A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

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The Basics of Turfgrass Fungicides Part 5: Record Keeping

by Eric B. Nelson
Cornell University

One of the more important aspects of maintaining highly effective fungicide programs is proper record keeping. This is also among the more critical aspects of developing successful IPM programs on golf course turf. Golf course superintendents, and other turfgrass managers for that matter, often take record keeping for granted. Even though the maintenance of fungicide and other pesticide records is required by state and federal laws, many superintendents fail to recognize the tremendous wealth of historical information and management insight that can be gained from properly prepared and maintained fungicide records. Often superintendents rely on memory for a large amount of this significant information. Unfortunately though, useful specific management knowledge is often lost as superintendents retire or move from course to course. In this article, we will explore the reasons for maintaining detailed records and show how these records can help not only in fungicide management, but in pest management in general.

Advances in spraying equipment have enabled superintendents to reduce the amount of fungicide applied while maintaining effective disease control. Photo courtesy: Smithco.

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Reasons for Record Keeping

There are a number of reasons for developing detailed records of fungicide applications and recording associated site and management factors. Perhaps most importantly, fungicide and other pesticide records are required by state and federal law. These requirements will be described later in this article.

Certainly one of the more important reasons for keeping detailed fungicide records is that they provide the only accurate historical record of fungicide applications to specific turfgrass sites. For example, documenting how the fungicide suspension was prepared, the precise rates applied, the weather conditions surrounding the application, and a detailed description of the outcome of the application may point to specific reasons for success or failure of the application as well as how such a control strategy might be improved in the future.

Proper fungicide records also provide a means of mapping important disease problems. Golf course superintendents often know where their problem disease areas are located. Keeping proper records will provide a means of tracking how disease symptoms change in these and potentially new areas with time and with fungicide application. In most cases, disease symptoms tend to appear in the same location year after year. This is due mainly to the fact that few fungicides actually eliminate pathogens from these sites. Rather, they simply stop the pathogen from growing. Some patchtype diseases, for example, tend to show increased patch diameters from year to year. Including this type of information in fungicide records will eventually allow you to map effectively disease symptoms and establish longer-term trends in control efficacy. Along those same lines, detailed records can help you keep track of other management practices, such as fertilization, irrigation, and cultivation practices, that impact disease severity and the efficacy of fungicide applications.

What Should Be Recorded?

Ideally all of the following items should be recorded in conjunction with any fungicide application. Modify them to fit your specific needs:

1. **The name of the material applied.** Include the trade name, formulation, active ingredient (common name), and EPA registration number. This is important for satisfying legal reporting requirements of pesticide usage.

2. **Date and time of application.** Of particular importance is the time of day, particularly if it varies from the usual application times

3. **The area treated.** Recorded either in square feet or in acres.

4. **Total amount of material applied.** Include the intended or measured rate of active ingredient as well as the total amount of material applied to the turf. It is also useful to record the rates of water in which the fungicide was applied (e.g. gallons/l000 ft^2).

5. **Tank storage time and pH.** It is usually best to apply fungicides immediately after mixing since a number of fungicides degrade with extended storage time in the tank. In cases where the water supply comes from multiple sources, it is important routinely to

monitor and record the water pH since this too will affect fungicide degradation.

6. **The amount of post-application irrigation.** This is best expressed as gallons of water per unit area.

7. **The target disease.** This information should indicate whether this diagnosis was a personal diagnosis or a clinical diagnosis. It is important to indicate whether the diagnosis was made prior to the fungicide application or after. The date and specific location of sampling and the date of diagnosis also should be recorded.

8. **Weather conditions.** These should include the conditions prior to the appearance of symptoms and the conditions at the time of application.

9. **Apparent results of the application.** This is one of the more important records to keep since often it is not clear whether the application was successful or if weather changes made the symptoms disappear.

Diagnostic Record

Golf Course ____________

Date & Time of Problem Appearance	*Hole & Section (Circle)*	*Specific Problem Location*	*Type of Diagnosis (on-site/lab)*	*Sample Collection Date*	*Diagnostic Lab Used*	*Date Sample Sent*	*Diagnosis*	*Response to Diagnosis*
	Hole # Tee Green Fwy							
	Hole # Tee Green Fwy							
	Hole # Tee Green Fwy							
	Hole # Tee Green Fwy							
	Hole # Tee Green Fwy							
	Hole # Tee Green Fwy							

Weather Notes

Date:

Prior to Symptoms:

At Symptom Appearance:

Other Notes

Cultivation:

Irrigation:

Fertilization

Other:

Legal Aspects of Recordkeeping

In May of 1993, federal regulations went into effect that require all certified pesticide applicators to maintain records on the use of all federally-designated restricted-use pesticides. Restricted-use pesticides are those designated as such under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The purpose of these records is to help licensed health care professionals in the event of a medical emergency. In most instances, the applicator has 30 days in which to record these applications. In the event that satisfactory records are not kept, the fine is at least $1000 for each violation.

Many states also have requirements for reporting information on specific pesticide use levels and rates. In addition to the records on the application of restricted use pesticides, material safety data (MSD) sheets are also to be compiled and kept in a place accessible by applicators, employees, and government officials.

These changes in accountability rules for pesticide applicators are only the beginning of what is seen as an ever-increasing level of detailed recordkeeping. It is certainly in the interest of all turfgrass managers to develop systems for keeping detailed records of all important and environmentally significant activities performed in the course of their turfgrass maintenance.

Computerization

Computers are having an increasing impact on turfgrass management. All new irrigation systems are now under computer control and many other pieces of equipment such as weather stations and diagnostic aids are highly computerized. Software also has been developed to the point where database development and management are easy and versatile. It should be obvious that computerized databases of fungicide records are the most valuable means of keeping track of all use-related information. Most of the programs available allow you to search easily for specific items of interest such as: a listing of the dates and sites when fungicides were applied for brown patch control, or a listing of the weather conditions when fungicide applications failed, or a listing of sites where anthracnose was diagnosed, and any other listing that may be important to your specific method of management. Furthermore, these programs allow you to print out the records in specific formats so that the records can be prepared easily for state and federal reporting or for individual analysis of trends, etc.

Another important aspect of computerization is the ability to map and monitor trends over long periods of time so that, for example, you can keep track of increases or decreases in fungicide applications, the increase or decrease in specific disease symptoms, and trends in weather conditions related to fungicide efficacy or disease severity that will allow you to make adjustments in your management approach to disease problems. These types of data are unquestionably important and vital for the development of IPM programs.

Sample Forms

The following are sample forms suitable for recording the types of information important to your management records. They include a record for reporting specific fungicide application information, a diagnostic record for reporting information related to disease diagnosis, and a cultural record to keep track of fertilization, irrigation, seeding, sodding, and other cultivation practices. These are suggested forms only and the specific arrangement of entries on any given form can and should be modified to fit your specific needs. You should keep in mind that the format of entries in computer databases may differ substantially from these suggested forms, but they can be manipulated to be printed in almost any format you wish. Equally important for computerized records is that the fungicide, diagnostic, and cultural records be linked so that you can access each of these databases simultaneously.

Cultural Record

Date and Time	*Hole & Section (Circle)*	*Fertilizer Applied*	*Rate of N*	*Rate of P*	*Rate of K*	*Rate of Other*	*Cultivation*	*Daily Irrigation Schedule*	*Turf Wetness Period*	*Mowing Frequency*
	Hole # Tee Green Fwy									
	Hole # Tee Green Fwy									
	Hole # Tee Green Fwy									
	Hole # Tee Green Fwy									

Notes:

Fungicide Application Record

Date and Time	*Hole & Section (Circle)*	*Fungicide Applied Name/Form.*	*EPA Reg. #*	*Rate*	*Area Treated*	*Total Material Applied*	*Tank pH & Storage Time*	*Target Disease*	*Results of Application*
	Hole # Tee Green Fwy								
	Hole # Tee Green Fwy								
	Hole # Tee Green Fwy								
	Hole # Tee Green Fwy								

Weather Notes:

Date:

Prior to Application:

At the Time of Application:

Other Notes:

Cultivation:

Irrigation:

Fertilization:

Other:

What to Do When a Spill Occurs

Provided by Agricom, Inc.

Adapted From The Reporter, Iowa Turfgrass Association Newsletter

1. Wear available protective clothing, gloves and safety apparatus.

2. Remove any injured persons from the spill. Consult the Material Safety Data Sheet for first aid information.

3. Control the spill as quickly as possible. Upright any overturned containers and contain the spill with any material available. Sand, dirt, or lime can be used to keep a spill from spreading. Every dealership should have absorbent material readily available for spills.

4. If the spill occurs on a roadway, contact the county sheriff, Highway Patrol, or DOT enforcement to provide traffic control.

5. Begin clean-up of the spill as soon as the situation is under control.

6. Contact the appropriate agency, such as the Department of Natural Resources. They will need the following information:

- Chemical name (CAS # if available)
- Tell them if the material is an extremely hazardous substance (EHS). (These are the same EHS products listed on your Tier II form).
- Quantity released or your best estimate.
- Time and duration of the release.
- Location of the release.
- Was it released into air, water, or soil?
- Any health effects - long or short term (this can be found on the MSDS).
- Emergency Procedures being followed.
- Name and telephone number of a contact person,

In Iowa, you have six hours from the time of release or discovery of a release to report to DNR. Hazardous materials do not have reportable quantities (RQ), so all spills must be reported.

If a spill occurs within the boundaries of your property or within a contaminated area, it does not have to be reported.

If a release of an extremely hazardous substance (EHS) occurs in excess of one hundred pounds or the RQ, whichever is lower, the National Response Center (NRC) must be notified within fifteen minutes of the release or discovery of the release. Their number is 800-424-8802.

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January 1996

"Reduced Herbicide Application Rates for Crabgrass and Goosegrass Control in Bermudagrass" B. J. Johnson, pp. 1-6
Keywords: bermudagrass, growth regulators, multiyear application, POST (postemergence) herbicide, PRE (preemergence) herbicide, reduced-rate application, sequential application, tank-mixed single application.

Bermudagrass is widely used on golf courses, athletic fields, lawns, industrial areas, parks, and other turf areas throughout the southern United States. To maintain a desirable quality turf, herbicides must be included for weed control in the overall management program. Several programs utilizing lower herbicide rates for full-season weed control in turfgrasses have been developed at the University of Georgia. These programs are: a) sequential applications of preemergence (PRE) and postmergence (POST) herbicides applied at different dates, b)tank-mixes of PRE and POST herbicides applied as a single application after weeds emerge, c) multiyear use of PRE herbicides applied at reduced rates over years, and d) role of turfgrass species on competition with weeds when treated with herbicides at reduced rates. PRE herbicides applied at 50 to 75% lower than the recommended rate in late winter and followed by one timely POST herbicide application in late spring or early summer controlled crabgrass and goosegrass in common bermudagrass as effectively as the maximum labeled rate of PRE herbicides applied alone. In general, tank-mixtures of PRE and POST herbicides applied in a single application at reduced rates were not as effective as sequential applications of PRE and POST herbicides in controlling crabgrass and goosegrass. When PRE herbicides are applied to the same plots for one to three years, the rates for selected herbicides for crabgrass can be reduced. For crabgrass, the rates can be reduced by 50% the first year and by 75% the following years. Reduced PRE herbicide rates were less effective on goosegrass than on crabgrass during the first year of treatment. However, the rates for selected PRE herbicides can be reduced from 50 to 75% the following two years. Most PRE herbicides did not control crabgrass as effectively in tall fescue as when applied to common bermudagrass.

"Herbicide-Resistant Weeds in Turfgrasses" Tim R. Murphy, pp. 7-10
Keywords: herbicide-resistance, goosegrass, dinitroaniline-resistance, dithiopyr-resistance.

In 1992, a Georgia golf course superintendent reported that goosegrass populations were increasing on fairways that had a history of annual applications of dinitroaniline herbicides. Field experiments were conducted at this golf course in 1993 and 1994 to determine if this population of goosegrass was resistant to dinitroaniline herbicides. Oxadiazon, prodiamine, pendimethalin, oryzalin and dithiopyr were applied at maximum labeled rates to separate plots on a common bermudagrass fairway either as single or sequential treatments. The initial herbicide application was in mid-February of 1993 and 1994. Sequential applications were made approximately 8 weeks later (mid-April) after the initial February application. Goosegrass control was recorded at 4 and 5 months after the initial February application in 1993 and 1994, respectively. Pendimethalin, oryzalin, prodiamine and dithiopyr did not control goosegrass either as a single or sequential application. Oxadiazon provided > 90% goosegrass control. Additional research showed that diclofop and MSMA + metribuzin applied postemergence at labeled rates would also control this population of goosegrass. Dinitroaniline-resistant goosegrass has been detected in turfgrasses; however, it can be controlled with oxadiazon, diclofop and MSMA + metribuzin. Additionally, dinitroaniline-resistant goosegrass is cross-resistant to dithiopyr.

"Conducting a Bioassay for Herbicide Residues" Joseph C. Neal, pp.10-12
Key Words: bioassay, chemicals, herbicides, residues.

The bioassay, a technique for determining if herbicide (or other chemical) residues are present in soil or water in high enough concentrations to adversely affect plant growth, is discussed. It is a simple and direct method that is useful in determining whether it is safe to seed or plant into areas previously treated with herbicides or into soil with an unknown history of herbicide use. This technique is also sometimes used to estimate herbicide concentrations in soil and water, and to identify unknown herbicide residues from the symptoms of injury. Step by step instructions on how to conduct a bioassay are given; as are options on steps that can be taken if residues are present.

February 1996

"Managing Turf for Maximum Root Growth: Are You Making Your Job More Difficult by Not Getting to the 'Roots' of Many Turf Management Problems?" Richard J. Hull, pp. 1-9

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Keywords: cool-season grass, cultural management, photorespiration, photosynthetic partitioning, root growth, sinks, sources, warm-season grass.

Turfgrasses acquire all water and most mineral nutrients through their roots. An extensive efficient root system enables turf to resist environmental stresses, recover from injury, and tolerate the assault of insect and disease pests. The turfgrass manager might minimize many problems by considering the impact of cultural practices on the condition of turf roots. In cool-season grasses, root growth follows an annual cycle of increase and decline but this pattern can be moderated by appropriate management strategies based on manipulating the source -sink relations within the grass. Mowing height, fertilization, irrigation and pest control practices can all be altered to maintain root condition. However, because root status is not obvious nor easily monitored, managing a turf root system requires an understanding of the physiology underlying root growth and development. This article attempts to outline some interactions between turf management practices and the physiological processes which control the growth and maintenance of roots. There is little doubt that root based turf management will pay dividends in the form of fewer and less serious problems in maintaining a high quality resilient turf.

"Maximizing Disease Control with Fungicide Applications: The Basics of Turfgrass Fungicides-Part One: Fungicide Use and General Properties"
Eric B. Nelson, pp. 10-17
Keywords: contact fungicide, disease control, fungal pathogens, fungicide labeling, penetrant fungicide, formulations, fungicides.

Fungicide applications have been the mainstay of golf course superintendents, lawn care operators, and other turfgrass managers for the control of fungal turfgrass diseases. Fungicides have revolutionized the turfgrass industry; however, turfgrass managers have become overly dependent on them. This has led to situations in which abuses of fungicide applications have become commonplace. Despite the dependency on fungicides for effective disease control, turfgrass managers have generally had insufficient information with which to make logical decisions regarding the selection and application of turfgrass fungicides. This article reviews some of the current trends in fungicide applications, as well as important information on types of fungicides available to the turfgrass manager and how these fungicides behave in plants and suppress fungal pathogens. This is the first part of a multipart series on fungicide use in turfgrasses.

"U.S. Environmental Protection Agency and Turf Organizations Form Partnership" Sherry L. Glick and Anne Leslie, pp. 17-19
Key Words: EPA, Golf Course Superintendent's Association of America, Pebble Beach, PESP, Pesticide Environmental Stewardship Program, pesticides, Professional Lawn Care Association of America, U.S. Environmental Protection Agency, US Golf Association.

The U.S. Environmental Protection Agency's voluntary program to reduce risk and use of pesticides is described. The voluntary program, called the Pesticide Environmental Stewardship Program (PESP) has both Partners and Supporters involved in reducing risk and use of pesticides. The turfgrass organizations that participate in PESP are named and several of their projects are described. The turfgrass organizations included in PESP are: the Golf Course Superintendent's Association of America, Pebble Beach, Professional Lawn Care Association of America and the US Golf Association.

March 1996

"Growth Regulators and *Poa annua*" Thomas L. Watschke, pp. 1-4
Key Words: annual bluegrass, GA, gibberellin, growth regulators, mitotic inhibitors, *Poa annua*, seedhead suppression, stand conversion.

The use of growth regulators for managing turf has increased greatly in the last 10 - 15 years; this is due to an expanded number of product choices, research into potential uses, and an experience base of successes among users. It is now considered a viable option for the management of fine turf. Two types of growth regulators are discussed: mitotic inhibitors, which provide growth suppression by reducing cell division, and gibberellin (GA) suppressers, which suppress growth by interrupting the plants ability to synthesize GA, a hormone which is necessary for the natural elongation of plant cells. The advantages and disadvantages of using either type of growth regulator for the management of *Poa annua* is also discussed.

"Maximizing Disease Control with Fungicide Applications: The Basics of Turfgrass Fungicides - Part Two: Behavior of Soil"
Eric B. Nelson, pp. 5-11
Keywords: adsorption, fungicide behavior, leaching, microbial degradation, soil properties, turfgrass pathogens, volatile losses.

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The efficacy of fungicide applications to turfgrass soils can be related, in part, to their behavior in soil. Since turfgrass pathogens are generally soil inhabiting fungi, turfgrass fungicides must find their way to the soil or thatch for effective disease control. However, the soil-thatch interface under a mature turfgrass canopy is one of the most difficult environments in which to apply fungicides successfully. In this zone, fungicides can be immobilized, degraded, dissipated, and inactivated quite rapidly. This is related to a number of factors, including the degree of sorption of fungicides to organic matter and soil particles, the amount of microbial and chemical degradation, photodecomposition, root absorption, and movement out of the soil profile through volatilization and leaching. An understanding of these factors that effect fungicide behavior can ultimately lead to more effective fungicide applications by helping to maintain maximum amounts of fungicidal activity with the least amount of undesirable side effects. This article reviews some of the major soil factors affecting fungicide performance in turfgrass systems.

"Poa Annua Management" Bridget Ruemmele, pp.11-14
Key Words: Poa annua, annual bluegrass, weed controls.

Poa annua, or annual bluegrass, has variable growth habits and adaptability to harsh environments. Compacted soils, inadequate drainage, excessive close mowing, high nitrogen, adequate water, and mild summers favor its growth. Annual bluegrass is susceptible to anthracnose, dollar spot, brown patch, pythium, and snow mold. Ice cover and repeated thawing and freezing can decrease *Poa annua* survival. New sites may be treated with soil sterilants. Pre-emergent chemical controls include benefin, bensulide, oxadiazon, prodiamine, pendimethalin, DCPA, and isoxaben. Post-emergent chemical control of plants is limited to ethofumesate, while seedhead suppression chemicals include maleic hydrazide, chlorfluorenol, mefluidide, and Paclobutrazol.

April 1996

"Maximizing Disease Control with Fungicide Applications: The Basics of Turfgrass Fungicides - Part Three: Plant and Pathogen Factors Affecting Fungicide Efficacy" Eric B. Nelson, pp. 1-7
Keywords: excessively-growing turfgrass, fungicide efficacy, fungicide resistance, inoculum, pathogen factors, phloem, translocation, vigorously-growing turfgrass, xylem.

Most often, turfgrass fungicides are applied to diseased turfgrass plants that are in a state of poor health or decline. In many cases under severe disease pressure, the effectiveness of many turfgrass fungicides is less than optimal or they may fail altogether. This is related to a large degree to several plant and pathogen characteristic that affect the uptake and distribution of fungicides inside the plant and the sensitivities of the pathogen to the fungicide. In this section, these and other aspects of the physiology of turfgrass plants and the life stages of the pathogens will be discussed in relation to the performance of fungicides.

"Herbicide Effects on Bermudagrass Turf" Fred Fischel, pp. 8-13
Key Words: Dimension, dithiopyr, Ronstar(r), oxadiazon, pendimethalin, Barricade, prodiamine, Surflan, oryzalin, bermudagrass, soil persistence.

Several experiments were conducted in recent years to evaluate the influence of pre-emergence herbicides on rooting characteristics of bermudagrass turf. The specific objectives of these experiments were to determine the effect of pre-emergence herbicides on root growth over time and to determine if such herbicides have the potential to cause root injury at various depths in the soil profile. Turf was treated in field plots, plugs were removed at various time intervals and grown in the greenhouse, and rooting characteristics were determined after six weeks of growth. Root fresh weight was reduced the greatest with Dimension(r) or Barricade(r). Pendimethalin caused fewer fresh weight reductions compared to Dimension or Barricade and these reductions were usually for only a short period of time. Lower root weight in these plots could be attributed to fewer roots produced and malformed roots. Additionally, greater numbers of malformed roots were observed for longer periods where Dimension or Barricade had been applied. Barricade and Surflan(r) were detected as deep as three inches in a light-textured soil which had received relatively high amounts of rainfall. In the top one-inch of the soil profile, Barricase, Dimension, Surflan and pendimithalin all caused a reduction in root weight. These findings were based upon a bioassay using Tifgreen bermudagrass as an indicator species.

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May 1996

"Multiple Considerations in Turfgrass and Landscape Pest Management" Michael G. Villani, pp. 1-7
Keywords: IPM (integrated pest management), pesticide hazards, risk assessment.

Growing pesticide use has created concerns about urban pesticide hazards to the environment and human health. The public considers risk factors such as: how well the action being considered is understood; how equitably the danger is distributed; how well individuals can control their exposure; and whether risk is assumed voluntarily. IPM (integrated pest management) involves consumers and professionals to control pest damage through scouting, pest identification, records keeping, and using the appropriate intervention technology rather than applying pesticides through pre-scheduled applications. Consumer awareness can be raised through education, use of cultural means, optimized pesticide use, and chemical alternatives for pest control. IPM Ornamentals Program addresses additional IPM techniques for the ornamentals producers. These tactics are: advancing host plant resistance, developing complex landscapes, better environmental management, use of natural biological control agents, pest barriers, traps, and quarantining imported plants. Consumer pressure has warranted the development and implementation of IPM techniques.

"The First Registered Biological Control Product for Turf Disease: Bio-Trek 22G" G.E Harman and C.T. Lo, pp.8-14
Key Words: Trichoderma, Trichoderma harzianum, Nontarget organisms.

The first registered biological control product, Bio-Trek 22G, for the control of turf diseases is now available. This product contains a strain of the beneficial fungus, Trichoderma harzianum, and is designed for broadcast application to turf. The fungus establishes on the roots and in the soil of turf and persists for months after application. Once establishment occurs, it can become a component of a healthy soil microbial community and reduce soilborne disease. It cannot, however, control foliar diseases and therefore must be used in conjunction with compatible fungicides. We anticipate that Bio-Trek 22G will be the first of several products for turf disease control. Other biological and integrated biological-chemical control products will be manufactured by TGT and they will extend usefulness of Bio-Trek 22G.

June 1996

"Enhancing Turfgrass Disease Control with Organic Amendments" Eric B. Nelson, pp. 1-15
Keywords: amendments, composts, disease suppression, organic fertilizers, peats, root-zone amendments, sludges, topdressing.

Organic amendments are gaining wider use in the turfgrass industry both as a means of increasing nutrient and water retention in sand-based growing media but also as fertilizers, thatch reducers, and materials to suppress turfgrass diseases. Among the more effective types of amendments have been composed amendments containing high levels of microbial activity and capable of inducing high levels of microbial activity in treated soils. Many of the microbes found in composts and in soils treated with composts can act as biological disease control agents. In this article, the author reviews some of the basic aspects of organic amendments in turfgrass management and some of the microbial aspects of composting that relate to the suppression of turfgrass diseases.

July 1996

"Heat Stress and Decline of Creeping Bentgrass" Leon T. Lucas, pp. 1-8
Keywords: anaerobic soil, bentgrass, heat stress, irrigation practices, North Carolina, Phthium root rot, Rhizoctonia brown patch, soil condition.

Heat stress is a major factor in the decline of bentgrass golf greens during hot and humid weather. Many factors are involved including temperature, metabolism, environmental factors, soil conditions and diseases. Bentgrass does not grow when temperatures are above 90 degrees and root growth ceases at 77 degrees. The photorespiration process of metabolism is less efficient at higher temperatures resulting in weaker plants that decline and do not recover from stresses and diseases during hot weather. Wet soil conditions result in low oxygen levels and encourage the development of diseases. Diseases such as Pythium root rot and brown have been shown to be involved in the summer decline of bentgrass. Modification of environmental conditions around greens and management practices have helped bentgrass to tolerate summer stress conditions. A fungicide program that includes Aliette plus Fore or Aliette plus Daconil has helped to manage summer decline of bentgrass in hot and humid regions in the country.

"The Oriental Beetle" Steven R. Alm, pp. 9-13
Keywords: oriental beetle, *Exomala orientalis*, distribution, pheromone, biological and chemical control.

The distribution, life history and habits, and turf damage caused by oriental beetles, *Exomala orientalis* (Waterhouse) are described. The use of a newly identified pheromone for monitoring and possible population suppression is discussed, as well as control of larvae with entomopathogenic nematodes, *Bacillus thuringiensis* var. japonensis strain Buibui, and insecticides.

August 1996

"Field Testing of Biological Pesticides" David J. Shetlar, pp. 1 - 9
Keywords: biological controls, entomopathogenic nematodes, field testing, LD50, pathogenic controls, target pests.

Biological controls ("biological pesticides") can be developed and used as a regular pesticide by determining the pathogens of target insect pests. The process includes discovering the pathogen, producing the pathogen, testing in small plots, testing in large production scale, and marketing the new product. The collection of pathogens involves looking at native populations of target pests or closely related insects for naturally occurring diseases or finding new forms of pathogens from soil and dust samples taken worldwide. Screening of new biological controls uses a uniform age-class of insects, therefore, field testing will result in more accurate efficacy results of the new controls. Biological pesticides are difficult to compare to a chemical standard because biological pesticides work much slower, over weeks or into the next season, but can be progressively more lethal over time. A case study on entomopathogenic nematodes, *S. carpocapsae, S. scapterisci,* and *S. riobravos* is highlighted.

"The Basics of Trufgrass Fungicides - Part Four: Handling and Applying Fungicides" Eric B. Nelson, pp. 10-15
Keywords: EC (emulsifiable concentrates), F (flowables), FLO (flowables), fungicide application, fungicide efficacy, WDG (water dispersable granules), WP (wettable powders).

The vast majority of turfgrass managers do not actually apply the rates of fungicides that they think they are applying. Nearly all make mistakes in mixing, loading, configuring equipment, and calibrating delivery devices. National losses due to these mistakes have been estimated to be in the billions of dollars. Additional losses have occurred because of reduced fungicide effectiveness resulting from improper measuring and calibration. This article reviews many of the important reasons and methods for careful measuring, mixing, and loading fungicides and in routinely calibrating and maintaining equipment. Additional problems such as proper timing and placement of fungicide applications are also reviewed.

September 1996

"Back to Basics-Insecticide Primer, Part One: What Insecticides Can and Cannot Do" Dr. Patricia J. Vittum, pp. 1-8
Keywords: insecticide, larva, leaching, pesticide, pH, Run-off, white grub.

Some turf managers and their customers expect insecticides and other pesticides to solve many, if not most, turf management problems. However, there is a limit to what insecticides can and cannot do. This article, which is the first in a six part series, discusses some of those limits, and points out a few areas where attention to detail can increase the effectiveness of insecticides. Many of the points made in this article hold true for other kinds of pesticides (for example, fungicides and herbicides) as well. The topics discussed include: reasonable expectations of the insecticide, accurate identification of the problem, choosing an appropriate material, using that material correctly (timing of application, accurate application, and use of water), and a few environmental considerations.

"Where to Find Product Information" Michael G. Villani, pp. 3
Keywords: Arthropod Management Tests, Handbook of Turfgrass Insect Pests, insecticide efficacy, product labeling, target insect pests.

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Turfgrass managers can find reliable information on insecticides by using some of these resources. The Arthropod Management Tests is an unbiased technical comparison of available insecticides based on a compilation of hundreds of field experiments conducted throughout the country. The Handbook of Turfgrass Insect Pests includes a listing of university turfgrass entomologists. Chemical company representatives can be knowledgeable of their company's products.

"Fungicide Index: EPA Registered Fungicides for Turfgrass Applications in the United States" Eric B. Nelson and Dan Dinelli, pp. 13-18
Keywords: active ingredient, EPA (Environmental Protection Agency), formulations, registered fungicides, registration number, trade name.

This is a list of all registered fungicides in the United States by active ingredient, trade name(s), formulation(s), EPA registration number, manufacturer's (or sub-registrant's) address and phone number, if available.

October 1996

"Managing Turf for Minimum Water Use" Richard J. Hull, pp. 1-8
Keywords: boundary layer, canopy resistance, cool-season grass, ET (evapotranspiration), stomates, warm-season grass, water conservation.

As water becomes increasingly in short supply for turf irrigation, a concept of efficient water use is emerging and being applied to refine irrigation practices. The basic physical laws governing water use by turf are outlined and the idea of water requirement is being challenged. Evapotranspiration (ET) is the primary route of water loss from turf and this process is discussed in relation to the function of stomates and the elements of plant canopy resistance to water movement. Efficiency of water acquisition is discussed as a function of root length density and its generic variability among turfgrasses. The role of turf management in promoting root growth is considered as well as the impact of soil drying on ET. Relationships between these two factors are developed as the basis for water deficit irrigation. These concepts offer the basis for a water management strategy that may reduce turf water use by fifty percent.

"Turfgrass Diagnostic Laboratories in the United States and Canada" Eric B. Nelson and Erin Kennedy, pp. 2-5
Keywords: disease diagnosis, insect identification, pest diagnosis, nematode detection, plant and weed identification.

This is a list of state-supported diagnostic laboratories current as of October 1996. Each entry includes a "Laboratory Services" key at the bottom of its entry.

November 1996

"Effect of Nitrogen Fertilization on Turfgrass Disease Injury" John E. Watkins, pp. 1-5
Keywords: dollar spot, brown patch, crown rust, nitrogen rate.

A study at the University of Nebraska-Lincoln showed that nitrogen levels of 6 and 8 lb. of actual N/1000 ft2/season caused significantly greater brown patch injury than 4 or less lb. on a Rebel tall fescue turf. The turf in those plots receiving no nitrogen was chlorotic, lacked vigor and was not aesthetically acceptable. At 2 or 4 lb. of nitrogen, turf quality was acceptable while disease injury remained low to moderate. A similar study comparing the effect of nitrogen rates on brown patch and crown rust injury in perennial ryegrass showed that as nitrogen rate increased from 0 to 8 lb., disease injury decreased. The color and quality of the plots fertilized at 4 and 8 lb. N was visibly better that that at 0 and 2 lb. N. These plots at the higher N rates recovered quickly from the disease injury and maintained a good verdure, color, and quality. Dollar spot injury to creeping bentgrass was effectively suppressed at the 6 and 8 lb. nitrogen rates in a 3-year study that compared quick-release urea (46-0-0) with slow-release, sulfur-coated urea (32-0-0) at 0, 2, 4, 6, and 8 lb. N/1000 ft2/year. There was no interaction between nitrogen rates and the slow- or fast-release carrier, however, by mid-season the quick-release urea was giving greater disease suppression than the sulfur-coated urea. At the higher rates, the bentgrass is able to quickly recover from dollar spot injury.

TurfGrass TRENDS - 1996 Abstracts

"Nitrogen Usage By Turfgrasses" Richard J. Hull, pp. 6-15
Keywords: nitrogen chemical properties, nitrogen mobility, nucleic acid, peptide bonds, protein catalysts.

Nitrogen is the most abundant mineral nutrient in plant tissues. Its abundance is a result of its roles in establishing and maintaining the structure of proteins and nucleic acids. Proteins function as catalysts for virtually all metabolic reactions and nucleic acids provide the genetic code and the template for the synthesis of all proteins. This review outlines those chemicals properties of nitrogen which are responsible for its role in protein and nucleic acid structure and function. The peptide bond is discussed as are those functions of nitrogen derived from its properties as a hard base: hydrogen binding resulting in cation formation, metal bonding in pigment and enzyme function, and electropositive group function in hormone action and stress tolerance. Variable nitrogen content of plant tissues is explained based on plant responses to enzyme inefficiency and the mobility of nitrogen in response to deficiency conditions. Turf management strategies for maximizing the efficiency of nitrogen use are reviewed in the context of nitrogen's basic physiological functions.

December 1996

"The Basics of Turfgrass Fungicides - Part 6: Human Health and Enviornmental Quality Considerations" Eric. B. Nelson, pp. 13-17
Keywords: fungicide toxicity, acute toxicity, LD50, chronic toxicity, nontarget effects, fungicide safety.

The impacts of fungicides on human health and the environment is becoming an increasing concern in golf course management. Fungicides, as all pesticides, have certain human risks associated with their handling and application. Since fungicides, like insecticides and herbicides, are designed to kill living organisms, they are potentially hazardous to humans as well as to the fungi they are intended to kill. Furthermore, they have the potential for exerting considerable environmental impacts and ecological disturbances. However, compared to other pesticides, fungicides generally are among the least toxic. In this article, I discuss the potential risks associated with fungicide use, the toxicities of turfgrass fungicides, and ways to maximize the human and environmental risks associated with these materials.

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The Basics of Turfgrass Fungicides Part 6: Human Health and Environmental Quality Considerations

by Eric B. Nelson
Cornell University

The toxicity of a substance is its capacity to cause injury to living systems. Living systems include the more obvious biological things such as organisms (including humans) or parts of organisms (organs). However, living systems can also include such things as ponds, lakes, streams, or any other type of ecosystem.

Because of the high frequency of fungicide applications, particularly on some golf course turfs, there is a high potential for negative environmental side effects. Furthermore, frequent fungicide applications coupled with a high level of contact between treated plants and people pose a significant potential risk to human health.

Fungicide Exposures

One of the more critical determinants of fungicide toxicity is the dose-time relationship. Dose is the quantity of the fungicide that something is exposed to while the time represents the frequency and duration of exposure. These dose-time relationships give rise to both acute and chronic toxicities. Acute toxicity refers to the toxicity of a fungicide after a short-term exposure. The effects of this type of toxicity are seen immediately following exposure. The acute toxicities of fungicides are the basis for label statements such as danger, warning, and caution. Chronic toxicities, on the other hand, refer to the delayed toxic effects from fungicide exposure. Those fungicides with high acute toxicity may not necessarily have high chronic toxicity. Similarly, those with low chronic toxicity may not necessarily have low acute toxicity One of the best ways to reduce the toxicity of a fungicide, whether it be acute or chronic, is simply to reduce your exposure.

Fungicides cause toxicities because they get into your body. They can enter your body either through your skin (dermal), through your mouth (oral), or in a vapor or mist form through your nose or mouth (inhalation).

Dermal Entry - Fungicide is absorbed directly through the skin. This is a function of the properties of the fungicide. Skin around the eyes, ear drums, scalp, and groin absorb fungicides more readily than other parts of the body. Common symptoms of acute dermal exposure include rashes and itches, headaches, and irritated eyes.

Oral Entry - Fungicides may enter the body on contaminated food, cigarettes, or other items placed in the mouth. This usually arises from contaminated hands or food containers. Common symptoms of acute oral exposures include dizziness, sweaty hands, nausea, muscle twitches, fainting, fatigue, diarrhea, loss of appetite, and swelling.

Inhalation Entry - Inhalation of fungicides can occur during mixing, spraying, and other handling procedures. Properly configured respirators can largely avoid problems with inhalation toxicities. Choosing formulations and handling procedures to avoid dusts or aerosols will also reduce the chance of inhalation exposures. Symptoms of acute inhalation exposure include many of the symptoms of oral exposures as well as a sore throat, coughing, irritated lungs, and irritated nostrils.

All of these modes of entry are important, particularly for golf course superintendents and golfers. Both groups have high exposure **potential** because of the frequency with which they come in contact with treated turf. There are numerous instances where fungicide applications are made just minutes before golfers begin play. This is particularly a problem on public golf courses where the volume of play often makes it impossible to shut down the golf course during spray applications. This makes it impossible for golf course superintendents to tightly adhere to reentry restrictions following some fungicide applications. Some mechanism needs to be implemented to avoid this type of public exposure to fungicide residues.

The nature of golf can also lead to potential fungicide exposures. The game of golf requires the frequent handling of golf balls, tees, and clubs, all of which harbor fungicide residues, particularly if golfers are on the course shortly after applications are made. The risk of exposure can be further increased if golfers do not wash their hands before visiting the clubhouse after a round of golf. Contaminated hands coming in contact with food and drink provide easy entry of fungicides into the body. Ultimately, regardless of the route of entry, the fungicide ends up in the blood stream where it is transported throughout the body.

Fungicide Toxicities

The toxicities of fungicides are usually determined as a function of either acute dermal, oral, or inhalation exposures. These toxicities are expressed either as LD50 or LC50. The LD50 is the lethal dose required to kill 50% of the test animals at a given time, whereas LC50 is the lethal concentration (in water or air) that kills 50% of the test animals at a given time. The following table indicates how certain toxicity levels are classified by the US Environmental Protection Agency (EPA).

Turfgrass fungicides vary in their mammalian toxicities. Even so, none are highly toxic. Nearly all have either a medium or low toxicity ranking. Among the more toxic fungicides are metalaxyl and etridiazole, both Pythium-selective fungicides. However, these toxicities are based on acute exposures and not chronic exposures. The effects of chronic exposure on toxicity are largely unknown for turfgrass fungicides. Among the least toxic of the commonly used turf fungicides are mancozeb, chlorothalonil, chloroneb, and vinclozolin.

Table 1. Categories of Acute Fungicide Toxicity

Toxicity Rating (Signal Words)	*EPA* Classification	*Type of* Exposure	*Amount of* Exposure[1]	*Probable Lethal Dose* (150-lb. man)
Very High (Danger, Poison)	I	Oral	0-50 mg/kg	0-1 tsp.
		Dermal	0-200 mg/kg	
		Inhalation	0-0.2 mg/l	
High (Warning)	II	Oral	50-500 mg/kg	1 tsp.-1 oz.
		Dermal	200-2,000 mg/kg	
		Inhalation	0.2-2 mg/l	
Medium (Caution)	III	Oral	500-5,000 mg/kg	1 oz. - 1 pint
		Dermal	2,000-20,000 mg/kg	
		Inhalation	2-20 mg/l	
Low (Caution)	IV	Oral	over 5,000 mg/kg	
		Dermal	over 20,000 mg/kg	
		Inhalation	over 20 mg/l	

1 LD50 or LC50 of fungicides within each rating class.

Field Tips: Post Signs for Golfers *by Dave W. Fearis, CGCS, Blue Hills Country Club*

When talking about the application of fungicides on golf courses, it should be noted that golf course superintendents are widely considered to be among the best educated and most judicious users of pesticide products.

A recent survey indicated that 71 percent of the GCSAA members have either a two- or four-year college degree. Another survey showed that 98 percent of GCSAA-member courses had at least one licensed pesticide applicator on staff. The *1996 GCSAA Golf Course Superintendents Report* further illustrated this environmental consciousness by superintendents with the following statistics:

• 85 percent of the superintendents responding to the survey have implemented an IPM program.
• 94 percent of the superintendents responding were making an effort to reduce the quantity of plant protectants used.

Golf course superintendents have made a concerted effort to make golfers aware of fungicide applications. They often post signs on the 1st and 10th tees and notices in the pro shop and on the locker room bulletin board. Many superintendents write articles for their club newsletter explaining the value of fungicides as part of an integrated disease management program. As a result, golfers feel informed about the steps necessary to provide quality playing conditions and involved in the protection of the environment.

Posting reminds golfers of common-sense precautions - washing hands before eating; not putting tees, markers or balls in the mouth; wearing socks and shoes on the course. You are making the effort to warn those who might be sensitive to fungicides, just as you would warn them of the chance of being stung by bees or struck by lightning. It's the responsible thing to do. You care about them and the environment.

Dave W. Fearis, CGCS, is a member of the Board of Directors of the Golf Course Superintendents Association of America.

Aside from negative side effects on human health, turfgrass fungicides might also give rise to some negative environmental and ecological side effects. This topic has been covered previously in *TurfGrass TRENDS*. Refer to the following articles for more infomation on this subject:

Vol. 4, Issue 5, May 1995. Nontarget Effects of Fungicide Applications.

Vol. 4, Issue 9, Sept. 1995. The Fate of Pesticides Used on Turf.

Vol. 4 Issue 3, March 1996. Maximizing Disease Control With Fungicides, Behavior in Soil.

Are Turfgrass Fungicides Hazardous?

Hazard is nothing more than the risk of danger. The hazards of turf grass fungicides are related not only to their inherent toxicity, but to the potential for exposure. For example a highly toxic fungicide may be considered hazardous because of the perceived risk it poses as a function of its toxic properties. However, with proper safe handling, a highly toxic fungicide may pose less of a risk and be less hazardous than a relatively low-toxicity fungicide that is misused.

Aside from its inherent toxicity, a number of other factors can make a particular fungicide hazardous. These include the concentration and dosage of the fungicide, the skill of the applicator, and the formulation of the fungicide.

Concentration And Dosage - Usually, the more concentrated the formulation, the more hazardous is the fungicide. As a general rule, it is always best to handle and apply the lowest possible concentration of a fungicide that is still in keeping with label instructions.

Skill of Applicator - It is important that, as an applicator, you have had the proper training and are certified in your state. A skilled and well-trained applicator is less of a hazard to himself, others, and the environment than perhaps a homeowner with little or no training or knowledge of the materials he or she is using.

Fungicide Formulation - The hazard of a fungicide is also influenced by its formulation. Formulations such as emulsifable concentrates (E or EC) that are easily absorbed through the skin or wettable powders (W or WP) that are easily inhaled during handling procedures pose the greatest risk to the turfgrass manager. In response to this hazard, many of the fungicide manufacturers have moved to safer formulations such as water soluble packets (WSP), water dispersible granules (WDG), and wet or dry flowables (F, FLO, DF).

Fungicide Safety

It is important that anyone handling and applying fungicides or any other pesticides treat them with a great deal of caution. Study after study has shown that proper protective clothing provides the greatest level of protection from exposure during mixing, handling, loading, and application procedures. Among the most valuable pieces of protective gear are a Tyvek or GoreTex suit, proper gloves, and a respirator.

An alarming number of turfgrass managers refuse to wear such clothing because it makes them too hot, or too uncomfortable. Keep in mind, however, that even though acute toxicities of fungicides are not of much concern when compared with other pesticides, the health effects from chronic exposures are largely unknown. In some cases, cancers, reproductive disorders, neurological diseases, immunological problems, and other organic disorders s have been observed following long-term fungicide exposures.

It should be recognized that even the most toxic of fungicides can be safe if handled properly, while even the least toxic fungicide can be hazardous if misused. Part of being a responsible turfgrass manager and environmental steward involves the safe and proper handling of fungicides and other pest management products.

Table 2. Mammalian Toxicity of Turfgrass Fungicides Ranked From Most Toxic to Least Toxic[1]

Fungicide	*Acute Dermal LD_{50} (rabbits)*	*Acute Oral LD_{50} (rats)*
Metalaxyl	>3,100	633
Triadimefon	>2,000	1,000
Thiram	>5,000	1,000
Cyproconazole	>2,000	1,020-1,333
Etridiazole	1,366	1,028
Propiconazole	>4,000	1,517
Quintozene	2,000-4,000	1,700-5,000
Propamocarb	>3,920	2,000-8,500
Iprodione	>2,000	>2,000
Fenarimol	4,500	2,500
Anilazene	>5,000	>4,000
Fosetyl Al	>2,000	5,800
Thiophanate Methyl	>10,000 (rats)	7,500
Flutolanil	>5,000	>10,000
Chlorothalonil	>10,000	>10,000
Benomyl	>10,000	>10,000
Chloroneb	>5,000	>11,000
Mancozeb	>15,000	11,200
Vinclozolin	>2,000	>16,000

1 Based on oral Ld50's.

Sources: Tomlin, C., 1994. The Pesticide Manual, British Crop Protection Publications, British Crop Protection Council, UK
Foster, R. Knake, E.L. McCarty, R.H., Mortvedt, J.J., Murphy, L. 1994 Farm Chemicals Handbook, Meister Publishing, US

Predictions for the Future

by Gail L. Schumann
University of Massachusetts

The next decade is likely to decide the future of biological control agents in turfgrass disease management. A number of products are becoming available, as are several different application methods. Turfgrass offers an excellent potential success story for these products because of the intense, daily management of turfgrass, the budgets available, the ease of application to turfgrass compared to many other types of plants, and the mowing and regrowth of turfgrass leaf blades. The current investigations into which fungicides are compatible with biological agents will also be important to protect plants during intense periods of disease pressure.

I hope that the next decade will also see a shift in management philosophy back to providing optimal growing conditions for turfgrass. The most destructive diseases are those associated with fungi which destroy the roots and crowns of the plants. These diseases are difficult or impossible to control with fungicides and require long recovery times for the turf. They are also associated with increased traffic, lower mowing heights, and compaction - all familiar problems to today's superintendent. Relatively modest modifications in playing conditions could prevent a lot of disease injury.

The next decade is likely to decide the future of biological control agents in turfgrass disease management.

There is no doubt that a computer will become a necessary tool for all turfgrass managers and will aid in management decisions from irrigation to fertilizer and pesticide applications. Computers will also be important in improved communication among superintendents and with turfgrass specialists through the internet.

Gail L. Schumann is Associate Professor and Turfgrass Pathologist at the University of Massachusetts, Department of Microbiology.

In Future Issues

- Insecticide Primer - Part II
  Classes of Insecticides
  Insect Resistance
  Speed of Efficacy
- Maximizing Irrigation Efficiency
- Advanced Concepts in Turfgrass Nutrition
- Physiology of Winter Injury

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