Evaluation of Japanese Beetle Oviposition Behavior among Transition Zone Turfgrasses

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Photo by anonymous

Adult Japanese beetle

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Summary. Japanese beetles were evaluated for ovipositional preferences among four turfgrasses commonly used in the transition zone. In a choice experiment with the cool-season turfgrass tall fescue (cultivar Millennium), and three warm-season turfgrasses, zoysiagrass (cultivar Zenith), common bermudagrass (cultivar Yukon), and hybrid bermudagrass (cultivar Tifway), females oviposited almost no eggs in the hybrid bermudagrass, and significantly fewer in common bermudagrass than zoysiagrass and tall fescue. In a second-choice experiment with only the three warm-season turfgrasses, significantly fewer eggs were oviposited in both hybrid and common bermudagrass than in zoysiagrass. In a no-choice experiment comparing the same four turfgrasses, hybrid bermudagrass again received the fewest number of eggs, indicating that although Japanese beetle females will burrow beneath the surface of Tifway hybrid bermudagrass, a chemical or physical characteristic is discouraging oviposition. The potential for using Tifway or similar turfgrasses as a cultural control component in an integrated pest management plan for Japanese beetle grubs is discussed.

Abbreviations: AAREC, Arkansas Agricultural Research and Extension Center

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Most research on Japanese beetle grubs, *Popillia japonica*, has focused on cool-season turfgrass common in northeastern and midwestern states. Less is known about how Japanese beetles affect and interact with turfgrasses common in southern regions. Although its establishment in northwest Arkansas in the late 1990s has led to increased economic damage to fruit, ornamental plants, and turf (Johnson, 2005; Gu et al., 2008), recent surveys suggest that grub densities in northwest Arkansas are much lower (<2 grubs per 1.0 ft^2) (Wood and Steinkraus, unpublished data) than those farther north which can exceed the highest economic thresholds (Vittum et al., 1999). Climatic and environmental differences might account for the pattern, but the types of turfgrasses grown in transitional climate zones such as northwestern Arkansas, could also play a role.

We hypothesized that one or more warm-season turfgrasses, which are common in the south, may express certain chemical or growth characteristics that deter or repel Japanese beetle oviposition. Choice and no-choice experiments were conducted to compare ovipositional response among three warm-season turfgrasses, and a cool-season turfgrass, tall fescue (*Festuca arundinacea*), known to be suitable for Japanese beetles (Potter et al., 1992; Crutchfield and Potter, 1995). The discovery of a resistant turfgrass to Japanese beetle ovipostion would provide an opportunity to proactively reduce grub infestations by altering oviposition habitat.

Materials and Methods

All experiments were conducted in June 2008. Turfgrasses tested were obtained from mature field plots at the Arkansas Agricultural Research and Extension Center (AAREC) in Fayetteville, Ark. The turfgrasses included tall fescue (cultivar Millennium), zoysiagrass, *Zoysia japonica* (cultivar Zenith), common bermudagrass, *Cynodon dactylon* (cultivar Yukon), and hybrid bermudagrass, *C. dactylon* x *C. transvaalensis* (cultivar Tifway). In choice experiments, 2-inch diam, 4-inch deep turfgrass cores were removed from turf fields and placed into 2-inch inner diam, 4-inch tall PVC pipes (choice cages). In the no-choice experiment, 4.25-inch diam, 5.5-inch deep turfgrass cores were removed from turf fields and placed into 5-inch inner diam, 8-inch tall PVC pipes (no-choice cages). The soil was a silt loam with an average pH of 6.2.

Japanese beetles were collected from traps placed at the AAREC. To ensure that females had mated, males and females were held together in 12.6-gal plastic tubs in the laboratory (72–77 °F, 16:8 L:D). Adults were fed Red Delicious apples and grape leaves, but given no oviposition medium. After 3 d, adults were removed and separated by sex, with only females found *in copula* being used in the experiments.

Four-choice and 3-choice assays were conducted in plastic tubs approximately 11 by 11.5 by 13 inches; hereafter termed arenas (Fig. 1). The arenas we used were modified from those in Szendrei and Isaacs (2005). In the 4-choice experiment, cores of each of the four turfgrasses were randomly inserted into arenas through holes in foam board which served as the floor for female Japanese beetles to walk across in search of an oviposition site. The 3-choice experiment was assembled in the same fashion with the exception of using only the three warm-season turfgrasses in the arena. To begin an assay, one mated female beetle was placed on a slice of Red Delicious apple (food source) in the center of each arena. Once a mated female was placed into an arena, mesh screen was secured to the top of the arena using hot glue. Both the 4-choice and 3-choice experiments were conducted as randomized complete block designs, consisting of 20 replications on 21 June (Block 1), and ten replications on 2 July (Block 2).

Choice cages were removed from the arenas after 7 d. Before removing the cages from the arenas, we recorded the condition of the turfgrasses, and examined the turfgrass cores for signs of female digging activity. All cores were visually inspected for eggs by gently breaking apart the soil and roots, and then the number of eggs found was recorded.

The no-choice experiment was conducted in no-choice cages that held only one of the four turfgrass treatments, giving the mated females no choice but to oviposit in the one turfgrass provided. At the start of the assay, a fresh slice of Red Delicious apple was added to each no-choice cage along with five mated Japanese beetle females. Then, the tops of the cages were covered with mesh screen held on with rubber bands. The treatments were arranged as a randomized complete block design. Five replications of the four turfgrasses were arranged into five rows (4 by 5 grid). The experiment was replicated in three time blocks beginning on 26, 27, and 30 June (Block 1, Block 2, and Block 3, respectively), giving a total of 15 replications per treatment. No-choice cages were removed after 7 d, and visually inspected for eggs as described above. The number of eggs was recorded.

Results and Discussion

All turfgrass cores appeared healthy, with sufficient moisture and good plant growth throughout all experiments. Block effects and treatment by block interactions were found in some analyses, but differences in rank among treatments were nearly identical in all experiments, so data were pooled for analyses in all cases.

Mean number of eggs differed significantly among treatments in all experiments (Tables 1, 2, and 3). Oviposition choice experiments showed that both common and hybrid bermudagrasses were nonpreferred for Japanese beetle oviposition. When females were confined on the particular turfgrasses in the no-choice experiment, they again oviposited fewer eggs in hybrid bermudagrass than the other treatments, suggesting that factors other than simply nonpreference are involved. Insight into mechanisms of a possible resistance in Tifway hybrid bermudagrass to Japanese beetle oviposition can be gained from observations and analyses of female activity (presence of female or eggs, or signs of female digging) within turfgrass cores in relation to the percentage of cores with eggs.

Analysis of the percentage of turfgrass cores with female activity did not differ significantly among the turfgrass treatments in either choice experiment (Tables 1 and 2), suggesting females did not initially reject a turfgrass based solely on above-ground visual or olfactory cues. Therefore, a wide array of turfgrasses may be, at first, viewed suitable to ovipositing Japanese beetles, and close-range contact stimuli are involved in females' choice of oviposition site.

Analysis of the percentage of turfgrass cores with eggs, on the other hand, did reveal significant differences among turfgrass treatments in both choice experiments (Table 1 and 2). Significantly fewer hybrid bermudagrass cores had eggs in the 4-choice experiment, meaning most females left hybrid bermudagrass cores after digging, but without ovipositing. A similar pattern occurred in the 3-choice experiment with both hybrid and common bermudagrass having significantly fewer cores with eggs, but no significant difference among the three turfgrasses in the percentage of cores with female activity.

Conclusion

This study suggests a previously undocumented mechanism by which turfgrasses may gain resistance to white grubs (physical barrier preventing oviposition). Previous research on resistance mechanisms of turfgrasses to *P. japonica* and other white grubs has focused on suitability of the roots for larval development, or tolerance to root herbivory (Potter et al., 1992; Crutchfield and Potter, 1994, 1995; Braman and Raymer, 2006; Bughrara et al., 2008). Our study suggests that hybrid bermudagrass has potential to reduce incidence of Japanese beetle grubs in lawns and golf courses by deterring oviposition. However, further studies are needed to determine the mechanism of this resistance to Japanese beetle oviposition, if that resistance carries over to the grubs, and how it affects other insects in the turfgrass system before recommending its use as a cultural control component in an integrated pest management plan.

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Table 1. Oviposition activity by mated female Japanese beetles given a choice between the cool-season turfgrass tall fescue, and three warm-season turfgrasses (4-choice oviposition experiment), or between just the three warm-season turfgrasses (3-choice oviposition experiment), or no-choice between tall fescue and the three warm-season turfgrasses (no-choice oviposition experiment).

Turfgrass	Mean ± SE no. eggs per core[z]			Mean ± SE % of cores with: Female activity[y]		Mean ± SE % of cores with: Eggs		
	4-choice	3-choice	No-choice	4-choice	3-choice	4-choice	3-choice	No-choice
Hybrid bermudagrass	0.2 ± 0.2a	0.6 ± 0.4a	14.7 ± 4.2a	40.0 ± 9.1a	63.3 ± 8.9a	3.3 ± 3.3a	10.0 ± 5.6a	93.3 ± 6.7a
Common bermudagrass	1.5 ± 0.5b	1.8 ± 0.7a	39.1 ± 3.6b	53.3 ± 9.3a	66.7 ± 8.8a	33.3 ± 8.8b	26.7 ± 8.2a	100.0 ± 0.0a
Zoysiagrass	3.2 ± 1.6c	4.7 ± 0.8b	39.5 ± 4.6b	66.7 ± 8.8a	83.3 ± 6.9a	46.7 ± 9.3b	70.0 ± 8.5b	100.0 ± 0.0a
Tall fescue	3.8 ± 1.0c	--	50.3 ± 4.8c	63.3 ± 8.9a	--	53.3 ± 9.3b	--	93.3 ± 6.7a

[z]Values within a column followed by the same letter are not significantly different

[y]Female activity included presence of female, eggs, and/or evidence of digging in turfgrass cores

Fig. 1. Assembled oviposition arenas.