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Title: Biorational control of important golf turf insect pests

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Objectives: The overall goal is to develop a better understanding of the role that biorational insecticides can play in the management of important golf turf insect pests with particular emphasis on the annual bluegrass weevil to facilitate insecticide resistance management in this difficult-to-control pest.

The annual bluegrass weevil (ABW), *Listronotus maculicollis*, is a serious and expanding golf course pest with demonstrated ability to develop resistance to a range of insecticides. The primary purpose of this project is to develop biorational alternatives for the management of ABW as safer and more sustainable alternatives to traditional synthetic insecticides that will also facilitate better insecticide resistance management. Biorational materials are being tested on golf course fairways against insecticide-susceptible and -resistant ABW adults and larvae. They are also being tested against larvae of white grubs and black cutworm because treatments against these pests could be done at the same time as for ABW, increasing chances of adoption of the biorational controls and further decreasing insecticide applications.

Biorationals tested include the products Grandevo (*Chromobacterium subtsugae* strain PRAA4-1 and its fermentation products), Venerate (heat-killed *Burkholderia* spp. strain A396 bacteria and their fermentation products), BotaniGard ES (entomopathogenic fungus *Beauveria bassiana* GHA strain), and Molt-X (botanical azadirachtin). They were chosen because they have reasonable costs, product stability, and relatively long shelf lives at room temperature, and have very different modes of action unlikely to be affected by the broad insecticide resistance observed with ABW.

Experiments presented here were conducted on fairways of golf courses with ABW populations that were considered fully susceptible to pyrethroid insecticides or pyrethroid-resistant with a resistance ratio (RR_{50}) of around 2x and 70x, respectively, compared to the most pyrethroid-susceptible population determined by us. Two application of Molt-X provided quite consistently around 40% control irrespective of resistance level when applied when eggs and first to second instar larvae peaked but was ineffective when applied against third and fourth instars (Fig. 1). Two application applied when third and fourth instar larvae peaked gave around 35% control with Grandevo, irrespective of resistance level, but only 23 to 30% with Venerate (not statistically significant against the resistant population). When targeting the overwintered adults around peak densities before the start of egg-laying, two application provided 36 to 47% control of susceptible and resistant populations with Grandevo and 49 to 55% control with Venerate.

Previously, we had observed a synergistic effect on ABW control of combinations of BotaniGard with the Talstar targeting overwintered adults in around peak densities in a pyrethroid-resistant population. Laboratory tests indicated that the synergistic interaction was due to the oil carrier in the BotaniGard formulation with combination of the oil alone with Talstar causing similar

mortality as the BotaniGard-Talstar combination. Hence, overuse of these combination could still select for pyrethroid resistance, and the combinations have to be used carefully.

The control rates observed with the above biorationals tend to be lower than those observed with the more effective synthetic insecticides against pyrethroid-susceptible ABW populations. However, against resistant ABW populations the biorationals are as effective or more effective (depending on resistance level) than most synthetic insecticides. They thus offer new options for the management of resistant ABW populations. And when rotated with still effective synthetic insecticides, they can be used in resistance management in resistant and susceptible populations.

- The pyrethroid bifenthrin (Talstar) and the organophosphate chlorpyrifos (Dursban) were ineffective against insecticide-resistant ABW adults.
- BotaniGard (AI: *Beauveria bassiana*) was ineffective against ABW larvae and adults.
- Talstar and BotaniGard interacted synergistically providing effective control of ABW adults.
- Molt-X, Grandevo, and Venerate (currently not labeled for turfgrass) can provide acceptable control of pyrethroid-susceptible and -resistant ABW and may be useful in the management resistant populations and in resistance management.

Table 1. Effect of pyrethroid resistance on densities (± SE) and percent control of annual bluegrass weevil developmental stages in early June (peak 4th to 5th instar) in golf course fairways treated with Talstar and sequential applications (about 1 week apart) of Grandevo and Venerate applied around the peak in densities of overwintered adults in late April/early May.[a]

Treatment	Rate (lb product/acre)[b]	No. of stages / ft^2 (% control)	
		susceptible	resistant
Untreated Control	---	148.9.1 ± 21.1 a	45.8 ± 6.1 a
Talstar P	0.1[c]	28.8 ± 3.7 d (80)	34.1 ± 4.0 ab (25)
Grandevo	2 x 4.0	88.9 ± 11.8 b (39)	---
Grandevo	2 x 8.0	79.1 ± 11.9 bc (47)	28.9 ± 4.1 b (36)
Venerate	2 x 8.0	69.0 ± 13.3 c (55)	23.3 ± 4.2 b (49)
Venerate	2 x 16.0	75.4 ± 12.9 bc (50)	---

Means within resistance level with same letter are not signficantly different ($P > 0.05$).
[a] Data are combined from two experiments for each resistance level.
[b] Rate for each application
[c] lbs A.I./acre for Talstar

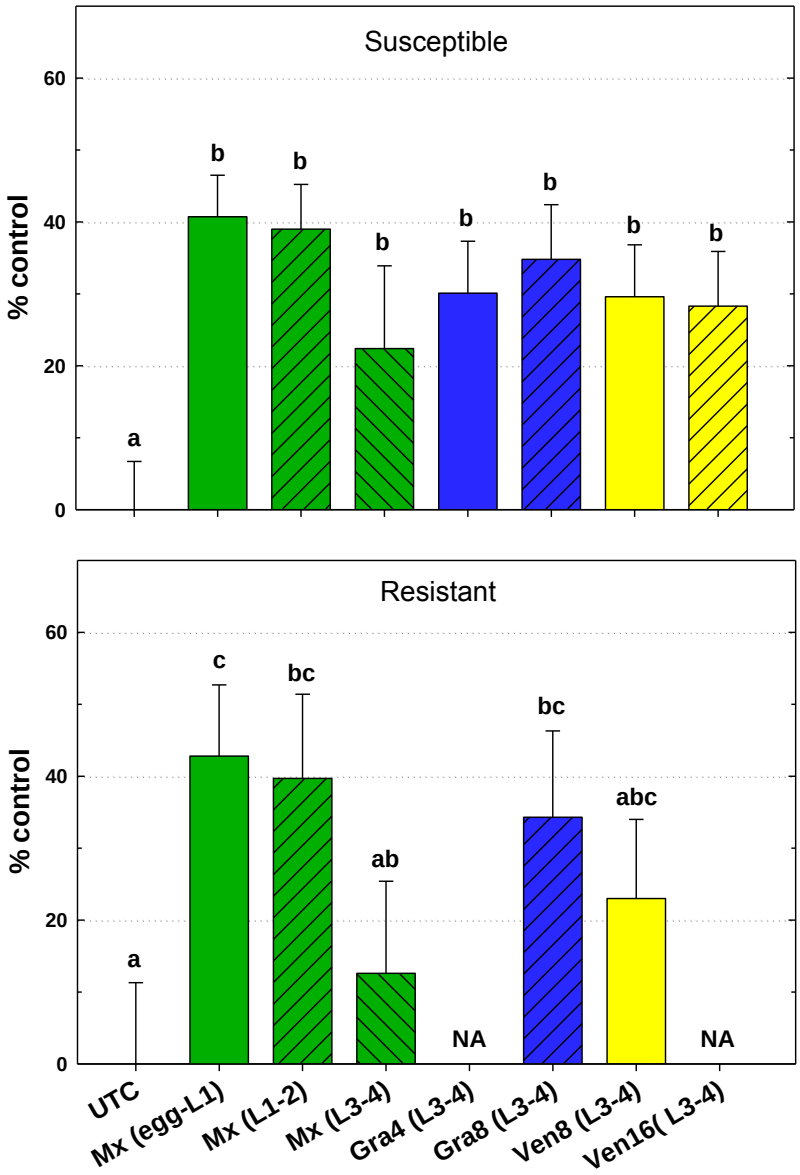

Fig. 1. Effect of pyrethroid resistance on control of annual bluegrass weevil developmental stages in early June (peak 4th to 5th instar) in golf course fairways treated with sequential applications of Molt-X (Mx; 1.44 lb product/acre per application), Grandevo (Gra; 4 and 8 lbs product/acre per application), and Venerate (Ven; 8 and 16 lb product/acre per application). Molt-X was applied at peak eggs and peak 1st instar larvae (egg-L1), at peak 1st instar and peak 2nd instar (L1-2), and at peak 3rd instar and peak 4th instar (L3-4). Grandevo and Venerate were applied at peak 3rd instar and peak 4th instar. Data are combined from two experiments for each resistance level. Means within each resistance level with the same letter did not differ significantly ($P > 0.05$).