CHAPTER FOUR

Efficacy of fipronil as barrier spray treatment for control of armoured bush cricket, (Orthoptera: Hetrodinae).

ABSTRACT

Fipronil 200 SC (Regent®), a compound belonging to the phenyl pyrazoles, was evaluated for residual toxicity against adult armoured bush cricket (ABC), *Acanthoplus discoidalis*. To determine the LD $_{90}$ residual dose rate at 14 days post application, four different doses (6.25 g a. i. ha^{-1}, 15.625 g a. i. ha^{-1}, 21.875 g a. i. ha^{-1} and 29.125 g a. i. ha^{-1}) were used to treat natural vegetation inside field enclosures. Insecticide application was made with a lever operated knapsack sprayer. ABC were released in cages and kept under field conditions over time. The dose rate that gave LC_{90} values varied with the intended effective residual period of the barrier treatment. The fipronil dose rates resulting in 90 % mortality after 2, 8 and 14 days are 11.8 g a. i. ha^{-1}, 20.2 g a. i. ha^{-1} and 28.6 g a. i. ha^{-1} respectively. The minimum effective dose of fipronil in barrier spraying was 22 g a.i./ha. Similar efficacy was obtained with fipronil applied at a rate of 28.6 g a. i. ha^{-1} to border rows of the sorghum crop. Subsequent field trials with a 3 m wide barrier strip of fipronil were undertaken against adult crickets in Botswana during March and April 2000. Low volume application of fipronil sprayed at 100 l/ha was made to vegetation along a 3 m wide strip barrier inside a flowering sorghum field. The number of ABC that infested treated plots decreased three-fold over a 14 day period compared to untreated plots. These studies have demonstrated the potential of fipronil as barrier spray treatment for control of the ABC.

Key words: *Acanthoplus discoidalis*, barrier treatment, Botswana, fipronil, phenyl pyrazole, residual dosage.

INTRODUCTION

The armoured bush cricket (ABC), *Acanthoplus discoidalis* (Orthoptera: Hetrodinae), is considered the second most economically important cereal pest in eastern Botswana after quelea birds (Matsaert *et al.* 2000). Bashir *et al.* (1991) estimated a total yield loss of 40 % in sorghum fields caused by an ABC outbreak during 1988, which affected six agricultural regions of Botswana. Ingram *et al.* (1973) and Manthe (2000) reported ABC as a destructive pest, which is difficult for resource-poor farmers in Botswana to control.

Insecticides, through Government support, have been the principal means used to control the ABC in Botswana. However, without government assistance, most resource-poor farmers cannot afford insecticides. This has prompted a search for alternative control strategies in which less insecticide is applied for controlling the ABC.

ABC typically invade crop fields from the surrounding shrubs at around the time of cereal panicle emergence. Since crickets attempt to invade farmers' fields at a predictable time (when panicles become available) and at predictable locations (field margins bordering scrub), the opportunity exists for farmers to prepare in advance and be ready for ABC control activities.

Barrier spraying could be an effective technique to control ABC that invades crop fields. Barrier treatment is a technique in which one or more strips of a persistent insecticide are sprayed onto the natural vegetation (Sayer 1959; Matthews 1992). Migrating insects are killed when they make contact with the barrier strip or feed on the vegetation in the barrier. Dieldrin is one insecticide that was well suited for barrier treatment but has been withdrawn because of its negative impact on the (Symmons 1992).

Most products currently available persist for just a few days and are therefore unsuitable for barrier treatments. Wohlleber (2000) evaluated pyrethroid barrier treatments against *A. discoidalis* in Namibia and observed effective control for only a few days after treatment. Insect Growth Regulators (IGRs) have been tested as environmental acceptable alternative barrier pesticides to dieldrin against locust hopper bands with promising results (Bouaichi *et al.* 1994). However, since IGRs act by disrupting the moult, these substances are only effective against juvenile stages of crop pests and would not be appropriate for control of the ABC because it is mostly adults that invade crop fields in Botswana. Fungal pathogens like *Metarhizium* are too slow in killing insects and crickets would continue to feed on the crop. A recent alternative insecticide for use in a barrier treatment is fipronil. Fipronil is a broad spectrum, persistent phenyl pyrazole insecticide that has excellent stomach action against chewing insects and has been shown to be effective when applied as a bait (Colliot *et al.* 1992). Fipronil also showed promise in spray barriers when tested against brown locust (*Locustana pardalina*) hopper bands in South Africa (Price & Brown 2000) and desert locust (*Schistocerca gregaria*) in Mauritania (Rachadi & Fourcart 1999). This product has not been previously tested against ABC.

The objectives of the present study therefore were to evaluate the efficacy of fipronil 200 SC (Regent®) sprayed at different dose rates in barrier treatments over time in order to control ABC.

MATERIALS AND METHODS

Study site

The study was undertaken during March to April 2000 at Mmatseta (24^0 06' S, 26^0 01'E), 25 km west of Botswana's capital city, Gaborone. The vegetation consisted largely of *Acacia tortilis* distributed around the periphery of crop fields. The common grasses found in the study area were *Cynodon dactylon*, *Cenchrus ciliaris* and *Digitaria eriantha*. Five 2.0 m long x 2.0 m wide x 0.5 m high enclosures open at the top were used in the study. The enclosures were placed in non-shaded areas in order to standardise conditions. Vegetation densities in enclosures were all similar.

Residual toxicity of fipronil doses to ABC

Four different dose rates of fipronil 200 SC (Regent®) supplied by Agrichem were evaluated for toxicity to ABC and water was used as a control. The fipronil doses tested were 6 g a. i. ha^{-1}, 16 g a. i. ha^{-1}, 22 g a. i. ha^{-1} and 29 g a. i. ha^{-1}. This corresponds to 2.5 ml, 7 ml, 9 ml and 12 ml per tank load respectively. The dose range was pre-determined in the laboratory. Each of these doses was replicated 3 times. The chemical was applied using a knapsack sprayer fitted with a flood type nozzle and calibrated to a chemical flow rate of 0.73 litres min^{-1} (see appendix 1). To ensure full cover spray, the spray solution was applied onto the vegetation until small droplets appeared. ABC were collected from the field just before the experiment and then kept in baskets. Ten crickets were released into each of the enclosures 2, 4, 6, 8,11 and 14 days after spraying. This procedure was replicated 3 times. The release was in the morning hours and crickets were left in the cages for 30 minutes and then removed. This exposure period was used since preliminary observations indicated that it took migrating ABC individuals approximately 30 minutes to cross a 3 m wide headland with similar vegetation density as found in the test enclosures. This is also the typical distance of non-cultivated area left by farmers in Botswana between the fence and the crop (Fig. 4.1).

After removal from the enclosures, crickets were placed in clean containers and removed to the laboratory where they were provided with food and water and kept at constant temperature. Mortality was recorded at 72 hours after removal of insects from the cages and used for analysis.

Residual toxicity of fipronil applied onto grasses

Following the determination of the residual toxicity at 14 days post treatment, studies were conducted with the highest dose rate (29 g a. i. ha^{-1}), to determine residual toxicity of fipronil when applied to headland grass strip. The study was conducted in enclosures similar to those described above, containing grasses. Each treatment was replicated three times. Insects were released in the enclosures at 2, 4, 8, 10, and 14 days following insecticide treatment and removed after 30 minutes as previously. Crickets were taken to the laboratory, provided with food and water. Mortality was recorded 72 hours after removal. The persistence of fipronil was thereafter monitored for 14 days after the spray application.

Barrier treatment with fipronil

A linear strip of six experimental plots (20 m x 10 m each), with a buffer zone of five metres between adjacent plots, was marked out in a farmer's field containing sorghum in the flowering stage. A fipronil barrier strip treatment of 3 m was applied around 3 of the test plots. A 3 m barrier strip width was achieved by spraying three overlapping swaths using a knapsack sprayer. Fipronil 200 SC (Regent®) was applied low volume (100 l/ha) at a rate of 28.6 g a. i. ha^{-1}. Water was sprayed around 3 control plots in the same way. Different knapsack sprayers were used for the control and the treatment. The average plant density was 4 plants m^{-2} inside the intended barrier. The entire study block was bordered on one side by an area dominated by *Acacia* bushes, which served as a continuous source of ABC that invaded the crops. ABC were removed from all the plots by hand 24 hours before barrier spraying took place in order to standardize the initial populations in the plots. Data on the numbers of ABC in the experimental sorghum plots was recorded at 2, 4, 8, 12, and 14 days after application of the spray barrier. A method based on the "modified zigzag method" developed for assessing incidence of quelea damage on cereals (Winkfield 1989) was used to survey and assess ABC population densities in the trial plots. All the plants in the range of an arm's reach from randomly selected points in each plot were sampled. This gave a sampling unit of 2.5 m^2 per sampling station. A minimum of 100 sorghum plants was thus sampled in each plot. The number of ABC on plants and on the ground in the sampling unit were counted and recorded.

RESULTS

Residual toxicity of fipronil doses to ABC

The different dosage rates of fipronil against ABC gave variable residual mortalities over time (Fig.4.2). At four days post application, mortality ranged between 40 - 100 % for the dose range of 6.25 – 28.6 g a. i. ha^{-1}. The mortalities were further reduced 11 days after application to a range between 0 % - 92 % for the same dose range. Residual toxicity of 75 –85 % was achieved at the two higher doses (Fig. 4.2). Mortality levels for 21.875 g a. i. ha^{-1} and 28.6 g a. i. ha^{-1} were not significantly different ($p < 0.05$) from each other 14 days post treatment. Not surprisingly, higher rates extended the period of lethal residual toxicity to ABC. The minimum effective dose for this time period was thus 22 g a.i./ha and is recommended for use in Botswana.

Residual toxicity of fipronil applied onto crops and grasses

When the crickets felt the effects of the insecticide, they stopped feeding, occasionally vomited and later twitched with legs upwards and finally died. Fipronil residual efficacy did not differ significantly with respect to substrate to which it was applied (Fig. 4.3: $t = 2.78$, $df = 4$, $p < 0.09$). When applied at a rate of 28.6 g a. i. ha^{-1}, both the sorghum and grass substrates retained adequate residues to kill 90 % and 78 % of ABC 10 and 14 days post treatment respectively.

Barrier treatment with fipronil

The number of crickets counted during sampling in control plots indicate that the ABC numbers returned to the pre-experiment population density within four days (Fig. 4.4). The average number of ABC in the fipronil barrier-protected plots was c. 65 % lower than in control plots throughout the 14d observation period (Fig. 4.4: $t = 2.44$, $df = 6$, $p < 0.003$. Dead ABC were commonly observed on the ground in the treated plots during the study period.

DISCUSSION

In the present study, fipronil dose rates of 21.875 g a. i. ha^{-1} and 28.6 g a. i. ha^{-1} gave sufficient mortality (75 % and 85 %) respectively at 14 days post treatment. Based on these results the dose rate of 21.875 g a. i. ha^{-1} provided the minimum effective dose to last for 14 days. Rachadi & Foucart (1999) and Price Brown (2000) effectively controlled nymphal bands of the desert locust, *S. gregaria* and brown locust, *L. pardalina*, with fipronil 5 UL applied at a dose rate of 12.50 g a. i. ha^{-1} over 48 hours.

The barrier technique adopted in this study is based upon high application rates of fipronil over a narrow border strip in order to achieve effective residual control. Several factors contribute to effective barrier treatment. These include spray swath, concentration and the persistence of the insecticide (Bouaichi *et al.* 1994). Clearly, it is desirable that the concentration of the insecticide should be adequate to achieve rapid kill before the invading pest inflicts damage to the crop. The presence of vegetation is essential for successful application of barriers (Symmons 1992). Dense vegetation will increase insecticide availability by reducing losses of insecticide to the ground surface. It also slows down migrating ABC (pers. observation) so that when crickets encounter a barrier, exposure will be prolonged, increasing uptake both by feeding and contact. Exposure time is very important and the longer the exposure, the greater the toxicity (Neuman & Guyer 1987).

The present evaluation of barrier spraying as a control measure for the ABC suggests it has considerable potential. There have been concerns voiced about the environmental impact and side effects of fipronil (US-EPA 1996; World Bank 1998; Dinham 2000). Generally, therefore, it seems advisable that barrier treatment should be limited to grasses and other vegetation surrounding arable crop areas in order to limit crop contamination. Future studies are needed to establish the environmental impact of fipronil on non-target invertebrates during ABC outbreaks (See chapter 5).

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Fig 4. 1. Field edge appearance in subsistence crop production in Botswana.

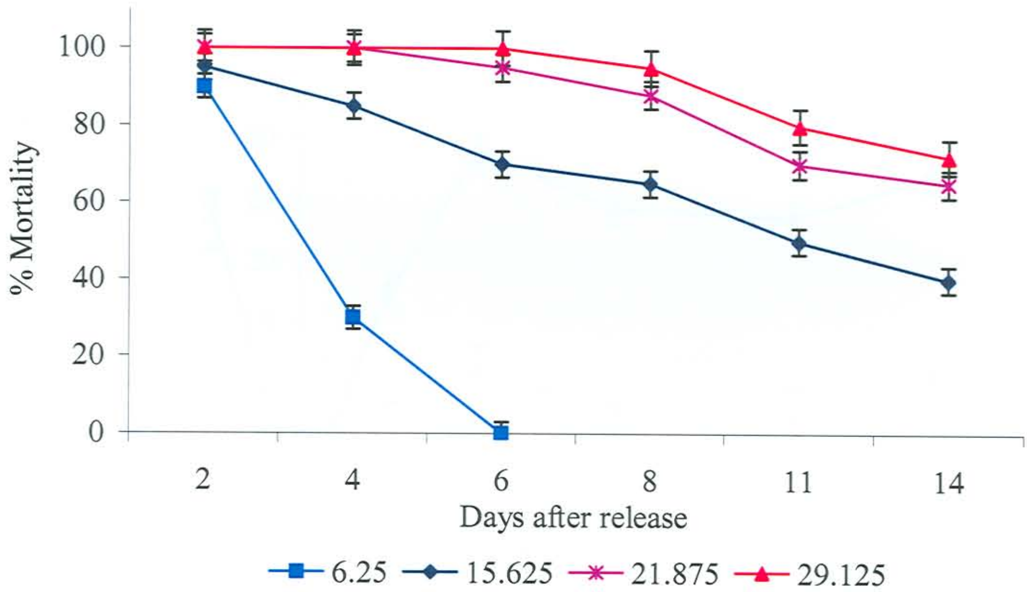

Fig. 4.2. Residual toxicity of fipronil at different application rates (g a.i./ha) against armoured bush cricket. Bars indicate standard error (SE).

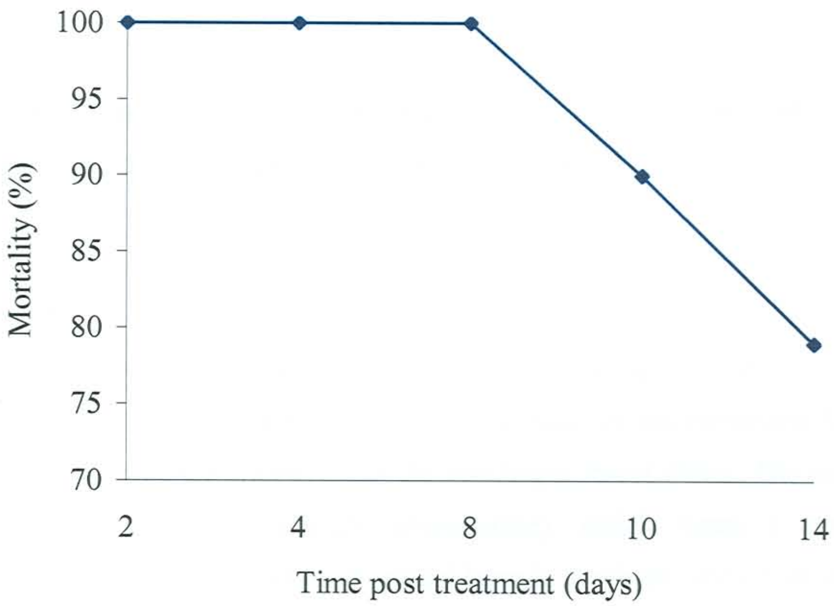

Fig. 4.3. Percentage mortality caused by fipronil sprayed at 28.6 g a.i./ha on grass as a barrier treatment against the ABC. Bars indicate standard error (SE).

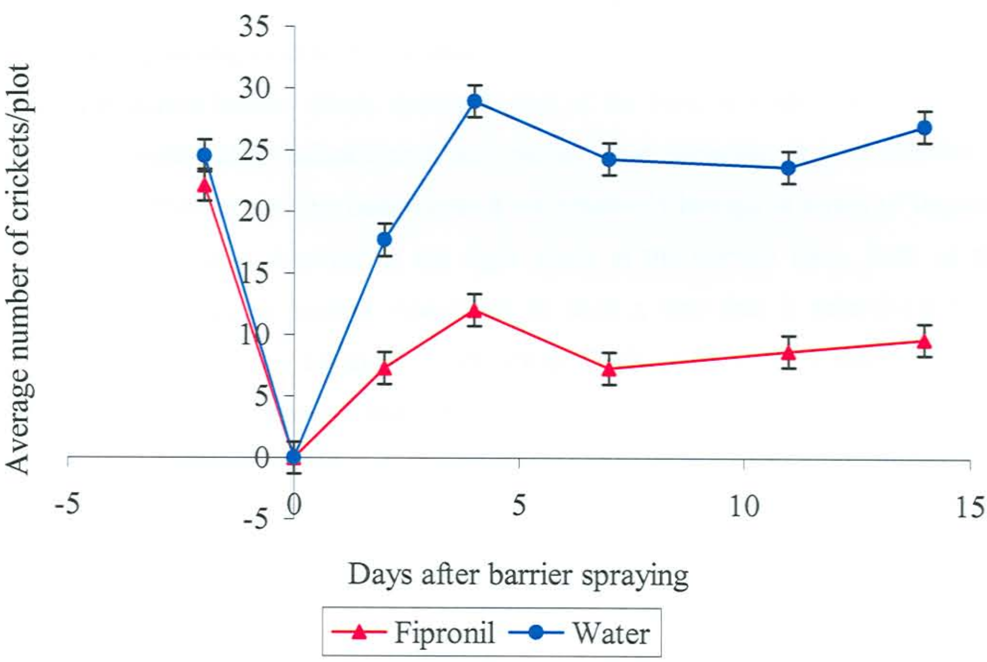

Fig. 4.4. Incidence of the armoured bush crickets in plots with or without a barrier spray of fipronil. Bars indicate standard error (SE). Crickets in the plots were counted and removed two days before the experiment.