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Acaricidal and stimulatory effects of insecticides on *Tetranychus urticae* Koch (Acari: Tetranychidae) in cotton

LJ Wilson,[1] GA Herron,[2] LR Bauer[1] and DA Lally[1]

[1]*CSIRO Division of Plant Industry, Cotton Research Unit, Locked Bag 59, Narrabri, NSW 2390, Australia (Email: lewisw@mv.pi.csiro.au).*
[2]*NSW Agriculture, Elizabeth Macarthur Agricultural Institute, PMB No. 8, Camden, NSW 2570, Australia.*

Abstract Possible stimulatory or acaricidal effects of thiodicarb, dimethoate and endosulfan on the two-spotted spider mite, *Tetranychus urticae* Koch, were tested in a glasshouse. Population development of *T. urticae* was monitored, with the expectation that any stimulatory or acaricidal effects would be reflected in different population growth relative to untreated plants. Acaricidal activity of the three insecticides was also investigated using a standard bioassay technique. Population growth on thiodicarb- or dimethoate-treated plants was no different to that on untreated plants but was slower on plants treated with endosulfan. Bioassays showed that endosulfan was moderately acaricidal, that *T. urticae* was highly resistant to dimethoate and that thiodicarb was of very low acaricidal activity. No evidence of stimulatory effects of dimethoate or thiodicarb was found. The data suggest that stimulation is an unlikely explanation for outbreaks of *T. urticae* in cotton and that endosulfan sprayed for control of *Helicoverpa* spp. may delay the development of mite outbreaks.

Key words dimethoate, endosulfan, stimulatory effects, thiodicarb, two-spotted mites.

INTRODUCTION

Outbreaks of tetranychid mites (Acari: Tetranychidae) in agricultural or horticultural systems often occur following application of broad-spectrum insecticides (McMurtry *et al.* 1970). Mechanisms proposed to explain such outbreaks include either reductions in the abundance of predators of mites (McMurtry *et al.* 1970) or 'stimulatory' effects, including hormoligosis (Bartlett 1968). Proposed stimulatory effects involve altered mite metabolism following contact with insecticide residues which results in faster development, increased fecundity or altered sex ratios of spider mites (Bartlett 1968; Dittrich *et al.* 1974). Less direct effects, such as improved nutritional quality of the host plant (Maggi & Leigh 1983) or dispersal and release from competition (Penman & Chapman 1988; Gerson & Cohen 1989), may also be involved. Although there is considerable evidence from laboratory studies to support the potential role of such stimulatory effects in outbreaks of mites, supporting evidence from field studies is limited.

Application of the insecticides thiodicarb or dimethoate to Australian cotton fields to control pests such as *Helicoverpa* spp. or thrips causes outbreaks of two-spotted mites (*Tetranychus urticae* Koch) (Wilson *et al.* 1996, 1998). These insecticides, although belonging to older insecticide groups (carbamate and organophosphate, respectively), are still widely used in Australian cotton. However, no information is available from Australia or elsewhere on the possible stimulatory effects of thiodicarb or dimethoate on *T. urticae*. The primary aim of this study was to test if stimulatory effects could explain the outbreaks of *T. urticae* on cotton following application of thiodicarb or dimethoate.

Conversely, application of endosulfan to field-grown cotton to control *Helicoverpa* spp. does not cause outbreaks of *T. urticae* in Australia (Wilson *et al.* 1998). It is possible that endosulfan is moderately acaricidal. However, there is little information on the susceptibility of *T. urticae* to this compound. The second aim of this study was to investigate the acaricidal efficacy of endosulfan against *T. urticae*.

MATERIALS AND METHODS

Influence of pesticide application on mite population growth

The rationale for this study was that by comparing the population growth of *T. urticae* on plants treated with insecticides with that of *T. urticae* on untreated plants, any stimulatory effects should be apparent as faster population development on the insecticide-treated plants. Conditions approximating those of the field were used to make the study more realistic. This included consideration of the plant canopy structure, method of insecticide application and the within-plant and within-leaf distribution of the spider mites.

Experiments were conducted during the spring of 1993, 1994 and 1995 (experiments 1–3, respectively) and one in late summer 1996 (experiment 4) in a temperature-regulated glasshouse at the Australian Cotton Research Institute (ACRI) (30°13′S, 149°47′E), 25 km west of Narrabri in New South Wales. Glasshouse temperatures ranged between 20 and 35°C. Cotton seeds, cultivar Deltapine 90, were sown into 25-cm diameter pots (two in each pot) filled with soil taken from a cotton field at ACRI. Pots were arranged in a randomised block design on benches where each block consisted of one pot of each treatment. Within each block, plants were rotated among positions each week to allow for any position effects that may affect growth within the glasshouse. Plants were thinned to one per pot at about the two-leaf stage.

At about the fonr- to eight-leaf stage, two freshly emerged adult female *T. urticae*, obtained from a glasshouse cnltnre, were placed on each of the third and fourth mainstem node leaves below the terminal of each plant. Spider mites were allowed to settle for a day, then counted, as described below, and spray treatments imposed. The cnlture of *T. urticae* was maintained on cotton in a separate glasshouse. It was initiated in 1989 using material from commercial cotton crops and regularly infused with new field material to maintain vigour and to reflect the pesticide resistance characteristics of local populations of *T. urticae*.

Insecticide treatments nsed emulsifiable concentrate formulations of dimethoate (140 g ai/ha, experiments 1 and 2), endosulfan (735 g ai/ha, experiments 1 and 2) and thiodicarb (750 g ai/ha, all experiments). Untreated controls were included in each experiment. Treatments were replicated 17 times in experiment 1 and 15 times in experiments 2, 3 and 4.

Insecticides were applied using a purpose-built ground sprayer in a manner that wonld give similar coverage to a standard field application (Maggi & Leigh 1983). The sprayer was set np with three nozzles per row as described in Wilson *et al.* (1998). Plants of each treatment were qnickly removed from the glasshonse and placed in a straight line on an adjacent grassed area, approximately 10–15 cm apart, and sprayed. Insecticides were applied at mid-morning in light winds. Plants were sprayed a total of three times at intervals of between 7 and 10 days.

Assessments were made by connting the total number of adult female *T. urticae in situ* on the top five mainstem node leaves of each plant. Other arthropods that had invaded the glasshonse were also counted, as they could have affected resnlts. Spider mites and invading predators were counted between insecticide sprays and a final connt made within 1 week of the final application. The final count for experiment 4 was made after mites had been washed from plants using a leaf-washing machine (Leigh *et al.* 1984). This allowed numbers of immature mites to be counted.

All data were transformed (ln x + 1) and analysed using the SuperAnova package (Version 1.1.1, Abacus Concepts,

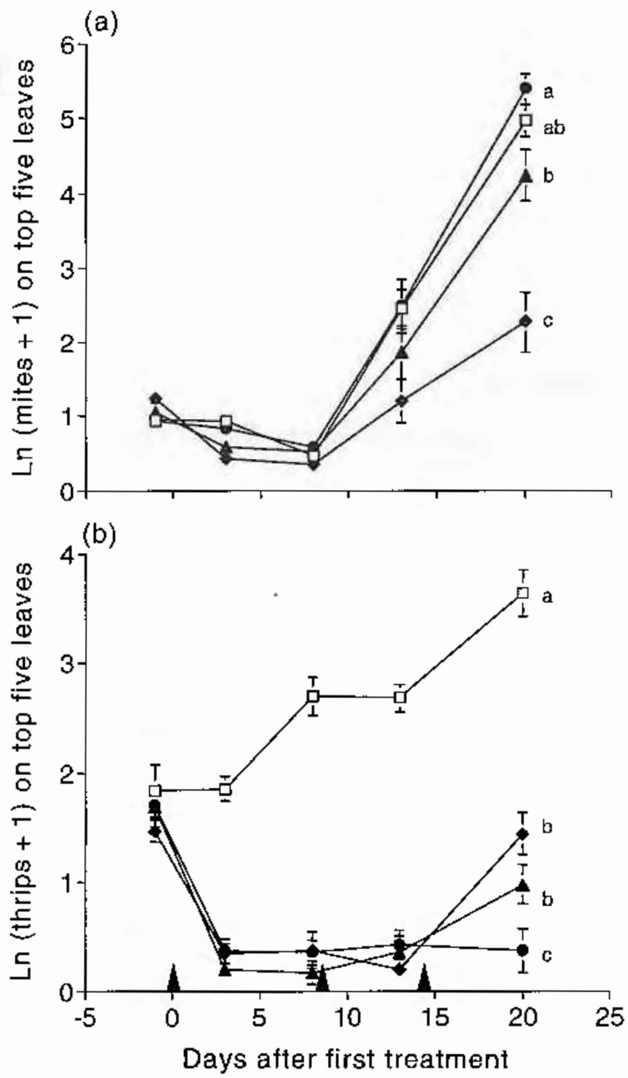

Fig. 1. Abundance (mean ± SE) of (a) *Tetranychus urticae* and (b) *Thrips tabaci* on glasshouse-grown cotton plants treated three times with three insecticides (applications indicated by arrows) or untreated in experiment 1: -□-, untreated; -◆-, endosulfan; -●-, thiodicarb; -▲-, dimethoate. Means with same letter are not significantly different ($P = 0.05$). Mean number of mites on the top five leaves: untreated, 143.8; endosulfan, 9.6; thiodicarb, 219.6; dimethoate, 68.7. Mean number of thrips on the top five leaves: untreated, 38.2; endosulfan, 4.2; thiodicarb, 1.4; dimethoate, 2.6.

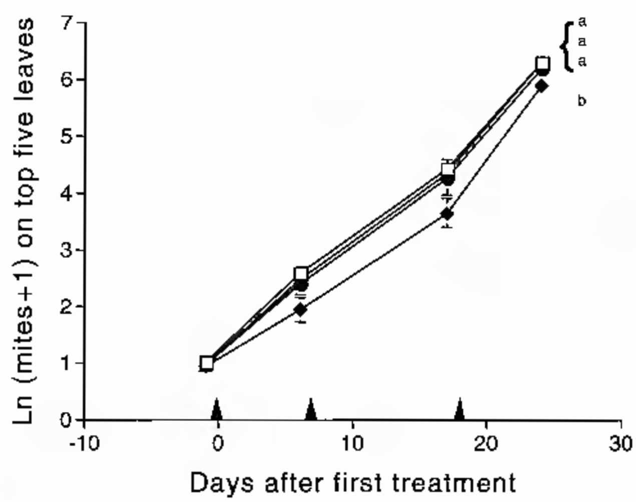

Fig. 2. Abundance (mean ± SE) of *Tetranychus urticae* on glasshouse-grown cotton plants treated three times with three insecticides (applications indicated by arrows) or untreated in experiment 2: -□-, untreated; -◆-, endosulfan; -●-, thiodicarb; -▲-, dimethoate. Means with same letter are not significantly different ($P = 0.05$). Mean number of mites on top five leaves: untreated, 541.9; endosulfan, 366.9; thiodicarb, 490.8; dimethoate, 548.9.

Acaricidal effects of endosulfan, dimethoate and thiodicarb

There was a negligible, 1.2-fold difference in response to endosulfan between the susceptible and field-collected strains (Table 1). In contrast, there was a > 1000-fold difference in the level of response to dimethoate between the susceptible and field-collected strains. The LC_{50} values for both the susceptible and field-collected strains against thiodicarb were found to be > 10 g ai/L; however, the dose–response tests could not be completed for either strain because of low mortality (susceptible 21% mortality at 10 g ai/L and field-collected 0% mortality at 10 g ai/L).

DISCUSSION

Spraying populations of *T. urticae* with thiodicarb or dimethoate did not cause them to increase in number at a faster rate than untreated populations. We therefore found no evidence that the insecticides we used changed the reproductive potential of *T. urticae* populations in any way. This indicates that possible stimulatory effects of these insecticides are not likely to significantly affect the population growth of *T. urticae* under field conditions.

Thrips tabaci was recorded in several experiments and, although predatory on eggs of *T. urticae*, was unlikely to have significantly influenced results as the numbers recorded were too low in comparison to the abundance of *T. urticae*. Any negative effect on population growth of *T. urticae* due to predation by *T. tabaci* would have resulted in reduced mite numbers on untreated plants, thereby exaggerating any stimulatory effects of insecticides, which we did not find.

In field experiments reported previously, applications of endosulfan have been found not to cause outbreaks of *T. urticae*, despite having a significant negative impact on the abundance of predators of this pest (Wilson *et al.* 1998). This finding is at least partially explained by the mild acaricidal activity of endosulfan, confirmed here. In the field, repeated applications of endosulfan could suppress the development of populations of *T. urticae*. Neither dimethoate nor thiodicarb could be expected to have any acaricidal effect on field populations of *T. urticae* in cotton due to high levels of resistance to the former and the extremely low toxicity of the latter.

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