3. Pesticide Resistance
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1. Twospotted spider mite, apple, pear

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Evidence for Reversion to Susceptibility to Vendex in Twospotted Spider Mite (*Tetranychus urticae*) populations from pear orchards in Washington. Resistance to organotins (OTs) in mite populations from pome fruits in the Pacific northwest has been well documented. Much of the original research was on the OT cyhexatin, but cross resistance to the closely related compound fenbutatin oxide (Vendex) was thought to occur. When cyhexatin was voluntarily withdrawn from the market by its manufacturer in 1987, growers were obliged to switch to other acaricides. Those already experiencing poor control with cyhexatin quickly found that fenbutatin oxide provided no better control. As field failures became common, the further use of fenbutatin oxide was precluded.

Mite control on apples since 1989 has generally been accomplished either with biological control (ca. 90% of the acreage) or with propargite. Mite control on pears has been achieved through the use of avermectin for pear psylla control. Rates of avermectin used for pear psylla are typically 16-20 fl oz/acre, much higher than the rate needed to control mites (ca. 5-10 fl oz/acre). Avermectin has been available for use on pears under an Emergency Exemption (Section 18 of FIFRA) from the 1988 through the 1994 growing seasons. Typically, it has been applied 1-2 times per season. Use of this material has been extremely widespread in Washington, with ca. 95% of pear acreage treated.

Fenoxycarb was available for the first time in 1994 under an Emergency Exemption for pre-bloom pear psylla control. The high cost ($200/acre) of this 2-spray program was a disincentive for growers to apply further controls for pear psylla unless absolutely necessary. Thus, mite populations became established in some pear orchards for the first time in seven years. This allowed a re-evaluation of susceptibility or resistance status to various miticides. On apples, there appeared to be a significantly greater number of reports of mite populations than in previous years. Although reasons for this are unknown, the increased use of carbamates in the pest management programs for fruit thinning, western tentiform leafminer (*Phyllonorycter elmaella* Doganlar & Mutuura), and aphid (*Aphis pomi* De Geer) control may be contributory.

T. urticae were taken from commercial orchards in Washington. Three were from pear and one was from a mixed population of *P. ulmi* and *T. urticae* on apple (Beebe 16b). A fifth population was from a laboratory colony reared on bean (Table 1). The populations from commercial orchards were reared on lima bean until sufficient numbers were obtained for bioassay. Bean leaf disks (2 cm diam.) were floated bottom surface uppermost in a plastic portion cup filled with cotton and distilled water. Five adult females were transferred to the lower surface of each disk. The bioassay consisted of six concentrations with ten replicate disks per concentration (50 females per concentration). The concentrations of fenbutatin oxide were made from Vendex 4L . Mites were treated topically for 5 s (with a 5 s settling time) with a Potter Spray Tower calibrated to deliver 1.1 kg/cm^2. The initial concentration series was 2,000, 1,000, 500, 250, 125 and 0 mg (AI)/liter. All concentrations but the check killed virtually 100% of the mites in the first two populations assayed. Based on these data, a new series (125, 62.5, 31.25, 15.625, 7.8125, and 0 mg [AI]/liter) was used for the succeeding bioassays.

All populations tested were reared for ca. 52 days in colony on bean, or approximately 5 generations (Table 1). It is possible that some reversion may have occurred while the mites were held in colony, but the degree to which this occurred is unknown. The estimated LC_{50}s range from 8.3 to 15.8 mg (AI)/liter (mean 12.6 mg [AI]/liter) (Table 2). These are admittedly poor estimates given the high χ^2 values, however, they are several orders of magnitude lower than

those found in 1989 (Knight et al. 1990). In the 1989 study, the 72 h LC_{50}s for *T. urticae* populations from apple and pear ranged from 98 to 4,507 with a mean of 843 mg (AI)/liter; there was an 8-fold difference between the lowest LC_{50} found in 1989 and the average LC_{50} found in this study. High mortality (>94-100%) was found in the three highest concentrations (Table 3). Substantial mortality (67-100%) occurred at the next highest concentration (15.6 mg (AI)/liter), and low to moderate mortality occurred at the lowest concentration (7.8 mg (AI)/liter).

Despite the questions raised by the intervening time in colony, these data provide the first indication that mite populations in Washington may have reverted to susceptibility to fenbutatin oxide. The LC_{50}s observed in this study should correspond to good field control with rates as low as 0.42 lb (AI)/acre (13.4 fl oz/acre).

Table 1. Characteristics of *T. urticae* populations bioassayed with fenbutatin oxide, 1994

Population	County	Source	Dated Collected	Date Assayed
Smith - Hill	Chelan	pear	22 July	12 Sept.
Smith - Home	Chelan	pear	22 July	12 Sept.
Laboratory	Chelan	vegetables	--	12 Sept.
Bryant	Chelan	pear		12 Sept.
Beebe	Douglas	apple	26 July	12 Sept.

Table 2. Probit analysis of five populations of *T. urticae* bioassayed with fenbutatin oxide, 1994

Population	χ^2	Heterogeneity	LC_{50}	(95% F. L.)	Slope ± SE
Smith - Hill	30.902	10.301	10.835	-	4.129 ± 0.677
Smith - Home	0.000	0.000	12.658	-	11.117 ± 8.791
Laboratory	29.411	9.804	15.877	-	27.614 ± 5931641
Bryant	3.254	1.085	15.229	(10.804 -19.745)	5.897 ± 0.986
Beebe	0.000	0.000	8.340	-	29.997 ± 5443247

Table 3. Mean percentage mortality of *T. urticae* adult females treated with various concentrations of fenbutatin oxide, 1994

Concentration (mg (AI)/liter)	Uncorrected % mortality				
	Beebe[z]	Bryant[z]	Laboratory	Smith/Hill	Smith/Home
125	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
62.5	100.00 a	100.00 a	100.00 a	97.78 a	100.00 a
31.25	100.00 a	94.17 a	100.00 a	100.00 a	100.00 a
15.625	100.00 a	67.59 b	76.00 b	84.00 a	87.78 a
7.8125	25.21 b	8.44 c	28.61 c	30.67 b	11.67 b
0	6.00 c	13.08 c	86.67 ab	12.21 c	10.00 b

Means within columns followed by the same letter are not significantly different (Waller-Duncan *k*-ratio *t*-test, *k*-ratio=100).
[z]Data transformed (arcsine$\sqrt{y}$) before analysis