Cygon</u>				
Carbaryl-OP-sulfur greenhouse	(field rate = 0.5 lb a.i./100 gal water)	1.0	160	56	
		0.5	160	54	
		water	20	100	
Lodi grapes		1.0	30	90	
		0.5	30	73	
		water	20	100	
Steffan almonds		1.0	30	97	
		0.5	30	70	
		water	20	90	

Table IX-1. (cont'd)

Colony	Pesticide tested	Rates tested (x field rate)	No. tested	% surviving	Notes
	<u>Thiodan</u>				
Carbaryl-OP-sulfur, greenhouse	(field rate = 1 qt. 3 EC/100 gal. water)	1.0	100	5	High spider mite mortality
		water	20	95	Many surviving predators are paralyzed.
Wasco almonds		1.0	20	5	
		water	20	95	
DeFreitas almonds		1.0	20	5	
		water	20	95	
	<u>Vendex</u>				
Carbaryl-OP-sulfur, greenhouse	(field rate = 1/4 pt. 4 L (42%)/100 gal. water)	1.0	100	74	Some predators are paralyzed.
		water	20	95	
Wasco almonds		1.0	20	85	
		water	20	95	
DeFreitas almonds		1.0	20	60	
		water	20	95	
	<u>Diazinon</u>				
Carbaryl-OP-sulfur, greenhouse	(field rate = 0.5 lb a.i./100 gal. water)	1.0	100	78	No spider mite mortality.
		water	20	95	
Carbaryl-OP-sulfur, laboratory		1.0	20	80	
		water	20	95	

X. Publications List

Wilson, L. T., M. A. Hoy, F. G. Zalom, and J. M. Smilanick. 1984. Sampling mites in almonds: I. Within-tree distribution and clumping pattern of mites with comments on predator-prey interactions. Hilgardia 52 (7):1-13.

Zalom, F. G., M. A. Hoy, L. T. Wilson, and W. W. Barnett. 1984. Sampling mites in almonds: II. Presence-absence sequential sampling for Tetranychus mite species. Hilgardia 52(7):14-24.

Hoy, M. A. and K. B. Smith. 1982. Evaluation of Stethorus nigripes (Col. Coccinellidae) for biological control of spider mites in California almond orchards. Entomophaga 27(3):301-310.

Hoy, M. A., H. E. van de Baan, J. J. R. Groot, and R. P. Field. 1984. Aerial movements of mites in almonds: implications for pest management. Calif. Agric. 38(9):21-23.

Hoy, M. A., W. W. Barnett, L. C. Hendricks, D. Castro, D. Cahn, W. J. Bentley. 1984. Managing spider mites in almonds with pesticide-resistant predators. Calif. Agric. 38(7/8):18-20.

Zalom, F. G., L. T. Wilson, M. A. Hoy, W. W. Barnett, J. M. Smilanick. 1984. Sampling Tetranychus spider mites in almonds. Calif. Agric. 38(5/6): 17-19.

Manuscripts in Press

Hoy, M. A., J. J. R. Groot, and H. E. van de Baan. 1984/85. Influence of aerial dispersal on persistence and spread of pesticide-resistant Metaseiulus occidentalis in California almond orchards. Entomol. Expt. Appl.

Hoy, M. A. 1985. Integrated Mite Management for California Almond Orchards, in: Spider Mites and Their Control, Eds., W. Helle and M. W. Sabelis, Elsevier Sci. Publ.

I look forward to cooperating on future projects, so please give me a call if I can be of any assistance.

Best regards,

Bill

W. W. Barnett
Area IPM Specialist

WWB:mlb

cc: Lowell N. Lewis
Edward S. Sylvester