INTEGRATED CONTROL OF THE CARMINE SPIDER MITE ON PAPAYA

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ABSTRACT

The potential importance of the western predatory mite, *Galendromus occidentalis* **Nesbitt in the management of the carmine spider mite,** *Tetranychus cinnabarinus* **(Boisduval) was evaluated during a 1-year period on papaya trees at Kapaa, Kauai, Hawaii. One summer spray of Vendex at 0.56 kg Al/ha allowed some western predatory mites to survive and it provided adequate control of the carmine spider mite. Also, Vendex was non-phytotoxic to fruit-bearing papaya trees. A combination of malathion and sulfur, which is the standard spray used for mite and insect control on papaya, was found toxic to the predators and its extended and frequent use appears to have caused some pests to develop resistance to this combination. Conversion from a standard program of mite control which uses malathion and sulfur sprays to an integrated control program, utilizing a predator,** *G. occidentalis* **and an acaricide, Vendex, appears promising.**

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KEY WORDS: Integrated control. Carmine spider mites. *Tetranychus cinnabarinus*. Western predatory mite. *Galendromus occidentalis*. Papaya. Acaricide. Biological control. Hawaii.

INTRODUCTION

The current approach recommended to control phytophagous mites damaging fruit trees is the use of integrated control (Hoyt, 1969; Croft, 1976). This approach to mite control requires the use of a selected pesticide to control key pests and an effective insecticide-resistant predatory mite to control phytophagous mites.

Although integrated control has been reported as successful on mites attacking fruit trees, this method of control has not been attempted on papaya to date. The carmine spider mite is a key pest of papaya (Figs. 1 and 2), and for its control, malathion + sulfur sprays have been applied frequently for several years. Recently, this species of spider mites has become difficult to control, probably because it has developed resistance to the chemical sprays used. It is, therefore, essential to try the integrated approach for better management of this spider mite. To achieve this, a good biological control agent and an effective acaricide were selected.

Galendromus occidentalis Nesbitt (Fig. 3) was selected because it is an effective predator of several species of plant feeding mites, survives on alternate food sources such as honeydew and on plant exudates when the prey population is scarce (Huffaker and Kennett, 1956), seldom resorts to cannibalism, withstands a wide range of insecticides, and can be mass reared on *Tetranychus cinnabarinus* (Boisduval) in the laboratory with ease. Vendex, a tin compound, was selected because it was found to be innocuous to papaya, safe towards some beneficial arthropods, and is known to be toxic to several species of phytophagous mites in different families.

This paper presents the results of a one-year study on integrated control of the carmine spider mite on papaya at the University of Hawaii, Kauai Branch Experiment Station at Kapaa, Kauai, U.S.A.

MATERIALS AND METHODS

Effects of Vendex and Malathion on Fruit-Bearing Papaya. — Two rates of Vendex (0.56 and 1.12 kg AI/ha) and one of malathion + sulfur were sprayed twice at monthly interval on papaya trees with flowers and fruits and carefully watched for phytotoxicity symptoms. Each treatment and the control consisted of 4 trees, replicated 3 times, and arranged in a randomized block design. All treatments were applied with a power sprayer and calibrated to deliver 935 1/ha of spray solution. Triton B-1956, a spreader-sticker, was added at the rate of 1 ml/4 1 of spray solution. Care was taken to insure that all of the fruits, flowers and leaves were completely covered with the spray material. All of the fruits and flowers on each tree were counted before each spraying to determine flower and fruit drop, if any, due to the sprays. Flowers, fruits and leaves were also observed for any phytotoxicity caused by Vendex sprays.

Integration of Chemical and Biological Controls for the Management of T. cinnabarinus. — A field study on integrated control utilizing an acaricide, Vendex [Hexakis (2-methyl - 2-phenylpropyl distannoxane], and an insecticide-resistant phytoseiid mite, *G. occidentalis,* was carried out on fruit-bearing papaya trees.

The plot size in each replicate consisted of 12 trees. Each treatment was replicated 3 times in a randomized block design (Fig. 4).

Fig. 1. Damage caused by the carmine spider mite on leaves of papaya.

Fig. 2. Eggs and adults of the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval).

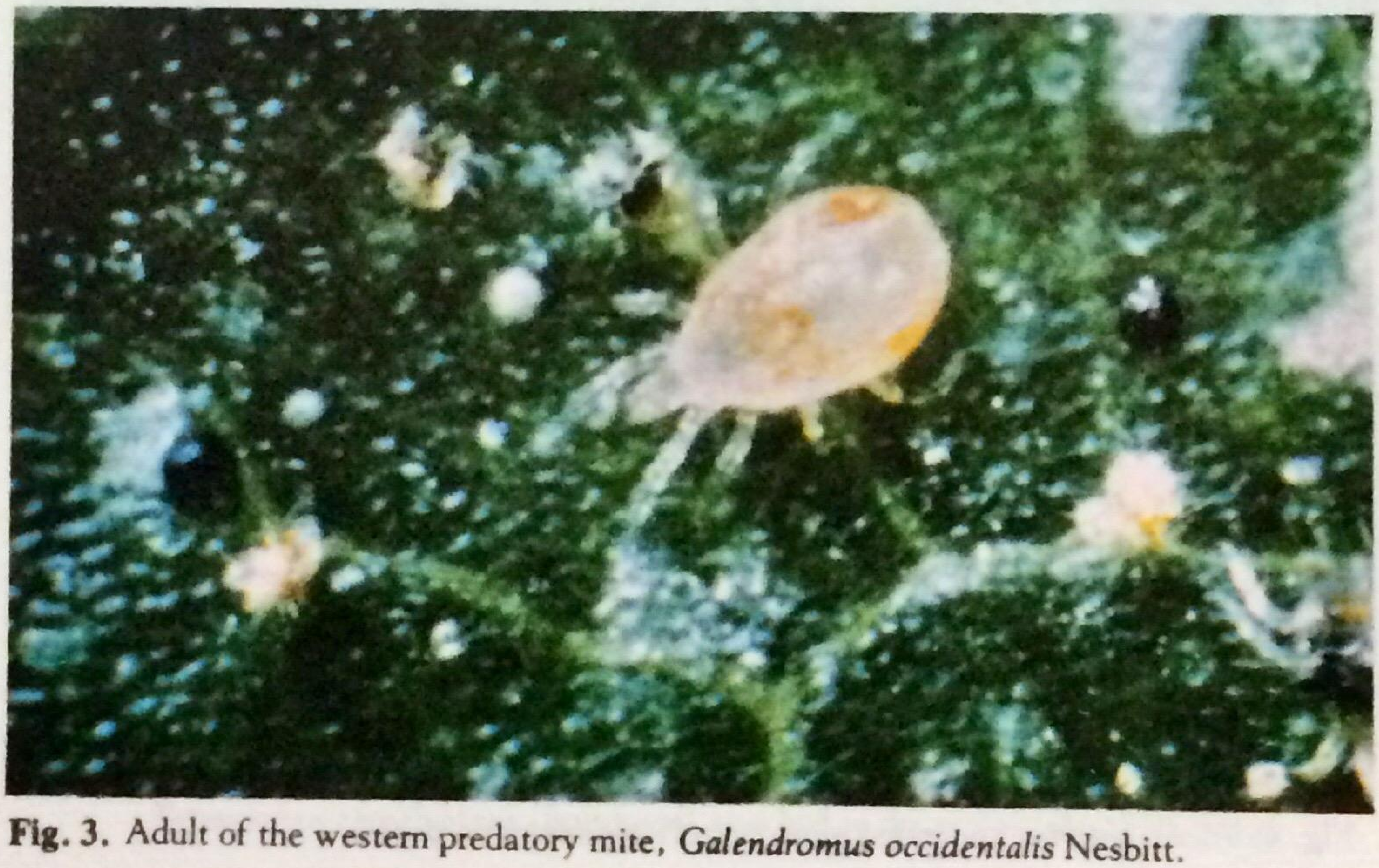

Fig. 3. Adult of the western predatory mite, *Galendromus occidentalis* Nesbitt.

The rates and frequency of spray treatments and releases of *G. occidentalis*, were as follows:

Treatment	Rate kg AI/ha	Frequency of Spraying	Predator Releases
Vendex 50% WP	0.56	3 times	3 times
Vendex 50 WP	0.56	3 times	No releases
Vendex 50% WP	1.12	3 times	3 times
Vendex 50% WP	1.12	3 times	No releases
Malathion 57% EC + Sulfur	2.24 + 6.72	3 times	3 times
Malathion 57% EC + Sulfur	2.24 + 6.72	3 times	No releases
X_1 Check		no spray	3 times
X_2 Check		no spray	No releases
X_3 Check		with pre-treatment spray	No releases

The spray volume used in this field test was 935 1/ha of spray solution. A spreader-sticker, Triton B-1956, was added to the spray solution at 100 ml/ha. The chemical solutions were applied up to drip point, using a power sprayer. Ven-

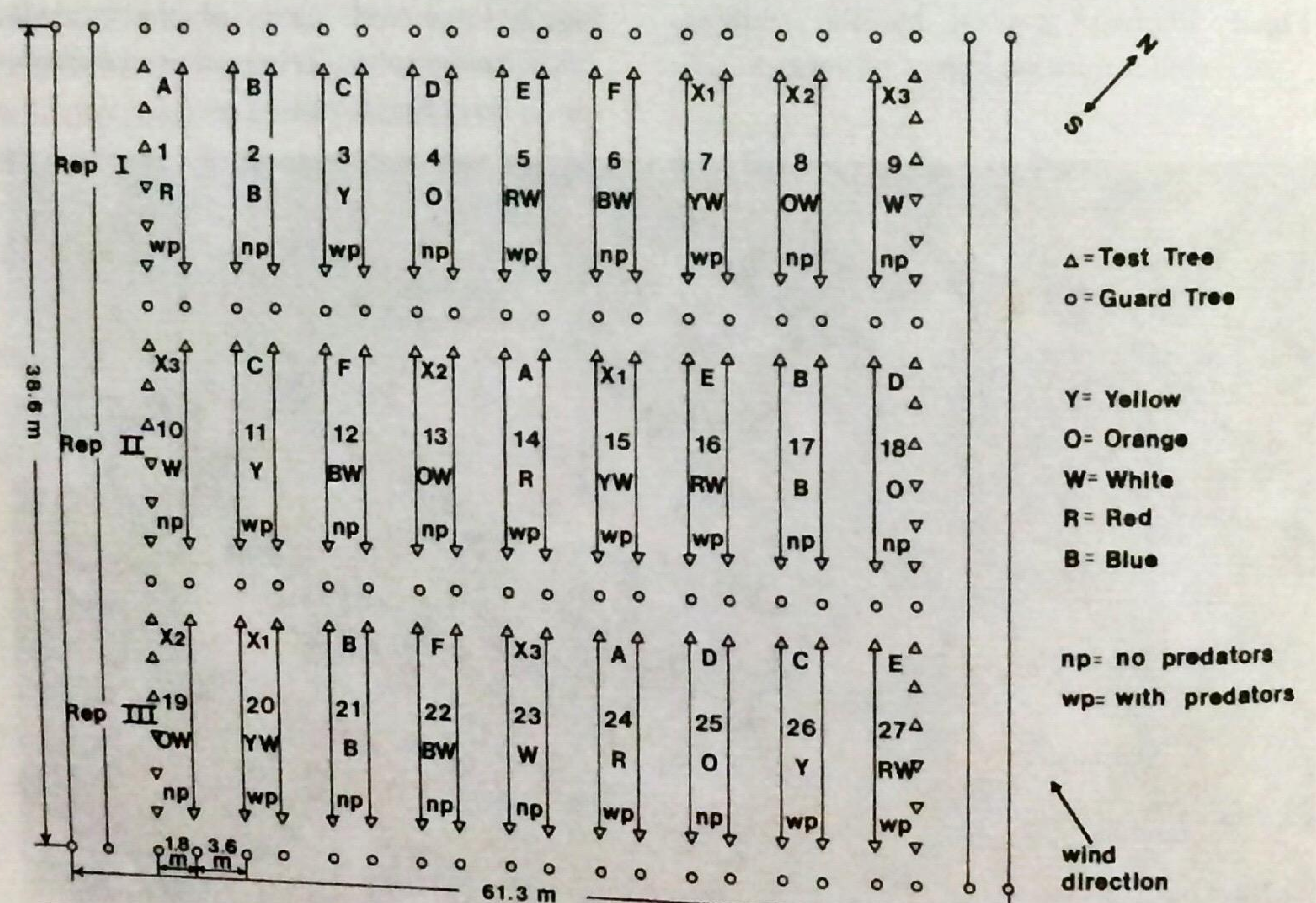

Fig. 4. Plot layout for integrated mite control experiment on papaya.

dex sprays were applied in July 1978 and in January and February 1979.

Active stages of *G. occidentalis* were released in May, June and July 1978. Initial release rates were equivalent to 50 predators per tree, or a total of 99,540 predators per hectare.

Adults of *G. occidentalis* were collected from insectary cultures by aspirating them into tubes made from plastic drinking straws. The capsules containing them were refrigerated while being transported to the field. Since carmine spider mite infestation usually starts on lower mature leaves, the capsules were attached on petioles of these leaves with flagging tapes. The polyethylene foam cup was removed allowing the predators to disperse naturally onto the other leaves. Bean leaves with carmine spider mites were also attached nearby so that food was readily available when the predators came out from the capsules (Fig. 5).

Population densities of the carmine spider mite, phytoseiid mite, and other predaceious arthropods were monitored each month starting from July 1978 to May 1979 by picking leaves from marked trees, after the third *G. occidentalis* releases were made. On each sampling date, 4 randomly selected mature leaves were taken from 8 trees in each treatment. They were cut into 10 cm^2, placed in plastic bags, transported to the laboratory and kept in the refrigerator for 24 hr. Active stages of the western predatory mite and the carmine spider mite and of other predators were

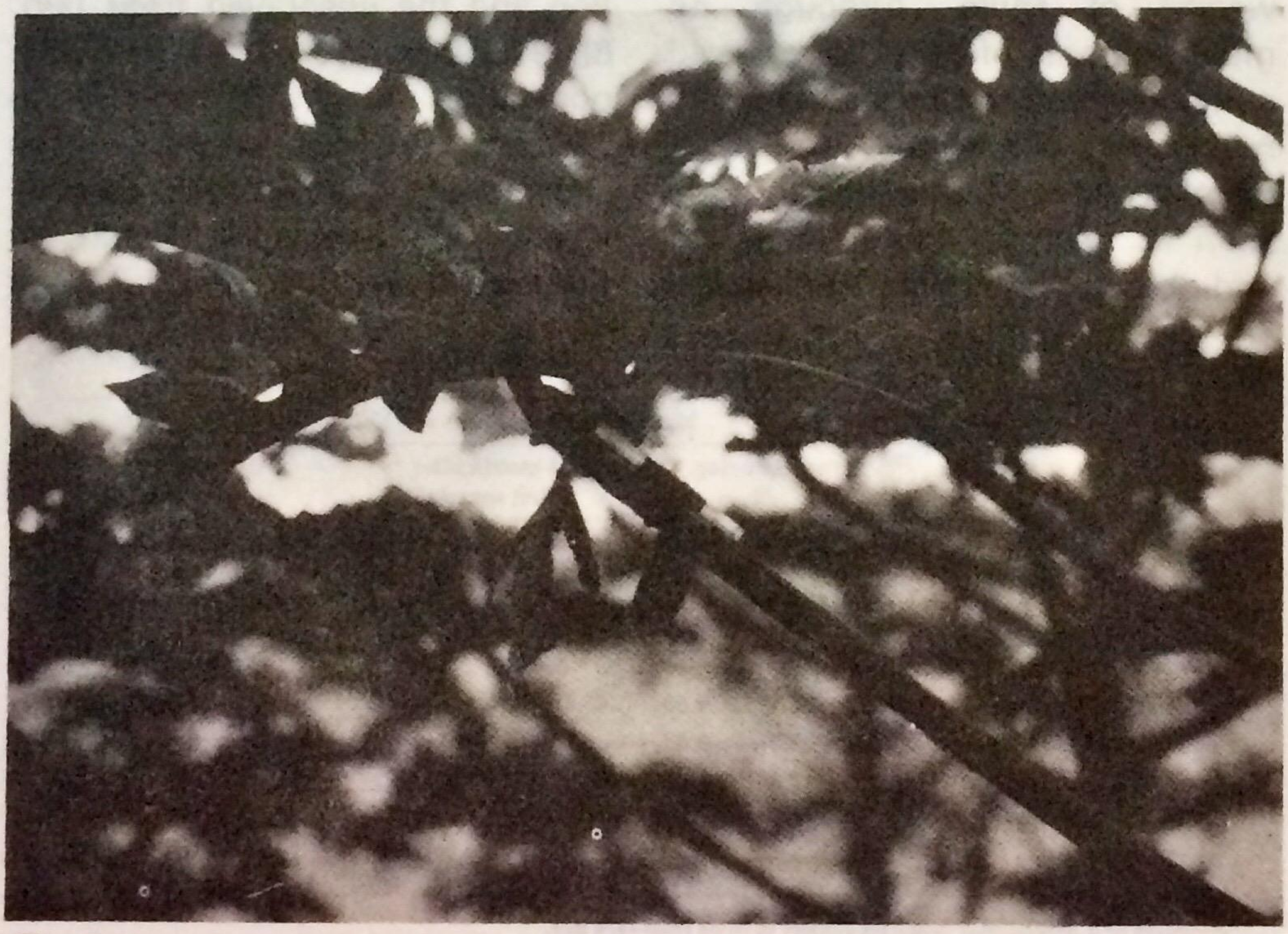

Fig. 5. Capsule with *Galendromus occidentalis* Nesbitt and bean leaflets infested with *Tetranychus cinnabarinus* (Boisduval) attached to the petiole of a papaya leaf.

counted directly by examining each leaf sample with the aid of a stereoscopic microscope.

RESULTS AND DISCUSSION

Effects of Vendex and Malathion on Fruit-Bearing Papaya.

One month after the first spray, Vendex at 0.56 and 1.2 kg AI/ha did not significantly affect the number of fruits and open flowers and weight of fruits when compared to the unsprayed trees (Table 1). Similar trend was observed in malathion + sulfur-sprayed trees. Furthermore, the second sprays applied 1 month later did not significantly affect the number of flowers and fruits and also the weight of fruits. Although no measurements of height of sprayed and unsprayed trees were made, no noticeable differences in height were evident. Morphological injury such as necrotic spots, distortion and oozing attributable to chemical sprays were not present on the fruits, flowers and leaves of trees sprayed with Vendex and malathion + sulfur.

Integration of Chemical and Biological Controls for the Management of the Carmine Spider Mite.

Table 2 and Figs. 6 and 7 show the carmine spider mite population on Vendex and malathion + sulfur sprayed and unsprayed trees. Noticeable differences occurred in the response of the carmine spider mite to Vendex and malathion + sulfur sprays in the July, September and December 1978 counts. In July 1978, both rates of Vendex significantly controlled the population of the carmine spider mite compared to the malathion + sulfur combination and the unsprayed trees (Fig. 8). The unsprayed trees had mite population ranging from 20 to 26/leaf. Vendex-sprayed trees showed significantly lower carmine spider mite population, again, in September and December 1978 and

Table 1. Effects of Vendex on fruits and flowers of papaya.[1]

Treatment	Rate	Mean Number of Fruits and Flowers[2]								
	kg AI/ha	Before Spraying			1 month after first spraying			1 month after second spraying		
		number of fruits	number of flowers	weight of fruits (kg)	number of fruits	number of flowers	weight of fruits (kg)	number of fruits	number of flowers	weight of fruits (kg)
Vendex	0.56	42.4	6.1	0.50	43.5	4.3	0.56	43.7	4.7	0.56
Vendex	1.12	42.0	3.9	0.47	45.1	4.7	0.56	45.3	4.3	0.56
Malathion + Sulfur	2.24 + 6.72	41.2	4.5	0.50	42.2	4.7	0.55	44.3	4.1	0.56
Control	—	43.0	3.8	0.49	39.6	4.9	0.55	46.9	4.8	0.57

[1] Averages of 3 replications; based on number of fruits from each tree.
[2] Means in the column are not significant at 5% level according to DMRT.

March 1979 counts. Vendex at 1.12 kg AI/ha seemed to be slightly better than Vendex at 0.56 kg AI/ha in controlling the carmine spider mite, although this higher dosage killed almost all of the predators as well.

Malathion + sulfur combination was less effective than Vendex in controlling the carmine spider mite, but trees sprayed with this combination had fewer carmine spider mite than the unsprayed ones. Although releasing *G. occidentalis* in addition

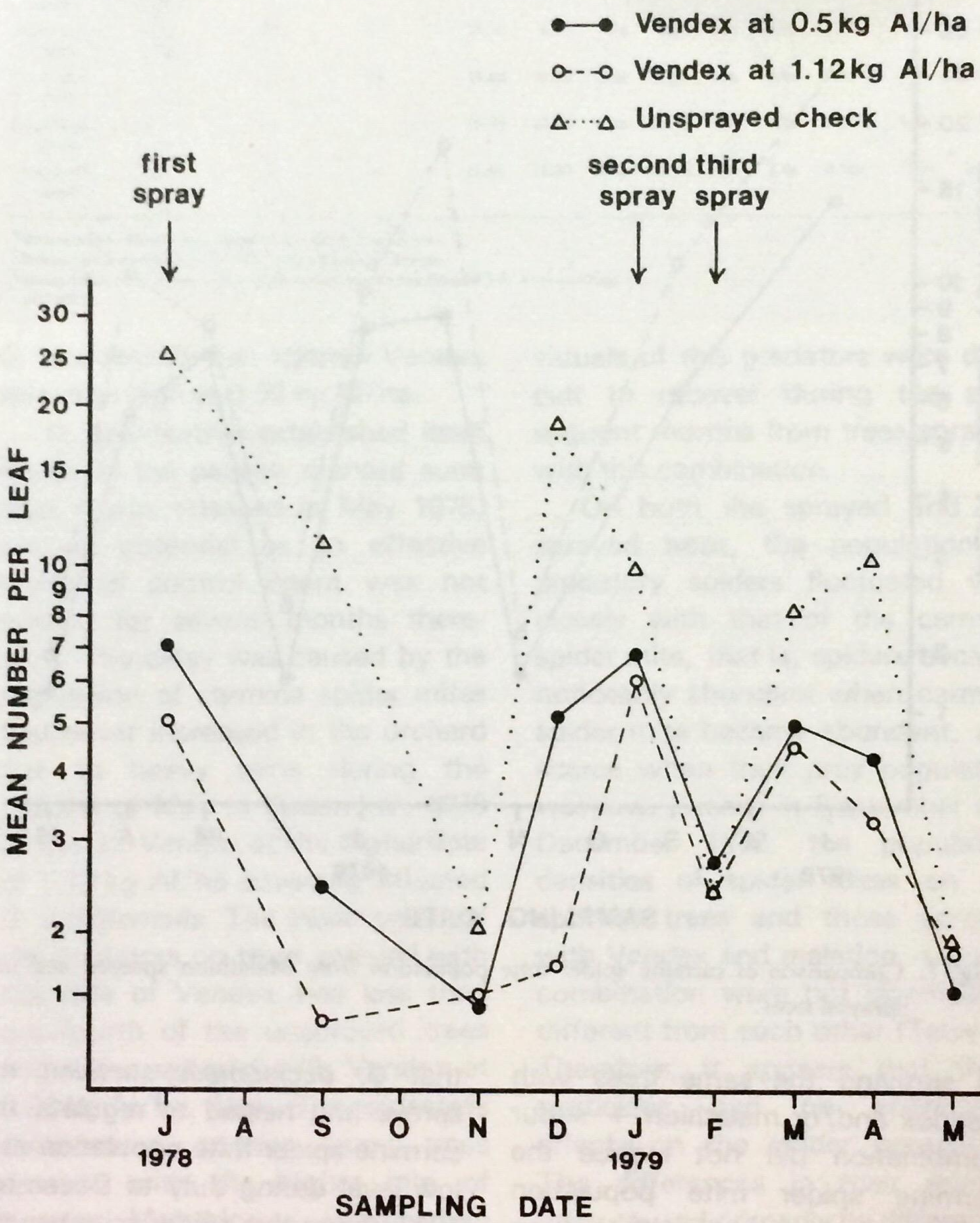

Fig. 6. Comparison of carmine spider mite population from Vendex sprayed and unsprayed trees.

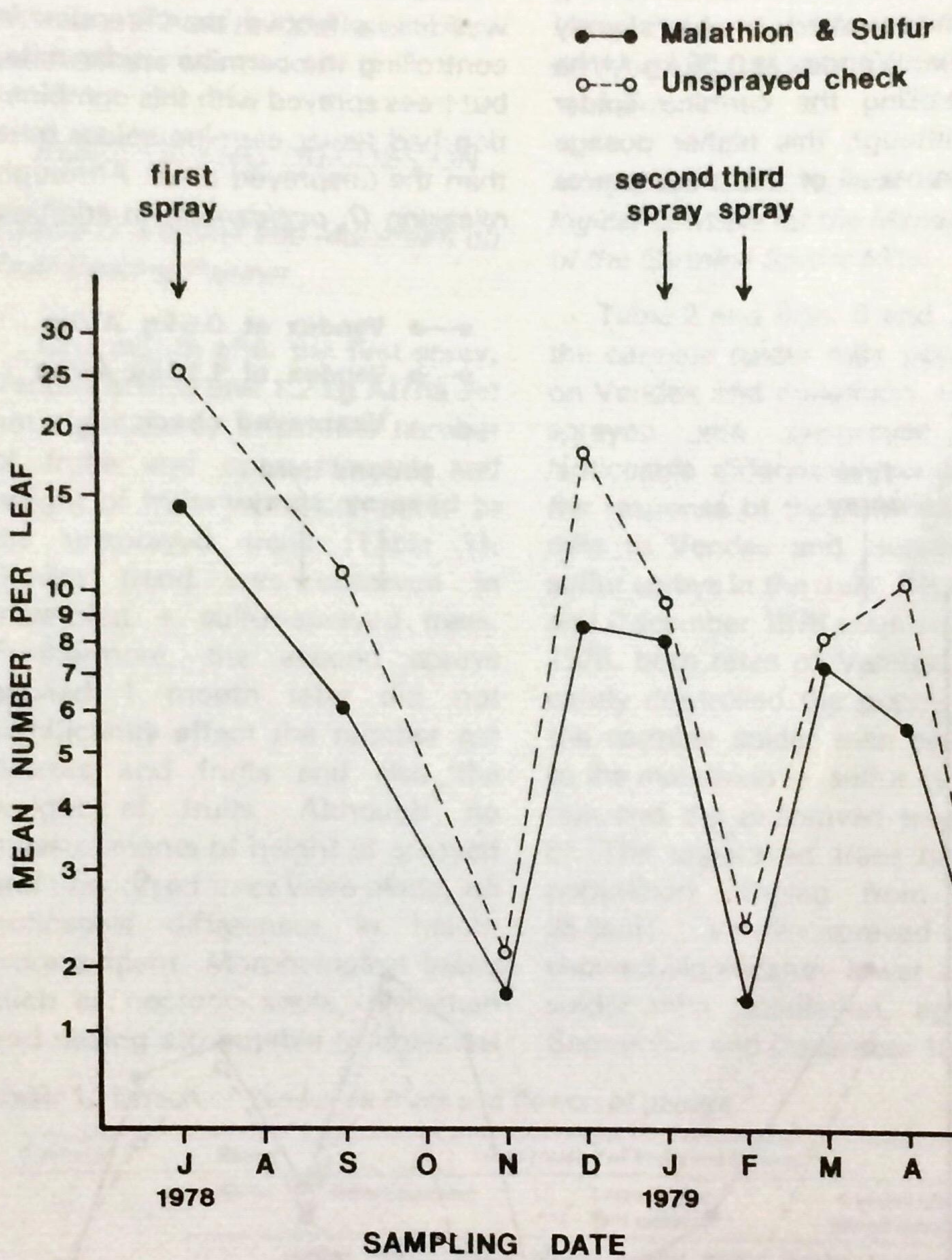

Fig. 7. Comparison of carmine spider mite population from Malathion sprayed and unsprayed trees.

to spraying the same trees with Vendex and/or malathion + sulfur combination did not reduce the carmine spider mite population faster or to a lower density than on trees sprayed with the pesticides alone, there were strong indications that *G. occidentalis* survived the sprays and helped to regulate the carmine spider mite population at a low level during July to December 1978, when this spider mite usually occurs in large numbers. Laboratory tests have confirmed that some

Table 2. Mean numbers of carmine spider mites on sprayed and unsprayed trees.[1]

Treatments	Rates kg AI/ ha	Frequency of spraying	Frequency of predatory mite releases[2]	Monthly mean numbers of carmine spider mites per 10 cm^2 leaf[3]								
				July 1978	Sept.	Nov.	Dec.	Jan. 1979	Feb.	March	April	May
Vendex WP	0.56	3X	3X	7.1ab	2.4ab	0.9a	4.2b	6.9a	2.7a	5.0ab	4.3a	1.1a
Vendex WP	0.56	3X	—	9.8b	2.3ab	1.3a	4.6b	7.3a	2.0a	5.0ab	4.3a	1.3a
Vendex WP	1.12	3X	3X	4.4a	1.4a	1.2a	1.5a	6.6a	2.1a	2.8a	4.3a	1.3a
Vendex WP	1.12	3X	—	5.0a	0.7a	1.0a	1.5a	6.1a	2.4a	4.7a	3.4a	1.8a
Malathion + Sulfur	2.24 + 6.72	3X	3X	15.9cd	5.1bc	1.2a	9.2c	8.5a	3.4a	6.3bc	7.0a	1.9a
Malathion + Sulfur	2.24 + 6.72	3X	—	14.8c	6.1c	1.6a	8.6c	8.2a	1.5a	7.3bc	5.7a	1.2a
Unsprayed check	—	—	3X	19.6d	10.2d	2.4a	10.9c	9.1a	3.0a	9.2c	8.2a	1.5a
Unsprayed check	—	—	—	19.7d	12.6d	2.1a	12.1d	9.8a	3.7a	9.0c	9.5a	1.9a
Unsprayed check	—	—	—	26.0e	11.3d	2.1a	18.3d	9.8a	2.4a	8.1bc	10.2a	1.9a

[1] Averages from 4 leaves per treatment; average of 3 replications.
[2] Release rate is equivalent to 99,540 *G. occidentalis* per hectare.
[3] Means followed by the same letter in the column are not significant at 5% level according to DMRT.

G. occidentalis can tolerate Vendex sprays as high as 0.56 kg AI/ha.

G. occidentalis established itself readily in the papaya orchard soon after it was released in May 1978, but its potential as an effective biological control agent was not evident for several months thereafter. The delay was caused by the population of carmine spider mites that never increased in the orchard due to heavy rains during the months of May to December, 1978 (Table 3). Vendex at the higher rate of 1.12 kg AI/ha adversely affected *G. occidentalis.* The initial count of the predators on trees sprayed with this rate of Vendex was less than one-fourth of the unsprayed trees and those sprayed with Vendex at 0.56 kg AI/ha. Also, *G. occidentalis* disappeared sooner from trees sprayed with the higher rate of Vendex. Malathion + sulfur spray also caused a reduction in the *G. occidentalis* population so that individuals of this predators were difficult to recover during the subsequent months from trees sprayed with this combination.

On both the sprayed and unsprayed trees, the population of predatory spiders fluctuated very closely with that of the carmine spider mite, that is, spiders became noticeably abundant when carmine spider mite became abundant, and scarce when their prey population was low. Except in September and December 1978, the population densities of spider mites on unsprayed trees and those sprayed with Vendex and malation + sulfur combination were not significantly different from each other (Table 4). Therefore, it appears that these pesticides had no appreciable effects on the spider population. The differences in their number were caused primarily by differences in the population densities of the carmine spider mite resulting from

Fig. 8. Comparison of Vendex sprayed (left) and unsprayed (right) papaya in controlling the carmine spider mite.

chemical sprays.

Table 5 shows the mean number of *Oligota* sp. on papaya sprayed with Vendex and malathion + sulfur. In December 1978 counts, both Vendex and malathion + sulfur significantly reduced the population of this staphylinid at a time when the prey was abundant. These pesticides, therefore, have to be applied carefully when *Oligota* sp. is abundant and actively preying on the

Table 3. Mean numbers of western predatory mite, *G. occidentalis*, on sprayed and unsprayed papaya trees.[1]

Treatments	Rates kg AI/ ha	Frequency of spraying	Frequency of predatory mite releases 2	Monthly mean numbers of *G. occidentalis*, per 10 cm^2 leaf								
				July 1978	Sept.	Nov.	Dec.	Jan. 1979	Feb.	March	April	May
Vendex WP	0.56	3X	3X	1.2	0.2	0	0.07	0.15	0.1	0	0	0
Vendex WP	0.56	3X	—	0	0.07	0	0	0	0	0	0	0
Vendex WP	1.12	3X	3X	0.3	0.07	0	0	0	0.2	0	0	0
Vendex WP	1.12	3X	—	0	0	0	0	0	0	0	0	0
Malathion + Sulfur	2.24 + 6.72	3X	3X	1.0	0.3	0	0.07	0.07	0	0	0	0
Malathion + Sulfur	2.24 + 6.72	3X	—	0	0	0	0	0	0	0	0	0
Unsprayed check	—	—	3X	1.7	0.3	0	0.3	0.4	0.2	0.13	0.06	0
Unsprayed check	—	—	—	0	0	0	0	0	0	0	0	0
Unsprayed check	—	—	—	0	0	0	0	0	0	0	0	0

[1] Averages from 4 leaves per treatment; averages of 3 replications.
[2] Release rate is equivalent to 99,540 *G. occidentalis* adults per hectare

Table 4. Mean numbers of spiders on sprayed and unsprayed trees.[1]

Treatments	Rates kg AI/ ha	Frequency of spraying	Frequency of predatory mite releases[3]	Monthly mean numbers of spiders per 10cm² leaf[4]								
				July 1978	Sept.	Nov.	Dec.	Jan 1979	Feb.	March	April	May
Vendex WP	0.56	3X	3X	0.7a	0.2ab	0.2a	0.3ab	0.8a	0.5a	0.3a	0.2a	0.1a
Vendex WP	0.56	3X	—	0.8a	0.2ab	0.4a	0.4ab	0.8a	0.2a	0.3a	0.2a	0.1a
Vendex WP	1.12	3X	3X	0.5a	0.1a	0.1a	0.2a	1.0a	0.4a	0.3a	0.2a	0.1a
Vendex WP	1.12	3X	—	0.3a	0.1a	0.07a	0.17a	0.8a	0.4a	0.3a	0.1a	0.1a
Malathion + Sulfur	2.24 + 6.72	3X	3X	0.9a	0.6cd	0.2a	0.67bc	0.9a	0.6a	0.5a	0.1a	0.1a
Malathion + Sulfur	2.24 + 6.72	3X	—	1.0a	0.9de	0.3a	0.5ab	0.8a	0.4a	0.3a	0.2a	0 a
Unsprayed check	—	—	3X	1.1a	0.4abc	0.4a	1.0c	1.1a	0.4a	0.4a	0.5a	0.1a
Unsprayed check	—	—	—	0.7a	0.8d	0.3a	1.0c	1.4a	0.5a	0.3a	0.3a	0.2a
Unsprayed check	—	—	—	1.2a	1.0e	0.7a	1.0c	1.3a	0.6a	0.5a	0.3a	0.3a

[1] Averages from 4 trees; average of 3 replications.
[2] Release rate is equivalent to 99,540 *G. occidentalis* adults per hectare.
[3] Means followed by the same letter in the column are not significant at 5% level according to DMRT.

Table 5. Mean number of staphylinid beetles on papaya sprayed with Vendex and malathion + sulfur.

Treatment	Rate kg AI/ha	Frequency of spraying	Frequency of predatory mite releases	Mean number of beetle[1/2] December 1978	January 1979	February 1979
Vendex	0.56	3X	3X	0.13a	0.5a	0.1a
Vendex	0.56	3X	—	0.30a	0.6a	0.2a
Vendex	1.12	3X	3X	0.07a	0.8a	0.3a
Vendex	1.12	3X	—	0.07a	0.6a	0.2a
Malathion + Sulfur	2.24 + 6.72	3X	3X	0.43a	0.8a	0.5a
Malathion + Sulfur	2.24 + 6.72	3X	—	0.13a	0.7a	0.1a
Unsprayed check	—	—	3X	1.30b	1.1a	0.3a
Unsprayed check	—	—	—	1.43bc	0.8a	0.2a
Unsprayed check	—	—	—	1.83c	1.4a	0.6a

[1] Averages from 4 leaves per treatment; average of 3 replications.
[2] Means followed by the same letter in the column are not significant at 5% level according to DMRT.

carmine spider mites.

Integrated control is a workable tool in managing the carmine spider mite on papaya. Like other fruit trees in the mainland United States, where integrated mite control was reported a success, papaya is also a long-term fruit crop which is often infested by the carmine spider mite throughout its growing period. The presence of sufficient number of carmine spider mites allows the western predatory mite to get established readily and assures its continuous survival on papaya.

Few acaricides are used for mite control on papaya because it is sensitive to most chemical sprays at any stage of its growth. At fruit-bearing stage, acaricides that are less toxic to man and do not leave harmful residues are needed because harvesting is done once or twice weekly for several months. Vendex is an acaricide that can be used for mite control at any stage of growth. It is less toxic to man, non-phytotoxic to the plant and effective against the carmine spider mite. Also, data from laboratory and field tests indicated that Vendex and *G. occidentalis* can complement each other in the management of *T. cinnabarinus* on papaya. At a rate of 0.56 kg AI/ha, Vendex was effective against the carmine spider mite and also allowed some western predatory mites to survive the treatments. Except for spiders, however, Vendex should not be recommended for use at rates above 0.56 kg AI/ha because an almost complete kill of natural enemies such as *G. occidentalis, P. maccropilis, S. siphonulus* and *Oligota* sp. is possible. Because it is a safe compound at lower dosages, effective against the carmine spider mite, and less toxic to the western predatory mite, registration for the use of Vendex at 0.56 kg AI/ha to suppress outbreaks of the carmine spider mite on papaya is being recommended.

An organo-phosphorus resistant strain of *G. occidentalis* was introduced into Hawaii from California in the early 1970's and became readily established in papaya fields sprayed frequently with malathion. It was found to be a predator easy to mass-rear on *T. cinnabarinus* in the laboratory. It has been reported to be resistant to malathion, maneb, copper sulfate and sulfur (Hussey and Huffaker, 1976), chemical compounds which are used heavily for insect and disease control on papaya. Since *G. occidentalis* is known to feed on other species of mite (Huffaker and Kennett, 1956), it may prove very useful for papaya culture as 6 species of mites other than *T. cinnabarinus* infest this crop in Hawaii (Yee *et al.* 1970).

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