Strategies for Insect Control

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Turf managers have been under increasing pressure to reduce their reliance on pesticides. Fortunately there are several alternatives which have been developed in recent years which can be incorporated into a turf management scheme which will reduce the insect pressure or perhaps reduce the stress under which the turf is growing. Normally this results in a decrease in damage caused by pest insects. However, such a management scheme is more complicated or involved than the old "spray and pray" approach, and turf managers must be much more knowledgeable about many more aspects of their turf and the environment surrounding the turf. The following are steps to maximizing the chances for success in managing turf insects.

Identifying the Pest

Most turf managers are familiar with the most common turf pests and can recognize many of them. Some turf insects resemble others but have very different life cycles. Insecticide applications directed toward one probably would not be effective against the other.

For examples, there are many different species of white grubs. The European chafer normally begins to lay eggs about two weeks earlier than Japanese beetles in a given location. In many parts of the country, May beetles have a two or three year life cycle and insecticide applications are only effective during a few fairly brief stretches during that time.

Thresholds of Tolerance

Turf is able to tolerate one or two stresses (low mowing height, nutrient deficiency or too much water) but begins to show visible signs of distress when additional stresses are added. In many cases a small population of insects is present in a stand of healthy, vigorous turf without evidence because the turf is not under other stresses and can outgrow the damage caused by the insects. But the same population of insects in grass which is already under stress could cause visible damage, because the grass is unable to respond quickly enough to mask the insect activity.

One golf course where I have conducted much of my work averaged 30 to 35 Japanese beetle grubs per square foot without showing any signs of weakness. Roots remained healthy and vigorous and the turf did not appear to be in drought stress. That golf course has a virtually unlimited water supply and relatively few rounds of golf per year. In contrast, a nearby public golf course has a limited water supply with 90,000 rounds of golf per year. That golf course experiences noticeable damage (torn up turf, pruned root systems) with as few as 5 grubs per square foot.

The challenge for a turf manager is to begin to determine the tolerance levels (how many insects is too many?) for insects in the turf areas being maintained. The main point to remember is that **tolerance levels are site specific and vary throughout the growing season.**

Several things must be taken into consideration when trying to establish tolerance levels. The **recuperative potential** of the turf varies during the growing season because of seasonal stresses. For example, when the availability of irrigation is limited and turf is under moisture stress, turf is less able to tolerate feeding activity from insects. Similarly if an area has been weakened by disease activity, it will be more vulnerable to insect or weed infestation.

The **species of insect** is often critical. For example, grub for grub, European chafers tend to be more damaging than Japanese beetles, in part because the European chafer is a larger species. In addition, European chafer grubs actively feed in the root zone later in the autumn and return to the root zone earlier in the spring, a longer period than other grubs. Cricket for cricket, tawny mole crickets often are more damaging than southern mole crickets, in part because tawny mole crickets feed directly on turf roots while southern mole crickets feed primarily on other insects.

Another factor which is sometimes overlooked when setting tolerance levels is the **expectations of the customer**. Most turf managers maintain turf for some specific purpose (golf course, athletic field, playground, or home lawn). In each case the "customer" has certain perceptions of what turf should look like. For example, many golfers expect (and virtually demand) nearly perfect conditions on putting greens and would not tolerate any visible evidence of insect activity. The same golfers normally don't expect the same level of perfection in the rough.

Levels of maintenance vary greatly, depending in part on the **budget** of the operation. Tolerance for insect activity will be lower in a highly maintained athletic field. Insect damage often goes unnoticed in a low-budget field.

Finally, sometimes there are excellent "curative" insecticides available for a given insect problem - materials that can be applied after a damaging population develops but still can kill enough of the immature insects to reduce the population back below tolerance levels. A turf manager can delay the treatment decision longer and treat only those areas that are attacked. Unfortunately, when there are no adequate curative insecticides, applications must be made before the insect population has developed fully.

Understanding the Life Cycle

The main reason to set thresholds or tolerance levels is to determine whether a given pest population must be managed (reduced). **All management strategies rely on a solid understanding of the life cycle.** As insects grow and molt, they pass through certain periods of their lives during which they are more vulnerable than others. The key to successful management is targeting the population when most of the individuals are in the most vulnerable stage.

Most insects are particularly susceptible to traditional insecticides when they have just hatched out of the egg. Conversely, the egg and pupa stages essentially are not susceptible to insecticides. So many turf insecticides are most effective when directed toward the insects when they are small larvae or nymphs. (Note that a few turf insect pests, such as annual bluegrass weevils, bluegrass billbugs, and black turfgrass ataenius, are vulnerable in the adult stage and insecticide applications often are directed at that stage.)

Several excellent references are available which outline the basic life cycles of the major turf insect pests, but local conditions can result in significant variations. A turf manager must be aware of those local differences and have a clear understanding of when the adults will be active, when eggs will be laid, and when the immatures (larvae or nymphs) are likely to begin hatching. **The most important aspect of insect management with insecticides is timing of application**, and the optimum timing of application can only occur when the life cycle and local conditions are understood.

Cultural management strategies

In recent years several turfgrass cultivars have been developed which are resistant to particular turf insects. The most notable example is cultivars which contain **endophytes**, fungi that grow within the turf plant and produce materials which are toxic to certain insects. Endophytic cultivars, available in perennial ryegrasses and some of the fescues, can significantly reduce the survival or population density of bluegrass billbugs, hairy chinchbugs, and some webworms. Turf managers who experience damage from these insects and are planning on renovating turf areas should consider using endophytic cultivars whenever possible.

Other forms of plant resistance have been identified and commercialized. Some cultivars of St. Augustinegrass have shown resistance to the southern chinch bug. Some cultivars of Kentucky bluegrass appear to be resistant to billbugs.

Many turf insects have specific grasses which they prefer to attack (for example, ryegrasses and fescues for hairy chinch bugs, St. Augustinegrass for southern chinch bugs, annual bluegrass for annual bluegrass weevils, bermudagrass and bahiagrass for mole crickets, Kentucky bluegrass and fescues for billbugs). A turf manager can renovate an area to reduce the prevalence of a preferred grass and incorporate a less preferred host instead.

Damage from many turf insects is often most severe when it occurs on turf under drought stress. For example, hairy chinch bug activity is greatest on turf growing on sandy (well drained) soils and exposed to sunlight - precisely the conditions which lead to drought stress. Sometimes the simple act of irrigating the vulnerable area enables the turf to recover from insect activity.

If good cultural management practices are followed, turfgrass often can tolerate insect activity without showing damage. **Fertilizer** schedules should reflect the seasonal needs of the plant as well as the specific nutritional requirements. **Raising mowing heights** often reduces stress ("the higher the shoot, the healthier the root") and enables turf to outgrow insect activity. Managing **traffic patterns** to avoid compaction also can reduce stress. **Syringing**, to avoid extremely high temperatures, is another cultural practice which can improve the overall vigor of the turf.

Biological Control Options

There are several biological pesticides available commercially for use on turf. Most of these either bacteria or nematodes which cause disease in certain insects. Many of these biological agents are relatively specific, and thus are unlikely to interfere with the many beneficial insects and other arthropods which occur in turf.

Bacillus thuringiensis (BT) is a bacterium that produces a toxin that paralyzes the digestive system in a target insect. There are several strains of BT, each of which is fairly specific and effects only a limited number of insects.

The "kurstaki" strain is effective against several kinds of caterpillars, including cutworms and webworms, and is available in formulations which are sprayed through traditional hydraulic sprayers. BT is less effective against large caterpillars, so it should be applied when caterpillars are still relatively small.

Entomopathogenic nematodes are small round worms which cause diseases in insects. Several species have been identified and at least three are available commercially. Most of these nematodes are sensitive to desiccation so applications should be made early in the morning or late in the afternoon and should be watered in immediately. *Steinernema carpocapsae* is effective against some caterpillars, and there is evidence that it could be effective against some species of billbugs. Field tests by several researchers suggest that this nematode is not effective against white grubs.

Steinernema riobravis and *Steinernema scapterisci* are two species which are effective against mole crickets. It appears that adult mole crickets are more susceptible to attack than smaller mole crickets, probably because the nematode must find a natural opening large enough to wriggle through to get into the host mole cricket. Field collection of mole crickets suggests that southern mole crickets might be more susceptible to attack than tawny mole crickets.

Researchers are investigating other kinds of biological control, including parasitic wasps and flies and predatory insects. For example, research is underway to determine whether a parasitic wasp which originated in South America can have a measurable effect on annual bluegrass weevils in field conditions. A tachinid fly which also originated in South America has been released in Florida to reduce mole cricket populations, and has become established in several locations.

Chemical Control Options

While cultural management and biological control options exist for many turf insects, the level of expectation of the customer often dictates that a turf manager will have to consider using traditional insecticides to maintain pest populations below tolerance levels.

Windows of Opportunity - Each insect has a period during its life cycle when it is most susceptible to insecticides. Normally this is when the insects have just hatched from eggs to small larvae or nymphs. Some insects and mites (e.g. bermudagrass mite) are only in the vulnerable stage for a short period of time. In such a situation, the material must be a reasonably fast acting product. The key to success is **timing of application**.

Other insects spend more time in the vulnerable stage, so the "window of opportunity" is longer. For insects which complete more than one generation per year, there is often a time during the growing season when all stages (adults, eggs, immatures, and pupae) can be found in a given location. Timing of insecticide applications in this situation seems more complicated. The turf manager must determine when **most** of the insects are most vulnerable and then take action. In some cases, more than one application will be necessary, because the first one will not affect the individuals which were eggs at the time the material was applied.

For many of the **cutworm** species which attack turf, adult flight can be an excellent indicator of the ideal time to apply an insecticide. Guidelines from state specialists usually recommend applying an insecticide 10-21 days after peak adult (moth) flights are observed. (The precise timing depends on the species of cutworm and the local weather conditions.) The peak flight occurs just as females begin to lay eggs, and time should be allowed for those eggs to hatch into caterpillars before an insecticide is applied.

The timing of application for **white grubs** depends in part on the kind of insecticide. White grubs hatch from eggs any time from early July through late August in the Northeast, depending on winter and spring conditions (cool spring temperatures delay beetle flight and egg hatch), species, and soil moisture. So the "window of opportunity" is relatively broad - from late July to early September.

Some insecticides (e.g., Proxol™ or Dylox™) are active against grubs within a few days after they are applied, but break down quickly. Such materials should be used **late** in the "window of opportunity" after most of the grubs have hatched out of eggs but before the early hatchers have begun to cause visible damage. Other insecticides (e.g. Oftanol™) take 10 to 14 days before they are active against grubs, but remain active for several weeks. Such materials should be used **early** in the "window of opportunity" before some of the individuals have hatched from eggs. This is because the turf manager risks incurring some damage if he or she delays the application too long. The longer residual activity of these materials ensures that the material will be active when the late hatchers emerge. If the application is delayed and made late in the "window of opportunity", many of the grubs will already be large enough to cause significant damage before they are killed by the relatively slow material. Most other insecticides on the turf market for grubs are somewhat intermediate - they become active within three to seven days after they are applied and remain active for three to six weeks.

Merit™ should be discussed separately because its use pattern is much different than that of any other insecticide currently available for grub control. Merit™ seems to be effective for at least ten weeks after application (and often considerably longer), so it can be applied to an area in which a damaging grub population is expected long before the grub activity begins. Applications made in May normally remain active against subsequent white grub infestations three or four months later. Such an application is well outside the "window of opportunity" but fits well into the scheduling needs of many turf managers. Note, however, that most turf specialists do not recommend that any single material (whether Merit™ or something else) be used more than two years in a row in a given location, primarily to reduce the chance of resistance by the insect population.

The timing of emergence of **mole crickets** varies widely from North Carolina to southern Florida, where they often complete two generations per year. So generalizations about timing of applications for mole crickets are risky at best. A good approach is to use soapy flushes to determine when small nymphs begin to hatch (often June or July in the Gulf States). Any adults which are flushed to the surface (or are attracted to lights at night or caught in pitfall traps) can be inspected for their reproductive development. When females are about ready to lay eggs, those eggs can be exposed by a careful inspection of the contents of the abdomen. When a significant percent of the females inspected have well developed eggs, soapy flushes should be conducted at least twice a week. As soon as small nymphs are found in the flushes, an insecticide application should be contemplated - at least in areas where the populations exceed the tolerance level.

Soil Insects - Soil insects are often more difficult to manage than surface feeders for several reasons. The insects are "out of sight and out of mind," so sometimes damaging populations develop before a turf manager realizes the insects are present. Because the insects spend much of their time below the thatch, it is more difficult to achieve good contact with an insecticide. Most insecticides are bound to some degree by thatch and much of the active ingredient does not reach the soil/thatch interface where grubs or mole crickets are active.

One of the critical steps in obtaining good control of soil insects like white grubs is to irrigate the treated area immediately after application or apply just before a steady rainfall. The water helps to move some of the active ingredient partway through the thatch, and also induces the grubs to move further into the thatch to take advantage of the improved moisture conditions. The end result is greatly enhanced insecticide/grub contact.

When the soil is unusually dry during the summer and there is barely enough moisture to keep the turf above the wilting point, grubs, mole crickets, and other soil insects often move downward in the soil profile. Some species of white grubs can move vertically as much as 24 inches in 24 hours. Not surprisingly, in these circumstances grubs are much too deep to be affected by any insecticide application made on the surface. The effectiveness of an application can be improved significantly by irrigating the area 24 to 36 hours BEFORE the intended application and irrigating again immediately after the application. Pre-watering increases soil moisture near the surface and induces the grubs to return to the root zone, where they come in contact with the insecticide.

Several field studies have suggested that different formulations of the same active ingredient are equally effective against white grubs. As a rule of thumb, most granular formulations will take a little longer to become active than sprayable formulations of the same active ingredient, but they also will remain active a little longer. So the ultimate choice of a formulation, at least for white grubs, depends on other considerations such as cost, needs and availability of storage space, application equipment, and perceptions of the customer. (Note that many homeowners still seem to think that a granular product is "safer" than a sprayable material.)

Sub-Surface Applications - Sub-surface application is a relatively new application technology that can enhance the performance of insecticides against soil insects. The concept is simple - if an insecticide can be placed directly at the soil/thatch interface, where white grubs and mole crickets tend to be most active, it should be much more effective than a traditional surface application.

One sub-surface technology uses **high pressure liquid injection** to drive sprayable formulations through the thatch. Some equipment uses pulsed injection, similar to that used with the Toro Hydroject liquid aerifier, and generates pressures up to 5,000 pounds per square inch. Other equipment uses steady (constant) stream injection, with a range of pressures up to 4,000 pounds per square inch.

Each system uses nozzles with tiny orifices placed on a drag bar which travels on the ground and directs the spray straight into the turf. The depth of penetration depends on the orifice size (smaller openings normally lead to greater penetration), pressure, ground speed, and density and thickness of thatch. The main concern is to avoid the temptation to "crank the unit up" and deliver the insecticide below the soil/thatch interface. Most high pressure units merely dent the turf so the surface is playable immediately after the application has been completed.

Another sub-surface technology uses slicing to produce slits in the turf, into which granular or liquid formulations can be deposited. These units vary widely, with many different techniques for cutting the slit and pulling the turf back over the slit as the unit passes. Some units are quite "tidy" and leave little evidence after the application, while others are quite disruptive to the turf surface. Sub-surface slicing does not have the inherit risks associated with high pressure injection (e.g., bursting hoses) Adjusting the depth of penetration is usually simple. In addition, slicing enables a turf manager to apply virtually any insecticide, regardless of formulation, and opens up opportunities to apply some of the biopesticides (bacteria, nematodes) that would benefit by being placed directly at the soil/thatch interface. Entomopathogenic nematodes which are applied through a high pressure injection system are not recognizable, and certainly are not viable, when they emerge from the business end of the unit!

Field trials conducted throughout the country (Dr. Pat Cobb in Alabama, Dr. Fred Baxendale in Nebraska, Dr. Dave Shetlar in Ohio, Dr. Pat Vittum in Massachusetts, among others) have demonstrated that sub-surface application has numerous advantages:

1. In some instances, the rate of application can be reduced (up to 50%) compared to surface application without any reduction in the level of control.
2. Surface residues of most insecticides are reduced 50 to 80% when applied sub-surface (Vittum, unpublished data).
3. The material is placed below the surface, so it is not broken down by sunlight as rapidly as a surface application.
4. The likelihood for run-off is reduced.
5. Some materials, such as fipronil (Chipco Choice™), are registered for use only when applied sub-surface.

One of the drawbacks of sub-surface application is that the current equipment is very specific and cannot be used for anything but sub-surface applications. Therefore, the equipment must be dedicated to a limited number of jobs (perhaps application of insecticides against soil insects, some fertilizer applications) and might not be cost effective for most turf managers. In the Southeast, a few companies have bought equipment and made sub-surface applications on a contract basis. The same approach has been initiated in the Northeast but has not been embraced nearly as widely yet.

Surface and Thatch Insects - While turf managers notice surface insects (cutworms, webworms, armyworms, bermudagrass mites) or thatch insects (chinch bugs, billbugs, leather jackets) more quickly than soil insects, managing them can still be challenging. Some of these insects have shorter development times and can complete several generations per year, particularly in warmer regions of the United States. As a result, populations can build up rapidly. Generations often overlap so that some individuals are in susceptible stages (small larvae or nymphs) while others are not vulnerable (eggs or pupae). This overlap makes it very difficult to time insecticide applications because there often is a substantial portion of the population in a non-vulnerable stage. Turf managers must try to determine when the majority of the population will be in a vulnerable stage and time an application accordingly.

For most surface and thatch insects, an insecticide application should not be watered in very heavily, but some water should be applied (either through irrigation or rain) shortly after the application to move the material off the tips of the grass blades and into the thatch. As with any insecticide application, check the pH of the water in the tank and use an additive if the pH is higher than 8 to guard against alkaline hydrolysis.

Some insecticides (e.g., Dursban™) are bound in the thatch more readily than others. While such insecticides usually are not appropriate against soil insects (because the material never gets to the soil), they are often excellent materials to use against surface and thatch feeders because they stay in the thatch, precisely where the target insects are. Some insecticides (e.g., Proxol™ or Dylox™) are highly soluble and pass through the thatch much more quickly than others. Such materials would not be as desirable for control of thatch insects because they move through the target zone too quickly.

The **formulation** of an active ingredient may play a greater role in determining the effectiveness of an insecticide when the material is directed toward surface or thatch feeders. Some researchers believe that pre-watering an area, applying a granular product, and then lightly watering the area will provide good coverage, and that the "bulk" of the granule helps to keep the active ingredient in the target zone. Others believe that sprayable formulations are more likely to achieve good contact with the blades and stems and provide a better level of control. Field trials appear to be inconclusive.

Final Thoughts

Even though turf managers are always trying to provide optimum growing conditions for the turf, that effort must be increased if an insect population approaches the level that will cause damage. While there are several biological control options available commercially and more under development, most managers of highly maintained turf still must rely on traditional insecticides to reduce insect populations. The main key to successful management of those populations is **TIMING** - an application must be made when the bulk of the population is vulnerable, or else the manager is wasting time and money.

The rest - selecting a suitable insecticide (speed of action, residual activity, movement in thatch, chemical class, formulation), deciding on a method of application (traditional surface application or new subsurface application), and arranging for pre- or post- application water - is, to a certain extent, peripheral.

So build up that reference library and start keeping files of information on different insects so you know what to expect - and when you should be prepared to take action.

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TurfGrass TRENDS is published monthly. ISSN 1076-7207.

Subscription rates: One year, $180 (US) $210 (all other countries.)

Postmaster: Send address changes to TurfGrass TRENDS, 131 West First St., Duluth, MN 55802-2065.

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