CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

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The Development of Microbial Fungicides for Turfgrass Disease Management

In a previous edition of *CUTT* (Vol.1, No.1), I considered some of the general approaches to biological control and the use of materials containing complex mixtures of microorganisms, such as composts and organic fertilizers, for the biological control of turfgrass diseases. In this article, I wish to consider the use of preparations of individual microorganisms as microbial fungicides for turfgrass disease control. Although no microbial fungicides are currently available for turf, products are likely to be labelled in the next few years. ■

Properties of Microbial Fungicides

Microbial fungicides consist of living preparations of microorganisms that have inhibitory properties toward plant pathogens. These organisms can act in a number of ways to inhibit plant pathogens. They may act as fungal parasites, compete with the pathogen for nutrients or alter the plant such that it is less susceptible to infection. For example, just as many of our medically important antibiotics come from soil microorganisms, similar microorganisms producing similar kinds of antibiotics are also effective in treating plant infections as well. In the development and use of microbial fungicides, we try to take advantage of the beneficial microorganisms commonly found in nature by isolating them from the environment (usually from soils or plant tissues), increasing their populations artificially, culturally or genetically improving their activity in the laboratory, and then reintroducing them back into the environment as an inoculant.

Unlike traditional synthetic chemical fungicides, microbial fungicides need more careful consideration of various aspects of their storage and application. Of particular importance is the shelf life of microbial fungicides since the organisms present in such products may not be able to remain viable for extended periods of time. One also needs to consider that, for any microbial-based fungicide to be effective, the organism(s) present in such a product must be able to establish itself in turfgrass plantings and must remain active throughout the period when disease pressure is greatest. Additionally, the organisms present in these types of products must be compatible with other agrichemicals used in management systems. For example, while bacterial preparations may generally be tolerant of most other chemical fungicides

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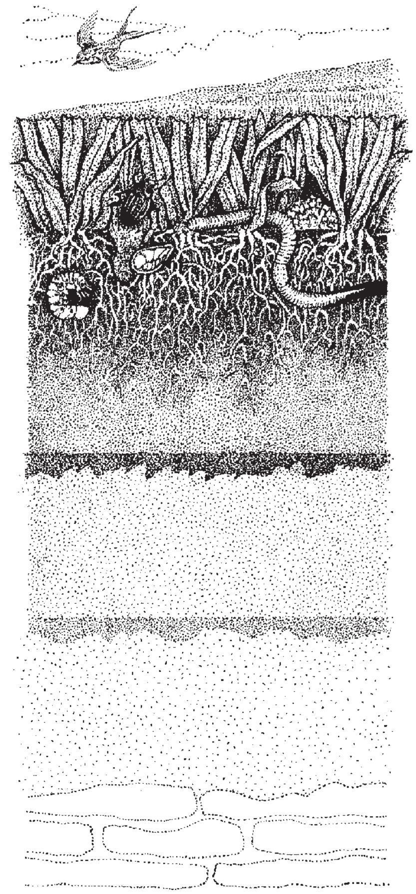

This Times

Short Cutts

Mark your calendar today: the Seventh Annual Turfgrass Management Short Course will be held January 6-10 and January 13-17, 1992

Cornell Cooperative Extension's Turfgrass Management Short Course

Since the first Cornell Turfgrass Management Short Course was held in January of 1986 more than 400 professional turfgrass managers from New York, New Jersey, Connecticut, Delaware, Pennsylvania, Maine, Massachusetts, Vermont, California, Wisconsin, Colorado, Canada and France have graduated. Forty instructors and assistants from Cornell University, SUNY Agricultural and Technical Colleges and the turfgrass industry are involved in teaching the lectures and laboratories. Class enrollment is limited so that laboratory sessions can maximize hands-on experiences. The 2-week Short Course includes 72 teaching hours, covering the principles of turfgrass establishment and maintenance. Topics include grass morphology, species identification and selection, soil science, drainage, irrigation, fertilization, cultivation, renovation and pest management topics (including identification and control strategies for insects, diseases and weeds). Other topics that help develop turfgrass professionals include: the selection, establishment and maintenance of ornamentals; developing budgets, communication skills, customer relations, motivation in management, and turfgrass management strategies. Daily student evaluations are collected and summarized to help improve subsequent Short Courses. A pass/fail final exam is given at the end of the course to assess achievement of the course's educational goals from both the instructor's perspective as well as from the student's perspective.

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The Cornell Turfgrass Science Program promotes continuing education and maintains contact with past graduates throughout the year at regional and statewide Cooperative Extension- and industry-sponsored educational programs and conferences. According to our graduates:

"The Cornell Short Course experience has made a positive impact on their job performance and in their careers as turfgrass managers."

The Short Course registration form will be sent out in October. You may want to make arrangements with your supervisor now to secure funding. If you wish to receive a registration form or if you have any questions contact Joann Gruttadaurio, Short Course Coordinator, at 607-255-1792.

Mark your calendar today: the Seventh Annual Turfgrass Management Short Course will be held January 6-10 and 13-17, 1992.

Norm Hummel Awarded Sabbatical Leave

July 1, 1991 – July 1, 1992

CUTT Editor-in-Chief Norm Hummel will leave his Cornell University responsibilities for the next year to pursue a number of projects that will concentrate on developing standard procedures for testing construction or topdressing mixes. A portion of his time will also be devoted to the refinement of existing USGA specifications.

Norm will be travelling all over the country and visiting commercial testing laboratories, as well as golf courses that have greens built to USGA specifications. He will be soliciting golf course architects, superintendents, contractors and academics for their input on greens specifications.

This project will result in better defined greens construction specifications and methods for testing greens mixes.

Welcome to Dave Davidson

While Norm Hummel is on leave Dave Davidson will be joining the rest of the Turfgrass Work Group (Rod Ferrentino, Joann Gruttadaurio, Joe Neal, Eric Nelson and Marty Petrovic) and assume some turfgrass extension responsibilities. Dave obtained his Masters degree from the University of Guelph where he concentrated on turfgrass plant nutrition. He then came to Cornell in 1984 to work with Norm Hummel. While obtaining his doctorate Dave focused on mineral nutrition of bentgrass grown on sand greens.

Dave is no stranger to turfgrass research and extension activities. He has been a speaker at the New York State Turfgrass Association Conference and an instructor at the Cornell Turfgrass Management Short Course. He will serve as the primary resource person for questions involving cultural aspects of turfgrass establishment and maintenance for professional turfgrass managers. Of course, your first line of defense is your local county Cooperative Extension agent (with turfgrass responsibilities). If they are not able to help you, you may contact Dave at 607-255-1629. Joann Gruttadaurio will continue to coordinate the Cornell Turfgrass Management Short Course and the Field Diagnostic Summer Course and will serve as the editor of *CUTT.* Any questions regarding these educational programs, call her at 607-255-1792.

Cornell Turfgrass Field Day

On June 27 more than 400 turfgrass professionals endured the scorching heat of Ithaca to see current research in action. The morning program included reports on projects which focused on:

- the impact of turfgrass culture on water use
- leaching properties of various nitrogen sources
- Pythium root rot control
- biological control of Brown patch
- organic amendments for greens
- golf course and lawn IPM demonstrations
- biological control of *Poa annua*
- crabgrass, veronica and broadleaf weed control studies

The afternoon tours and discussions highlighted the sampling techniques for turf insects and an update on biocontrol options; weed control studies on bentgrass; compost microbiology and how it influences disease suppressive activity of a compost; variety trial results for bentgrass, bluegrass, fine fescues, tall fescue, ryegrass, buffalograss, and zoysiagrass; and fertilizer and pesticide leaching studies.

The results of these studies have been published in the 1989-90 Cornell University Turfgrass Research Report. A limited number of copies are available for $6 from: Cheryl Koroluck, Department of Floriculture and Ornamental Horticulture, 20 Plant Science Building, Ithaca, NY 14853.

Cornell's Matching Fund Program Grows

Stephen Smith, President of the New York State Turfgrass Association, presented Dean David Call with a $35,000 donation during the opening ceremony of the Cornell Turfgrass Field Day. The College of Agriculture and Life Sciences will match this grant and all funds will be designated in support of turfgrass research.

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Disease Control

Early to mid-autumn is the best time to apply preventive fungicide treatments to control Pythium root rot. For sites with a history of Pythium root rot problems, applications of either Banol, Aliette, Koban, or Subdue (or any other Pythium fungicide with active ingredients contained in the above fungicides) should be made in mid-October to mid-November prior to turf dormancy. To get the most effective control, fungicides should be thoroughly watered-in usually with 3/4 inches of water. Immediately after turf resumes growth in the spring, another follow-up application of a Pythium fungicide should be made. As always, be sure to avoid repeated and continuous applications of the same fungicide on sites with known Pythium root rot problems.

Our research has shown that covering golf course putting greens with composts after turf dormancy will protect playing surfaces from gray snow mold and possibly freezing injury. Only composts that are well-decomposed and mature should be used and can be applied at rates of 200 pounds/1000 sq. ft. It is important that the excess compost remaining in the spring be removed from green surfaces prior to new turf growth, otherwise some turf damage may occur.

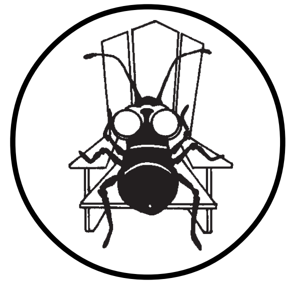
ERIC NELSON, DEPT. OF PLANT PATHOLOGY

Fall is for Broadleaf Weed Control

Autumn is the recommended time to apply postemergent herbicides for broadleaf weed control in turf. Compared to spring treatments, winter annual broadleaves are easier to control, perennials are more effectively controlled, and the turf has more time to fill-in the gaps before new weed germination. In the Fall 1990 issue of *CUTT,* we discussed this subject in some detail; however, one recurring question is, "How late can I spray?" The best time in upstate New York is from mid-September to mid-October. However, in our research plots we have sprayed as late as mid-November (in a mild Fall) with excellent results. Keep in mind that when you apply your herbicides later in the fall, do not expect to see results until next spring.

In October and November the weeds are not growing vigorously and therefore do not rapidly respond to the herbicides. Have faith! The herbicides are absorbed and translocated to the roots and rhizomes where they begin working on the growing points. The next spring, the weeds will either not grow at all, or may produce one twisted shoot and then die. For more information see the Fall 1990 issue of *CUTT.*

JOSEPH C. NEAL, DEPT. OF FLOR. & ORN. HORT.



Pest Watch

Early to mid autumn is the best time to apply preventive fungicide treatments to control Pythium root rot.

The best time to apply postemergent herbicides for broadleaf weed control in turf in upstate New York is from mid-September to mid-October.

Microbial fungicides consist of living preparations of microorganisms that have inhibitory properties toward plant pathogens.

They can provide levels of disease control that, in many cases, facilitate reduced applications of fungicides and, in a few cases, eliminate the need for fungicide applications altogether.

When one considers the volumes of fungicides being utilized for turfgrass disease control, the economic feasibility of microbial fungicide development seems quite attractive.

Microbial Fungicides

continued from cover

used in management programs, fungal preparations are not.

Through the past couple of decades, it has become apparent that the use of microbial fungicides is fraught with limitations, primarily due to the fact that we are trying to manipulate a living organism instead of a synthetic chemical. However, through continued evaluation in agronomic and horticultural systems, it has become evident that microbial fungicides have a very important place in commercial plant production and realistically offer important alternatives to plant health management. They can provide levels of disease control that, in many cases, facilitate reduced applications of fungicides and, in a few cases, eliminate the need for fungicide applications altogether. In addition, microbial fungicides are a potentially important tool in managing fungicide resistance among pathogen populations. Resistance is becoming more of a problem with many of the newer systemic fungicides on the market today. Furthermore, the success of sustainable plant production is largely dependent on the integration of biological and other non-chemical means of control into disease management strategies. Recent developments in Integrated Pest Management (IPM) are a direct result of the awareness of the importance of biological controls in holistic approaches to plant health management.

The Development and Use of Microbial Fungicides in the United States

Several requirements must be met before the successful development of a commercially viable microbial fungicide can take place. The product must be 1) needed in the marketplace; 2) technically feasible to produce; 3) economically feasible to produce; 4) competitively attractive with conventional fungicides; 5) acceptable to environmentalists and regulatory agencies; and 6) compatible with activities and interests of the company developing the product. Certainly, the turf industry and its clientele as well as the agrichemical and pharmaceutical industries can satisfy all of these criteria. When one considers the volumes of fungicides being utilized for turfgrass disease control, the economic feasibility of microbial fungicide development seems quite attractive. For example, the development of microbial fungicides in the United States is estimated to take approximately 2-3 years at a cost of less than $500,000 while chemical fungicides are estimated at approximately 10-15 years at a cost exceeding $80 million. Current costs of applying one of the more recent microbial fungicides, DAGGER G®, is estimated at approximately $9.50 per acre. If these figures can be used as a general standard with which to base future product economics, microbial fungicides will be extremely attractive if the product is used by a large portion of the turfgrass industry.

Since the 1920's, when interest in biological control of plant diseases first arose, there have been only five commercial biological controls targeted for plant diseases put into the marketplace in the United States. Four of those, QUANTUM-4000® (Gustafson Chemical Co., Dallas, TX, USA), a preparation of the bacterium *Bacillus subtilis;* DAGGER G® (Ecogen, Inc., Langehorne, PA, USA), a preparation of the bacterium *Pseudomonas fluorescens;* BINAB-T® (U.S. distributor unknown), a preparation of the fungus *Trichoderma harzianum;* and most recently a preparation of the fungus *Gliocladium virens* (unknown trade name but developed by W.R. Grace) are targeted for fungal pathogens. A fifth, GALLTROL-A® (AgBioChem, Inc., Orinda, CA, USA), a preparation of the bacterium *Agrobacterium radiobacter,* is effective against one specific bacterial disease. Likewise, there are only a few commercial products available in Europe and the Middle East. Unfortunately, none of these materials are labelled for turf disease control at this time. However, in the last few years, there has been intense interest among the traditional chemical pesticide producers in developing microbial fungicides for turf. Similarly, research here at Cornell is being directed toward the discovery and utilization of microbial antagonists for turfgrass disease control. Since our knowledge of the types, nature, and ecology of microbial antagonists active against turfgrass pathogens is rapidly increasing, it is likely that in the next three to five years, microbial turfgrass fungicides will begin appearing on the market.

Microbial Fungicides for Turf

Although biological control of turfgrass diseases is still very much in its infancy, there have been promising studies using preparations of individual organisms as tools for managing fungal diseases (Table 1). Although limited in scope, these studies indicate the potential of soil and plant associated microorganisms to suppress turfgrass diseases. Additionally, our research at Cornell has shown that individual microorganisms, when applied at the proper time and in an appropriate manner, can establish in bentgrass putting greens and can be as effective as some of the newest chemical fungicides in controlling turfgrass diseases (Table 2). The future use of these antagonists in microbial fungicides will come only from a better understanding of how antagonists function and how they interact with other turfgrass management inputs. Recent developments in molecular biology have tremendously increased our abilities to answer some of these questions. As a result, we are now gaining a better understanding of how antagonists can be manipulated to get the most out of them in the tasks they are being asked to perform. For example, antagonist technology has developed to such a level that we now have the potential to introduce and establish antagonists on specific plant parts or in specific ecosystems, the techniques to identify genes conferring biological control activity, and the ability to understand their interactions with the environment. Undoubtedly, advances in antagonist molecular biology have been one of the principal reasons that biological control of fungal plant pathogens has become more of a reality today than just a few years ago. Future developments of microbial fungicides for turf will come only from this type of understanding of antagonist biology.

Table 1. Known Examples of Research on the Biological Control of Turfgrass Diseases

Disease *(pathogen)*	Antagonists	Location	Reference
Brown Patch *(Rhizoctonia solani)*	*Rhizoctonia* spp.	Ontario Canada	Burpee & Goulty, 1984
	Laetisaria spp.	N. Carolina	Sutker & Lucas, 1987
	Complete mixtures	New York	Nelson & Craft, 1989
Dollar Spot *(Sclerotinia homoeocarpa)*	*Enterobacter* spp.	New York	Nelson & Craft, 1990
	Fusarium spp.	Ontario Canada	Goodman & Burpee, 1989
	Complex mixtures	New York	Nelson & Craft, 1989
Gray Snow Mold *(Typhula* spp.)	*Typhula* spp.	Ontario Canada	Burpee, *et al.,* 1987
			Lawton & Burpee, 1990
	Trichoderma spp.	Massachusetts	Harder & Troll, 1973
Pythium Blight *(Pythium aphanidermatum)*	*Enterobacter* spp.	New York	Nelson & Craft, 1989
	Various bacteria	New York	Nelson & Craft, 1991
		Ohio	O'Leary, *et al.,* 1988
		Illinois	Wilkinson & Avenius, 1984
	Complex mixtures	New York	Nelson & Craft, 1989
	Trichoderma spp.	Ohio	O'Leary, *et al.,* 1988
Red Thread *(Laetisaria fuciformis)*	Complex mixtures	New York	Nelson & Craft, 1989
Southern Blight *(Sclerotium rolfsii)*	*Trichoderma* spp.	N. Carolina	Punja, *et al.,* 1982
Take-All Patch *(Gaeumannomyces graminis* var. *avenae)*	*Pseudomonas* spp.	Colorado	Wong & Baker, 1984, '85
	Gaeuman. spp.	Australia	Wong & Siviour, 1979
	Phialophora spp.		
	Complex mixtures		

Table 2. Comparison of Biological and Chemical Suppression of Dollar Spot on Creeping Bentgrass with *Enterobacter cloacae* (EcCT-501) and the Fungicide Propiconazole

	Rating 1 (30 dpi)[1]		Rating 2 (23 dpi)	
Treatment	Spots per Plot	%Control	Spots per Plot	%Control
Untreated	3.4 a	0.0	19.8 a	0.0
Propiconazole[2]	1.4 c	58.8	0.6 b	97.0
E. cloacae (EcCT-501)[3]	2.2 b	35.3	8.6 b	56.5
Autoclaved cornmeal (carrier)[4]	3.6 a	0.0	21.0 a	0.0

[1] Rating 1 (June 26, 1989) 30 days after first application. Rating 2 (July 19) 23 days after second application. dpi = days post-inolucaltion.
[2] Propiconazole (BANNER®) applied at the rate of 174 mg a.i./m² as a fungicide check.
[3] Cornmeal/sand preparations of EcCT-501 applied at monthly intervals. Recoverable populations at the time of application were approx. 10^9 cells/g dry wt. thatch.
[4] Cornmeal/sand mixture consisted of 70% fine sand and 30% cornmeal (v/v) and was used as a carrier for *E. cloacae.*

Numbers followed by the same letter are not significantly different (P = 0.05) according to the LSD test.

Future Perspectives

Because microbial pesticides are relatively new to the marketplace, it is not yet clear, particularly in the United States, whether they will compete well with chemical fungicides and be acceptable to environmentalists and regulatory agencies. Although it is encouraging that more and more biological control products are becoming available, time will tell whether biological fungicides turn out to be effective enough to either replace or augment traditional fungicides. It is critical that some of these initial products consistently perform as well as or better than conventional fungicides if the future of microbial fungicides is to be successful. Biological control is on the verge of a new era of discovery and commercialization. One must believe that the benefits of biological controls, once realized, will overcome any limitations currently impeding development and ultimately change the way in which disease control is approached.

Eric Nelson, Dept. of Plant Pathology

Scanning the Journals

A review of current journal articles

Researchers report the successful suppression of dollar spot in both preventative and curative applications by a biological control agent, the bacteria* Enterobacter cloacae, *in field experiments on putting greens in New York.

Extremely low levels of atrazine in irrigation water can significantly damage creeping bentgrass, especially when applied over a long period of time.

Bacterial Agent Suppresses Dollar Spot

In one of the few studies of its kind, Cornell researchers Eric Nelson and Cheryl Craft (Dept. Plant Pathology, College of Agriculture and Life Sciences) report the successful suppression of dollar spot in both preventative and curative applications by a biological control agent, the bacteria *Enterobacter cloacae*, in field experiments on putting greens in New York. While laboratory and greenhouse studies of similar biocontrol agents are not uncommon, investigations under actual field conditions are rare.

The two-year study was conducted on 60 year-old native soil putting greens (alkaline clay-loam, pH 7.2) at the Country Club of Rochester. Greens turf consisted of a mixture of creeping bentgrass and annual bluegrass, with a natural infestation of dollar spot.

In 1988, a one-time-only topdressing with the bacterial agent was applied as a preventive measure, and in a separate experiment a curative application was compared to the fungicide iprodione on highly diseased turf. The preventive application significantly reduced dollar spot as compared to control, and the curative application was as effective as the fungicide.

In 1989 monthly preventive treatments of the bacteria were applied, paired with parallel applications of the fungicide propiconazole. The bacterial agent was as effective as the fungicide, both achieving significant suppression of dollar spot as compared to controls. For some strains of bacteria, significant suppression of disease was observed for up to 2 months after application in both the preventive and curative studies. The bacterial agent was considered more effective as a preventive than a curative. The mechanism by which *E. cloacae* inhibits the fungal pathogen is unknown, but the authors suggest that both an enhanced nitrogen uptake by the plant as well as direct interference with fungal adherence to the host may be responsible. The authors further note that application of suitable bacterial strains could be made during routine topdressing of greens and tees, hence requiring no additional scheduling to achieve the preventive benefit.

(From: E.B. Nelson and C.M. Craft. 1991. Introduction and Establishment of Strains of Enterobacter cloacae *in Golf Course Turf for the Biological Control of Dollar Spot. Plant Disease 75(5): 510-514.)*

Creeping Bentgrass Ultra-sensitive to Atrazine

Researchers at Kansas State University, Manhattan, have discovered that extremely low levels of atrazine in irrigation water can significantly damage creeping bentgrass, especially when applied over a long period of time. Workers tested mature and seedling 'Penncross' creeping bentgrass in greenhouse pots with daily waterings contaminated by atrazine at levels ranging from 0.01 to 2.56 mg/liter. After 20 days of watering, damage thresholds were established at 0.05 and 0.08 mg/liter for seedling and mature bentgrass, respectively. Compare these numbers to the atrazine concentrations found in some groundwaters in the Midwest: 21.1 - 42.4 mg/liter, as reported in this paper!

The authors point out that warm season turfgrasses (Zoysiagrass, bermudagrass, centipedegrass, St. Augustinegrass) can detoxify atrazine whereas cool season turfgrasses cannot. Therefore, this problem can be especially acute in the north-south transition zone where both types of turfgrass may be grown on the same golf course, irrigated from the same groundwater source, and where atrazine is used for weed control on the warm season turf species. In these situations, sudden declines in the quality of bentgrass greens may be due to atrazine contamination of irrigation water, rather than disease.

(From: J.L. Nus and M.A. Sandburg. 1991. Creeping Bentgrass Damaged by Low Levels of Atrazine in Irrigation Water. HortScience 26(4):392-394.)

Short Cutts

continued from page 3

Continuing Support Appreciated

A special thanks goes out to those who have donated equipment in support of Cornell's Turfgrass Program:

Sponsor:	*Equipment Donations:*
S. V. Moffet Co., Inc. W. Henrietta, NY	- Jacobsen Greensking IV - Cushman Front Line - Ryan Jr. Sod Cutter
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Eaton Equip. Corp. Hamburg, NY	- TORO Groundsmaster 224 - TORO Greensmaster 1000

Insect Pests of Turfgrass in Autumn and Winter

This is the last in our 3 part series focusing on the common turfgrass insect pests of New York State. The important information concerning the ecology, damage potential, and need for control of these insect pests in autumn will be discussed. Turfgrass managers interested in more detailed information are directed to the *Turfgrass Insect and Mite Manual* by Shetlar, Heller & Irish, or *Turfgrass Insects of the United States and Canada* by Haruo Tashiro.

Sod Webworm

Although the adults of most webworm species have distinct summer flights, a common New York webworm is often seen flying in September. Remember that the presence of large numbers of lawn moths (webworm adults) is not a reliable indication of subsequent damaging caterpillar populations. The use of a disclosing solution to flush caterpillars from thatch is the preferred method for determining webworm populations. Webworms overwinter in protective chambers in the soil as mature caterpillars.

Chinch Bug

July and August are the months usually associated with extensive chinch bug damage but populations unchecked by natural controls such as weather, predators or disease, or insecticides will continue to feed and multiply well into autumn. As temperatures drop in autumn, chinch bugs search for sheltered sites to pass the winter. Leaf litter, dense weeds or turf, and heavy thatch all serve as preferred overwintering sites for adult chinch bugs.

Annual Bluegrass Weevil

The second generation larvae of the annual bluegrass weevil, seen in September, is usually less distinct and often less destructive than the spring or first generation. Adult weevils overwinter in clumps of grass or leaf litter. White pine needle duff has been shown to be an exceptional weevil overwintering site, the removal of this material can cause significant winter mortality of adults and lead to a reduction of larval populations and feeding damage the following spring.

Bluegrass Billbug

Adult billbugs are commonly found walking on sidewalks and driveways during September and October. As temperatures drop, these adults will seek out protected areas to spend the winter. Removal of leaf litter and weedy or overgrown areas adjacent to driveways, sidewalks or house foundations will reduce protected sites and should help reduce billbug populations the following fall.

Annual White Grub

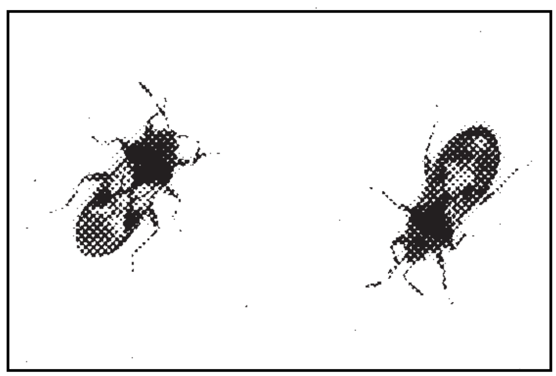
(Japanese beetle, Oriental beetle, Asiatic Garden beetle, European chafer, Northern masked chafer)

Large third instar grubs will be found feeding in the upper root zone through October. Grub feeding damage and turf damaged by searching skunks, raccoons and birds is often first evident in mid-September. As soil temperatures cool in the fall, grubs will migrate down into the soil to avoid hard frosts at the surface. European chafer grubs are more cold-tolerant than the other grub species and may be found feeding at the surface during mid-winter thaws. In general, application of insecticides for grub control should be applied before September 15 for maximal effectiveness.

Silver Sod Webworm.

Black Cutworm

Little is known about the overwintering habits of the black cutworm in the northeast. It is believed that this species can only overwinter in the extreme southern states. Annual migrations to New York and other northern states result in heavy spring populations. One or two additional generations of Black cutworms will develop in summer and early fall in most northern areas. Since there is no evidence that northern adults migrate south in the fall it is assumed the final cutworm population, unable to escape the cold, are lost every year. For this reason, heavy fall populations of black cutworms in a particular site will not translate into heavy pest pressure the following spring.



Adult Hairy Chinch Bugs, short and long winged.

Black Turfgrass Ataenius

Adult ataenius are the most often observed life stage during September and October, although larvae and pupae may be found in the soil in early autumn. Fall treatment for ataenius is not usually required unless large numbers (>100 actively feeding grubs per square foot) are found. Falling soil temperatures in autumn will reduce insecticide efficacy. Much like the annual bluegrass weevil,

continued next page

Autumn and winter control of turf pests can reduce problems next spring.

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Insect Pests

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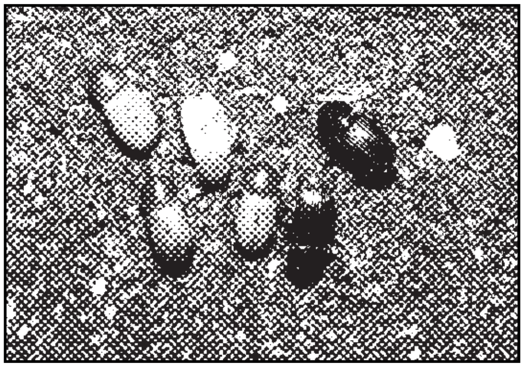
black turfgrass ataenius overwinter as adults in leaf litter and pine duff.

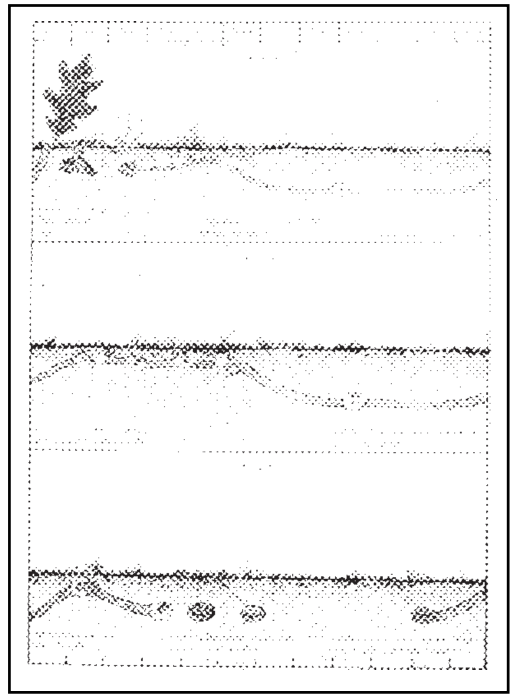


Adult Black Turfgrass Ataenius of varying ages.

May & June Beetles *(Phyllophaga spp.)*

Because May and June beetles require two or more years to develop from egg to adult, one commonly finds overwintering small and large grubs as well as adults. Eggs hatch in mid-summer and small, first instar grubs feed and overwinter. These small grubs will feed and grow in the soil for a second year and overwinter as large, third instar grubs. Third instar grubs will feed during the spring of their third year, pupate, and mature into adults. In some species of June bugs the adults will emerge in late summer or early fall and overwinter in protected areas, while in other species the adults remain under the turf in their pupal cell and emerge the following spring. Positive identification and management of small grubs are key to the successful control of May and June beetles.

M. G. VILLANI, DEPT. OF ENTOMOLOGY - GENEVA



June Beetle life cycle

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