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Chemical Control of Insects, Diseases, Weeds, and Nematodes for Commercial Turf Managers

Cooperative Extension Service

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# **Chemical Control of Insects, Diseases, Weeds and Nematodes for Commercial Turf Managers**



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# Chemical Control of Insects, Diseases, Weeds and Nematodes for Commercial Turf Managers

Departments of:  
Botany and Plant Pathology  
Crop and Soil Sciences  
Entomology  
Pesticide Education, MSU Extension

With support and encouragement from the  
**Michigan Turf Foundation**

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*Revised 5:00 - 2M - KMF - BRD, Price \$10.00, for sale only (Turfgrass).*

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The pesticide label is the legal document that regulates the use of a pesticide. Pesticide labels can change suddenly. Always read the label before making a pesticide application. The following recommendations are not intended to replace the specific product labels. The following products were labeled for the uses listed and were registered with the Michigan Department of Agriculture as of March, 2000.

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# Turfgrass Pest Management and Pesticide Use

**M**aintaining high-quality turfgrass for golf courses, in lawns or recreational areas requires combining sound pest management with sound turfgrass management principles. This publication provides a recommended list of insecticides, fungicides, nematicides and herbicides that are appropriate for use in an integrated pest management system for turf.

Providing conditions for dense, healthy turfgrass is effective in minimizing damage from weed, insect, disease and nematode problems. For most Michigan growing conditions, proper species selection, fertilization, mowing and irrigation practices will result in turfgrass that will withstand most pest problems. For example, weeds have difficulty becoming established in dense turfgrass stands, and vigorous turfgrass swards can tolerate moderate insect and disease injury by quickly regenerating damaged plants. Turfgrass temporarily thinned by a Japanese beetle invasion can quickly recover once the insects complete their life cycle and stop feeding. Vigorous turf can withstand feeding injury from two or three times the number of grubs that would seriously injure weak or thin turf.

Though a good maintenance program helps reduce pest problems, it will not completely eliminate insects, weeds and diseases. These pests are always present at some level, and the population that is considered tolerable depends entirely on the turf owner or user. Decisions to apply turfgrass pesticides should be made only after identifying the pest problem and assessing its potential impact.

Setting simple objectives for the turf area will help identify the threshold for pest damage that can be tolerated. For instance, home lawns vary widely in use and objectives for the turf. Some people desire a low-maintenance approach, while others desire a

formal appearance. Lawns with high traffic or use will demand a different maintenance regime to satisfy their objectives than those lawns receiving little use. The professional turf manager's role is to design a program that will meet the objectives of the owner or user and provide maximum protection of natural resources.

The beginning section of this manual is designed to address the environmental and legal responsibilities of using pesticides on turfgrass for commercial applicators in Michigan.

A sound pest management program demands proper pest identification. Examine turfgrass regularly for stress or signs of pest activity. If you suspect insects or diseases are causing damage and you are having difficulty with identification or management schemes, remove a turf sample and contact your local MSU Extension office. For additional assistance, send the sample to MSU Diagnostic Services. Your local MSU Extension office can give you the address and the cost.

## Safety and Environmental Considerations

In choosing a pesticide for a particular pest, it is important to consider the impact that a pesticide will have on the environment. Some questions to ask about a pesticide application (other than its efficacy) are:

### 1. Is it harmful to beneficial insects or fungi?

In general, herbicides do not harm beneficial insects and fungi, so all herbicides can be considered harmless to non-target organisms other than plants. Though harmless to insects and wildlife, fungicides used to suppress turf diseases

are also toxic to fungi involved in the decay of dead plant material and to beneficial fungi that cause insect disease. One such beneficial fungus is *Beauveria*. The *Beauveria* fungus infects chinch bugs and billbugs, often helping to keep them under control in home lawns and other types of turf. A fungicide application made to suppress turf diseases will also suppress *Beauveria*.

Insecticides used to control turf pests can also kill many other types of insects, including predators and parasites that help keep turf pests under control. Read the insecticide label to see if it is a selective product that targets one type of insect pest without harming all insects. Some of the selective insecticides available to use on turf are the *Bacillus thuringiensis* products, Mach 2, Grub-X, M-Pede and Conserve. Merit also is only mildly toxic to earthworms and predatory insects. To maintain healthy turf, use selective products as much as possible and limit insecticide applications to portions of lawns or fairways where turf pests are active rather than treating the entire lawn or fairway.

Honeybees and many native bees are important to agriculture because they pollinate numerous fruit, seed and vegetable crops. Because of the importance of these insects, pesticides must be used in such a way as to avoid poisoning them.

Following the guidelines below will minimize the killing of bees when controlling undesirable insects and diseases.

- a. Do not apply poisonous sprays when bees are visiting plants in bloom.
- b. When there is little difference in effectiveness between two insecticides, use the one that is less injurious to bees.
- c. Avoid leaving puddles when the spray rig is emptied or cleaned. Large numbers of bees will often visit such poisonous puddles.
- d. Spray during the evening to reduce damage to bees in flight.

- e. Avoid spray or dust drift to blooming crops or weeds in nearby fields.
- f. Know the location of nearby hives.
- g. Notify the beekeeper if his/her bees are in danger.

## **2. Is it hazardous to applicators if improperly handled?**

If a pesticide is applied correctly and the reentry instructions on the label are followed, there is no danger to people and pets.

### ***Reentering treated areas.***

It is important to recognize and understand the regulations that govern reentry into pesticide-treated turfgrass areas. Specific standards apply to sod production farms. The Worker Protection Standard is a federal regulation that restricts entry onto a treated sod field by the sod farm employees. Each pesticide product that is registered for use on sod production will have specific directions for reentering treated sod fields. The minimum reentry time for all products is 12 hours. These standards may differ from the directions prescribed for the use of the product on general turf or golf course turf areas. There will be separate and specific directions for reentry into treated general turf or golf course turf areas. Make sure to read the label carefully and comply with the reentry directions for your specific use.

### ***Handling and mixing pesticides.***

Always wear protective clothing and equipment when handling, mixing and applying pesticides, and when cleaning application equipment. Personal protective equipment required during mixing, loading and applying is listed on the pesticide label under the "Precautionary Statements" section.

Mix pesticides below eye level and with your back to the wind. Avoid excessive splashing and sloshing. If you spill pesticides on yourself, wash immediately with large amounts of water and

change your clothing. Resume the spray job after cleaning up any accidents. Try to use closed handling/mixing systems whenever possible.

Mix only that amount required to treat the area to be sprayed according to label directions. Avoid mixing excessive amounts — leftover pesticide is a hazardous waste that is difficult and expensive to discard. Keep unauthorized persons out of the area in which you handle pesticides.

### **3. Is it harmful to wildlife?**

Though poisonings are rare, birds may become sick when they ingest the toxicant in granules, baits or treated seed; drink and use contaminated water; or feed on pesticide-contaminated prey. In general, insecticides are the most toxic group of pesticides to wildlife because they are designed to work on small animals (insects). Following label directions and using the most selective insecticides will minimize undesirable effects on wildlife. Most toxic to least toxic to earthworms are Mocap > Turcam > Sevin > Dylox > Dursban > Diazinon > Oftanol > Talstar > Tempo > Merit > Mach 2.

### **4. Can it directly injure turfgrass under certain conditions?**

Chemical burn can occur if sprayers or chemical spreaders are improperly calibrated. Applications should not be made to drought-stressed turf. Read the product label — since a pesticide is sometimes toxic to one type of turf (e.g., Mocap and bentgrass) but not others.

### **5. What is the potential for runoff to streams and ponds?**

Runoff is the movement of pesticides in water across the soil surface. It occurs as water moves over a sloping surface, carrying pesticides either mixed in the water or bound to eroding soil. The amount of pesticide runoff depends on the grade or slope of an area, the erodibility and texture of the soil, the soil moisture content, the amount

and timing of irrigation or rainfall, and properties of the pesticide.

### **6. What is the potential for groundwater contamination?**

*Groundwater* is the water beneath the earth's surface occupying the saturated zone (the area where all the pores in the rock or soil are filled with water). It is stored in geological formations known as *aquifers*. Groundwater moves through aquifers and can be obtained at points of natural discharge such as springs or streams, or by wells drilled into the aquifer.

The upper level of the saturated zone in the ground is called the *water table*. The water table depth below the soil surface fluctuates throughout the year, depending on the amount of water removed from the ground and the amount of water added by recharge and connected surface waters. *Recharge* is water that seeps through the soil from rain, melting snow or irrigation. Surface waters are visible bodies of water such as lakes, rivers and oceans.

Both surface water and groundwater are subject to contamination by *non-point source pollution*. This type of pollution generally results from land runoff, precipitation, acid rain or percolation rather than from a discharge at a specific, single location (such as a single pipe or wellhead). Contamination from these single sites is known as *point source pollution*.

Many people who live in Michigan get their drinking water from wells. Well water is groundwater, so it is easy to see why you should be concerned about keeping pesticides out of groundwater. Several processes determine the fate of pesticides and whether they will end up in the drinking supply.

Adsorption is the binding of chemicals to soil particles. The amount and persistence of pesticide adsorption vary with pesticide properties, soil moisture content, soil pH and soil texture. Soils

high in organic matter or clay are the most adsorptive; coarse, sandy soils are much less adsorptive. A soil-adsorbed pesticide is less likely to volatilize, leach or be degraded by microorganisms, but it is also less available for uptake by plants.

Volatilization occurs when a solid or liquid turns into a gas. Volatilization of pesticides increases with higher air temperature and air movement, higher temperature at the treated surface (soil, plant, etc.) and low relative humidity. It is also more likely when spray droplets are small. Pesticides also volatilize more readily from coarse-textured soils than from medium- to fine-textured soils with high moisture content. A pesticide in a gaseous state can be invisible and be carried away from a treated area by air currents.

Leaching also moves pesticides in water. Leaching occurs as water moves downward through the soil. Factors that influence leaching include the pesticide's solubility in water, soil structure and texture, and the amount and persistence of pesticide adsorption to soil particles.

Absorption is the process by which chemicals are taken up by plants. Once absorbed, most pesticides degrade within plants. Some residues may persist inside the plant, however, and may be released back into the environment as the plant tissues decay.

Microbial degradation occurs when microorganisms such as fungi and bacteria use a pesticide as a food source. Conditions that favor microbial growth include warm temperatures, favorable pH levels, adequate soil moisture, aeration (oxygen) and fertility. Adsorbed pesticides are more slowly degraded because they are less available to some microorganisms.

Chemical degradation is the breakdown of a pesticide by processes not involving a living

organism. The adsorption of pesticides to soil, soil pH levels, soil temperature and moisture all influence the rate and type of chemical reactions that occur. Many pesticides, especially the organophosphate insecticides, are susceptible to degradation by hydrolysis in high pH (alkaline) soils or spray mixes.

Photodegradation is the breakdown of pesticides by the sunlight.

### ***Keeping pesticides out of groundwater***

A pesticide that is not volatilized, absorbed by plants, bound to soil or broken down can potentially move through the soil to groundwater. The movement of groundwater is often slow and difficult to predict. Substances that enter the groundwater in one location can turn up years later in other locations. A major difficulty in dealing with groundwater contaminants is that the sources of pollution are not easily recognized. The problem is occurring underground, out of sight.

It is very difficult to clean contaminated groundwater. The best solution is to prevent contamination in the first place. The following pesticide application practices can reduce the potential for surface and groundwater contamination.

Consider the geology of your area — Be aware of the water table depth and the permeability of the geological layers between the surface soil and groundwater. Sinkholes can be especially troublesome because they allow surface water to reach groundwater quickly.

Avoid back-siphoning — The end of the fill hose should remain above the water level in the spray tank at all times to prevent back-siphoning of chemicals into the water supply. Use an antibackflow device when siphoning water directly from a well, pond or stream.



Consider weather and irrigation — If you suspect heavy rain will occur, delay applying pesticides. Control the quantity of irrigation to minimize potential pesticide leaching and runoff.

Avoid spills — When spills occur, contain and clean them up quickly with an absorbent material such as cat box filler.

Mix on an impervious pad — Mix and load pesticides on an impervious pad if possible, where spills can be contained and cleaned up. In Michigan, commercial pesticide applicators are required to have a mixing and loading pad if mixing and loading of pesticide products are conducted on the same site more than 10 days a year.

Store and mix pesticides away from water sources such as wells, ponds and springs.

Pesticides can be harmful to all kinds of vertebrates such as fish and other wildlife. Most recognizable are the direct effects from acute poisoning. Fish kills can result from water pollution by a pesticide (usually insecticides). Pesticides can enter water via drift, surface runoff, soil erosion and leaching.

## **Regulations and Proper Use of Pesticides**

### ***Posting and notification***

In Michigan, pesticide application to a turfgrass area by a commercial applicator and applications on golf courses are subject to specific posting and notification requirements. For general turf areas, an approved sign must be placed at the point of entry to the property or treated area that will notify the owner or users of the turf area that a pesticide was recently applied. Approved signs for lawn applications are available from most turf industry product suppliers. The signs direct the property owners to remove them 24 hours after application. For golf course

applications, an informational sign must be posted at all times in the clubhouse or locker rooms that identifies the use of pesticide products on the property and whom to contact for more information. In addition, a sign must be placed on the first and tenth tee areas from the time pesticide applications are being conducted and must stay in place until the sprays have dried or the dust has settled. If the label has more specific directions for applications to golf areas, these directions must be followed in addition to the Michigan regulation. For more information on the regulation, refer to Rule 11, Regulation 637 (Pesticide Use) of Michigan Act 451 of 1994, Part 83.

### ***Recordkeeping***

Regulation 636, "Pesticide Applicator," requires that all commercial applicators shall maintain records of their pesticide applications. The following items must be recorded and kept for one year for general-use pesticides and for three years for restricted-use pesticides:

- Name and concentration of the pesticide applied.\*
- Amount of pesticides applied.\*
- Target pest or purpose.
- Month, day and year the pesticide was applied.\*
- Address or location of pesticide application.\*
- Where applicable, the method and the rate of application.

The Michigan Department of Agriculture would like to see several other items included in the record-keeping system. They are:

- Name and certification number of the applicator or the applicator's supervisor.\*
- Product EPA registration number.\*
- Pest and crop stages at time of application.
- Initials of the applicator.
- Weather conditions.
- Date of last calibration of the sprayer.

- Crop, commodity or site that received the application.\*
- Size of area treated.\*

The new federal pesticide record-keeping regulations mandated by the 1990 Farm Bill took effect May 10, 1993. The \* indicates items that private applicators are required to keep for restricted use pesticide (RUP) applications. Commercial applicators are encouraged to meet these requirements for both general-use and restricted-use pesticides. Commercial applicators must also provide a copy of the RUP pesticide application record to the client within 30 days.

### ***Storing pesticides***

Store pesticides where they will be protected from temperature extremes, high humidity and direct sunlight. The storage facility should be heated, dry and well ventilated. It should be designed for easy handling of pesticide spills and made of materials that will not absorb any pesticide material that leaks out of a container. Store only in original containers.

Do not store any feed, seed, food or fertilizer with pesticides. Do not store any protective clothing or equipment in the pesticide storage facility. Try to store herbicides separately from insecticides and fungicides — volatile materials in herbicides will cross-contaminate other materials.

Keep the facility locked when not in use to prevent animals, children and irresponsible adults from entering and becoming poisoned. Post the facility as "pesticides storage facility" to warn others that the area is off-limits. Make a habit of storing pesticides only during the growing season. Also, always read and follow the storage and disposal section of all pesticide labels. For further information on proper storage and plans for constructing a facility, consult MSU Extension bulletin E-2335.

### ***Disposing of pesticide containers***

All pesticide containers are considered hazardous waste unless they are triple rinsed (or equivalent) and

the rinsate is used as additional dilution in the spray mixture. After triple rinsing all empty pesticide containers, perforate both ends so that the container cannot be reused.

All metal and plastic triple-rinsed containers should be offered for recycling. Contact your local pesticide dealer to see if he/she participates in the Michigan Pesticide Container Recycling program. Staff members at participating dealerships will inspect your containers and package them for shipment to one of the pesticide container grind sites. If this option is not available, dispose of them in a state-licensed sanitary landfill. Dispose of all paper containers in a sanitary landfill or a municipal waste incinerator. Do not bury or burn any pesticide containers on personal property. Do not reuse any empty pesticide containers for any purpose.

### ***Unused and unwanted pesticides/Clean Sweep***

The proper disposal of unused and unwanted pesticides is the goal of the Clean Sweep program in Michigan. The Michigan Groundwater Stewardship Program, in cooperation with county and local units of government, has established permanent Clean Sweep sites throughout the state.

Michigan residents may dispose of unused and unwanted pesticides by taking them to one of these Clean Sweep sites where they will be collected, packaged for shipping and disposed of properly. There is no charge for this service. Program costs are covered by the Michigan Groundwater Stewardship Program, a grant from the U.S. Environmental Protection Agency and services provided by the local cooperators. Pesticide dealers and individuals that sell and/or apply pesticides for hire may also, at the Clean Sweep site manager's discretion, dispose of unused or unwanted pesticides at cost. This cost is typically less than 20% of the normal cost of pesticide waste disposal because of economies of scale and competitive bidding of waste disposal accounts.

Persons interested in participating in the Clean Sweep program should contact their local MSU Extension office for the location nearest to them.

### ***Pesticide spills and releases***

The Michigan Department of Agriculture's Agriculture Pollution Hotline (1-800-405-0101) provides immediate access to appropriate technical assistance, regulatory guidance for notification and remediation, common sense approaches for taking care of pesticide spills, and financial assistance possibilities. The hotline is available 24 hours a day and serves as the reporting center when pesticides, fertilizers and manures are accidentally spilled or released.

### ***Pesticide emergency preparedness***

When you purchase a pesticide, ask the chemical dealer for a complete specimen label of the product. This label and labeling information packet is an exact duplicate of the label information affixed to and/or that must accompany the pesticide container. Use the specimen label material as a reference during any pesticide emergency. Bring the specimen label material along with any person who has been poisoned and needs medical attention.

Follow closely all the warning statements outlined in the "precautionary statements" section of a pesticide label. Be certain you have on hand and use all protective clothing and equipment specified by the label. Make certain that all persons involved in the application operation know and can carry out the "statement of practical treatment" given on the front panel of all pesticide labels.

### ***SARA (Superfund Amendments and Reauthorization Act) Title III Emergency Planning and Community Right-to-Know Act***

The Emergency Planning and Community Right-to-Know law under SARA Title III requires applicators to notify their State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC) and local fire department if they store extremely hazardous materials. Pesticide applicators should check with their state Department of Environmental Quality or MSU Extension office to receive a list of

EPA-established "extremely hazardous substances" and their reportable quantities.

This list is also available in Extension bulletin E-2575, "Emergency Planning for the Farm: Including SARA Title III Emergency Planning Requirements." This bulletin is applicable for the turf industry. The SERC, LEPC and local fire chief may request maps of your storage facility and detailed lists of materials you store.

This law also requires that, in the event of a spill, the SERC, LEPC and National Response Commission be notified. You may call the Michigan Department of Agriculture's Agriculture Pollution Hotline (1-800-405-0101) for help with the reporting and spill cleanup. The reportable quantities for spills are much less than those for storage and can be obtained from the above sources. See Extension bulletin E-2575 for more details on SARA Title III.

## **Selecting Pesticides**

Always thoroughly read the label and the supplemental labeling material for any pesticide that you may consider using. Understand the label instructions and limitations. Make certain your operation will use the pesticide only for the purposes listed and in the manner directed on the label. Select only those pesticides that are labeled for the pest you wish to control and the plant you wish to treat. To do otherwise will cost you, in terms of effective and economical product performance, and may lead to an unacceptable risk to humans, the plant(s) and the surrounding environment.

Pesticides that are highly soluble, relatively stable and not readily adsorbed to soil tend to be the most likely to leach. Read labels carefully and consult your chemical dealer, if necessary.

## Signal Words

On the EPA-approved label for every pesticide is a signal word. The signal word will give the user an indication of the relative toxicity of the pesticide to humans. The signal word is based on the toxicity of all of the contents of the formulated product. The hazard indicator criteria rate all of the compounds on four criteria: oral, dermal and inhalation toxicity, and eye damage potential. A pesticide may be more dangerous when ingested than when skin contact is made, or the reverse may be true. In any case, the rating is based on the hazard criterion that produces

the highest risk. The three signal words are "danger", "warning", and "caution". The signal word DANGER tells the user that the product can cause severe damage to eyes or severe skin irritation or is extremely toxic if ingested orally or is absorbed through the skin or lungs. The word WARNING indicates that the product is considered moderately toxic orally, dermally or through inhalation, or causes moderate eye or skin irritation. The signal word CAUTION indicates that the product is slightly toxic orally, dermally or through inhalation, or causes slight eye or skin irritation.

<b>Signal word</b>	<b>DANGER or DANGER/POISON</b>	<b>WARNING</b>	<b>CAUTION</b>
<b>Toxicity</b>	<b>HIGH</b> May cause death! See a physician immediately.	<b>MODERATE</b> Possible serious illness! See a physician if symptoms persist.	<b>LOW or SLIGHT</b> May cause illness! See a physician if symptoms persist.
<b>Oral LD<sub>50</sub> mg/kg</b>	0 - 50	50 - 500	500 - 5,000
<b>Dermal LD<sub>50</sub> mg/kg</b>	0 - 200	200 - 2,000	2,000 - 20,000
<b>Inhalation LC<sub>50</sub> mg/liter</b>	0 - 0.2	0.2-2	2 - 20
<b>Eye effects</b>	Corrosive	Irritation persisting for 7 days	Irritation reversible within 7 days
<b>Skin effects</b>	Corrosive	Severe irritation	Moderate irritation

*Source: "Reading a Pesticide Label," bulletin E-2182, Kamrin, M., Michigan State University Extension, May 1989, p.4.*

Most of the toxicity categories in the table are defined in terms of LD<sub>50</sub>. This is the dosage of pesticide necessary to kill 50 percent of the test animals. LD<sub>50</sub> figures are always calculated as mg of pesticide per kg of test animal body weight. For example, 50 mg/kg ("danger" category) means that 1/10 oz ingested would be lethal to a person weighing 150 lbs.

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# Plant Parasitic Nematodes and Their Management

**P**lant-parasitic nematodes are microscopic roundworms that feed on plants. They are obligate parasites of plants. This means they must have living plant tissue to feed on to grow and reproduce. The majority of plant-parasitic nematodes feed on root tissue but some are found in foliage. Because they are all microscopic, diagnosis of nematode problems is quite difficult and requires sampling.

Many species of plant-parasitic nematodes are associated with turfgrasses grown in Michigan. They differ in the amounts of damage they do to various grass species. Virtually every sample collected from habitats where turf is grown will contain at least one species of plant-parasitic nematode.

## Symptoms

Feeding by plant-parasitic nematodes does not usually produce characteristic symptoms, so nematode problems frequently go undetected in turf. The one exception is feeding by root-knot nematodes. Root-knot nematode feeding causes small swellings on roots called galls. If galls are observed on roots, you have positive diagnosis of a root-knot nematode problem.

Stunting, wilting, yellowing and thinning of turf are common aboveground symptoms produced by nematode feeding. Greenhouse studies conducted at MSU demonstrated that creeping bentgrass plants infested with plant-parasitic nematodes produced far fewer tillers and subsequently fewer leaves than nematode-free plants, though the total weight of the foliage often did not differ between treatments.

Parasitism by nematodes reduces root volumes and weights in turfgrasses. Nematode-infested root systems will not function as well as healthy roots. Therefore, diseased plants cannot acquire water and soil nutrients adequately. For example, root-knot nematode-infested plants typically appear "starved" for water.

## Sampling

If you think you have a nematode problem, collect soil and plant tissue samples and send them to a nematode diagnostic lab, such as the one at MSU, so the nematodes can be identified and quantified. This is the only way to get a positive diagnosis. Remember that you will not be able to see plant-parasitic nematodes with the naked eye (in most situations), so it is imperative to send samples to a lab for the proper analyses.

If turf exhibits symptoms of undetermined causes, sampling for nematodes is advised. Soil and root tissue should be collected from the margins of diseased areas and also from healthy areas for comparison. A soil probe is required. In general, the more soil cores collected, the better the sample. Soil and roots for nematode tests should be placed in plastic bags to prevent desiccation and the bags clearly labeled. The samples should be kept in a cool location until they are submitted to a nematode laboratory. Additional information on sampling for nematodes and sample care can be found in MSU Extension bulletin E-2199, "Detecting and Avoiding Nematode Problems."

## Management

Under no circumstances should management strategies or tactics be employed against a pest or pathogen until it has been properly identified or diagnosed. Utilizing improper control tactics can exacerbate problems instead of alleviating them. Always be sure to identify the causal organisms responsible for any given problem before proceeding.

Sites should always be tested for the presence of plant-parasitic nematodes before the establishment of any high value turf. If testing finds population densities of plant-parasitic nematodes that pose a risk to turf, action may be recommended. Soil fumigation is an option.

## PREPLANT RECOMMENDATIONS

**Telone C-17** (1,3-dichloropropene + chloropicrin). Broadcast at a rate 10 to 40 gal/A, depending on soil type. Soil temperature must be 50 to 80°F at time of application. The site should be free of clods and the soil moist. The material must be placed 10 to 12 inches below the soil surface using fumigation equipment. After fumigation, the soil should be sealed to prevent fumigation loss. Allow at least two weeks after fumigation before seeding or sodding the site.

**Busan 1020** or **Vapam** (sodium methyldithiocarbamate). Broadcast at a rate of 50 to 100 gal/A (1 to 2 pt/100 sq ft), depending on soil type. Soil temperature must be 40 to 70°F at the time of application. The site should be free of clods and the soil moist. These products can be applied in a variety of ways. Allow a minimum of two weeks following the application before seeding or sodding.

**Methyl Bromide.** This product is labeled for use on commercial turf, but it is targeted for withdrawal by the EPA, so its use will not be described.

## POSTPLANTING OPTIONS

If nematode problems develop on established turf, postplanting control options need to be considered. The nematode lab at MSU does not recommend any action be employed against nematodes unless soil and tissue samples indicate that the plants are optimally fertilized. The symptoms due to nematode feeding can often be alleviated by proper fertilization. In many situations, lower numbers of nematodes are associated with healthy plants than with those under nutrient stress.

If soil and plant tissue analyses indicate the turf is optimally fertilized and nematode population densities are above damage threshold levels, a postplant nematicide treatment may be recommended. It is important to adhere to the reentry intervals after applying these materials.

**Mocap 10G GC** (ethoprop). Broadcast at a rate of 100 lbs/A (2.3 lbs/1,000 sq ft) using a drop or broadcast spreader. Apply no more than 400 lbs of this product per year to any site (four applications can be made at 60 to 90 day intervals if necessary). Following application, incorporate with at least 0.1 inch of rainfall or irrigation. **Note: Bentgrass and ryegrass are quite sensitive to ethoprop. Phytotoxicity may occur when the material is applied to these grass species.**

**Nemacur 10G** (phenamiphos). Broadcast at a rate of 100 lbs/A (2.3 lbs/1,000 sq. ft.) using a drop or broadcast spreader. Apply no more than 200 lbs of this product per year to any site. Apply a minimum of 1/2 inch of water within six hours following the application to move the product into the soil. **For use only on golf courses.**

**Biological controls.** Materials are available, such as **DiTera G** and **Deny**, that are living microorganisms or the byproducts of microorganisms. These materials have not been tested intensively in turf systems. The advantage is that they are not restricted use pesticides, so they have very short reentry intervals.

In testing to date, however, some of the products have not provided good control of turfgrass nematodes.

If you opt for a nematicide treatment, it is recommended that you collect an additional nematode sample 30 to 60 days after the application to determine whether the product provided nematode control.

## **Home Lawns**

Synthetic nematicides are not registered for uses on home lawns. Nematodes are commonly found in these situations, however. If nematodes are present in a home lawn and the growth of the turf is quite patchy, cultural tactics should be employed to help alleviate these symptoms. Home lawns may need to be watered more frequently — at least  $\frac{1}{2}$  to 1 inch of water per week to promote root growth deep in the soil profile. Nematode-infested home lawns should be fertilized in the spring, summer and fall. It may be beneficial to use fertilizers with ample potassium, especially in the fall, because this element is very important to the plants' ability to withstand stress.

## **Additional Readings:**

More information about plant-parasitic nematodes on turf can be found in many turf management textbooks. Consult pp. 64-67 in:

- ***Compendium of Turfgrass Diseases*** (2nd ed.) by R. Smiley, American Phytopathological Society, 1992 (ISBN 0890541248).

**Table 1. Nematicide trade names.**

Below are the active ingredients of the nematicides available for use on turf. The nematicide common names are followed with some names of products containing the active ingredients. Always read the label of each product that you use for proper rates and uses. The following is a list of labels taken from the 1999 and 2000 *Turf and Ornamental Reference* from C & P Press, New York, NY.

LD<sub>50</sub> values are determined from toxicological tests involving pure active ingredient. The LD<sub>50</sub> is expressed as the number of milligrams of active

ingredient per kilogram of body weight of the test animal. The LD<sub>50</sub> of a pesticide is the amount of the chemical that kills 50% of the test animals. Oral LD<sub>50</sub> values are determined from toxicity to male rats. The higher the LD<sub>50</sub>, the less toxic the compound is to mammals. The LD<sub>50</sub>'s listed in the following table are the lowest from either W.T. Thomson *Agricultural Chemicals – Book I: Insecticides* (14th ed.), 1998, Thomson Publications, Fresno, CA or G.W. Ware, *The Pesticide Book* (4th ed.), 1988, Thomson Publications, Fresno, CA.

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<b>oral LD<sub>50</sub> of a.i.</b>	<b>Formulation</b>	<b>Manufacturer</b>	<b>Signal Word</b>	<b>WPS</b>	<b>Restricted Use</b>
	<b>Class</b>						
Trade Name							
<b>dichloroprene</b>	<b>soil fumigant</b>	<b>150</b>					
Telone C-17			78% liquid	Dow Agrosiences	danger	x	x
Telone II			94% liquid	Dow Agrosiences	danger	x	x
Telone C-35			61% liquid	Dow Agrosiences	danger	x	x
<b>ethoprop</b>	<b>organic phosphate</b>	<b>62</b>					
Chipco Mocap 10G GC			10G	Aventis	warning		x
<b>fenamiphos</b>	<b>organic phosphate</b>	<b>6</b>					
Nemacur 10%			10G	Bayer	danger	x	x
Nemacur 3 Turf			3 lb/gal	Bayer	danger	x	x
<b>metam-sodium</b>	<b>soil fumigant</b>	<b>820</b>					
Vapam HL			4.25 lb/gal	Amvac	danger	x	
Busan 1020			33% liquid	Buckman Labs	danger	x	



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# Turfgrass Insect Management

Identifying turfgrass insect pests is the first and most critical step in proper insect management on home lawns, recreational turf, golf courses and sod farms. Visiting problem sites with someone experienced in diagnosing insect problems is the best way to learn. Attending turf tours and educational programs is another way. Several excellent reference books that contain many pages of color plates are:

- ***Turfgrass Insects of the United States and Canada***, by P. Vittum, Cornell University Press, 1999 (ISBN 0-8014-3508-0).
- ***Handbook of Turfgrass Insect Pests***, edited by R. Brandenburg and M. Villani, Entomological Society of America, 1995 (ISBN 0-938522-52-3).
- ***Destructive Turfgrass Insects***, by D. Potter, Ann Arbor Press, 1998 (ISBN 1-57504-023-9).

Turf experts must become familiar with adult and larval stages of the most important insect pests. Understanding the life cycle of each pest will help you diagnose problems correctly. You need to know what time of year to look for insect pests, the damage they inflict on turfgrass and the proper time to apply an insecticide if it is needed. Life cycle and management information is available in the books listed above and in the following MSU Extension bulletins: E-2623 (black cutworms), E-2624 (*Ataenius* and *Aphodius*), E-2499 (white grubs), E-2497 (bluegrass billbug), E-2496 (hairy chinch bug), E-2498 (sod webworm), E-2500 (European chafer) and E-2655 (Japanese beetle). Insect specimens can also be sent to the Michigan State University Insect Diagnostic Clinic for identification (517-353-9386).

## Management Strategies

After a problem has been correctly identified, consider an assortment of management strategies. You can prevent most turf insect problems by using good cultural practices. Home lawns receiving regular irrigation rarely have insect problems. With adequate water and fertilizer, grass plants quickly overcome insect injury. An evenly scattered 30 percent loss of grass plants due to billbug injury will be easily filled in by actively growing, well maintained grass plants. A poorly managed lawn, however, may experience an overall thinning effect if a scattered 30 percent plant loss occurs.

Occasionally, even well managed lawns become infested with grubs, webworms, chinch bugs or other insect pests to the extent that damage becomes obvious. When turfgrass insect injury is severe, even when grass is being maintained at the highest level, consider using an insecticide.

Insecticides should not be used unless a current problem exists or damage occurred at the site the previous year. Overuse of insecticides will create other problems.

**Do not apply an insecticide to subthreshold populations of turf pests.** Unnecessary insecticide applications may create several problems, including pest problems. Pesticides may destroy beneficial insect predators such as big-eyed bugs, which prey on chinch bugs. The result is a secondary resurgence of chinch bugs. Insecticide applications will drastically affect insects and other arthropods that degrade thatch and so cause thatch to build up. Earthworms are also sensitive to insecticides. A loss in earthworms will result in greater soil compaction, which will slow root growth. Also, insecticides are

potentially harmful to applicators, wildlife and residents if they are not handled or applied properly. The most dangerous pesticide incidents occur when people come in contact with the concentrated insecticide before it is diluted in a spray tank.

For safety and conservation, it is wise to apply insecticides only when necessary and then use the safest insecticides that are still effective. You can evaluate the safety factor by considering the signal word on the pesticide label. "Caution" pesticides have the lowest mammalian toxicity and are therefore the safest. You can also compare the LD<sub>50</sub>'s of insecticides. Higher LD<sub>50</sub>'s are safer. If an insecticide has an oral LD<sub>50</sub> of 20 for the active ingredient, the estimated lethal dose for a 150 lb person would be 1.4 grams, or the equivalent of three 500 mg tablets. If the same insecticide was formulated as a 50% WP, the oral LD<sub>50</sub> for a 150 lb person would be equivalent to six 500 mg tablets. Promote the concept of minimum pesticide impact to conserve natural enemies and reduce risks associated with applying pesticides.

Always read the label before applying any pesticides and wear the recommended safety equipment. Also keep in mind that all people who apply pesticides as part of their job or on a contractual basis for pay on property not belonging to them must be certified as commercial pesticide applicators by the Michigan Department of Agriculture.

### **Minimum Pesticide Impact**

Minimum impact starts with proper cultural practices that reduce the need for insecticide applications. You can also reduce the amount of pesticide applied by treating only the most heavily infested areas and using the lowest effective application rate. Another way to minimize pesticide impact is to use safe and selective products, such as the insect growth regulator Mach 2.

**Table 2. Insect control recommendations for home lawns, commercially maintained turf and athletic fields.**

**Bluegrass billbug larvae** — If damage was observed the previous year, apply insecticides for control of larvae in late June. Billbug damage is best observed in late July and early August.

Diazinon	Dylox	Merit	Mocap
Oftanol	Sevin	Turcam	

**Bluegrass billbug adults** — Heavily infested turfgrass can be treated from May 10 to May 30 in central Michigan to control adult weevils.

DeltaGard	Dursban
Talstar	Merit

**Chinch bugs** — Apply insecticide to heavily infested turf in late June to July for control of actively feeding bugs. Only one generation per year occurs throughout most of Michigan. An effective predator of chinch bug, the big-eyed bug, can be easily confused with chinch bugs.

Astro	Battle	DeltaGard	Diazinon	Dursban
M-Pede	Oftanol	Orthene	Scimitar	Sevin
Tempo				

**Cutworms, armyworms and sod webworms** — Treat only if damage is found. Caterpillar pests usually do not damage the same lawns year after year because they are normally kept under control by predators and parasites.

Astro	Azatin	Battle	Bt	Conserve
DeltaGard	Diazinon	Dursban	Dylox	M-Pede
Oftanol	Orthene	Pinpoint	Scimitar	Sevin
Talstar	Tempo			

**White grubs** — Larvae of European chafer, Japanese beetle and June beetle. Apply a curative insecticide (all of the following except Mach 2 and Merit) if enough grubs are present to cause damage (greater than 15 per ft<sup>2</sup> for high-maintenance turf and greater than 5 per ft<sup>2</sup> for low-maintenance turf). Apply liquids in 4 gallons of finished spray per 1,000 ft<sup>2</sup>. Merit and Mach 2 are very effective when applied before the grubs hatch. Apply Merit or Mach 2 where damage occurred the year before. Merit or Mach 2 should be applied in early July to be most effective. Use ½ inch of irrigation to soak insecticide into soil.

Diazinon	Dylox	Mach 2	Merit	Oftanol
Sevin	Turcam			

**Table 3. Insect control recommendations for golf courses.**

**Ants** — Ants are beneficial because they feed on insect pests of turf. Use an insecticide for ants only when mounds interfere with play on tees, greens or fairways. Ants from underground nests usually reappear two to three weeks after treatment. Repeat as needed.

Astro	Battle	DeltaGard	Dursban	Scimitar
Sevin	Talstar	Tempo	Turcam	

**Bluegrass billbug larvae** — If damage was observed the previous year, apply insecticides for control of larvae in late June. Billbug damage is best observed in late July and early August.

Dylox	Merit	Mocap	Oftanol	Sevin
Turcam				

**Bluegrass billbug adults** — Heavily infested turfgrass can be treated from May 10 to May 30 in central Michigan to control adult weevils.

DeltaGard	Dursban	Merit	Talstar
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**Cutworms, armyworms and sod webworms** — Apply insecticide to golf course greens, including a 15-ft swath surrounding greens where cutworms are first observed. Repeat as necessary. Watch for damage from early June through September.

Astro	Azatin	Battle	Biobit	Conserve
DeltaGard	Dipel	Dursban	Dylox	M-Pede
Mocap	Oftanol	Orthene	Pinpoint	Scimitar
Sevin	Talstar	Tempo		

**White grubs** — Larvae of European chafer, Japanese beetle and June beetle. Apply a curative insecticide (all of the following except Mach 2 and Merit) if enough grubs are present to cause damage (greater than 15 per ft<sup>2</sup> for high-maintenance turf and greater than five per ft<sup>2</sup> for low-maintenance turf). Apply liquids in 4 gallons of finished spray per 1,000 ft<sup>2</sup>. Merit and Mach 2 are very effective when applied before the grubs hatch. Apply Merit or Mach 2 where damage occurred the year before. Merit or Mach 2 should be applied in early July to be most effective. Use ½ inch of irrigation to soak insecticide into soil.

Dylox	Mach 2	Merit	Mocap	Oftanol
Sevin	Turcam			

**Table 4. Insect control recommendations for sod farms.**

*All products used on sod farms must be labeled with Worker Protection Standards.*

**Bluegrass billbugs** — If damage was observed the previous year, apply insecticides for control of larvae in late June. Billbug damage is best observed in late July and early August. Heavily infested turfgrass can be treated from May 10 to May 30 in central Michigan to control adult weevils.

Chipco Sevin brand 80 WSP (adults and larvae)	Chipco Sevin SL (adults and larvae)
Turcam (larvae)	DeltaGard GC 5SC
DeltaGard GC Granular	Dursban 50 W WSP (adults)
Dursban TNP (adults)	Talstar Nursery Flowable (adults)

**Chinch bugs** — Apply insecticide to heavily infested turf in late June to July for control of actively feeding bugs. Only one generation per year occurs throughout most of Michigan. An effective predator of chinch bug, the big-eyed bug, can be easily confused with chinch bugs.

Astro	Chipco Sevin brand 80 WSP
Chipco Sevin SL	DeltaGard GC 5SC
DeltaGard GC Granular	Dursban 50 W WSP
Dursban TNP	M-Pede
Orthene Turf, Tree & Orn Spray	Pinpoint 15G
Turcam	

**Lepidoptera larvae** such as cutworm, armyworm and sod webworm. Watch for damage from early June through August. Treat only around damaged areas.

Astro	Azatin XL
Biobit	Chipco Sevin brand 80 WSP
Chipco Sevin SL	Conserve SC
Turcam	DeltaGard GC Granular
DeltaGard GC 5SC	Dursban 50 W WSP
Dipel 2X	Mattch
Dursban TNP	MVP II
M-Pede	Pinpoint 15G
Orthene Turf, Tree & Orn Spray	

**White grubs** — Larvae of European chafer, Japanese beetle and June beetle. Apply a curative insecticide (all of the following except Mach 2) if enough grubs are present to cause damage (greater than 15 per ft<sup>2</sup> for high-maintenance turf and greater than 5 per ft<sup>2</sup> for low-maintenance turf). Apply liquids in 4 gallons of finished spray per 1,000 ft<sup>2</sup>. A preventive application (Mach 2) should be applied in early July. Use ½ inch of irrigation to soak insecticide into soil.

Chipco Sevin brand 80 WSP	Chipco Sevin SL
Mach 2 Granular	Mach 2 Liquid
Turcam	Turcam 2 G

**Table 5. Insecticide trade names.**

Below are the active ingredients of the insecticides available for use on turf. The insecticide common names are followed with some names of products containing the active ingredients. There may be several different formulations of each chemical available. Different formulations of the same chemical may have different instructions on the package, may or may not include Workers Protection Standards (WPS), and may or may not be a restricted-use product. Application rates are often given as a range and may be different for different insects. Always read the label of each product that you use for proper rates and uses. Labels from the manufacturers were obtained in 1999 and taken from the 1999 and 2000 *Turf and Ornamental Reference* from C & P Press, New York, NY.

LD<sub>50</sub> values are determined from toxicological tests involving pure active ingredient. The LD<sub>50</sub> is expressed as the number of milligrams of active

ingredient per kilogram of body weight of the test animal. The LD<sub>50</sub> of an insecticide is the amount of the chemical that kills 50% of the test animals. Oral LD<sub>50</sub> values are determined from toxicity to male rats. The higher the LD<sub>50</sub>, the less toxic the compound is to mammals. The LD<sub>50</sub>'s in the following table are the lowest from either W. T. Thomson *Agricultural Chemicals - Book I: Insecticides* (14th ed.), 1998, Thomson Publications, Fresno, CA or G.W. Ware, *The Pesticide Book* (4th ed.), 1988, Thomson Publications, Fresno, CA.

Note that the formulations marked GC are intended for golf course use. Several of the GC formulations of synthetic pyrethroid compounds are restricted-use pesticides because of their toxicity to fish. Diazinon is not labeled for use on golf courses or commercial sod farms because of avian toxicity. Only products labeled with WPS information may be used on sod farms. Mocap may be phytotoxic on bentgrasses.

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>	<b>Class</b>	<b>oral LD<sub>50</sub> of a.i.</b>	<b>Formulation</b>	<b>Manufacturer</b>	<b>Signal Word</b>	<b>WPS</b>	<b>Restricted Use</b>
<b>acephate</b>	<b>organophosphate</b>	<b>866</b>					
Orthene Turf, Tree & Ornamental Spray			75 WP	Valent	caution	x	
Pinpoint			15 G	Valent	caution	x	
<b>azadirachtin</b>	<b>insect growth regulator</b>	<b>5,000</b>					
Azatin XL			0.265 lb ai/gal	Olympic	caution	x	
<b>Bacillus thuringiensis kurstaki (Bt)</b>	<b>bacteria</b>	<b>5,000</b>					
Biobit			14.5 BIU/lb	Abbott	caution	x	
Dipel 2X			14.5 BIU/lb	Abbott	caution	x	
Dipel DF			14.5 BIU/lb	Abbott	caution	x	
Mattech			1.05 lb ai/gal	Mycogen	caution	x	
MVP II			1.8 lb ai/gal	Mycogen	caution	x	

## Turfgrass Insect Management

**Table 5. Insecticide trade names (continued).**

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<i>oral LD<sub>50</sub> of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal Word</i>	<i>WPS</i>	<i>Restricted Use</i>
<b>bendiocarb</b>	<b>carbamate</b>	<b>40</b>					
Turcam			76 WP	Aventis	warning	x	x
Turcam 2.5 G			2.5 G	Aventis	warning	x	x
<b>bifenthrin</b>	<b>synthetic pyrethroid</b>	<b>55</b>					
Talstar Lawn & Tree Flowable			0.66 lb gal	FMC	caution		
Talstar GC Granular			0.2 G	FMC	caution		
Talstar GC			0.66 lb gal	FMC	caution		x
Talstar Nursery Flowable			0.66 lb gal	FMC/Whitmire	caution	x	x
<b>carbaryl</b>	<b>carbamate</b>	<b>307</b>					
8% Sevin Granular Carbaryl Insecticide			8 G	The Andersons	caution		
Fertilizer with Sevin			6.2 G	The Andersons	caution		
Sevin 4% and fertilizer			4 G	Lesco	caution		
6.3% Sevin brand Gran- ular Carbaryl Insecticide			6.3 G	Lesco	caution		
Sevin brand SL			4 lb ai/gal	Lesco	caution		
Chipco Sevin brand 80 WSP			80 WSP	Aventis	warning	x	
Chipco Sevin brand SL			4 lb ai/gal	Aventis	caution	x	
Sevin 10 G			10 G	United Hort. Supply	caution		
<b>chlorpyrifos</b>	<b>organophosphate</b>	<b>135</b>					
2.32% Dursban			2.32 G	The Andersons	caution		
0.97% Dursban			0.97 G	The Andersons	caution		
0.5% Dursban			0.5 G	The Andersons	caution		
Fertilizer with Dursban (various)			0.92/0.65/0.57 G	The Andersons	caution		
Dursban 50 W WSP			50 WSP	Dow AgroSciences	warning	x	
Dursban Pro			2 lb ai/gal	Dow AgroSciences	caution		
Professional Pest Control Dursban 0.5 G			0.5 G	Lesco	caution		
Dursban .74% & fertilizer			0.74 G	Lesco	caution		
Dursban .97% & fertilizer			0.97 G	Lesco	caution		
1% Dursban			1 G	Lesco	caution		

## Turfgrass Insect Management

**Table 5. Insecticide trade names (continued).**

		Toxicity of Active Ingredient					
Common Name	Class	<i>oral LD<sub>50</sub></i> <i>of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal</i> <i>Word</i>	<i>WPS</i>	<i>Restricted</i> <i>Use</i>
<b>chlorpyrifos (cont.)</b>		<b>organophosphate</b>		<b>135</b>			
2.32 Granular Insecticide			2.32 G	Lesco	caution		
Insecticide III			1.34 G	Scotts	caution		
Turf Fertilizer plus Insecticide			0.65 G	Scotts	caution		
Dursban 2 Coated Granules			2 G	United Hort. Supply	warning		
Dursban TNP			4 lb ai/gal	United Hort. Supply	warning	x	
<b>cyfluthrin</b>		<b>synthetic pyrethroid</b>		<b>500</b>			
Tempo 20 WP			20 WP	Bayer	caution		
Tempo 2			2 lb ai/gal	Bayer	warning		
Tempo 20 WP (Golf Course WSP)			20 WP	Bayer	caution	x	
Tempo 20 WP (Power Pak)			20 WP	Bayer	caution		
<b>deltamethrin</b>		<b>synthetic pyrethroid</b>		<b>135</b>			
DeltaGard GC			5 SC	Aventis	caution		x
DeltaGard T&O			0.1 G	Aventis	caution		
DeltaGard T&O 5 SC			5 SC	Aventis	caution		
DeltaGard GC Granular			0.1 G	Aventis	caution	x	x
<b>diazinon</b>		<b>organophosphate</b>		<b>300</b>			
5% Diazinon Fertilizer with 3.33 Diazinon			5 G 3.33 G	The Andersons The Andersons	caution caution		
Diazinon			3.33 G	Lesco	caution		x
Diazinon AG 600			4.67 lb ai/gal	Lesco	caution		x
Diazinon 4 E			4 lb ai/gal	Terra	caution		
Diazinon			5 G	United Hort. Supply	caution		
<b>ethoprop</b>		<b>organophosphate</b>		<b>62</b>			
Chipco Mocap brand 10G GC			10 G	Aventis	warning		
<b>halfenozide</b>		<b>insect growth regulator</b>		<b>2,850</b>			
Mach 2 Granular			1.5 G	Rohmid	caution	x	
Mach 2 Liquid			2 lb ai/gal	Rohmid	caution	x	



## Turfgrass Insect Management

**Table 5. Insecticide trade names (continued).**

		Toxicity of Active Ingredient					
Common Name		<i>oral LD<sub>50</sub></i> <i>of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal</i> <i>Word</i>	<i>WPS</i>	<i>Restricted</i> <i>Use</i>
Trade Name	Class						
<b>imidacloprid</b>		<b>424</b>					
Fertilizer with Merit Insecticide	neonicotinoid		0.2 G	The Andersons	caution		
Merit 0.5 G			0.5 G	Bayer	caution		
Merit 75 WP			75 WP	Bayer	caution		
Merit 75 WSP			75 WSP	Bayer	caution		
Lebanon Fertilizer with Merit 0.3% Insecticide			0.3 G	Lebanon	caution		
Merit 0.2 plus fertilizer			0.2 G	Lesco	caution		
Turf Fertilizer plus Merit Insecticide			0.2 G	Scotts	caution		
<b>isofenphos</b>		<b>20</b>					
Oftanol 1.5%	organophosphate		1.5 G	The Andersons	caution		
Fertilizer with Oftanol			1.5 G	The Andersons	caution		
Oftanol 2			2 lb ai/gal	Bayer	warning		
Oftanol 1.5% and fertilizer			1.5 G	Lesco	caution		
Oftanol 1.5%			1.5 G	Lesco	caution		
<b>lambda-cyhalothrin</b>		<b>243</b>					
Battle CS	synthetic pyrethroid		0.88 lb ai/gal	Lesco	caution		
Battle GC			0.88 lb ai/gal	Lesco	caution		x
Battle WP			10 WP	Lesco	warning		
Scimitar CS			0.88 lb ai/gal	Zeneca	caution		
Scimitar GC			0.88 lb ai/gal	Zeneca	caution		x
Scimitar WP			10 WP	Zeneca	warning		
<b>permethrin</b>		<b>430</b>					
Astro	synthetic pyrethroid		3.2 lb ai/gal	FMC	caution	x	x
<b>soap</b>		<b>16,900</b>					
M-Pede	insecticidal soap		49% ai	Mycogen	warning	x	
<b>spinosad</b>		<b>5,000</b>					
Conserve SC	actinomycete - fermentation derived		1 lb ai/gal	Dow AgroSciences	caution	x	
<b>trichlorfon</b>		<b>144</b>					
Dylox 6.2 G	organophosphate		6.2 G	The Andersons	caution		
Dylox 6.2 G			6.2 G	Bayer	caution		
Dylox 80 T&O			80 WP	Bayer	warning		

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# Turfgrass Disease Management

**T**he term "management" is used in preference to "control" because "control" implies finality and often leads people to draw the wrong conclusions. "Control" suggests that the treatment being applied will eradicate the disease, which will disappear and not return. Most diseases appear year after year and sometimes several times during the same year. Strategies need to be developed to manage these diseases on a continuing basis. These strategies should include an integrated approach that incorporates any cultural or biological means of managing the disease and applies fungicides only when necessary (Table 6).

Turfgrass disease management begins with selecting the correct species or cultivars. The improved types of Kentucky bluegrass are the best cultivars for high-maintenance lawns. They have resistance to most major diseases, especially melting-out. Resistance to stripe smut can be obtained by planting a blend of three or more of these improved Kentucky bluegrass cultivars. Necrotic ring spot may be a problem on the improved Kentucky bluegrasses, but this disease can be managed fairly well by cultural and biological

means. The perennial ryegrasses currently available have too many diseases to be recommended at this time. They also grow too poorly for most home lawn situations.

Good cultural practices that encourage biological management are important in maintaining a healthy lawn. For the improved Kentucky bluegrass cultivars used on home lawns, these include coring, fertilizing and irrigating. Coring should be done once a year, with the soil from the cores reincorporated to help modify the thatch. Early spring or fall is the ideal time for coring. Four to five pounds of actual nitrogen per 1,000 sq ft should be applied throughout the growing season. Have a soil test done before initiating a fertility program to determine the levels of phosphorus and potassium in the soil. Application of P plus K can then be made more accurately. Irrigate lightly and frequently where necrotic ring spot is a problem. Daily irrigation of approximately 1/10 inch per day is most effective in maintaining high populations of beneficial microorganisms that will help manage necrotic ring spot.

**Table 6. Guide to controlling turfgrass diseases.**

<b>Disease</b>	<b>Susceptible Turfgrasses</b>	<b>Cultural and Biological</b>	<b>Chemical</b>
Algae	All turfgrasses	Reduce shade. Avoid excessive watering. Improve soil drainage.	Fore, Daconil Ultrex, Junction, Manicure, Dithane, Mancozeb, Protect
Anthracnose and crown-rotting anthracnose ( <i>Colletotrichum graminicola</i> )	Annual bluegrasses, creeping bentgrass, tall fescue, fine-leaf fescue	Fertilize and irrigate to maintain vigor.	Bayleton, Banner, Rubigan, Fungo 50, Cleary's 3336, Systec 1998, Heritage, Scott's Systemic, Lesco Granular, Strike, Compass
Brown patch ( <i>Rhizoctonia solani</i> )	Creeping bentgrass, Kentucky bluegrass, tall fescue, perennial ryegrass	Reduce nitrogen levels. Increase circulation by removing surrounding vegetation.	Heritage, Daconil Ultrex, Fore, Prostar, Dithane, Mancozeb, Protect, Compass
Dollar spot ( <i>Rutstroemia floccosum</i> )	Creeping bentgrasses, annual bluegrasses, perennial ryegrass, fine-leaf fescue, colonial bentgrass, Kentucky bluegrass, zoysiagrass	Maintain adequate levels of nitrogen. Remove dew.	Daconil Ultrex, Banner, Rubigan, Bayleton, Chipco 26GT, Vorlan, Curalan, Touche'
Fairy rings (Basidiomycete - soil fungi)	All turfgrasses	Remove infested sod and soil; replace with clean soil, and reseed or sod. Improve water penetration with aerification or wetting agents.	Prostar Heritage (works on some Fairy Rings)
Microdochium patch (pink snow mold) ( <i>Microdochium nivale</i> )	Annual bluegrass, creeping bentgrass, fine-leaf fescue, perennial ryegrass, Kentucky bluegrass	Avoid fall nitrogen applications. Rake leaves. Control drifting snow; may occur without snow cover.	Fore, Chipco 26GT, Vorlan, Eagle, Curalan, Heritage, Bayleton, Banner, Rubigan, Compass, Fungo 50, Cleary's 3336, Systec 1998
Gray leaf spot	Perennial ryegrass	Reduce nitrogen. Irrigate during the day.	Daconil Ultrex, Heritage

**Table 6. Guide to controlling turfgrass diseases (continued).**

<b>Disease</b>	<b>Susceptible Turfgrasses</b>	<b>Cultural and Biological</b>	<b>Chemical</b>
Leaf spot ( <i>Bipolaris sorokiniana</i> )	Kentucky bluegrasses, perennial ryegrass, fine-leaf fescue, creeping bentgrass	Remove clippings. Raise cutting height. Provide adequate levels of nitrogen.	Chipco 26 GT, Vorlan, Curalan, Daconil Ultrex
Melting-out ( <i>Drechslera poae</i> )	Kentucky bluegrass	Remove clippings. Raise cutting height. Provide adequate levels of nitrogen.	Chipco 26 GT, Vorlan, Curalan, Daconil Ultrex
Necrotic ring spot ( <i>Leptosphaeria korrae</i> )	Kentucky bluegrass, annual bluegrass	Provide adequate nitrogen as a complete fertilizer. Slow-release nitrogens work the best. Provide light, daily irrigation.	Rubigan, Banner, Cleary's 3336, Fungo 50, Systec 1998, Scott's Systemic
Pink patch ( <i>Limonomyces roseipellis</i> , <i>L. culmeginus</i> )	Red fescue, perennial ryegrass, colonial bentgrass	Provide adequate levels of nitrogen.	Curalan, Chipco 26GT, Vorlan, Bayleton, Banner, Rubigan, Eagle
Powdery mildew ( <i>Erysiphe graminis</i> )	Kentucky bluegrasses, fine-leaf fescue	Reduce shade. Increase circulation by removing surrounding vegetation.	Bayleton, Banner, Rubigan, Eagle
Pythium blight ( <i>Pythium aphanidermatum</i> )	Annual bluegrass, perennial ryegrass, creeping bentgrass	Improve soil drainage. Increase circulation by removing surrounding vegetation.	Koban, Banol, Signature, Subdue, Teremec, Koban
Red leaf spot ( <i>Drechslera erythrospila</i> )	Creeping bentgrass	Fertilize to maintain vigor.	Chipco 26 GT, Vorlan, Curalan, Daconil Ultrex
Red thread ( <i>Laetisaria fuciformis</i> )	Fine-leaf fescue, perennial ryegrass, Kentucky bluegrass, annual bluegrass, creeping bentgrass	Remove clippings. Fertilize to maintain vigor.	Chipco 26 GT, Vorlan, Curalan, Bayleton, Banner, Heritage, Eagle

**Table 6. Guide to controlling turfgrass diseases (continued).**

<b>Disease</b>	<b>Susceptible Turfgrasses</b>	<b>Cultural and Biological</b>	<b>Chemical</b>
Rust ( <i>Puccinia</i> spp.)	Kentucky bluegrasses, perennial ryegrass, zoysiagrass, Bermudagrass	Provide adequate levels of nitrogen. Mow frequently.	Fore, Daconil Ultrex, Bayleton, Rubigan, Banner, Eagle
Slime molds ( <i>Myxomycete</i> spp.)	All turfgrasses	Remove mechanically by mowing or raking.	
Stripe smut ( <i>Ustilago striiformis</i> )	Kentucky bluegrass, creeping bentgrass	Reduce nitrogen. Irrigate to prevent dormancy.	Bayleton, Banner, Rubigan, Eagle
Summer patch ( <i>Magnaporthe poae</i> )	Kentucky bluegrass, annual bluegrass	Apply light, frequent watering during dry periods to reduce heat stress. Do not water heavily or deeply. Provide adequate nitrogen.	1. Bayleton, Banner, Rubigan, Heritage before symptoms are evident. 2. Cleary's 3336, Fungo 50, Systec 1998 after symptoms are present.
Typhula blight ( <i>Typhula incarnata</i> , <i>Typhula ishikariensis</i> )	Creeping bentgrass, annual bluegrass, fine-leaf fescue, perennial ryegrasses	Avoid early fall nitrogen applications. Rake leaves and cut short. Control drifting snow.	Terraclor, Turfcide 400, Chipco 26GT plus Daconil Ultrex, Revere
Take-all patch ( <i>Gaeumannomyces graminis</i> )	Creeping bentgrass, colonial bentgrass	Avoid drought stress.	Rubigan, Banner, Heritage, Eagle
Yellow tufts ( <i>Sclerophthora macrospora</i> )	Annual bluegrass, Kentucky bluegrass, creeping bentgrass	Avoid standing water.	Subdue

**Table 7. Fungicide trade names.**

Below are the active ingredients of the fungicides available for use on turf. The fungicide common names are followed with names of some products containing the active ingredients. Several different formulations of each chemical may be available. Different formulations of the same chemical may have different instructions on the package, may or may not include Workers Protection Standards (WPS), and may or may not be a restricted use product. Application rates are often given as a range and may be different for different diseases. Always read the label of each product that you use for proper rates and uses.

LD<sub>50</sub> values are determined from toxicological tests involving pure active ingredient. The LD<sub>50</sub> is expressed as the number of milligrams of active ingredient per kilogram of body weight of the test animal. The LD<sub>50</sub> of an insecticide is the amount of the chemical that kills 50% of the test animals. Oral LD<sub>50</sub> values are determined from toxicity to male rats. The higher the LD<sub>50</sub>, the less toxic the compound is to mammals. The LD<sub>50</sub>'s in the following table are the lowest from either W. T. Thomson *Agricultural Chemicals - Book IV: Fungicides* (12th ed.), 1997, Thomson Publications, Fresno, CA or G.W. Ware, *The Pesticide Book* (4th ed.), 1988, Thomson Publications, Fresno, CA.

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<b>oral LD<sub>50</sub> of a.i.</b>	<b>Formulation</b>	<b>Manufacturer</b>	<b>Signal Word</b>	<b>WPS</b>	<b>Restricted Use</b>
<b>azoxystrobin</b>	<b>methoxyacrylate</b>	<b>5,000</b>					
Heritage			50 WP	Zeneca	caution	x	
<b>chloroneb</b>	<b>chlorophenyl</b>	<b>5,000</b>					
Teremec SP			65 SP	PBI/Gordon	caution		
<b>chlorothalonil</b>	<b>nitrite</b>	<b>10,000</b>					
Daconil Ultrex			82.5 WDG	Zeneca	danger	x	
Manicure 6 Flowable			6 F	Lesco	warning	x	
Manicure T/O Flowable			29.6% F	Lesco	warning	x	
Manicure Ultrex Turf Care			82.5 WDG	Lesco	danger	x	
<b>copper hydroxide</b>	<b>inorganic</b>	<b>925</b>					
Junction			46.1% DF	Griffin	danger	x	
<b>etridiazole</b>	<b>triazazole</b>	<b>1,070</b>					
Koban 1.3 G			1.3 G	Scotts	caution	x	
Koban 30			30% liquid	Scott	warning	x	
<b>fenarimol</b>	<b>pyrimidine</b>	<b>2,500</b>					
Rubigan A.S.			1 EC	Dow AgroSciences	caution	x	

**Turfgrass Disease Management**

**Table 7. Fungicide trade names (continued).**

Common Name	Class	Toxicity of Active Ingredient					
		oral LD <sub>50</sub> of a.i.	Formulation	Manufacturer	Signal Word	WPS	Restricted Use
<b>flutolanil</b>	<b>benzamide</b>	<b>10,000</b>					
Prostar 70 WP			70 WP	Aventis	caution	x	
<b>fosetyl-aluminum</b>	<b>organic phosphate</b>	<b>2,000</b>					
Chipco Signature			80 W	Aventis	caution	x	
Aliette T & O			80 WDG	Terra	caution	x	
<b>iprodione</b>	<b>dicarboximide</b>	<b>3,500</b>					
Chipco 26 GT Flo			2 lb/gal	Aventis	caution	x	
<b>mancozeb</b>	<b>carbamate</b>	<b>4,500</b>					
Dithane			75 W	Rohm & Haas	caution	x	
Dithane WF			4 WF	Rohm & Haas	caution	x	
Flowable Mancozeb 4			4 F	Lesco	caution		
Fore			80 W	Rohm & Haas	caution	x	
Fore Flowable			4 F	Rohm & Haas	caution	x	
Fore FloXL			4 F	Rohm & Haas	caution	x	
Mancozeb DG			75 DF	Lesco	caution	x	
Protect T/O			80 WSB	Cleary	caution	x	
<b>mefenoxam</b>	<b>acylanine</b>	<b>669</b>					
Subdue Granular			2 G	Novartis	caution		
Subdue 2X WSP			43.6 WSP	Novartis	caution	x	
Subdue MAXX			21.3% F	Novartis	caution	x	
Subdue GR			0.97 G	Novartis	caution		
<b>myclobutanol</b>	<b>triazole</b>	<b>1,600</b>					
Eagle			40% WS	Rohm & Haas	warning	x	
<b>pentachloronitrobenzene (PCNB)</b>	<b>chlorinated hydrocarbon</b>	<b>1,700</b>					
Revere 4000 Flowable Fungicide			4 F	Lesco	caution	x	
Revere WSP			75 WSP	Lesco	caution	x	
Scotts FFII			15.4%	Scotts	caution		
Terraclor			75 WP	Lesco	caution	x	
Terraclor 400			4 F	Uniroyal	caution	x	
Turfcide 10% Granular			10 G	Uniroyal	caution	x	
Turfcide 400			4 F	Uniroyal	caution	x	

## Turfgrass Disease Management

**Table 7. Fungicide trade names (continued).**

Common Name	Class	Toxicity of Active Ingredient					
		oral LD <sub>50</sub> of a.i.	Formulation	Manufacturer	Signal Word	WPS	Restricted Use
<b>propiconazole</b>	<b>triazole</b>	<b>1,517</b>					
Banner GL			41.8 WSP	Novartis	warning	x	
Banner MAXX			14.3% EC	Novartis	warning	x	
<b>propamocarb</b>	<b>carbamate</b>	<b>2,000</b>					
Banol			6 E	Aventis	caution	x	
<b>thiophanate-M</b>	<b>carbamate</b>	<b>7,500</b>					
3336 F			4.5 F	Cleary	caution	x	
3336 G			2.08 G	Cleary	caution	x	
3336 WSP			50 WSP	Cleary	caution	x	
Fungo Flo			4.5 F	Scotts	caution	x	
Fungo 50 WSB			50 WSB	Scotts	caution	x	
Systemic Fungicide			2.3 G	Scotts	caution		
Systec 1998 Flowable			4.5 F	Regal Chemical	caution	x	
Systec 1998 WDG			85 WDG	Regal Chemical	caution	x	
<b>triadimefon</b>	<b>triazole</b>	<b>250</b>					
Accost 1G			1 G	United Hort. Supply	caution	x	
Bayleton 25			25 WSP	Bayer	caution		
Bayleton 50			50 WSP	Bayer	caution		
Granular Turf Fungicide			1 G	Lesco	caution		
Strike 25 WDG			25 WDG	Olympic	caution	x	
<b>trifloxystrobin</b>	<b>methoxyacrylate</b>						
Compass			50 WDG	Novartis	caution	x	
<b>vinclozolin</b>	<b>dicarboximide</b>	<b>10,000</b>					
Curalan			4.17 F	TopPro	caution	x	
Curalan DF			50 DF	TopPro	caution	x	
Curalan EG			50 WDG	TopPro	caution	x	
Vorlan DF			50 DF	Scotts	caution	x	
Touche' Flowable			4.17 F	Lesco	caution	x	
Touche' EG			50 WG	Lesco			



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# Turfgrass Weed Management

The most important step in controlling weeds in turf is to maintain a dense, vigorous stand. It is difficult for weeds to become established in a properly maintained turf. Many weed species need light to germinate, so a tall, dense turf helps prevent weed seeds from germinating. In many situations, however, herbicide applications are necessary to maintain a weed-free turf.

Weeds in turf can be classified as broadleaves, grasses and sedges. These plants can be further divided according to their life cycles as annuals, biennials or perennials. Annual grasses have historically been controlled with preemergence (before emergence) herbicide applications. Annual grasses can be controlled postemergence (after emergence) but usually with more difficulty. Germinating perennial grass seeds can be controlled by preemergence application, but once established, perennial grasses are very difficult to control. Perennial grass weeds are often turfgrasses out of place, such as creeping bentgrass or tall fescue in a Kentucky bluegrass lawn. Broadleaf postemergence herbicides, typified by 2,4-D, have been available since the 1950s and are economical and effective and thus have always been the first choice for broadleaf weed control.

Most preemergence herbicides are used for grass control, though some preemergence grass herbicides also control a limited spectrum of broadleaf weeds. A preemergence grass herbicide can, therefore, also serve as a narrow-spectrum, preemergence broadleaf herbicide. Isoxaben (Gallery) is a broad-spectrum preemergence herbicide controlling more than 30 turf broadleaf weeds. Isoxaben offers a preventive approach to broadleaf weed control and, like most other preemergence herbicides, poses little or no risk of leaching to groundwater. Postemergence broadleaf

herbicides move readily in soils and thus can reach groundwater. Relatively low use rates and short soil half-lives reduce the risk of high levels of groundwater contamination from postemergence broadleaf herbicides. The efficacy and economy of postemergence broadleaf herbicides most likely have reduced the market for preemergence broadleaf weed control.

## Principles of Broadleaf Control

Fall is the best time to control perennial broadleaf weeds and germinating winter annuals and biennials. As a rule of thumb, the younger a plant is, the easier it is to control. Winter annuals are easily controlled with fall herbicide applications. Established perennials are also effectively controlled in the fall because they are actively growing and storing food reserves in their roots, and this increases the movement of herbicide into the roots. Also, non-target injury from volatility and/or spray drift is less likely because ornamental and vegetable plants are dying or hardening off for the winter. Non-target injury is most likely in the spring, when plants are beginning new growth, which is extremely sensitive to most postemergence broadleaf herbicides.

Spring applications of broadleaf herbicides are sometimes necessary to control summer annuals and spring-germinating perennials. However, you can control many of these weeds by selecting a preemergence annual grass herbicide with some broadleaf weed activity. For example, herbicides such as pendimethalin (Pendulum, others), dithiopyr (Dimension) and benefin plus trifluralin (Team) will provide preemergence control of oxalis and spurge as well as some other broadleaf weeds. The spectrum of broadleaf weeds controlled by preemergence herbicides is not as well documented as it is for the postemergence broadleaf herbicides.

Spring is a good time to control broadleaf weeds, though it's not as good as fall unless the weeds are germinating. In the spring, perennial broadleaf weeds are beginning active growth by utilizing reserves stored in the roots for new top growth with very little translocation to the roots. Herbicide applications at this time may not give acceptable control because the herbicide kills the plant foliage but does not move to the roots, so the plant can regenerate a new shoot system from its root reserves. Therefore, spring applications may not give the expected results, depending on the stage of growth of the broadleaf weeds.

Summer is the most difficult time to control broadleaf weeds. During dry spells, it is often difficult to get as much as 10 percent weed control. When plants are drought stressed, they respond by slowing or stopping growth and modifying their leaves to reduce transpiration. The primary method to reduce transpiration is to increase the waxy coating on the surface of the leaves. The additional wax makes it more difficult for the herbicide solution to stay on the plant foliage and for the herbicide to penetrate the wax and enter the plant. Ester-formulated herbicides are recommended for controlling weeds in summer because the esters are better able to penetrate the waxy surface of the leaves. Spot treating weeds is recommended in the summer to reduce the overall herbicide load applied to the turf and thus reduce the potential for volatility injury to non-target plants.

### **Difficult-to-Control Broadleaf Weeds in Turf**

The standard broadleaf herbicide in the turf industry is 2,4-D, a broad-spectrum herbicide that is the main ingredient in many of the packaged broadleaf herbicide mixtures.

Postemergence broadleaf herbicides used in turfgrass management only control existing weeds. The activity of broadleaf herbicides, for the most part, depends on

the timing of application in relation to the growth stage of the weed. In general, younger plants are easier to control than mature plants. Herbicide uptake and translocation are favored in younger plants. In addition to growth stage, the time of year plays a major role in determining the effectiveness of a herbicide application. Care should be taken to avoid applications during extreme stress periods such as drought or heat. In general, broadleaf herbicides have a greater potential for injury than preemergence herbicides. Herbicide efficacy is diminished and turf may be damaged when herbicides are applied during periods of stress.

For 50 years, broadleaf weed control has been accomplished with phenoxy herbicides such as 2,4-D, 2,4-DP, MCPA and MCPP. Dicamba, a benzoic acid, is another traditional broadleaf herbicide. These products are the standards against which any new herbicides are measured. Mixtures of these herbicides are common and numerous. Probably the mixture most familiar to turf managers would be some combination of 2,4-D + MCPP + dicamba. This three-way mixture is inexpensive, has good turf safety and provides control of a wide range of weeds. This combination is synergistic and it provides better weed control than if the individual herbicides were applied separately. The predominance of three-way herbicides can be illustrated by viewing a list of "hard-to-control" weeds. These lists usually reflect weeds that persist after three-way herbicides have been applied (Table 10). Many formulations of these products exist, from pure acids to salt-based amines and the alcohol-based esters. Amine formulations are very common and have low potential for volatility. Ester formulations are more effective than amines, but high volatility potential limits their use because of increased risk for off-site damage. Factors that determine which formulations to use include the growth stage of the weeds, climatic conditions and sensitivity of landscape plants.

Quinclorac was recently registered. It is primarily a postemergence crabgrass herbicide that also has good activity on clover and knotweed. Quinclorac has shown excellent cool-season turfgrass safety. Mature crabgrass plants (3+ tillers) can be controlled with a single application. Historically, two or more applications of MSMA were needed to manage crabgrass that advanced past the one- to three-tiller stage. In addition, MSMA can cause turfgrass discoloration immediately after application. Fenoxypop offers improved efficacy and turf safety over MSMA. However, fenoxypop is antagonized by 2,4-D and can result in significant turfgrass injury. This prevents using them in a tank mix to control broadleaf and annual grassy weeds in one application. Conversely, quinclorac may be tank mixed with 2,4-D or products containing 2,4-D. There also appears to be synergism between 2,4-D and quinclorac. Results from 1997, 1998 and 1999 indicate that broadleaf weed control (ground ivy, speedwell and clover) of several broadleaf herbicides can be dramatically increased by tank mixing them with quinclorac. Products containing 2,4-D have benefited the most from this combination. These combinations deserve consideration to be used for callbacks and mid- to late-summer weed control applications.

These herbicides and herbicide combinations still dominate the weed control landscape, but in recent years new herbicides have become available. Triclopyr and clopyralid are pyridine herbicides. These products are very active on a number of broadleaf weeds and are primarily used in cool-season turf. Triclopyr is used alone and in combination with other herbicides. Triclopyr is active against many weeds that are traditionally labeled hard-to-control (2,4-D didn't work). For this reason, triclopyr is probably the first alternative to try when a 2,4-D mixture has failed to provide acceptable control. Because of their complementary weed activity, combinations of triclopyr + 2,4-D can be very effective.

## **Principles of Grass and Sedge Weed Control**

Grass weeds are classified as either annuals or perennials. Fortunately, there are few perennial grass weed problems in Michigan. Control of these perennial grasses is often very difficult because turfgrasses are also perennial grasses and it is difficult to find a herbicide that will kill the weedy perennial grass without harming the desirable turfgrass species. The only true perennial grass weed problem that occurs frequently in Michigan is quackgrass (*Elytrigia repens*). This aggressive grass spreads by an extensive rhizome system, and there is currently no selective control. If mowing and increased fertility are not effective, then a quackgrass-infested turf should be killed off with a suitable non-selective herbicide and reestablished.

Sedges are classified as either annuals or perennials. Sedges are easily distinguished from grasses by their triangle-shaped stems. They are commonly found in wet areas or poorly drained turf. The most prolific sedge in Michigan is yellow nutsedge (*Cyperus esculentus*), a perennial. Manage it culturally by ensuring adequate drainage and avoiding excess irrigation. Postemergence applications of bentazon (Basagran, others) or halosulfuron (Manage) will provide effective control of this weed.

## **Annual Grass Control**

Crabgrass (*Digitaria sanguinalis* or *D. ischaemum*) is the principal annual grass weed problem in turf in Michigan. Foxtails, barnyardgrass and goosegrass may occasionally be problems, but crabgrass is generally present each year.

Historically, preemergence herbicides have been used to control crabgrass. These compounds provide good to excellent control when properly applied by providing a chemical barrier. As crabgrass seed germinates, the seedlings contact the herbicide and

are killed if the herbicide is present in sufficient quantity. These herbicides are, in general, immobile in the soil and present little risk to groundwater or surface waters.

Postemergence grass herbicides are not as plentiful as preemergence products (Table 8). Currently, four choices exist for controlling crabgrass postemergence, with choice depending on the maturity of the weed. Numerous products use the methanearsonate chemistry (e.g., MSMA) as listed in the recommended herbicide section. This is an older product that does not have great efficacy on crabgrass when applied at rates that are safe to cool-season turf. Generally, two applications spaced 10 to 14 days apart are needed to provide desirable control.

Dithiopyr (Dimension) is a preemergence herbicide that provides postemergence control of crabgrass at the one- to three-leaf stage of growth only. Fenoxaprop (Acclaim) provides good to excellent crabgrass control up to the three-tiller growth stage. As crabgrass matures or becomes drought stressed, the efficacy of this product decreases. Quinclorac (Drive) is a newly registered herbicide that provides some preemergence but mainly postemergence control of crabgrass beyond the three-tiller growth stage. However, like all of the aforementioned postemergence herbicides, it's more effective on younger crabgrass plants. Quinclorac also has postemergence activity on certain broadleaf weeds, including dandelion, clover and speedwell.

On golf courses and other low-cut turf, annual bluegrass (*Poa annua*) can be a serious perennial weed problem. Some strides have been made in the control of annual bluegrass, and those are noted in the herbicide recommendation section.

Other perennial grass weed problems are typically turfgrasses out of place, such as creeping bentgrass or tall fescue in a Kentucky bluegrass lawn. There is no selective herbicidal control for creeping bentgrass — the best control measure is a sod cutter. Selective control of tall fescue in Kentucky bluegrass can be achieved using the herbicide chlorsulfuron (TFC).

## **Principles of Non-selective Weed Control**

Several non-selective herbicides are now available for use in turf and landscape situations. Pelargonic acid (Scythe), diquat (Reward) and glufosinate (Finale) are contact-type herbicides; in other words, they are not translocated in the plant. These herbicides provide rapid foliar burn, usually within hours up to a couple of days. Their best uses are on annual vegetation, for edging and for rapid foliar burn. Glyphosate (Roundup Pro) is the only systemic or translocated non-selective herbicide available. Glyphosate is the best choice for perennial vegetation control.

**Table 8. Herbicide recommendations.**

<b>Weed problem</b>	<b>Herbicide common name, trade name and formulation</b>	<b>Comments</b>
Annual grasses — Crabgrass Foxtails Barnyardgrass Goosegrass		
Preemergence control — new seeding	Siduron Tupersan 50 WP	Safe on most cool-season turfgrass species; does not give seasonlong control; reapplication may be necessary.
Preemergence control — established turf	Benefin Balan 2.5 G  Benefin + Trifluralin Team Pro 2 G  Benefin + Oryzalin XL 2 G  Bensulide Bensumec 4 LF Betusan 4 E Pre-San 7 G  Dithiopyr Dimension 1 EC  Oryzalin Surflan 4 AS  Oxadiazon Chipco Ronstar 2G	Safe to apply to all established turfgrass except bentgrass. Do not apply to putting greens.  Use on lawns and golf course fairways of bentgrass, fescue and perennial ryegrass.  Use on tall fescue.  May be applied to all established turfgrass including bentgrass putting greens.  May be applied to all cool-season turfgrasses except colônia bentgrass. Use on putting greens.  Use on established tall fescue.  Use in established perennial bluegrass, bentgrass, ryegrass and tall fescue. Do not apply to putting greens or tees. Do not apply to bentgrass mowed at less than 3/8 in. Do not apply to wet turf. Do not apply to home lawns.

**Table 8. Herbicide recommendations (continued).**

<b>Weed problem</b>	<b>Herbicide common name, trade name and formulation</b>	<b>Comments</b>
Preemergence control — established turf (cont.)	<p>Pendimethalin Pendulum 2G, 3.3 EC, 60 WDG Pre-M 3.3 EC, 60DG</p> <p>Prodiamine Barricade 65 WG</p> <p>Siduron Tupersan 50 WP</p>	<p>Use on established fine fescue, Kentucky bluegrass, perennial ryegrass and tall fescue.</p> <p>May be used on established fine fescue, creeping red fescue, perennial bluegrass and ryegrass, and creeping bentgrass. Do not apply to putting greens.</p> <p>May be used on established fine fescue, creeping red fescue, perennial bluegrass and ryegrass, and creeping bentgrass. Do not apply to putting greens.</p>
Crabgrass Postemergence — established turf	<p>Dithiopyr Dimension 1 EC</p> <p>Fenoxaprop Acclaim Extra 1 EC</p> <p>Quinclorac Drive 75 DF</p> <p>MSMA Daconate 6 MSMA 6.6, SG, Turf</p>	<p>Apply to one- to three-leaf stage only.</p> <p>Rate depends on leaf numbers or tillers. Most effective up to three tillers. Repeat applications may be necessary. Consult label before tank mixing with broadleaf herbicides. Do not apply to putting greens.</p> <p>Greater activity on mature plants (three + tillers). For use in residential and non-residential turf. Apply to Kentucky bluegrass, annual bluegrass, tall fescue, perennial ryegrass and creeping bentgrass. Can also be applied to fine fescue but must be in a blend of herbicides. Do not apply to putting greens or collars.</p> <p>Bluegrass and fescue are slightly sensitive. Do not apply to other cool-season turfgrass species. Repeat applications are necessary.</p>

**Table 8. Herbicide recommendations (continued).**

<b>Weed problem</b>	<b>Herbicide common name, trade name and formulation</b>	<b>Comments</b>
Annual bluegrass Preemergence - established turf	Benefin Balan 2.5 G  Benefin + Trifluralin Team 2 G  Benefin + Oryzalin XL 2 G  Bensulide Bensumec 4 LF Betasan 4 E Pre-San 7 G  Dithiopyr Dimension 1 EC  Oryzalin Surflan 4 AS  Oxadiazon Chipco Ronstar 2 G  Pendimethalin Pendulum 2 G, 3.3 EC, 60 WDG Pre-M 3.3 EC, 60 DG  Prodiamine Barricade 65 WG	
Postemergence - established turf	Ethofumesate Prograss 1.5 EC	

**Table 8. Herbicide recommendations (continued).**

<b>Weed problem</b>	<b>Herbicide common name, trade name and formulation</b>	<b>Comments</b>
Yellow nutsedge Postemergence — established turf	MSMA Daconate 6 MSMA 6.6, SG, Turf  Bentazon Basagran SG  Halosulfuron Manage	Bluegrass and fescue are slightly sensitive. Do not apply to other cool-season turfgrass species. Repeat applications are necessary.  Use on established bluegrass, fescues, bentgrass and ryegrass. Repeat applications may be necessary. Do not apply to putting greens.  Use on all major cool-season turfgrasses except those on putting greens. Repeat applications may be necessary. Use non-ionic surfactant.
Certain broadleaf weeds Preemergence — established turf	Isoxaben Gallery	All established turfgrasses are tolerant. Check label for specific weeds controlled.
Tall fescue Postemergence — established turf	Chlorsulfuron TFC	
Non-selective vegetation control. Postemergence — systemic	Glyphosate Roundup Pro	Most effective on perennial species. Repeat applications may be necessary.
Postemergence — contact	Diquat Reward  Glufosinate Finale  Pelargonic acid Scythe	Most effective for rapid kill on annual species or for use in chemical edging.  Same as above.  Same as above.



**Table 9. Broadleaf herbicide activity on persistent weeds.**

	<b>2,4-D</b>	<b>MCPP</b>	<b>Dicamba</b>	<b>MCPA</b>	<b>2,4-DP</b>	<b>Triclopyr</b>	<b>Clopyralid</b>	<b>Chlorsulfuron</b>	<b>Quinclorac</b>
Ground ivy	○	▲	●	○	▲	●	▲	○	○
Wild strawberry	○	○	●	○	▲	●	○	○	○
Spurge	○	▲	▲	○	○	▲	○	○	—
Oxalis	○	○	▲	○	●	●	○	○	○
Corn speedwell	○	○	▲	○	○	●	○	○	▲
Creeping speedwell	○	○	○	○	○	▲	○	—	▲
Wild violet	○	○	○	○	○	▲	○	●	—
White clover	○	▲	▲	○	○	○	●	▲	●
Prostrate knotweed	○	▲	●	○	▲	●	▲	▲	●
Yarrow	▲	○	●	○	▲	—	—	○	—

Weed susceptibility by herbicide where reported:

○ = resistant, ▲ = intermediate and ● = susceptible. Blank cells (—) indicate incomplete data.

**Table 10. Commonly used broadleaf herbicide combinations.**

	2,4-D	MCP	Dicamba	MCPA	2,4-DP	Triclopyr	Clopyralid	Bromoxynil	Glyphosate	MSMA
Formula 40, Weedone LV4, Weedar 64, Lesco 2-4D										
MCP 4-Amine, Lescopec, Turfgo MCP 4K										
2 Plus 2										
Banvel										
Four-power Plus, Super D Weedone										
Trimec Classic, Trimec Encore, Trimec Plus, Trimec Turf Amine, Trimec Turf Ester, Strike 3, Three Way Selective, Trimec Bent, Bent Selective, Triplet, Trexan, MEC Amine-D, MEC Amine-BG										
Trimec Plus (Quadmec)										
Super Trimec										
Weedone DPC, Turf D-DP										
Tri-Power										
Tri-Ester II, Tri-Amine II										
Three Way Ester, Tri-Ester, Tri-Amine, Dissolve										
Turflon, Garlon										
Chaser, Turflon II										
Lontrel										
Confront										
Momentum										
Millenium Ultra										
Cool Power, Eliminate, Horsepower										
Buctril										
Campaign										

**Table 11. Herbicide trade names.**

Below are the active ingredients of the herbicides available for use on turf. The herbicide common names are followed with some of the products containing the active ingredients. There may be several different formulations of each chemical available. Different formulations of the same chemical may have different instructions on the package, may or may not include Workers Protection Standards (WPS), and may or may not be a restricted use product. Application rates are often given as a range and may be different for different weeds. Always read the label of each product that you use for proper rates and uses.

LD<sub>50</sub> values are determined from toxicological tests involving pure active ingredient. The LD<sub>50</sub> is expressed as the number of milligrams of active ingredient per kilogram of body weight of the test animal. The LD<sub>50</sub> of an insecticide is the amount of the chemical that kills 50% of the test animals. Oral LD<sub>50</sub> values are determined from toxicity to male rats. The higher the LD<sub>50</sub>, the less toxic the compound is to mammals. The LD<sub>50</sub>'s in the following table are the lowest from either W. T. Thomson, *Agricultural Chemicals - Book II: Herbicides (13th ed.)*, 1997, Thomson Publications, Fresno, CA or G.W. Ware, *The Pesticide Book (4th ed.)* 1988, Thomson Publications, Fresno, CA.

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<i>oral LD<sub>50</sub> of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal Word</i>	<i>WPS</i>	<i>Restricted Use</i>
<b>2,4-D</b>	<b>phenoxy</b>	<b>375</b>					
many, often as a mixture with other herbicides				many manufacturers			
<b>2, 4-DP</b>	<b>phenoxy compound</b>	<b>500</b>					
many, usually as a mixture with other herbicides				many manufacturers			
<b>benefin</b>	<b>dinitroaniline</b>	<b>5,000</b>					
Balan			2.5 G	United Hort Supply	caution		
<b>benefin + oryzalin</b>							
XL 2 G			2 G	Dow AgroSciences	caution		
<b>benefin + triflurain</b>							
Team 2G			2 G	Lesco, United Hort Supply			
<b>bensulide</b>	<b>sulfonamide</b>	<b>270</b>					
Bensumec			4 LF	PBI/Gordon	caution		
Betasan			4 E	Helena	caution		
Pre-San			7 G	PBI/Gordon	warning		

**Turfgrass Weed Management**

**Table 11. Herbicide trade names (continued).**

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<i>oral LD<sub>50</sub></i> <i>of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal Word</i>	<i>WPS</i>	<i>Restricted Use</i>
<b>Trade Name</b>	<b>Class</b>						
<b>bentazon</b>	<b>benzothiadizaole</b>	<b>1,100</b>					
Basagran			5 G	TopPro	danger	x	
Basagran T/O			4 S	TopPro	caution	x	
Lesogran				Lesco	caution	x	
<b>bromoxynil</b>	<b>hydroxybenzonitrile</b>	<b>190</b>					
Buctril			2 lb/gal	Aventis	warning	x	
<b>chlorsulfuron</b>	<b>sulfonylurea</b>	<b>3,053</b>					
TFC			75 DG	Lesco	caution	x	
<b>clopyralid</b>	<b>pyradine</b>	<b>4,300</b>					
many, usually in mixtures with other herbicides							
Lontrel			3 EC	Dow Agrosiences	caution	x	
<b>dicamba</b>	<b>benzole acid derivative</b>	<b>1,040</b>					
many, usually as a mixture with other herbicides				many manufacturers			
<b>diquat</b>	<b>non-selective desiccant</b>	<b>215</b>					
Reward 6 S				Zeneca	warning	x	x
<b>dithiopyr</b>	<b>pyridine</b>	<b>3,600</b>					
Dimension			1 EC	Rohm and Haas	warning	x	
<b>ethofumesate</b>	<b>benzofuran</b>	<b>6,400</b>					
Prograss			1.5 EC	Aventis	danger	x	
<b>fenoxaprop</b>	<b>aryloxyphenoxy propionate</b>	<b>2,357</b>					
Acclaim			1 EC	Aventis	caution	x	
<b>glufosinate-ammonium</b>	<b>phosphoric acid</b>	<b>1,620</b>					
Finale			1 lb/gal	Aventis	warning	x	
<b>glyphosate</b>	<b>phosphoric acid</b>	<b>4,900</b>					
Roundup Pro			4 S	Monsanto	caution	x	
<b>halosulfuron</b>	<b>sulfonylurea</b>	<b>1,287</b>					
Manage			75 WP	Monsanto	caution	x	

**Turfgrass Weed Management**

**Table 11. Herbicide trade names (continued).**

		<b>Toxicity of Active Ingredient</b>					
<b>Common Name</b>		<i>oral LD<sub>50</sub></i> <i>of a.i.</i>	<i>Formulation</i>	<i>Manufacturer</i>	<i>Signal</i> <i>Word</i>	<i>WPS</i>	<i>Restricted</i> <i>Use</i>
Trade Name	<b>Class</b>						
<b>isoxaben</b>	<b>benzamide</b>	<b>10,000</b>					
Gallery			75 DF	Dow AgroSciences	caution	x	
<b>MCPA</b>	<b>phenoxy</b>	<b>76</b>					
many, usually as a mixture with other herbicides				many manufacturers			
<b>MCPP</b>	<b>phenoxy compound</b>	<b>558</b>					
MCPP 4K			4 lb/gal	United Hort. Supply	caution		
<b>MSMA</b>	<b>organic arsenical</b>	<b>700</b>					
Daconate			6 S	ISK Biological	caution	x	
MSMA 6.6			6.6 S	Lesco	caution	x	
MSMA			5 G	Lesco	caution	x	
MSMA Turf			6 S	United Hort. Supply	caution	x	
<b>oryzalin</b>	<b>dinitroaniline</b>	<b>10,000</b>					
Surflan			4 AS	Dow AgroSciences	caution	x	
<b>oxadiazon</b>	<b>oxadiazole</b>	<b>3,500</b>					
Chipco Ronstar			2 G	Aventis	warning	x	
<b>pendimethalin</b>	<b>dinitroaniline</b>	<b>1,250</b>					
Pendulum			2 G	American Cyanamid	caution	x	
Pendulum			3.3 EC	American Cyanamid	caution	x	
Pendulum			60 WDG	American Cyanamid	caution	x	
Pre-M			3.3 EC	Lesco	caution		
Pre-M			60 DG	Lesco	caution		
<b>prodiamine</b>	<b>dinitroaniline</b>	<b>5,000</b>					
Barricade			65 WG	Novartis	caution	x	
<b>pelargonic acid</b>	<b>pelargonic acid</b>	<b>NONE LISTED</b>					
Scythe			4.2 lb/gal	Mycogen	warning	x	
<b>quinclorac</b>	<b>quinoline</b>	<b>2,200</b>					
Drive			1.5 EC	BASF	caution	x	
<b>siduron</b>	<b>urea</b>	<b>7,500</b>					
Tupersan			50 WP	PBI/Gordon	caution		
<b>triclopyr</b>	<b>pyradine</b>	<b>630</b>					
Turflon Ester			4 lb/gal	Dow AgroSciences	caution	x	



# PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of February 2000



## Human Pesticide Poisoning

M I C H I G A N P O I S O N C O N T R O L S Y S T E M

From anywhere in Michigan, call

**1 - 8 0 0 - P O I S O N 1**  
**1 - 8 0 0 - 7 6 4 - 7 6 6 1**

## Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

Phone No.

Or

Animal Health Diagnostic Laboratory (Toxicology) Michigan State University: (517) 355-0281

Phone No.

and

Fire Marshal Division, Michigan State Police: **M-F: 8-12, 1-5** (517) 322-1924

\* Telephone Number Operated 24 Hours

Pesticide Fire

Local fire department:

Traffic Accident

Local police department or sheriff's department:

Environmental Pollution

Pollution Emergency Alerting System (PEAS), Michigan Department of Environmental Quality:

Pesticide Disposal Information

Michigan Department of Environmental Quality, Waste Management Division. **Monday - Friday: 8 a.m.-5 p.m.** (517) 373-2730

Phone No.

and

Operations Division, Michigan State Police: \*(517) 336-6605

District MDEQ Office Phone No.

and

For environmental emergencies: \*1-800-292-4706 also \*1-800-405-0101 Michigan Department of Agriculture Spill Response

National Pesticide Telecommunications Network

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

**7 days a week; excluding holidays**  
**6:30 a.m. - 4:30 p.m. Pacific Time Zone**  
1-800-858-7378  
FAX: 1-541-737-0761



Sampling for grubs



Dandelion



Snow mold on bentgrass



Pesticide storage facility