Insecticidal Mixture Interactions Against B-strain Sweetpotato Whitefly (Homoptera: Aleyrodidae)[1]

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Abstract During 1992-1993, nine insecticides and eight mixtures of these insecticides at a 1:1 ratio were tested for their toxicity to adults of the B-strain whitefly, *Bemisia tabaci* (Gennadius), collected from cotton plants in a greenhouse in the Lower Rio Grande Valley of Texas. Synergistic, additive, or antagonistic properties of the mixtures were determined in a glass vial bioassay. Endosulfan+bifenthrin was the most toxic mixture tested and was synergistic with a median lethal concentration (LC50) that was significantly less than the LC50s of either insecticide tested alone. Acephate+bifenthrin and amitraz+bifenthrin provided additive toxicity while amitraz+buprofezin and endosulfan+methyl parathion were antagonistic in their effect on adult whiteflies.

Key Words B-strain whitefly, insecticide mixtures, glass vial method, antagonism, additivity, synergism.

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius) B-strain (also known as silverleaf whitefly, *Bemisia argentifolii* [Bellows and Perring]), is an important crop pest (Norman et al. 1993) and has become resistant to many insecticides in parts of the United States. Resistance development could threaten traditional chemical control techniques (Cahill et al. 1995, Denholm et al. 1995). Certain combinations of contact insecticides, such as fenpropathrin or bifenthrin plus acephate, have provided excellent control of whitefly in greenhouse and field studies as long as there was thorough coverage of the foliage (Riley and Sparks 1993). Mixtures of bifenthrin with endosulfan or methomyl were very toxic to adults (Toscano et al. 1994). Little specific information is available on whether mixtures used against the B-strain whitefly are synergistic, additive, or antagonistic (Horowitz and Ishaaya 1995). In this study we determined the toxicity of insecticide mixtures and insecticides alone against the B-strain whitefly using a glass vial bioassay.

Materials and Methods

Common names of the insecticides used in the study and their sources were: acephate and fenpropathrin (Valent, Inc., Richmond, CA); amitraz and buprofezin (Agr-Evo, Inc., Wilmington, DE); azinphosmethyl (Bayer, Inc., Kansas City, KS); bi-

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fenthrin and endosulfan (FMC. Princeton, NJ); methyl parathion (Cheminova, Denmark); and piperonyl butoxide (Roussel-Uclaf, Inc., Passaic, NJ).

Adults of the B-strain whitefly used in these bioassays were collected from vegetable crops at the Texas A&M experiment station in Weslaco. Whiteflies were maintained on cotton in a greenhouse for 1 yr prior to these bioassays and handled as described by Gage et al. (1992). They were determined to be B-strain by Polymorphic Chain Reaction (PCR) conducted by A. C. Bartlett (pers. comm., 1991).

Bioassays were conducted from September 1992 to June 1993 at Weslaco. The interior surfaces of glass vials (13 mm diam × 100 mm length) were coated with 0.625 ml of solutions containing a range of concentrations (µg/vial) in a 1:1 ratio with minimum and maximum levels as follows: acephate+bifenthrin (0.00625 to 0.625); acephate+fenpropathrin (0.0000625 to 6.25); amitraz+bifenthrin (0.12 to 62.5); amitraz+buprofezin (0.2275 to 62.5); azinphosmethyl+piperonyl butoxide (0.00625 to 62.5); amitraz+endosulfan (0.055 to 62.5); endosulfan+bifenthrin (0.000625 to 250.0); and; endosulfan+methyl parathion (0.91 to 62.5). Tested in the same manner were minimum and maximum levels of acephate (0.00625-250.0); amitraz (0.006-312.5); azinphosmethyl (0.125-250.0); bifenthrin (0.031-62.5); endosulfan (0.00625-62.5); fenpropathrin (0.00000078-62.5); methyl parathion (0.000125-75.0); piperonyl butoxide (0.975-125.0), and; buprofezin (15.625-250.0). The number of concentrations tested ranged from eight to 15 for mixtures or compounds alone. Fewer number of concentrations were used for mixtures than for insecticides alone.

From 10 to 30 adults were dislodged from infested leaves of various crops into a yellow plastic funnel (15 cm diam and 20 cm length) and were transferred to an insecticide-coated vial. Each concentration was replicated 2 to 8 times with each vial containing the same concentration representing a replicate. Vials containing insects were held in the laboratory at 25 ± 3°C, with a photoperiod of 14:10 (L:D) h. The exposure to light increased the chances of adults contacting the insecticide coating because they are positively phototrophic. Untreated check vials were included for each concentration of each test. After 3 h (Gage et al. 1992), dead and moribund adults were gently tapped from the vials onto a flat, black surface. Dead adults were characterized as those individuals that did not move, walk or fly, and moribund adults as those that could not right themselves or, if on their backs, could not move their legs and wings in a coordinated manner. Live insects remained in the vial and moved as they commonly move when free. The number of adults tested in each category was determined and the dead+moribund adults were totalled for each vial.

The total numbers of dead+moribund adults for each concentration were subjected to probit analysis (SAS 1988) to determine slope ± SE (standard error), LC50, and 95% confidence intervals (CI). Ratios of ≤ 1.96 for slope/SE indicated a nonsignificant regression. LC50 values were not considered to be significantly different if the 95% CIs overlapped.

Synergism, additivity, or antagonism between the two insecticides in a mixture were determined by comparing overlapping or nonoverlapping 95% CIs of the LC50 values of the compounds alone with the LC50 values of the 1:1 ratio of their mixture (Robertson and Preisler 1992). If the LC50 value of the mixture was significantly less than the value for either compound alone, the mixture was considered to be synergistic. If the LC50 value of the mixture was not significantly different from that of one of the compounds, the mixture was classed as additive. If the LC50 value of the mixture was significantly greater than the value of one or both of the compounds

Table 1. Toxicity of mixtures and their insecticide components to adults of a greenhouse reared B-strain sweetpotato whitefly bioassayed in glass vials. Weslaco, Texas. 1992–1993

Mixture and components	Number treated	Slope ± SE	LC50 (μg/vial)	95% confidence interval
Acephate + bifenthrin	783	1.28 ± 0.24	0.14	0.044–0.35
Acephate + fenpropathrin	756	0.90 ± 0.16	0.031	0.0092–0.089
Amitraz + bifenthrin	699	0.70 ± 0.17	0.11	0.00092–0.47
Amitraz + buprofezin	1028	0.33 ± 0.15	21805.0	∞
Amitraz + endosulfan	540	0.26 ± 0.16*		
Endosulfan + bifenthrin	773	0.73 ± 0.10	0.00023	0.000058–0.00059
Endosulfan + methyl parathion	778	0.81 ± 0.18	326.81	108.7–540.29
Azinphosmethyl + piperonyl butoxide	438	−0.01 ± 3015400.0*		
Acephate	467	0.57 ± 0.18	46.18	3.11–21197
Bifenthrin	697	1.33 ± 0.14	0.13	0.082–0.19
Amitraz	906	0.94 ± 0.27	13.66	3.69–83.74
Endosulfan	426	1.64 ± 0.34	9.05	4.49–14.36
Buprofezin	789	0.27 ± 0.076	7313752.0	49940–1.25×10^{14}
Fenpropathrin	1388	0.16 ± 0.097*		
Azinphosmethyl	801	0.096 ± 0.18*		
Piperonyl butoxide	792	0.63 ± 0.27	193.18	∞
Methyl parathion	924	4.27 ± 1.78	39.42	7.63–60.95

* Slope/SE ratios of ≤1.96 indicating non significant regressions.

alone, the mixture was classed as antagonistic. No comparisons were possible where nonsignificant regression was determined.

Results and Discussion

Endosulfan+bifenthrin was the most toxic mixture of eight tested (Table 1) and was synergistic (95% CI of the mixture did not overlap with those of either compound alone). The mixture was 39,348 and 565-fold more toxic than endosulfan and bifenthrin alone, respectively. It was interesting to note that the slopes of endosulfan and bifenthrin alone were steeper (between 1 to 2) than the slope of the mixture (<1). The slope for the mixture did not parallel either insecticide alone.

The mixtures of acephate+bifenthrin, and amitraz+bifenthrin were determined to be additive because 95% CI overlapped one of the compounds alone. Amitraz+buprofezin, and endosulfan+methyl parathion were antagonistic as toxicants of adult silverleaf whitefly. Acephate+fenpropathrin, amitraz+endosulfan, and azinphosmethyl+piperonyl butoxide resulted in a nonsignificant regressions.

Bifenthrin was the most toxic to adults with an LC50 of 0.13 µg/vial. Fenpropathrin treatments resulted in a nonsignificant regression, and mortality effects were distributed equally over all the concentrations. LC50 values with organophosphorus insecticides were 39.42, and 46.18 µg/vial for methyl parathion and acephate, respectively, and they were not statistically different ($P > 0.05$). Azinphosmethyl caused 10% mortality at 125 µg/vial. The LC50 value for endosulfan was 9.05 µg/vial. The growth regulator buprofezin was not toxic to adults of the B-strain. Piperonyl butoxide and endosulfan were toxic, but not as toxic as bifenthrin (Table I).

Mixing chemicals offer many possibilities in the search for better and more potent use of toxicants. This investigation shows endosulfan+bifenthrin as a synergistic mixture and the most toxic of these tested here. The use of this mixture can provide effective control of *B. argentifolii* which has demonstrated an ability to reduce efficacy of single insecticides. High cost and development of resistance have proven to be limiting factors in insecticide use to control *B. argentifolii,* and the effectiveness of the few currently registered insecticides could be lost if they are excessively and repeatedly applied. Mixtures of insecticides which are synergistic are excellent alternatives to the use of single insecticides and may lower insecticide doses, extend the commercial life of toxicants, enchange pest control and, help retard the evolution of resistance. Presumably the endosulfan+bifenthrin mixture will be effective even if one of the insecticides losses its effectiveness and perhaps costs for mixture will be less than either insecticide alone.

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