Mortality of Susceptible and Resistant *Heliothis virescens* Larvae Exposed to Various Petroleum Oils and Insecticide Rates[1]

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ABSTRACT Spray table tests with cotton *Gossypium hirsutum* L. leaves demonstrated that petroleum oil/diluent residues caused higher mortality in laboratory susceptible tobacco budworm, *Heliothis virescens* L., larvae than in a laboratory resistant strain. Paraffinic diluents with bifenthrin caused higher mortality of the susceptible and resistant larvae under conditions of long-term exposure to spray residues than bifenthrin in an isoparaffinic oil or an aromatic solvent. None of the bifenthrin-oil treatments increased mortality above water-bifenthrin in either resistant or susceptible strains.

KEY WORDS Cotton, tobacco budworm, resistant, susceptible, bifinthrin, petroleum oil.

In the United States during 1993 over 5 million ha were planted to cotton. Cotton production in the Mississippi Delta and in most other production areas of the U. S. requires extensive use of insecticides to maintain arthropod pest populations below economic levels. The Mississippi Cotton Insect Control Guide lists sixteen different pests that feed on cotton from emergence to maturity. At least 300% more insecticide per ha is used on cotton than on any other major field crop, with an average of 1.8 kg [AI]/ha of insecticide applied annually (USDA 1989a, b).

Oils have been used as insecticide additives for many years. Herbert (1933) reported that the brown apricot scale was controlled by aerial sprays of nicotine-dormant oil mixtures. Various other oils have been used as pesticide additives, and directly as insecticides or acaracides. Laboratory tests (Ochou 1985, Hesler 1986) showed that mineral oils significantly increase mortality of eggs and first-instar tobacco budworm, *Heliothis virescens* (F.), larvae when applied at dosages of 300 µg/vial. Oils are commonly used in the field as adjuvants in conventional sprays and as carriers in ultra low-volume insecticide applications. In some cases the effectiveness of an insecticide was increased when mixed in oil rather than water (Luttrell and Wofford 1984, Treacy et al. 1985). However, oils have not always improved insecticide efficacy (Ware et al. 1983, Ochou 1985).

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Resistance to pyrethroid insecticides by field populations of the tobacco budworm is well documented (Plapp and Campanhola 1986, Luttrell et al. 1987, Roush and Luttrell 1987, Elzen et al. 1990). In Mississippi, the majority of all pesticide applications to cotton are applied in water. There are no new chemicals readily available to replace the presently used pyrethroid insecticides. Research aimed at increasing the efficacy of pyrethroid insecticides is needed. The present study determined the effects of various synthetic oils used alone and in combination with the pyrethroid bifenthrin on mortality of tobacco budworm larvae.

Materials and Methods

Several petroleum oils and solvents with and without bifenthrin (FMC, Philadelphia, PA) were applied to Delta Pine 20 (DPL-20) cotton leaves utilizing a laboratory spray chamber as described by Elzen et al. (1987, 1989). The petroleum oils tested were Orchex 796, Isopar V, Aromatic 200 (Exxon Company, Houston, TX) and Sunspray 7N (Sun Refining and Marketing Co., Philadelphia, PA). Orchex 796, Isopar V, and Aromatic 200 are paraffinic petroleum oil (C-23), isoparaffinic solvent (C-17), and an alkylnaphthalene aromatic solvent (C-11/C-12), respectively (Manthey et al. 1989). Sunspray 7N is a paraffinic petroleum oil (C-15-C-30) (Sun 1990).

Susceptible larvae used in the test were obtained from the USDA's rearing facility at Stoneville, MS. The resistant larvae were from a field population brought into the laboratory after surviving two applications of cypermethrin at 0.04 kg [AI]/ha. Exposure to the same rate of cypermethrin in the laboratory resulted in 98% and 40% mortality in the susceptible and resistant strains, respectively. In the bioassay procedure, leaves were placed in Petri dishes (100 × 15 mm) on moistened filter paper, sprayed with oils and formulated bifenthrin (0.24 kg[AI]/liter)/oil combinations using an air-assist Lo-Air nozzle calibrated to deliver the equivalent of 3.1 liters per ha. Third-instar tobacco budworms were immediately placed on sprayed leaves. Petri dishes were covered with a ventilated lid to confine larvae to treated leaves. Susceptible larvae were exposed to the oils and oils plus bifenthrin at rates of 0.011 and 0.022 kg [AI]/ha. Resistant larvae were exposed to the oils and oils plus bifenthrin at rates of 0.034 and 0.056 kg [AI]/ha. Bifenthrin rates were purposely kept below the low and high recommended rates of 0.045 and 0.11 kg [AI]/ha so that the effects of the treatments could be determined on each strain. Each treatment had 3 replications of ten sprayed leaves with one larva per leaf. Constant temperature (26°C) and humidity (70%) with 12 h light were maintained during the test. Mortality was recorded at 24, 48, and 72 h, and the effects of the various treatments were determined by using the total mortality after 72 h.

The experimental design was completely random with treatments (bifenthrin rate and oil) in a 2 × 5 factorial arrangement. Susceptible and resistant populations were subjected to separate analyses of variance with treatment means separated by least significant difference (SAS Institute 1987).

Results and Discussion

Significantly less ($P < 0.05$) mortality due to the four petroleum oils was observed in the resistant strain (4.7%) than in the susceptible (8.85). The factors that confer resistance to insecticides may have helped produce the higher survival rate of the resistant larvae exposed to the various oils. The application of different rates of bifenthrin caused significant differences in mortality in both susceptible ($P > F = 0.0004$) and resistant ($P > F = 0.0247$) populations. Rate and oil interactions for both susceptible ($P > F = 0.4207$) and resistant larvae ($P > F = 0.7746$) were not significant. The average mortality of the resistant population exposed to the 0.034 and 0.056 kg[AI]/ha rates of bifenthrin was 38.7 and 53.0%. Average mortality of the susceptible when exposed to 0.011 and 0.022 kg[AI]/ha was 59.3 and 79.3%. Mean percent mortality of resistant and susceptible tobacco budworm exposed to excised cotton leaves treated with bifenthrin (averaged over two rates) in different oil carriers is shown in Fig. 1. In the susceptible strain the highest mortality (among oil treatments) was observed in the Orchex plus bifenthrin treatment, although it did not differ statistically from the water plus bifenthrin and the Sun Oil plus bifenthrin treatments. All three treatments had significantly higher mortality ($F = 10.49$, df = 4, $P > 0.0001$) than the Aromatic and Isopar plus bifenthrin treatments.

Similar trends for mortality were observed in the resistant strain that were exposed to increased rates of bifenthrin. The water, Orchex and Sun Oil treatments had significantly higher mortality ($F = 5.00$, df = 4, $P = 0.0024$) than the Isopar and Aromatic treatments. Again, the water plus bifenthrin treatment had the highest morality but did not differ statistically from Orchex or Sun Oil.

Earlier studies of petroleum oils applied in two droplet sizes showed that there was a decrease in mortality of tobacco budworm associated with the use of Aromatic 200 and Isopar V (Womac et al. 1990). Our results agree with these findings and also demonstrate that certain petroleum oils used as carriers of insecticide can have a negative effect on efficacy. The increased resistance of the tobacco budworm to pyrethroid insecticides has resulted in reduced levels of control. As demonstrated here, some carriers reduce efficacy; therefore, more investigations into the interactions of insecticides with various petroleum and crop oils are needed to ensure optimum insecticide efficacy.

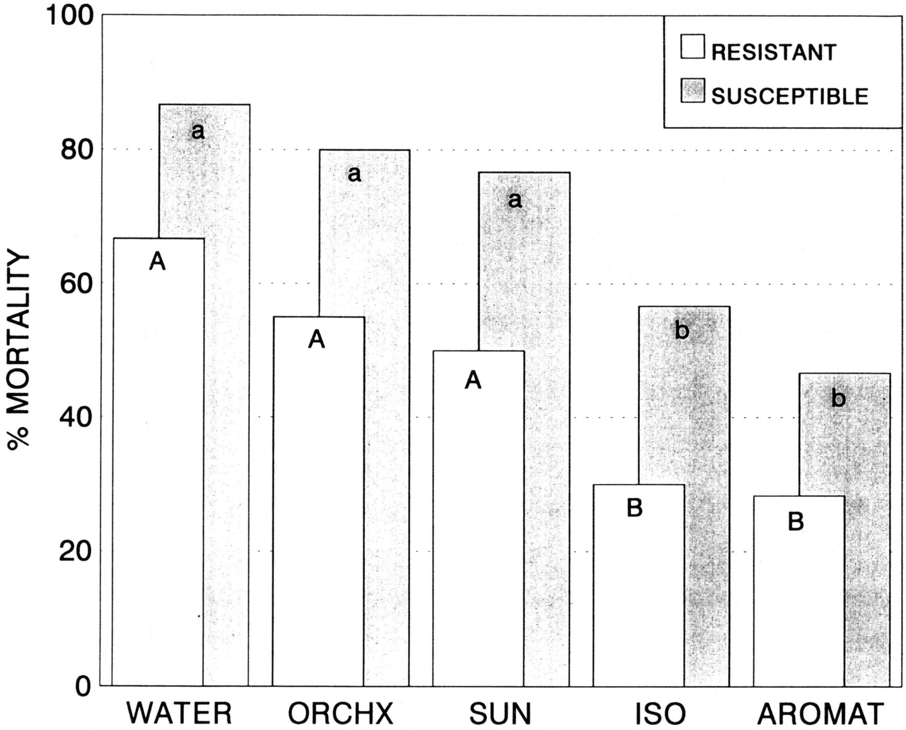

Fig. 1. Mean percent mortality of resistant and susceptible 3rd-instar tobacco budworm exposed to excised cotton leaves treated with bifenthrin (averaged over rates) in different oil diluents. Means with the same letter (resistant insects have capital letters) are not significantly different ($P > 0.05$; LSD, LSD test [SAS Institute 1985].

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