Survey on Major Insect Pests and Management Practices Adopted for Georgia Golf Courses and Sod Farms[1]

Midhula Gireesh[2] and Shimat V. Joseph[3]

Department of Entomology, University of Georgia, Griffin, Georgia 30223 USA

J. Entomol. Sci. 57(2): 194–203 (April 2022)

Abstract Because turfgrass is maintained in various settings, such as golf courses, lawns, and commercially grown in sod farms, it is critical to understand its major insect pests and management practices. A survey was conducted to determine the major insect pests and current management practices in the commercial turfgrass industries in Georgia. A total of 32 respondents representing golf courses and sod farms participated in the survey. A significantly greater number of respondents represented golf courses (75% of 32 respondents) than sod farms (25%). The respondents ($n = 31$) identified fall armyworm, *Spodoptera frugiperda* J.E. Smith (32.5%), white grubs, *Phyllophaga* spp. (20.8%), mole crickets (Orthoptera: Gryllotalpidae; 16.9%), and others (22%) as major pests in comparison to billbugs, *Sphenophorus* spp. (7.8%) and chinch bugs, *Blissus* spp. (0%). Of 31 respondents, 64.5% applied insecticides two to five times and 22.5% respondents applied insecticides 5–10 times for insect management each year. Among nonchemical tools ($n = 24$), most respondents opted to do nothing (70.8%) than use biological control (0%), host plant resistance (25%), or other management tools (4.2%).

Key Words IPM, sod farms, golf courses, damage, fall armyworm

Turfgrass is an inseparable component in many urban, suburban, and rural landscapes in the United States (Monteiro 2017). It is planted in recreational facilities, such as golf courses, athletic fields, and public lawns. In the United States, turfgrass (sod) production is valued at \$40–60 billion USD annually and covers approximately 20 million ha (Morris 2003). In Georgia, sod is produced on approximately 10,785 ha across 64 counties and is valued at \$118.3 million USD (Wolfe and Stubbs 2019).

Although both cool-season or warm-season grasses are grown in Georgia, warm-season grasses are more widely planted. The warm-season grasses are better adapted to the conditions characteristic of most areas in Georgia. These grasses require temperatures ranging between 26 and 35°C for growth and development, which is inhibited at temperatures below 10°C (Vittum 2020). The major warm-season grasses planted in Georgia include bermudagrasses [*Cynodon dactylon* (L). Pers], zoysiagrass [*Zoysia* spp.], St. Augustinegrass [*Stenotaphrum*

[1]Received 26 July 2021; accepted for publication 4 December 2021.
[2]Current address: University of Florida, Gulf Coast Research and Education Center, 14625 CR 672, Wimauma, FL 33598.
[3]Corresponding author (email: svjoseph@uga.edu).

secundatum (Walter) Kuntze], bahiagrass [*Paspalum notatum* Flüggé], and centipedegrass [*Eremochloa ophiuroides* (Munro) Hack] (Hanna et al. 2013, Potter and Braman 1991). These turfgrass species are planted based on geographical location, type of facility (e.g., golf courses or parks or residential settings), and type of activity for which the grass is being used. Regardless, aesthetic appearance and ease of management of turfgrass are critical considerations for turfgrass selection and planting. Any discoloration of turfgrass can quickly become unacceptable in any setting, especially in golf courses and sod farms whose revenues entirely depend on the health and quality of turfgrass (Beard 1972, Dupuy and Ramirez 2016).

Turfgrass presents unique ecological conditions, and several arthropods are adapted to survive and thrive in the various turfgrass systems. Turfgrass is managed differently depending on the needs and priorities. For example, turfgrass in sod farms is in production mode where the grass is grown within 2 yr then harvested and sold. In golf courses, they are typically maintained for several years, and management practices vary by specific area within the course. Thus, the occurrence, abundance, diversity, and distribution (spatial and temporal) of arthropods are subjected to various factors, including the type of turfgrass system. In Georgia, several species of arthropod pests invade turfgrass. The major pests include mole crickets, *Neoscapteriscus vicinus* Scudder and *Scapteriscus borellii* Giglio–Tos (Potter and Braman 1991, Vittum 2020), white grubs, such as Japanese beetle, *Popillia japonica* Newman (Potter and Braman 1991), hunting billbug, *Sphenophorus venatus vestitus* Chittenden (Gireesh and Joseph 2020), black cutworm, *Agrotis ipsilon* (Hufnagel) (Held and Potter 2012), fall armyworm, *Spodoptera frugiperda* J.E. Smith, several species of sod webworms (Lepidoptera: Pyralidae), southern chinch bug, *Blissus insularis* Barber, bermudagrass mite, *Eriophyes cynodoniensis* (Sayed) (Huang 2008), and rhodesgrass mealybug, *Antonina graminis* (Maskell) (Joseph and Hudson 2019).

Although many herbivorous arthropod pests can invade turfgrass, not all pests equally invade all the turfgrass systems. Similarly, the current management practices adopted against major pest species problems can vary by turfgrass genotype and the system. Most arthropod pests are managed using insecticides that can cause exposure to nontargets, including predators, parasitoids, and pollinators. The primary objective of this survey was to determine the major pests and management approaches adopted by managers of various turfgrass systems in Georgia. The information generated will shape the focus of research and extension efforts and allocation of resources. There is a growing need to develop turfgrass management practices that protect the community and environmental health (Held and Potter 2012, Thompson and Kao-Kniffin 2017).

Materials and Methods

Survey design. A survey questionnaire was developed to collect information on the major pests and their management from golf course and sod farm industries in Georgia. The survey was conducted from May to September 2020 using Qualtrics (Provo, UT), an online survey tool under the subscription of the University of Georgia. Before the release of the survey, the questions were reviewed by an

Table 1. Survey questionnaire with percentage responses to specific questions, $n = 32$.

No.	Question*	Response rate (%)
1	What type of turfgrass facility are you associated with?	100
2	Where is your facility located?	100
3	What type of turfgrass is grown at your facility? (Check on multiple choices)	100
4	How many acres of turfgrass (sod, golf course, or landscapes under supervision)	100
5	Three major pests of turfgrass in your facility?	96.9
6	How many insecticide sprays are applied per year in your facility?	96.9
7	Which attribute would you consider before choosing an insecticide for pest management? (Check on multiple choices)	84.4
8	How do you make decisions on pest management?	75
9	Alternative approaches adopted to reduce the use of chemical pesticides (Check on multiple choices)	75
10	How do you get information about pest's biology and management options (Check on multiple choices)	75

*Questions 1–5 focused on facility type, grass type grown, facility location and size, and major pest problems; questions 6–10 focused on current integrated pest management (IPM) approaches adopted against turfgrass pests.

Extension Specialist with the Department of Entomology, University of Georgia. An institutional review board at the University of Georgia reviewed the questionnaire and exempted it from approval as there was no personal information requested in the survey (IRB#PROJECT00002269). Ten questions were organized into two groups (Table 1). The first group of questions (1–5) was mostly on facility type, grass type grown, facility location and size, and major pest problems. The second group of questions (6–10) focused on current integrated pest management (IPM) approaches adopted for turfgrass pests.

Survey distribution. The survey was initially distributed to members of turfgrass and ornamental industry associations, such as Georgia Urban Agriculture Council and the Golf Course Superintendents Association of America through email list-servs. These members include sod producers and golf course superintendents in Georgia. Sod producers and golf course superintendents were also contacted through phone calls as reminders to complete the survey. The responses obtained from 12 May to 3 September were included in the analysis.

Statistical analysis. The questions with multiple choices were converted into categorical data. Each question with multiple-choice data was analyzed using nominal logistic regression (JMP 2019). When there was a significant effect in the likelihood ratio test for each question, the responses were compared by examining the odds ratio. The analyses were conducted for choices with $n = 0$ after adding 0.2 for all the choices to establish homogeneity.

Results

Turfgrass facility, location, grass genotype, and major pests. A total of 32 respondents from golf course and sod farm industries in Georgia participated in the survey. There were significantly more respondents from golf courses ($n = 24$) than from sod farms ($n = 8$; $\chi^2 = 16.7$, df $= 1$, $P < 0.001$; Fig. 1A). When asked about species of turfgrass grown, a significantly greater percentage of respondents indicated that they have bermudagrass ($n = 31$; golf course $n = 24$; sod farm $n = 7$) than other turfgrass species ($n = 14$), such as tall fescue (*Festuca arundinacea* Schreb), *Paspalum* spp., and bentgrass (*Agrostis palustris* Huds.) ($\chi^2 = 10.7$, df $= 2$, $P = 0.005$; Fig. 1B). However, there was no significant difference in the percentage of responses between bermudagrass and zoysiagrass ($n = 19$) and between zoysiagrass and other turfgrass species. The hectarage of a significantly greater number of respondents were between 12 and 81 ha ($n = 22$; golf course $n = 21$; sod farm $n = 1$) than < 12 ha ($n = 1$), or 81–201 ha ($n = 5$), 201–404 ha ($n = 1$ [sod farm]), 404–2023 ha ($n = 2$ [sod farm]), and $> 2{,}023$ ha ($n = 2$ [sod farm]; $\chi^2 = 57.1$, df $= 5$, $P < 0.001$; Fig. 1C).

A significantly greater percentage of respondents identified fall armyworm ($n = 25$; golf course $n = 18$, sod farm $n = 7$) as a major turfgrass pest than billbugs ($n = 6$; $\chi^2 = 16.2$, df $= 4$, $P < 0.003$; Fig. 1D). However, there were no significant differences in the percentage of respondents who selected among fall armyworm, white grubs ($n = 16$), mole crickets ($n = 13$), and other turfgrass pests, such as ants, nematodes, cutworms, and sod webworms ($n = 17$). Similarly, the percentage of responses was not significantly different among white grubs, mole crickets, and other turfgrass pests as well as among billbugs, white grubs, mole crickets, and other turfgrass pests (Fig. 1D).

Current IPM approaches. For the question on the number of insecticide applications per year for pest management in turfgrass, a significantly greater number of respondents indicated that they spray two to five times per year ($n = 20$; golf course $n = 16$; sod farm $n = 4$) than one application ($n = 2$), and > 10 times per year ($n = 2$; $\chi^2 = 36.4$, df $= 3$, $P < 0.001$; Fig. 2A). However, there was no significant difference between the number of spray categories 2–5 and 5–10 times, among 1, 5–10, and > 10 times and between 1 and > 10 times per year (Fig. 2B). As for factors governing insecticide selection, a significantly greater percentage of respondents considered the efficacy of insecticide ($n = 21$; golf course $n = 16$; sod farm $n = 5$) over other attributes ($n = 3$), such as environmental safety ($\chi^2 = 21.9$, df $= 3$, $P < 0.001$; Fig. 2B). However, there was no significant difference in respondents who chose among efficacy, cost ($n = 8$), and applicator safety ($n = 10$), between cost and safety, and among cost, applicator safety, and environmental safety.

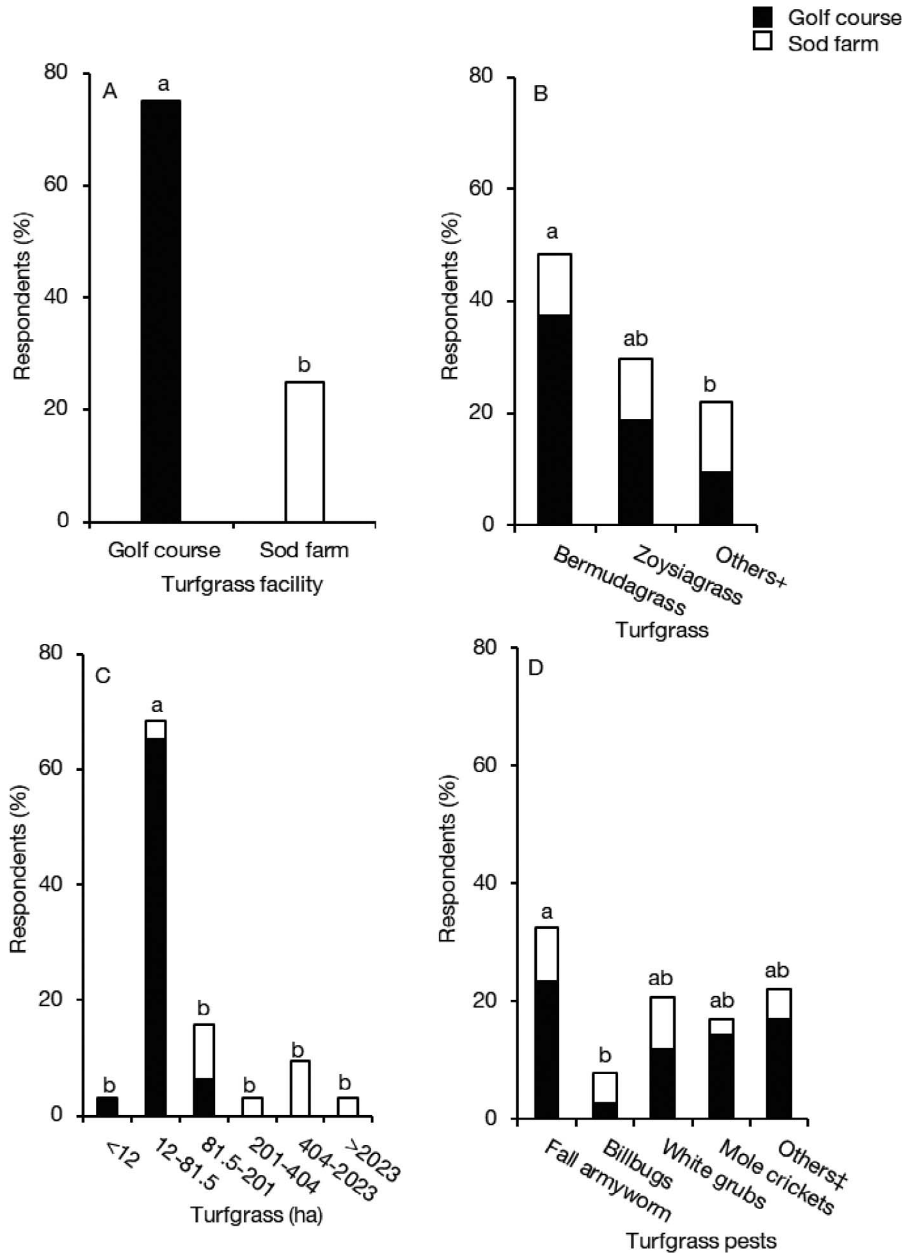

Fig. 1. The percentage of survey respondents (A) representing various turfgrass facilities ($n = 32$), (B) turfgrass genotype planted ($n = 32$) and (C) size of turfgrass facility in ha ($n = 32$), and (D) major turfgrass pests ($n = 31$). $^{+}$Other genotypes planted were tall fescue ($n = 4$), paspalum ($n = 1$), bentgrass ($n = 3$), and centipedegrass ($n = 6$). ‡Other

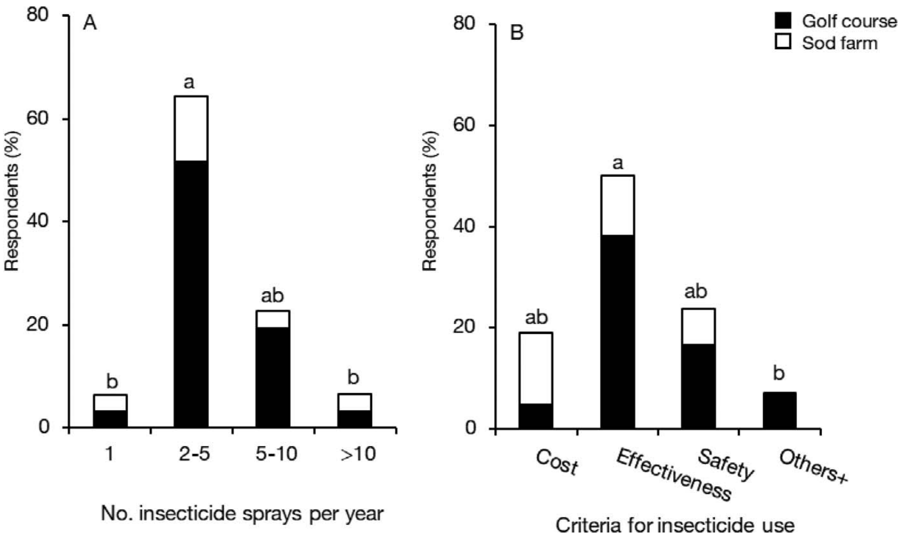

Fig. 2. The percentage of survey respondents responding to (A) the number of insecticide applications per year ($n = 31$), and (B) selection attributes for insecticide use in their facility ($n = 27$). +Others include cost, effectiveness and applicator safety ($n = 1$), environmental safety ($n = 1$), and residual activity ($n = 1$). Bars with same letters are not significantly different (comparing χ^2 of odds ratio, $\alpha = 0.05$).

For pest management decisions, there was no significant difference in the percentage of respondents spraying either by the calendar ($n = 4$ [golf course]), when damage was detected ($n = 9$; golf course $n = 5$; sod farm $n = 4$), when insects were detected ($n = 4$), adopting university extension recommendations ($n = 2$) or using other approaches ($n = 5$), such as spraying based on regular monitoring and scouting ($\chi^2 = 7.3$; df = 4, $P = 0.121$; Fig. 3A). When the respondents were asked about the nonchemical options adopted in their facilities, a significantly greater percentage of respondents adopted no specific measures ($n = 17$; golf course $n = 13$; sod farm $n = 4$) than biological control ($n = 0$) or other approaches ($n = 1$), such as cultural control ($\chi^2 = 44.5$, df = 3, $P < 0.001$; Fig. 3B). However, there was no significant difference in respondents who adopted no specific measures and planted resistant grass varieties ($n = 6$). Similarly, there was no significant difference among respondents who opted for biological control, planting resistant turfgrass varieties, and other approaches and between biological control and other approaches. When the respondents were asked about the source of pest biology

←

pests include ants ($n = 5$), nematodes ($n = 4$), sod webworms ($n = 1$), cutworms ($n = 4$), fire ant and cutworms ($n = 2$), and cutworms and nematodes ($n = 1$). Bars with same letters are not significantly different (comparing χ^2 of odds ratio, $\alpha = 0.05$).

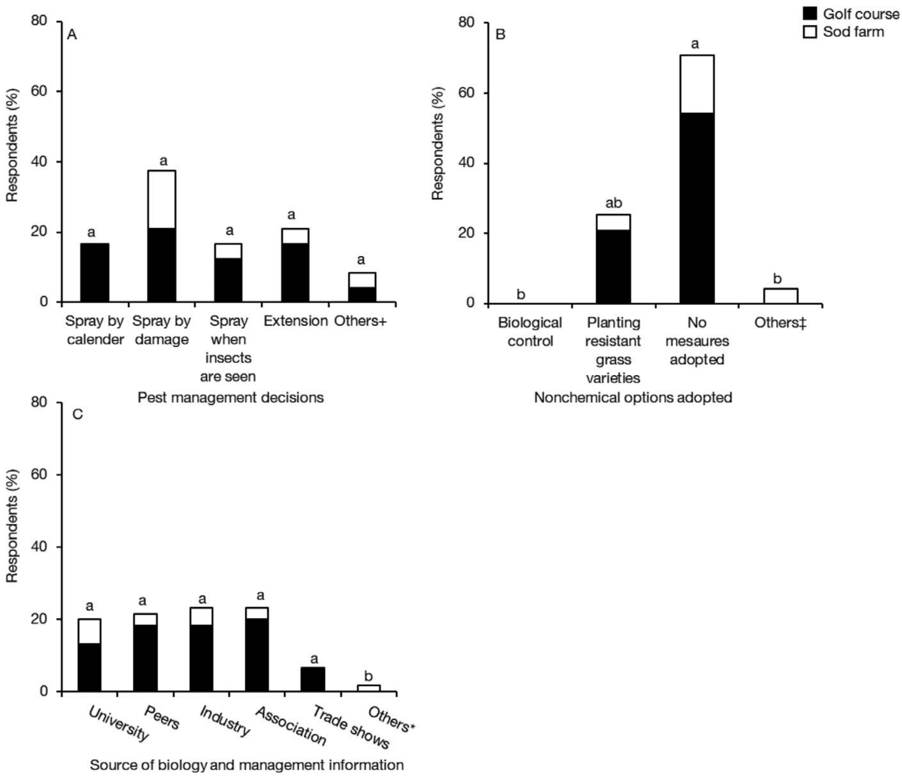

Fig. 3. The percentage of survey respondents responding to (A) decisions taken for pest management ($n = 24$), (B) alternate approaches adopted to reduce the use of chemical pesticides ($n = 24$), and (C) source of pest biology and management information ($n = 24$). +Others include spray by the calendar, when damage is noticed, and when insects are seen ($n = 1$) spray based on regular monitoring, threshold met ($n = 1$), scouting periodically to determine when to spray ($n = 1$), first application by the calendar, then by scouting and curative control ($n = 1$), the combination of all options indicated ($n = 1$). ‡Others include best management practices ($n = 1$). *Others include internet ($n = 1$). Bars with same letters are not significantly different (comparing χ^2 of odds ratio, $\alpha = 0.05$).

and management information, a significantly greater number of respondents indicated that the source of such information was from university extension sources ($n = 12$), peers working in the same business ($n = 13$), industry ($n = 14$), turfgrass-related associations ($n = 16$), and trade shows ($n = 4$) than other sources, such as the internet ($n = 1$; $\chi^2 = 27.2$, df $= 5$, $P < 0.001$; Fig. 3C). However, there was no significant difference in the percentage of respondents who consulted university extension, peers working in the same business, industry, turfgrass-related associations, and tradeshows.

Discussion

Respondents in the current survey were primarily representing golf courses across Georgia. Although the respondents representing sod farms were relatively fewer than those from golf courses, sod producers represented a large hectarage (Fig. 2A). Based on the survey, most of the respondents grow or maintain bermudagrass genotypes in their facilities. Bermudagrass cultivars are typically planted in golf courses (Waldo et al. 2021) and are produced in sod farms in large areas. The second most widely grown turfgrass genotype was zoysiagrass. Zoysiagrass is increasingly produced in sod farms in Georgia (Waltz 2021). The demand for zoysiagrass has increased significantly as more golf courses and residential lawns have shifted to this turfgrass genotype (Patton 2009, Patton et al. 2017). Among other turfgrasses, a few respondents indicated growing or maintaining centipedegrass, tall fescue, paspalum, and bentgrass. Bentgrass is primarily planted in the putting greens of golf courses, and other grasses except centipedegrass are planted in fairways. The survey suggests that future research and extension programs should focus on arthropod issues on bermudagrass and zoysiagrass.

Most of the respondents identified fall armyworm, white grubs, and mole crickets as the major pest problems in their facilities. A few respondents identified billbugs as a major turfgrass pest problem. Recently, billbugs were reported as a major issue in sod farms (Gireesh and Joseph 2020). None of the respondents identified chinch bugs as a major turfgrass pest, which is typically a pest in St. Augustinegrass [*S. secundatum* (Walter) Kuntze] and are not widely planted in commercial sites in Georgia. It is also possible that chinch bugs were not a problem in the survey year. Understanding of current status of economic pests in turfgrass facilities is critical as the IPM research, and extension efforts can be appropriately prioritized to meet clientele needs.

Results show that most respondents spray insecticides multiple times (two to five times) every year. This suggests that most insecticide use is likely preventative sprays as the tolerance to arthropod pest injury in the facilities is almost zero. Most respondents depend on the incidence of damage, pest, or calendar-based (preventative application) for pest management decisions. The results also suggest that a low number of respondents sought extension recommendations for pest management. Turfgrass pest management can be achieved by adopting nonchemical options, such as host plant resistance for fall armyworm (Singh et al. 2020), using entomopathogenic nematodes for white grub control (Guo et al. 2020) and mole crickets control (Barbara and Buss 2006), and biological control agents for billbugs (Dupuy and Ramirez 2019), all of which can be effective alternatives for addressing insecticide resistance. However, based on our results, none of the respondents preferred using any nonchemical tactics to prevent insecticide resistance among turfgrass pests. Efficacy of insecticides against the pest was the most important criteria for choosing insecticide than insecticide cost, applicator safety, environmental safety, and residual activity of insecticide. This suggests that the tolerance of pest infestation is extremely low for the turfgrass industry, and aesthetic appearance is the most valued attribute of the industry. To reduce the use of insecticide, some respondents were considering planting resistant turfgrass varieties based on the current survey. However, none of the respondents considered biological control an effective way to reduce the use of synthetic insecticides. Even though the exact reason for not using biological control tactics is unclear, this result shows the existing gaps in education about the benefits of using biological control tactics in pest management. More research is warranted to develop or refine reliable biological control tactics comparable with the efficacy of insecticide in turfgrass systems. Most of the respondents sought universities, peers working in the same business, industry professionals, and industry associations alike for information on the biology and management of pests.

In summary, the current survey indicated that the respondents identified fall armyworm, white grubs, and mole crickets as major turfgrass pests. Other major turfgrass pests identified by the respondents included nematodes, sod webworms, cutworms, and billbugs. This suggests that the research and extension efforts should include programs to address fall armyworm, white grubs, and mole crickets. The survey also indicated that management of the major pests is driven mainly by insecticide use, and biological control tactics are rarely used. Respondents also use insecticides multiple times a year, suggesting opportunities to incorporate cultural and biological control tactics to reduce insecticide use in turfgrass. Those respondents who chose not to use insecticides for pest management needs tend not to administer any control measures. These turfgrass facilities might already be in conservation mode or serve as ideal grounds for conserving beneficial arthropods. More research and extension efforts are warranted to improve IPM approaches in turfgrass systems across Georgia.

Acknowledgments

We thank the turfgrass and ornamental industry associations, such as Georgia Urban Agriculture Council and Golf Course Superintendents Association of America, for distributing the survey through emails and newsletters. We thank W.G. Hudson and D.G. Riley for reviewing the survey questionnaire and earlier versions of the manuscript. We also thank F.C. Waltz for providing access to the sod producer list of Georgia. We appreciate U. Bhattarai for help with data analyses and University of Georgia (Hatch project) for funding this project.

References Cited

Barbara, K.A. and E.A. Buss. 2006. Augmentative applications of *Steinernema scapterisci* (Nematoda: Steinernematidae) for mole cricket (Orthoptera: Gryllotalpidae) control on golf courses. Florida Entomol. 89: 257–262.

Beard, J.B. 1972. Turfgrass: science and culture. Prentice-Hall, Englewood Cliffs, NJ.

Dupuy, M.M. and R.A. Ramirez. 2016. Biology and management of billbugs (Coleoptera: Curculionidae) in turfgrass. J. Integr. Pest Manag. 7: 6.

Dupuy, M.M. and R.A. Ramirez. 2019. Consumptive and non-consumptive effects of predatory arthropods on billbug (Coleoptera: Dryophthoridae) pests in turfgrass. Biol. Cont. 129: 136–147.

Gireesh, M. and S.V. Joseph. 2020. Seasonal occurrence and abundance of billbugs (Coleoptera: Curculionidae) in Georgia sod farms. J. Econ. Entomol. 113: 2319–2327.

Guo, W., G. Zhao, C. Wang, X. Zhou, Y. Zhai, X. Men and Y. Yu. 2020. Efficacy of entomopathogenic nematodes for the control of white grub, *Anomala corpulenta* Motschulsky, in laboratory and field. Nematol. 22: 1111–1120.

Hanna, W., P. Raymer and B. Schwartz. 2013. Warm-season grasses: Biology and breeding. Turfgrass: Biol. Use Manag. 56: 543–590.

Held, D.W. and D.A. Potter. 2012. Prospects for managing turfgrass pests with reduced chemical inputs. Annu. Rev. Entomol. 57: 329–354.

Huang, T.I. 2008. Billbug (*Sphenophorus* spp.) composition, abundance, seasonal activity, development time, cultivar preference, and response to endophytic ryegrass in Florida. Ph.D. Dissertation, University of Florida, Gainesville.

JMP 12.01. 2019. SAS Institute, Inc., Cary, NC.

Joseph, S.V. and W. Hudson. 2019. Rhodesgrass mealybug: Biology and management. University of Georgia Circ. No. C1159.

Monteiro, J.A. 2017. Ecosystem services from turfgrass landscapes. Urban For Urban Green 26: 151–157.

Morris, K.E. 2003. National turfgrass research initiative. National Turfgrass Federation, Inc., and National Turfgrass Evaluation Program, Beltsville, MD.

Patton, A.J. 2009. Selecting zoysiagrass cultivars: Turfgrass quality, growth, pest and environmental stress tolerance. Appl. Turfgrass Sci. doi:10.1094/ATS-2009-1019-01-MG.

Patton, A.J., B.M. Schwartz and K.E. Kenworthy. 2017. Zoysiagrass (*Zoysia* spp.) history, utilization, and improvement in the United States: A review. Crop Sci. 57: S–37.

Potter, D.A. and S.K. Braman. 1991. Ecology and management of turfgrass insects. Annu. Rev. Entomol. 36: 383–406.

Singh, G., S.V. Joseph and B. Schwartz. 2020. Screening newly developed bermudagrasses for host plant resistance against fall armyworm (Lepidoptera: Noctuidae). Hort. Sci. 1: 1–6.

Thompson, G.L. and J. Kao-Kniffin. 2017. Applying biodiversity and ecosystem function theory to turfgrass management. Crop Sci. 57: S–238.

Vittum, P.J. 2020. Turfgrass insects of the United States and Canada. Cornell University Press, Ithaca, NY.

Waldo, B., F. Soto-Adames and W. Crow. 2021. Nematicide effects on arthropods in bermudagrass. Florida Entomol. 103: 458–464.

Waltz, F.C. 2021. Sod producers report: Annual survey examines inventory and price. University of Georgia. 9 July 2021. (https://turf.caes.uga.edu/content/dam/caes-subsite/georgiaturf/docs/publications/sod_survey/SPReport_2021.pdf).

Wolfe, K.L. and K. Stubbs. 2019. Georgia Farm Gate Value Report 2018 AR-19-01. University of Georgia, Coll. Agric. Environ. Sci., Athens, GA.