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Evaluation of Turfgrass Selections for Resistance to Fall Armyworms (Lepidoptera: Noctuidae)

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Abstract. **Turfgrass selections including 21 paspalums (*Paspalum vaginatum* Swartz) and 12 zoysiagrasses (*Zoysia* sp.) were compared with susceptible 'KY31' tall fescue (*Festuca arundinacea* Schreb.) and more resistant common bermudagrass (*Cynodon dactylon* Pers.) and common centipedegrass [*Eremochloa ophiuroides* (Munro.) Hack] for potential resistance to fall armyworm [*Spodoptera frugiperda* (J.E. Smith)], an occasionally serious pest of managed turf. Turfgrass and pasture grasses annually suffer sporadic damage by this pest, often severe in the Gulf Coast states. Resistant grasses offer an alternative management tool for the fall armyworm, reducing the need for pesticide use. Laboratory evaluations assessed the degree of antibiosis and nonpreference present among more than 30 turfgrass genotypes to first and third instar fall armyworms, respectively. Zoysiagrasses exhibiting high levels of antibiosis included 'Cavalier', 'Emerald', DALZ8501, DALZ8508, 'Royal', and 'Palisades'. Paspalum selections demonstrating reduced larval or pupal weights or prolonged development times of fall armyworm included 561-79, Temple-2, PI-509021, and PI-509022.**

The fall armyworm [*Spodoptera frugiperda* (J.E. Smith)] annually migrates northward, invading much of the continental United States and Canada (Potter and Braman, 1991). Pasture grasses and turf, especially in the southeast and Gulf states, can be severely damaged by this sporadic pest. Wiseman et al. (1982) compared common centipedegrass, 'Coastal' bermudagrass, and carpetgrass (*Axonopus affinis* Chase) for susceptibility to this pest. Nonpreference and antibiosis in centipedegrass were observed. Bermudagrass, centipedegrass, and zoysiagrass (*Zoysia* sp.) were also evaluated for susceptibility to fall armyworm by Chang et al. (1985, 1986), revealing a high level of antibiosis among bermudagrass selections. Wiseman and Duncan (1996) investigated 81 *Paspalum* sp. for resistance to the larvae of fall armyworm. They discovered very high levels of resistance in *Paspalum modestum* Mez and *Paspalum scrobiculatum* L. Larvae that were fed these two species were significantly smaller at 9 d than those fed other *Paspalum* sp., and failed to develop to pupation. Grasses used for turf on golf courses, recreational areas, and home lawns have rarely been characterized for their resistance to turfgrass pests, including the fall armyworm (Quisenberry, 1990; Reinert, 1982). Therefore, we examined the potential resistance among selected paspalum and zoysiagrass taxa to fall armyworm.

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Materials and Methods

The genotypes used were primarily experimental selections of zoysiagrass [*Zoysia matrella* (L.) Merr. and *Z. japonica* Stued.] and seashore paspalum. Seashore paspalum is a warm season, salt-tolerant turfgrass found in tropical, subtropical, and warm temperate regions of the world (Duncan, 1999). The two zoysiagrasses were evaluated previously for resistance to mole cricket (*Scapteriscus* sp.) (Braman et al., 1994). Laboratory experiments evaluated fall armyworm response to turfgrass selections using both choice and no-choice assays.

Expt. 1. Seashore paspalums (Table 1) were compared with susceptible KY 31 tall fescue and the more resistant common bermudagrass, common centipedegrass, and zoysiagrasses in a no-choice test. Larvae were confined individually, with 25 replications arranged in a completely randomized design, within an environmental chamber (Percival Co., Boone, Iowa) maintained at 27 °C, 85% relative humidity (RH), and a 15-h light : 9-h dark photoperiod. Neonate larvae were individually confined to 32-mL clear plastic cups with snap-on lids. Cups were in turn held in stacked 30-cell transluscent plastic rearing trays (Bioserve, Frenchtown, N.J.). Larvae were provided daily with an excess of turfgrass clippings from cultivars maintained in the greenhouse in 15-cm-diameter pots. Pots were watered daily and fertilized weekly with a solution containing 250 mg·L^{-1} Peters 20N–20P–20K (Scotts-Sierra Horticultural Products Corp., Maryville, Ohio). Larval survival, larval weights at day 13, pupal weights, and days to pupation were compared among grasses. The experiment, conducted from 19 June to 31 July 1995, was terminated when all larvae had either successfully pupated or died, a process requiring a total of 50 d.

Expt. 2. Methods identical to those described for Expt. 1 were used to compare 12 zoysiagrasses (Table 2), susceptible KY 31 tall fescue, and less susceptible common bermudagrass and common centipedegrass in a no-choice test. Data collected were as described for Expt. 1, except that n = 20 larvae per turfgrass selection. This experiment was conducted 17 Nov. 1995 to 10 Jan. 1996, and was terminated when all larvae had either successfully pupated or died (58 d total).

Expt. 3. In a preference test conducted during Apr. 1995, third instar fall armyworms were introduced into the center of a 15-cm-diameter petri dish arena. Each dish contained 4-cm sections of 21 paspalums (Table 3), with two zoysiagrasses and KY 31 tall fescue as standards. Sections of all grasses were oriented equidistant from each other in a pattern resembling the spokes of a wheel (as illustrated in Chang et al., 1985), in each dish, which was lined with moistened filter paper. Five third-instar larvae were introduced to the center of each dish. Dishes were immediately placed in an environmental chamber held at 24 °C, 15 h light : 9 h dark. Turfgrasses were arranged in a randomized complete-block design with six replications. Larvae were allowed to feed for 16 h. Damage was rated from 0 (no damage) to 9 (greatest damage = completely consumed) were made for each grass.

Data analysis. Data were subjected to analysis of variance using the GLM procedure (SAS Institute, 1985) with mean separation accomplished using Fisher's protected LSD test.

Results and Discussion

Expt. 1. All turfgrass species and cultivars supported growth and development of the fall armyworm in this trial. However, larval and pupal weights were significantly influenced by turfgrass selection (Table 1). Larval survival to the pupal stage ranged from only 8% on 'Emerald' zoysiagrass to 100% of the initial 25 larvae on 'Temple 2' paspalum. Paspalum selections that reduced survival to the pupal stage relative to 'KY 31' were 561-79, 310-79, PI-509022, HI-1, HI-39,

Table 1. Fall armyworm larval weight at day 13, days to develop and pupal weight when fed grass clippings of tall fescue, paspalum, bermudagrass, centipedegrass or zoysiagrass.

Plant introduction	Mean larval wt (mg)	No. of larvae pupating	Mean pupal wt (mg)	No. of larvae pupating	Mean days to develop to pupal stage
'KY31' tall fescue[z]	157.7	24	154.0	23	19.2
Paspalums					
AP-10	157.7	24	135.4	22	19.1
AP-14	140.2	25	131.7*	24	19.4
'Excalibur'	98.9*	17	153.1	16	20.8*
'Fidalayel'	95.7*	21	141.0	21	20.3
Glenn Oaks 'Adalayd'	97.5*	20	149.5	20	19.7
HI-1	86.4*	22	146.7	19	20.9*
HI-2	137.4	24	145.6	22	19.8
HI-39	125.9*	22	136.6	19	19.2
K-6	127.3*	24	148.7	22	19.4
K-7	148.2	25	164.0	21	19.3
K-8	136.0	24	165.0	21	19.5
'Mauna Kea'	90.1*	22	136.6	21	22.2
PI-299042	144.7	18	148.2	18	18.4
PI-364985	87.9*	23	171.5	23	20.6*
PI-377709	143.8	25	171.5	24	19.2
PI-509018	127.6*	25	139.9	23	19.8
PI-509020	101.1*	24	167.5	24	20.3
PI-509021	73.2*	23	148.4	20	21.3*
PI-509022	76.8*	21	145.5	19	21.5*
PI-509023	88.2*	22	172.5	22	21.4*
'Salam'	122.0*	24	145.2	21	19.1
SIPV-1	107.4*	24	151.2	24	20.3
SIPV-2	109.5*	23	152.8	20	19.9
Taliaferro	168.8	25	175.0	24	18.7
Temple-1	141.5	18	146.4	18	20.4
Temple-2	64.5*	25	127.7*	25	21.9*
'Tropic Shore'	120.0*	21	147.2	20	19.2
310-79	127.1*	22	146.7	17	19.9
561-79	45.5*	23	123.5*	17	24.7*
Centipedegrass					
Common centipedegrass	28.6*	24	141.0	23	29.4*
Bermudagrass					
Common bermudagrass	16.5*	24	113.7*	23	31.4*
Zoysiagrass					
'Cavalier'	8.9*	14	144.4	13	32.6*
DALZ8516	10.6*	19	135.5	19	24.4*
'Emerald'	5.5*	8	103.0*	2	46.0*
$P \leq$	0.0001	---	0.0001	---	0.0001
$LSD_{0.05}$	25.5	---	21.2	---	1.2

[z]Selection used as standard.
*Significantly different from value for susceptible 'KY31' tall fescue by Fisher's protected $LSD_{0.05}$.

Table 2. Fall armyworm larval weight at day 13, time to develop, and pupal weights when fed grass clippings of tall fescue, zoysiagrass, bermudagrass or centipedegrass.

Plant introduction	Mean larval wt (mg)	No. of larvae pupating	Mean pupal wt (mg)	No. of larvae pupating	Mean days to develop to pupal stage
'KY 31' tall fescue[z]	147.5	15	143.8	15	18.8
Bermudagrass					
Common bermudagrass	88.7*	5	82.0*	3	28.0*
Centipedegrass					
Common centipedegrass	52.3*	8	132.7	6	30.2*
Zoysiagrass					
'Cavalier'	0.0*	---	---	---	---
'Crowne'	3.8*	6	108.0	3	43.3*
DALZ 8501	4.0*	3	91.0*	2	50.0*
DALZ 8508	2.0*	1	90.0*	1	44.0*
DALZ 8516	93.3*	11	154.5	11	28.8*
DALZ 8701	11.2*	5	120.4	5	34.0*
'Diamond'	29.7*	10	115.0	10	33.4*
'El Toro'	19.2*	6	115.2	4	44.0*
'Emerald'	12.7*	---	---	---	---
'Palisades'	13.4*	4	123.0	2	43.5*
'Royal'	9.1*	6	86.7*	3	50.0*
P value	0.0001		0.0004		0.0001
$LSD_{0.05}$	26.2		36.7		7.6

*Significantly different from value for susceptible 'KY 31' tall fescue by Fisher's protected $LSD_{0.05}$

PI-299042, Temple 1, and 'Excalibur'. Paspalums that resulted in high survival, similar to the susceptible standard 'KY 31' tall fescue, were Temple 2, PI-509020, PI-377709, Taliaferro PV, AP-14, PI-509018, and PI-364985. Paspalum selections with the lowest larval weights (Table 1), suggesting some degree of antibiosis, included 561-79, Temple 2, PI-509023, PI-509022, PI-509021, PI-364985, and HI-1. Low pupal weights were observed for common centipedegrass, all three zoysiagrasses, 310-79, 561-79, Temple 2, AP-14, AP-10, PI-509018, HI-39, 'Mauna Kea', and 'Fidalayel'. Extended development times (from first instar to pupation) were observed for the zoysiagrasses, bermudagrass, centipedegrass, and 561-79, 'Mauna Kea', Temple 2, PI-509021, PI-509022, and PI-509023 paspalums.

Expt. 2. Fall armyworm larvae in this test failed to survive to the pupal stage when fed on 'Emerald' or 'Cavalier' zoysiagrass (Table 2). Larval development time was greater on all remaining grass selections than on susceptible tall fescue, but was most prolonged on DALZ8501, 'Royal', 'El Toro', 'Crowne', and 'Palisades' zoysiagrasses. Similarly, larval weights were lower on all grasses than on tall fescue. Among the zoysiagrass selections evaluated, DALZ8516 was the most suitable (susceptible) host, as measured by larval survival, and larval and pupal weights.

Expt. 3. Most selections were severely damaged by larvae during this 24-h petri dish assay (Table 3). Damage ratings for most paspalum selections were statistically similar to that for the susceptible tall fescue, except for Temple 2 paspalum, in which the rating was similar to that for DALZ8516 zoysiagrass. 'Cavalier' zoysiagrass was the least preferred turfgrass in this experiment.

Antibiosis to the fall armyworm was demonstrated among zoysiagrass selections ('Cava-

Table 3. Damage rating for fall armyworm larvae for turfgrass species and cultivars in a petri dish assay.

Entry	Mean damage rating[z]	Entry	Mean damage rating[z]
'KY31' tall fescue	8.2		
Paspalums			
'Excalibur'	8.3	PI-509023	7.8
'Fidalayel'	7.0	SIPV-1	8.2
Glenn Oaks 'Adalayd'	7.7	SIPV-2	8.5
HI-1	7.3	Temple 1	7.5
HI-2	7.7	Temple 2	5.5*
'Mauna Kea'	8.8	'Tropic Shore'	6.7
PI-299042	7.7	310-79	7.8
PI-364985	8.2	561-79	7.5
PI-377709	8.2		
Zoysiagrass			
PI-509018	8.5	DALZ8516	3.0*
PI-509020	7.5	'Cavalier'	0.2*
PI-509021	8.7		
PI-509022	8.3		
	P > F	0.0001	
	$LSD_{0.05}$	1.9	

[z]0 = no damage, 9 = complete removal.
*Significantly different from value for susceptible 'KY 31' tall fescue by Fisher's protected $LSD_{0.05}$.

lier' and 'Emerald' zoysiagrasses in particular). Nonpreference, sometimes a related attribute, was also observed for 'Cavalier' zoysia. Other zoysiagrasses exhibiting high levels of antibiosis to fall armyworm included DALZ8501, DALZ8508, 'Royal', and 'Palisades'. Zoysiagrasses previously exhibiting improved tolerance to mole cricket included 'Diamond', DALZ8514, and DALZ8701 (Braman et al., 1994). Paspalum selections evaluated here were all suitable hosts for fall armyworms, although larvae and pupae feeding on the Argentine selection 561-79 were significantly smaller than those feeding on the susceptible standard tall fescue (Table 1). Larvae fed this selection, which has demonstrated improved mole cricket (Braman et al., 2000) and spittlebug resistance (Braman unpublished data), also required a significantly longer period of time to complete development to the pupal stage. In a previous study (Wiseman and Duncan, 1996), fall armyworm larvae that were fed *Paspalum modestum* or *Paspalum scrobiculatum* were significantly smaller than larvae that were fed 79 other Plant Introduction *Paspalum* sp., and failed to develop to pupation. *Paspalum vaginatum* selections in that study (Tropic Shore, PI 364985) were suitable hosts, but larval weights were lower and development times extended in comparison with those of larvae fed a control pinto bean (*Phaseolus vulgaris* L.) diet. Experimental lines and named cultivars with resistance to fall armyworm identified here could be used as sources of armyworm-resistant germplasm for the development of additional commercial turfgrass cultivars that require fewer chemical inputs to maintain the high aesthetic standards required of managed turf.

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