Turfgrass and Environmental Research Online

...Using Science to Benefit Golf

The fall armyworm, *Spodoptera frugiperda*, is one of the most serious insect pests of grasses. Researchers at the University of Georgia are investigating the interactive effects of natural resistance to fall armyworm by various turfgrass hosts and the action of natural enemies such as parasites, parasitoids, and predators of this insect.

Volume 4, Number 23
December 1, 2005

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***.

Dual Defense: Pest-resistant Turf and Natural Enemy Interactions

S. Kristine Braman, R. R. Duncan, W. W. Hanna, and M. C. Engelke

SUMMARY

University of Georgia research is evaluating the potential for resistance to multiple insect pests among turfgrasses for the southeastern US. They report effects of different grasses on the occurrence and activity of natural enemies.

- The six grasses tested ('Sea Isle I' and '561-79' seashore paspalum, *Paspalum vaginatum*; 'TifSport' and 'TifEagle' hybrid bermudagrass, *Cynodon dactylon* x *C. transvaalensis*; and 'Cavalier' and 'Palisades' zoysiagrass (*Zoysia japonica* and *Z. matrella*, respectively) represented a range in resistance to fall armyworm, *Spodoptera frugiperda*.
- Among six turfgrass genotypes tested, the braconid wasp, *Aleiodes laphygmae*, varied in percent parasitism of fall armyworm larvae.
- A total of 20,400 first-instar larvae of fall armyworm were placed in the field; 2,368 were recovered; 468 parasitoids were subsequently reared; 92.2% were *A. laphygmae*.
- The greatest percent reduction in *S. frugiperda* larvae by *A. laphygmae* occurred on the armyworm-susceptible seashore paspalums followed by bermudagrass and then zoysiagrass. Percent parasitism of *S. frugiperda* in this field study decreased with increasing resistance levels to the host insect.
- The predaceous big eyed bug, *Geocoris uliginosus*, nymphs varied in ability to reduce numbers of fall armyworm larvae.
- In the laboratory, the greatest reduction in *S. frugiperda* larvae by *G. uliginosus* occurred on the resistant 'Cavalier' zoysiagrass. Larvae remained on the resistant grass for a longer period in a size range susceptible to predation.
- In field studies, the greatest reduction in *S. frugiperda* larvae by *G. uliginosus* occurred on 'Sea Isle I' and '561-79' seashore paspalum .
- The high levels of parasitism observed in the more susceptible paspalums suggests potential candidates for conservation biological control efforts targeting the specific parasitoids and predators that occur in these grasses.

S. KRISTINE BRAMAN, Ph.D., Professor of Entomology, University of Georgia, Griffin; R. R. DUNCAN, Ph.D., Turf Ecosystems, L.L.C., Boerne, TX; W. W. HANNA, Ph.D., Professor, Crop and Soil Sciences Dept., University of Georgia, Tifton; and M. C. ENGELKE, Ph.D.; Professsor of Turfgrass Breeding, Texas A&M University, Dallas.

The fall armyworm, *Spodoptera frugiperda*, is one of the most serious pests of grasses throughout the Americas (3). While Luginbill (11) lists more than 60 host plants, corn (*Zea mays*), sorghum (*Sorghum bicolor*) and grasses such as common bermudagrass (*Cynodon dactylon*) are preferred. Ashley (2) listed 53 species of fall armyworm parasitoids from 43 genera and 10 families.

More recently, Molina-Ochoa et al. (13) reported approximately 150 species of parasitoids and parasites from 14 families in the Americas and Caribbean basin. Ashley (1) reported that the highest levels of parasitism occurred in corn and that *Chelonus insularis* had the highest parasitism rates. Gross and Pair (10) reported that the dominant, endemic parasitoids of the fall armyworm in the southern U.S. include the tachinid *Archytas marmoratus*, the braconids *Cotesia marginiventris*, *C. insularis*, and the ichneumonids *Campoletis spp.*

An increase in predation by the big eyed bug, *Geocoris uliginosus*, on fall armyworms was observed on resistant 'Cavalier' zoysiagrass compared to bermudagrass or paspalum in the laboratory. That increase in predation was explained by the lengthened developmental time of larvae feeding on resistant zoysiagrass. The larvae remained in an acceptable prey size range longer on the resistant grass.

USGA Turfgrass and Environmental Research Online 4(23):1-7.
TGIF Record Number: 108119

At the end of each exposure period, turf plugs inside PVC cylinders were pulled up, placed in large plastic bags, and returned to the laboratory. Parasitoids emerging from larvae collected from the field were identified and recorded.

The genus *Rogas=Aleiodes* reportedly has the least impact on fall armyworm populations (1) although the highest parasitization rates by this genus occurred in forage grasses. Similarly, Molina-Ochoa (13) found that *Aleiodes laphygmae* was the only parasitoid limited to a single collection among 251 parasitoids representing 11 species from three families reared from *S. frugiperda* collected from corn or sorghum in Mexico.

Limited studies have examined extrinsic resistance potential of beneficial arthropods among turfgrass species and cultivars (6, 7). This study was undertaken to determine what type and degree of parasitism can be expected for fall armyworm in turfgrass in the southeastern U.S., and the influence of turfgrass species and cultivars that represent a gradient in resistance to the pest.

Field Evaluation

Four trials evaluating the relative parasitism of first- and second-instar fall armyworms among the various turfgrass cultivars were conducted. Two hundred first-instar fall armyworms were exposed to parasitism within open 15.2 cm diameter polyvinyl chloride (PVC) pipe cages inserted 5 cm into the soil in each turf plot May 23-27 and July 30- August 4, 2003. Fifty and 150 larvae were exposed in open cages during the time periods August 7-13, and October 8-15, respectively.

At the end of each exposure period, turf plugs inside PVC cylinders were pulled up, placed in large plastic bags, and returned to the laboratory. Each turf plug was destructively sampled. All larvae were counted and transferred to 32-ml plastic cups containing fall armyworm diet. Cups containing diet and individual fall armyworms were placed in environmental chambers at 24º C, 15 hours light: 9 hours dark photoperiod, and monitored for parasitoid pupae formation.

Parasitoids emerging from larvae collected from the field were identified and recorded. All fall armyworm larvae were kept until parasitoid emergence, adult armyworm emergence, or death of the larva. Percent larval recovery and percent parasitism were compared among the three genera and six cultivars for individual cultivar or genus effects.

turf genotype	May		July		August		October	
	recovery of larvae (%)	parasitism (%)	recovery of larvae (%)	parasitism (%)	recovery of larvae (%)	parasitism (%)	recovery of larvae (%)	parasitism (%)
Seashore paspalum								
'561-79'	nd	nd	27.7 a	42.7 ab	11.2 ab	8.4 abc	nd	nd
'Sea Isle-1'	35.2 a	6.4 a	25.6 ab	51.9 a	16.0 a	35.1 ab	5.5 a	35.9 a
Bermudagrass								
'TifSport'	28.3 a	1.7 ab	2.8 c	8.2 bc	11.0 ab	38.5 a	3.1 ab	27.3 a
'TifEagle'	27.8 a	5.2 ab	10.1 bc	26.1 abc	9.7 ab	2.8 bc	nd	nd
Zoysiagrass								
'Cavalier'	2.2 b	0 b	0 c	0 c	1.3 b	0 c	nd	nd
'Palisades'	6.3 b	1.2 ab	0.2 c	16.6 abc	0.2 b	16.7 abc	0.3 b	16.7 a

Mean separation by Least Significant Differences. Means within a column with different letters are significantly different.
nd = no data available for these plots.

Table 1. Mean recovery and parasitism by the braconid wasp, *Aleiodes laphygmae* of fall armyworm larvae caged in turfgrass field plots during May-October, 2003

Results

Parasitoids Recovered

Parasitoids were reared from fall armyworms in each of the four trials where larvae were exposed as first/second instars. A total of 20,400 first/second instar larvae were placed in the field; 2,368 were recovered from the field; 486 parasitoids were reared with 448 (92.2%) being *Aleiodes laphygmae*. In addition to *Aleiodes laphygmae*, parasitoids reared from larvae exposed in the field as first/second instars were the hymenopterans *Cotesia marginiventris*, *Meteorus sp.* , and two tachinids. The braconid, *Aleiodes laphygmae*, the most numerous parasitoid collected, parasitized 18.1% of larvae recovered over all grasses in all four first/second instar trials. *Cotesia marginiventris* emerged from 1.0% of the larvae collected among all grasses in the same trials. The remaining parasitoids accounted for less than 1% parasitism.

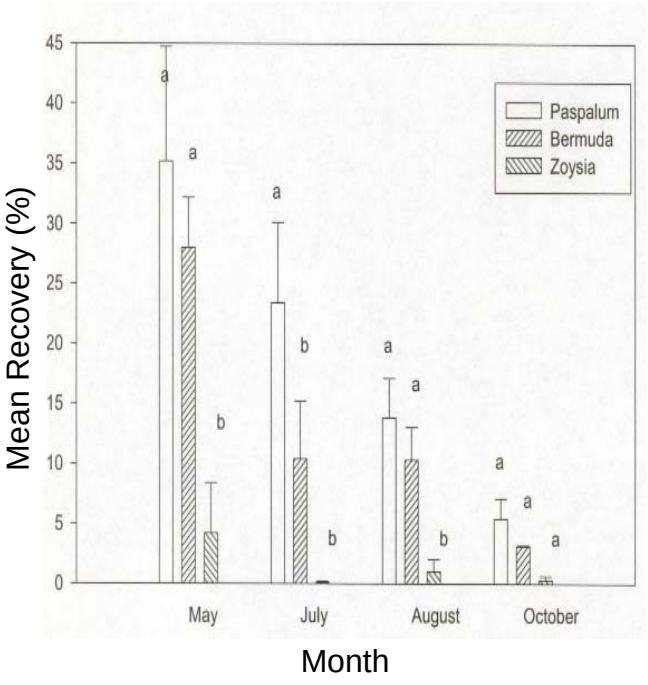

Figure 1. Mean recovery (%) of fall armyworms after 4-7 days of exposure in turfgrass field plots subsequent to release as first-instar larvae. Columns with the same letter within each month are not significantly different (P>0.05).

Turfgrass Genus and Cultivar Effects

First/second instar recovery from field plots varied significantly among both cultivar and turfgrass genera for all four trials (Table 1, Figure

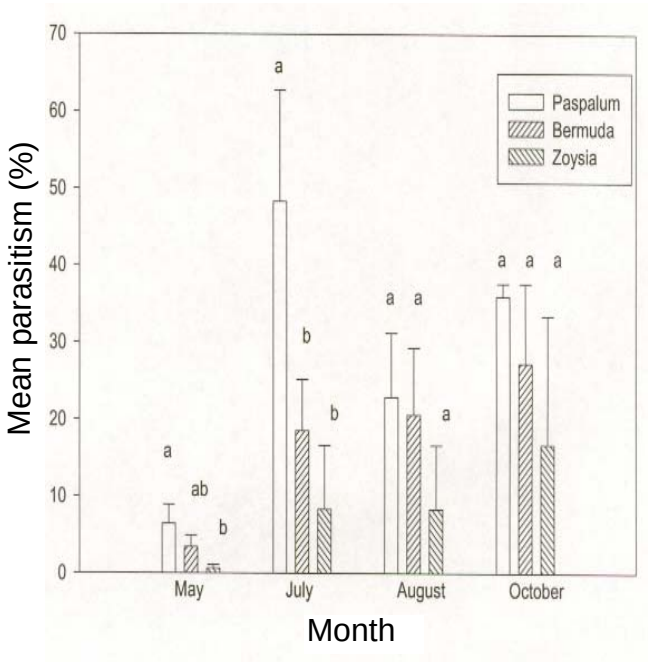

Figure 2. Mean % parasitism by the braconid *Aleiodes laphygmae* of fall armyworm larvae recovered from turfgrass field plots after 4-7 days exposure following release as first-instar larvae. Columns with the same letter within each month are not significantly different (P>0.05).

1). Recovery of caged larvae was least among zoysiagrasses, especially 'Cavalier' zoysiagrass, and greatest for the paspalums, especially 'Sea Isle I'. Percent recovery of larvae decreased as the season progressed, perhaps reflecting increasing predation observed in earlier studies (7) and/or disease pressure in the field.

Parasitism by *A. laphygmae* peaked during July on the paspalums, especially 'Sea Isle I' at 51.9% of recovered larvae (Table 1). No parasitoids were recovered from larvae exposed in the highly resistant 'Cavalier' zoysiagrass. Minor cultivar-related differences in % parasitism by *A. laphygmae* were observed during the May, July, and August exposure periods (Table 1). Significant differences in parasitism among turfgrass genera by *A. laphygmae* were evident during May and July measured as % parasitism of recovered larvae (Figure 2). In general, parasitism was highest in paspalum, lower on bermudagrass, and least for larvae recovered from zoysiagrass.

A continued, yet non-significant trend in parasitism was observed during August and October. A low percentage (0.4- 5.0% depending on cultivar) of larvae were parasitized by *Cotesia marginiventris* during May, July, and October. No larvae were parasitized by *C. marginiventris* during August. There were no significant differences among turfgrass cultivar or genera with respect to parasitism by *C. marginiventris*. This parasitoid was reared from larvae collected from all cultivars except 'Cavalier' zoysiagrass.

Discussion

Cultivar and genera-related differences in recovery of fall armyworm larvae reflect the spectrum of resistance to this insect observed in previous studies with these grasses (6, 7, 8). Previous and present studies demonstrated a gradient in resistance to fall armyworm when exposed to grasses as neonates where, in general, grasses exhibit fall armyworm resistance of 'Cavalier' > 'Palisades' > 'TifSport' = 'TifEagle' > '561-79' = 'SeaIsle I'. Larger larvae and pupae demonstrated fewer differences in cultivar-related survival in

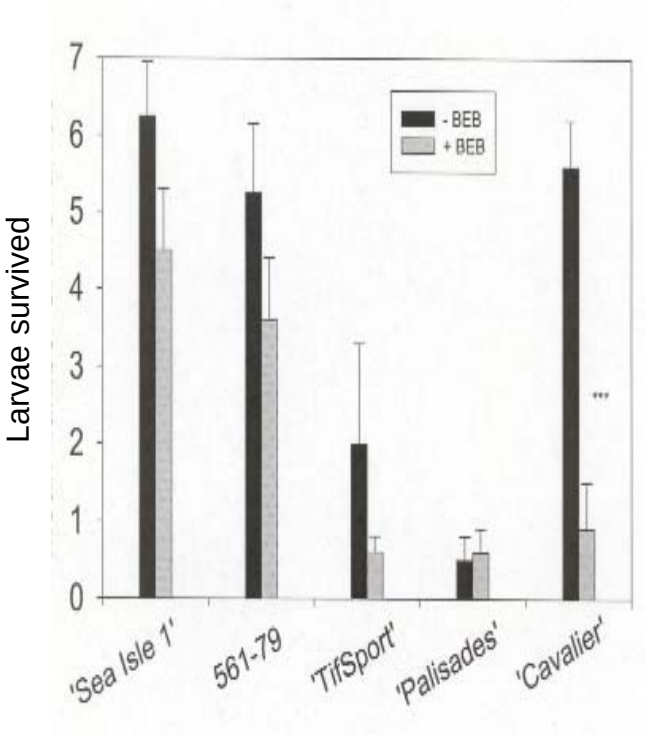

Figure 3. Mean survival of fall armyworm larvae following exposure of first instars to fourth-instar big eyed bugs (BEB) on seashore paspalum ('Sea Isle I', '561-79'), bermudagrass ('TifSport') and zoysiagrass ('Palisades', 'Cavalier') in the laboratory. *** P< 0.001.

the field. Percent parasitism of fall armyworm by *A. laphygmae*, measured in the present field study, was least in 'Cavalier' zoysiagrass and greatest in 'SeaIsle I' paspalum.

Parasitism observed here would be indicative of that which would occur when an egg mass hatches in the field and approximately 50-300 larvae disperse in the grass. The increase in percent parasitism in grasses that are more susceptible to fall armyworm may reflect a density response on the part of the parasitoid to a greater number of surviving caterpillar hosts within the same area over the 4-7 day trial periods. Alternatively, it may indicate an increased abundance of parasitoids especially in the paspalums, increased attraction to herbivore-damaged grass, more favorable plant architecture for host location in susceptible grasses, or a possible deterrent to host location or parasitism in zoysiagrass.

In addition, parasitoids may experience greater mortality in hosts feeding on the more resistant grasses, which would be expressed as a reduction in percent parasitism. Parasitoid abundance independent of the lepidopteran host was not measured during this trial. In a previous report (7), however, no differences among these same turfgrass cultivars or genera were determined for parasitic hymenoptera as a group when measured by vacuum samples. Distinct turfgrass cultivar and species related differences in predator fauna were noted in that earlier study, e.g. higher densities of predatory Heteroptera in the paspalums and increased abundance of spiders in the zoysiagrasses (7).

In another experiment (7), an increase in predation by the big eyed bug, *Geocoris uliginosus*, on fall armyworms was observed on resistant 'Cavalier' zoysiagrass compared to bermudagrass or paspalum in the laboratory (Figure 3). That increase in predation was explained by the lengthened developmental time of larvae feeding on resistant zoysiagrass. The larvae remained in an acceptable prey size range longer on the resistant grass (Figure 4). Release of the same big eyed bug predator species in the same grasses in the field, however, resulted in additional significant reductions in larval survival in paspalums in plots

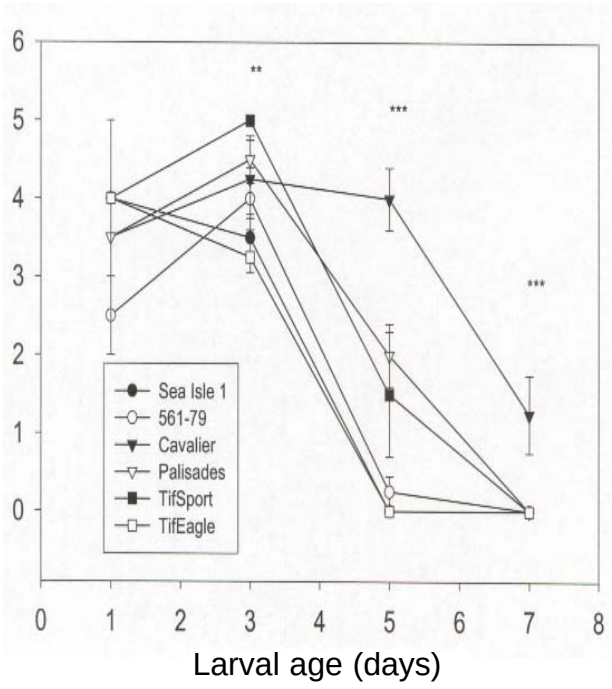

Figure 4. Mean fall armyworm larvae killed in 24 hours by big eyed bugs as affected by prey age on paspalumgrass ('Sea Isle I', '561-79'), bermudagrass ('TifEagle', 'TifSport') and zoysiagrass ('Cavalier', 'Palisades'). ** P< 0.01; *** P< 0.001

receiving the big eyed bugs (Figure 5).

Percent parasitism of fall armyworm in our field study decreased with increasing resistance levels to the host insect. However, substantial parasitism on 'TifSport', a cultivar of bermudagrass demonstrating intermediate levels of resistance to fall armyworm, suggests a promising potential synergy between modest levels of host resistance and pest suppression by natural enemies. The high levels of parasitism observed in the more susceptible paspalums in addition to earlier observations of significant predation, suggest potential candidates for conservation biological control efforts targeting the specific parasitoids and predators that occur in abundance in these grasses. Future work will examine the potential mechanisms responsible for the observed differences in parasitism.

The predominance of parasitism by *A. laphygmae* in each of four trials, resulting in 92% of the parasitoids collected is in stark contrast with the much lower proportion of total para-

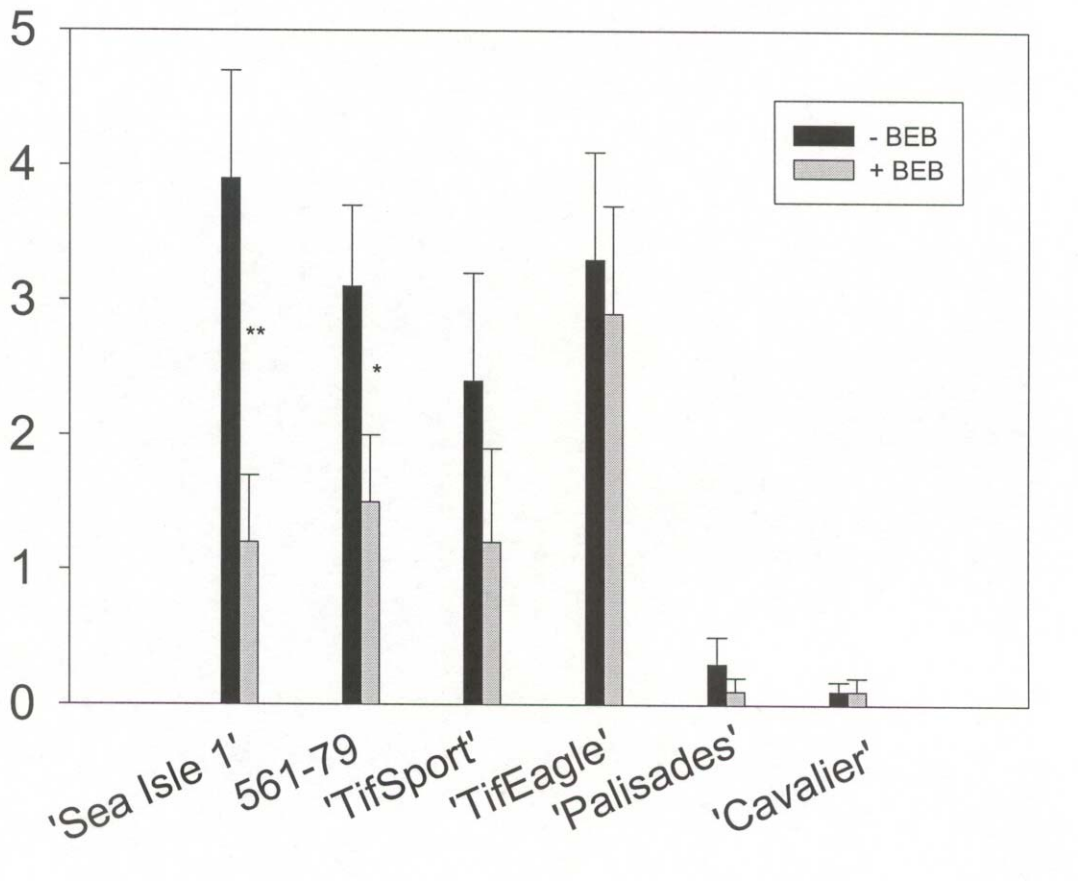

Figure 5. Mean survival of fall armyworm larvae following exposure of first instars to fourth-instar big eyed bugs (BEB) on paspalumgrass ('Sea Isle I', '561-79'), bermudagrass ('TifEagle, 'TifSport') and zoysiagrass ('Palisades', 'Cavalier') in the field. * P< 0.05; ** P< 0.01.

sitoids of fall armyworm represented by this species in agricultural crops (2,10,12,13,14). Further investigation of parasitoid species of importance in managed turfgrasses is warranted.

Acknowledgments

The United States Golf Association, the Georgia Turfgrass Foundation, USDA/CSREES Pest Management Alternatives Program (award no. 2001-34381-11214) and the International Turfgrass Producers provided funding for the project.

Literature Cited

1. Ashley, T.R. 1979. Classification and distribution of fall armyworm parasites. *Fla. Entomol.* 62:114-123. (TGIF Record 107989)

2. Ashley, T.R. 1986. Geographical distributions and parasitization levels for parasitoids of the fall armyworm, *Spodoptera frugiperda*. *Fla. Entomol.* 69:516-524. (TGIF Record 107996)

3. Ashley, T. R., F. M. Wiseman, F.M. Davis, and K.L. Andrews. 1989. The fall armyworm: a bibliography. *Fla. Entomol.* 72:152-202. (TGIF Record 107998)

4. Braman, S.K., A.F. Pendley, R.N. Carrow, and M.C. Engelke. 1994. Potential resistance in zoysiagrasses to tawny mole crickets (Orthoptera:

Gryllotalpidae). *Fla. Entomol.* 77:302-305. (TGIF Record 35584)

5. Braman, S.K., R.R. Duncan, W.W. Hanna, and W.G. Hudson. 2000. Evaluation of turfgrasses for resistance to mole crickets (Orthoptera: Gryllotalpidae). *HortScience*. 35:665-668. (TGIF Record 66470)

6. Braman, S.K., R.R. Duncan, and M.C. Engelke. 2000. Evaluation of turfgrass selections for resistance to fall armyworms (Lepidoptera: Noctuidae). *HortScience* 35:1268-1270. (TGIF Record 71846)

7. Braman, S.K., R.R. Duncan, W.W. Hanna, and M.C. Engelke. 2003. Arthropod predator occurrence and performance of *Geocoris uliginosus* (Say) on pest-resistant and susceptible turfgrasses. *Environ. Entomol.* 32:907-914. (TGIF Record 90845)

8. Braman, S.K., R.R. Duncan, M.C. Engelke, W.W. Hanna, K. Hignight, and D. Rush. 2002. Grass species and endophyte effects on survival and development of fall armyworm. *J. Econ. Entomol.* 95:487-492. (TGIF Record 80172)

9. Braman, S.K., A.F. Pendley, and W. Corley. 2002. Influence of commercially available wildflower mixes on beneficial arthropod abundance and predation in turfgrass. *Environ. Entomol.* 31:564-572. (TGIF Record 80976)

10. Gross, H.R., Jr., and S.D. Pair. 1986. The fall armyworm: status and expectations of biological control with parasitoids and predators. *Fla. Entomol.* 69: 502-515. (TGIF Record 108000)

11. Luginbill, P. 1928. The fall armyworm. United States Dept. Agr. Tech. Bull. 34. 92 pp. (TGIF Record 108030)

12. Molina-Ochoa, J., J.E. Carpenter, E.A. Heinrichs, and J. E. Foster. 2003. Parasitoids and parasites of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas and caribbean basin: an inventory. *Fla. Entomol.* 86:254-289. (TGIF Record 108001)

13. Molina-Ochoa, J., J.J. Hamm, R. Lezama - Guiterrez, M Lopez-Edwards, M. Gonzalez-Ramirez and A. Pescador-Rubio. 2001. A survey of fall armyworm (Lepidoptera: Noctuidae) parasitoids in the Mexican states of Michoacán, Colima, Jalisco, and Tamaulipas. *Fla. Entomol.* 84:31-36.

14. Riggin, T.M, B.R. Wiseman, D.J. Isenhour, and K.E. Espelie. 1992. Incidence of fall armyworm (Lepidoptera: Noctuidae) parasitoids on resistant and susceptible corn genotypes. *Environ. Entomol.* 21: 888-895.

15. Shortman, S.L., S.K. Braman, R.R. Duncan, W.W. Hanna, and M.C. Engelke. 2002. Evaluation of turfgrass species and cultivars for potential resistance to two-lined spittlebug, (Hemiptera:Cercopidae). *J. Econ. Entomol.* 95: 478-486. (TGIF Record 80171)