

# PERFORMANCE OF TRIFLUMURON AGAINST *BLATTELLA GERMANICA* (L.)

P. F. MILLER<sup>1</sup>, B. A. PETERS<sup>1</sup> and G. SMITH<sup>2</sup>

<sup>1</sup>Department of Health Sciences, University of Technology, Sydney, P.O. Box 123, Broadway NSW 2007, Australia

<sup>2</sup>Bayer Australia Limited, 875 Pacific Highway, Pymble NSW 2073, Australia

**Abstract.**—The Chitin Synthesis Inhibitor, triflumuron, has great potential for the control of German cockroach, *Blattella germanica* (L). Field trails were carried out to evaluate its efficacy in combination with a short residual, conventional, insecticide DDVP, and when used alone. The insecticides were applied in Sydney, Australia as sprays to domestic premises which had medium to heavy cockroach infestations. There were eight properties sprayed per treatment and pre and post assessments of population numbers were made using sticky traps. Untreated (control) properties were monitored during the course of study.

In the first study, properties were sprayed with DDVP alone (0.6% a.i.), triflumuron alone (0.096% a.i.), and a tank mix DDVP plus triflumuron at the same rates. Post assessments were carried out at one week, one month, two months and four months after spraying. At one week, DDVP alone and the DDVP plus triflumuron gave similar reductions (90% and 85% reduction). The triflumuron alone gave 47% reduction. After four months the triflumuron and DDVP plus triflumuron were providing 90% and 94% population reduction respectively. In the properties treated with DDVP alone the percentage reduction had dropped to 50%.

A follow up study examined three rates of triflumuron – the same rate as that used in the first study (0.096% a.i.), and 0.048% a.i. and 0.024% a.i. Post treatment assessments were carried out at two weeks, one month, two months, four months, and thirteen months after spraying. At two weeks the lower rates were giving a similar reduction of about 25%. The high rate gave 52% reduction. At four months there was no obvious dose relationship. The high, medium and low rates gave 63%, 64% and 69% population reduction respectively. At thirteen months, control at the low rate properties had dropped to 40% reduction while the other two rates had maintained their four month reduction levels.

This study demonstrates that triflumuron is effective and long lasting under difficult field conditions at rates of 0.096% a.i. and 0.048% a.i. Its low initial activity can be overcome by tank mixing with a knockdown insecticide such as DDVP

## INTRODUCTION

Insect growth regulators are gradually being incorporated into cockroach management programmes (Edwards, 1993). They generally have low mammalian toxicity and since their mode of action is different to that of conventional adulticides may be useful in resistance management programmes (Denholm and Rowland, 1992).

One group of insect growth regulators, the juvenile hormone analogues, cause sterility and pest populations gradually decline because of decreased production of offspring. They are slow in giving population reduction because they produce little mortality of either nymphs or adults (Patterson and Koehler, 1985). Marked population reduction only occurs as the extant population dies out and is not replaced. This can be a particular problem in pest species with extended life histories such as American cockroach (*Periplaneta americana*) because numbers can remain high for many months.

Chitin synthesis inhibitors (CSIs) are another group of insect growth regulators and these interfere with moulting. They inhibit the synthesis of chitin and thus prevent the formation of normal endocuticle (Hajjar, 1985). They have been shown to be effective against a range of agricultural, structural and public health pests, (Chang, 1979, Weaver and Begley, 1984, Nan Yao Su and Scheffrahn, 1993, Ali and Lord, 1980). They have the potential to give faster population control than juvenile hormone analogues but retain their appeal from a safety and resistance management perspective.

Triflumuron (Starycide®) is the subject of this study. This is a long lasting CSI with a broad range of activity (Hammann and Sirrenberg, 1980). These authors suggest that triflumuron works as a stomach poison after ingestion and a number of studies have confirmed and extended this observation on the German cockroach. Ross and Brady (1983) showed that triflumuron can be effective against all nymphal stages when used as a surface treatment, but that high rates were

required to cause mortality at later instars. These authors also concluded that triflumuron was not repellent. Weaver *et al* (1984) demonstrated that triflumuron was effective as a bait against early instar nymphs, with mortality of between 73% and 100% occurring after 4 weeks.

They also showed that this compound could inhibit oothecal development when fed to newly eclosed adult females. Koehler and Patterson (1989) demonstrated that this effect on fecundity could persist to a second oothecal cycle even through these females were no longer exposed to the bait. They demonstrated that oothecal effects could also result when German cockroaches were exposed to treated surfaces with CSI's arena tests. DeMark and Bennett (1989 and 1990) confirmed that triflumuron could be effective in causing nymphal mortality and oothecal effects when used as a bait against German cockroach. They noted also that the effects could be age dependent and that later instar nymphs required high doses to cause mortality.

Mrusek (1993) demonstrated the effectiveness of a commercial spray formulation of triflumuron, Starycide, against German cockroaches. This author also noted that later stages were less susceptible than early instars and that frequent short contacts with a treated surface can be more effective than single contacts of a similar or longer duration. Mrusek found that three exposures of 1 minute of second instar nymphs to a treated surface (25mg-100mg ai/m<sup>2</sup>) could result in 100% mortality with 2-3 weeks.

The above studies suggest that triflumuron has great potential for control of German cockroaches when applied to surfaces in standard pest control treatment. It can cause nymphal mortality in a few weeks and has the ability to interfere with oothecal production by female cockroaches.

## MATERIALS AND METHODS

The CSI investigated in this study was triflumuron (Starycide<sup>®</sup> SC 480g/L, Bayer). This was used alone or in combination with DDVP (Mafu H500 500g/L, Bayer). DDVP was chosen because it has high vapour pressure (Worthing, 1983) and a short residual life on surfaces. Thus any resulting long term residual control, when DDVP is used in combination treatment with triflumuron, might be expected to be due to the action of the triflumuron. In the first study there were three treatments; DDVP alone, triflumuron alone and DDVP plus triflumuron as a tank mix at the same rate. In the second study the treatments were triflumuron at three application rates, the rates used in the first study and two lower rates. The treatments, application rates and replication in Studies 1 and 2 are summarised in Table 1:

The studies were started during the summers of 1993 and 1994 in Sydney, NSW, Australia. Sydney is at a latitude of 33°S and has a subtropical climate comparable to that of New Orleans, U.S.A. in the Northern hemisphere. The average summer temperature in the day in February is 25.6C with an average relative humidity of 72%. The studies were carried out in government housing and apartments in the inner city. These are high density dwellings which are not regularly treated for cockroach infestations and have higher than normal German cockroach populations. Populations were monitored using sticky traps (Zoro Zoro brand, Taisho Pharmaceutical Company, Japan). These are large traps (21 cm x 9.5cm) and half traps were used in this study. Four half traps were placed out at each property at pre-assessment (in the week before treatment) and at each post treatment assessment. One trap was placed out at each of the following four locations in the kitchen - under the refrigerator, by the stove, under the sink and on the kitchen bench. These were left out for two nights. After the pre-treatment assessment count properties were assigned to particular treatments so that the distribution of initial population sizes was equivalent among the treatments.

These data were analysed using a Kruskal-Wallis test to check that there were no significant differences between pre-assessment levels. Eight properties were assigned to each treatment and there were 8 untreated properties (control). The only pest control intervention at these untreated properties was the use of sticky traps during population monitoring.

The properties were treated by a licensed and experienced pest control operator under supervision of the authors. The pest control operator used a 8 litre Rega Nupet compressed air hand held sprayer (Rega Pumps, Garrard's Pesticides Pty. Ltd., Lawnton, Queensland, Australia)

Table 1. Study treatments, application rates and replication in Study 1 (1993–1994) and Study 2 (1993–1995)

Time Period	Product	Application Rate	Number of Replicates (Dwellings)
<i>Study 1</i> February 1993 to June 1994	Mafu H500 <sup>®</sup> (DDVP 500g/L)	0.6% a.i.	8
	Starycide <sup>®</sup> (Triflumuron 480g/L)	0.096% a.i.	8
	Mafu H500 <sup>®</sup> (DDVP 500g/l)	0.6% a.i.	8
	Starycide <sup>®</sup> (Triflumuron 480g/l)	0.096% a.i.	
	Control	No Treatment	8
<i>Study 2</i> December 1993 to January 1995		0.024% a.i.	8
	Starycide <sup>®</sup> (Triflumuron 480g/l)	0.048% a.i.	8
		0.096% a.i.	8
	Control	No Treatment	8

fitted with Spraying Systems' number 6 adjustable nozzle (Spraying Systems, Wheaton, Illinois, USA).

A standard crack and crevice and surface spray pest control treatment was carried out in the kitchen, bathroom and laundry. The bedrooms and lounge room were not treated. However, the home owner was consulted about any other areas where German cockroaches were a particular problem and these were treated if thought to be a significant breeding area. An average of 2 litres of diluted spray were applied per property.

All items were removed from the cupboards in the areas sprayed and where possible the fridge and stove were moved away from the wall to facilitate spraying behind these appliances.

During the pest control treatment properties were assessed on their state of sanitation. The properties were placed into three categories:

- |   |                 |  |
|---|-----------------|--|
| G | Good Standard   | Good sanitation level i.e. floor and kitchen benches clean - no residual food and grease.  |
| M | Medium Standard | Medium sanitation level. Some dirt on floor and food scraps present.   |
| P | Poor Standard   | Poor sanitation level. Dirt and grease on floors and benches, food scraps present, open garbage containers, unwashed plates and utensils. Often moisture present from dripping taps and leaking refrigerators. |

This sanitation assessment was carried out to ensure that no treatment had a very high number of properties with poor sanitation and also to see if there was a correlation between any control breakdown and poor sanitation.

In the first study post treatment assessments were made at 1 week, 1 month, 2 months and 4 months after treatment. In the second study the assessments were at 2 weeks, 1 month, 2 months, 4 months and 13 months after treatment.

Trap catch data were converted to percentage reduction for each apartment:

$$\% \text{ reduction} = \frac{(\text{no. before treatment} - \text{no. after treatment})}{\text{no. before treatment}} \times 100$$

Percentage reductions were ranked for each week of each field trial and ranks were analysed by Wilcoxon's signed rank test.

## RESULTS

The infestation levels of the 32 dwellings were assessed before any treatment (the pre-assessment). The pre-assessment trap catch per night in the sprayed properties (average of 4 traps) ranged from 119.5 in properties with severe infestations to 7 in mild infestations. A Kruskal-Wallis test showed that there were no significant differences ( $p > 0.05$ ) between the pre-treatment assessment levels in the dwellings assigned to the four different treatments.

The control population showed a slight elevation (25.7%) at one week and at the four month assessment in June, the start of winter, a slight reduction (-21.6%).

For the control group, Wilcoxon matched pairs signed ranks tests showed that there were no significant differences between the pre-treatment assessment level and the infestation levels at any of the other time periods ( $p > 0.05$  in each case).

DDVP alone and DDVP plus triflumuron gave good initial population reduction at one week (90% and 85% reduction respectively). The triflumuron gave a medium level of reduction (47%). Population reduction in the triflumuron treated properties gradually increased during the trial and reached 94% reduction at four months. The populations in the properties treated with DDVP alone dropped to 38.7% reduction at four months.

In all post treatment assessments, except DDVP at four months, the three active treatment groups (DDVP, triflumuron, and DDVP plus triflumuron) showed a significant reduction on their respective pre-assessment levels at all four time periods (Figure 1). DDVP at the four month assessment showed no significant improvement over pre-assessment levels ( $p > 0.05$ ). The significant differences were  $p < 0.01$  for nine Wilcoxon matched pairs signed ranks tests and  $p < 0.025$  for two

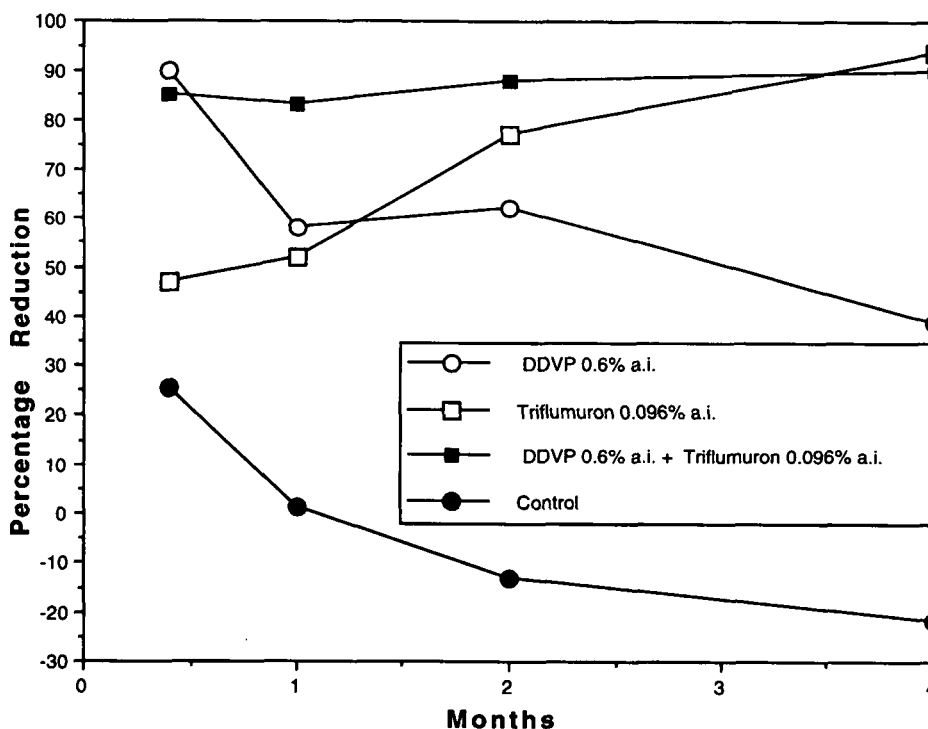


Figure 1. Average percentage reduction of German cockroach at various times after treatment. (Study 1).

Wilcoxon matched pairs signed ranks tests (which were for DDVP at the two month assessment and triflumuron at the four month assessment).

Among the active treatment effects, four Wilcoxon ranks sum tests were run to detect differences between DDVP and triflumuron. No significant differences were found except for at the one week assessment when DDVP significantly outperformed triflumuron ( $p < 0.01$ ).

In summary all active treatments were effective at all assessment periods except for DDVP at the four month assessment, and there were no significant differences between DDVP and triflumuron except at the one week assessment when DDVP performed significantly better.

Because of the good level of control achieved using triflumuron alone a second study was carried out to investigate the efficacy of various lower rates of triflumuron without a companion adulticide.

The results of this second study are presented graphically in Figure 2.

The pre-treatment assessment trap catch per night in the sprayed properties (average of 4 traps) ranged from 151 in properties with severe infestations to 11.5 in mild infestations. A Kruskal-Wallis test showed that there were no significant differences ( $p > 0.05$ ) between the pre-assessment levels in the dwellings assigned to the four different treatments.

The control population showed a slight elevation over pre-assessment levels up to four months (25.5% increase to 5.1% increase). At thirteen months there was a small population reduction (5.9%).

For the control group, Wilcoxon matched pairs signed ranks tests showed that there were no significant differences between the pre-assessment level and the infestation levels at any of the other time periods ( $p > 0.05$  in each case).

The two low rates of triflumuron gave poor levels of control at two weeks (25.3% and 24.1% reduction) and the higher level achieved a 52% reduction. The populations gradually declined up to four months and at this time all rates were giving a population reduction of around 65%. At the two higher doses this reduction was maintained through a second summer, but there was an indication of breakdown at the lower dose as population reduction had fallen to 39.9%.

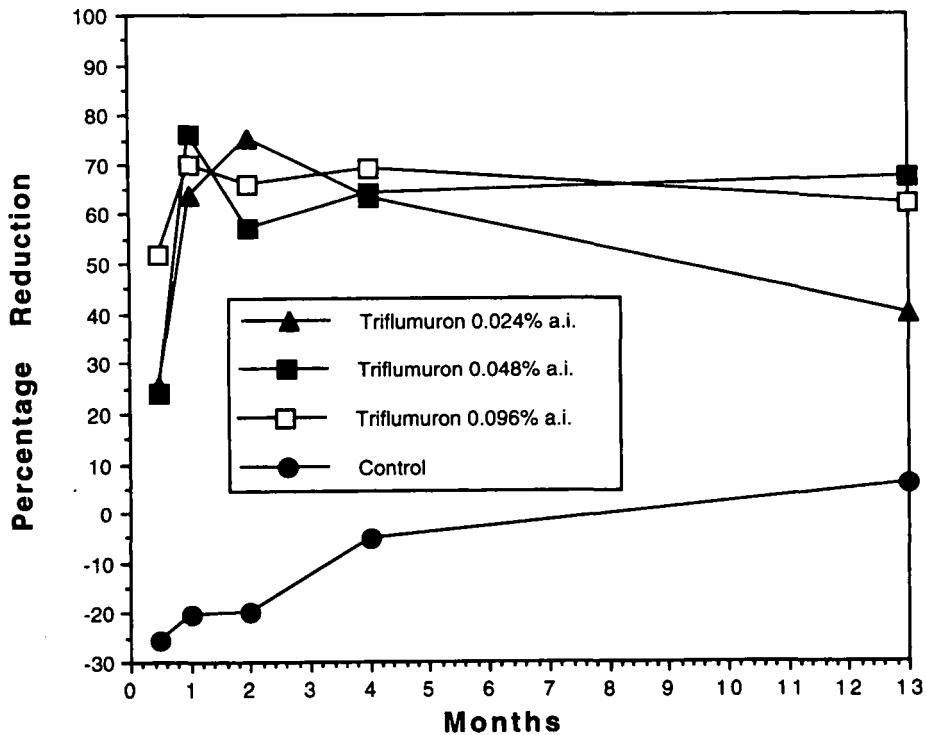


Figure 2. Average percentage reduction of German cockroach at various times after treatment. (Study 2).

The three active treatment groups (triflumuron 0.024% a.i., 0.048% a.i. and 0.096% a.i.) showed a significant reduction on their respective pre-assessment levels at all time periods except for triflumuron 0.024% a.i. and triflumuron 0.048% a.i. at the two week assessments, triflumuron 0.096% a.i. at the four month assessment and triflumuron 0.024% a.i. and 0.096% a.i. at the thirteen month assessments. These last five all showed no significant difference from their pre-treatment assessment levels ( $p > 0.05$ ), but it should be noted that this is probably the result of the small sample sizes (5–6 properties) at the thirteen month assessments since a number of owners had moved or no longer wished to participate in the study. The significant results were  $p < 0.01$  for seven Wilcoxon matched pairs signed ranks tests,  $p < 0.025$  for two Wilcoxon matched pairs signed ranks tests (triflumuron 0.024% a.i. at one month and triflumuron 0.096% a.i. at two weeks) and  $p < 0.05$  for one Wilcoxon matched pairs signed ranks tests (triflumuron 0.048% a.i. at thirteen months).

Among the active treatment groups five Wilcoxon rank sum tests were run to detect differences between triflumuron 0.024% a.i. and triflumuron 0.096%. No significant differences were found ( $p > 0.05$  in each case).

In summary all three concentrations of active treatments seems effective at all assessment periods and there was no statistical evidence of differences in performance between the concentrations.

## DISCUSSION

The triflumuron high rate (0.096% a.i.) gave surprisingly rapid population reduction in both studies (46.9% reduction after one week in the first study and 52.0% reduction after two weeks in the second study). It was higher than expected based on laboratory studies. Owens and Bennett (1983) estimated that nymphs comprised 85–90% of German cockroach populations in apartments in the U.S.A.

In warm conditions the period between moults can be short and progression from egg to adult in the laboratory at 30°C can be as rapid as 33.7 days in males and 33.2 days in females (Perkins and Grayson, 1961). This present field study was carried out in the warm summer months with an average maximum temperature of 25.6°C in February. High nymphal numbers in the population and rapid nymphal development may explain this early population reduction. The study demonstrated that there are benefits from the inclusion of an adulticide in the tank mix. This may be advantageous where a quick population reduction is required, for example, in food production establishments. Nevertheless, a short lived insecticide such as DDVP or pyrethrins should be sufficient. Triflumuron has a low oral  $LD_{50}$  (>5000 mg/kg body weight, rat) and a coupling with a short lived adulticide with a low mammalian toxicity such as pyrethrins has particular appeal in a pest management programme.

Mrusek (personal communication) demonstrated at least 6 weeks residual control of German cockroach in laboratory studies. This study confirmed that triflumuron demonstrated good residuality, even when used alone at low rates (0.024% a.i.). It will provide medium term population suppression to four months and the reduction can still be present thirteen months after application at the higher rate.

In conclusion, the present studies indicate that triflumuron is a useful addition in the control of German cockroach populations when used alone or in combination with an adulticide.

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