Comparative Toxicity and Efficacy of Selected Insecticides in Field and Greenhouse Assays Against Tawny and Southern Mole Crickets (Orthoptera: Gryllotalpidae)[1]

R. L. Brandenburg[2], Y. Xia[3], and B. Watson

Department of Entomology, North Carolina State University, Box 7613, Raleigh, NC 27695 U.S.A.

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Abstract The toxicity of thiamethoxam against nymphs and adults of the tawny mole cricket, *Scaptericus vicinus* Scudder, and the southern mole cricket, *S. borellii* Giglio-Tos, was evaluated in the field and greenhouse. Thiamethoxam demonstrated varying levels of mole cricket control in the field studies. The performance of the insecticide appeared to be related to the application timing and formulation. Applications made in late June 1998 provided the best mole cricket control compared to the other two field studies. The LC_{50} and LC_{90} values of thiamethoxam against adult southern mole crickets were 1,816 and 9,978 ppm, respectively, using a greenhouse bioassay technique. Another greenhouse study indicated that thiamethoxam at application rates ranging from 154 to 616 g (ai)/ha did not provide acceptable control against medium sized nymphs (third to six instars) of tawny and southern mole crickets. An additional study with fipronil, bifenthrin, and deltamethrin compared mortality of the two species of mole crickets in greenhouse bioassays. In these assays, all insecticides resulted in different levels of mole cricket mortality between the two species. The use of bifenthrin resulted in significantly higher mortality of tawny than southern mole crickets.

Key Words Mole cricket, insecticides, Gryllotapidae, control

Mole crickets are economically important soil-dwelling insect pests that damage turfgrass in the southeastern United States (Walker and Nickle 1981, Brandenburg 1997). The tawny mole cricket, *Scaptericus vicinus* Scudder, and the southern mole cricket, *S. borellii* Giglio-Tos, are the most destructive mole cricket species on turfgrass in North America. Both species are univoltine in most of their range and have similar life cycles and morphology. The southern mole cricket is primarily carnivorous; whereas, the tawny mole cricket is herbivorous (Ulagaraj 1975, Taylor 1979, Matheny 1981). Tunneling behavior which is partly determined by feeding preference, differs between the two species (Brandenburg et al. 2002).

Thiamethoxam and imidacloprid belong to the novel class of neonicotinoid insecticides (Gobel et al. 1999). Neonicotinoids work at the nicotinic acetylcholine receptor (Tomizawa and Yamamoto 1992). In addition to mode of action, the two insecticides share other physical and toxicological characteristics. Both insecticides are systemic and have contact and stomach modes of activity against a range of insect pests

[1]Received 27 May 2004; accepted for publication 10 August 2004.
[2]Address inquiries (email: rick_brandenburg@ncsu.edu).
[3]1100 Partners Building I, North Carolina State University, Centennial Campus, Box 7553, Raleigh, NC 27695.

(Mainefisch et al. 1999). Studies have shown that thiamethoxam and imidacloprid are excellent insecticides for controlling white grubs in turfgrass (Brandenburg and Royals 1999, Heller and Walker 1999, Shetlar and Niemczyk 1999).

In this study, we examined the toxicity of thiamethoxam against the two species of mole crickets in field studies and in greenhouse studies. We also investigated the different levels of mortality between the two species of mole crickets when treated with fipronil, bifenthrin, and deltamethrin in an additional greenhouse study.

Materials and Methods

Field studies. Three field studies were conducted on bermudagrass, *Cynodon dactylon* (L.) Pers., fairways at golf courses in Brunswick Co., NC, in 1997, 1998 and 1999. The test plots were arranged in a completely randomized block design with four replications per treatment. The fairway irrigation system was used to apply 0.6 cm of water to each plot immediately after treatment. The depth of thatch was variable ranging from 3 to 12 mm. Soil samples were taken at each test site and sent to the North Carolina Department of Agriculture for analysis.

In 1997, thiamethoxam 2SC (Syngenta Crop Protection, Greensboro, NC) was evaluated against second through fifth instar mole cricket nymphs. Ethoprop (Mocap®, Bayer CropScience, Research Triangle Park, NC) was used as a standard. The study was conducted at Fox Squirrel Country Club (Brunswick Co., Boiling Spring Lake, NC) on 8.3 × 8.3 m plots. Thiamethoxam was applied using a back pack sprayer powered by CO_2 to deliver an application volume of 380 liters/ha. Ethoprop was applied using a Republic EZ Handspreader® (Republic Tool Manufacturing Corp., Carlsbad, CA). Both applications were made on 1 Aug. The soil (10 cm depth) and air temperatures were both 26°C at the time of application. The entire test site was pre-irrigated with 0.6 cm of water using the golf course irrigation system. The soil was classified as Kureb fine sand with a pH of 5.8 and 0.41% humic matter. Soapy water flushing (Short and Koehler 1979) indicated that the population at the course was approximately 83% southern and 17% tawny mole crickets (>100 crickets).

Mole cricket control was evaluated at 6, 13, 19, and 26 d after insecticide treatment using the damage rating method of Cobb and Mack (1989). Five damage ratings were taken from each plot per evaluation by assessing fresh mole cricket damage on a scale of 0 to 9, with a rating of 0 for no damage and 9 for severe damage.

In 1998, the efficacy of surface and subsurface applications of thiamethoxam was compared against second through fourth instar mole crickets. Chloropyrifos (Dursban®) Pro 2E, Dow Agrosciences, Indianapolis, IN) and imidacloprid (Merit® 75 WP, Bayer Corp., Kansas City. MO) were used as standards. The study was conducted at Oyster Bay Golf Links in Brunswick Co., NC, on 5 × 13 m plots. Chloropyrifos (subsurface application) and imidacloprid (surface application) were applied at a rate of 2,268 and 475 g (ai)/ha, respectively, on 25 June. The soil was moist at the time of application, and air and soil (10 cm depth) temperatures were 32.8 and 30.0°C, respectively. Thiamethoxam 25 WG treatments, at 225 g (ai)/ha (surface and subsurface), were applied on 28 June. At the time of application, the soil was moist, and air and soil temperatures were 34.4 and 30°C, respectively. All subsurface treatments were applied using a tractor-drawn Toro Subsurface Liquid Injector® (The Toro Co., Bloomington, MN). This equipment uses slicing blades spaced at 7.6-cm intervals to cut slits in the turf. These blades are closely followed by stainless steel nozzles which inject the insecticide solution to a depth of 1.3 cm below the soil surface. Equipment ground speed was 9.7 km/h, delivering an application volume of 1400 L/ha under 11 kg/cm^2. All surface applications were applied using a John Deere (Deere & Co., Moline, IL) Turf Gator® mounted research sprayer (R & D Sprayers Inc., Opelousas, LA) to deliver 218 L/ha. Soil at the test site was classified as Wando fine sand with a pH of 6.5 and 0.22% humic matter. Soapy water flushing at the time of applications indicated that the population was approximately 79% southern and 21% tawny mole crickets (>100 crickets). Control was evaluated using the Cobb and Mack (1989) damage rating method at 16, 23, 38 and 53 DAT.

In 1999, second to fourth instars of tawny mole crickets were used to compare the efficacy of two thiamethoxam formulations (25 WG and 0.22 G). Fipronil (Chipco Choice® 0.1 G, Bayer ScienceCrop) was used as the standard compound. The study was conducted at Meadowlands Golf Links in Brunswick Co., NC, on 7.6 × 7.6 m plots. The soil was moist at the time of application, and air and soil temperatures were 34.4 and 30.0°C, respectively. Insecticides were applied on 7 July. Wettable granular formulation was applied using the John Deere Turf Gator mounted research sprayer delivering 237 liters/ha. Granular formulations were applied using a Scotts Easy® hand-held granular spreader (Scotts Co., Maryville, OH). Soil at the site was classified as Grifton Fine Sandy Loam with a pH of 6.2 and 1.14% humic matter. Soapy water flushing at the time of application indicated that the population was 100% tawny mole crickets. Control was evaluated using the Cobb and Mack (1989) damage rating method at 14, 21, 28, 35, and 42 DAT.

Greenhouse study. Greenhouse assays were conducted at North Carolina State University greenhouse facilities in Raleigh, NC, in 1998 and 1999. Mole crickets used in this study were collected from golf course fairways using a soapy water flushing (Short and Koehler 1979) and rinsed immediately in water. These mole crickets were maintained in a laboratory with house cricket diet (Purina Cricket Chow®, St. Louis, MO) for at least 10 d before using in studies. Nineteen-liter plastic buckets (37 cm in length and 28.5 cm in diam) with three drainage holes (2 mm diam) in the bottom (Walker 1979) were filled to a depth of 13 cm with native soil from the original collection site (Fox Squirrel Golf Course in Brunswick Co., NC). The soil was classified as Kureb fine sand with a pH of 5.8 and 0.41% humic matter. Each bucket was a replicate. Four replicates were used per treatment. Mole crickets of a given species were introduced into each bucket and the two species were tested separately. These studies used large nymphs and adults which are more difficult to control than smaller nymphs.

In the first bioassay, seven adult southern mole crickets were placed into each bucket 1 d before insecticide application. Thiamethoxam at rates of 500, 1,000, 5,000 and 10,000 ppm were used. Insecticides were applied on 3 June 1998, using a MeterJet® spray gun (Spraying Systems Co., Wheaton, IL), delivering 4.5 ml of solution per bucket (equivalent to 133.28 liter/ha based on the surface area of a bucket). Bermudagrass (Tifway 419) sod was then placed on top of the soil. Post-treatment irrigation was applied with 0.6 cm of water using a watering can. All buckets were covered with mesh screens during the experimental period to prevent mole cricket escape. Mortality was checked 72 h after application by pouring the soil out of each bucket and counting the number of dead and alive mole crickets. Mole crickets not recovered were regarded as dead (Green et al. 1984).

In the second bioassay, medium to large (third to seventh instars) tawny and southern mole crickets were used. The two species were tested separately. Five mole crickets of each species were placed into each bucket 1 d prior to insecticide application. Thiamethoxam at rates of 154, 308 and 616 g/ha and bifenthrin at 120 g/ha were used on the tawny mole crickets. (Southern mole crickets were treated with thiamethoxam at a rate of 308 g/ha only.) Insecticides were applied on 21 September 1999 using the MeterJet® spray gun delivering 3 ml of solution per bucket. The buckets were then covered with mesh screens. Mortality was checked by pouring the soil out of each bucket and counting the number of dead and alive mole crickets. Mole crickets not recovered were considered dead. Live mole crickets, along with the soil, were placed back into the bucket for continued observation. This initial evaluation altered the distribution of the insecticide in the soil. The highly mobile nature of mole crickets in a limited quantity of soil most likely results in significant exposure to the insecticide both before and after the first evaluation. Previous trials had not indicated any significant increase in mortality immediately following such soil disturbances. Mole crickets were checked at 7, 14, and 21 d after insecticide treatment.

In the third bioassay, an application of 0.007 g of fipronil granular formulation (equivalent to 14 g [AI]/ha) (Chipco Choice®), or 1.4 g of bifenthrin granular (equivalent to 560 g [AI]/ha (Talstar® G, FMC Corporation, Philadelphia, PA) was incorporated with 6,000 cm^3 of soil in a bucket. Bermudagrass (419), *Cynodon dactylon*) Pers, sod was placed on top of the soil. Five adult tawny mole crickets and last-instar nymphs of southern mole crickets were used. Buckets were treated on 11 December 1998. The buckets were then covered with mesh screens. Post-treatment irrigation with 0.6 cm of water was applied once every other day starting 1 day after treatment. Mortality was checked by pouring the soil out of each bucket and counting the number of dead and alive mole crickets. Mole crickets not recovered were considered dead. Live mole crickets, along with the soil, were placed back into the bucket for continued observation. Mole cricket mortality was evaluated at 7, 14, 21 and 28 d after treatment.

In the fourth bioassay, deltamenthrin (DeltaGard® G and DeltaGard® SC, Bayer USA Company, Montvale, NJ) and bifenthrin (Talstar® GC Flowable) were used in this study. Five mole crickets were medium-size nymphs (third to fifth instars) were used. Insecticides were applied on 31 August 1999 for the tawny mole crickets and 21 September 1999 for the southern mole crickets. Sprayable formulations (equivalent to 550 liters/ha) of bifenthrin or deltamethrin were delivered into each bucket using a CO_2 powered MeterJet® spray gun (No. 23623-31-1/4F) with a full cone nozzle (C-35) at a volume of 3 ml of solution per bucket. No sod was placed on top of the soil. Post-treatment irrigation with 0.6 cm of water was applied immediately after treatment, then once every other day thereafter. The granular product was evenly distributed across the surface of a bucket with a gloved hand. The buckets were then covered with mesh screens. Mortality was checked at 7 and 14 d after treatment by pouring the soil out of each bucket and counting the number of dead and alive mole crickets. Mole crickets not recovered were regarded as dead. Live mole crickets and soil, were placed back into the buckets for continued observation.

Statistical analysis. Abbott's formula was used if mortality in the untreated control of each corresponding species was >5% (Abbott 1925, Busvine 1971). All data were transformed (square root X + 0.5 for field data and arcsine for percentage data) prior to statistical analysis. Analysis of variance procedure (ANOVA, MEANS, SAS Institute 1990) was used to conduct analysis of variance among treatments and to compute means and standard errors of dependent variables. Waller-Duncan K-ratio test (ANOVA, Waller option. SAS Institute 1990) was used to compare damage ratings before and after insecticide treatment, and mortality between treatments. Probit analysis was conducted using the Polo-PC program to estimate LC_{50} and LC_{90} (LeOra Software 1997).

Results

In the 1997 field study, thiamethoxam applied at 135 to 405 g/ha did not demonstrate significant control of southern and tawny mole cricket nymphs, compared to the untreated control (Table 1).

The 1998 field study showed numerically fewer mole crickets in all treated plots compared to the untreated control at 16 DAT (Table 2). All treatments exhibited significant control of mole crickets when compared to the untreated at 23 DAT with the high rate of thiamethoxam applied to the surface and the chlorpyrifos subsurface treatment providing significantly better control than the lower rate of thiamethoxam applied to the surface. At 38 DAT, all treatments still had significantly less damage than the control, and the chlorpyrifos-treated plots had less damage than the 300 g(ai)/ha surface treatments of thiamethoxam. The lowest rate of thiamethoxam (surface) no longer provided significant control compared to the untreated at 53 d. Imidacloprid and chlorpyrifos provided significantly better control than the low or high rate of thiamethoxam applied to the surface after 53 d.

The two treatments of the wettable granular (WG) formulation of thiamethoxam applied in the 1999 study gave better mole cricket control than the untreated control only at 35 DAT (Table 3). However, the granular formulation provided significantly better control at 14, 28, 35, and 42 DAT. Fipronil always had lower damage ratings than the untreated control. There was no significant difference in mole cricket damage ratings between fipronil and thiamethoxam dry granular formulation during the study period. Damage ratings in fipronil treated plots were significantly lower than those in thiamethoxam WG treatment at a rate of 225 g/ha at 28, 35, and 42 DAT, and 300g/ha at 35 and 42 DAT.

The first greenhouse bioassay estimated the toxicity of thiamethoxam against adult southern mole crickets with a LC_{50} and LC_{90} of 1,816 ppm (95% confidence interval: 1,219 to 2,661 ppm), and 9,978 ppm (95% confidence interval: 5,948 to

Table 1. Efficacy of thiamethoxam for control of mole cricket nymphs, Brunswick Co., NC, 1997

Insecticide/form.	Rate g (ai)/ha	Average mole cricket damage ratings*,** 6 DAT	13 DAT	19 DAT	26 DAT
Untreated		2.7a	3.4b	2.2b	3.4b
Thiamethoxam/2SC	135	1.4a	2.0ab	1.8ab	2.5b
Thiamethoxam/2SC	270	1.3a	2.1ab	2.8b	2.4b
Thiamethoxam/2SC	405	1.0a	2.6b	2.0ab	3.0b
Ethoprop	11,220	0.4a	0.3a	0.1a	0.4a

* Mole cricket damage rate ranged from 0 to 9, 0 = no damage and 9 = severe damage.

** Means within each column are not significantly different (α = 0.05, 0 DAT: Waller–Duncan K-ratio T-test, ANOVA, SAS Institute 1990).

Table 2. Comparison of surface and subsurface application of thiamethoxam for control of mole cricket nymphs, Brunswick Co., NC, 1998

Insecticide/form.	Rate g (ai)/ha	Application placement	Mole cricket control* 16 DAT**	23 DAT†	38 DAT†	53 DAT†
Untreated			5.5b	7.6c	8.4c	8.7d
Thiamethoaxam/25 WG	225	Surface	0.7a	2.6b	3.9ab	7.0cd
Thiamethoxam/25 WG	225	Subsurface	0.4a	1.8ab	3.1ab	5.8abc
Thiamethoxam/25 WG	300	Surface	0.5a	2.4ab	4.1b	5.2ab
Thiamethoxam/25 WG	925	Surface	0.2a	1.4a	2.7ab	6.4bc
Chloropyrifos/Pro 2E	2,268	Subsurface	0.1a	1.4a	2.2a	4.4a
Imidacloprid/75 WP	475	Surface	0.6a	1.6ab	3.0ab	4.3a

* Means within each column are not significantly different (α = 0.05, 0 DAT: Waller–Duncan K-ratio T-test, ANOVA, SAS Institute 1990).

** No. of mole crickets/m^2 by soapy water flushing.

† Mole cricket damage rating range from 0 to 9, 0 = no damage and 9 = severe damage

Table 3. Efficacy of thiamethoxam for control of tawny mole cricket nymphs, Brunswick Co., NC, 1999

Insecticide/form.	Rate g (ai)/ha	Mole Cricket Damage Ratings*,** 14 DAT	21 DAT	28 DAT	35 DAT[3]	42 DAT
Untreated		2.9b	2.6b	3.7c	4.3c	5.1c
Thiamethoxam/25 WG	225	1.9ab	2.1ab	3.2bc	2.3b	4.0bc
Thiamethoxam/25 WG	300	1.7ab	1.1ab	2.2abc	2.0b	2.9bc
Thiamethoxam/.22 G	300	0.6a	1.1ab	1.1ab	1.1ab	1.7ab
Fipronil/0.1 G	14	0.2a	0.0a	0.15a	0.0a	0.2a

* Mole cricket damage rating range from 0 to 9, 0 = no damage and 9 = severe damage.

** Means within each column are not significantly different (α = 0.05, 0 DAT: Waller–Duncan K-ratio T-test. ANOVA, SAS Institute 1990).

24,652 ppm, respectively (Table 4). The LC_{90} value of 9,978 ppm is equivalent to that of a field application rate of 3,013 g(ai)/ha, which is much higher than the rates 135 to 925 g(ai)/ha used in these field studies.

In the second bioassay, thiamethoxam provided less than 50% control against medium-sized nymphs under various application rates similar to those used in the field studies (Table 5). Bifenthrin applied at the field rate equivalent provided high mortality at 21 DAT.

The third bioassay compared fipronil and bifenthrin and indicates mortality of

Table 4. LC_{50} and LC_{90} values of thiamethoxam against adult southern mole crickets, North Carolina State University greenhouse, 1998

LC values	Dose (ppm)	Limited	Probability 0.90	0.95	0.99
LC_{50}	1,816	Lower	1,309	1,219	1,046
		Upper	2,492	2,661	3,058
LC_{90}	9,978	Lower	6,378	5,948	5,244
		Upper	20,319	24,652	39,457

Table 5. Efficacy of thiamethoxam and bifenthrin against nymphs of mole cricket in North Carolina State University greenhouse bioassay 1999

Insecticide/form.	Rate g (ai)/ha	Species	% Mole cricket mortality* 7 DAT	14 DAT	21 DAT
Untreated		Tawny	5a	15a	20a
Thiamethoxam/25 WG	154	Tawny	5a	10a	20a
Thiamethoxam/25 WG	308	Tawny	10ab	40b	45a
Thiamethoxam/25 WG	616	Tawny	20b	30ab	45a
Bifenthrin/GC-Flowable	120	Tawny	50c	85c	100b
Untreated		Southern	5a	10a	25b
Thiamethoxam/2SC	308	Southern	15ab	30ab	35a

* Means within each column are not significantly different ($\alpha = 0.05$, 0 DAT: Waller-Duncan K-ratio T-test. ANOVA. SAS Institute 1990).

southern mole crickets from the fipronil application was significantly higher than that of tawny mole crickets at 7, 21, and 28 DAT after treatment (DAT) (Table 6). Bifenthrin gave significantly higher mortality of tawny mole crickets than southern mole crickets at 28 days. Mortality of southern mole crickets with fipronil at 28 d was significantly higher than that of tawny mole crickets with fipronil or southern mole crickets with bifenthrin.

In the fourth bioassay bifenthrin produced higher mortality against tawny mole crickets than southern mole crickets at 14 DAT (Table 7). Two formulations of deltamethrin showed some different insecticidal activity against the two mole cricket species. At 7 DAT, all southern mole crickets were killed using granular deltamethrin, which was significantly different from either formulation against tawny mole crickets and better than the bifenthrin on either species. After 14 d, the granular formulation of deltamethrin applied against tawny mole crickets provided lower mortality than all but the bifenthrin on southern mole cricket and the spray formulation of deltamethrin. The spray formulation of deltamethrin did not result in different levels of mortality in the two species.

Table 6. Toxicity of fipronil and bifenthrin against southern and tawny mole crickets, North Carolina State University greenhouse, 1998

Treatment	Rate g (AI)/ha	Species	% corrected mole cricket mortality* 7 DAT	14 DAT	21 DAT	28 DAT
Fipronil	14	Tawny	0a	25ab	25a	25ab
Fipronil	14	Southern	27b	63b	67b	85c
Bifenthrin	560	Tawny	5a	13a	50ab	50bc
Bifenthrin	560	Southern	0a	7a	7a	10a

* Means followed by the same letter in each column are not significantly different (α = 0.05, Waller-Duncan K-ratio T-test, SAS Institute 1990).

Table 7. Toxicity of deltamethrin and bifenthrin against nymphs of southern and tawny mole crickets, NCSU greenhouse, 1999

Treatment	Rate g (AI)/ha	Species	% corrected mortality* 7 DAT	14 DAT
Deltamethrin (DeltaGard® SC)	145	Southern	74ab	88ab
Deltamethrin (DeltaGard® SC)	145	Tawny	33a	95b
Deltamethrin (DeltaGard® G)	145	Southern	100b	100b
Deltamethrin (DeltaGard® G)	145	Tawny	59a	72a
Bifenthrin (Talstar® GC Flowable)	127	Southern	53a	68a
Bifenthrin (Talsta® GC Flowable)	127	Tawny	54a	100b

* Means followed by the same letter in each column are not significantly different (α = 0.05, Waller-Duncan K-ratio T-test, SAS Institute 1990).

** Data from 7 DAT.

Discussion

Across the three field studies, thiamethoxam provided the highest level of mole cricket control in the 1998 trial, probably due to the timing of the thiamethoxam application. The study conducted in August showed little efficacy of thiamethoxam. It has been well documented that early application (mid-June to early-July in North Carolina) generally provides better mole cricket control (Brandenburg 1997). The 1997 trial suggests that it may be necessary to apply thiamethoxam in June.

The estimated LC_{90} value of thiamethoxam was 9,978 ppm against adult southern mole crickets. This is equal to a field rate of 3,013 (ai)/ha, which is approximately 10 times higher than the rates used in this study. The LC values should be much lower when tested against the early instars. Early instars are the target for most insecticides, and the rate required herein demonstrated the challenge of controlling larger crickets. These results also suggest that thiamethoxam has little potential as a rescue treatment.

Subsurface application usually provides better control against soil insects because insecticides are applied directly into the soil. Results of the 1998 trial, however, suggest that subsurface application did not significantly improve the performance of thiamethoxam. We speculate that, due to its moderate water solubility, thiamethoxam, like imidacloprid, can readily move through the thatch layer to the site where mole crickets reside.

Thiamethoxam showed variable toxicity against tawny or southern mole crickets when evaluated at field application rates, while bifenthrin performed well in greenhouse tests. This lack of toxicity helps explain sporadic field performance. In field situations, pesticides usually remain at the grass canopy, thatch, and top soil after application (Niemczyk and Krueger 1987, Stahnke et al. 1991, Xia et al. 2004). Few insecticides penetrate more than 0 to 2.5 cm into the soil regardless of the amount of irrigation applied (Villani and Wright 1988). Therefore, the efficacy of both bifenthrin and thiamethoxam, in the greenhouse tests, may not accurately represent field situations. In addition, adult and large nymphs were used. Field studies suggest that all insecticides, except for bait formulations, work best against small nymphs, and insecticide efficacy decreases as the size of the mole cricket increases (Brandenburg 1997).

Fipronil provides excellent control of both species of mole cricket in field situations and typically is recognized as the industry standard. The use of adult crickets or larger nymphs may have contributed to the low mortality and slow action observed in this study. However, based on the results of this and other studies, fipronil is more effective against southern mole crickets than tawny mole crickets when large nymphs or adult crickets are present (Xia and Brandenburg, unpubl. data). These observations confirm this conclusion.

In field studies, bifenthrin generally provided good control against the two species of mole crickets with proper timing of the application (against small nymphs). Control was usually unsatisfactory if applications were made after early August in NC. This suggests that the difference in the efficacy of bifenthrin against these two species of mole crickets may become more significant as the size of the mole crickets increase. Based on the results of this study, bifenthrin may be one of the better choices for late-season mole cricket control if tawny mole crickets are the dominant species at the location.

This is the first report on comparative mortality of two species of mole crickets to insecticides in North Carolina. Results of this study provide significant information for further research on selection of insecticides in mole cricket control programs, especially for late-season control. Late-season mole cricket control is often necessary in many locations where mole crickets have historically been a problem. The effective residual activity of many insecticides used for mole cricket control usually less than one month. Mole crickets hatching after August can cause serious damage.

There are several possible explanations as to why insecticides may cause different field mortalities between the two species. First, the behavior of the mole crickets varies between the species other than direct susceptibility. Southern mole crickets are more active in for prey tunneling (Tsedeke 1979) and may have a greater likelihood of contacting soil-applied insecticides. Second, the mobility of an insecticide in the soil and its application rate may affect control. Lack of mobility of fipronil in the soil, due to its soil binding properties and its low water solubility (United States Environmental Protection Agency 1996) and the extremely low field application rate (14 g[ai]/ha) probably make the active tunneling of targeted insect pests more critical. Finally, the mode of action of an insecticide may be important. Theoretically, insecticides which have some systemic toxicity may kill more tawny mole crickets because the species is an herbivore. However, only contact toxicity contributed to the mortality in this study.

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