COMPARATIVE EFFICACY OF FIPRONIL AND GUTHION FOR BOLL WEEVIL CONTROL

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Abstract

Comparative efficacies of fipronil and azinphosmethyl were assessed against high population levels of boll weevils in small plot (12 rows by 100 ft) tests. When insecticides were applied at 7-d intervals, beat net samples indicated that fipronil temporarily reduced boll weevil population levels, but efficacy was not sufficient to prevent population increases between applications. Whole plant samples indicated that populations were not reduced by either insecticide. A lower percentage of squares were oviposition punctured in the fipronil treatment than in other treatments, but numbers of oviposition punctured squares per plant were similar among treatments. When insecticides were applied at 3-d intervals, both fipronil and azinphosmethyl reduced boll weevil numbers in beat net and whole plant samples, and both materials reduced the percentage of oviposition punctured squares. However, the number of punctured squares per plant was highest in the fipronil treatment. Leaf bioassays indicated that both fipronil and azinphosmethyl were highly effective against boll weevils immediately after application, but residual activity of fipronil was greater than that of azinphosmethyl. Boll weevil population trends in the untreated check tended to follow a pattern similar to those of the insecticide treatments, indicating that the plot size used was too small to prevent considerable inter-plot movement of adult weevils.

Introduction

After severe secondary pest problems plagued cotton crops in the Lower Rio Grande Valley of Texas in 1995 (Summy *et al.* 1996), the Boll Weevil Eradication Program, cotton producers, and scientists expressed considerable interest in substituting alternate materials for ULV malathion in area-wide boll weevil suppression programs. Fipronil, an experimental product of Rhone Poulenc, has attracted particular attention. Because measurable boll weevil populations failed to develop in large plot tests intended to evaluate the early-season efficacy of fipronil and described elsewhere in these Proceedings, we conducted small plot tests and a leaf bioassay study to assess the efficacy of fipronil relative to the widely used boll weevil insecticide, azinphosmethyl.

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Materials and Methods

Plots, 12 rows by 100 ft each, were arranged in a randomized complete block design in blooming cotton heavily infested with boll weevils. Plots within a block were separated by four treated buffer rows that were not sampled, and blocks were separated by a 10 ft-wide buffer of untreated cotton. Experimental treatments were fipronil (Regent 2.5 EC; 0.05 lb. a.i./acre), azinphosmethyl (Guthion 2L; 0.25 lb. a.i./acre), and an untreated check. Insecticides were applied using a high clearance sprayer delivering 10 gal./acre of spray mixture at 40 psi through three TeeJet TX5 hollow cone nozzles per row, with one nozzle over the row and two nozzles on drops. Treatments were initially applied at 7-d intervals (29 May, 4 and 11 June), and were followed by 3 additional treatments applied at 3-day intervals (14, 17, and 20 June).

Rather than depend only on the customary but indirect measure of percent of squares oviposition punctured, treatment efficacy was also assessed based on measures of the adult boll weevil populations. Boll weevils were sampled using a beat net technique similar to that described by Sparks and Boethel (1987), in which the upper 12-15 in. of the plants were shaken vigorously into a standard 15 in. diam. sweep net. A single beat net sample consisted of 10 subsamples in the same row, each separated from the next by 6-12 in. of row. Four beat net samples were collected from each plot on each sample date. Adult boll weevils were also quantified by visually searching 20 whole plants per plot on each sample date. On selected sample dates, oviposition punctured squares and total squares ≥⅓-grown were also recorded from these samples. When treatments were applied at 7-d intervals, beat net and whole plant samples for adult boll weevils were collected 24 h before, and 24 and 48 h after treatment application. When treatments were applied at 3-d intervals, these samples were collected at 24 and 48 h after treatment application. Square data were collected 24 h before and after the first two applications, and 24 h before the third application applied at 7-d intervals, and at 24 h after the second application applied at 3-d intervals.

Leaf bioassays were performed using leaves collected following the last three treatment applications. Fully expanded leaves were collected from the upper canopy at 0, 24, 48, and 72 h after treatment application, taken immediately into the laboratory, and placed singly in 15 mm × 100 mm plastic petri dishes. Enclosed with each leaf was a single field- or trap-collected boll weevil previously fed in the laboratory for 2-3 days on fresh squares and 10% sucrose solution, and a 2-cm length of dental wick saturated with distilled water. Petri dishes were sealed with a strip of parafilm to avoid weevil escape and maximize humidity within the dish. Twenty weevils of mixed sexes were used for each combination of treatment, application date, and exposure time after application. Bioassay dishes were maintained in the laboratory at about 75°F under continuous

light, and mortality was assessed at 24, 48, and 72 h after initial exposure.

Because field samples and bioassay mortality estimates represented repeated observations of individual experimental units, the data were analyzed by repeated measured analysis using the SAS procedure PROC GLM and the REPEATED statement (SAS Institute, 1988). A test of sphericity was used to determine if the data satisfied the Huynh-Feldt condition. When the Huynh-Feldt condition was accepted ($P>0.05$), all data were assessed using the usual univariate F tests. In our analyses, when the Huynh-Feldt condition was rejected it was rejected at $P \leq 0.0001$, and multivariate tests (Wilks' Lambda) were used to assess repeated factors and their associated interactions. When interactions involving main factors of between subject effects were not significant, they were omitted from the analysis of variance model provided their omission reduced the error mean square. Means corresponding to between subject main effects were compared using the Ryan-Einot-Gabriel-Welsch multiple range test (REGWQ option of the MEANS statement of PROC GLM; SAS Institute, 1988).

Results

The overall analysis of beat net samples when treatments were applied at 7-d intervals indicated that only fipronil reduced boll weevil populations at 24 and 48 h after treatment application, relative to populations in the untreated check (F=6.36; df=2, 18; P=0.0081). Fipronil also reduced weevil populations relative to those in the azinphosmethyl treatment at 48 h after treatment application. Regardless, efficacy supplied by fipronil applied at 7-d intervals was not sufficient to prevent boll weevil population increases (Fig. 1). Analysis of weevil counts from whole plant samples did not indicate differences in the weevil populations among treatments (F=1.87; df=2, 22; P=0.1773; Fig. 2). Most of the weevils detected in these samples were in protected sites, such as within the bracts of squares, and their exposure to applied materials was probably limited. Fipronil tended to have a lower percentage of squares that were oviposition punctured than did other treatments (F=6.03; df=2, 6; P=0.0367), but differences were numerically small (Fig. 3). In contrast, no differences were detected among treatments in the numbers of punctured squares per plant (F=1.19; df=2, 8; P=0.3541; Fig. 4) or the total numbers of squares per plant (F=3.30; df=2, 6; P=0.5052). In general, none of the treatments applied at 7-d intervals supplied useful levels of boll weevil control.

The analysis of beat net samples when treatments were applied at 3-d intervals indicated by 24 h after treatment both fipronil and azinphosmethyl reduced boll weevil populations relative to that of the untreated check (F=29.08; df=2, 12; P=0.0001); only fipronil reduced population levels relative to the check at 48 h after treatment. Applications applied at 3-d intervals resulted in a marked reduction of boll weevil populations in all treatments (Fig. 1). Analysis of whole plant samples revealed trends almost identical to those of the beat net samples (F=47.70; df=2, 12; P=0.0001; Fig. 2); fewer weevils were detected in both fipronil and azinphosmethyl treatments than in the untreated check at 24 h after treatment application, but only fipronil reduced populations at 48 h after treatment. On the single date when square populations were assessed, both fipronil and azinphosmethyl treatments had lower percentages of squares oviposition punctured than the untreated check (F=9.62; df=2, 6; P=0.0134; Fig. 3), but more punctured squares per plant were observed in the fipronil treatment than in other treatments (F=24.76; df=2, 6; P=0.0013; Fig. 4). The fipronil treatment also had a larger number of total squares per plant than other treatments (F=11.61; df=2, 6; P=0.0087; Fig. 5).

Leaf bioassays indicated that apparent efficacy of assayed materials depended on the time elapsed between assessment of mortality and initial exposure of weevils to treated leaves (Wilks' Lambda=0.221; F=40.62; df=2, 23; P=0.0001). On average, mortality caused by insecticide treatments was approximately doubled between the 24 and 48 h mortality observations, and increased an additional 50% between the 48 and 72 hour observations. When the data were pooled over time intervals (0, 24, 48, or 72 h) between treatment application and initial exposure of weevils, fipronil provided higher mortality than the azinphosmethyl treatment, which resulted in greater mortality than the untreated check (F=51.31; df=2, 24; P=0.0001) at all times of mortality assessment. Significant differences also occurred among time intervals between treatment application and initial exposure of the weevils to treated leaves (F=9.93; df=3, 24; P=0.0002). Fipronil continued to kill weevils when initial exposure was at 72 h after treatment application while efficacy of azinphosmethyl diminished quickly with increasing time after application (Fig. 6). The relatively long residual activity of fipronil that we observed may have occurred in part because of the short treatment interval and the number of applications. This level of residual activity may not be observed when treatments are fewer or less frequent.

Discussion

Most notable in our study were observations concerning our inability to impact heavy boll weevil infestations by applying insecticides to small plots at weekly intervals, and the appropriateness of the varied sampling techniques. Bioassays indicated that lack of control of boll weevil populations was not caused by lack of toxicity of the insecticides. The high numbers of boll weevils that were observed in protected situations suggested that many of the boll weevils present at the time of treatment application were not exposed to the toxicants. As a consequence, oviposition and recruitment of new adult weevils continued. The improved control achieved when treatment application interval was decreased to 3 d was probably facilitated by

maintenance of effective levels of toxicants on plant surfaces between treatment applications. Consequences of this aspect of boll weevil behavior in fruiting cotton illustrate the hazards of assessing expected field performance of insecticides based on the results of standard laboratory bioassays. In addition, the general similarity of population trends among treatments, including the untreated check, suggested that our plot size was too small to prevent the influence of movement of adult weevils between treatments. Our results also illustrate the value of boll weevil population measurements in evaluating insecticide efficacy. Although it is often inconvenient to monitor populations of adult boll weevils in efficacy trials, information supplied by sampling techniques intended to estimate population levels of both exposed (beat net samples) and protected (whole plant samples) boll weevils facilitated a better understanding of treatment effects than would have been possible had we relied solely on square sampling. This was particularly so in those instances when results of analyses of percent of squares punctured were inconsistent with those of analyses of numbers of punctured squares or numbers of weevils.

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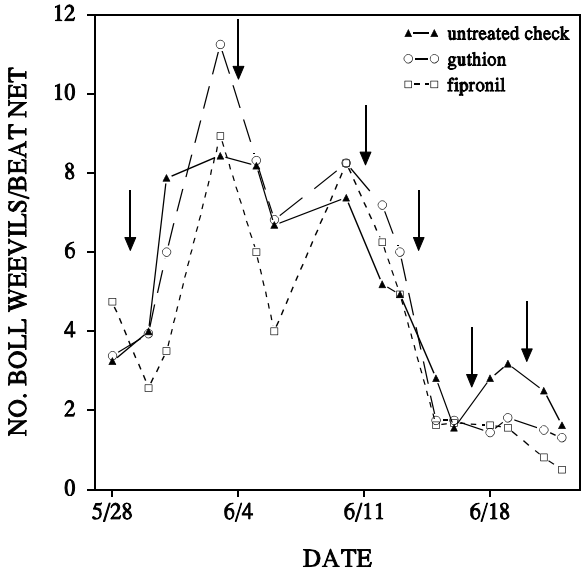

Fig. 1. Mean number of adult boll weevils per beat net sample from insecticide-treated cotton plots. Arrows indicate dates of treatment applications.

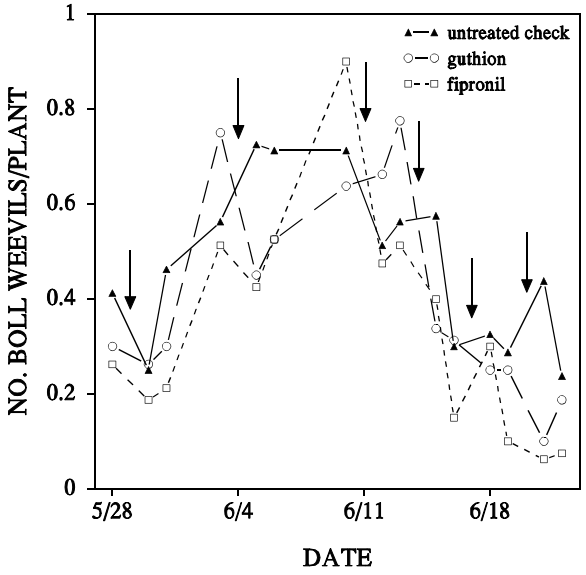

Fig. 2. Mean number of adult boll weevils per plant in insecticide-treated cotton plots. Arrows indicate dates of treatment applications.

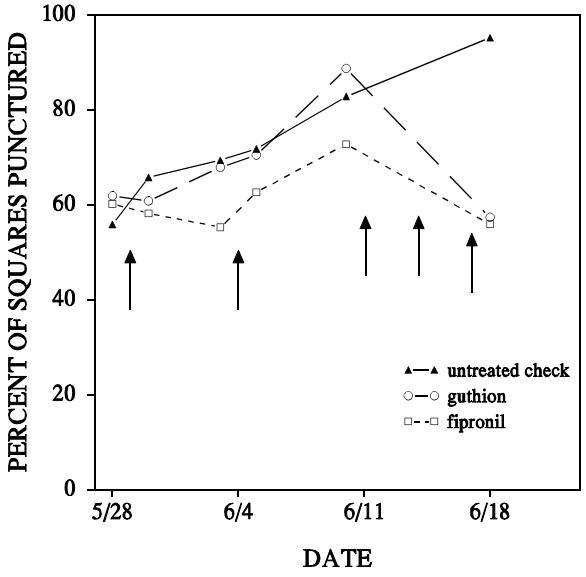

Fig. 3. Mean percentage of squares oviposition punctured in insecticide-treated cotton plots. Arrows indicate dates of treatment applications.

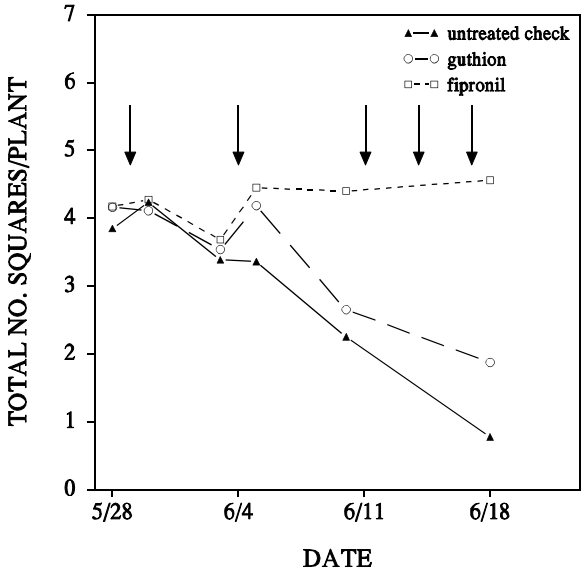

Fig. 5. Mean total number of squares per plant in insecticide-treated cotton plots. Arrows indicate dates of treatment applications.

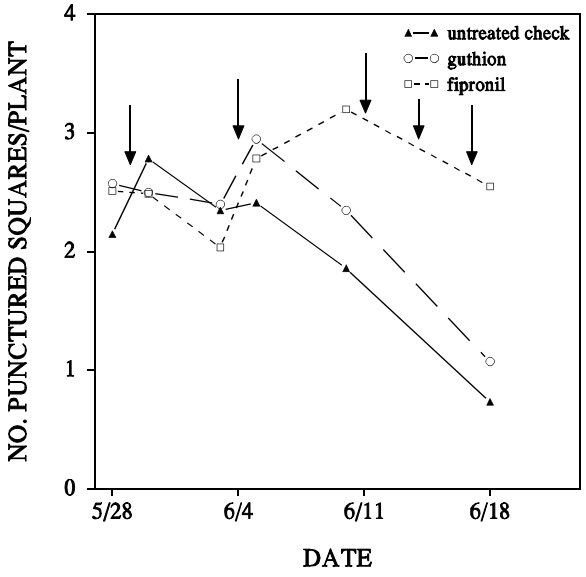

Fig. 4. Mean number of oviposition punctured squares per plant in insecticide-treated cotton plots. Arrows indicate dates of treatment application.

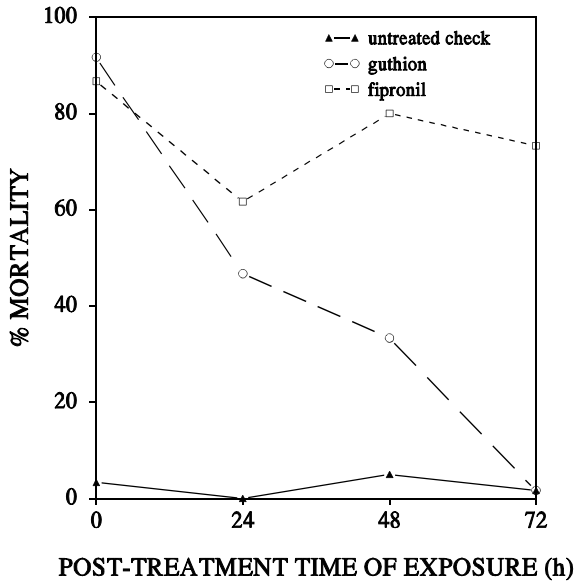

Fig. 6. Mortality of boll weevils exposed to insecticides at different times after treatment application. Mortality was assessed at 72 h after initial exposure.