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This publication includes lecture notes of papers presented at the 2010 GREEN EXPO Turf and Landscape Conference. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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Dr. Ann Brooks Gould, Editor
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MANAGING ANNUAL BLUEGRASS WEEVIL RESISTANT TO PYRETHROIDS

Richard S. Cowles[1]

Golf course superintendents in the Northeast continue to have problems managing populations of *Listronotus maculicollis*, the annual bluegrass weevil (ABW), formerly called the Hyperodes weevil. Extensive field work by University of Rhode Island student Darryl Ramoutar (now Ph.D.) revealed that populations of annual bluegrass weevils throughout Connecticut vary tremendously in their susceptibility to pyrethroid insecticides (Ramoutar et al., 2009).

Susceptibility of weevils to pyrethroids is measured by the LD_{50}, the median lethal dose, which is the quantity of insecticide that when applied to a population of insects will kill half of the individuals; the lower the LD_{50}, the more sensitive the weevils are to the tested insecticide. In the case of ABW, the most susceptible population we have measured has an LD_{50} of approximately 0.3 ng of bifenthrin per insect (*unpublished data*), whereas the most resistant has an LD_{50} of over 200 ng (Ramoutar et al., 2009).

The variation in resistance to pyrethroids is likely related to previous pesticide practices – the superintendent at the course with the most susceptible population doesn't spray to manage ABW, whereas the most resistant populations have been sprayed multiple times each year for more than ten years. The correlation between intensity of spraying and how resistant the weevils are points to both the cause and possible solution to the ABW problem. In some respects, intensive use of pyrethroid insecticides has created the challenging situation that superintendents face. These products initially are extremely effective and have long residual activity. Their use results in intense selection for weevil survivors genetically endowed with characteristics that will allow their progeny to better survive the next application of pyrethroids. Furthermore, because this class of insecticides has broad-spectrum activity (all insects are initially poisoned), pyrethroid residues eliminate predators that could act as a biological control safety net for maintaining low weevil populations. Therefore, once pyrethroid resistance occurs in ABW populations, continued use of pyrethroids only serves to exacerbate the problem because the insecticide application then mostly kills beneficial predators, and weevil populations can then multiply unchecked.

Another somewhat unexpected outcome from pyrethroid resistance is an increased likelihood that insecticides belonging to unrelated classes of insecticides may fail. Pyrethroid resistance is due to metabolic detoxification: enzymes belonging to three classes degrade the insecticide so it no longer works. The number of enzyme systems involved in resistance depends on how resistant the ABW population is. Populations with a low level of resistance rely upon mixed function oxidases (MFOs), intermediately resistant weevils use both MFOs and glutathione transferases, and the most highly resistant weevils use the first two enzyme systems plus carboxylase enzymes. These families of enzymes can metabolize a wide array of substrates, and so selecting for a high level of resistance jeopardizes all other insecticides. It is notable that differences in susceptibility to chlorantraniliprole (Acelepryn) were noted immediately between pyrethroid resistant and susceptible populations of ABW, yet at that time these weevil populations had never previously been exposed to this new class of insecticides. Therefore, when resistance is due to detoxification mechanisms, using insecticides with new modes of action will not necessarily solve the problem.

All populations of ABW found to be resistant to pyrethroids are easily demonstrated to use MFOs as their first line of defense. Superintendents can easily test for resistance by applying a pyrethroid to a piece of filter paper at the field dosage, and then placing adult weevils on this treated paper. Similar paper can be treated with a combination of the pyrethroid and a synergist, such as piperonyl butoxide (PBO). An

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untreated piece of paper and a piece of paper treated only with PBO completes the set. Live adult weevils (about ten per treatment) are then placed on the four moistened filter papers and enclosed in a plastic bag in a cool location. One and two days later, the surviving weevils are counted. If the only weevils that die are those exposed to the combination of pyrethroid + PBO, the weevils are pyrethroid resistant. If the same numbers die on the pyrethroid and on the pyrethroid + PBO treatments, then the weevils are susceptible. When significant numbers of weevils die in the PBO check group, it signifies that the weevils were dosed with insecticides in the field prior to the test.

Even though pyrethroid activity can be restored with a synergist in these filter paper bioassays, synergists have not been proven to be useful on golf courses. In my field studies, slight increases in mortality when combining pyrethroids with synergists (such as PBO, DMI fungicides, and gibberellin-blocking growth regulators [Ramoutar et al., 2010]) have not been statistically significant. Therefore, the down-side of using pyrethroids (continued selection and destruction of predators) probably outweighs their benefits, once pyrethroid resistance is detectable.

An appropriate response to finding pyrethroid resistant ABW on a golf course is to change the pesticide practices to eventually restore some ecological balance. There are two insecticides with good selective characteristics that suppress damaging populations of weevil larvae. Substituting selective insecticides for pyrethroids will encourage predators (principally ants, predatory ground beetles, and rove beetles) to keep ABW populations in check. Spinosad (Conserve®), reliably kill approximately 85 to 90% of weevil larvae of all stages. Indoxacarb (Provaunt®) has been somewhat less satisfactory in the field, but usually kills about 70% of late instar larvae. Chlorantraniliprole (Acelepryn®) has been inconsistent, ranging from no measurable degree of control to virtual elimination of weevil larvae. Factors involved in being able to reliably obtain high degrees of pyrethroid-resistant weevil suppression with chlorantraniliprole need to be studied further. In all cases, these products bind tightly to organic matter and are readily broken down by sunlight. Therefore, they need to be adequately incorporated with approximately 0.2 inches of precipitation or irrigation immediately following the spray, hopefully before the spray has had a chance to dry. Be careful to calculate the amount of irrigation that your sprinklers provide, so that you permit sufficient time to irrigate the products into the soil. Superintendents may have to treat only as much of their course at a time as can allow proper incorporation, before moving on to spray the next section of the course.

Using products targeting larvae has an advantage: you may only need to treat areas where protection of the turf is most important (greens, collars, and tees), and otherwise allow the weevil populations to suppress annual bluegrass through the fairways. It seems ironic that superintendents have been spending so much effort to manage a weevil that could be a valuable biological control for, what is to many, an unwelcome weed. However, there have been repeated observations that ABW does not only feed on and damage *Poa annua*, but can also damage bentgrass, and so keeping the populations below damaging levels is still necessary. Bentgrass is not usually damaged by ABW and so suppression of *P. annua* may be one strategy to minimize the likelihood that ABW feeding will cause aesthetic injury to the course.

SUMMARY

- Use test kits to determine whether you have pyrethroid resistant weevils on your course
- Discontinue pyrethroid use if you have resistant weevils
- Target larvae rather than adults to manage resistant populations
- Conserve, Provaunt, and possible Acelepryn are more selective and appropriate products than pyrethroids to manage ABW
- Suppress *Poa annua* on the course to minimize damage from ABW

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