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University of Georgia research is evaluating the potential for resistance to multiple insect pests among turfgrasses for the southeastern US. The goal is not to simply replace one management tactic (insecticides) with another (host plant resistance). Their research examines the potential to integrate turf with varying levels of resistance with other IPM strategies including chemical and biological control.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Fall Armyworm Response to Insecticides: Influence of Turf Type

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SUMMARY

University of Georgia research is evaluating the potential for resistance to multiple insect pests among turfgrasses for the southeastern US. Their research examines the potential to integrate turf with varying levels of resistance with other IPM strategies including chemical and biological control. Results to date include:

- The residual activity of six concentrations of chlorpyrifos, spinosad, and halofenozide on fall armyworm, *Spodoptera frugiperda*, as mediated by five warm- season turfgrass cultivars expressing varying levels of genetic resistance was evaluated in greenhouse trials.
- Similarly, varying concentrations of halofenozide were applied to six turfgrass cultivars in the field; mortality of first and third- instar fall armyworms was assessed.
- Reduced rates of chlorpyrifos resulted in lower fall armyworm survival on resistant zoysiagrass cultivars relative to that on bermudagrass or paspalum. In a separate trial, when treated with spinosad, survival on the same zoysiagrasses was equal to or greater than that on more susceptible bermuda or paspalum.
- Reduced rates of halofenozide resulted in lower survival on resistant zoysiagrasses at some concentrations at 7, but not at 14 days exposure compared to more susceptible grasses.
- In the field, at the full labeled rate of halofenozide, 100% mortality was observed regardless of turfgrass cultivar. Larval survival on the most susceptible turf, 'TifEagle', was higher than that on the remaining turf cultivars at the intermediate rate applied. Larvae exposed to treated turf as third instars displayed a trend toward greater survival at intermediate rates on the two paspalums,' Sea Isle 1' and 561-79, while a trend toward lower survival was observed on 'Palisades' and 'Cavalier' zoysiagrasses.
- Factors potentially contributing to the variation in responses observed in the present study include different modes of action of insecticides, host-plant resistance mechanisms, differential foliar consumption rates, and insecticide dose in relation to body weight.
- Development of guidelines for pest management practitioners must address the complexity of potential interactions and may require “case by case” evaluations.

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Potential synergistic interactions between pest-resistant turfgrasses and reduced doses of insecticides could offer benefits for management that have yet to be fully realized. Effective integration of management approaches requires that more attention be given to the interaction and compatibility of various strategies. Few studies have addressed the integrated effects of host-plant resistance and pesticides for grasses.

Plant resistance among warm-season grasses has been observed for fall armyworm in varying turfgrass species and cultivars (1, 4, 10, 15, 17, 18, 19, 21, 21). Some turfgrass cultivars recently identified as demonstrating resistance to fall armyworm have also demonstrated antibiosis and/or tolerance to other turfgrass pests including two lined spittlebug, *Prosapia bicincta* (20), zoysiagrass mite, *Eriophyes zoysiae* (16), and mole crickets, *Scapteriscus spp*. (6, 9).

Turfgrasses showing varying levels of resistance to fall armyworm and other pests were also evaluated for extrinsic resistance characteristics

The fall armyworm is one of the most destructive turf insects in the South. Larvae become full grown in 2-3 weeks reaching a length of about 1. 5 inches. Large populations, often occuring after cold, wet springs, can eat grass down to the crown.

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where it was determined that occurrence and performance of predators was influenced by turfgrass type and resistance status (5). Research reported here examined the relationship between these same turfgrasses, reduced rates of three insecticides with differing modes of action, and survival of and plant damage by the fall armyworm.

Insects and Plants Used in Experiments

The armyworm colony was initiated with eggs obtained from the USDA/ARS Crop Protection and Management Research Unit (Tifton, GA) in 1994 and supplemented annually with new material from the USDA colony. Cultivars evaluated were 'Palisades' and 'Cavalier' zoysiagrasses (*Zoysia japonica* and *Z. matrella*); 'TifSport' and 'TifEagle' bermudagrasses (*Cynodon dactylon* x *C. transvaalensis*); and 'Sea Isle 1' seashore paspalum (*Paspalum vaginatum*). Previous work demonstrated that fall armyworm survival should be greatest on 'TifEagle' bermudagrass, followed by paspalum grasses and 'TifSport' hybrid bermudagrass, and least on the

	Concentration (ml chlorpyrifos 2 formulation per 400 ml water)					
Turf Cultivar	0.000	0.001	0.030	0.090	0.270	0.810
	.....Mean number of surviving larvae per rep.....					
	3 days post-treatment					
TifEagle	3.3 a	3.0 a	2.8 a	1.8 ab*	1.2 a*	0.7 a*
TifSport	3.0 a	3.0 a	2.7 a	1.5 b*	0.8 a*	0.0 b*
Sea Isle 1	3.2 a	2.8 a	2.5 ab	2.2 a*	0.9 a*	0.1 b*
Cavalier	2.9 a	2.8 a	1.8 c*	1.2 b*	0.9 a*	0.0 b*
Palisades	2.7 a	2.6 a	1.9 bc	1.3 b*	0.7 a*	0.2 b*
	7 days post-treatment					
TifEagle	2.7 a	2.3 a	1.3 ab	0.4 a*	0.8 a*	0.2 a*
TifSport	1.6 b	2.0 a	1.8 a	0.4 a*	0.7 a*	0.0 a*
Sea Isle 1	2.0 b	2.3 a	1.3 ab*	0.9 a*	0.5 a*	0.1 a*
Cavalier	1.5 b	1.8 ab	0.8 +b*	0.3 a*	0.3 a*	0.0 a*
Palisades	1.7 b	1.3 b	0.8 b*	0.3 a*	0.2 a*	0.0 a*
	14 days post-treatment					
TifEagle	1.0 a	0.9 a	0.9 a	0.4 bc*	0.3 a*	0.1 a*
TifSport	1.0 a	1.2 a	1.0 a	0.5 b*	0.2 ab*	0.0 a*
Sea Isle 1	1.1 a	1.0 a	0.7 a*	0.7 a*	0.1 ab*	0.1 a*
Cavalier	1.0 a	1.0 a	0.4 a*	0.3 c*	0.0 b*	0.0 a*
Palisades	1.1 a	1.0 a	0.8 a	0.1 d*	0.0 b*	0.0 a*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).
* Significantly (P<0.05) lower larval survival than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test.

Table 1. Number of surviving *Spodoptera frugiperda* larvae of four initial larvae per rep (n=18) when reared in a greenhouse on chlorpyrifos- treated turfgrasses expressing varying levels of host plant resistance

Turf Cultivar	Concentration (ml chlorpyrifos 2 formulation per 400 ml water)					
	0.000	0.001	0.030	0.090	0.270	0.810
	.....Fresh weight (grams).....					
TifEagle	0.0 c	0.03 b	0.06 b	0.2 b	0.5 bc*	0.4 b*
TifSport	0.04 bc	0.03 b	0.05 b	0.2 b	0.4 c*	0.6 b*
Sea Isle 1	0.0 c	0.0 b	0.2 b	0.2 b	1.0 a*	1.1 a*
Cavalier	0.1 a	0.2 a	0.5 a*	0.6 a*	0.4 c*	0.9 a*
Palisades	0.09 ab	0.2 a	0.5 a*	0.5 a*	0.6 b*	0.6 b*
	..... Dry weight (grams).....					
TifEagle	0.00 b	0.01 b	0.03 b	0.06 b*	0.20 a*	0.10 c*
TifSport	0.01 b	0.01 b	0.02 b	0.05 b	0.10 a*	0.30 b*
Sea Isle 1	0.00 b	0.00 b	0.05 b	0.06 b	0.20 a*	0.20 b*
Cavalier	0.04 a	0.10 a	0.20a*	0.20 a*	0.20 a*	0.40 a*
Palisades	0.02 ab	0.04 a	0.20a*	0.20 a*	0.20 a*	0.30 b*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).

* Significantly (P<0.05) greater plant weight than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test.

Table 2. Average fresh and dry weights of grasses expressing varying levels of host plant resistance to *Spodoptera frugiperda* larvae when treated with various concentrations of chlorpyrifos and infested with larvae for two weeks in a greenhouse

two zoysiagrasses (6, 7, 8). Day length was 14 h, maintained using high intensity, metal halide light.

Effects of Cultivar and Insecticide on Survival of Fall Armyworm in the Greenhouse

Individual tillers of each turfgrass cultivar were transplanted into 300-ml plastic containers of Turface and allowed to establish for 3 weeks prior to evaluation. Six concentrations of each of three insecticides were applied. Insecticides were chlorpyrifos (Chlorpyrifos Pro 2, Micro Flo Company, Memphis TN), halofenozide (Mach 2, Dow AgroSciences, Indianapolis IN) and spinosad (Conserve, Dow AgroSciences, Indianapolis IN). Applications were made using a CO_2 powered backpack sprayer with a Meter Jet Gun (Spray Systems Co., Wheaton, IL).

Space constraints did not allow evaluation of all three insecticides simultaneously. Three separate sequential trials were conducted, one for each insecticide. Larval survival and turfgrass top growth, measured as fresh and dry weights, were compared among turfgrass cultivars for each of the six insecticide concentrations. Each turfgrass cultivar x insecticide concentration combination was replicated 18 times in a randomized complete block design. Pesticides were applied to grasses in cups at 0800 h. Four, 3-day-old fall armyworm larvae were placed in each cup between 1000 and 1200 h the same day and kept confined to the cups using opaque nylon screens. Numbers of larvae surviving in each cup were counted at days 3, 7, and 14 days for chlorpyrifos and at days 7 and 14 for the slower-acting halofenozide and spinosad. After 14 days, plants were clipped at the base, weighed, placed in paper bags, oven-dried, and weighed again.

Turf Cultivar	Concentration (ml formulation of spinosad per 400 ml water) 0.000	0.000375	0.00075	0.00375	0.0375	0.375
	.....Mean number of surviving larvae per rep.....					
	7 days post-treatment					
TifEagle	2.8 a	2.8 a	0.7 a*	0.4 a*	0.1 b*	0.0 a*
TifSport	2.8 +a	1.8 a	0.9 a*	0.2 a*	0.2 b*	0.0 a*
Sea Isle 1	3.0 a	2.2 a	0.5 a*	0.0 b*	0.1 b*	0.0 a*
Cavalier	2.7 a	2.1 a	0.5 a*	0.2 a*	0.3 b*	0.0 a*
Palisades	2.5 a	2.0 a	0.7 a*	0.1 b*	0.5 a*	0.0 a*
	14 days post-treatment					
TifEagle	1.1 a	0.6 b*	0.4 a*	0.4 a*	0.1 a*	0.0 a*
TifSport	0.7 a	0.7 b	0.5 a*	0.1 a*	0.1 a*	0.0 a*
Sea Isle 1	1.0 a	1.0 a	0.4 a*	0.1 a*	0.1 a*	0.0 a*
Cavalier	1.0 a	0.9 ab	0.4 a*	0.1 a*	0.3 a*	0.0 a*
Palisades	1.3 a	0.9 ab*	0.3 a*	0.1 a*	0.3 a*	0.0 a*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).

* Significantly (P<0.05) lower larval survival than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test

Table 3. Number of surviving *Spodoptera frugiperda* larvae of four initial larvae per rep (n=18) when reared in a greenhouse on spinosad (Conserve) -treated turfgrasses expressing varying levels of host plant resistance

Fall armyworm adults are noticed mostly at night because they are attracted to light. Females lay hundreds of eggs, depositing them on the underside of leaves and other surfaces.

Turf Cultivar	Concentration (ml spinosad formulation per 400 ml water) 0.000	0.000375	0.00075	0.00375	0.0375	0.375
	.....Fresh weight (grams).....					
TifEagle	0.1 b	0.8 a	1.5 a	3.0 a*	3.4 a*	2.4 ab*
TifSport	0.0 b	0.0 b	1.1 a*	1.6 b*	0.9 d*	2.3 b*
Sea Isle 1	0.0 b	0.5 a	1.9 a*	2.7 a*	2.1 b*	1.1 a*
Cavalier	0.5 a	0.7 a	0.6 a	1.2 bc*	1.5 c*	0.8 d*
Palisades	0.4 a	0.1 b	0.7 a	1.0 c*	0.5 d*	1.6 c*
	.....Dry weight (grams).....					
TifEagle	0.03 a	0.3 a*	0.2 c	1.1 a*	1.2 a*	0.9 a*
TifSport	0.00 a	0.00 d	0.4 b*	0.6 c*	0.4 c*	0.9 a*
Sea Isle 1	0.00 a	0.1 bc	0.6 a*	0.9 b*	0.7 b*	0.8 a*
Cavalier	0.2 b	0.3 ab	0.3 c	0.4 d*	0.6 bc*	0.4 b*
Palisades	0.2 b	0.06 cd	0.3 c*	0.3 d*	0.2 d*	0.6 b*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).

* Significantly (P<0.05) greater plant weight than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test.

Table 4. Average fresh and dry weights of grasses expressing varying levels of host plant resistance to *Spodoptera frugiperda* larvae when treated with various concentrations of spinosad (Conserve) and infested with larvae for two weeks in a greenhouse

Fall Armyworm Responses Vary with Grass and Insecticide

Significant turfgrass cultivar and concentration effects occurred on larval survival three, seven, and 14 days after exposure to chlorpyrifos-treated grasses (Table 1). Mortality was 97.5 to 100% at the highest concentration (Table 1). At 3-days post-treatment, intermediate concentrations resulted in enhanced mortality on cultivars previously demonstrating resistance to fall armyworm, 'Palisades' and 'Cavalier' zoysiagrasses and, to a lesser extent, 'TifSport' bermudagrass (Table 1). Conversely, survival on the very susceptible 'TifEagle' was significantly higher than on other grasses at the highest chlorpyrifos concentration three days after application.

By seven days after application, no significant effect of cultivar on larval survival was evident at the three highest concentrations. However, at the two lowest concentrations, the least fall armyworm survival was observed on the more resistant 'Cavalier' and 'Palisades' (Table 1). Grass top growth on untreated plants, measured as fresh and as dry weight of clippings at the end of the exposure period, was significantly greater for the two most resistant grasses 'Cavalier' and 'Palisades' zoysiagrasses (Table 2). These two resistant grasses also began to show enhanced growth relative to the untreated plants of the same cultivars in the second lowest chlorpyrifos concentration as is shown in fresh and dry weight comparisons.

Spinosad applications resulted in 100% mortality at the highest concentration applied (Table 3). Fewer cultivar effects were evident within each pesticide concentration comparison than were observed in the prior trial with chlor-

Turf Cultivar	Concentration (ml formulation of halofenozide per 400 ml water) 0.000	0.001	0.010	0.10	1.000	2.000
	.....Mean number of surviving larvae per rep.....					
	7 days post-treatment					
TifEagle	1.9 a	2.3 a	2.0 a	1.7 a	0.7 ab*	0.7 a*
TifSport	2.5 a	1.4 b*	1.5 b*	1.9 a*	0.8 a*	0.8 a*
Sea Isle 1	1.9 a	2.0 a	1.7 ab	2.1 a	0.3 c*	0.6 ab*
Cavalier	1.2 a	0.9 b	0.8 c	1.2 b	0.1 c*	0.2 b*
	14 days post-treatment					
TifEagle	1.1 a	1.3 a	1.0 a	0.9 b	0.5 a*	0.3 ab*
TifSport	1.4 a	1.4 a	1.8 a	1.6 a	0.3 a*	0.4 a*
Sea Isle 1	1.6 a	1.8 a	1.6 a	2.1 a	0.2 a*	0.0 c*
Cavalier	0.9 b	0.9 a	0.8 a	1.2 ab	0.1 a*	0.05 bc*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).
* Significantly (P<0.05) lower larval survival than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test.

Table 5. Number of surviving *Spodoptera frugiperda* larvae of four initial larvae per rep (n=18) when reared in a greenhouse on halofenozide (Mach 2) -treated turfgrasses expressing varying levels of host plant resistance

pyrifos. In contrast with what was observed with chlorpyrifos, mortality at low concentrations of spinosad was not significantly higher on the more resistant grasses in comparison with the more susceptible 'TifEagle' and 'Sea Isle 1'. In fact, a slight trend occurred toward increased mortality on susceptible cultivars compared with the more resistant zoysiagrasses, possibly indicating greater ingestion of effective dose on more susceptible plant material (Table 3). Again, when plants were not treated, top growth was greatest for more resistant 'Cavalier' and 'Palisades' (Table 4). 'TifEagle', 'TifSport' and 'Sea Isle 1' demonstrated greater fresh and/or dry weights at the three highest spinosad concentrations than 'Cavalier' or 'Palisades' in contrast to what was observed following chlorpyrifos application in the previous trial.

Application of halofenozide also resulted in significant cultivar, concentration, and interaction effects for larval survival and grass weights (Table 5, 6). In this greenhouse trial, fall armyworm larval survival on the more resistant 'Cavalier' was significantly less than that on the more susceptible cultivars at day seven for each pesticide concentration (Table 5), but by day 14, few differences in survival were apparent. Concentration effects on larval survival were most evident for the partially resistant 'TifSport' bermudagrass where a significant reduction in survival compared to the untreated grasses occurred by day 7 at the lowest concentration. Effects on plant top growth were, however, most evident for 'Sea Isle '1 seashore paspalum with a significant increase in plant weight observed at intermediate concentrations (Table 6).

Effects of Cultivar and Halofenozide on Survival of Fall Armyworm in the Field

Plots (each 25 m^2) were located at the Research and Education Garden of the Georgia

Turf Cultivar	Concentration (ml formulation of halofenozide per 400 ml water) 0.000	0.001	0.010	0.100	1.000	2.000
	.....Fresh weight (grams).....					
TifEagle	0.0 b	0.0 a	0.0 b	0.1 b	1.1 b*	0.3 b*
TifSport	0.0 b	0.0 a	0.0 b	0.0 b	0.6 b*	0.6 b*
Sea Isle 1	0.1 b	0.1 a	0.2 a	1.1 a*	2.8 a*	4.0 a*
Cavalier	0.2 a	0.1 a	0.2 a	0.1 b	0.7 b*	0.5 b*
	.....Dry weight (grams).....					
TifEagle	0.0 b	0.0 a	0.0 a	0.03 b	0.4 ab	0.01 c
TifSport	0.0 b	0.0 a	0.0 a	0.0 b	0.2 c	0.01 c
Sea Isle 1	0.01 b	0.02 a	0.01 a	0.3 a*	0.5 a*	0.7 a*
Cavalier	0.1 a	0.01 a	0.01 a	0.0 b	0.3 bc*	0.2 b*

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.05).

* Significantly (P<0.05) greater plant weight than in the untreated (0.000 concentration) group within the same cultivar (row) by Fisher's protected least significant difference test.

Table 6. Average fresh and dry weights of grasses expressing varying levels of host plant resistance to *Spodoptera frugiperda* larvae when treated with various ncentrations of halofenozide (Mach 2) and infested with larvae for two weeks in a greenhouse

Station in Griffin. Cultivars evaluated were 'Palisades' and 'Cavalier' zoysiagrasses; 'TifSport' and 'TifEagle' bermudagrasses; and 561-79 and 'Sea Isle 1' seashore paspalums. Turfgrass cultivars were arranged in a randomized complete block design with six replications. Fifteen fall armyworm larvae were introduced into 144 cages, each constructed from a length of 15.2-cm diameter polyvinyl chloride (PVC) pipe inserted 5 cm into the soil in each turf plot. Halofenozide (Mach 2) was applied at varying rates using a CO_2 powered backpack sprayer with a Meter Jet Gun two hours prior to introduction of larvae. Larvae were confined to the cages using nylon screen. Cages were removed and plots were sampled after ten days. Larvae were counted using a standard soap flush sampling method (30 ml liquid dishwashing soap per 3.8 L water) to bring the larvae out of the thatch layer.

When fall armyworm neonates were exposed to a ¼ X rate of halofenozide in field plots, turfgrass taxa influenced larval survival (Table 7). At the full labeled rate, 100% mortality was observed regardless of turfgrass cultivar. Larval survival on the most susceptible turf, 'TifEagle', was higher than that on the remaining turf cultivars at the intermediate rate applied. Larvae exposed to treated turf as third instars displayed a trend toward greater survival at intermediate rates on the two paspalums, 'Sea Isle 1' and 561-79 (Table 7), while a trend toward lower survival was observed on 'Palisades' and 'Cavalier' zoysiagrasses.

About the Insecticides

Chlorpyrifos is an organophosphate insecticide and an acetylcholinesterase inhibitor involving phosphorylation of the enzyme. It kills by both contact and ingestion. Chlorpyrifos has certainly been one of, if not the most widely used insecticides on turf (2, 3, 7, 14). As a broad-spectrum insecticide it can be harmful to natural

Turf Cultivar	Concentration (halofenozide expressed as a fraction of the labeled rate X*)		
	0.000	¼ X***	½ X***
	Percent survival (%) Exposed as first instar larvae		
TifEagle	34.4 a	15.6 a	7.8 a
TifSport	31.1 a	5.6 b	3.3 ab
Sea Isle 1	25.3 a	0 b	1.3 b
561-79	28.9 a	3.3 b	1.1 b
Cavalier	10.0 a	4.4 b	2.2 b
Palisades	22.2 a	5.6 b	0 b
	0.000	1/16 X**	¼ X
	Percent survival (%) Exposed as third instar larvae		
TifEagle	20.0 a	8.3 abc	3.3 a
TifSport	16.7 a	11.7 abc	3.3 a
Sea Isle 1	33.3 a	20.0 ab	3.3 a
561-79	30.0 a	22.0 a	2.0 a
Cavalier	11.7 a	6.7 bc	0 a
Palisades	22.0 a	1.7 c	5.0 a

Means within a column followed by the same letter are not significantly different by Fisher's protected least significant difference test (P>0.10**;P>0.05***)
* Full labeled rate X resulted in 100% mortality of larvae regardless of turfgrass cultivar.

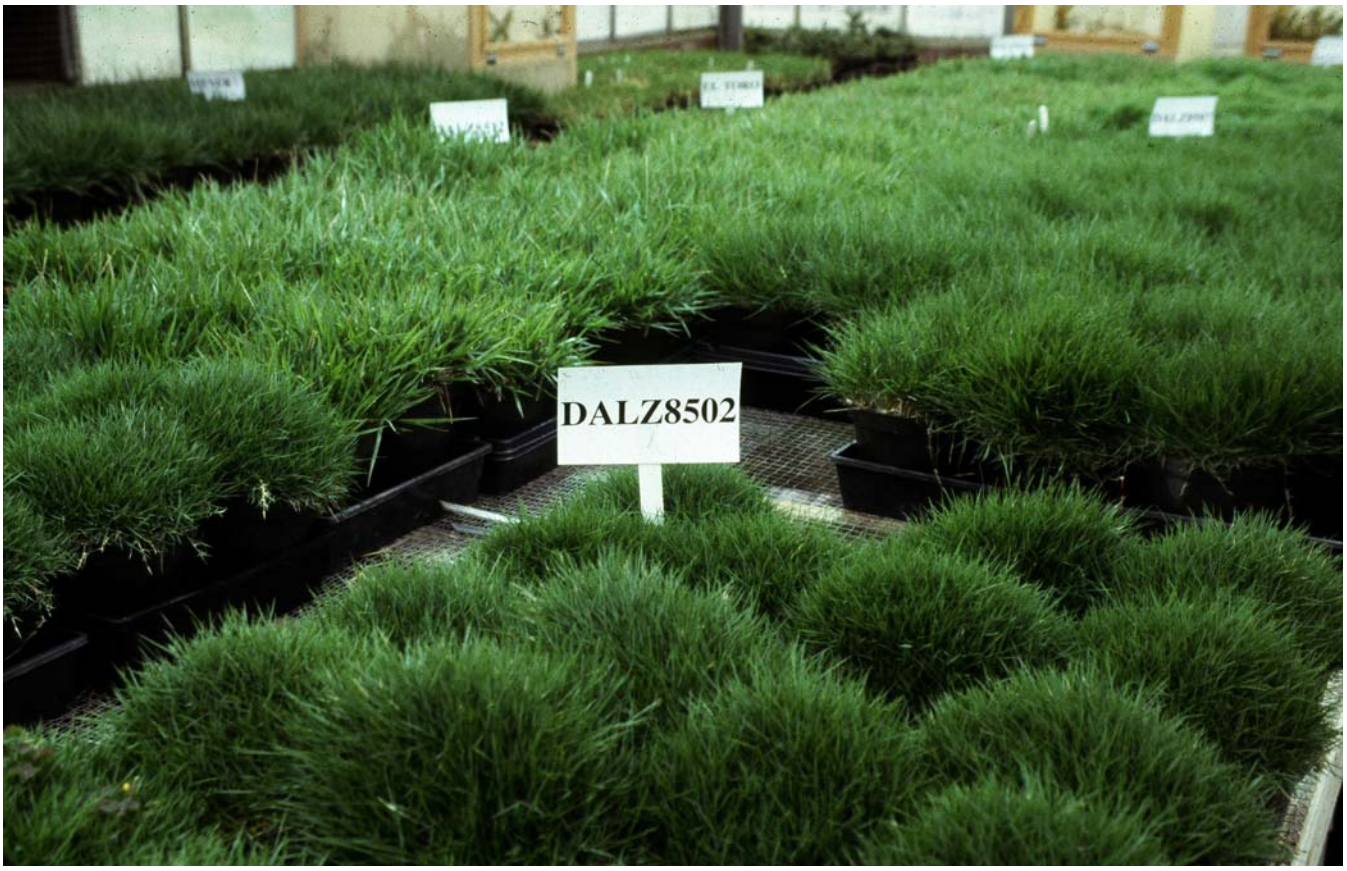
Table 7. Percent survival of *Spodoptera frugiperda* larvae per rep when exposed in the field to halofenozide-treated turfgrasses expressing varying levels of host plant resistance

enemies.

Spinosad and halofenozide are alternatives for fall armyworm suppression that have a narrower spectrum of activity and demonstrated improved margin of safety to many beneficial insects (11, 13,). Spinosad is a naturalyte, derived from a soil-dwelling actinomycetes bacteria, *Saccharopolyspora spinosa*. It is a mixture of the two metabolites spinosyn A and D produced by the bacteria. The unique mode of action involves excitation of the insect nervous system by affecting the nicotinic acetylcholine receptors, and also affects the GABA (gamma-aminobutyric acid) receptor function. Spinosad acts as a contact and stomach poison.

Halofenozide is a molting accelerator that acts on the insect steroidal hormone required for the molting process. Ingestion causes larvae to attempt a premature, lethal molt. It has some systemic and considerable residual activity.

Fall armyworm in our trials responded differently to lower concentrations of insecticide depending on turfgrass cultivar and insecticide type. Numerous factors play a role in the complex interactions between plant resistance, insecticides, and herbivores. Factors potentially contributing



The residual activity of six concentrations of chlorpyrifos, spinosad, and halofenozide on fall armyworm, *Spodoptera frugiperda*, as mediated by five warm-season turfgrass cultivars expressing varying levels of genetic resistance was evaluated in greenhouse trials.

to the variation in responses that were observed in the present study include different modes of action of insecticides, host-plant resistance mechanisms, differential foliar consumption rates, age of target pest, and insecticide dose in relation to body weight. In relation to the development of management guidelines for pest management practitioners, the complexity of the interactions must be stressed. An understanding of the variable responses may require "case by case" evaluation.

Acknowledgments

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