BY RICK BRANDENBURG, PH.D.

Behaving badly

Soil insects' below-ground activity affects pesticide applications

In most areas where high-quality turfgrass is maintained, insects typically rank third behind weeds and diseases on a turfgrass manager's priority list. But insects cause serious turfgrass damage and in some areas are the biggest problems that need to be addressed.

The cost of controlling insects, especially insects that live in the soil, can be quite significant. The cost is often related to the fact that insects living in the soil often require a higher recommended rate of insecticide than those insects that live above the soil. The soil and thatch often make it more difficult for the insecticide to get the job done.

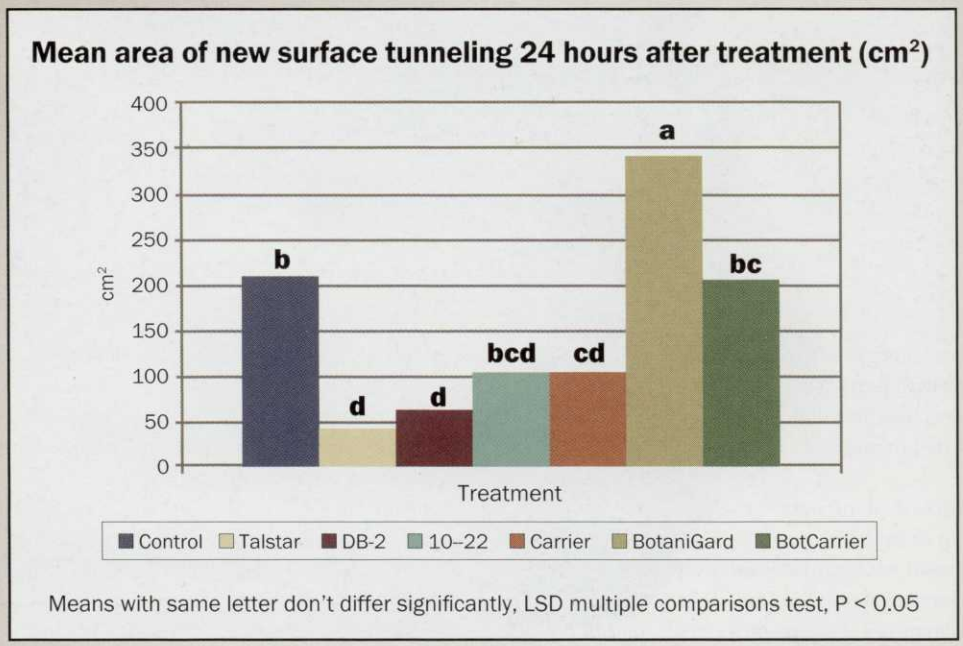
However, effective management of soil insects such as white grubs and mole crickets is challenged by more than just the fact that the insects are surrounded by soil and often protected by thatch. Insects behavior, which is something we typically can't observe, can create many headaches. These insects are often able to survive a wide range of environmental and man-made stresses. Insects' survivability isn't based solely on the insect's hardiness. While many insects are well adapted and designed to tolerate some severe conditions of drought and temperature, the physical adaptations might not be the only characteristic they possess to help them cope and survive.

Insects also have a hard, waxy cuticle or skin and can withstand severe stress. In addition to the physical features of insects that make them tough, many also have behavioral characteristics that might help them avoid stresses. For many years, we've known and observed that some soil insects might burrow deeper in the soil

Mole crickets are a serious golf course pest worldwide. Their underground life and mobility make them more difficult to detect, monitor and manage. Photo: N.C. State University

during dry periods. This allows them to move to locations where the soil moisture may be more appropriate for their survival. Above-ground insects might shift their location on the plant during conditions of environmental stress to help them tolerate the situation.

Many years ago in agricultural crops, it was observed that in some instances insects would move to the lower leaf surfaces of plants to avoid exposure to insecticides. Continuing to spray for insects with insecticides has the potential to select those insects that move to the lower leaf surface and avoid exposure to the spray. If the behavior was genetically controlled, then the percentage of insects that move to the lower leaf surfaces to avoid treatment would increase because the insects that stayed on the upper surfaces most likely die, and those genes would be eliminated from the population.



Measuring mole crickets' avoidance behavior away from control products indicate that biological control agents demonstrate a repellency equivalent to convential insecticides.

MOLE CRICKET BEHAVIOR

Although we've been treating insects with pesticides for a long time, it shouldn't surprise anyone if we saw behavioral traits that might help them survive. The area where this behavior has been demonstrated quite clearly and has significant implications for control is with soil insects such as white grubs and mole crickets.

Mole crickets are serious turfgrass pests in many parts of the world, especially in warmer climates. These insects dig and tunnel through the soil, creating physical damage affecting the appearance of turfgrass. They also can cause drought stress by loosening the soil and feeding on the turf roots. The end result is that by late summer, the turfgrass can be seriously damaged, and in some cases, the turf in localized areas might be destroyed completely. Additionally, birds often probe for and feed on mole crickets, adding to the turfgrass damage.

Once the lifecycle of the mole cricket is understood in a particular area, we've had good results developing a management strategy. There are three key components to effective mole cricket control. They are mapping, monitoring and timely treatments. Mapping is critically important because it will guide your efforts to monitor in early to mid-summer when the turfgrass looks its best. However, the appearance of turf on the surface can be deceiving when mole cricket eggs are hatching and the small nymphs begin feeding on the roots. The nymphs are small in early to mid-summer, and the turfgrass can tolerate their feeding. Early summer is the timing for the most effective treatments. Rather than attempt to determine where on the whole golf course eggs might be hatching, good maps from the previous year's infestation tell you exactly where to begin looking.

Mole crickets are creatures of habit and usually occur over and over again in the same locations each year. Therefore, records of where

The behavioral characteristics of many soil insects make accurate monitoring a critical step in developing a management program. Photo: N.C. State University

they were last year can be used to help you determine which sites to monitor during the egg-hatch time. Starting about two weeks before local information indicates mole crickets eggs might be hatching, mix up a 2 percent soapy water solution and pour about one gallon of the solution on a square yard area. Observations of this area for the next three to five minutes after application of this solution to the turfgrass will reveal whether any mole crickets have begun to hatch. Determining the time at which mole crickets first begin to hatch is important for the third component, timely treatment. There are absolutely no above ground indicators of when the eggs are hatching, and there won't be any for about a month after egg hatch. By then, the best opportunity for control has been missed.

TIMELY TREATMENT

There are two factors that affect treatment timing and why their effectiveness is affected by application date. The first, and perhaps the most obvious, is that as the mole crickets grow larger, they're harder to kill. As the crickets grow larger, they becomes hardier and require exposure to a larger dose of insecticide. This is true for many of the insect pests, including surface-feeding insects such as armyworms.

Laboratory tests with choice chambers always demonstrate a tendency for mole crickets and other turfgrass insect pests to avoid soil treated with conventional insecticides and many biological control materials. The chamber with untreated soil on the left has significant tunneling from mole cricket activity while the treated chamber on the right has very little insect activity. Photo: N.C. State University

IMPACT ON THE BUSINESS

Getting bugged down South

BY PAT JONES

I was talking recently with one of those rare superintendents who had relocated from the North to the South. He'd gone from a major club in the Mid-Atlantic to a nice facility in South Carolina as his "retirement job."

I half-jokingly asked if he even had a spray rig anymore. He fired back immediately that he'd trade any disease he ever dealt with up North for the difficult mole cricket infestation he'd inherited at his new place.

As Rick Brandenburg points out in the highly-readable and sensible article above, mole crickets are among the worst of the subsurface feeders that plague golf courses. But, a little common sense goes a long way when dealing with these nasty little critters.

Initial control is all about scouting. As Brandenburg notes, they tend to be homebodies, so mapping areas of frequent infestation over the years is critical. Scouting for early infestation, particularly in mid-summer, is also part of the plan. Find the timing of the hatch, and your work is half-done.

"Get 'em while they're young" is a phrase used in many contexts, but it's particularly true for mole crickets. As Brandenburg explains, the larger and more mature they are, the harder they are to kill.

A 2001 report from IFAS and other sources indicate the following offer control opportunities for mole crickets (check current regulations and restrictions in your area):

- Acephate
- Bifenthrin
- Chlorpyrifos
- Cyfluthrin
- Deltamethrin
- Fipronil
- Imidacloprid
- Lambda-cyhalothrin
- Permethrin
- Steinernema scapterisci
- Trichlorfon

Baits:

- Bifenthrin
- Carbaryl
- Chlorpyrifos
- Indoxacarb

Mole cricket treatments are not inexpensive. They range from $2,000 to $20,000 per year, depending on infestation and the number of holes treated. But, given the potential extent of damage and the difficulty of eliminating established colonies, the return on investment is considerable for treatment.

The battle against mole cricket damage is, quite simply, an ongoing battle.

Timing is everything and chances are you know that timing best. The early application will likely get the mole cricket. GCI

The other less obvious factor is the behavior the insect exhibits in the soil. Certain pests such as mole crickets are mobile in the soil, and the larger they become, the greater their ability to tunnel and move deep in the soil. If the insects are more mobile, then potentially they're moving up and down through the soil profile. This increased movement could expose them to more insecticide if the movements were random. At the same time, if the greater mobility encouraged movement away from the insecticide, then the impact on control might be significant.

Our research during the past 10 years has found that mole crickets try to avoid exposure to insecticides. This is true for virtually every insecticide, even for natural or biological control measures. From a biological or scientific perspective, it's interesting that mole crickets avoid a recently developed synthetic insecticide the same as they do a naturally occurring control agents, such as a fungal pathogen they've been exposed to for eons.

Our research has shown that the mole crickets' ability to detect and avoid a pesticide is consistent and rather dramatic. Mole crickets move deeper into the soil and stay there as long as they can without feeding on turfgrass roots. The larger the cricket (later in the summer), the greater the ability of the mole cricket to tunnel deep into the soil and stay there, avoiding the pesticide for a longer period of time. If the pesticide applied had relatively short residual activity (less than two weeks) the mole crickets might avoid it all together and little, if any, control will result. Treating earlier in the summer, when mole crickets are small, enhances mole-cricket-control performance because mole crickets aren't able to dig as deep or stay away from the insecticide treated soil (the root zone) for as long a period of time. The end result is better control when crickets are smaller.

Additional research shows mole crickets respond in a similar fashion to natural or biological control organisms. Studies using *Beauveria bassiana*, a naturally occurring fungal pathogen of a number of insects, have demonstrated the same avoidance behavior as was observed for synthetic insecticides. These results become increasingly obvious when one considers that natural, organic or biological control products usually don't last as long or have the residual activity of synthetic insecticides.

Is there any question then as to why mole crickets are harder to control once they get more than a half-inch long? We made our job more difficult than it needs to be. Mapping, monitoring and timely applications suddenly take on a whole new meaning. It's easy to see why timely applications make all the difference as to how well an insecticide might or might not work. The importance of treating before the majority of the mole cricket population gets to be a half-inch long can't be overstated.

Turf insect pests such as mole crickets have the ability to detect and avoid naturally ocurring pathogens as much as they do conventional pesticides. Photo: N.C. State University

Similar behavioral responses have been observed in other soil insects such as white grubs. The main difference is that white grubs aren't as mobile as mole crickets, but the concept of timely applications still applies. Keep this in mind as more companies publicize the ability of their products to control white grubs late in the summer. While this is true, maximum control will happen when treatments are applied to the most susceptible stage.

BIOLOGY AND LIFE CYCLES

Understanding pest biology and life cycles are important to cost effective and environmentally sound pest management. There aren't that many soil insects we have to deal with each year, so the

challenge of mapping, monitoring and timely applications shouldn't be too overwhelming.

Even though insects probably don't rank at the top of your list of priorities on a daily basis, the rules of engagement are pretty simple, and there's no excuse for not doing the job correctly. The time, effort and expense of managing turfgrass insects correctly are no more than to do it haphazardly or without a little forethought. The end result, however, is quite different in terms of turfgrass quality and final cost. Get current on the insect pests you have to contend with each season. The time invested will pay huge dividends. GCI

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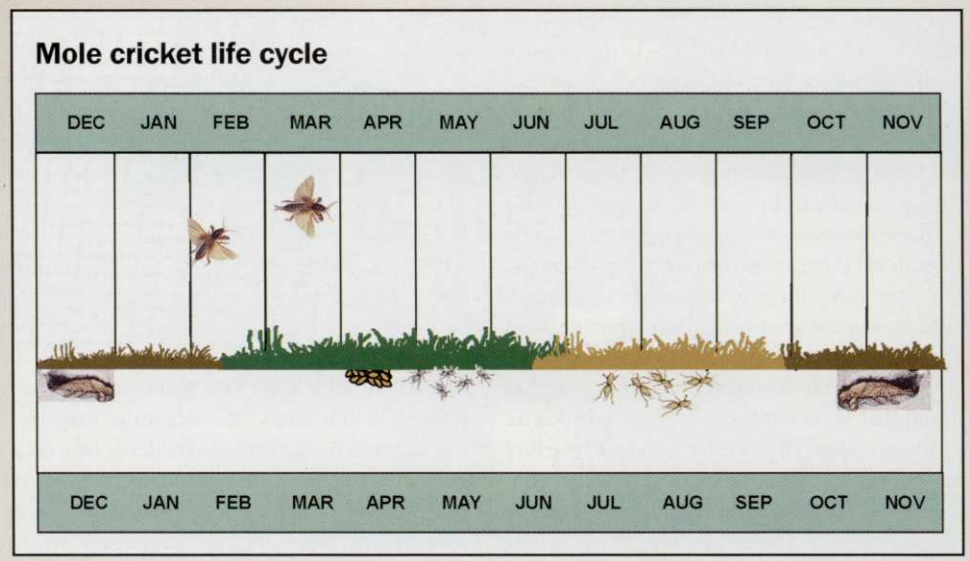

The life cycle of many soil insects allows the small stages of the insect to escape detection in the soil under aggressively growing turfgrass. Image: N.C. State University