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

Elizabeth H. Beers
Tree Fruit Research & Extension Center
1100 N. Western Ave.
Wenatchee, WA 98801

Evidence for Resistance to Agri-Mek in Twospotted Spider Mite (*Tetranychus urticae*) populations from pear orchards in Washington. Spider mites were taken from various commercial pome fruit orchards in Washington. In general, *Tetranychus urticae* was most common on pear, and *Panonychus ulmi* on apple. *P. ulmi* populations were tested within 48 h of collection from the field, and stored at ca. 5°C during the interim. *T. urticae* populations were either tested immediately upon receipt from the field (within 48 h), or 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. Ten adult females were transferred to the lower surface of each disk. The bioassay consisted of six concentrations (0.01, 0.005, 0.0025, 0.00125, 0.000625 and 0 mg (AI)/liter), with highest concentration at the discriminating concentration for *T. urticae* as reported by Knight et al. (1990). The same concentration series was used for *P. ulmi*, although Knight et al. (1990) considered the data too variable to recommend a discriminating concentration. The highest concentration had 10 replicates, the other concentrations five. The concentrations of avermectin were made from Agri-Mek 0.15EC.

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. They were held at 24°C for 72 h, then evaluated by prodding gently with a camel hair brush. Data were analyzed initially with POLO-PC. Resistance ratios were calculated as the LC_{50} colony tested/LC_{50} baseline for that species. The baseline used was the mean LC_{50} for that species as reported by Knight et al. (1990), viz., 0.0026 for *P. ulmi*, and 0.0011 mg AI/liter for *T. urticae*. Overall, fit of the probit model was poor for the majority of the populations (Table 1). Fiducial limits were generated for only 6 of the 17 populations tested. The difficulty in interpreting avermectin bioassays may have contributed to variability of results; some severely intoxicated mites were still capable of locomotion. Actual levels of mortality were probably underestimated.

Despite these caveats, there is evidence for resistance to Agri-Mek in all *T. urticae* populations from commercial orchards. The maximum allowable use in Washington during this period (1988-1994) on pear would be 2 applications/season at 20 fl oz/acre/application; most of the orchards received 6-12 applications. Using the criteria of Flexner et al. (1988) (see footnote), none of the *P. ulmi* populations tested were resistant. All *T. urticae* populations except the laboratory colony were considered either in transition to resistance (6 populations) or resistant (3 populations). Even the *T. urticae* population from apple, with no history of avermectin use, showed a transitional level of resistance.

The likelihood of predicting field failure with a discriminating concentration bioassay is related to the difference between the discriminating concentration, the LC_{99} and the field rate. In this case, the discriminating concentration of 0.01 mg (AI)/liter (0.8 ml formulation/acre) is still ca. 700-fold lower than the full field rate of 20 fl oz/acre (7.02 mg [AI]/liter). Although this is an extremely large "safety margin", continued selection pressure could rapidly increase the level of resistance. Mite populations in Washington pear orchards are at a stage where the development and implementation of a resistance management strategy, through rotation of acaricides or enhanced biological control, is a necessity if we are to prevent field failures of Agri-Mek.

Table 1. Probit analysis of populations of *P. ulmi* and *T. urticae* bioassayed with avermectin, 1994

Mite Species	Crop Source	Orchard	n	LC_{50} (mg AI/liter)	90% Fiducial Limits lower	upper	slope	SE of slope	χ^2	Resistance Ratio[z]
ERM	Apple	Arnold, G. #1	182	0.0029	0.0012	0.0041	3.918	1.357	1.955	1.11
ERM	Apple	Arnold, G. #2	166	0.0037	0.0020	0.0054	4.523	0.813	6.317	1.41
ERM	Apple	Beebe 16b	296	0.0016	--	--	6.903	1.606	8.310	0.60
ERM	Apple	Mathison	203	0.0026	--	--	27.514	3170595	0.425	0.99
ERM	Apple	Mattawa Organic	164	0.0039	--	--	5.489	1.259	13.247	1.48
ERM	Apple	Soaring Eagles	155	0.0032	--	--	5.255	1.311	18.819	1.22
ERM	Apple	Vaughn	232	0.0018	0.0015	0.0021	3.164	0.405	2.080	0.68
TSM	Apple	CV-11	289	0.0071	--	--	3.131	1.015	6.256	6.41
TSM	Bean	Lab colony	293	0.0025	--	--	26.184	2241949	4.235	2.26
TSM	Pear	Bryant	287	0.0076	--	--	2.529	0.563	7.847	6.93
TSM	Pear	Griggs, Marcus	249	0.0143	--	--	2.342	1.049	3.581	13.04
TSM	Pear	Lane, Bruce	187	0.0054	0.0033	0.0073	4.482	0.962	4.087	4.92
TSM	Pear	McDivett	221	0.0109	--	--	22.767	1712317	2.349	9.91
TSM	Pear	Smith, Fred (hill)	256	0.0056	0.0037	0.0072	4.283	0.601	7.148	5.06
TSM	Pear	Smith, Fred (home)	287	0.0048	--	--			20.158	4.34
TSM	Pear	Soaring Eagle	285	0.0155	--	--	4.115	3.439	2.968	14.08
TSM	Pear	Talley, Randy	291	0.0072	0.0046	0.0087	6.384	1.120	7.035	6.52

[z]Resistance Ratio = Observed LC_{50}/Susceptible LC_{50}. Baselines for susceptible mite popualations were 0.0026 (ERM) and 0.0011 (TSM) (Knight et al. 1990).
Resistance Ratio Classification (Flexner et al., 1988: RR<3, not resistant; 3≥RR≤7, in transition; RR>7, resistant)