A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

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TURFGRASS ENTOMOLOGY

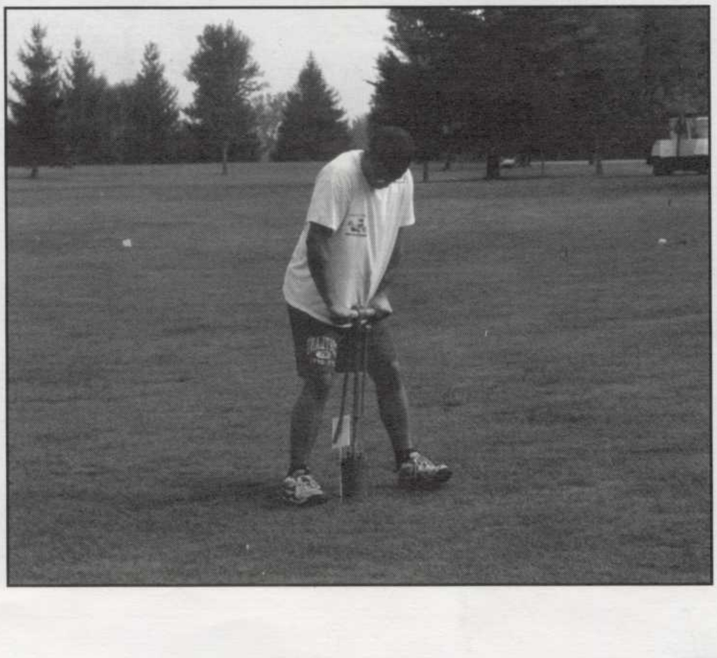
Sampling Grubs on Golf Courses:
Mapping and Predicting Populations

Michael G. Villani, Ph.D.

Among the most damaging turf insect pests in northeastern United States are white grubs, the immature forms of several different scarab beetles species. White grubs feed on turfgrass roots and can cause serious damage to both residential and golf course turf when populations are high.

Within this group, commonly referred to as the white grub complex, Japanese beetle (*Popilla japonica*) grubs are one of the most important turf insect pests in central New York. Additionally, the grubs of European chafer (*Rhizotrogus majalis*) and Black Turfgrass ataenius (*Ataenius spretulus*) can also cause extensive damage to golf course turf in central New York, but the damage from these two scarab species tends to be less widespread and less consistent than damage from Japanese beetle grubs. Both the Japanese beetle and the European chafer have a lifecycle consisting of one generation per year, while the Black Turfgrass ataenius has two generations per year in New York State.

Crewmember samples for grubs on a golf course fairway.



IN THIS ISSUE

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Grub control past and present

Historically, chlorinated hydrocarbon insecticides, like Chlordane, were used to control Japanese beetle and European chafer grubs in turf. These products were relatively inexpensive and highly effective on a broad spectrum of grub species when first introduced, and remained active in the soil for several years.

Because of their extended residual properties and the breadth of their control, turfgrass managers could apply these chemicals at any time during the year with little regard for identifying the targeted species or the growth stage the species were in. They could be confident that the insecticide would remain active to control grubs for several years.

The chlorinated hydrocarbon insecticides were lost as a tool for grub control in the late 1960s and early 1970s due to rapid development of insect resistance and EPA's concerns about human health and environmental effects.

The chlorinated hydrocarbon soil insecticides were replaced by a group of much shorter residual organophosphate and carbamate insecticides whose breadth of control was more species specific and whose effective soil life ranged from several days to a few months. This dramatic change in efficacy, spectrum of control and residual has placed a premium on knowing which scarab species is causing problems and what, when, and how to apply these insecticides.

Strategies for short-residual soil insecticides

In general, turfgrass managers have traditionally taken two different approaches to

How to Recognize the Japanese Beetle

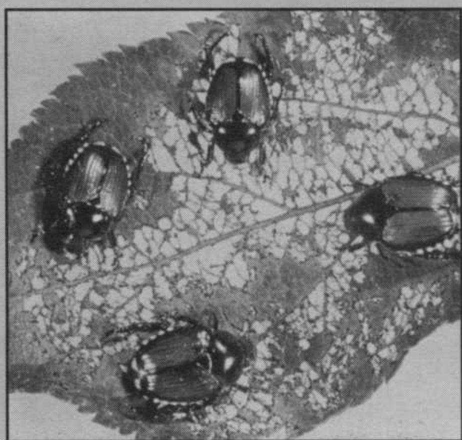
Japanese Beetle *(Popilla japonica)*

Range: All states east of the Mississippi River except Louisiana, plus Nebraska and Kansas.

Hosts: Most cool- and warm-season grasses.

Site Damage Symptoms: Areas of wilting turf in full sun even under irrigation or adequate rainfall. In mixed stands, fine fescues and annual bluegrass usually show damage first with bluegrasses next. Ryegrasses and tall fescues are last to show damage.

Plant Symptoms: Browned or wilted turf shows no signs of obvious insect feeding, but can easily be easily pulled up.



Japanese beetle

Sites Vulnerable to Infestation: Areas of full sun or that have greater than 60 percent sunlight and have consistent soil moisture and sandy or loamy soil texture.

Life Cycle: Grubs overwinter as larva deep down in the soil to avoid cold winter temperatures. As soils warm in spring, they move back up and resume feeding near the soil surface. In mid- to late May, larva pupate to emerge as adults in late June to early July. Mating occurs over several weeks with eggs being deposited in turf areas which are neither too wet nor too dry. The eggs hatch and grubs and start feeding in early August. They actively feed and molt twice over the next 10 to 12 weeks, before cooler soil temperatures force them down in the soil profile to overwinter.

managing grubs in turf when using short residual control products - curative and preventative.

The ***curative approach*** is to wait until the first signs of grub damage are obvious in early fall and then treat the damaged areas curatively. Signs of grub damage include direct damage to the turf from grub feeding (i.e., areas of turf in apparent water stress even under irrigation) or, more commonly, damage from skunks, raccoons, and birds digging for grubs and dislodging turf in the process. This approach has a benefit in that it tends to limit the total area treated with insecticides. But, treatment at this time often provides less than satisfactory control because the insecticide is applied to larger, more resistant grubs just prior to their migration down into the soil to escape winter temperatures at the soil surface. (The best time to apply a curative grub treatment is when the grubs are small.) In addition, the cost of repairing the dislodged turf and waiting for symptoms to appear has its downside.

Alternatively, the ***preventive approach*** uses short-residual insecticides applied before grub damage is obvious, usually in early to midsummer in central New York. Such applications are often successful when label instructions are followed because the smaller grubs are feeding near the surface where they come in contact with the insecticide.

Furthermore, this early treatment strategy allows for an extended overlap of the insecticide's residual and grub population feeding, prior to the grubs moving down into the profile for the winter.

The acceptance and use of new insecticides has led to a shift in research from mapping existing populations of grubs for spot treatment to predicting their location and intensity for accurate treatment.

However, since there are few early symptoms of feeding activity, it is often difficult to determine just what areas to treat using this approach. Some risk-adverse turf managers simply treat "wall-to-wall," applying insecticide to all turf as insurance against grub damage.

This approach can be very expensive as the newest grub controls are often three to five times more expensive than the

How to Recognize the European Chafer

European chafer
(Rhizotrogus majalis)

Range: Northeast states minus Vermont and Maine plus Ohio and Michigan.

Hosts: Most cool season grasses.

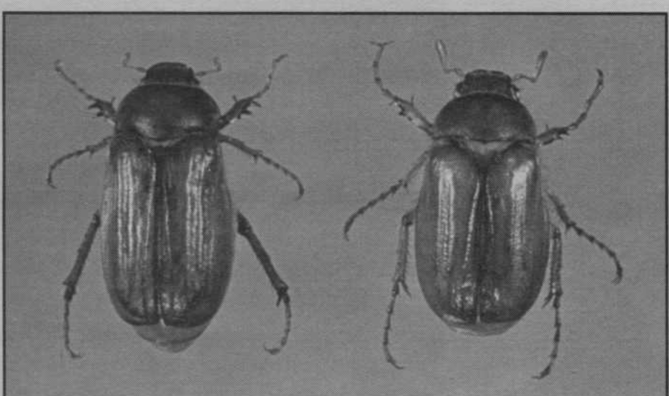
Site Damage Symptoms: Areas of wilting turf under heat stress even with irrigation or adequate rainfall. Areas that dry out occasionally are first to show damage.

Plant Symptoms: Browned or wilted turf that can be easily pulled up and that show extensive root damage.

Sites Vulnerable to Infestation: Areas of full sun or areas that have greater than 60% sunlight and have consistent soil moisture early in the summer. Low maintenance areas or areas near trees, vertical surfaces, or nighttime illumination most vulnerable.

Life Cycle: Grubs overwinter as larva down in the soil. They feed actively and stop only when the soil freezes. In the spring or during warmer winter spells, they move back up and feed near the soil surface. Adults emerge in mid-June to early July to mate in trees or near nighttime lights. Females deposit their eggs in turf areas that are near mating location. The eggs hatch and grubs start feeding in early August. They feed and molt twice over the next several months until the ground freezes.

European chafer



How to Recognize the Black Turfgrass Ataenius

Black Turfgrass Ataenius
(Ataenius spretulus)

Range: Northeast and mid-Atlantic states plus Tennessee, North Carolina, Missouri, and Iowa. Also West except Wyoming and Colorado.

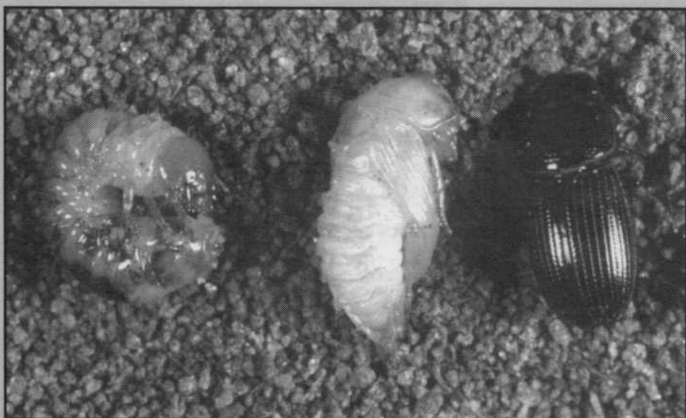
Hosts: Bentgrasses, annual bluegrass and ryegrass

Site Damage Symptoms: Areas of wilting turf in late spring to early summer in spite of irrigation or adequate rainfall.

Plant Symptoms: Browned or wilted turf shows no signs of obvious insect feeding, but plants can be easily pulled up with a minimum of effort and show extensive damage to root structures at the plant/soil interface.

Sites Vulnerable to Infestation: Tees, greens, fairways, sports facilities or areas with high soil organic matter levels.

Life Cycle: Ataenius overwinter as adults (~ one four inch long). In the spring, usually February through late April, they can be seen swarming on the surface of vulnerable turf sites. During the next several months, they hatch, feed, molt through three instars, pupate and emerge as adults to start the cycle anew. In areas with longer growing seasons more than one generation may occur. It has been reported that as many as seven generations per year can occur in areas of southern California and the desert Southwest.



Black turfgrass aetenius. Left to right: larvae, pupae, adult.

organophosphates of 10 to 15 years ago.

The more adventurous managers or those with smaller chemical budgets will spot treat selected areas of turf based upon experience, intuition or historical patterns of damage. This can save money in the short run, but picking the wrong areas to treat or the wrong control product can prove more expensive and troublesome to repair than to blanket treat early in the season.

Mapping and sampling grub populations

The apparent conundrum of balancing application and restoration costs versus damage has led to an increasing interest in the mapping of grub populations as a simple, cost effective and risk-free approach to determine which turf areas have grub populations high enough to require the application of short residual organophosphate or carbamate insecticides.

Mapping is the process of scouting vulnerable turf areas to locate, identify and count the number of grubs found in that area. Ideally, the best time to look for beetle grubs in the soil is usually in mid summer. At this time most grubs have hatched and, though they are usually small, they can be easily seen and identified. The early detection of heavy grub populations at this time will give managers adequate time to treat the grubs before they grow larger and more resistant or they begin to move down into the soil profile.

Systematic grub sampling is used to determine where the highest grub populations are found, which grub species are the most common, and the predominant developmental stage, or instar, of the grubs.

Systematic sampling can provide addi-

The Economics of Systematic Sampling and Mapping

Jennifer Grant, working with the New York State IPM Program, sampled and mapped 36 golf courses in Central New York for Japanese beetle and European chafer grubs each fall over a four-year period.

How sampling was done — Each fairway was sampled using a standard cup cutter. Four cores were taken equidistant across the width of a fairway at 30-yard intervals with sampling skewed toward the roughs on the wider fairways. The sampling team consisted of three to ten people, all trained to recognize grubs and larval stages and one or more persons capable of species identification.

Each six-inch-deep sample was broken apart working on a cardboard or wooden piece; the grubs were counted and identified; and the soil and turf were replaced and pressed back down. The findings were logged on a map or in a table along with their approximate location on the fairway.

By carefully monitoring the total time it took to map the golf courses, Jennifer determined that it took an average of two labor hours to sample and map a typical hole, or 36 hours to map a typical 18-hole golf course.

Using site conditions to predetermine areas to sample — Sampling was done on 300 home lawns in the Rochester area for Japanese beetle and European Chafer grubs. Researchers concluded that there were three factors that affected the level of damage that occurred from grub activity - shade, turf species, and age of the turf.

Any turf area that has direct sunlight for less than 60% of the day is less likely to have a significant grub population. Fine fescues or fine fescue and bluegrass mixtures were the most likely to harbor damaging grub populations. Older, established turf stands were less likely to have damaging grub populations than younger stands.

Cost comparison — Using the time estimates for sampling and mapping a typical golf course of approximately 36 labor hours, the annual cost of sampling would be $180 if workers were paid $5.00 an hour, $252 if they were paid $7.00 an hour, or $360 if they earned $10.00 an hour.

Contrast these estimated costs against the estimated cost of grub control insecticides. The cost for treating 25 acres of fairway turf could range from $1825-$3684, while treating 60 acres could cost between $4380-$8842 using standard grub insecticides. The cost of the newest grub control materials is higher.

Results of implementing grub sampling — During the four years of this study, systematic grub sampling and mapping allowed 17 golf courses to avoid grub insecticide treatments altogether, 16 golf courses to use spot treatments when required, and only three golf courses required treatments on all fairways.

Depending on the size of the courses involved and their previous grub control strategies, the total cost savings over the four-year period for the 17 no-treatment courses alone was well over $100,000. Based on these estimates, the cost of annual systematic sampling and mapping compares quite favorably. All our research to date has pointed to the fact that decisions based upon current conditions are almost always less costly and produce better results than those based on past practices, history or convenience.

The average reduction in pesticide applications for those courses that implemented IPM practices, such as grub sampling and mapping, has averaged 52%, while overall course quality went up. Making control decisions based on a system that provides managers with the most current information possible is always best.

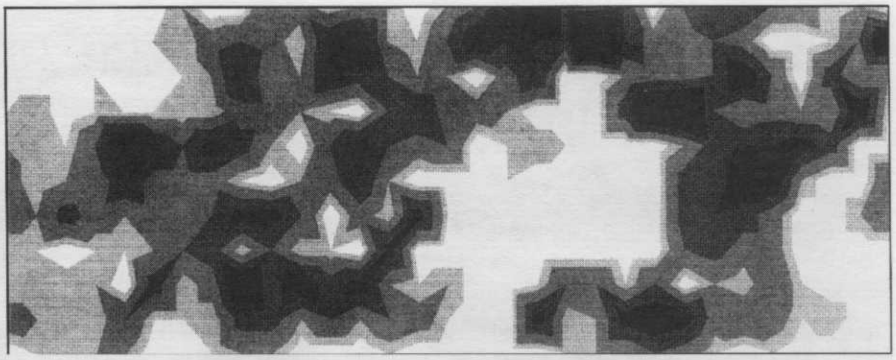


Figure 1. Cumulative Japanese beetle grub counts from Fairway 12 at Tuscarora Golf Course. Darkest shading represents 12-14 grubs per sample to no grubs per sample (lightest shading) from 1995 to 1998.

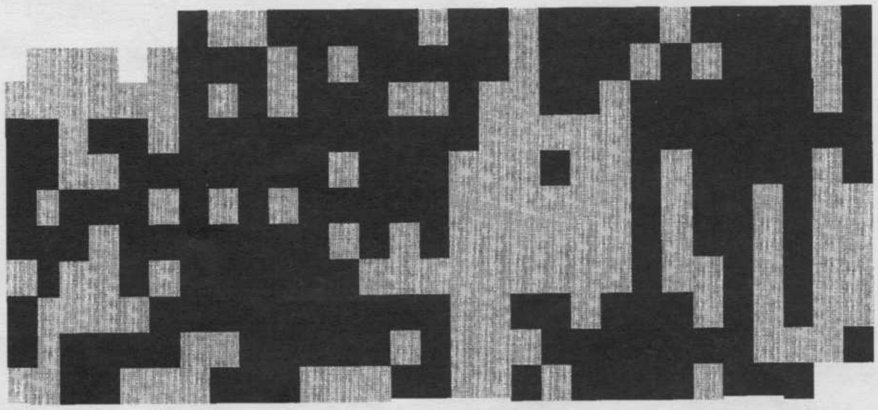


Figure 2a. Summary of the presence of Japanese beetle grubs from 1995 to 1997.

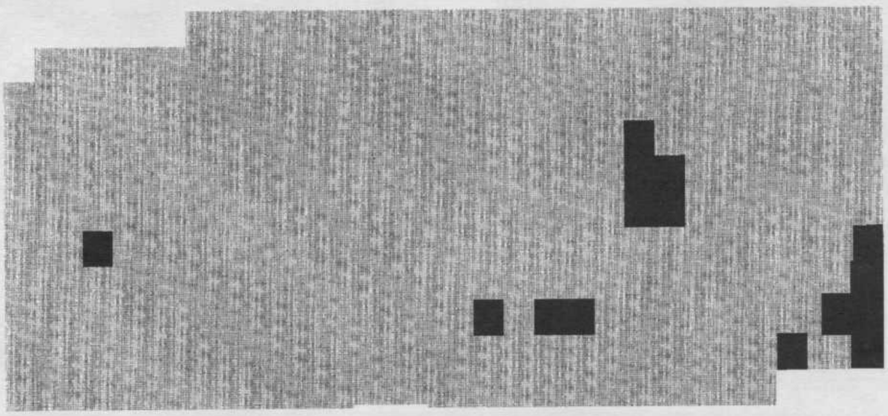


Figure 2b. Summary of the presence of black turfgrass ataenius grubs from 1995 to 1997.

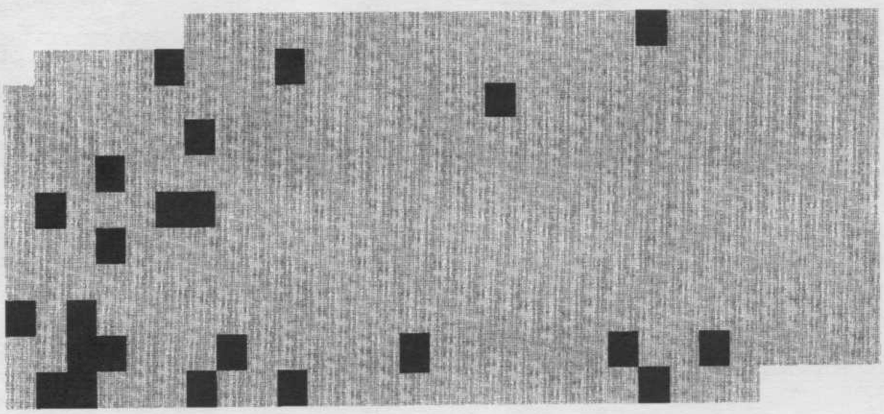


Figure 2c. Summary of the presence of European chafer grubs from 1995 to 1997.

tional short-term benefits by indicating if a large number of the grubs are infected with natural bacterial or fungal pathogens; the condition, size and health of turf's root system; the depth, density and condition of thatch; and the texture, compaction and moisture levels of the soil.

The longer-term benefits of systematic sampling are the identification of susceptible or favorable turf areas, the development of action or no treatment thresholds, and treatment efficacy when undertaken before and after the application of an insecticide.

Determining thresholds

Just as when sampling is not used to determine treatment scheduling, personal and site usage values should be incorporated in setting up control action and treatment thresholds. The population tolerance level (no action taken) or the action threshold (a population level that triggers a control action) are often very site-specific and depend on many factors:

- pest species or complex found
- pest population and developmental stage found
- turfgrass speciesand cultivar managed
- current and future turf use
- turf vigor, time of year, quality
- curative control options available
- budget

A population of a specific species of white grubs (i.e., 10 - 12 Japanese beetle grubs per square foot) may not trigger an action in a naturally wetter, low-use turf area, when a much smaller number (5 - 7 per square foot) in a high use, dryer area would.

Additionally, some managed turfgrass species, like high endophyte ryegrass and tall fescue varieties, seem to be able to tolerate higher grub population levels with little or no apparent damage.

A new focus with the newest control products

Sampling and mapping existing populations of scarab grubs is an ideal strategy when used in conjunction with the application of short-residual insecticides to areas heavily infested with grubs. However, the newest generation of scarab insecticides (such as imidacloprid) and the insect growth regulators (such as Mach 2) are more efficacious when they are applied as a preventative rather than a curative treatment.

The best results with these products are achieved when they are applied at, or just prior to, grub egg hatch. In other words, before managers can map a current year's grub population in the field.

The rapid acceptance and extensive use of these products by turf managers has led to a major shift in the focus of our research efforts from mapping existing populations of grubs for spot treatment to predicting where (and at what level of intensity) grub populations will occur.

Although damage thresholds can be fairly arbitrary for scarab grubs in turfgrass, our historical understanding of the activity of the three targeted species we are focusing on make the commonly accepted and published control action thresholds fairly high:

- European chafer, 7-10 grubs/sq.ft.
- Japanese beetle, 10-15 grubs/sq.ft.
- Black turfgrass ataenius, 50-200 grubs/sq.ft.

Because of these widely published action thresholds, providing turf managers with an accurate understanding of environmental and site conditions most likely to harbor high levels of each grub species would help them anticipate which species to expect different sites based upon conditions.

Since turf managers rarely take the time to identify scarab species, and because small grubs can be difficult to identify to species, the mapping studies undertaken here are intended to improve the use of control action thresholds on golf course turf by identifying the conditions and locations of potential threshold populations of each species.

Since turf managers rarely take the time to identify scarab species and small grubs can be difficult to identify, mapping will improve the use of control action thresholds on golf course turf by identifying the conditions and locations of likely threshold populations of each species

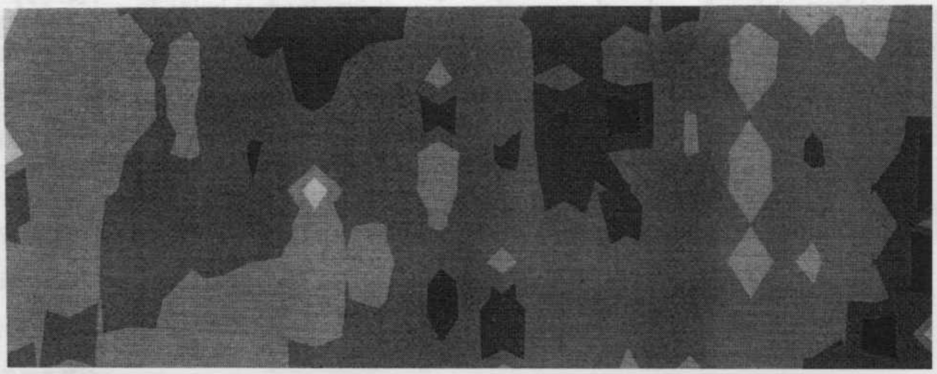


Figure 3a. Percent organic matter is soil on Fairway 12. Shading represents organic matter levels from 16 percent (darkest) to two percent.

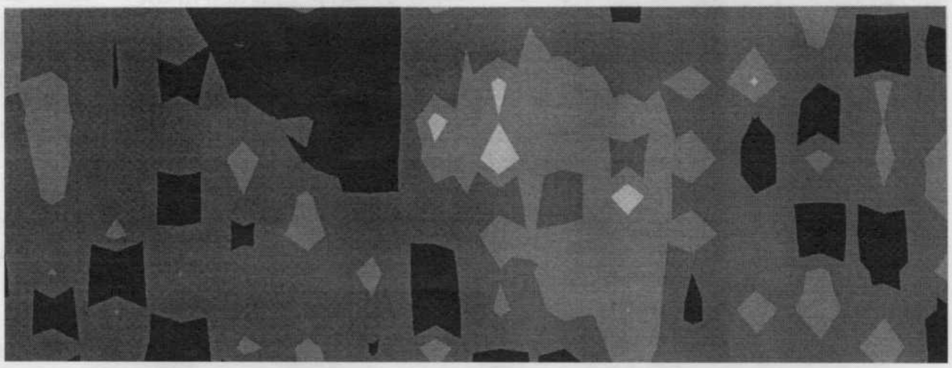


Figure 3b. Percent clay content of soil on Fairway 12. Shading represents clay content from more than 25 percent (darkest) to less than five percent.

Mapping procedures used in this study

The population densities of Japanese beetle, European chafer and black turfgrass ataenius grubs were sampled on 10 fairways by locating a grid on each fairway. A four-inch diameter plug cutter was used to remove a 6-inch-deep core of soil and turf from each grid node from which larvae were counted.

In 1995, grid points were located at 15-foot intervals across fairways and at 45-foot intervals along fairways. In 1996, 1997 and 1998 samples were collected at the same grid points and from additional points midway between the 45-foot intervals. The increased sampling intensity was undertaken to evaluate the precision of the generated maps with twice as many samples. This intensive sampling of fairways and roughs from 1995 through 1998 allowed us to map the location of Japanese beetle, European chafer, and black turfgrass ataenius grubs.

Figure 1 gives a graphic representation of the total number of Japanese beetle grubs on the 12th fairway and rough of the Tuscarora Golf Club (Camillus, NY) from 1995 through 1998. White areas indicate 0 Japanese beetle grubs. The shading intensity increases as grub numbers increase. The regions with the darkest shades of gray have cumulative grub counts greater than 150 grubs/sq.ft.

Figure 2 provides a summary of the location of the three grub species over the three years of the survey without regard to absolute population numbers at each site (a "presence or absence" map). What is obvious from Figure 2 is that there are clear differences in where we find the various grub species on this fairway. The European chafer grubs are found predominately in the rough areas, the Japanese beetles are found mostly on fairways, and the black turfgrass ataenius grubs appear to be in sites not occupied by the other two species.

As part of this study, the site characteristics of soil texture, organic matter, vegetation and slope were also taken. Figure 3 shows the percent organic matter and percent clay content found in soil samples collected from the 12th fairway and rough of the Tuscarora Golf Club in 1998. During July 1996, 1997 and 1998 the spatial pattern of adult Japanese beetles was estimated at each fairway. This was done by mapping each woody or upright herbaceous plant or groups of plants around the border of the fairway and then rating the size of the plant(s) as well as the abundance of adult's beetles on the plant(s).

Conclusions of the grub study

Based on these studies and information found in the research and extension literature, the following generalizations can be made.

Preferences of Japanese Beetles

Japanese beetle adults crawl out of the ground in late June and early July and fly to find food sources and mating partners. Although they can fly as much as a half a mile a day, Japanese beetles females tend to prefer well managed irrigated turfgrass that is close to vegetation suitable for adult feeding — they feed on the foliage of over 300 different species of plants. The beetles mate, and the females are ready to lay as many as 20 mature eggs about one week after emergence. In many cases, females lay a high number of eggs close to the turf from which they emerged.

Laboratory studies have documented that Japanese beetle females will discriminate among oviposition (egg laying) sites differing in soil texture, soil moisture, and percent organic matter.

Shade and Soil – Interestingly, we found very few Japanese beetle grubs directly under trees, possibly because adult beetles seem to prefer areas in full sun rather than heavy shade leading to lower oviposition under trees (see Figure 4). A second possibility might be that Japanese beetle grubs have high mortality in shaded areas with poor turf quality.

Japanese beetle females did not lay eggs in completely dry soils. As soil particle size increased, soil moisture requirements for oviposition decreased.

Soil texture and organic matter analysis suggests that highest Japanese beetle grub populations are found in sites with loamy textured soils with moderate levels of organic matter. Eggs and young grubs are sensitive to temperature and moisture extremes. Under extreme environmental conditions eggs will not hatch and young grubs will not survive.

The ideal soil for egg laying appears to be one that is well drained, non-compacted and loamy. Such a soil does not flood in rainy periods nor dry completely during drought.

Japanese beetle grubs are also found in higher numbers in the irrigated fairways rather than unirrigated roughs perhaps due to improved turf quality.

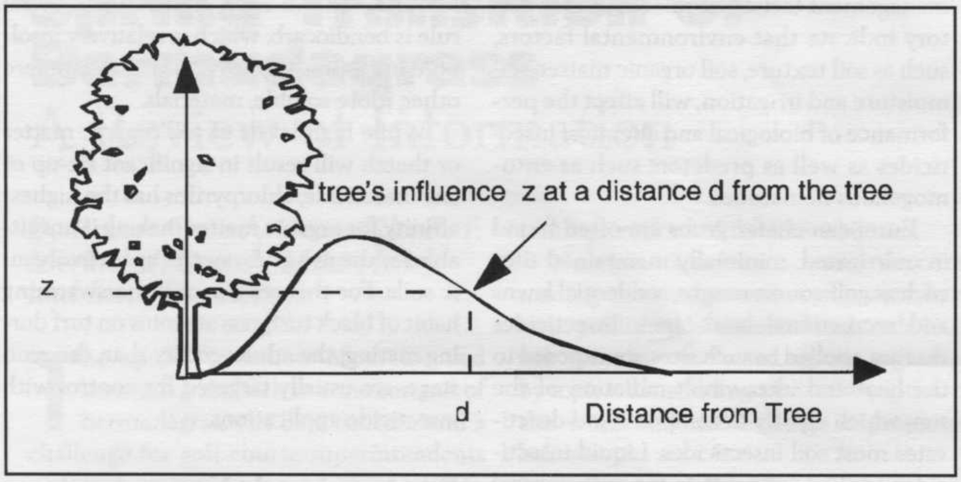


Figure 4. The influence of a host plant of Japanese beetle adults on the probable distribution of grubs at various distances from the tree. Very few grubs are found directly under the tree crown, due partle to heavy shading. Grub densities decrease as the distance from the tree increases. Unfavorable soil factors will alter this pattern.

Preferences of Other Grubs

European chafer and black turfgrass ataenius grubs were found in much lower numbers than were Japanese beetle grubs in Tuscarora. In comparison to Japanese beetles, **European chafer** grubs were found in lower maintenance turf sites without irrigation and with sandy, well-drained soil textures.

The European chafer grubs are also commonly found surrounding small trees that serve as aggregation sites for mating pairs. European chafer adults usually emerge slightly earlier in the spring than Japanese beetles emerging at dusk and attracted to lights and vertical objects in the landscape, often forming large swarms around small trees.

Adult European chafers do not feed, staying above ground just long enough to mate. Mating pairs of European chafers fall from the trees and crawl back into the turf where females lay several dozen eggs over several days.

Black turfgrass ataenius grubs are found almost exclusively on high organic and turfgrass with heavy thatch.

It is possible that the use of organic amendments may increase the likelihood of black turfgrass ataenius populations.

It is possible that the environmental conditions preferred by the different grub species may also affect the performance of management tactics. Studies in our laboratory indicate that environmental factors, such as soil texture, soil organic matter, soil moisture and irrigation, will affect the performance of biological and chemical insecticides as well as predators such as entomogenous nematodes.

European chafer grubs are often found in unirrigated, minimally maintained sites such as golf course roughs, residential lawns and recreational landscapes. Insecticides that are applied to such sites are exposed to the heat and ultra-violet radiation of the sun, which rapidly decomposes and deactivates most soil insecticides. Liquid insecticides applied to turfgrass for grub control must be washed off the grass blades, stems and crowns before they have the opportunity to dry. Granular insecticides must also be watered soon after application to wash the active ingredient from the carrier (clay or corncob particles) down to the lower thatch in the turfgrass-soil profile. *For this reason, irrigation is essential for maximum soil insecticide activity against white grubs.* The lack of timely irrigation can contribute to difficulty in controlling European chafer grubs in the field.

High Organic Matter – Although the overall populations of black turfgrass ataenius grubs were low in our sampling sites (1995 through 1997), those grubs that we found occurred in areas of dense thatch and in soils with high organic matter. This high organic matter soil condition can pose additional problems for grub control. Heavy dense organic matter layers (i.e., thick thatch) can physically prevent the movement of insecticides to the soil surface. Additionally, the organic matter in the soil itself may adsorb insecticides, further restricting the downward movement of insecticides.

Modern soil insecticides must move through the thatch zone rapidly to be effective because of their short residual activity (often less than one month). In general, those insecticides that are least water-soluble (i.e., chlorpyrifos) have the greater chance of being bound to thatch while more soluble materials (i.e., trichlorfon) are less affected. An exception to this general rule is bendiocarb, which is relatively insoluble but is less sensitive to thatch than are other, more soluble, materials.

While high levels of soil organic matter or thatch will result in significant tie-up of any insecticide, chlorpyrifos has the highest affinity for organic matter making it unsuitable for use as a grub control agent in organic soils. For this reason, and the swarming habit of black turfgrass ataenius on turf during mating, the adults, rather than the grub stage, are usually targeted for control with insecticide applications.

Recommendations

Even if turf managers are using older shorter-residual organophosphate and carbamate insecticides, systematic sampling of vulnerable areas for targeting control is still a very viable alternative to blanket "wall-to-wall" applications of grub control.

This technique, along with information developed in our earlier research (see "The Economics of Scouting") can provide managers with the accurate information about grub populations, species and growth stages needed to make more precise control decisions. Systematic sampling can also provide additional information regarding the condition, size and health of turf root systems; thatch depth and density; soil texture, compaction and moisture levels; and many other valuable inputs in the overall management process.

For managers who have embraced the newest grub control materials, knowing the site conditions of vulnerable areas, combined with specific information about scarab grub activity tendencies, can help ensure the efficacious use of these materials.

M. G. Villani is an entomologist with Cornell University in Ithaca, NY.

Keep the following basic information regarding scarab beetle grubs in mind even if you don't have the resources to carry out sampling and mapping practices:

- Well managed, irrigated locations near vulnerable vegetation will tend to harbor Japanese beetle grubs, often at very high populations.
- Dryer, low-maintenance locations near vertical surfaces or sources of nightime illumination will tend to harbor European chafer populations.
- High organic content or heavily thatched soils will tend to harbor populations of black turfgrass ataenius.

LITERATURE REVIEW

Spring Transition of Bermudagrass

A Review of Information

By Robert Green[1], Grant Klein[1], F. Merino[1], J. Evans[1], Mike Henry[2] and Steve Cockerham[1].

The spring transition of overseeded bermudagrass back to a monostand of bermudagrass can be a concern and a challenge for golf course superintendents and turfgrass managers of sports fields, parks and other turfgrass areas in southern California. Spring transition is a common concern of turfgrass managers across the southern regions of the United States.

Numerous articles concerning the overseeding of warm-season turfgrasses have been published in technical and trade journals. A review of selected reports, organized by topic and including a brief description of the work and the findings is presented below.

Importance of Healthy Bermudagrass

A strong, healthy bermudagrass is essential for a rapid spring transition. Healthy rhizomes, roots and bud tissue associated with the crown are characteristic of a healthy bermudagrass prior to spring growth. Freezing, traffic and extremely low mowing heights are examples of the many factors attributed to plant stress which can result in weak bermudagrass prior to spring growth. (It should be noted that freezing stress may not be a dominant plant stress factor in southern California.)

Maintaining a strong, healthy bermudagrass in late summer and fall is recommended to help provide for a strong, healthy bermudagrass in the following spring. Recommendations for maintaining a strong, healthy bermudagrass in the fall normally involve good nutrition, higher heights of cut and the least disruptive renovation practices.

Horgan B. and F. Yelverton (North Carolina State Univ.) 1997. Removal of Perennial Ryegrass From Overseeded Bermudagrass. Agron. Abstr. 89:123.

Description: Bermudagrass plots maintained at a 0.75-inch mowing height were overseeded with perennial ryegrass. Spring-applied cultural and chemical treatments were evaluated for the removal of overseeded perennial ryegrass.

Findings: Cultural treatments (which included vertical mowing, scalping, vertical mowing plus scalping, and core cultivation) did not affect bermudagrass transition. Environmental conditions (high air temperatures and high relative humidity) were the determining factors in removing the overseeded turfgrass. Results from the chemical treatments indicated that Kerb applied in mid-spring or early summer provided excellent perennial ryegrass removal and transition.

Bruneau, A., J. DiPaola, W. Lewis, W. Gilbert, and L. Lucas (North Carolina State Univ.) 1985. Overseeding Bermudagrass Turf. North Carolina Extension Serv. AG-352.

Description: General article concerning the overseeding of bermudagrass.

Findings: Recommends the spring management practices of reducing mowing height, delaying fertilization, and reducing soil moisture to hasten the transition of cool-season grass to bermudagrass. However, response from vertical mowing and coring have not been consistent. In a second article, authors recommended that when night temperatures approach 60°F, begin mowing the overseeded turfgrass lower. This will stress the ryegrass, reduce its ability to compete with the bermudagrass and help the soil warm up faster.

Influence of Air and Soil Temperatures

Spring transition occurs when air and soil temperatures favor the growth of bermudagrass and discourage the growth of the cool-season overseeded turfgrass. One paper reported that spring transition naturally occurs when soil and air temperatures are above 80°F, when ryegrass roots begin to decline. A second paper recommended that mowing heights should be lowered when night temperatures approach 60°F. Cultural practices designed to hasten the bermudagrass transition could be timed when air and soil temperatures favor the growth of bermudagrass and discourage growth of cool-season overseed turfgrasses. It should be noted that several weeks of threshold temperatures are probably needed to maintain substantial warm-season turfgrass growth in the spring.

DiPaola, J. and J. Beard (North Carolina State Univ. and Texas A&M Univ.) 1992. Physiological Effects of Temperature Stress. Chapter 7. In D.V. Waddington, R.N. Carrow and R.C. Shearman (ed.) Turfgrass Agron. Monogr. 32, ASA, CSSA,SSSA, Madison, WI.

Description: Literature review concerning temperature stress of turfgrass.

Findings: Optimum temperature range for cool-season shoot growth is 59° to 75°F. Optimum temperature range for warm-season shoot growth is 80° to 95°F. Optimum temperature range for cool-season root growth is 50° to 64°F. Optimum temperature range for warm-season root growth is 75° to 84°F. Lethal temperature (LT50) for freezing stress of Tifgreen and Tifdwarf bermudagrasses is 17.6° to 23°F.

Beard, J. and W. Menn (Texas A&M Univ.) 1988. The Texas System of Winter

Overseeding. Grounds Maintenance, Sept. pg. 14, 16.

Description: The Texas System of Winter Overseeding described. Recommends minimal renovation for a strong bermudagrass in the fall. Annual bluegrass control. Seed when four-inch soil depth is 72° to 78°F with 80% perennial ryegrass plus 20% *Poa trivialis* (by weight). For best spring transition, mow closely, maintain a high N fertility level and lightly vertical cut weekly.

Findings: These recommendations are based on ten years of research. It should be noted that other investigators have reported that water and fertilizer have been shown to extend the competitiveness of the overseeded grasses. Also, other investigators have reported that high intensity vertical mowing slowed bermudagrass emergence. The success of management programs often depends on weather conditions and timing of practices to hasten the spring transition period. Other investigators suggest that the condition of the bermudagrass roots and rhizomes before spring growth will predict the transition. Those years when they found dead, small or off-white rhizomes were followed by poor spring transition. This type of inspection will aid in decisions concerning the timing of transition or the need to hold the overseed grass while the bermudagrass recovers.

Batten, S. (Texas A&M Univ.) 1985. The Hidden Connection. Weeds Trees & Turf. July: 32,34,37,38.

Description: General article concerning overseeding with selected data from the Texas System of Winter Overseeding.

Findings: Reported that spring transition natural occurs when spring soil and air temperatures above 80°F cause the ryegrass roots to decline in active growth. Other investigators indicate that bermudagrass initiates growth as soil temperatures approach 60°F.

However, competitive, vigorous bermudagrass growth is associated with air and soil temperatures in the 90°F range. Also, when temperatures are consistently in the 80° to 90°F range, there is a rapid decline of perennial ryegrass from stress and disease pressure. Other reports suggest that mowing heights should be lowered when night temperatures approach 60°F.

Mazur, A. and D. Wagner (Clemson Univ.) 1987. Influence of Aeration, Topdressing, and Vertical Mowing on Overseeded Bermudagrass Putting Green Turf. Hort Science. 22:1276-1278.

Description: Studied the effect of spring-applied core cultivation, vertical mowing and topdressing on the rate of bermudagrass emergence and quality of putting green turf during spring transition.

Findings: All practices were shown to have no effect on bermudagrass transition. It should be noted that other investigators have reported that vertical mowing and aeration hasten bermudagrass emergence.

Spring-Applied Treatments to Hasten Transition

There have been numerous studies employing spring-applied treatments to hasten the bermudagrass transition. Unfortunately, the majority of the findings from these studies are not consistent. The treatments that have been tested include: core cultivation, vertical mowing, topdressing, scalping, vertical mowing and scalping, nitrogen applications, herbicide applications and plant growth regulator applications. No doubt, successful and consistent adoption of spring-applied treatments to hasten the bermudagrass transition will require timing based on soil and air temperatures.

Johnson, B. (Univ. of Georgia) 1990. Effects of Pronamide on Spring Transition of a Bermudagrass (*Cynodon dactylon*) green overseeded with perennial ryegrass (*Lolium perenne*). Weed Technology. 4:322-326.

Description: Studied the influence of Kerb applications on spring transition of bermudagrass greens overseeded with perennial ryegrass.

Findings: Found that applications of Kerb hastened bermudagrass transition. However, there was some injury to the bermudagrass and correct rate and timing of application were essential. It should be noted that Johnson has published other papers concerning the testing of other herbicides.

Johnson, B. (Univ. of Georgia) 1990. Influence of Plant Growth Regulators on Transition of a Bermudagrass Golf Green Overseeded with Perennial Ryegrass. Georgia Agr. Expt. Sta. Res. Report 580.

Description: Studied the influence of plant growth regulators on the transition of a bermudagrass golf green overseeded with perennial ryegrass.

Findings: Found that some PGR applications did not severely injure the turf. However, the transition was not acceptable. It should be noted that other investigators have reported more positive results.

Menn, W. and R. White (Texas A&M Univ.). 1995. Effects of Primo on perennial ryegrass overseeding establishment. Progress Report, Novartis Crop Protection, Inc., p. 7.

Description: Tifway bermudagrass, overseeded with perennial ryegrass, 0.625-inch mowing height, Primo 1EC applied at 0 to 0.75 oz. per 1,000 sq. ft, minimal bermudagrass renovation.

Findings: Fall applications of Primo did not appreciably affect spring transition of bermudagrass.

Genetic Variation

Genetic variation for spring/summer persistence among overseed turfgrass species has been reported by a number of researchers.

Dudeck, A. and B. McCarty (Univ. of Florida) 1989. Comparison of Overseeded Grasses for Putting Greens. Proc. Fla. State Hort. Soc. 102: 127-133.

Description: Studied differences among 27 cool-season turfgrass treatments for overseeding bermudagrass putting greens.

Findings: Noted differences in germination rate, rate of ground cover and visual ratings of turfgrass color and quality for seeding rates of cultivars, mixtures and blends of: perennial ryegrass; Chewings fescue; tall fescue; roughstalk bluegrass (*Poa trivialis*); Kentucky bluegrass; redtop; and creeping, colonial and velvet bentgrass.

Goatley, J., J. Krans, V. Maddox, H. Philley, J. Osteen and M. Atkin (Mississippi State University) 1997. Seeding Rate by Date Comparisons of Roughstalk Bluegrass Overseedings. Agron. Abstr. 89:132.

Description: Studied various seeding methods for applying 12 lb. of *Poa trivialis* per 1,000 sq. ft. Total of 12 pounds of seed applied in one application; two applications (9 lb. + 3 lb. or 6 lb. + 6 lb.); or three applications (6 lb. + 3 lb. + 3 lb.).

Findings: Split seeding treatments 6 lb. + 3 Lb. + 3 lb. (every two weeks) and 6 lb. + 6 lbs. (four week interval) and 9 lb. + 3 lb. (four week interval) tended to perform better than one seeding at 12 lb./1,000 sq. ft.

DiPaola, J. (North Carolina State Univ.) 1987. Spring Transition of Warm-Season Grasses. Grounds Maintenance. February: 34,38,40,42.

Description: Evaluated 60 different cool-season overseedings in Tifgreen bermudagrass under putting green conditions for spring/summer persistence.

Findings: Differences for persistence among perennial ryegrass cultivars was large. Intermediate ryegrass, *Poa trivialis*, and several perennial ryegrass cultivars were least persistent. Plots overseeded with the least persistent grasses had the greatest amount of bermudagrass regrowth.

All the authors, except for Mike Henry, work for the University of California, Riverside. Henry is a cooperative extension agent for Riverside and Orange Counties.

The Bridge Between Researchers and Users in the Field

Sue Gibson

Maybe it's the fact that fall seems to be a time of planning, but we've certainly got the bug at Advanstar's Landscape Group. It's my pleasure to take the position of executive editor for these publications: *TurfGrass Trends*, *Landscape Management*, *Athletic Turf Maintenance & Technology* and our newest publication — *Golfdom* (coming in February).

TurfGrass Trends is a key element of this group because it offers a unique bridge between research and field use. Because all of our publications cover the growth and management of turfgrass, we want to be your best source on innovative research and practical applications. Our plans for *TurfGrass Trends* include regular reader surveys and coordination with the Editorial Review Board and Field Advisors.

I think this is going to be an exciting and interesting challenge, personally and for all those involved in taking *TurfGrass Trends* to a new level.

We invite you to be involved, too — as an active, responsive reader or as a volunteer to assist our advisor boards. Please call me at 800-225-4569 or email me at sgibson@advanstar.com. I would love to hear your opinions and ideas for *TurfGrass Trends'* future.

Sue Gibson
Executive Editor

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- More research reports from the Northwest and Southwest
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