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What's new in turfgrass insect pest management products:

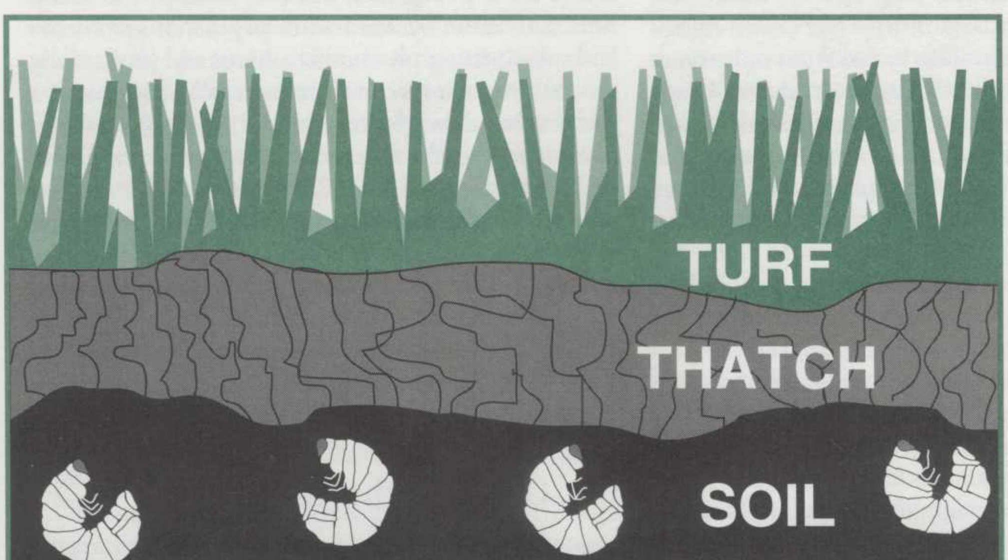
Focus on biological controls

By Michael G. Villani

In years past, the development of pest management products for turf has taken a distant back seat to products that targeted pests of field crops such as corn, soybeans and cotton. Products that were not effective against one or more insect pests on major food or fiber commodities had little chance of being tested against insects particular to turfgrass.

This is no longer true. A minor revolution has occurred over the past ten years as the crop protection industry has focused greater attention on so-called specialty markets like turfgrass. There is a growing appreciation that these specialty markets, although not as large as traditional agricultural markets, provide an important and lucrative product niche. As such, several insect control products targeted at the turfgrass market have been recently registered or are in an advanced stage of development.

The following is a brief review of some of these products, together with the results of representative laboratory and field studies conducted over the last several years by my research team at Cornell. It is important to remember that these studies were conducted under ideal conditions with regard to timing, equipment calibration, quality of control agents, and environmental conditions. Field efficacy may consequently differ.



Grubs Feeding At Thatch/Soil Interface

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Chemical pesticides

Merit

Since organochlorine insecticides such as chlordane and DDT were removed from the market there have been no traditional insecticides labeled for control of scarab grubs that are sufficiently persistent in the field to be applied to turfgrass prior to grub oviposition (usually late spring to early summer for most annual grub species), and continue to provide consistent control of grubs into late summer and fall. For this reason, the most prudent use of soil insecticide for grub control has been to sample for small grubs in late summer (early to mid-August in New York State) and then treat areas showing high grub populations.

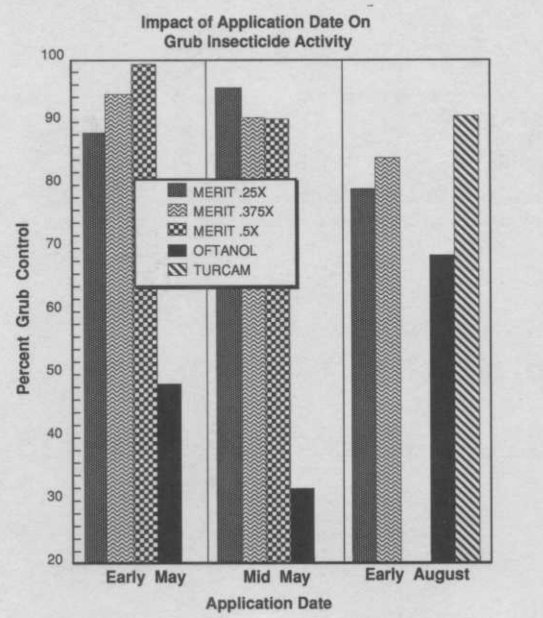


Fig 1. Impact of application date on the activity of Merit insecticide against Japanese beetle grubs on three golf course fairways. Merit insecticide, when applied in early and mid-May, showed no significant loss of residual activity for control of fall Japanese beetle populations. By contrast, May applications of Oftanol did not provide satisfactory reductions in fall grub populations. Appropriately-timed application of Merit shows grub reduction activity comparable to traditional insecticides.

Merit (common name Imidacloprid) is a new-chemistry, broad-spectrum, long residual insecticide, registered by Miles to control soil- and crown-inhabiting insects in turfgrass. This includes not only scarab grubs such as Japanese beetle, European chafer, Asiatic garden beetle, May and June beetles, Oriental beetle, northern and southern masked chafer, green June beetle and black turfgrass Ataenius but also turfgrass inhabiting weevils such as billbugs and the annual bluegrass weevil.

This newly-registered insecticide has shown sufficient residual activity in turfgrass to control the fall brood of annual scarab grubs when applied the previous spring or summer (Figure 1). High levels of grub control can be achieved when applications are made between April 1 and August 15 which is prior to annual scarab grub egg hatch. An application of Merit in spring for billbugs or annual bluegrass weevils will control fall grubs.

There has been considerable debate among turfgrass entomologists about the use of insecticides such as Merit that are designed for application before the size and damage potential of an insect population is known. That is, these products are not only applied before insect eggs are hatched but in many instances several months before the eggs are laid. There is consequently great potential for abuse of this product if turf managers apply it indiscriminately, or without regard to the likelihood of having a damaging population of insects on a treated area some time in the future.

A multi-year study of home lawns in the upstate New York region (see August 1994 TGT) indicated that approximately 80% of those surveyed did not require lawn grub insecticide applications for an acceptable turf stand. The use of pheromone and light traps to assess adult populations can provide some indication of the potential size of a future larval population, but past research has found little correlation between adult populations of beetles and subsequent grub numbers. Merit and similar long residual insecticides can fit into an IPM program if a turf site has a long history of grub damage or shows consistently high grub populations over several years.

Merit carries a CAUTION toxicity signal word on its label, and the label warns of high toxicity to aquatic invertebrates and bees exposed to direct treatment or residues on blooming crops or weeds. As always, appropriate precautions should be taken.

Biological controls

B.t. (Bacillus thuringiensis)

Bacillus thuringiensis is a soil bacterium, common in nature, that was first discovered in Japan in 1901. Since then over 30 subspecies and varieties of B.t. have been identified. This family of bacteria produces a protein crystal that is toxic to a fairly limited number of species or groups.

B.t. products have been used to control insects for many years. Various strains have been identified acting against caterpillars, fly larvae, and beetle larvae. B.t. varieties that are currently being commercialized include B.t. kurstaki and B.t. aizawai (caterpillars), B.t. israelensis (mosquitoes) and B.t. tenbrionis (potato beetles).

Because B. t. bacteria are environmentally friendly and can be produced in great quantities on artificial media, there is great interest in the commercialization of this bacterium for insect control. Unlike other biological control agents, these bacteria do not normally reproduce in the insect host, persist in the environment, or spread from the treatment site to other areas. As a result, B. t. has typically been used as a microbial insecticide for short-term control.

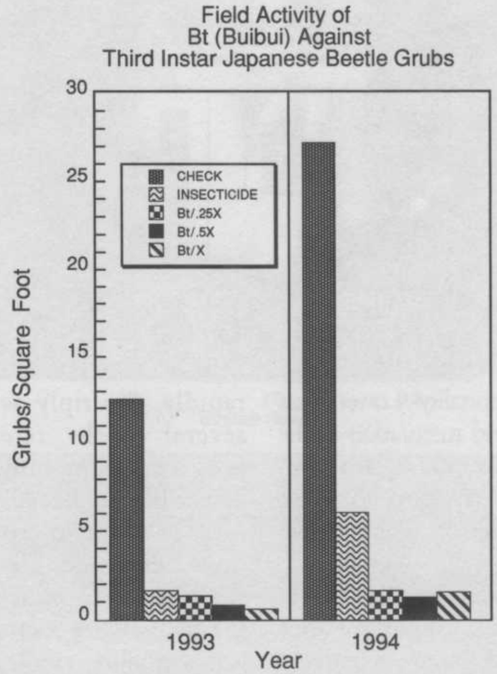


Fig 2. Field evaluation of B.t. Buibui against Japanese beetle grubs in New York State. Three rates of B.t. Buibui, provided by the Mycogen Corp. of San Diego, CA, were field tested during the fall of 1993 and again in 1994 against third instar Japanese beetle grubs on unirrigated golf course roughs containing significant levels of dense thatch. Plots were evaluated six weeks after application. B.t. treated plots had significantly fewer grubs than untreated plots. The B. t. product gave grub reductions equal to or greater than a standard insecticide commonly used against scarab grubs in New York State.

How B. t. kills insects is fairly well understood. First,because it acts as a stomach poison, its protein crystals must be eaten by the insect to be effective. In some cases, additional products produced by the living bacteria must be consumed for maximal activity. If an insect's gut content is of the proper acidity (pH) the crystals will dissolve there. Proteins released from the dissolved crystal bind to a specific site in the gut lining of susceptible insect species, causing rapid paralysis of the gut. The insect stops feeding almost immediately as the gut wall deteriorates.

In most cases a susceptible insect will die 2-7 days after ingestion of the B. t. toxin. The major reasons for the lack of activity of a B. t. strain against an insect species are, first, gut pH that does not allow the toxic protein crystal to dissolve, and second, the inability of the toxic protein to bind to the insect's gut.

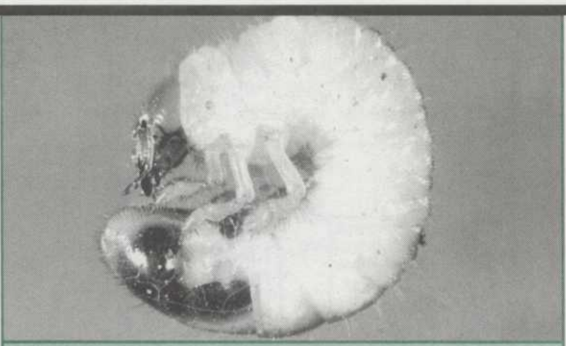
Although B.t. products are registered for use against several turf-feeding caterpillars, including cutworms and sod webworms, these products have not been widely recommended or accepted in the turf industry, most probably because of their short residual, slow activity, and inability to kill larger larvae.

Until recently, there were no B.t. varieties known to cause significant mortality in scarab grubs inhabiting turf. In 1991, however, B.t. variety japanensis strain Buibui (B.t. Buibui) was discovered in Japan. Development and commercialization of B.t. Buibui has been undertaken by a biotechnology company, the Mycogen Corporation, of San Diego, CA. They expect registration of this product against certain scarab grubs in 1996. Unlike most B. t. products currently on the market, maximal activity of B.t. Buibui against scarab grubs occurs when formulations include not only the toxic protein crystals but also live spores produced by the bacteria.

In laboratory and field studies, Japanese beetle, Oriental beetle, northern and southern masked chafer and green June beetle grubs have all been shown to be highly susceptible to B.t. Buibui. June beetle, black turfgrass Ataenius beetle and Aphodius beetle grubs appear much less sensitive to this product. Two field studies of the activity of this B. t. against Japanese beetle grubs that were conducted in New York State showed its efficacy to be equal to standard grub insecticides six weeks after application (Figure 2). According to Mycogen, B.t. Buibui is nontoxic to all vertebrates, earthworms, honeybees and plants.

Insect growth regulators (IGRs)

Several chemical companies are developing artificial compounds that, by mimicking the action of the natural hormone ecdysone, interfere with the normal insect molting process. High doses of these compounds typically cause rapid insect mortality. Lower doses show sublethal effects, including rapid maturation to the adult stage, larvae showing deformities, and larvae undergoing additional molts instead of changing to pupa. Specific IGR products have shown activity against scarab grubs, cutworms and sod webworms.



Healthy Grub

Insect growth regulators typically require ingestion for optimum activity, so it is important that they are applied when the target insect is actively feeding. The use of an IGR on scarab grub populations late in the fall, as they prepare to move down into the soil for winter, or its application to grubs in late spring as they prepare to pupate, is liable to prove ineffective.

Laboratory and field studies indicate that early larval stages are susceptible to insect growth regulators. They also suggest that there is wide-ranging activity among closely-related insects, such as different species of scarab grubs (Figure 3). Our studies have pointed to one IGR that shows truly impressive activity against Japanese beetle grubs, but much less dramatic activity against either European chafer or Oriental beetle grubs. The target-specificity of these products demands that, to avoid disappointing results, turfgrass managers determine which insect species is present before application.

Entomogenous nematodes

Entomogenous nematodes have recently received attention as alternatives to insecticides for turf insect control. There are many factors that in theory make nematodes the ideal biological control agent: they have a broad host range, will not attack plants or vertebrates, are easy to mass-produce and can be applied with most standard insecticide application equipment. Additionally, nematodes will search out their target hosts and kill them rapidly, multiply within the host, and within several weeks release thousands of mobile progeny, programmed to locate and infect new insect hosts. Because they are considered predators, and not microbial insecticides, entomogenous nematodes are exempt from registration by the U.S. Environmental Protection Agency. This means they are exempt from long-term safety and water quality studies, which greatly reduces the costs and risks associated with bringing a new insecticide to the market.

Entomogenous nematodes enter the target insect through natural openings: most commonly the mouth, less commonly the skin. The nematodes then move through the gut into the blood, where they release a colony of bacteria they carry within their bodies. Once inside the insect, the bacteria multiply and begin to produce toxins that rapidly kill the infected insect.

Nematodes feed and reproduce inside dead insects, each producing several thousand new nematodes. Under ideal conditions, thousands of next-generation nematodes will emerge from a dead insect in as little as ten days and begin to search for new hosts.

There have been many successful field applications of entomogenous nematodes for control of turf insects, although problems with product quality, persistence, and host-specificity have led to unsatisfactory results in some instances. While demonstrating fairly broad host ranges in laboratory studies, different strains and species of nematodes vary in activity against different insect species in the field.

Grubs Infected With Nematodes

Overall, because they move down in the soil profile and search for insects (Figure 4), the nematodes Heterorhabditis bacteriophora (Hb) and Steinernema glaseri (Sg) are more effective against white grubs than the more commonly marketed Steinernema carpocapsae (Sc). Conversely, Steinernema carpocapsae is effective in control of billbugs and caterpillars such as cutworms, webworms, and armyworms.

Many unsuccessful field applications of entomogenous nematodes for scarab grub control can be traced to improper environmental conditions, either at the time of application or for several weeks after application. Nematodes are extremely sensitive to ultraviolet light, and will last only a matter of minutes when exposed to full sunlight. They are also quite prone to desiccation, requiring high relative humidity and a film of moisture on leaf and soil surfaces to survive and move.

For these reasons, they should be applied early in the morning or late in the day, and be irrigated immediately after application with at least a half inch of water. Nematodes searching for grubs move over soil particles on thin films of water. They will not search efficiently in saturated soils, however. Failure to provide appropriate soil moisture for several weeks after application limits the utility of nematodes in many situations.

One mistake often made by turfgrass managers is to save money by applying nematodes at rates lower than recommended. Extensive field studies on New York golf courses over the past five years confirm that there is a strong positive correlation between the number of nematodes applied and grub mortality.

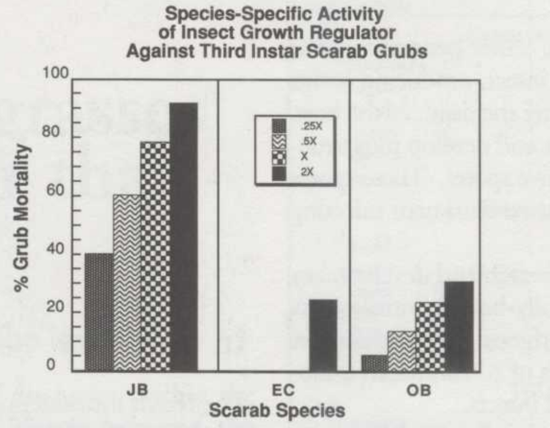


Fig 3. Laboratory evaluation of four rates of an insect growth regulator against third instar Japanese beetle (JB), European chafer (EC) and Oriental beetle (OB) grubs. There was a significant dose response of this product against each species of scarab grub and significant difference in activity of the product among the three grub species.

Although often treated as insecticides, entomogenous nematodes are living organisms, and must be handled with care to be effective. Only nematodes in the best condition will be able to search successfully for an insect host, overcome the defenses of the insect to infect and kill it, and multiply within the dead insect producing progeny to infect new hosts. To maximize the probability of applying healthy nematodes, it is critical that directions regarding storage and application rates are followed carefully.

Fungal pathogens

Virtually every group of turfgrass insect pests, including scarab grubs, chinch bugs, billbugs, annual bluegrass weevils, sod webworms, cutworms and mole crickets, is susceptible to endemic populations of fungal pathogens such as Beauveria bassiana and Metarhizium anisopliae. Commercial interest in fungal pathogens as biological control agents has ebbed and flowed over the last decade as the promising results seen in laboratory and greenhouse research have run up against the hard realities of producing an effective, consistent, price-competitive and safe commercial field product. At present, there are no commercial fungal products available for management of turf pests.

Fungi differ from most other microorganisms because they do not have to be ingested to be effective. Infection is initiated by the adhesion of a fungal spore to the body of an insect. If conditions are correct, the spore will germinate and a tube will grow from the spore into the insect, pen-

Grub Infected With a Fungal Pathogen

etrating its circulatory system. After penetration, the fungus reproduces within the insect, producing toxins that quickly kill the insect. After the death of the host, hyphae emerge from the insect and develop into structures that produce more infective spores. These spores can then be spread through the environment infecting additional insects.

Studies in our long-term research and development program to introduce biologically-based control agents for scarab grub control in turfgrass have focused on evaluating a number of isolates of Metarhizium anisopliae, a fungal pathogen of soil insects.

Fourteen Metarhizium anisopliae isolates were tested against Japanese beetle grubs. Two isolates, MADA and 1020, have generated sufficient interest for commercialization. The other 12 isolates were chosen because they were isolated from scarab grubs obtained around the world. MADA and 1020 performed well at various treatment rates, but other isolates clearly performed consistently better. There were considerable differences in how well several fungal isolates performed under a variety of environmental conditions that are commonly found in northeastern golf courses.

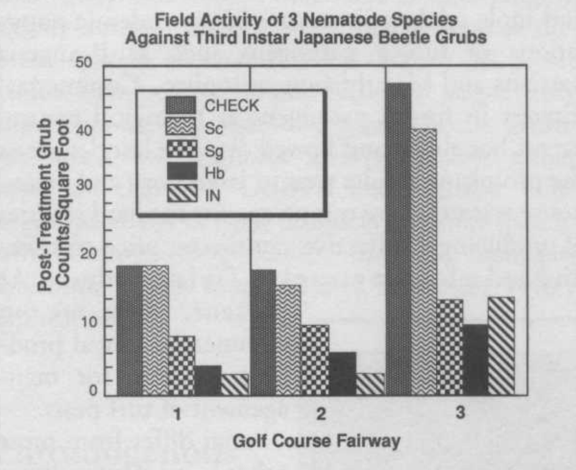


Fig 4. Field evaluation of three species of entomogenous nematodes against Japanese beetle grubs on three golf course fairways in New York State. Overall, the nematodes Heterorhabditis bacteriophora (Hb) and Steinernema glaseri (Sg) were more effective against Japanese beetle grubs six weeks after treatment than the more commonly marketed Steinernema carpocapsae, (Sc) and provided grub reduction equal to or greater than a standard insecticide commonly used against scarab grubs in New York State.

In summary

The recent introduction of new materials for turfgrass insect control, both chemically-based and biologically-based, has increased the number and variety of tools available for turfgrass pest management. At the same time, each of these new developments reinforces an old imperative: before a proper control decision can be made, turfgrass managers must correctly identify the species involved, estimate the size of the population and determine its stage of growth. "Shoot first and ask questions later" is liable to wind up wide of the mark.

Dr. Michael G. Villani is an Associate Professor of Soil Insect Ecology in the Department of Entomology at NYSAES/Cornell University. He has degrees from the State University of New York at Stony Brook and — in entomology — from North Carolina State University. Dr. Villani, who is active in both research and extension work, concentrates on the interrelationships between soil insects, their host plants, and the soil environment. His most recent contribution to *TurfGrass TRENDS* appeared in the August 1994 issue.

Terms to know:

- **Organochlorine** - belonging to the family of chlorinated hydrocarbon pesticides, such as, aldrin, DDT, deldrin, etc.
- **Oviposition** - to lay eggs
- **Scarab** - a family of stout-bodied, mostly brilliantly-colored beetles (including June beetles)
- **Molting** - periodically casting off an outer covering or shell prior to its replacement by new growth
- **Entomogenous** - preying on insects
- **Nypae** - the threadlike structures that make up the asexual reproductive aparatus of a fungus.