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Tolerance/Resistance to Annual Bluegrass Weevil Among Bentgrasses

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Summary: Clear evidence of bentgrass resistance or tolerance to annual bluegrass weevil (ABW) was obtained: compared to annual bluegrass, bentgrasses were less preferred for oviposition; less suitable for larval growth and development; and could tolerate higher densities of larvae with less visible damage. However, females laid eggs in all bentgrasses even if annual bluegrass was available, and ABW could develop from eggs to pupae on all bentgrasses tested. Among the tested bentgrasses, creeping bentgrasses were most resistant and tolerant to ABW.

The annual bluegrass weevil (ABW), *Listronotus maculicollis*, is the most important and difficult to control insect pest of short-mown golf course turf (greens, collars, approaches, fairways, tee boxes) in the Northeastern US and Eastern Canada. Severe damage to grass plants is caused by the larvae that initially tunnel stems, later feed externally on the crowns. The pest has consistently expanded its range of impact over the last decades with severe infestations now reported from all states of the Northeast and Mid-Atlantic.

Presently, chemical insecticides are the only effective option for ABW control with turf managers typically preventively applying insecticides over much of the short-mown areas of the golf course, often 2-6 times during the season. Over-reliance on and misuse of synthetic insecticides, particularly of the pyrethroid class, has led to the development of insecticide-resistant populations some of which are already resistant to most of the presently available chemistries. The only insecticide thus far unaffected appears to be spinosad (Conserve) but only when applied against larvae. The presently preferred alternative as an adulticide is the organophosphate chlorpyrifos. But ABW populations are already showing resistance to chlorpyrifos, albeit not at the level as to the pyrethroid. There is no good reason to assume that chlorpyrifos overuse will not lead to loss of this material within a few years as well. And there is no silver bullet on the horizon for resistant ABW at this time.

There is an urgent need to develop better IPM tools to assess and monitor the ABW's impact, and to develop more effective, preferably more environmentally benign management practices. Therefore, the overall goal of our research is to develop a basis for more effective methods for the management of ABW populations by pursuing different aspects of IPM: 1. monitoring methods, 2. plant resistance/tolerance, 3. biological control, and 4. to develop a better understanding of insecticide resistance in ABW and how to manage it. Here we will present our findings on plant resistance/tolerance and their implications.

Plant resistance/tolerance to pests is the most likely to be successful component in IPM. While annual bluegrass, *Poa annua*, is considered to be a preferred host of ABW and/or particularly susceptible to it, experimental evidence for host preferences has been very limited and variable. And there are also an increasing number of field observations on ABW damaging creeping bentgrasses. We studied the susceptibility to ABW and suitability as ABW hosts of different bentgrass species/cultivars in comparison with wildtype *P. annua* using the following bentgrasses: 1. Creeping bentgrass (CBG) (*Agrostis stolonifera*) cvs. 'L93' and 'Penncross' (older still widely used) and '007'and 'Declaration' (newer high quality); 2. Velvet bentgrass (*A. canina*) cvs. 'Villa' and 'Greenwich'; 4. Colonial bentgrass (*A. capillaris*) cvs. 'Tiger II' and cv. 'Capri'.

ABW oviposition preferences

A series of experiments investigated egg-laying preferences of female ABW in environmental chambers and in small enclosures in the field. Females were either offered just one core of one of the above grasses or were given a choice between Poa annua, one of the older creeping bentgrasses, one of the newer creeping bentgrasses, and the colonial bentgrass cv. 'Capri' or the velvet bentgrass cv. 'Greenwich'.

No choice experiments. In the environmental chamber experiments, egg-laying in *P. annua* was six times higher than in creeping bentgrasses (data combined across cultivars) and 12 times higher than in colonial and velvet bentgrasses. Among the creeping bentgrasses, egg-laying tended to be higher in the older (L-93, Penncross) than in the newer cultivars (Declaration, 007). In field experiments, egg-laying was higher in cv 'Capri' and particularly in *P. annua* than in the four creeping bentgrasses and cv. 'Villa'.

Choice experiments. If a choice was provided, ABW females clearly preferred *P. annua* to all bentgrass cultivars for egg-laying with at least six times more eggs found in *P. annua* than in any bentgrass cultivar in both the environmental chambers and the field experiments (Figure 1). The only bentgrass cultivar that showed a trend (not in all experiments, though) toward lower egg-laying than in other bentgrasses was cv. 'Declaration'.

Host suitability of bentgrasses for ABW

In two greenhouse pot experiments ABW females were allowed to lay eggs for 1 week and the grass searched for ABW larvae and pupae after another 4 weeks. *P. annua* had the highest average number of ABW life stages per pot followed by colonial bentgrasses (cvs.'Capri' and 'Tiger II') and velvets (cvs. 'Villa' and 'Greenwich') (Table 1). The most consistently low larval densities were observed in creeping bentgrass cvs. 'L93' and 'Penncross'. Number of stages recovered also differed significantly among grass species. The highest number was recovered from *P. annua*, followed by colonial and velvet bentgrass with the lowest numbers recovered in creeping bentgrass.

Third through fifth stage larvae and pupae were recovered from the pots. The average life stage reached was higher in *P. annua* than in any of the bentgrass species. Among cultivars, 'L-93' and 'Penncross' consistently had the lowest average life stage whereas cvs. 'Capri', 'Greenwich', 'Villa', and Tiger II' did not differ significantly from *P. annua*; cvs. 'Declaration' and '007' fell between these two groups. Fifth stage larvae grown on *P. annua* were significantly heavier than in most bentgrasses; there were no significant differences among bentgrasses. Damage ratings were the highest for *P. annua*. Overall, these findings show that ABW larvae grow better and develop faster if feeding on *P. annua* as compared to the tested bentgrass cultivars.

Tolerance of bentgrasses. to ABW larval feeding

Greenhouse-reared fourth stage larvae were placed onto potted turf cores that were kept in the greenhouse. Grasses were exposed to 0, 6, 12, and 24 larvae/pot (= 0, 71, 142, 284/ft2). Turf quality was evaluated 7 and 14 day after release. After the 14 day rating, the number of ABW stages present in the turf was determined. At the lowest larval density all grasses had low to moderate damage ratings (2-13% at 7 days; 5-23% at 14 days) which were not significantly different from control pots (Figure 2). At 12 and 24 larvae per pot, *P. annua* had the highest damage ratings after 7 and 14 days. Overall, bentgrasses were more tolerant of ABW feeding than *P. annua*. In *P. annua*, damage became apparent after 7 days at higher ABW densities and reached 64% at 24 larvae per pot after 14 days. In contrast, it took the highest larval density and 14 days to express damage in some creeping bentgrasses. Cultivars 'Capri' and 'Villa' seem to be the least tolerant among bentgrasses. Our data model predicts that bentgrasses generally can tolerate 2-3 times higher densities of ABW larvae than *P. annua* before sustaining the same damage level (20%). This confirm previous field observations that suggested that creeping bentgrasses can tolerate several times higher densities of ABW larvae than *P. annua*.

Implications

Poa annua is clearly preferred for egg-laying by ABW females and is also a better host for ABW development than bentgrasses. Among the bentgrasses, creeping bentgrasses tend to be preferred for egg-laying over colonial and velvet bentgrasses. However, larval survival is lower in creeping bentgrasses than in colonial and velvet bentgrasses so that larval densities tend to be the lowest in creeping bentgrasses. Damage therefore also is generally the lowest in creeping bentgrasses. Among the four creeping bentgrasses tested, none stands out significantly with regards to ability to withstand damage by ABW. Hence newer bentgrass cultivars should be preferable over older ones due to their improved performance with other stresses.

Replacement of *P. annua* with new creeping bentgrass cultivars should be the most effective, sustainable, and environmentally acceptable tactic for ABW management. Superintendents should consider replacing *P. annua* with new creeping bentgrass cultivars wherever possible. This should start with fairways where percentage *P. annua* tends to be lower than in lower cut areas. Fairways, if treated over large areas also represent a much larger area than greens and tees with much greater amounts of insecticides applied. The much greater tolerance of creeping bentgrasses will allow for fewer applications which would reduce the selection pressure for insecticide resistance. Less treated fairways would also allow natural enemies of ABW and other turfgrass insect pests to play a greater role, thereby further reducing the need for applications. Less treated fairways could also serve as a reservoir of insecticide susceptible ABW that could outbreed the resistant ABW in the more intensely treated areas. And superintendents worried about ABW causing damage to creeping bentgrass should keep in mind that the damage caused by ABW to creeping bentgrass vs. the damage to *P. annua* is like the effects of the common flue vs. those of Ebola. Creeping bentgrass generally recovers from ABW damage, *Poa annua* does not.

Table 1. Mean number per pot of ABW immatures recovered from *Poa annua* or cultivars of three bentgrass species in two greenhouse larval survival pot experiments.

Grass species/ cultivars	No. of larvae and pupae per arena Expt. 1	Expt. 2
Poa annua	**31.2 Aab**	**34.4 Aa**
A. stolonifera	**13.1 C**	**6.5 0.6 C**
L93	11.1 d	4.8 d
Penncross	9.8 d	5.3 d
Declaration	13.8 cd	8.4 cd
007	17.6 c	7.7 cd
A. capillaris	**18.0 B**	**12.5 B**
Tiger II	10.8 d	12.3 bc
Capri	25.2 b	13.8 b
A. canina	**21.8 B**	**11.2 B**
Villa	38.1 a	10.0 bc
Greenwich	18.1c	11.3 bc

Means within columns followed by the same upper (lower) case letter did not differ among grass species (cultivars) (α=0.05).

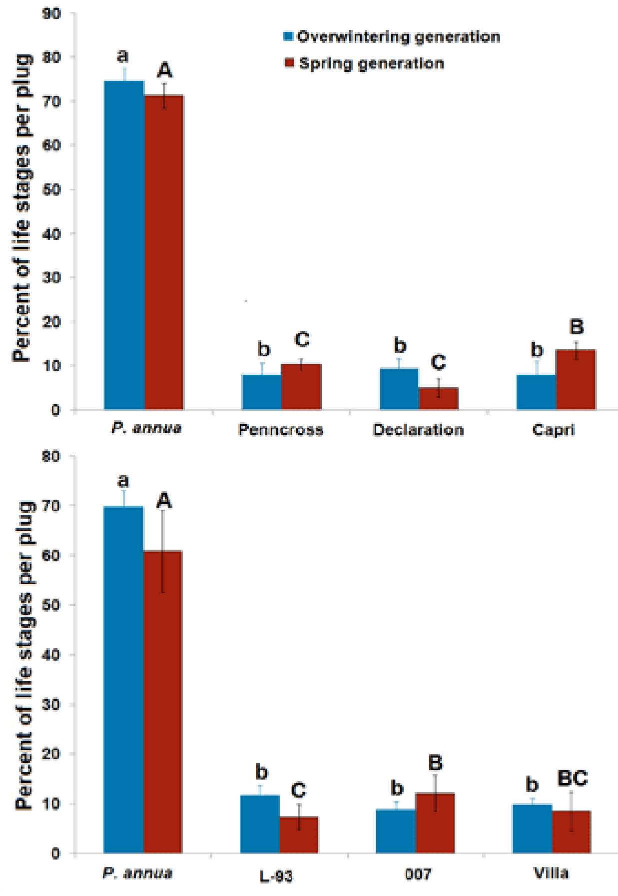

Figure 1. Oviposition choices of ABW females from two phenologically different populations in two field experiments. Means with same letter within populations are not statically different (α=0.05).

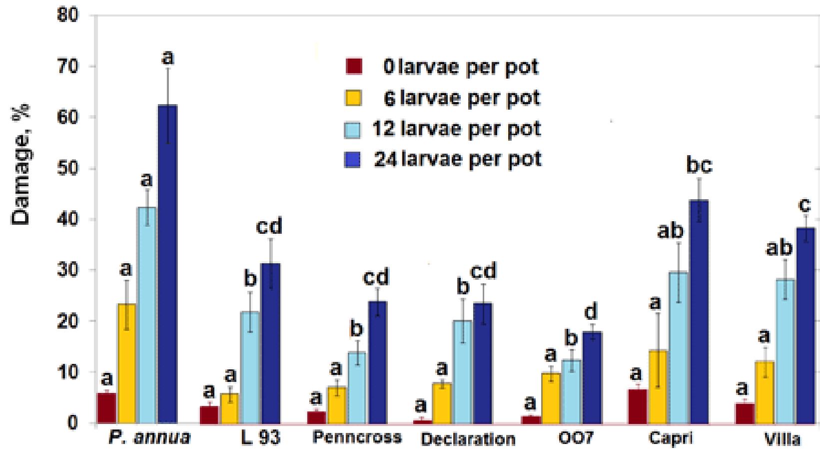

Figure 2. Percent damage caused by ABW larval feeding (0, 6, 12, and 24 larvae per pot) on *P. annua* and selected bentgrass cultivars 14 days after introduction of larvae into the pots. Means marked with the same letter did not differ significantly between cultivars at same larval densitiy ($\alpha = 0.05$).

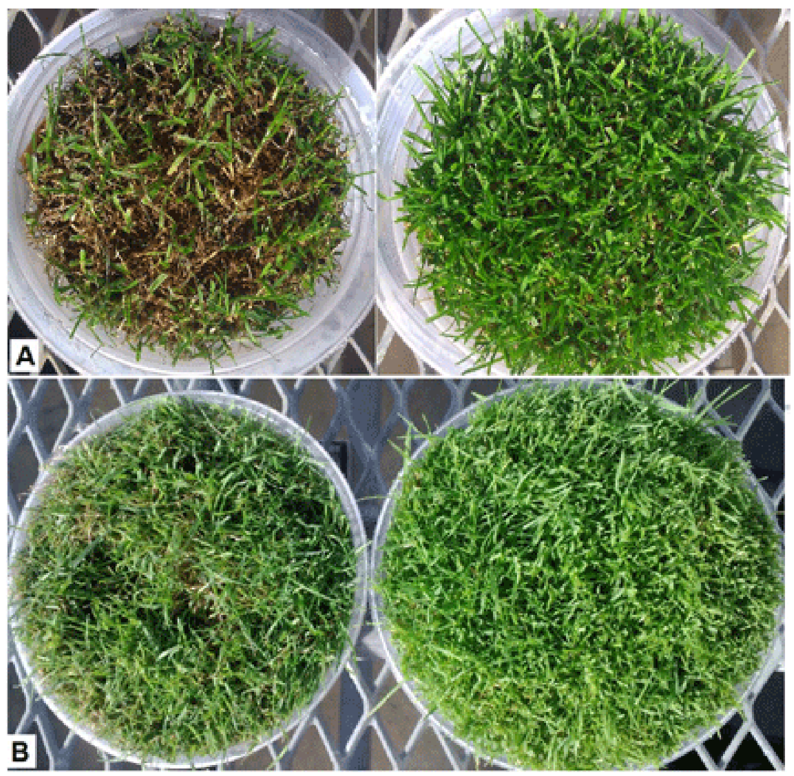

Figure 3. Cumulative damage 4 weeks after adult introduction at the highest ABW density (left) compared to control (right) in *P. annua* (A) and creeping bentgrass cv. 'Declaration' (B).

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