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Impact of Insecticides on the Spider Mite Destroyer and Twospotted Spider Mite on Red Raspberries in Washington

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ABSTRACT

The effect of insecticide sprays on numbers of the spider mite destroyer, *Stethorus punctum picipes* Casey and twospotted spider mites, *Tetranychus urticae* Koch, in red raspberry fields, was studied. Two sprays of malathion had no effect on numbers of *Stethorus* captured in trap-colonies of spider mites. In contrast, bifenthrin and permethrin applied to raspberry fields destroyed the *Stethorus* populations and were associated with rapid increases in spider mite numbers. In a field treated with permethrin, *Stethorus* reappeared after 6–7 weeks, rapidly increased in numbers, and the spider mite population quickly decreased to virtually zero. Another commercial red raspberry field had large numbers of spider mites in 1987 and 1988 when many synthetic insecticides were used. No such chemicals have been applied since 1988. From 1989–1992 the mite population was near zero and *S. p. picipes* was found frequently on leaves and in trap colonies. Thus, *Stethorus* appeared to control mites.

KEYWORDS spider mite destroyer, *Tetranychus urticae, Rubus*, biological control, IPM

IMPACT OF INSECTICIDES ON THE SPIDER MITE DESTROYER AND TWOSPOTTED SPIDER MITE ON RED RASPBERRIES IN WASHINGTON

NOTE: This bulletin describes actual research performed in 1992. At the time of the experiments all of the named pesticides were either registered or exempted from registration under Section 18 of FIFRA. As of the revision date of this publication, many of the products are no longer registered for use on raspberries. Experimental results, therefore, should be viewed in historical context and are not to be considered recommendations for use unless specific registration status is verified with the appropriate agencies by the user.

About 80% of the red raspberries in the Pacific Northwest are harvested by machines. Many insects, along with ripe berries, are shaken off the plants by the machines. This necessitates the use of preharvest "clean-up" sprays of malathion to remove these contaminating organisms (Crandall et al. 1966, Kieffer et al. 1983). Other insecticides are also applied at times to control lepidopteran larvae and adult root weevils, especially *Otiorhynchus* spp. Permethrin and bifenthrin have both been used on red raspberries to control adult root weevils in Oregon and Washington under Section 18 Emergency Exemptions granted by the U.S. Environmental Protection Agencies.

Stethorus punctum picipes Casey is consistently found in western Washington red raspberry fields and appears to keep spider mite populations low (Congdon et al. 1993). Many pesticides are slightly to highly toxic to *Stethorus* spp. (Bartlett 1963, Colburn and Asquith 1971, Croft 1975, Hull and Beers 1985). In fact, even a moderate number of applications of most synthetic insecticides has been associated with increases in numbers of twospotted spider mite, *Tetranychus urticae* Koch, in raspberry fields (Shanks et al. 1991). Here we present the results of experiments conducted to determine the effect of insecticides on *Stethorus* and, subsequently, on spider mites in red raspberry fields and to determine how quickly *Stethorus* could repopulate a raspberry field when a population was virtually destroyed.

MATERIALS AND METHODS

Effects of Malathion on *Stethorus*. Fifty-one trap-colonies of spider mites (small artificial infestations of mites established to monitor predator activity [Congdon et al. 1993]) were placed on raspberry leaflets in both 0.1-ha. red raspberry plantings at the Washington State University (WSU) Research and Extension Unit at Vancouver, Washington, on 20 April 1992. The plantings were approximately 150 m. apart. The trap-colonies were examined for the presence of *Stethorus* adults and eggs one week later. On 28 April, one of the plantings was sprayed with malathion (Cythion 50WP [wettable powder], Chas. H. Lilly Co., Portland, OR) at the rate of 2.24 kg. (AI)/ha. in 1150 liters of water per hectare. A second set of trap-colonies were placed in both plantings on 5 May and also examined for *Stethorus* on 12 May. The sprayed plantings were resprayed on 14 May. New trap-colonies were placed in both plantings on 18 May, and these colonies were examined for *Stethorus* on 26 May.

Effects of Prebloom Sprays of Azinphosmethyl on *Stethorus*. A 0.1-ha. field of red raspberries at WSU in Vancouver, Washington, was sprayed with azinphosmethyl (Guthion 50WP) at the rate of 0.27 kg. AI in 1,975 liters of water per hectare on 10 May 1993. A similar field about 150 m. away was left untreated. Fifty-one trap-colonies of mites were placed in each field before and at irregular intervals after spraying and examined one week after placement for the presence of *Stethorus* adults and eggs.

A 1.0-ha. block of red raspberries at a commercial farm near Vancouver was sprayed with azinphosmethyl at 0.27 kg. AI by the grower, using an air-blast sprayer. An adjacent 1-ha. block was left unsprayed. Fifty-six trap-colonies of mites were placed in each block before and several times after treatment.

Effects of Bifenthrin on *Stethorus* and Spider Mites. Both the azinphosmethyl-treated block and untreated block in the previously described experiment at the commercial farm were sprayed with bifenthrin at 0.11 kg. per ha. by the grower on 21 June 1993. Fifty leaflets were picked at random from each block at approximately biweekly intervals from 11 May to 29 September and the mites were counted.

A 0.1-ha. block of red raspberries at WSU was sprayed with bifenthrin at 0.11 kg. (AI) per ha. and a second one was left untreated on 21 June 1993. The blocks were about 150 m. apart. Fifty trap-colonies of spider mites were placed in each field on 14 June and at approximately weekly intervals through 25 August. Also, fifty leaflets were collected at random from each block until 29 September and the mites and *Stethorus* were counted.

Trap-colonies of spider mites were placed on 100 leaflets in a second commercial red raspberry field of about 150 ha. on 7 June 1993 and at 1–2 week intervals thereafter. They were examined for *Stethorus* after a week. The grower applied bifenthrin at 0.11 kg. (AI) per ha. on 16 June. Trap-colonies were placed in the field through mid-August. On 16 July and at 9–14 day intervals thereafter until 29 September, 50 leaflets were picked at random and the mites were counted.

Effects of Permethrin on *Stethorus* and Spider Mites. Sixty trap-colonies of spider mites were placed in the 1.9 ha. northwest corner of a commercial field of about 20 ha. of red raspberries on 27 April 1992 and at 2–3-week intervals thereafter. The grower sprayed the field with permethrin (Ambush 2EC [emulsifiable concentrate], ICI Americas, Wilmington, DE) at the rate of 0.22 kg (AI)/ha. on 5 June 1992. Beginning 5 June, before the spray was applied, one leaflet was picked about 5 m. from both ends of rows 3–12, 18–27, 33–42, and at 2-week intervals thereafter until 21 October. The total number of mites, percentage of traps with one or more *Stethorus* of any stage, and the total number *Stethorus* of all stages was recorded on each date.

Commercial Planting with and without Synthetic Insecticides. The spider mite populations in a commercial field of red raspberries were observed for six years. In 1987, the grower applied azinphosmethyl on 4 May, malathion on 21 June, and cyhexatin on 12 August. In 1988, malathion was applied 20 May and 23 June and fenbutatin-oxide on 7 August. Additionally, dinoseb was applied to the soil and crowns in April 1987 and 1988 and the fungicides captan, benomyl, vinclozolin, and iprodione were used both years during the bloom and harvest periods. Beginning 1989, the grower applied no synthetic pesticides. *Bacillus thuringiensis* preparations were used for leafroller control thereafter.

The mite counts in 1987–89 were part of a study by Shanks et al. (1991). Fifty leaflets were collected periodically from the same five rows each year. Mite numbers were estimated in 1990–92 by collecting 50 leaflets at random in the field and counting the mites and *Stethorus.*

Results

Effects of Malathion on *Stethorus.* *Stethorus* adults were found in 12% of the trap-colonies in both the sprayed and unsprayed plantings on 27 April (before first spray). Two weeks after the first spray (12 May), the sprayed block had *Stethorus* adults in 14% of the traps while in the unsprayed block, 6% of the traps had adults. On 26 May (12 days after the second spray), 8% of the traps in both the sprayed and unsprayed plantings had *Stethorus* adults. The malathion sprays either killed few *Stethorus* beetles or the beetles repopulated the field very quickly. Although spider mites were not counted, it was obvious from looking at the foliage that very few mites were present.

Effects of Prebloom Sprays of Azinphosmethyl on *Stethorus*. Dead *Stethorus* were found in the traps early every week from spraying until the last trapping week that began on 14 June (Table 1). At that time, 54 live and 56 dead adults were found on leaves where trap-colonies were placed in the treated WSU field and 50 live and 90 dead ones were found in the treated commercial field. Additionally, some dead *Stethorus* probably fell off the leaves before they were counted. There were about three times as many live *Stethorus* seen in the unsprayed as in the sprayed fields, but egg production per live adult *Stethorus* was higher in the sprayed than in the unsprayed fields during the 5-week post-spray period. Egg production during those 5 weeks was 5.5 and 2.8 eggs per trap in the sprayed blocks and 0.8 and 0.7 eggs per live adult in the unsprayed blocks at WSU and in the commercial field, respectively. No increase in mite numbers was seen during this period.

Effects of Bifenthrin on *Stethorus* and Spider Mites. Bifenthrin rapidly killed the *Stethorus* beetles and numbers remained low the rest of the season in Commercial Field No. 1 (Table 2). Mite numbers were low until 12 August, after which they rose rapidly. By 29 September there were >740 and >220 mites per leaflet on the plots that were and were not previously treated with azinphosmethyl, respectively. No *Stethorus* were seen in either part of the field after it was treated with bifenthrin.

Bifenthrin virtually eliminated *Stethorus* at WSU (Table 2). Almost no *Stethorus* were found in trap-colonies of mites on bifenthrin-treated raspberries during the rest of the summer. Spider mite numbers were >380 and <10 mites per leaflet in the bifenthrin-treated, and untreated fields, respectively, by 29 September.

No *Stethorus* were seen after bifenthrin was applied either in the trap-colonies or on leaflets on which mites were counted in Commercial Field No. 2. On 16 July, mites were nearly nonexistent, but the numbers quickly increased thereafter. On 29 September, there were >1,000 times more mites than on 28 July.

Effects of Permethrin on *Stethorus* and Spider Mites. From 15–33% of the trap-colonies of mites had *Stethorus* adults or eggs on them before the field was sprayed with permethrin on 5 June (Table 3). No *Stethorus* were found in the traps on 17 June or 9 July. However, on 23 July, 5% of the traps had *Stethorus* adults and/or eggs and on 5 August, 26% of the leaves had *Stethorus* adults, eggs, larvae, or pupae.

No spider mites were found in the 60-leaflet sample collected on 5 June, the date of spraying. By 1 July the population averaged about 1.5 mites per leaflet, on 15 July the average was 5. Thereafter, the numbers rose rapidly to a peak of 235 mites per leaflet on 28 August. *Stethorus* began appearing 6–7 weeks after the spray was applied and the numbers grew to a peak of 2.3 *Stethorus* (all stages) on 9 September. Mite numbers began declining soon after *Stethorus* reappeared and by 7 October none were found.

Commercial Planting with and without Synthetic Insecticides. In 1987 and 1988, while synthetic pesticides were still in use in this field, spider mite numbers rose to 35 and 364 mites per leaflet (Fig. 1), respectively. In 1989, the first year of no synthetic pesticides, mite numbers remained below one per leaflet all summer. *Stethorus* numbers were not monitored from 1987–1989 because its importance as a mite predator had not yet been realized. Mite numbers also remained less than one per leaflet (near zero usually) from 1990–92. During the last three years of observation, *Stethorus* was consistently seen in low numbers (less than one per leaflet) and the mite population remained very small.

Discussion

Bartlett (1963) reported that malathion 25WP was highly toxic to *S. picipes* Casey in laboratory tests, but it had little effect on *Stethorus* numbers in our field trials. The short residual life of malathion under field conditions, plus the fact that in the field the beetles were not confined to

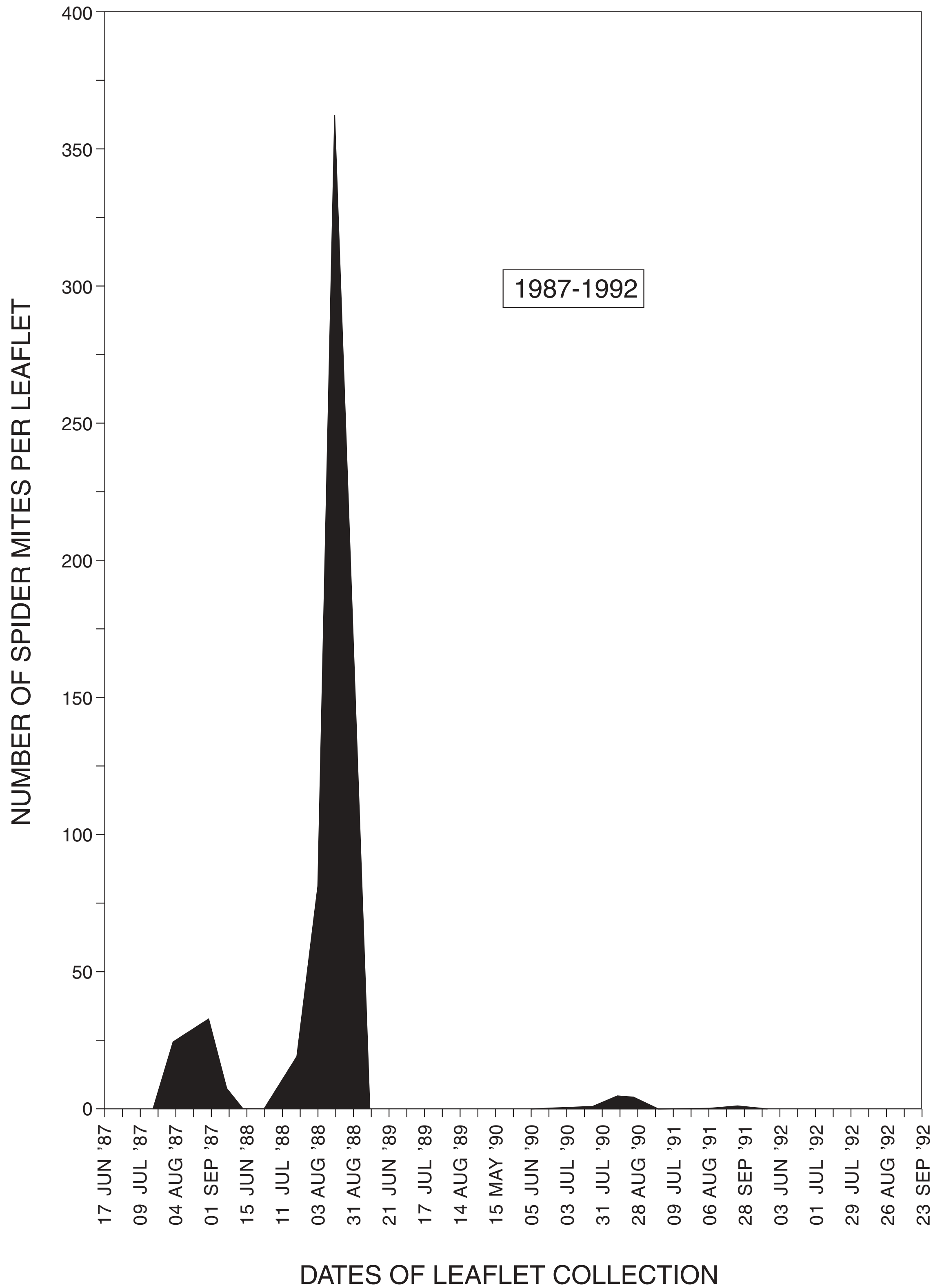

Figure 1. Number of spider mites on red raspberry leaflets when using synthetic pesticides (1987–88) and using only *Bacillus thuringiensis* (1989–92), Puyallup, WA.

Table 1. The number of *Stethorus* per 50 trap-colonies of spider mites on red raspberry leaves after prebloom sprays of Azinphosmethyl. Vancouver, WA, 1993.

	Sprayed			Unsprayed		
Dates traps were in the fields	Live adults	Dead adults	Eggs	Live adults	Dead adults	Eggs
			WSU Fields			
15–21 April	4	0	4	13	0	0
26 April–3 May[a]	17	0	0	15	0	0
11–18 May	8	13	0	11	0	6
18–25 May	25	30	0	54	0	30
25 May–1 June	8	9	77	49	0	37
1–7 June	12	0	60	24	0	19
7–14 June	5	2	121	17	0	20
14–21 June	1	5	56	7	4	11
TOTALS: prespray	20	0	4	28	0	0
TOTALS: postspray	59	59	314	162	4	122
			Commercial Fields			
26 April–3 May	–	0	0	2	0	0
3 May–11 May[a]	110	0	0	4	0	0
11–18 May	4	32	0	29	0	3
18–25 May	25	35	1	15	0	4
25 May–1 June	8	6	64	34	0	45
1–7 June	7	2	41	32	7	27
7–14 June	7	4	3	28	0	11
14–21 June	10	4	55	16	0	14
TOTALS: prespray	169	0	0	159	0	0
TOTALS: postspray	59	81	163	153	7	102

[a]Azinphosmethyl applied on 10 May (0.25 lb ai per acre).

Table 2. Populations of *Stethorus punctum picipes* and twospotted spider mites on red raspberry leaves following applications of insecticides, Vancouver, WA, 1993.

Dates of observations[a]	% traps with adult *Stethorus*	No. Mites/ 50 leaflets	% traps with adult *Stethorus*	No. Mites/ 50 leaflets	% traps with adult *Stethorus*	No. Mites/ 50 leaflets
	WSU Field					
	Azinphosmethyl, 10 May Bifenthrin, 23 June		Untreated			
15 April	11	–	24	–		
25 April	29	–	26	–		
3 May	29	–	20	–		
12 May	35	0	16	1		
18 May	65	–	72	–		
25 May	67	–	69	–		
1 June	41	1	47	2		
7 June	49	–	40	–		
26 June	0	10	0	4		
7 July	0	–	0	–		
14 July	0	–	0	2		
21 July	0	–	8	–		
29 July	0	15	12	–		
4 August	0	–	–	–		
12 August	0	388	6	16		
18 August	0	65	6	–		
25 August	–	–	0	–		
1 September	–	4,766	–	148		
15 September	–	18,630	–	59		
29 September	–	19,050	–	487		
	Commercial Field No. 1				*Commercial Field No. 2*	
	Azinphosmethyl, 10 May Bifenthrin, 23 June		Bifenthrin, 23 June		Bifenthrin, 16 June	
3 May	4	–	4	–	–	–
7 May	7	1	8	–	–	–
18 May	7	–	43	–	–	–
25 May	27	–	19	–	–	–
1 June	9	9	50	4	–	–
7 June	7	–	45	–	–	–
14 June	7	–	43	–	17	–
21 June	11	1	24	0	0	–
30 June	0	11	0	0	–	–
16 July	0	–	0	5	0	2
28 July	0	1	0	0	0	50
12 August	0	396	0	14	0	563
18 August	0	211	0	24	0	2,182
1 September	–	7,619	–	191	–	11,984
15 September	–	24,120	–	4,455	–	35,025
29 September	–	37,725	–	11,190	–	51,525

[a]Traps were in the field for 1 week prior to observations.

one treated surface, may explain why the chemical had little effect on the beetle in most fields. The results indicate that malathion applied to red raspberries at registered rates usually is not a threat to this valuable predator.

Hull et al. (1985) reported that permethrin was the only one of six pyrethroids applied to apple trees that allowed substantial survival of *S. punctum* (Le Conte). Hull and Starner (1983) also reported susceptibility of *S. punctum* to four pyrethroids, including permethrin, but observed possible selectivity in favor of *S. punctum* after three years of applications. However, in our study permethrin virtually eliminated *S. punctum picipes* from one raspberry field for about 6 weeks, which resulted in a rapid and severe increase in spider mites (Table 3).

Bifenthrin was selected in 1993 for use against adult black vine weevil, *Otiorhynchus sulcarus* (F.), under a U.S. Environmental Protection Agency Section 18 Emergency Exemption. Permethrin was used in this way in 1987–92 and growers reported that they almost always had spider mite problems later. Since bifenthrin has acaricidal properties, it was hoped that it would keep mites in check along with the weevils. However, the opposite happened and mite numbers were much higher in the bifenthrin-treated field than in the permethrin-treated field. Hull et al. (1985) observed that bifenthrin (FMC-54800) suppressed *S. punctum* populations through July and August, but because of its acaricidal activity, European red mite, *Panoncychus ulumi* (Koch), numbers remained low. That

Table 3. Effect of a Permethrin spray on numbers of *Stethorus* adults and eggs in trap-colonies of spider mites on red raspberry leaflets before and after treatment and *Stethorus* and spider mites after treatment, Vancouver, WA, 1992.

		Counts on leaflet samples	
Date[a]	% traps with *Stethorus*[b]	No. mites per leaflet	No. *Stethorus*[c] per leaflet
27 April	33	–	–
12 May	15	–	–
5 June[d]	17	0	0
17 June	0	0	0
1 July	–	2	0
9 July	0	–	–
15 July	–	5	0
23 July	5	–	–
29 July	–	31	0.3
5 August	26	–	–
28 August	–	235	1.1
9 September	–	106	2.3
23 September	–	4	0.5
7 October	–	0	0.1

[a] Date that traps were examined or that leaflets were picked.
[b] Adults and eggs.
[c] All life stages.
[d] Field was sprayed on this day after the traps were examined and leaflets were collected.

was not true with twospotted spider mite on red raspberry in the Pacific Northwest. In addition to the results reported herein, some growers and county agents also reported severe mite problems after the use of bifenthrin, although other growers reported no mite problems. Bifenthrin should not be used to control mites.

A strong negative association existed between the amount of pesticide usage and spider mite numbers in the field reported in Fig. 1. It is impossible to know which chemicals or combinations of chemicals were responsible, but it is assumed that destruction of *Stethorus* caused the high mite numbers in 1987 and 1988. It is the only predator of spider mites present in Washington raspberry fields in sufficient numbers and at the right time to suppress the mites. Malathion was the only synthetic insecticide used in 1988, and it had no effect on *Stethorus* numbers in other field trials reported herein. It is possible that factors such as timing of application, weather, etc., might have made the malathion residues more detrimental to the beetle. Also, effect of fungicides on the beetle is not known.

Since most of the data were collected in commercial or commercial-type red raspberry fields, it was not possible to arrange experiments so that the data could be analyzed by traditional statistical methods. However, since there were multiple sites, we can conclude that the use of broad-spectrum insecticides such as azinphosmethyl and bifenthrin harms or kills *Stethorus* predators and can lead to increases in numbers of spider mites on red raspberries in Washington State.

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