Ornamental and Turfgrass Pest Management

A Pesticide Applicator Certification Manual for the Carolinas and Georgia

North Carolina Cooperative Extension Service
North Carolina State University

Cooperative Extension Service/The University of Georgia
College of Agricultural and Environmental Sciences

Clemson Cooperative Extension Service
Clemson University

Disclaimer:

The use of brand and common names and any mention or listing of commercial products or services in this manual does not imply endorsement by North Carolina State University, Clemson University, or the University of Georgia nor discrimination against similar products or services not mentioned. Individuals who use pesticides are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your local Cooperative Extension Service agent.

Contents

Manual Coordinator

Wayne G. Buhler, North Carolina State University

Contributing Authors

James R. Baker, Department of Entomology (Emeritus), North Carolina State University
Robert Bellinger, Department of Entomology, Clemson University
Rick L. Brandenburg, Department of Entomology, North Carolina State University
Wayne G. Buhler, Department of Horticultural Science, North Carolina State University
Mark Czarnota, Department of Horticulture, University of Georgia (Griffin)
Erv Evans, Department of Horticultural Science (retired), North Carolina State University
Paul Guillebeau, Department of Entomology, University of Georgia (Athens)
Bruce Martin, Department of Plant Pathology, Clemson University
Tim R. Murphy, Department of Weed Science (Emeritus), University of Georgia (Griffin)
Lane P. Tredway, North Carolina State University, (former employee)
Colleen Y. Warfield, North Carolina State University, (former employee)

Sources and References

Pesticide Applicator Training Manual, Category 3, Turf and Ornamentals. 1992. S. C. Merrigan and P. B. Baker. University of Arizona, Cooperative Extension, Tucson, AZ. 260 pp.

Turfgrass Pest Management Manual, A Guide to Major Turfgrass Pests and Turfgrasses. 1998. A. Bruneau (ed.). North Carolina Cooperative Extension Service, AG-348.

A Training Manual for Commercial Pesticide Applicators (Category 3a). Turf Pest Management. 1998. K. Sichneder. Michigan State University Extension, Extension Bulletin E-2327.

Turf Pest Control, Category 3b, Indiana Commercial Pesticide Applicator Manual. 2000. A. Martin, T. Gibb, Z. Reicher, and C. Throssell. Purdue Pesticide Programs, Purdue University Cooperative Extension Service, PPP-36.

The North Carolina Master Gardener Training Manual. 1998. E. Evans (ed.). North Carolina Cooperative Extension Service.

Turf and Ornamental Weed Management Principles. 1994. C. M. Boerboom, C. A. Ramsay, G. L. Thomasson, G. K. Stahnke, R. R. Maleike. Washington State University, MICS0170.

Ornamental Pest Control, A Guide for Ornamental Plant Managers in Virginia. 2000. J. Derr, et al. Virginia Cooperative Extension, Publication 456-223.

Calibrating Turfgrass Chemical Application Equipment. 1991. H. E. Ozkan. Ohio Cooperative Extension Service. The Ohio State University, Extension Bulletin 817.

Acknowledgments

Reviewers

The entire manual was reviewed by:

Erv Evans, Toby Bost, Matt Martin and Wayne Mitchem, North Carolina State University, Cooperative Extension Service

Paul Guillebeau, University of Georgia

Colleen Hudak-Wise and James Choate, North Carolina Department of Agriculture and Consumer Services

Robert Bellinger, Clemson University

Portions of the manual were reviewed for technical accuracy by:

Milton Taylor, Dan Horton, Gil W. Landry, Alfredo Martinez, Mike Mengak, Paul Sumner, and Gary Wade, University of Georgia

Steve Bambara, Mike Benson, Christine Casey, Bob McRackan, David Monks, Joe Neal, and Fred Yelverton, North Carolina State University

Carl Betsill, North Carolina Wildlife Resources Commission

Tom Augspurger, North Carolina Fish and Wildlife Service

Derrel Shipes, South Carolina Department of Natural Resources

Technical information

Bruce Paulsrud, University of Illinois, provided information on fungicide terminology in Chapter 9.

Joe Neal and Stu Warren, North Carolina State University, provided information on weed management.

Photographs

Art Bruneau, Joe Neal, Eric Nelson, Lane Tredway, Colleen Warfield, and Wayne Buhler

Illustrations

James Baker, Sandy Shultz, and Grace Jenkins

Editing and Design

Lynn Padgett

Certification Requirements in North Carolina, Georgia, and South Carolina

A Note to the Reader

This manual is intended to prepare pesticide applicators for the Ornamentals and Turfgrass Pest Control certification examination in North Carolina, South Carolina, and Georgia. Questions on the exam are based on information in this manual as well as information about pesticide laws, regulations, and safe handling procedures. After studying the manual, you should be familiar with the topics in the Learning Objectives and Terms to Know lists in each chapter and be able to answer the review questions.

This manual is not a comprehensive guide to ornamental and turfgrass pest management. For more information on turfgrass and ornamental plant care, refer to the Resources section at the end of each chapter.

Certification and licensing requirements for each state are described in the following sections. You need to read only the information for the state in which you want to be certified.

North Carolina
Pesticide Applicator Certification

If you apply any pesticide to the property of another for pay, you must be licensed with the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) Pesticide Section or work under the direct supervision of a licensed pesticide applicator. To be eligible for a license, you must first become certified and be at least 18 years old by January 1 of the year in which your application is submitted. A certified applicator has passed the exams to demonstrate competence to handle and apply pesticides. Certification exams are administered and graded by the NCDA&CS Pesticide Section. The passing score is 70 percent. After passing the exam, your certification is valid for five years.

North Carolina Certification Exams and Licensing

The certification exam is given by NCDA&CS Pesticide Section on the second day of the Pesticide Schools offered by the NC Cooperative Extension Service at various dates and locations throughout the state. For a schedule of Pesticide Schools, log onto the following Web site: www.pesticidesafety.ces.ncsu.edu and click on the link for "Training Schools." This information is also available by calling (919) 515-3113.

The certification exam is also offered at other times and places. To schedule an appointment to take the exam without attending a Pesticide School, you must call the NCDA&CS Pesticide Section at (919) 733-3556. For a complete list of exam dates and locations, go to www.pesticidesafety.ces.ncsu.edu and click on "License Exam Schedule."

NOTE: When you take the exam, you will need to bring (1) a government-issued photo ID (driver's license, for example), (2) a calculator, and (3) a pencil.

Test results will be mailed to you within two weeks of your exam date. When you pass the exam, you are eligible to become a licensed applicator. If you fail the exam, you may take it two more times during the same calendar year.

FEES: Commercial Applicators (those who use pesticides in a landscaping business, on golf courses, or on other privately owned sites) must pay an annual fee of $75 for a pesticide license. A form for submitting your fee will be sent to you by NCDA&CS. **Public Operators** (those who use pesticides while employed with federal, state, or local governmental agencies) do not need to pay a license fee, but must submit a signed license application form each year. Public utility employees are also considered Public Operators, but these individuals must pay a $75 annual licensing fee. The Ornamental and Turfgrass license category is specified with the letter "L." If you will not be applying pesticides in any year of the five-year certification period, you do not need to purchase a license for that year.

The license expires on **December 31** each year.

Recertification

You must earn at least **10 hours** of continuing certification credits by **June 30** of the fifth year of certification to renew your certification for the next five-year period. This is the process

of recertification. You can earn recertification credits by attending seminars, field days, or workshops that have been pre-approved for category "L" recertification by the NCDA&CS Pesticide Section. You must obtain credits in more than one calendar year of the five-year certification period, so you cannot wait until the last year to get all 10 credits.

Near the end of each year, the Pesticide Section will mail you a recertification transcript to help you track the number of credit hours you have earned. You may also see your recertification transcript by visiting the Pesticide Section's Web site at: www.ncagr.gov/SPCAP/pesticides/license.htm and clicking on "Credit Status Search." If you do not earn a minimum of 10 hours of credit spread over at least two years of your certification period, you must pass the certification exam again in order to recertify.

To learn about recertification opportunities and training events, call your local Cooperative Extension Service Center (listed in most telephone directories under County Government Offices) or visit the Pesticide Section's Web site. To receive recertification credit for any training you attend, be sure to sign the attendance roster or have your card scanned at the end of the session. Recertification credit hours cannot be carried over from one five-year certification period to the next.

Reciprocity

If you are not a resident of North Carolina, but have a valid certification card from Virginia, South Carolina, Georgia, or Florida and expect to make pesticide applications in North Carolina, you may request a reciprocal North Carolina Ground Applicator license from the NCDA&CS Pesticide Section. Once you become a resident of North Carolina, reciprocity is no longer an option, and you must pass the certification exam. The annual cost of a reciprocal license is $75. Recertification can be maintained through the applicator's home state or by earning the appropriate number of credits in North Carolina. If you are licensed in North Carolina, the requirements for a similar license in another state may be reduced. Contact the appropriate state agency for details. (A list of state regulatory agencies can be found at npic.orst.edu/reg/state_agencies.htm.

For information regarding training or to order manuals contact:

Pesticide Safety Education Office
North Carolina State University
Campus Box 7609
Raleigh, NC 27695-7609
Phone: (919) 515-3113

For information regarding certification and licensing contact:

North Carolina Department of Agriculture and Consumer Services
Structural Pest Control and Pesticides Division
Pesticide Section
1090 Mail Service Center
Raleigh, NC 27699-1090
Phone: (919) 733-3556

Georgia

Pesticide Applicator Certification

Pesticide Applicator Licenses

If you want to purchase, use, or supervise the use of either a general use or restricted use pesticide to the lands of another person or business for a fee, you must have a Commercial Applicator License in the appropriate category and a Pesticide Contractor License. Companies must have a separate Pesticide Contractor License for each location and must have at least one Commercial Pesticide Applicator in full-time employment per location.

To purchase, use, or supervise the use of restricted use pesticides on your property or the property of your employer (unless you are producing an agricultural or forestry commodity), you will need a Commercial Applicator License in the appropriate category. The Commercial Pesticide Applicator license does not permit you to charge a fee unless you also have a Pesticide Contractor License.

If you wish to purchase, use, or supervise the use of any restricted use pesticide on your property or the property of your employer for the production of an agricultural or forestry commodity, you will need a Private Applicator License. Contact your local Extension office to obtain a Private Applicator License. You are not required to pass a test on this manual.

Commercial Applicator License Examination

To obtain a Commercial Applicator License, you must pass both Commercial Applicator examinations, one a General Standards exam testing for general knowledge on the safe use of pesticides and the appropriate category-specific exam. These exams are administered by the Georgia Technical Colleges at various locations around the state numerous times each year. You can find the testing schedule at the Georgia Department of Agriculture Pesticide Program website (http://agr.georgia.gov/pesticides.aspx). Look under "Related Links" for "Georgia Commercial Pesticide Exam Registration and Study Materials."

Currently, you must pay $45 to take the exam. Bring a check or money order payable to the Georgia Department of Agriculture to the exam location. Cash is not accepted. To pass, you must make a score of 70 percent or more on the general standards test and 70 percent on one major category test, such as Ornamentals and Turf. Your exam results will be mailed to you within four weeks.

If you pass one of the tests, you have up to one year to pass the other test.

License Expiration and Renewal

Both the Private and Commercial Pesticide Applicator Licenses are valid for five years.

To renew your license, you may (1) take the tests again or (2) earn the required recertification credit hours during the five years before your license expires. The Ornamentals and Turf category requires 10 hours of recertification credit. Notice of all recertification credit hours must be received in the Georgia Department of Agriculture Pesticide Division office at least 90 days before the expiration date of your license.

You can check your recertification status and get information about recertification opportunities at the Georgia Department of Agriculture Pesticide Program website (http://agr.georgia.gov/pesticides.aspx). Look for "Pesticide Applicator Licensing and Certification" under "Licenses, Compliance Information, Forms, and Facts." All licensees who obtain the required recertification credit hours will be mailed a renewal notice approximately 90 days prior to license expiration.

Pesticide Contractor Licenses

You or your company must have a Georgia Pesticide Contractor License if you contract to apply any type of general use or restricted use pesticide to the property of someone else. Each business location or company branch office must have a Pesticide Contractor License and at least one full-time employee with a Georgia Commercial Applicator License. The fee for the Contractor License is $55 per year, and this license must be renewed each year.

The forms to obtain the Pesticide Contractor License are available from the Georgia Department of Agriculture Pesticide programs website (http://agr.georgia.gov/pesticides.aspx). Look for "Pesticide Commercial Contractors" under "Licenses, Compliance Information, Forms, and Facts." Return the completed forms along with a check or money order (no cash) made payable to the Georgia Department of Agriculture. Your Pesticide Contractor License will be sent to you in the mail, and must be displayed in a prominent place in each business location.

Licenses from Other States

You must have a Georgia Pesticide Applicator and Pesticide Contractor license to operate a business that uses pesticides in Georgia. The Georgia Department of Agriculture will reciprocate commercial licenses with any state that has an EPA approved pesticide program, provided that:

· The license is current and in good standing

· The license is not a structural pest control license (Structural Pest Control licenses are not reciprocal)

· Georgia has an appropriate matching category

· The individual pays Georgia's $90 licensing fee.

Copies of this manual may be ordered from the UGA Extension Store. (https://estore.uga.edu/C27063_ustores/web/store_cat.jsp?STOREID=203&CATID=778&SINGLESTORE=true)

South Carolina

Pesticide Applicator Certification

Licensing

The Rules and Regulations for the Enforcement of the South Carolina Pesticide Control Act require mandatory licensing for Commercial and Noncommercial applicators in Category 3 - Turf and Ornamental Pest Control. If you use or apply herbicides, or insecticides or other pesticides to commercially or privately owned turf or ornamental plantings for compensation, or engage in other specified pest control activities in this category on the property of another, you are required to be licensed.

In addition to application, Category 3 - Turf and Ornamental Pest Control activities also include the soliciting, advertising, or making of sales proposals in any form for any services involving the use of herbicides, insecticides, or other pesticides or devices with the intent to prevent, destroy, repel, or otherwise mitigate any pest of turf or ornamental plantings.

A *Commercial Pesticide Applicator* is someone over the age of 17 who applies or supervises the application of Restricted Use Pesticides (RUPs) for other individuals for pay. You must be certified as a Commercial Applicator if applying pesticides for hire. In mandatory certification categories, such as Category 3, you must be licensed even if you are *not* applying RUPs on personal property or employer's property. Commercial Applicators may obtain certification in one or more categories, but may use RUPs *only* in the category (or categories) in which they are certified.

A *Noncommercial Pesticide Applicator* is an individual who applies or supervises the application of RUPs as an *employee of a federal, state, or local government agency* but *only* in the performance of their duties as government employees. As in the case of Commercial Applicators, these individuals may use or supervise the use of RUPs *only* in the category(s) in which they are certified.

Certified Commercial Applicators who sell RUPs must also be licensed as Pesticide Dealers. Applicators requiring a Dealer's license should contact the Department of Pesticide Regulation (DPR) for an application.

If you *only* ever use herbicide products which contain *only* the active ingredient glyphosate you must be licensed in Category 12e – Limited (Glyphosate Only). There is no Core exam required for this license. The required Category 12e exam is 50 questions.

If you *only* cut lawns; do weed-eating; spread grass seed, mulch, or fertilizers *not* mixed with pesticides; blow and rake leaves; and/or trim ornamental trees and plants, you are *not* required to be licensed.

To obtain a Commercial Applicator License, you must

- Be at least 18 years old
- Pass a two-part exam (70 question Core and 30 question Category exam)*

* Unless you are seeking reciprocal licensing you must take the Core and Category 3 exams for your license.

- Pay the annual license fee
- Show financial responsibility (liability insurance) in the amount of $50,000 with an annual aggregate claims limit of not less than $100,000.00. "Binders" are not accepted **
- Fill out the application form
- Send in the application and application fee to the DPR.

Exams for Commercial and Noncommercial Pesticide Applicators and for Pesticide Dealers consist of two parts. The 70-question general knowledge "core" exam covers pesticide labels, environmental factors, knowledge of pesticides and pests, pesticide laws, pesticide equipment and application techniques, and safe pesticide use. A 30-question category exam covers specific areas of pesticide expertise. Test questions for exams are derived from category training materials and from professional experience.

Training for the core and category exams is by "self study" using prescribed training materials. These materials include the South Carolina core manual, the appropriate category manual(s), the Rules and Regulations for the Enforcement of the South Carolina Pesticide Control Act, and other materials chosen by the DPR. The study materials (Core and category manual) for the exams are available to help you prepare for all parts of these exams. You should purchase and study these materials as it is unlikely that you will pass an exam without studying. The DPR website has a downloadable, printable form to order these materials through PSA Publishing, or you may order online directly from PSA Publishing at: clemson.edu/psapublishing/. You may also be able to purchase study materials from your local County Extension office. You should order training materials well in advance of the exam to allow time for study. No training is provided by the DPR at the exam sessions.

All Commercial and Noncommercial Pesticide Applicator exams are given by the DPR. *You must pre-register and pay the appropriate exam fees no later than two (2) weeks prior to taking the exams.* You must prepay the exam fees by money order or check payable to Clemson University. **You must present a government-issued photo identification, such as a driver's license, at any exam session.** You will receive your exam results four to six weeks after the exam. If you are eligible for a license, the appropriate licensing materials will be included with your test results. Exam schedules and pre-registration information can be found on the DPR website. Exams are paper exams or on-line exams given at specific times and locations around the state. See the DPR website for the exam schedule or call the DPR at (864) 646-2150.

No refunds will be granted once you have pre-registered for an exam session; however, you may reschedule for the *next exam session only*, provided you have called DPR's main office prior to the exam date. If you do not take the exam at the next exam session, you must repay the fees to take the exams.

Certified Crop Advisors (CCAs) may receive pesticide applicator exam equivalency. The DPR believes that the CCA program meets or exceeds the competency standards required by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) for certain categories of pesticide applicators. Therefore, anyone who is a CCA in good standing is qualified to receive a

---

** *You must maintain continuous insurance coverage.* If your insurance lapses, your license will be suspended immediately. You must renew your insurance within three (3) months of its expiration or by December 31st, whichever occurs first. If you do not renew your insurance within three (3) months or before your license expires, whichever occurs first, you will be obligated to take the exam again *and* reapply for your license.

pesticide license in the areas listed below without taking the required competency examinations in the following areas:

1) Private Applicator
2) Pesticide Dealer
3) Commercial Applicator in
Category 1 (Agricultural Pest Control)
Category 3 (Ornamental & Turf Pest Control) and
Category 10 (Demonstrational & Research Pest Control)

NOTE: *Only the exam is waived for Certified Crop Advisors.* All other requirements must be met, including completion of the application forms, fee payments, and, for Commercial Applicators, demonstration of the required insurance. Individuals wishing to pursue this opportunity should contact the Head of the DPR at (864) 646-2150.

After you have obtained your license and insurance, the Regulations require that you:

1. Provide the appropriate level of supervision to your unlicensed employees. *If your business is based outside of SC, a certified applicator in charge must be within 30 minutes of the site of application. He or she must be available immediately by telephone or radio.*

For applicators based in South Carolina,

- A certified applicator in charge must be within 30 miles of the application site and immediately available by phone or radio when **Restricted Use Pesticides** are being applied.
- For pesticides with "**danger**" or "**warning**" on their label, a certified applicator in charge must be within 60 miles and immediately available by phone or radio.
- If the word "**caution**" is depicted on the label, a certified applicator in charge must be within 100 miles of the application site and immediately available by phone or radio.
- If the label contains stricter language than the Regulations, the label overrides the Rules and Regs. Remember, "The Label is the Law!"

2. At any time, if a customer requests disclosure of what you are applying and/or why, you must provide for them a fully legible statement that, at the very minimum, states your company or firm name and address, the pest(s) that are being controlled, and the chemical or common name of the pesticide (not the product name) that you are applying.

3. After any application for any customer, you must maintain records of all herbicides, or insecticides or other pesticides that you used. The record must include the quantity of each pesticide used, the common chemical name of the active ingredient(s) (this does *not* mean the product name), the pest or purpose for which the pesticide(s) was applied, and the date and place of the application. These records must be kept for a minimum of two (2) years, and they must be immediately available to any DPR field staff upon request.

4. Licenses expire on December 31st of each year. *If you do not renew your license by April 1st, you will have to take the examinations again and re-apply for a license. You cannot legally make pesticide applications until your license is renewed.*

5. Vehicles used to transport pesticides used in Category 3 (and any other categories of application in which licensing is mandatory) **must bear two (2) yellow identification stickers on both the left and right sides of the vehicle.** These stickers are provided by the DPR. Call the DPR number at (864)-646-2150 for more information.

There are additional provisions of the Regulations that directly affect commercial applicators in the landscape industry. Applicators should be aware that SC considers descriptive phrases with a legally defined meaning on a pesticide label to be enforceable restrictions on the distribution, sale, storage, and use of the affected product. Descriptions such as "for use only by a certified applicator" or "pest control operator," for example, mean that the product can be distributed to or used by certified applicators *only*.

Recertification

Applicators certified in Category 3 must accumulate 10 CEUs in each recertification period, and no less than three (3) must be category-specific. Recertification periods, or blocks, are five (5) years. All applicators must attend trainings to gain recertification credit in their respective five-year block. When you attend a training session, it is your responsibility to sign the appropriate attendance form to receive credit toward your recertification.

Each recertification block begins on January 1st of the first year and ends on December 31st of the fifth year. Thus, recertification blocks begin in 2013, 2018, 2023, and every five (5) years thereafter. During each recertification block *after* the one in which the license is issued each Commercial Applicator must accumulate no less than the category-specified number of Continuing Certification Units CEUs. If you are licensed in more than one category you must accumulate the category-specified CEUs for *each category* in which you are licensed, up to a maximum of 24 CEUs.

Applicators may obtain *no more than one-half of the total number of required category-specific CEUs and no more than one-half of the core-competency CEUs during the last year of any recertification block.* Applicators may see their earned CEUs on DPR's Web site at http://dpr.clemson.edu/.

Once the required number of category-specific CEUs has been accumulated, either core-competency CEUs or additional category-specific CEUs may be used to fulfill the remaining CEU requirements.

Applicators may "carry over" to the next recertification block any CEUs they obtain in excess of the minimum required, both category-specific and core-competency, during the *final year* of any recertification block.

To learn of recertification training opportunities, contact the DPR, your local Cooperative Extension County office, or your local, state, or national trade organization(s).

Reciprocal Licensing

Possession of a valid license from certain states (below) waives examination (only) for obtaining a pesticide applicator license in SC, provided other criteria are met. Mere possession of a valid pesticide applicator license from another state does not allow you to apply pesticides or Restricted Use Pesticides in SC or apply any pesticide in SC in a mandatory licensing category, such as Category 3.

SC offers reciprocal licensing for Category 3 with 12 states: GA and NC, plus AL, MS, LA, AR, FL, TN, KY, VA, IN, and NJ. Applicators in any of these states who hold a license in an equivalent category (or categories) to SC's Category 3 may obtain a SC Pesticide Applicator's License by filling out the Application for Reciprocal License and paying the applicable fee.

The documents below *must* be submitted to receive a reciprocal license from SC: they are online on the DPR's website: dpr.clemson.edu/

- Application for Reciprocal License
- Evidence of Financial Responsibility for Commercial Pesticide Applicators Form
- Reciprocal License Affidavit Form
- A copy of your current license from your reciprocating state.

If your state is not included in the listed 12 states and you would like to establish a Reciprocity Agreement with SC, contact your state's agency head and refer them to the DPR's main office at (864) 646-2150.

For more information on pesticide licensing contact:
Department of Pesticide Regulation
511 Westinghouse Road
Pendleton, SC 29670
Voice: 864-646-2150
Fax: 864-646-2162
Website: dpr.clemson.edu/

Introduction to Pest Management in Turfgrass and Ornamentals

Wayne G. Buhler
James R. Baker

Learning Objectives

After study of the material in this chapter, you should be able to:

1. List four basic principles of Integrated Pest Management.
2. Name four tools or techniques that you could use to study a plant problem as you look for pests.
3. Describe strategies that delay development of pesticide resistance.

Terms to Know

IPM

threshold

indicator plant

particle drift

vapor drift

buffer

re-entry period

pesticide resistance

phytotoxicity

pesticide breakdown

Chapter 1.

Introduction to Pest Management in Turfgrass and Ornamentals

Turf and ornamental plant care professionals need to know about Integrated Pest Management (IPM). IPM is a way of looking at all the topics related to pest control in an organized way. In other words, IPM combines appropriate pest-control tactics into a single plan to reduce pests and their damage to an acceptable level.

Basic Principles of Integrated Pest Management

Produce Healthy Plants that Resist Pests

This means selecting healthy plants, using certified seed, providing good growing conditions (checking soil pH and fertility and moisture), and making a good match between the plant and the site. Turfgrass, for example, will not do very well in shade. Become familiar with the recommendations for cultural methods of pest control described in Chapters 2 (Turf) and 6 (Ornamentals) and in the chapters about weeds, insects, and diseases.

Figure 1-1. Healthy plants have fewer pest problems and are less likely to be seriously damaged when pests do occur.

Identify the Problem

Always find out whether the damage to a particular plant is caused by a pest or by an environmental condition such as freezing or drought. And always determine the exact pest you are dealing with. Even closely related pests (for example, yellow nutsedge and purple nutsedge) may need different action strategies. Guides to weeds, insects, and diseases are listed in the Resources section at the end of each chapter. Cooperative Extension Service staff members are often able to help identify an unknown pest.

Expect Some Pests and Tolerate Some Damage

No landscape is ever totally free of potential pests, but a small number of pests may not cause enough damage to justify spending money on treatment. Deciding how many pests and how much damage to tolerate is more difficult for ornamentals and turf than it is for field crops. With a field crop, it is often possible to set an **economic threshold** for pests. If you can predict how much yield will be lost to a certain number of insects or weeds, you will know whether the cost of pesticides can be justified. Except in nurseries and commercial sod production facilities, damage to ornamentals and turfgrass is related to appearance rather than income, so the

threshold for pesticide use depends on the client's preferences, the value and/or visibility of the plants, and other factors.

Use Pesticides Only When Needed

An IPM user usually treats observed problems instead of applying pesticides on a routine schedule. Pesticides are labeled for use only on specific pests and types of plants. Using a pesticide on a site not listed on the label is illegal.

If an infestation is small, a "spot" treatment may be used just on the affected area or the infested plants. Using pesticides less often is safer for the applicator and the environment and will slow the development of pesticide resistance. However, some products are intended to be used to prevent problems. Before applying one of these, you need to be fairly certain that a weed, insect, or disease problem would be unavoidable without its use.

What's the Problem?

Most chapters in this manual describe common weeds, insects, and diseases of turfgrass and ornamentals. Here are some general tips for diagnosing problems, finding pests, and carrying out the regular scouting or monitoring that will help you find problems at an early stage when treatment is most likely to be successful.

Learn about Symptoms

When you see damage to a plant, you will need to find out whether the damage is caused by a pest, a cultural problem (a poor location, for example, or too much or too little fertilizer), or an environmental condition like freezing or drought. Before you can take action against an insect, disease, or weed, you need to know exactly what the pest is. Different diseases and insects can cause similar symptoms. Yellow leaves, leaf spots, wilting, and rotting roots may be caused by different diseases and insects. Don't leap to a quick conclusion. Study every situation carefully and seek advice if you are not sure what the problem is.

Use a Hand Lens

Most insects and mites are smaller than house flies. A hand lens will help you to see and identify tiny pests such as scales and mites. Choose a lens of at least 5 power but no more than 10 power.

Carry an Index Card

Tiny mites on junipers and other evergreens can be found by tapping the leaves against a white index card several times. If mites are present, you will see them crawling around on the card.

Recognize Indicator Plants

Some landscape plants can indicate the onset of a pest infestation. These are typically the first plants to be affected by a pest. Keep notes about where infested plants are found and the degree of infestation. You can then revisit these **indicator plants** to find out if there is a change in the number of pests or if a treatment is working.

For example, Japanese beetles feed on a multitude of host plants, but rose plants are a favored host and a good indicator plant for their presence.

Keep Records

Keep notes on each visit to a site. A map or drawing of the site will also be helpful. Records made in past years should tell you where and when problems occurred so that you will know where and when to look first during the current season. Records will help you learn which treatments are effective. They can also help you comply with pesticide regulations.

Action Choices

Once you are sure that plant symptoms are caused by a specific pest that now requires action, you need to consider different control options (cultural, biological, mechanical, and chemical), safety, and cost. New products for pest control are heavily promoted every year, but it is a good idea to get an opinion about their effectiveness from an independent source such as the Cooperative Extension Service. Before applying any product, review the cultural requirements for the damaged plant. No amount of pesticide treatment will "cure" a plant that is under constant stress from being in the wrong place or getting too little water or too much fertilizer.

Many homeowners now ask if you can use a biological control instead of a chemical pesticide. Biological controls use living natural enemies to control pests. In the Southeast, biological control is used mostly for insect and mite pests. Bacteria, fungi, insects, mites, and nematodes are all available for biological control of different pests. Not all of the biological control agents on the market are effective, but some work well. More information on biological control is given in the chapters of this manual on insect pests.

Pesticide Application and Mixing

Drift is the movement of pesticides through the air away from the target site of application. There are two kinds of drift—particle drift and vapor drift. **Particle drift** is the movement of fine particles (droplets or dust) through the air while the pesticide is being applied. **Vapor drift** is the movement of the pesticide in the form of a gas or vapor during or after application.

When you apply pesticides, you need to minimize pesticide drift. Choose pesticides that are least toxic to nontarget plants and animals and follow the directions provided in the core manual and on the pesticide label to help minimize drift. You can shield a susceptible plant with a piece of cardboard or remove potted plants from the area. Do not apply pesticides in places where pesticide particles or vapors will be drawn into heating, cooling, or ventilation systems. Maintain a **buffer** (nontreated) zone between the area to be treated and sensitive areas such as ponds, streams, wells, and drains.

Figure 1-2. Use a broom or leaf blower to remove granules from areas like sidewalks and driveways.

People, Pets, and Places

Take precautions to prevent pesticide exposure to people, pets, and wildlife. Remove toys, pet food dishes, birdfeeders, and lawn furniture from the site before applying a pesticide. Do not use pesticides when people or pets cannot be kept away from the site during the re-entry period specified on the label. The **re-entry period** is the length of time that must pass before anyone can enter a treated area. If the re-entry period is not specified on the label, make sure that the treated surface is dry before allowing re-entry. This is also true for pesticides that need to be watered in after application.

Be careful to clean up pesticide and/or fertilizer granules that have fallen on paved or cement surfaces. Blow or sweep them back onto turf or plant beds so that they do not get picked up by bare feet or pets or stuck in shoes and tracked into the house (Figure 1-2).

Pesticide applications should be scheduled well before sporting events or other activities involving the public. Applications at or near schools and child care facilities should not be made when children are present.

Resistance

When the same pesticide is used repeatedly for the same pest, it may lose its effectiveness. You need to know something about the pest life cycle to know how long to use the same product or type of product. To slow the development of **resistance**, use a pesticide only when needed and choose alternative pesticides from different chemical classes. Goosegrass, chinch bugs, the boxwood leafminer, and downy mildew of roses are pests that have become resistant to some pesticides.

Tank Mixes

Combining two or more pesticides or a pesticide and fertilizer in your spray tank is called tank mixing. Tank mixes are legal if they are not prohibited on the *Directions for Use* section of the label, but combinations of some active ingredients can cause plant damage or **phytotoxicity**. Even when a tank mix includes active ingredients at the labeled concentration, the double dose of emulsifiers and additives in the tank mix may damage plants. In some cases, mixing chemicals together (including pesticides and fertilizers) may cancel their effectivenes. In other cases, some products may be more effective when they are applied together. Before you use a new tank mix, seek advice from the Cooperative Extension Service or others with experience in the field.

Formulation Effects

Emulsifiable concentrates are more likely to burn plants than wettable powders or flowable formulations. However, wettable powders and flowable formulations are more likely to leave a residue that will be noticeable after the spray dries and that may upset users of the landscape. In general, liquid formulations seem to perform better for control of above-ground pests. Liquids or granulars work on below-ground pests. Granulars are probably better for sites that cannot be irrigated soon after the application.

Pesticide Breakdown

Bacteria and fungi in the soil naturally break down most pesticides into nontoxic substances. In some cases, these microbes have become abundant enough to degrade some pesticides very rapidly. The result is a loss of control because the pesticide is not around long enough to be effective. This fast **breakdown** occurs most commonly when the same pesticide is used several times during the same season. When the same pesticide is used over and over, the microbes that have "learned" how to degrade one pesticide may be able to degrade several related pesticides.

Test Your Knowledge

1. Resistance to pesticides comes from
a) using the same pesticides over and over.
b) applying pesticides at the wrong time of year.
c) applying too much pesticide at a time.
d) applying pesticides to plants that are too dry.

2. Pesticides in the soil
a) never go away.
b) are eventually broken down by bacteria and fungi.
c) have the same effect as fertilizer.
d) are harmless to beneficial insects.

3. You should apply a pesticide
a) based on the calendar date.
b) as soon as you see the first pest.
c) when pests are abundant enough to cause unacceptable damage.
d) every 10 days during the growing season.

4. What hand lens magnification is recommended for insect identification?
a) less than 3 power
b) 5 power to 10 power
c) at least 10 power
d) the highest power you can find

5. In an IPM program you should
a) control all the insects you see.
b) produce healthy plants that can resist pests.
c) rely totally on natural biological control.
d) never use chemical control.

6. Which of these statements is TRUE?
a) It is legal to use an insecticide on any plant to control insects.
b) Different diseases and insects can cause the same symptoms.
c) Yellow leaves are always a sign of disease.
d) It is safe to use a broad-spectrum herbicide on plants not listed on the label.

7. Which of these statements is FALSE?
a) Records are helpful in knowing when to look for a pest each year.
b) Records are a way to know whether a treatment was effective.
c) Record keeping takes more time than it's worth.
d) Record keeping helps you comply with pesticide regulations.

Answers: 1-a; 2-b; 3-c; 4-b; 5-b; 6-b; 7-c.

Resources

Web Sites

The following Web sites have a great deal of useful information about Integrated Pest Management and related topics:

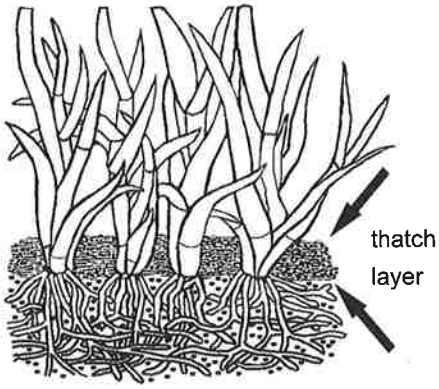
North Carolina State University: https://ipm.ces.ncsu.edu

The University of Georgia: http://blog.extension.uga.edu/ipm/

Clemson University: Pest identification: www.clemson.edu/cafls/departments/esps/factsheets/turforn/index.html

Chapter 2

Cultural Management for Turfgrasses



Wayne G. Buhler

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Identify your geographic region.
2. List at least four of the major cool-season grasses.
3. List at least four of the major warm-season grasses.
4. Identify three site problems that could contribute to poor turf stands and pest problems.
5. Identify four mistakes in turf plant management that could contribute to poor turf stands and pest problems.

Terms to Know

cultivar

geographic region

warm-season grass

cool-season grass

dormant

certified seed

thatch

aeration

compaction

Chapter 2.

Cultural Management for Turfgrasses

The first line of defense against pests in turfgrass should be cultural practices that promote dense growth. Turfgrass injury is often due to inappropriate growing conditions or poor maintenance practices. Good turf management includes

- selection of a cultivar that will stand up to the site use,
- proper site preparation,
- proper mowing, thatch removal, and aerification, and
- correct watering and fertilizing.

Failure in any of these areas can lead to pest problems that will continue until the underlying management deficiency is repaired.

Turfgrass Selection

Site Use

State guides to turfgrass cultivars will help you select the best ones for different regions and uses. Home lawns, athletic fields, and golf courses need different grasses. Grasses that are well suited for the intended use and site will have fewer pest problems. If you are treating an existing turfgrass site, be sure you know whether you are dealing with a warm-season grass or a cool-season grass (Table 2-1).

Table 2-1. Major turfgrass species.

Cool-season	Warm-season
Creeping bentgrass	Bermudagrass
Tall fescue	common
Fine fescues	hybrid
Creeping red	Centipedegrass
Hard	Bahiagrass
Chewings	St. Augustinegrass
Perennial ryegrass	Zoysiagrass
Kentucky bluegrass	Seashore paspalum
	Carpetgrass

Climate

The three major geographic regions in the southeastern states are the mountains, piedmont, and coastal plain (Figure 2-1). Cool-season grasses such as fescue, bluegrass, and ryegrass do well in the mountain regions where they become dormant in hot, dry weather. Warm-season grasses such as centipedegrass, St. Augustinegrass, bermudagrass, and zoysiagrass do well in the coastal plain where they become dormant in the winter. The piedmont region is a transitional zone where both warm-season and cool-season grasses are used. Cool-season grasses do better in the upper piedmont. Warm-season grasses do better in the lower piedmont.

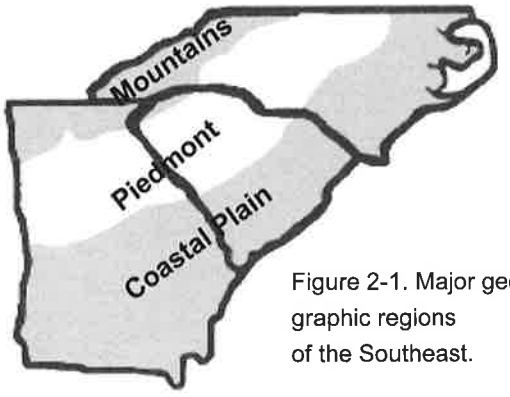


Figure 2-1. Major geographic regions of the Southeast.

Cultivars and Pest Management

- One of the best ways to prevent weed problems is to select **certified** turfgrass seed that meets standards for low numbers of weed seed.
- **Cultivars** are genetically different groups within a species. Some of the newer cultivars have improved resistance to certain diseases such as leaf spot, rust, and dollar spot. You may also be able to plant one of the perennial ryegrasses or tall fescues that contains a fungus (an endophyte) that may increase resistance to insects.
- If you are planting cool-season turfgrasses, use a blend of three or more compatible cultivars to reduce the likelihood of widespread disease damage. When a planting of a single cultivar is attacked by a disease, the entire turf area will be affected. When three or more cultivars are used, a disease that attacks only one cultivar will damage only one-third of the plants, and the others will fill in over time. New varieties of seeded bermudagrasses are the only warm-season grasses that might be blended.

Site Preparation

To reduce the potential for future weed problems, kill weeds or remove them by cultivation before seeding, sprigging, or sodding. Make soil improvements before planting by adding fertilizer and lime as recommended by soil test results. (Contact your County Extension Center for soil sampling instructions.)

Drainage

- Most plants grow best in well-drained, well-aerated soil.
- Be sure that there is good surface drainage to help reduce disease.
- Compacted soils keep water from sinking into the soil. When the top of the soil stays very wet, roots can drown and disease is more likely. Aerating the turf from time to time will help improve drainage.

Air Flow, Humidity, and Shade

- Removing trees or branches can reduce shade as well as competition from tree roots. This also improves air movement and lowers humidity.
- Do not place structures such as tall fences or outbuildings where they might reduce air flow.
- Large electric fans that increase air movement are helpful in stagnant areas on golf courses.
- Although there are some shade-tolerant turfgrass species and cultivars that grow without full sun, planting groundcovers or using mulch may be a better choice in shady locations where trees cannot be cut.

Cultural Practices for Healthy Turfgrass

Proper Mowing

- Always use sharp mower blades. Cutting with dull mower blades (or poorly adjusted reels) shreds the leaves, slows healing, and increases the chance of fungal infection.
- Mow at the correct height for the grass (Table 2-2). Cutting the grass too short weakens it and helps weeds, diseases, and insects invade the turf. Very short grass may also suffer injury during dry weather or when temperatures are very hot or very cold.
- Mow often enough so that you remove no more than one-third of the grass blade (Figure 2-2). If the height after mowing should be 2 inches, then mow before the turf reaches 3 inches.
- Clippings left on turf are a good source of nitrogen and other nutrients. However, if grass is too long when cut, clippings should be collected and composted so that they do not create a mat that blocks out light and favors disease.

Table 2-2. Mowing heights.

Turfgrass species	Height after Mowing (inches)
Bermudagrass	0.75 to 1.5
Zoysiagrass	0.75 to 1.5
Centipedegrass	1 to 1.5
Kentucky bluegrass	1.5 to 2.5
Fine fescue	1.5 to 2.5
Tall fescue	2.0 to 3.5
Perennial ryegrass	1.0 to 2.5
Bahiagrass	2 to 3
St. Augustinegrass	2 to 3
Seashore paspalum	0.75 to 3.0
Carpetgrass	1.5 to 2.0

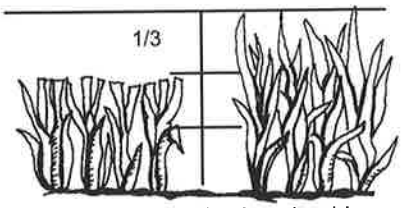


Figure 2-2. Mowing should remove only one-third of the grass blade.

Dethatching

Thatch is the layer of living and dead plant stems, leaves, and roots that develops between the soil surface and green vegetation (Figure 2-3). Grass clippings are not a component of thatch. Although a thin thatch layer is good for the soil, a thatch layer more than ½-inch thick can form a tight mat that keeps water and air from reaching the soil. It may also prevent pesticides from getting to the soil where they are needed to control insects and nematodes. To check thatch, cut a small, pie-shaped cross section in the turf and measure thatch thickness.

Heavy fertilization, vigorous cultivars, low pH, and compacted, poorly drained soils all contribute to excess thatch. Repeated applications of some synthetic pesticides can kill earthworms and other soil organisms that naturally break down thatch. To prevent an excess thatch layer, use less fertilizer and aerate the soil.

Dethatching is the process of reducing or removing thatch. It can be done by raking the turf with a stiff-tined rake or by using a power rake or vertical mower. Dethatching and aerating should be done when turf is actively growing.

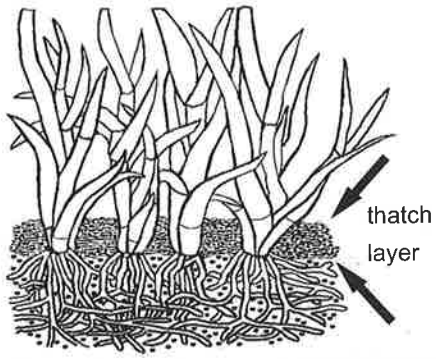


Figure 2-3. Thatch more than 1/2-inch thick can keep water from reaching the soil and roots, reduce pesticide effectiveness, and create shelter for pests.

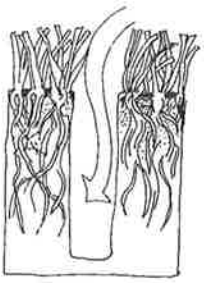


Figure 2-4. Core aeration will reduce soil compaction and allow air and water to reach grass roots.

Aerating

Roots need air, water, and nutrients. If you cannot easily push a screwdriver into the soil, the soil is too hard for air and water to reach the roots. If soil **compaction** is a problem, **aeration** should be done before or after dethatching. Aeration is done by machines that remove soil cores, punch holes into soil, or slice it. Coring machines that remove 1/4-inch to 1-inch diameter cores (Figure 2-4) are more efficient aerators than those that spike or slit the soil.

Irrigating

- Thorough watering at proper intervals encourages plants to develop deep and healthy roots. Most turf areas need about one inch of water per week, which should be applied in a single application if possible.
- Watering too much and too often makes roots shallow and encourages disease. However, if a disease such as summer patch or necrotic ring spot or a high population of plant parasitic nematodes infects the roots, more frequent irrigation may be needed.
- Light and frequent irrigation is needed when starting new turfgrass from seed or sprigs, but once it has been mowed three times, it should be irrigated infrequently and deeply.
- Turf should be watered when you first see signs of wilting such as footprints, leaf curling, and discoloration.
- Apply enough water to wet the soil to just below the root depth.
- Early morning (5 to 7 a.m.) is the best time to irrigate. There is less risk of disease because the length of time that water remains on leaf blades before evaporating is minimal. Watering in the late afternoon or evening will leave water on the turf for a long time and encourage certain fungal diseases. Check timer settings on automatic irrigation systems.

Fertilizing

Making sure that the grass has the right amount of nitrogen fertilizer will help it compete with weeds or recover from disease or insect attacks. Fertilizer requirements and times of application vary by cultivar.

- Test the soil every two or three years and follow the recommendations in turfgrass manuals for fertilizer amounts and application schedules.
- Too much nitrogen can lead to a build-up of thatch and lush plants that are more likely to get diseases such as leaf spot, brown patch, large patch, and *Pythium* blight.
- Too little fertilizer can leave turf thin or bare and susceptible to weed invasion.
- Low nitrogen levels favor dollar spot. A light application of nitrogen when the first symptoms of dollar spot appear can limit or even control the disease.

Test Your Knowledge

1. Proper mowing means
- a) using sharp mower blades to make a clean cut.
- b) mowing as close as you can for a neat appearance.
- c) collecting all clippings after each mowing.
- d) taking off one-half of the leaf.

2. To promote healthy turf and reduce disease
- a) irrigate every day.
- b) irrigate in the late afternoon.
- c) water thoroughly when you first see wilting.
- d) water lightly and often.

3. When fertilizing
- a) wait until turf goes dormant.
- b) apply nitrogen once a month to get lush growth.
- c) always use a liquid formulation.
- d) determine fertilizer need through results of a soil test.

4. Which of these statements is FALSE?
- a) Thatch should be at least 2 inches thick to keep soil cool.
- b) Thatch should be no more than 1/2 inch thick.
- c) Excess thatch keeps water and fertilizer from reaching roots.
- d) Thatch provides a good environment for turf pests.

5. Cool-season cultivars
- a) can be mixed to minimize disease.
- b) are a good choice for the coastal plain.
- c) prefer humid conditions.
- d) do well in shady locations.

6. Good soil drainage
- a) makes turfgrass areas more susceptible to weeds.
- b) dries out the roots too quickly.
- c) promotes root diseases.
- d) promotes healthy turfgrass.

7. Which of these statements is FALSE?
- a) Too much fertilizer promotes thatch buildup.
- b) Too much fertilizer can make grass more susceptible to brown patch and leaf spot.
- c) Too little fertilizer makes turf susceptible to bare spots and weed invasions.
- d) Do not fertilize turfgrass infected with dollar spot.

Answers: 1-a; 2-c; 3-d; 4-a; 5-a; 6-d; 7-d

Resources

Web Sites

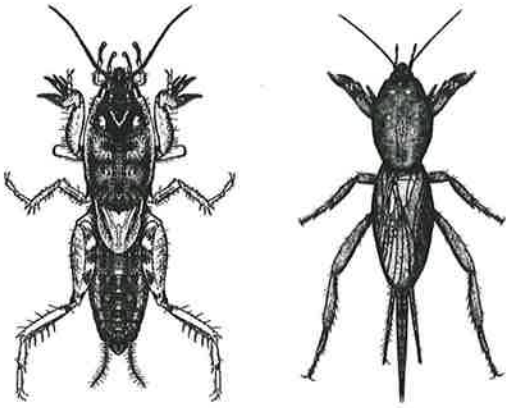
North Carolina State University: Turf Files: www.turffiles.ncsu.edu

Clemson University: Turfgrass Program: www.clemson.edu/extension/horticulture/turf/

University of Georgia: www.commodities.caes.uga.edu/turfgrass/georgiaturf/index/index.html

Chapter 3

Insect Pests of Turfgrasses



Rick L. Brandenburg

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Explain the difference between complete and gradual metamorphosis.
2. Describe chinch bug damage to turf.
3. Identify four pests that might cause root damage to turf.
4. Explain how frequent mowing impacts fire ants.
5. Describe three ways to find turf insects in the soil.
6. Explain the role of traps in monitoring turf insects.
7. Describe four pest-control problems caused by a thick thatch layer.
8. Describe three types of organisms used in biological control of turf insects.
9. Explain why some insecticide formulations should be watered in.
10. Explain why a granular formulation would be used on a site without irrigation.

Terms to Know

developmental stage
gradual metamorphosis
complete metamorphosis
grub
caterpillar
larva (plural: larvae)
pupa (plural: pupae)
nymph
scouting
sampling
monitoring
resistant cultivar
endophyte
predator
parasite
pathogen
Bt
milky spore disease

Chapter 3.

Insect Pests of Turfgrasses

Many insects damage turf, but most of the damage is done by only a few species. You need to be able to identify the most common turf insect pests and learn which **developmental stages** are likely to cause problems and which stages are vulnerable to various treatment choices. For example, **grubs** and **caterpillars** are two different types of turf-damaging **larvae**, the young worm-like stage of beetles and moths. If you find a large population of adult insects, you are likely to find large numbers of the destructive larvae as soon as eggs hatch. When you read the pest descriptions below, notice which stages of development cause turf damage.

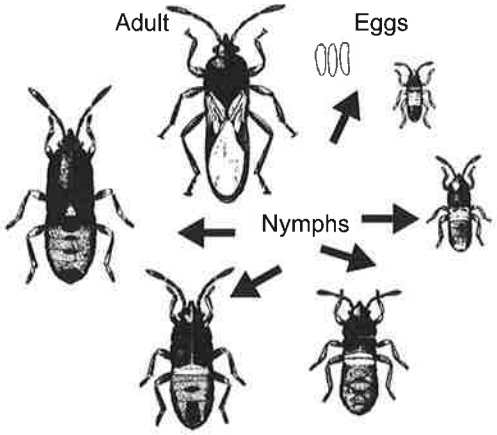


Figure 3-1. Gradual metamorphosis. An insect like the chinch bug goes through *gradual* metamorphosis. The nymphs that hatch from the eggs go through a series of nymphal stages that look like small versions of the adult.

Insect pests of turfgrass undergo either **gradual** or **complete metamorphosis** (change of form). **Nymphs** (young stages) of insects that undergo **gradual metamorphosis** look like small versions of the adult (Figure 3-1). In contrast, the young stages of insects that go through **complete metamorphosis** look very different from the adults before they become **pupae** and change into adults (Figure 3-2). The immature stage of most beetles is a grub. The immature stage of moths is a caterpillar. Complete metamorphosis is the most common type of development among turfgrass pests.

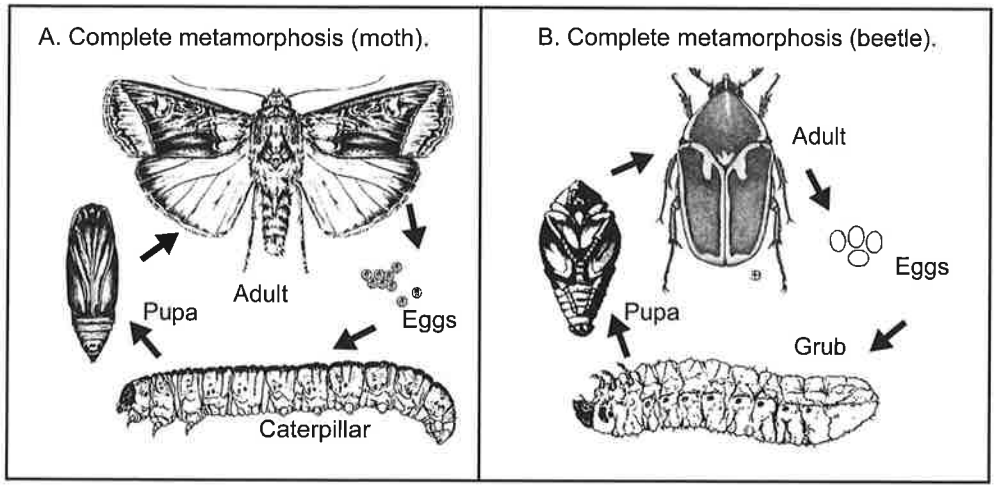


Figure 3-2. Complete metamorphosis. Insects like moths (A) and beetles (B) go through *complete* metamorphosis. They hatch from eggs into a caterpillar or grub that looks very different from the adult. The larva eventually goes into a resting pupa that hatches into an adult. Development through all stages of this cycle is one generation.

Identifying Insect Pests

The following sections of this chapter describe common turfgrass insects. Except for the red imported fire ant, they have been grouped by the type of feeding or damage that they do because insect damage is often more noticeable than the pest itself. Following the steps of a key to turf damage will help you narrow down the pest species that may be causing the problem. See the Resources section for keys to insect identification and damage. Keep in mind that many pests cause similar types of injury and that it is often impossible to identify the pest on the basis of damage alone.

Pests that Feed on Leaves and Stems

Cutworm

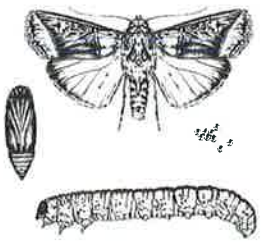


Figure 3-3. Cutworms are about 1¼ inches long when fully grown. Adults are heavy-bodied, night-flying moths.

The black cutworm (Figure 3-3) and bronze cutworm both attack turf. Cutworms hide in burrows (or aeration holes) during the day. At night, they clip the turf surrounding the burrow, resulting in brown circles or streaks on the lawn. Damage on tall grass may not show. Thresholds vary with the situation. On a putting green, the threshold is very low—from one to two larvae per square yard. On other sites, it may range from three to eight larvae per square yard.

Life Cycle: Cutworms usually spend the winter as larvae in the soil under the turf. As spring arrives, the caterpillars feed on grass leaves. Once fully grown, they dig into the soil again to molt into the pupal stage. They emerge from the pupa as adult moths. The black cutworm has two or more generations per year. The bronze cutworm has one. New moths feed on flower nectar and mate at night. Females seek out turf and lay up to 300 eggs. Predators often eat most of these eggs. In golf tees and greens where the routine use of pesticides eliminates predators and parasites, massive infestations of cutworms sometimes occur.

Armyworm

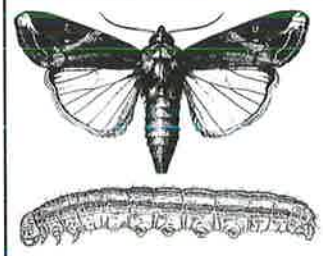


Figure 3-4. Armyworm caterpillars have distinctive stripes that run the length of the body.

The fall armyworm (Figure 3-4) and yellowstriped armyworm are more commonly found in southern and transition turf zones. Armyworms sometimes feed together and "mow" the turf in an ever-expanding front. Armyworms do not burrow into thatch or soil during the day.

Life Cycle: The fall armyworm has continuous generations during the year and development merely slows down during the cooler winter months.

Billbug

The bluegrass billbug is most common in cool-season turfgrasses. The hunting (or zoysia) billbug is most common in transition-zone and warm-season turf-grasses, but it attacks all types. Billbug grubs (Figure 3-5) bore into the stems of grasses until they are too large to fit inside. Billbug damage is easy to diagnose by grabbing hold of the dead

turf and pulling up. If the stems break off easily at the ground level, look at the broken edges. Billbug larvae leave hollow stems and sawdust-like waste called frass. Feeding by large numbers of billbug grubs during the winter months may kill or delay greening of zoysia, bermudagrass, and St. Augustinegrass. No thresholds are available for billbugs, but treatments should be directed against active adults or applied when young grubs are detected in the turf.

Life Cycle: The bluegrass billbug has a single generation per year. Adults spend the winter in the turf and surrounding areas, and females lay eggs in grass stems in early spring. Grubs hatch from the eggs, feed in turf through early July, and pupate in the soil. New adults emerge from mid-July through August. The hunting billbug appears to have one major generation per year, but adults and grubs remain active over much of the summer.

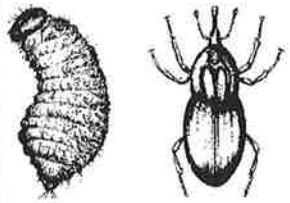


Figure 3-5. Legless, cream-colored billbug grubs have a distinct brown head. Adults are 3/8 inch long, black to reddish-brown, and often covered with soil.

Pests that Discolor Leaves and Stems

Sometimes damage to turf appears as yellow or brown patches. You will need to determine whether these symptoms are caused by insect feeding or by disease. Some pests discolor turf by sucking juices out of leaves and stems. The most important pest in this group is the hairy chinch bug.

Chinch Bug

The hairy chinch bug (Figure 3-6) is associated with cool-season turfgrasses, especially fine fescues and perennial ryegrass. The southern chinch bug does not survive heavy freezes and is most commonly associated with bermudagrass and St. Augustinegrass. In areas where chinch bugs remain active all season and pesticides are commonly applied, southern chinch bugs have become resistant to common insecticides. Using resistant turfgrass cultivars and switching to other classes of insecticides should help manage pesticide-resistant chinch bugs. During cool, moist periods, chinch bugs are susceptible to infections from naturally occurring fungi. Therefore, watering regularly during the time that chinch bugs are active may cause them to be killed by disease.

Because chinch bugs tend to feed in clusters, damage first appears as circular patches of yellowing turf that resemble drought injury. Large infestations of the southern chinch bug may completely kill St. Augustinegrass lawns. A threshold of 15 to 20 chinch bugs per square foot is suggested for all species. Use the flotation technique (described on page 41) for sampling.

Life cycle: Chinch bugs undergo gradual metamorphosis with nymphs and adult stages present during spring, summer, and fall.

Figure 3-6. Chinch bugs are small (1/5 inch), black and white bugs with sucking mouthparts.

Pests that Feed on Roots

White grubs and mole crickets are the most serious root-feeding pests of turfgrass in the southeastern states. Almost no turf is immune from white grub attack. The immature stage (larvae) of the Japanese beetle, green June beetle, masked chafer, and Oriental beetle are white grubs. In cool-season turf, the major grub pests are usually Japanese beetle grubs and masked chafers. In southern and transition zones, the green June beetle grubs are more common. All white grubs can

be transported in sod or in soil of ornamental plants. Although the species described here all have one generation per year, control strategies are slightly different.

Eggs of pests that hatch into white grubs need moist soil. If there has been no rain during the late summer when beetles and masked chafers are laying eggs, do not irrigate even though the turf may go dormant. Irrigating to keep the turf green only makes it more attractive for egg-laying and improves egg survival. If grubs are already established in a lawn, it is wise to keep irrigation going to help the turf recover from the loss of roots. Moist soil also encourages the grubs to remain at the soil-thatch level where biological controls or insecticides will be most effective.

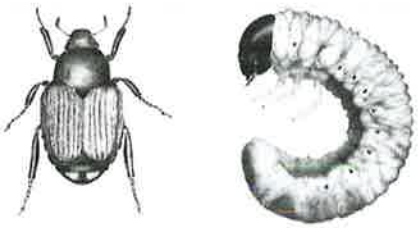


Figure 3-7. Japanese beetle adults are shiny green with copper-colored wing covers. The whitish grubs are C-shaped and about 1 inch long. The head is yellowish-brown.

Japanese Beetle

Japanese beetle grubs (Figure 3-7) feed on roots and organic matter at the soil-thatch junction. Heavily infested turf turns brown in dry weather and may die out in patches.

Life Cycle: Adults emerge from the ground from mid-June through July. They congregate on trees (especially fruit trees), shrubs, and other plants to feed and mate. Females dig into turf to lay groups of eggs. The tiny grubs hatch in 9 to 30 days, depending on temperatures and moisture. The grubs feed until cold temperatures signal the time to dig into the soil for overwintering. When the soil warms in April, the grubs return to the surface to finish feeding. When fully grown, they dig down into the soil and form an earthen pupal cell where it takes 2 to 3 weeks for the pupa to develop into the adult.

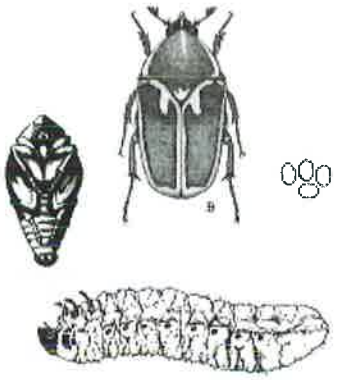


Figure 3-8. Green June beetle grubs are 1½ inches long with a brown head and brown spots along the body.

Green June Beetle

Although green June beetles (Figure 3-8) do not eat grass roots, the larvae emerge from a central burrow at night to feed on thatch or manure. They often push up mounds of soil around their burrows that look like miniature mole tunnels, and they loosen the soil and uproot grass seedlings. Once at the surface, the grubs crawl on their backs. During the summer, green June beetle adults feed on ripe fruits and sap from wounds on trees.

Life Cycle: Females lay eggs in turf or under livestock manure. Grubs emerge to feed on organic matter. They pupate underground.

Figure 3-9. The adult masked chafer is light brown and ½ inch long, (Illustration courtesy of D. Sholtar, Ohio State University).

Masked Chafer

Turf heavily infested with masked chafers (Figure 3-9) shows drought stress and dead patches that do not recover after irrigation. Wildlife often dig around the dead patches, and moles sometimes tunnel where grub populations are high. Infested turf feels spongy and lifts easily. Adults are often mistaken for May/June beetles.

Life Cycle: Adult beetles emerge from the turf from mid-June to mid-July. Each night, females come to the surface, release a pheromone (sex-attractant odor), and mate. After mating, the females may dig back down into the turf or fly a short distance before returning to the soil. Masked chafer adults do not feed, and they fly only at night.

Mole Cricket

Tawny and southern mole crickets (Figure 3-10) are the most damaging insect pests of warm-season turfgrasses in the southern states. The tawny mole cricket is mainly vegetarian. The southern mole cricket often feeds on other insects.

Mole cricket adults and nymphs damage turf roots and churn up the soil so that roots dry out. To manage mole crickets, you need to track the development of the nymphs. Monitoring of spring adult tunneling is a good predictor of where nymphs are likely to occur and where insecticide should be applied. The best time to treat is after all the eggs have hatched, generally in mid-June to early July, depending on location.

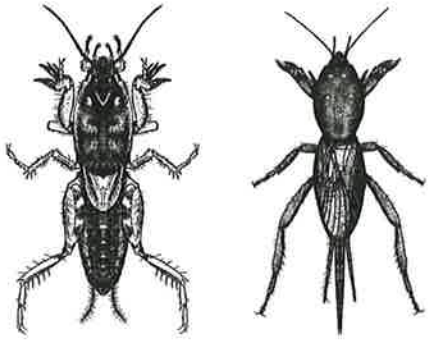


Figure 3-10. Tawny mole cricket (left) and southern mole cricket (right) are about 1½ inches long and light brown. Both have large front legs for digging. Nymphs resemble adults, but lack wings.

Life Cycle: Over most of their range, mole crickets spend the winter months as adults or nearly mature nymphs. Heavy flights often occur after warm spring rains. From March through May, adults mate, and females dig 3 to 10 inches into the soil and lay several clutches of eggs over several weeks. The eggs hatch in about 20 days, and the young nymphs dig to the surface to begin feeding. Young nymphs are common in late May through June. The nymphs molt six to eight times over the summer, and most mature by the end of October. The new adults may dig deep into the soil during dry or cool conditions.

The Red Imported Fire Ant

Red imported fire ants build mounds in open areas, often near stumps and other objects (Figure 3-11). Colonies also occur in or under buildings. Red imported fire ants readily swarm from the mound to sting when the mound is disturbed. Some people are highly allergic to fire ants, and people and animals sometimes die from fire ant stings.

Colonies frequently migrate from one site to another, and flooding can cause colonies to leave their mounds and float until they can reach land to establish a new mound. A queen and a half dozen workers can start a new colony several hundred feet away from the original nest almost overnight.

Figure 3-11. Mounds built by red imported fire ants may be 12 inches tall.

Cultural Control

Frequent mowing is a non-chemical control method that golf course managers use to force red imported fire ant colonies to less disturbed areas. The more times areas are mowed, the less time fire ants have to establish colonies. For example, greens can be mowed seven times a week, tee boxes and fairways three times a week, and roughs once a week. Spot treatments may be needed on roughs only.

Chemical Control

Broadcast baits and apply individual mound treatments using dusts, granules, granules drenched with water after application, liquid drenches, baits, or aerosol injections. In areas with just a few ant mounds, mounds can be treated individually. This approach preserves beneficial insects as well as native ant colonies which compete with red imported fire ants.

Castes

Fire ant communities are made up of different castes or groups with well-defined roles for colony survival (Figure 3-12).

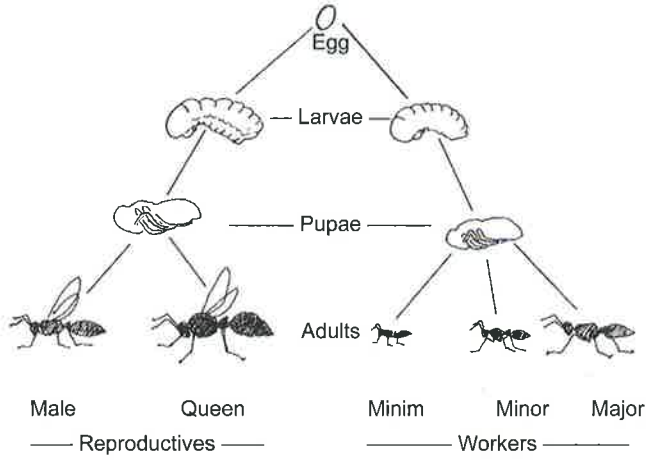


Figure 3-12. Red imported fire ant types and castes.

Worker ants feed the queen and protect her by defending the nest from intruders and by moving the queen from danger. They also search for food and care for the developing brood. The brood is made up of tiny, cream-colored eggs, grubs, and pupae of all the castes. The wingless worker ants generally live about 5 weeks.

Winged ants or *reproductives*, live in the mound until their mating flight. Mating flights are most common in spring and fall in the afternoon soon after a rainy period. Males die soon after mating. The newly fertilized queen digs a chamber in which to start a new colony. A mature queen can lay up to 800 eggs per day. The average colony contains 100,000 to 500,000 workers and up to several hundred winged ants and queens. Queen ants can live seven years or more.

Finding Pests

To manage insects in turf, you need to know when and how to look or **scout** for them and how to identify them. You can use several methods to **sample** for insect pests in turf. Select one that is appropriate for the location and habits of the pest. If you find a pest, you also need to know whether it is causing enough problems to justify control. This may mean **monitoring** the numbers found over a period of time. Some insects will always be present in turf, but they will not always cause damage that makes control necessary.

Inspect the Turf

Figure 3-13. Cutting back the turf is a good way to look for grubs.

Taking a close look at the turf is probably the best way to detect pests. This means getting down close enough to see individual leaf blades and the base of the plants. Always check the turf where the damaged area meets the green, healthy grass. This is where the insects are likely to be most abundant.

- Spread the turf and look at the base of the stems for insects or discoloration.
- Grab hold of the turf and pull up. If the turf breaks off easily, look for the sawdust-like waste of billbugs. If the turf pulls up, cut a flap and sift through the soil for white grubs (Figure 3-13).

Soap and Water Flush

To detect mole crickets, armyworms, and other caterpillars, mix 2 ounces of dishwashing liquid in 4 gallons of water and pour it over a square yard of turf in an area where you suspect an infestation. The insects will be irritated by the dishwashing liquid and rise to the surface.

Flotation

Cut the top and bottom off a large coffee can (or other cylinder) and push it down into an area of yellowed and declining turf. Fill the can with water. Wait 5 minutes for chinch bugs and other turf-inhabiting insects to float to the surface for counting. Repeat at three or four other places in the suspected area.

Action Thresholds

Although turfgrass management manuals and other publications list action threshold levels for certain pests, you should keep in mind that these thresholds are only suggestions and that many other factors will influence the quality of the turf.

Threshold suggestions also change over time. In the past, controls were recommended for annual grubs when populations reached 6 to 10 per square foot. We now know that with good irrigation and fertilizer management even 20 or more grubs per square foot may not cause noticeable damage.

The goal for pest management is not to eliminate every pest, but to keep damage at an acceptable level. At any site, you will probably need a combination of cultural, biological, and chemical controls.

Using Traps to Monitor Insects

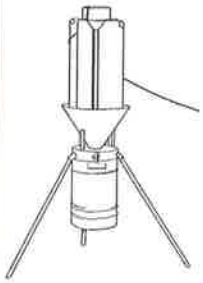


Figure 3-14. Light traps attract night-flying insects.

Light Traps—Moths of cutworms and many of the night-flying beetles can be collected in light traps. These generally use an ultraviolet (UV) bulb that attracts most night-flying insects. By running a trap for several nights and counting the numbers of adult insects that will produce turf-damaging caterpillars, grubs, or cutworms, you can predict when turf damage could occur. After you catch large numbers of moths or beetles, wait 10 to 14 days and then look for cutworms by using the soapy water method or look for white grubs under a slice of turf.

Pheromone Traps—Pheromone traps have been developed for the Japanese beetle adult and the black cutworm moth. Pheromone traps will let you monitor a single species. You should be aware that traps for Japanese beetles actually attract far more beetles than they catch and may create more problems.

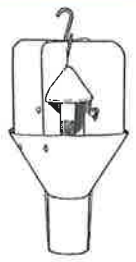


Figure 3-15. Pheromone trap.

Pitfall Traps—Billbugs can be monitored by using a 16-ounce cup buried up to the rim in or next to turf. Billbug adults fall into the trap and can be counted to monitor the beginning of activity in the spring. Petroleum jelly applied in a band near the top of the cup will prevent billbugs from crawling out. After two weeks of steady captures, it is time to consider control action for adults.

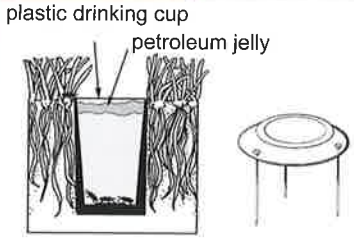


Figure 3-16. (Left) Pitfall trap for adult billbugs. (Right) Make trap lid from plastic plate and nails.

Cultural Control

Healthy, dense turfgrass is much better able to withstand pests than weak, thin stands. When you consider the pest problems at any site, try to find out whether the turf is getting adequate management. Review the turf management recommendations in Chapter 2. Although applying a pesticide may feel like a positive step in dealing with a pest problem, making adjustments in cultural practices can be just as effective and is more likely to prevent future pest problems. Different pests have different needs for moisture. Once you have identified a pest problem at any site, check whether irrigation may make a problem better or worse.

Thatch and Insect Pests

Take a look at the thatch buildup at any site. Keeping thatch below ½ inch thick has several benefits for pest management:

- It reduces winter shelter for many pests.
- Thick thatch creates a more uniform humidity zone for cutworms and chinch bugs. Thinner thatch allows the soil surface to dry out.
- Billbug larvae and (sometimes) white grubs feed on thatch.
- Thatch hinders the movement of biological controls or pesticides. Thatch may bind a pesticide so tightly that it does not get through to the soil to come into contact with the target pest.
- Matted thatch may prevent irrigation or rainwater from reaching the soil and will keep out the water that is necessary to "wet in" certain pesticides.

Resistant Cultivars and Pests

- Some turfgrasses are especially attractive to pests or may decline badly when pests attack. Other species and cultivars of turfgrasses appear to have natural resistance or tolerance to insect pests. Your local Cooperative Extension Center may have a list of turfgrasses that rates performance for different areas and different uses.
- When establishing new turf or carrying out a renovation, use the most **resistant cultivars.**
- Most perennial ryegrasses and tall fescues contain an **endophyte** (a fungus that lives within the plant). This fungus, which does not seem to harm the turf, produces toxins that may kill chinch bugs, billbugs, and turf caterpillars.

Biological Control

Most insect pests have naturally occurring enemies, and you will want to protect these natural enemies when making management decisions. You may also decide to buy and use insects, parasites, and disease organisms to control a pest. This pest management technique is called biological control. Bacteria, fungi, insects, mites, and nematodes that are damaging to various pest species are on the market. Not all of these biological control agents are really useful for pest management, but

some work well if an appropriate species can be applied correctly in a timely way. Biological controls are usually described as **predators**, **parasites**, and **pathogens** (disease-causing organisms). Because they are living organisms, biological control agents need special handling. Always read the instructions for storage and application.

Biological Control Choices

Predator—These insects actively seek out their prey and attack them. Predators such as bigeyed bugs, earwigs, lacewings, ground beetles, lady beetles, and rove beetles feed on various insect and mite eggs, caterpillars, chinch bugs, and aphids. Commonly used insecticides also kill most of these predators, so you should not apply turf insecticides as "preventive" treatments unless insect pests are a serious problem. Once naturally occurring predators have been killed, pest species may get worse or a different pest may become a problem.

Parasites—Several wasps seek white grubs and caterpillars in order to paralyze them, lay an egg, and provide food for their larvae. Several strains of parasitic nematodes that kill cutworms, billbugs, and white grubs are now available. Some of these nematodes search out insects and enter their bodies through natural openings or by drilling through the skin. Once inside the insect, the nematodes release bacteria that kill the pest within hours. The nematodes then complete their development within the body of the dead insect and produce new infective nematodes. These nematodes that attack insects are different from the nematode species that infect plants. As with most biological controls, getting good results from parasitic nematodes can be difficult. The nematodes are very susceptible to drying and sunlight, and they should be applied to the turf with water, preferably in the morning or evening. Daily watering may be required for a week or more after application. Be sure to obtain the strains that are most active against turf caterpillars, billbugs, or white grubs.

Pathogens—From time to time, most turf insect pests are infected by bacterial and fungal diseases. Some of these disease-causing pathogens are used as biological control products. Most of these require special handling or application techniques in order to be fully effective.

- ***Bacillus thuringiensis*** or **Bt** is a common bacterium that kills many types of caterpillars. However, cutworms in turf are apparently not affected by Bt. Recently discovered Bt strains have activity against white grubs, and products containing these strains are under development.
- ***Bacillus popilliae.*** Several bacterial diseases attack white grubs and cause their blood fluids to turn a milky color. The best known of these is **milky spore disease** caused by the bacterium, *Bacillus popilliae*. It is commercially available but only infects Japanese beetle grubs, so make sure the grubs being treated are actually those of Japanese beetle. Japanese beetle milky spore disease is applied to the turf as a powder or granule. The bacterial spores work their way into the turf where they are eaten by grubs. Although it takes several weeks or months before enough bacterial spores are in the soil to protect against grub damage, once the spores are established they seem to last up to 20 years.

Chemical Control

Chemical control tactics rely mainly on insecticides. However, insecticides have changed dramatically in recent years, and you need to use special care to get the maximum performance from them.

Irrigation and Pesticides

Read the product label to find out if an insecticide should be watered in.

- In general, most insecticides targeted for chinch bugs, greenbugs, mites, and sod webworms should be on the leaf surface or in the top layers of thatch and should not be watered in.
- Most soil insecticides for control of white grubs or billbugs need to get as far into or through the thatch layer as possible. Soon after an insecticide application is made for grubs, apply water until the top inch of soil under the thatch layer is wet.
- When the soil is dry, insects like white grubs and mole crickets burrow deeper into the soil and are hard to control. Irrigating before the pesticide is applied helps move these insects closer to the soil surface where they are more likely to encounter the insecticide.
- Granular formulations must be rained on or irrigated to activate the pesticide. Granular formulations are often preferred where you can't irrigate because granules last longer than liquid formulations while waiting for rain.

Hints for Chemical Control

1. Do not expect an insecticide (or any other pesticide) to provide 100 percent control. Choose an insecticide based on its label and on its performance under your local conditions.
2. Apply the insecticide when the insect is in its most vulnerable stage.
3. Be sure equipment is calibrated accurately and that application patterns are well planned to avoid skips and overlaps.
4. Do not use insecticides where they will run off the site or get into ponds, streams, or drains. Do not apply insecticides when heavy rain will cause runoff or when wind will cause drift.
5. In general, liquid applications seem to perform better for control of the insects that feed on turf leaves and stems.

Test Your Knowledge

1. Which of these methods will NOT help monitor cutworms?
a) soap and water.
b) light traps.
c) pheromone traps.
d) pitfall traps.

2. Apply an insecticide
a) to get total eradication of turf pests.
b) when the insect is at its most vulnerable stage.
c) at anytime during the pest life cycle.
d) when granular formulations will stay dry for several days.

3. *Bacillus thuringiensis* (Bt)
a) controls Japanese beetles.
b) attracts predators to the turf.
c) controls caterpillars.
d) controls mole crickets.

4. The milky spore disease bacterium
a) is only effective against Japanese beetle grubs.
b) gives quick results.
c) controls many species of caterpillar.
d) makes turf look pale and stunted.

5. To control fire ants
a) flood the mounds with water.
b) destroy the mounds and kill the queen.
c) mow less frequently.
d) use a combination of broadcast bait and mound treatments.

6. An insecticide applied to control white grubs
a) will work best on the leaf surface.
b) should be applied to dry soil.
c) should be watered in to reach the soil.
d) will work best on a thick thatch layer.

7. Mole crickets
a) are a minor problem in warm-season grasses.
b) are found by monitoring pheromone traps.
c) are damaging only in the adult stage.
d) have only one generation per year.

Answers: 1-d; 2-b; 3-c; 4-a; 5-d; 6-c; 7-d.

Resources

Web Sites

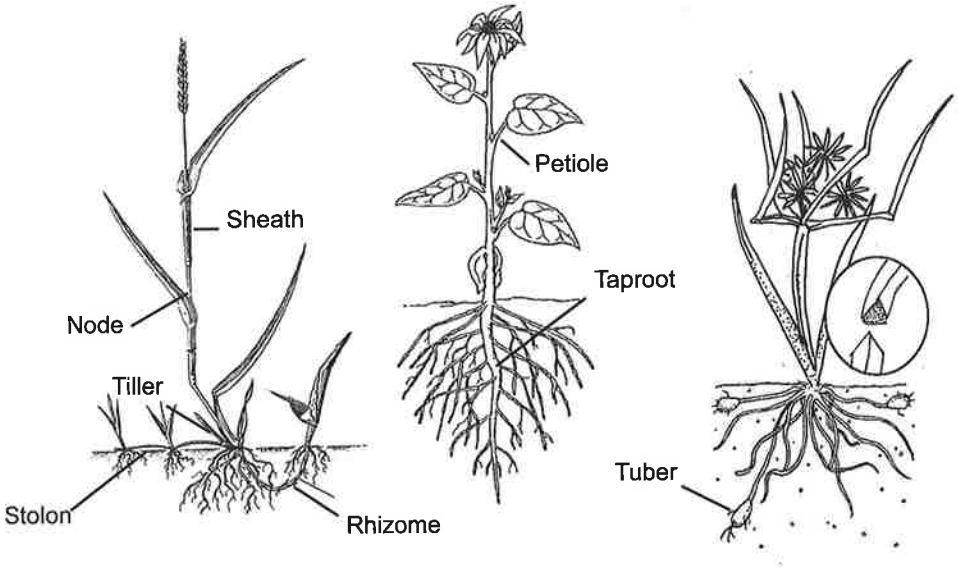
North Carolina State University: http://ipm.ncsu.edu/AG268/html/damage_key.htm and also http://www.turffiles.ncsu.edu

Clemson University: Turfgrass Program: www.clemson.edu/extension/horticulture/turf/

University of Georgia: www.commodities.caes.uga.edu/turfgrass/georgiaturf/index/index.html

Chapter 4

Weeds of Turfgrasses



Wayne G. Buhler

Timothy R. Murphy

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Describe cultural management practices that will reduce weed problems in turf.
2. Describe a situation where a broad spectrum, non-selective herbicide could be used on turf.
3. Explain when weather conditions might cause herbicide failure.
4. Explain how to use herbicides to slow the development of resistant weeds.
5. Identify the best time to control biennial weeds.
6. List two summer annual grasses and describe the best time to control them.
7. Describe three problems that could cause failure of preemergence herbicide.
8. Describe the best approach to control undesirable perennial grasses.
9. Describe the best approach to control yellow nutsedge.
10. Describe the best approach to control winter annuals.
11. Describe the stage of plant growth and weather conditions that favor successful use of postemergence herbicides.
12. Explain when herbicides can be used on newly seeded areas.

Terms to Know

selective herbicide
nonselective herbicide
susceptibility
tolerance
resistance
preemergence
postemergence
contact herbicide
systemic herbicide
translocation
germination
residual activity
rhizome
tuber
stolon
volatilize
spot treatment

Chapter 4.

Weeds of Turfgrasses

Weeds are plants growing where they are not wanted. Whether a plant is considered a weed depends on personal opinion and the intended purpose of the turf. Before making a weed-management plan, the turfgrass manager should know the users' opinion about which plants are weeds and how many weeds they will accept in any particular area. Only turf that has great visual importance or requires uniformity for its use really needs to be totally weed-free. For most sites, a practical goal is to keep weeds at tolerable levels.

Top 10 reasons to control weeds.

1. Weeds compete with turfgrass for light, moisture, and nutrients.
2. Weeds decrease the economic value of landscapes.
3. Weeds damage the appearance of lawns, parks, playing fields, and recreational turfs.
4. Weeds make athletic and recreational turfs slippery and increase the chance of injury to players.
5. Weeds produce large quantities of seeds.
6. Weeds produce pollen that can cause allergic reactions.
7. Weeds become a fire hazard along roads and near buildings when the top growth dries.
8. Weeds harbor pest insects and rodents.
9. Weeds provide a good place for the development of disease-causing organisms.
10. Weeds are sometimes poisonous to people, pets, and livestock.

An Integrated Approach to Weed Control

Effective weed management takes a season-long, integrated approach. Weeds are not usually the cause of problems in turf. They often appear when turf is already weak or thin. Poor turf conditions where weeds become problems are usually caused by mowing too high or too low and applying too much or too little water and fertilizer. Shade, soil compaction, diseases, and insects also weaken the turf.

The first line of defense in controlling weeds is to promote a healthy stand of the desired turfgrass with no bare areas for weeds to invade. A dense stand keeps sunlight from reaching the soil surface and stimulating weed seed germination. If weed seeds do germinate, their leaves will not get enough sunlight for photosynthesis, and the plant will die.

To reduce weed problems, follow the recommendations on turf selection, installation, and care outlined in Chapter 2. Cultural practices that help with weed management include:

- planting a turf species that is adapted to the site.
- mowing at the correct height.
- fertilizing only when turf is actively growing (to avoid stimulating weed germination).
- dethatching or aerating at times when weed seeds are **not** germinating.
- managing disease and insect pests to prevent thin areas in the turf.
- watering infrequently and deeply.

Sources of Weeds

Turf weeds may be introduced:

- in contaminated seed, sprigs, or sod. Always use high-quality, weed-free seed or sod, particularly to prevent introduction of perennial weeds such as quackgrass and nutsedge species that are very difficult to control.
- in contaminated topsoil, manure, compost, or mulch.
- by wind, water, equipment, or animals.

Herbicides

You should consider a number of factors before choosing any herbicide. You need to know what weeds you are treating and whether the herbicide is non-injurious to the turf species. Always read the label. Important terms associated with herbicide use are defined in Table 4-1.

Table 4-1. Herbicide Terms to Know.

Selectivity	**Selective**	A selective herbicide controls certain plant species without adversely affecting the growth of a different plant species. For example, a selective broadleaf herbicide kills broadleaf weeds, but does not harm turfgrass.
	Nonselective	A nonselective herbicide typically kills all plants, weeds as well as desirables.
Susceptibility	**Susceptible**	A susceptible plant is killed or injured by a herbicide. Susceptibility varies among plant species. Check the label carefully for a list of susceptible weeds and for restrictions concerning the use of herbicides on specific turfgrasses.
	Tolerant	Tolerance refers to the natural ability of a plant to remain unaffected by a herbicide. Weeds that are closely related may differ in tolerance. For example, a herbicide that kills yellow nutsedge may have little effect on purple nutsedge.
	Resistant	Resistance occurs as populations of weeds become more tolerant of a herbicide as a result of it being used over and over again on the same site.
Timing	**Preemergence**	Preemergence herbicides are applied to existing turfgrass areas before weed seed germination to control susceptible weeds during the very early stages of germination.
	Postemergence	Postemergence herbicides are applied to emerged weeds.
Mode of Action	**Contact**	Contact herbicides kill or injure only the part of the plant that is touched by the spray.
	Systemic	Systemic herbicides are absorbed by the leaves or roots and circulate within the plant to kill it.

Herbicide Failure

Herbicides can be the most effective and economical way to control weeds, but using pesticides as the only method of weed control often leads to disappointing results. Unless improvements are made in the management of a weedy turf site, the same types of weeds will come back, or new weeds that are even more difficult to control will show up.

If the herbicide application did not control the target weeds, try to figure out why it failed. Application errors are the major cause of herbicide failure, but weather and stage of plant growth may also be factors.

Application Errors

- When the application rate is too low, weeds may be injured but continue to grow.
- When the rate is too high (particularly with translocated or systemic herbicides), the chemical can kill the leaves before it can be translocated through the plant.
- Applying a herbicide at a higher-than-recommended rate also increases the chances of herbicide injury to the turfgrass or leaching into the soil to nontarget plants (such as tree roots) and to groundwater. Remember that exceeding the label rate is illegal!

Environmental Conditions

The performance of any herbicide depends on the weather conditions before, during, and after application. If weeds are not actively growing because the weather is too dry, too hot, or too cold, they will not absorb herbicide through their foliage or roots and will not translocate it throughout the plant. Preemergence herbicides must be rained on or watered-in, but too much or too little water reduces their effectiveness. Soil organic matter and clay can tie up certain herbicides and may affect the dose of some preemergence herbicides required for adequate weed control.

Always operate application equipment carefully and pay close attention to weather conditions in order to prevent particle drift and vapor drift during and after herbicide application. Read the label to see whether certain combinations of temperature and humidity are likely to promote **volatilization** (a change from liquid to vapor) of the chemical formulation that you are using.

Herbicide Resistance

When the same herbicide is used over and over, weeds can develop **resistance** to it. When these plants produce seeds, the new generation also shows resistance. You can slow the development of resistance by 1) making fewer herbicide applications, 2) using herbicides that have different modes of action, and 3) mowing to remove flowers before seeds form.

Identifying Weeds

Weed identification is the first step in a weed management program. Use pictures, keys, and other identification aids (see Resources). Several common turfgrass weeds are described in this chapter.

Weeds are grouped by botanical classification and also by life cycle. By classification or appearance, turf weeds may be grasses, broadleaf plants, or sedges (Figure 4-1). In terms of their life cycles, weeds may be annuals, biennials, or perennials.

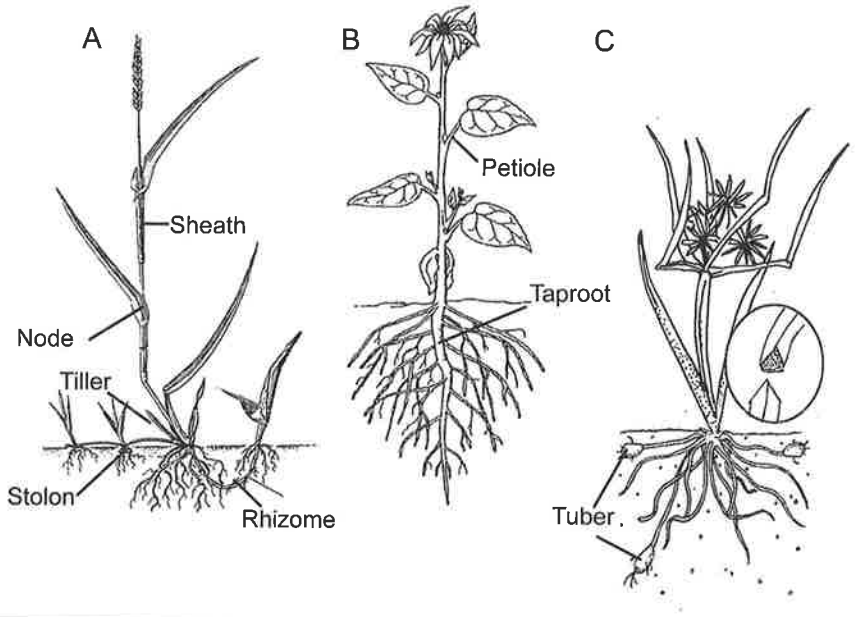


Figure 4-1. (A) **Grasses** have jointed, hollow stems, parallel leaf veins, and a fibrous root system.

(B) **Broadleaf** weeds have net-like veins in their leaves and usually have colorful flowers.

(C) **Sedges** have a solid triangular stem, and may spread by tubers and rhizomes as well as by seed.

Annuals complete their life cycle in a single year (Figure 4-2). **Summer annuals** germinate in the spring, then flower, and produce seed in late summer and early fall. They die when the temperature goes below freezing. **Winter annuals** germinate in the fall, persist in a dormant state throughout the winter, then flower, and produce seed in mid to late spring. They die in hot summer temperatures.

A **biennial** completes its life cycle in two years (Figure 4-3). In the first year, the plant forms a circular, ground-level, basal rosette and develops a large taproot. In the second year, it produces flowers and seeds and dies. Biennial weeds are usually easier to kill in their first year, but their rosette forms are often overlooked. All biennials are broadleaf plants.

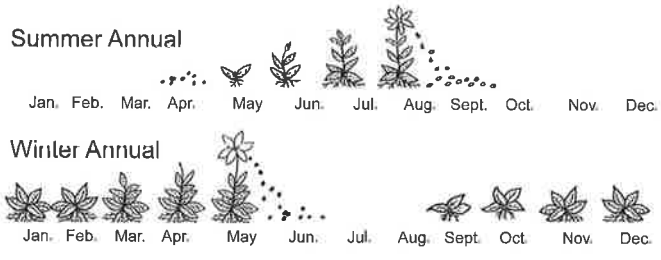


Figure 4-2. Annuals germinate, grow into mature plants, produce seed, and die in one year.

Figure 4-3. A biennial plant spends its first year as a nearly flat rosette that develops a deep taproot. It flowers and sets seed in the second year.

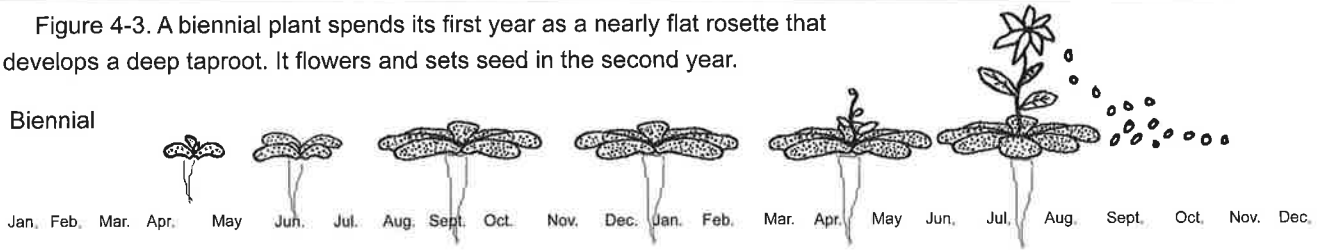
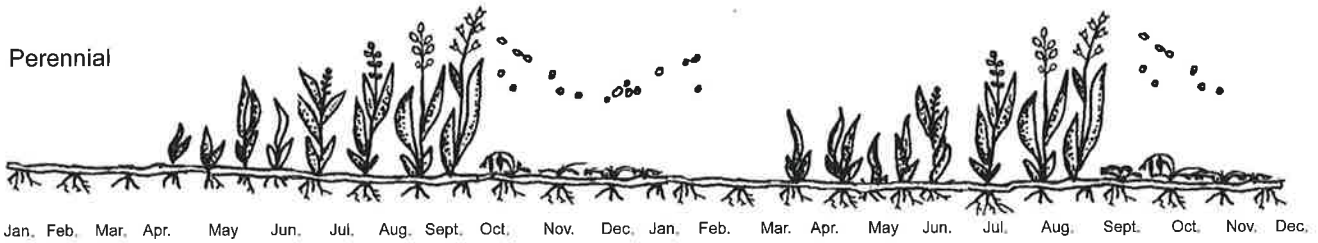


Figure 4-4. A perennial plant persists from year to year because the underground plant parts grow into new plants each year. Perennials also spread by seed.



Perennials can live indefinitely (Figure 4-4). Depending on the species, they may regenerate from vegetative (non-seed) structures such as roots, rhizomes, stolons, or tubers. **Simple perennials** reproduce primarily by seed, but if weeding severs the taproot, the piece left in the soil can regenerate a new plant. **Creeping perennials** reproduce vegetatively by rhizomes (Figure 4-5A), stolons (Figure 4-5B), tubers (swollen underground stems), bulbs, and creeping roots. To manage perennial weeds successfully, you must eliminate the underground plant parts.

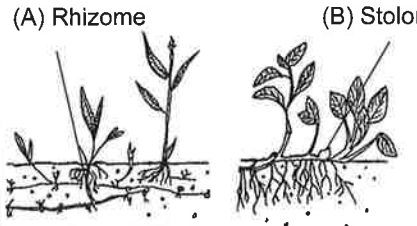


Figure 4-5. Rhizomes are creeping underground stems (A) and stolons are creeping above-ground stems (B).

Annual Grasses

Winter Annual Grass

Annual bluegrass (Figure 4-6) is a light-green bunch-type to slightly spreading winter annual. Annual bluegrass is highly invasive and tends to fill in stressed areas of turfgrasses. The seeds sprout whenever moisture is adequate in the spring and fall. Plants develop quickly, often flowering 6 to 8 weeks after germination. Annual bluegrass tolerates poor drainage, compacted soils, and close mowing, but not drought. Some subspecies of bluegrass, which are particularly evident in bentgrass golf greens, are classified as short-lived perennials.

Figure 4-6. The whitish seed heads of bluegrass are most abundant in mid-spring, but appear throughout the growing season.

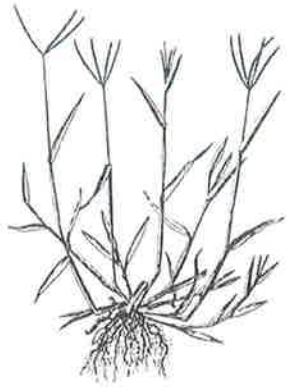


Figure 4-7. Young crabgrass lies flat with pale stems branching from the center. Crabgrass becomes upright when crowded.

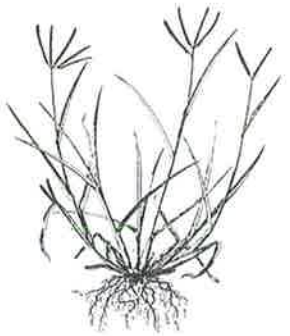


Figure 4-8. Goosegrass flowers look like zippers.

Summer Annual Grasses

Crabgrasses (Figure 4-7) germinate from March through early May and live until frost in the fall. Both large crabgrass and smooth crabgrass are common and grow best with adequate light and moisture. In August and September, the flowers and seeds of crabgrasses extend like fingers from the tip of a stalk. The leaves of large crabgrass are hairy, pale bluegreen, and 2 to 6 inches long. Smooth crabgrass has smooth, dull green leaves 1 to 4 inches long with sharply pointed ends.

Goosegrass (Figure 4-8) germinates about 2 weeks later in the spring than crabgrass. The stems are pale at the base, and they do not root at nodes like crabgrass. Because it grows flat, goosegrass is a very troublesome weed in athletic fields, golf greens, tees and fairways, and in other turfgrasses that are mowed short. In July and September, the flowers occur on 10 to 12 fingers. It prefers full sun and can tolerate poorly drained and compacted soils.

Management of Annual Grasses

Annual grasses are so similar to desirable turfgrass species that control is difficult once they become established.

Only a few selective **postemergence** herbicides control crabgrass and other annual grasses in certain turfgrasses (read label for species). Remember that postemergence herbicides only control growing weeds and that seedlings are more susceptible to chemical control than mature weeds. Additional treatments may be necessary to control summer annual grasses that emerge after the initial application.

More commonly, **preemergence** herbicides are used to control annual grasses.

Postemergence Herbicides

Postemergence herbicides are most effective when weeds are actively growing. Most of the postemergence herbicides used for control of broadleaf weeds are systemic and are applied to the leaves and translocated inside the plant. They must remain on the leaves long enough for the herbicide to penetrate and circulate (several hours to a full day). If it rains before enough time has elapsed, weeds may not be killed.

Postemergence herbicides work best in bright sunlight, when soil moisture is adequate, humidity is high, and air temperatures are between 65° and 85°F.

Using Post-emergence Herbicides

- Do not apply postemergence herbicides to newly seeded grass until it has been mowed at least three times.
- Wait 4 to 6 weeks before applying herbicide to a newly sodded area.
- Do not apply when rain is expected.
- Try to avoid mowing a treated area for at least 3 days after application.
- Wait 3 to 4 weeks before seeding bare spots left by killed weeds. Do not seed until the area has received rain or irrigation to break down any herbicide remaining in the soil.

Using Pre-emergence Herbicides

- You may need to wait 2 to 4 months before it is safe to reseed. Read the label.
- Do not use a preemergence herbicide before laying sod or at the time of turfgrass seeding unless indicated on the label.
- Do not add a surfactant or wetting agent to a preemergence herbicide unless indicated on the label.
- Wait until after new turfgrass seedlings have been mowed three or four times before applying a preemergence herbicide.
- Return clippings to the turfgrass area for 2 to 3 weeks after the herbicide application to give time for any herbicide absorbed by the leaves to be returned to the thatch layer and contribute to the chemical barrier.
- Try to avoid use of preemergence herbicide on thin, weak, or damaged turf.

Preemergence Herbicides

Preemergence herbicides are applied to the soil 2 to 4 weeks before expected weed seed germination. For summer annuals, make applications in late winter/early spring. Crabgrass germinates between forsythia bloom and dogwood flowering (usually when soil temperatures 4 inches deep reach 55°F). A second treatment 8 weeks later may be needed. For winter annuals, applications are made in late summer/early fall. Preemergence herbicides persist in the soil for several weeks. Most preemergence herbicides have little or no effect on emerged weeds.

Preemergence herbicides must reach the soil surface to be effective. Thick thatch can trap sprays or granules. Some herbicides volatilize or photodegrade (break down in sunlight) if they do not move through the thatch and into the soil. To help an herbicide reach the soil, remove thatch or irrigate with ½ inch of water to make sure that the herbicide moves through the thatch and reaches the soil surface to create a uniform chemical barrier.

Perennial Grasses

Dallisgrass

Dallisgrass (Figure 4-9) is a coarse, fast-growing, perennial warm-season grass that produces abundant seeds. Dallisgrass can invade landscapes rapidly. If it is not mowed, it can grow to 4 feet high in clumps. The seed stalks are 1 foot or more tall, and the flower head has 3 to 5 terminal branches that open out and then droop.

The leaf sheath, often reddish and looking slightly bloated, is somewhat flat and hairy at the base. Although the tillers (shoots) do not root at the nodes as crabgrass does, dallisgrass grows faster than most desirable turfgrasses, which increases the need for frequent mowing.

Figure 4-9. Dallisgrass produces leaves near the base of the plant on short shoots that form a knotty mass of very short rhizomes.

Management

Undesirable perennial grasses are usually the hardest weeds to control. Because perennial grass weeds are so similar to turfgrasses, herbicides that kill the grass weeds may also injure the turf. If only small, scattered areas of the weeds are present, it may be possible to remove them by hand-weeding or with a golf-hole cup cutter. The only effective method of controlling a large infestation of some perennial grasses is to spot-treat the infested area with a selective or nonselective, systemic (translocated) herbicide.

If a large area is infested, complete turf renovation may be the best choice. Before reseeding or resodding a treated area, it may be necessary to wait several weeks after application to allow the herbicide to break down. The **residual activity** (duration of effectiveness) of different nonselective herbicides varies. A second application of the herbicide may be required for very difficult-to-control perennial grasses.

Sedges

Sedges look like grasses, but their stems are triangular instead of round (see Figure 4-10). It is important to know whether a weed is a sedge or a grass because management choices for sedges are different. Some sedges are annual weeds, others are perennial.

A troublesome perennial, **yellow nutsedge,** is most conspicuous during the warm growing season. It looks like a pale-green, upright, weedy grass (Figure 4-10A). Yellow nutsedge spreads rapidly in moist soils from rhizomes that produce tubers. The yellow-green leaves are shiny and waxy on top and dull on the backside. The fibrous roots are mixed with rhizomes. The tubers form at the end of each rhizome, and they can persist in the soil for years. The yellowish-brown flowers occur as spikelets at the end of a triangular stem. Yellow nutsedge blooms from July through September.

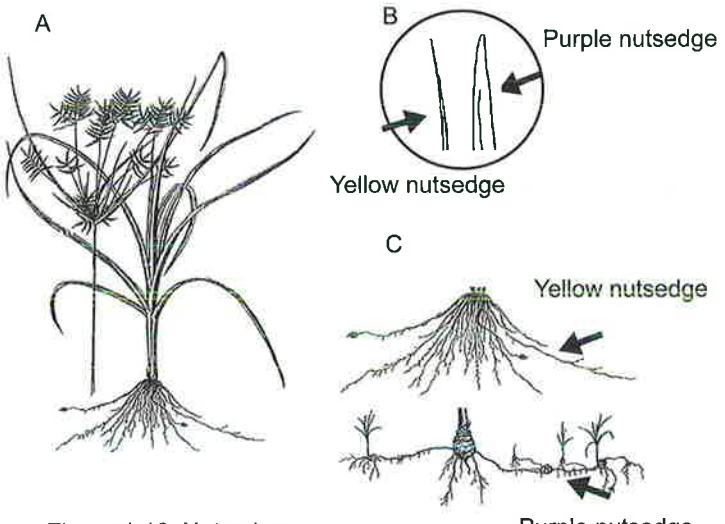


Figure 4-10. Nutsedge.
(A) Yellow nutsedge.
(B) Leaf tips of yellow nutsedge are more pointed than those of purple nutsedge.
(C) Yellow nutsedge has tubers only at ends of rhizomes. Purple nutsedge has chains of tubers along rhizomes.

Purple nutsedge looks very much like yellow nutsedge except that the leaves are dark green and less pointed at the tip (Figure 4-10B). Purple nutsedge produces tubers in chains along the length of the rhizomes instead of at the tips (Figure 4-10C). The flower spikelets are reddish brown or purple.

Management

To manage sedges, you need to be able to identify them and understand their biology. Because many sedges can be identified only by the seed heads, which do not often develop when turf is mowed repeatedly, it may be necessary to remove a sedge plant from the managed turfgrass area and place it in a pot to allow seed heads to develop.

Most of the sedge species found in turfgrass grown in the Southeast are perennials and require persistent control. Unlike perennial sedges, annual sedges do not reproduce from rhizomes or tubers and therefore are more easily controlled.

Both yellow and purple nutsedge are perennials that spread rapidly in moist soils from rhizomes that produce tubers or nutlets.

Control of sedges begins in the late spring to early summer after maximum shoot emergence, but before new tuber production (May and June). Purple nutsedge is much more difficult to control than yellow nutsedge and requires multiple herbicide applications a year for several years to get control of heavy infestations. Depending upon the herbicide used, repeat applications are necessary every 2 to 3 weeks. Read the label for information on repeat applications.

Broadleaf Weeds

Summer Annuals

Prostrate spurge has freely-branched stems that form a mat at the soil surface (Figure 4-11). The leaves are small (5/8 inch or less), oval, and close to the stem. They may be hairy or have small purple spots. Prostrate spurge blooms from June through October. The flowers are very small and occur in clusters at the bases of the leaves and at the tips of the branches. Seeds of prostrate spurge germinate at soil temperatures from about 60° F to over 90° F.

Management of Summer Annuals

Summer annual broadleaf weeds, depending on the species, can be controlled with certain preemergence herbicides applied in the early spring or with postemergence herbicides applied in the late spring and early summer months. Correct weed identification is critical to selecting the appropriate herbicides. For best results with postemergence herbicides, applications should be made when broadleaf weeds are small and are actively growing under good soil moisture conditions. Additionally, applications should be avoided at air temperatures above 90°F to lessen the risk of injury to the turfgrass and nearby trees and shrubs.

Figure 4-11. Prostrate spurge has a central taproot, and the branches form a mat up to 2 feet wide.

Winter Annuals

Common chickweed is a mat-forming winter and spring weed with many branched stems (Figure 4-12). The leaves are oval. Lower leaves have petioles; upper leaves sit against the stem. The stems are weak and the plants sprawl along the ground as they mature. The white, star-shaped flowers are very small and inconspicuous. Common chickweed prefers cool, moist, shady areas, and it can survive in compacted soils.

Figure 4-12. Creeping stems of common chickweed form roots at the nodes where they rest on the soil.

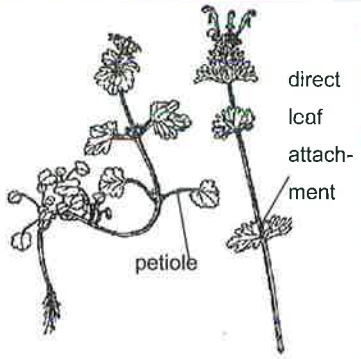


Figure 4-13. Like other mints, henbit has a four-sided stem.

Henbit is a small mint plant that branches at ground level and grows 3 to 12 (or more) inches tall (Figure 4-13). The square stems are green to purple. The dark green leaves are hairy on top with crinkled edges. The lowest leaves have petioles, but the upper leaves attach directly to the stem and may wrap around the stem. From February to June, henbit has ¾-inch, purple, tube-shaped flowers in groups just above the upper leaves. The plants die down in summer, and seeds survive to sprout in the fall.

Simple Perennials

Dandelions (Figure 4-14) are most conspicuous in cool seasons. Seeds germinate in fall, and the new seedling soon forms a sturdy taproot and a flattened rosette of narrow leaves with ragged edges. In fertile soil, the leaves may eventually grow to 10 inches long with jagged lobes pointing backward toward the stem. Every breeze scatters the delicate seeds widely. Dandelions bloom from spring though fall.

Plantains are relatively common weeds that reproduce by seeds and by shoots from the fibrous root system. The leaves radiate from a low rosette. The flower stems are leafless and slender with a flower spike at the top. The seeds form densely along the top half of the flower stalk. Broadleaf plantain flowers from June to September.

Buckhorn plantain (Figure 4-15) is similar to broadleaf plantain, but the leaves are narrower and have ribbed veins on the lower surface. Buckhorn plantain blooms in the spring. The flower head is much shorter than that of broadleaf plantain.

Creeping Perennials

White clover produces numerous seeds, but it can also spread by creeping stems that root at the nodes (Figure 4-16). The distinctive leaf has three round, ¾-inch leaflets that often have a faint, white, crescent mark. White clover flowers from May though September. Each flower resembles a tiny pea flower, but they are found in ball-shaped heads of 40 to 100 white or pink flowers. White clover occurs throughout the growing season, especially in moist, infertile soil.

Figure 4-14. Dandelion has yellow flowers and hollow, leafless stalks.

Figure 4-15. Long-stalked flower spikes grow from the basal rosette of buckhorn plantain.

Figure 4-16. White clover has a fibrous root system and forms patches in turf.

Wild Garlic

Wild garlic (Figure 4-17) is a small, dark green, grass-like weed that grows during the winter and spring and then dies down. The leaves are hollow, slender, and almost round. Wild garlic sometimes blooms and produces seeds. It is placed in this section because management practices for wild garlic are the same as those for biennial and perennial broadleaf weeds.

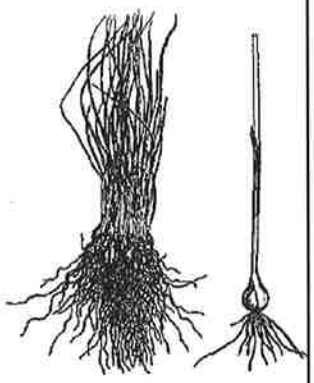


Figure 4-17. Wild garlic reproduces by forming new bulbs underground and by producing bulblets at the tops of slender, flexible stems.

Management of Winter Annual and Perennial Broadleaf Weeds

Mid to late fall and early winter is the best time to use selective, postemergence broadleaf herbicides for control of winter annual, biennial, and perennial broadleaf weeds as well as wild garlic. These weeds grow actively at this time of year, and a systemic herbicide is readily taken up by the growing weed and translocated throughout the entire plant. This is necessary for complete control.

Mid to late spring is the second best time to control winter annual, biennial, and perennial broadleaf weeds, again using selective, postemergence broadleaf herbicides. The target weeds should be growing actively to absorb herbicides readily. At this time of year, however, a sufficient amount of herbicide is not always translocated to the roots, and some perennial weeds may resprout. Although some preemergence herbicides control certain broadleaf weeds, the selectivity of postemergence herbicides makes them a more common choice for control of broadleaf weeds.

Test Your Knowledge

1. Herbicides are
- a) one tool for managing weeds.
- b) the best way to control weeds.
- c) too dangerous to use in most landscapes.
- d) not really pesticides.

2. Annual weeds
- a) are rarely a problem in turfgrass.
- b) only grow in the winter.
- c) live from 3 to 6 years.
- d) grow, flower, go to seed, and die within 12 months.

3. Biennial weeds
- a) form a rosette of leaves the first year and flower the next.
- b) grow, flower, go to seed, and die within 12 months.
- c) live 3 or more years.
- d) are not a problem in landscapes.

4. Perennial weeds
- a) never have seeds.
- b) have seeds every other year.
- c) can live indefinitely.
- d) die immediately when you cut the tops off.

5. Dandelions
- a) reproduce only from tubers.
- b) can be controlled only by hand pulling.
- c) are summer annuals.
- d) have a sturdy taproot.

6. Winter annual broadleaf weeds are
- a) best controlled in mid to late fall and early winter.
- b) best controlled in early summer.
- c) best controlled in late spring.
- d) best controlled in spring and summer.

Answers: 1-a; 2-d; 3-a; 4-c; 5-d; 6-a.

Resources

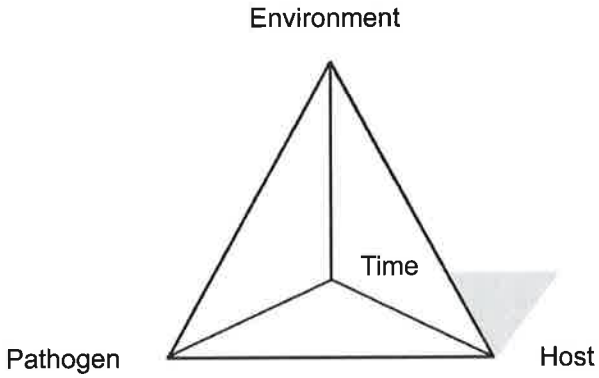
Web Sites

North Carolina State University Weed Info Fact Sheets: http://weedinfosearch.ces.ncsu.edu/

Virginia Tech Weed Identification Guide: http://oak.ppws.vt.edu/~flessner/weedguide/

Vascular Plant Image Library, Digital Flora of Texas: http://botany.csdl.tamu.edu/FLORA/gallery.htm

Diseases of Turfgrasses



THE DISEASE PYRAMID

Lane P. Tredway
Bruce Martin
Wayne G. Buhler

Chapter 5

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Name the components of the disease pyramid.
2. Describe how understanding the disease pyramid components will help you manage disease problems in turf.
3. Identify five cultural practices that change the environment for the pathogen.
4. Explain the difference between diseases and disorders.
5. Describe stand symptoms of common turf diseases.
6. Describe plant symptoms of common turf diseases.
7. Describe common signs of fungal infection.
8. Describe turf symptoms that would lead you to test for nematodes.
9. Explain the difference between protectant (contact) fungicides and systemic fungicides.

Terms to Know

disease
disorder
disease pyramid
pathogen
susceptible
host
stand symptom
plant symptom
sign
mycelium (plural: mycelia)
systemic
translocate

Chapter 5.

Diseases of Turfgrasses

Diseases are the most difficult turf pest problems to diagnose and manage. Often, the disease-causing organism is not visible, and the symptoms that are clearly visible could be caused by several different diseases or disorders. **Disorders** are caused by unfavorable growing conditions such as temperature extremes, soil compaction, injury from machines and chemicals, or too little or too much water, fertilizer, or light. Disorders are not infectious and cannot be spread from plant to plant. **Diseases** are caused by pathogens such as fungi, bacteria, and viruses, which can multiply and spread from plant to plant. Pathogens are usually microscopic. Nematodes (tiny roundworms) are often grouped with pathogenic organisms, although they are not necessarily microscopic. Fungi and nematodes cause most turf diseases. Very few diseases caused by bacteria or viruses cause serious damage to turf.

Disease Development

The development of an infectious disease requires four factors:

1. A **susceptible host** plant.
2. A disease-causing **pathogen**.
3. An **environment** favorable for infections and development of the disease (this usually means certain temperature and moisture conditions).
4. **Time** for the disease to develop. This can vary greatly: symptoms of some diseases can become obvious very quickly, even overnight, under conditions that favor the pathogen.

The relationship among these four factors is usually shown as a "disease pyramid" (Figure 5-1). If any one of these factors is missing, no disease will occur. This means that when you are trying to manage a disease, you need to look for ways to eliminate one or more of the factors in the disease pyramid. This may mean changing the host or the environment or applying a pesticide to kill the pathogen. Use of pesticides is likely to provide only a short-term solution to a disease problem.

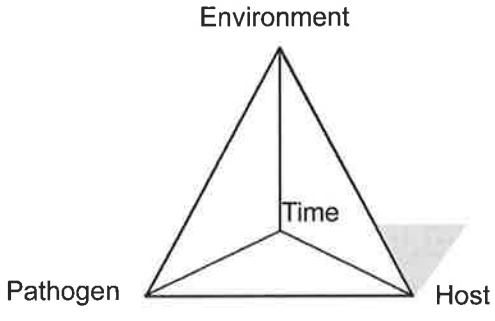


Figure 5-1. The disease pyramid.

Managing the Host

Diseases are most severe when conditions are favorable for pathogen development and unfavorable for turf growth. Turf that is healthy and growing vigorously is far more resistant to disease than turf that is weak and stressed. Review the recommendations in Chapter 2 for cultural management practices that relate to disease management. An experienced turfgrass manager promotes a healthy turf capable of resisting, tolerating, or outgrowing infectious diseases and damage. When you find a turfgrass site that seems to be suffering from disease, consider the following host-related factors.

- **Cultivar**–Make sure that the cultivar is one that is well-adapted to the site and its use. If renovation is necessary, select disease-resistant cultivars when available.
- **Mixture**–If the location is suitable for cool-season grasses, consider planting a mixture of compatible cultivars.
- **Fertilizer and pH**–Have a soil test done to check whether nutrient levels and soil pH are appropriate for the cultivar.
- **Sharp blades**–Look at the leaf blade tips to see if they are shredded from dull mower blades. Split ends heal slowly and offer an entry point for pathogens.
- **Mowing height**–Check the mowing height for the turf species. Diseases tend to be more common in grasses under stress from being mowed too short, so always mow at or near the maximum height recommended for the species. Mow as often as necessary to remove no more than a third of the leaf blade at a time. It is better to mow frequently rather than let the lawn grow too long.

Managing the Environment

- **Irrigation**–Proper irrigation is also a major factor in disease management. Irrigate established turfgrass only as needed. As a general rule, deep and infrequent irrigation is most beneficial. Irrigate thoroughly to wet through the root zone, then do not water again until the first signs of drought stress (foot-printing or bluish-gray color) appear. Watering too frequently produces shallow-rooted plants and stimulates the development of many diseases. However, if a root-infecting disease or a high population of plant parasitic nematodes becomes a problem, more frequent irrigation may be needed to compensate for the plants' decreased ability to take up water. Remember to irrigate early in the morning to reduce the length of time that water remains on leaf blades before evaporating.
- **Air flow**–Most diseases are more likely to occur in areas with limited air movement. Trimming underbrush and low-hanging branches or removing trees in or near turfgrass helps to increase air movement. High-value turf such as golf greens planted with cool-season grasses may benefit from installation of large electric fans to increase air movement in otherwise stagnant areas.

- **Drainage**–Grass plants grow best in well-drained, well-aerated soil. Good drainage helps reduce disease. When establishing turfgrass, it is worthwhile to improve both surface and subsurface drainage. Better drainage, even in established turfgrass, decreases risk of disease development.
- **Compaction**—Soil compaction restricts root growth and reduces the amount of water that can soak into the soil. When the root zone gets completely saturated with water, roots may die and diseases may develop. Aerify the soil from time to time to overcome soil compaction.
- **Thatch**—A thick layer of thatch creates an excellent environment for disease organisms to multiply and spread. Thatch layers should be kept at ½ inch or less. Regular aerification and/or dethatching helps reduce thatch.

Managing the Pathogen

Fungicides and bactericides are the primary short-term method of managing disease-causing pathogens. Over the long term, relying on pesticides as the only means of managing disease may not be successful. Pesticides should be used in combination with the steps listed above for managing the host and the environment. Because fungi cause most turfgrass diseases, the following section will focus on fungicides. Although a few fungicides can be used to "cure" a turfgrass plant that is diseased, preventive fungicide applications made before symptoms appear are generally more effective than "curative" applications.

Protectant Fungicides

Protectant (contact) fungicides and bactericides coat a susceptible plant to create a protective barrier against fungal infection. The turfgrass does not absorb them, and they do not circulate (translocate) within the plant. Thorough plant coverage is critical for effective disease control with protectant fungicides.

- Protectant fungicides work well in turf because their broad spectrum activity prevents infection by several different fungi and because they are not prone to disease-resistance problems.
- The major disadvantage of protectant fungicides is that they do not protect new plant growth that emerges after treatment. Also, their protective barrier is easily washed off by rain, swept away by mowing, and degraded by sunlight or microbes.
- During periods of disease development and spread, reapplication will be necessary every 5 to 10 days.

Systemic Fungicides

Systemic fungicides circulate (translocate) within the turfgrass plant and can control fungi already in the plant. They generally provide longer periods of residual disease control because most of the fungicide is absorbed through the cuticle (waxy outer layer) of the plant in several hours so that it will not be washed off by rain or degraded by sunlight. A systemic fungicide will also protect roots and crowns and newly formed tissue.

However, because most systemic fungicides act in a specific way against the target pathogen, there is a greater likelihood that fungicide resistance will develop. Fungicide resistance occurs when naturally occurring strains of a pathogen that are not controlled by a particular fungicide build up over time in response to its repeated use. To extend the useful life of systemic fungicides, it is a good idea to rotate among different products or to tank mix systemic with protectant fungicides where they are available.

Signs and Symptoms

When you notice plant injury, the first thing to do is determine whether the damage is caused by a disease or by some cultural or environmental condition. If you decide that the problem is a disease, you need to find out which one. Knowing exactly which disease is present will help you select management practices that reduce damage to the turf.

Different pathogens favor different grasses. Many of them also tend to be associated with distinct weather conditions such as cold, wet weather or hot, humid weather. When you are trying to make a diagnosis, you will need to determine what kind of grass is affected and learn what the recent weather conditions have been (humidity, day and night temperatures, etc.).

Look at the Symptoms and Signs

Usually a diagnosis is made by careful examination of symptoms rather than by identification of the pathogen. Two types of disease symptoms are observed in turfgrasses:

1) **Stand** symptoms are the symptoms on the turf that are evident from a distance. Examples of stand symptoms are spots, circles, patches, and rings.
2) **Plant** symptoms are evident on the individual plant or plant parts. Examples of plant symptoms are leaf spots and lesions, stem lesions, foliar blight, foliar dieback, and crown and root rot.

Each turfgrass disease produces very specific stand symptoms and plant symptoms. Careful examination of symptoms can also help you tell diseases from disorders, which do not produce distinct symptoms on the turf stand or individual plants.

Fungal pathogens sometimes produce visible structures known as **signs**. Signs may be very useful for diagnosing a disease. Look for mushrooms, white powdery mildew, or red or black pustules on leaves. **Mycelial growth**, which looks like cobwebs on the grass, is made up of the microscopic thread-like structures (hyphae) that are the vegetative body of a fungus. Depending on the fungus involved, mycelial growth may be white and fluffy or pink and gelatinous. Spores are the microscopic seed-like structures that arise from stalks or branches of the mycelium.

When symptoms and all other pieces of information such as visible signs and environmental conditions do not provide a clear diagnosis, you should seek help from the Cooperative Extension Service in your county.

Common Diseases

NOTE: Color plates showing stand and plant symptoms for the diseases described below are on the inside front and back covers of this manual.

Common turf diseases are described below. For each disease, look at the components of the disease pyramid (host, environment, time, and pathogen). Diseases are most likely to occur when the turfgrass is under stress. For cool-season grasses, this will be when weather is hot and humid. For warm-season grasses, this will be when the weather is cool and wet. This means that fertilizer and irrigation should be managed to keep plant stress to a minimum during seasons that favor disease outbreaks.

Brown Patch

Brown patch or *Rhizoctonia* blight, refers to symptoms of diseases caused by the fungus *Rhizoctonia solani*. Brown patch is the most common disease of tall fescue in the Southeast, but most other cool-season grasses are also susceptible. Brown patch is also a persistent problem in the maintenance of creeping bentgrass for golf course putting greens. This disease does not develop on warm-season grasses. Severe infections result in death or thinning of turf areas, allowing opportunity for weed invasion.

Stand Symptoms (Color Plate 1a)

Irregular rings or patches of brown or tan foliage become visible and are especially evident on close-cut grasses early in the morning. A grayish "smoke ring" around the margins of the patches may also be evident on close-cut turfgrasses early in the morning when the leaves are wet and the disease is developing actively. The mycelia are occasionally seen in very humid or wet weather. When conditions are favorable, large areas may become blighted very rapidly.

Plant Symptoms (Color Plate 1b)

Irregularly shaped gray or tan lesions with dark brown borders are present on infected leaves. If conditions are only marginally favorable for disease development, only leaf lesions may develop. However, if conditions remain favorable for disease development, entire leaves may be consumed.

Management

- Good surface and subsurface drainage will help prevent brown patch.
- Avoid excessive irrigation. Irrigate early (before sunrise) to reduce duration of leaf wetness.
- Promote air circulation by pruning or removing trees and shrubs or installing electric fans around putting greens.
- Avoid high nitrogen fertilization, especially during warm weather.
- Mowing short generally results in more disease when conditions favor disease development.
- Fungicides are most effective when applied preventively. Where brown patch has been a problem in the past, begin applications in late spring when night temperatures stay above 60°F for several consecutive days.

Large Patch

Large patch is a disease of warm-season grasses caused by the fungus *Rhizoctonia solani*. Of the warm-season grasses, centipedegrass and St. Augustinegrass are most susceptible. Bermudagrass is occasionally affected, but recovers from the damage so quickly that it is rarely cause for concern. Large patch also commonly occurs in zoysiagrass.

Large patch develops in the fall and spring when temperatures are cool and the warm-season grasses are growing slowly. The symptoms usually appear in the spring as the turf is greening up from winter dormancy. In severe cases, symptoms may be observed in the fall. Large patch is encouraged by wet weather, excessive nitrogen in the fall and spring, poor soil drainage, overirrigation, and low mowing height.

Stand Symptoms (Color Plate 2a)

Irregular brown, yellow, or orange patches of thin turf are initially 1 to 2 feet in diameter, but expand to several yards. Multiple patches may merge to produce huge areas of symptomatic turf. No mycelium or other signs of pathogen activity are evident.

Plant Symptoms (Color Plate 2b)

Reddish-brown oval-shaped lesions are observed on the leaf sheaths, but not on the leaves themselves. As the disease progresses, the leaf sheath and crown area of the infected plants become rotten and greasy looking.

Management

- Do not fertilize warm-season grasses with nitrogen within 6 weeks of expected dormancy.
- Nitrogen fertilizer application 3 weeks after turf green-up in the spring will encourage rapid recovery from large patch.
- Aerify and dethatch regularly to keep thatch to ½ inch or less.
- Irrigate only as needed in the fall and spring, when warm-season grasses are growing slowly and need little water.
- Mow at the recommended cutting height.
- Fungicides are most effective when used preventively in the fall. Begin applications when soil temperatures drop below 70°F for several days and repeat at recommended intervals until turf is dormant. Applications in the spring after large patch symptoms are evident will not control the disease, but will minimize further spread and encourage recovery.

Dollar Spot

Dollar spot is a very common and persistent disease on several turfgrasses. Susceptible cool-season grasses are bentgrass, fescue, bluegrass, and ryegrass. Susceptible warm-season species are bermudagrass, zoysiagrass, and occasionally centipede and St. Augustinegrass. Dollar spot fungi do not form spores, and disease spread is due to mycelial growth and movement of infected plant parts, infested equipment, or traffic.

Dollar spot is favored by warm, humid weather and is more severe on nitrogen-deficient turf. Dollar spot is worse in humid conditions on soils that are typically dry. Cycles of warm days and cool nights encourage dollar spot because heavy dew forms on the grass. Excessive thatch accumulations and low mowing heights also encourage dollar spot development.

Stand Symptoms (Color Plate 3a)

On closely mowed turf, small bleached white spots from 1 to 2 inches in diameter develop. This disease symptom is easily confused with early stages of *Pythium* blight. On higher-cut turf, the spots may expand into patches exceeding 5 inches in diameter. In early morning, or when conditions favor prolonged high relative humidity, the white, cottony mycelia of the fungus can be seen in the infected turf patches.

Plant Symptoms (Color Plate 3b)

Individual diseased leaves of grasses exhibit characteristic bleached white lesions with distinct reddish-brown margins. Leaves may be girdled and collapse at the lesion even though the leaf tips remain green.

Management

- Select turfgrass cultivars that exhibit resistance to dollar spot (see Resources).
- Fertilize to avoid nitrogen deficiencies and to reduce disease severity.
- Irrigate during early morning hours to limit periods of high humidity and leaf wetness.
- Mow regularly at the correct height.
- Several fungicides provide good control, but are generally unnecessary in lawns. Fungicides are frequently necessary on golf course greens to ensure high turf quality. Where fungicides are used, preventive treatments are most effective. Begin applications in the spring and fall when low night temperatures are between 50° and 70°F.

Fairy Ring

Fairy rings caused by numerous species of mushroom or puffball fungi occur in all turfgrasses. Some of the fungi associated with fairy rings produce toxic substances that may accumulate in soil and kill the turfgrasses. More often, however, problems develop when mushroom mycelia accumulate in the soil and cause the soil to become difficult to wet so that the turfgrass comes under stress and declines due to lack of water. Fairy rings may be very persistent and may increase in diameter year after year. The fungi that cause fairy rings feed on old roots, stumps, or thatch accumulations in the turf. Fairy rings become most damaging when the turf is stressed by warm weather, drought, and nutrient deficiencies, particularly nitrogen.

Stand Symptoms (Color Plate 4)

Fairy rings appear as rings or arcs of green stimulated turf that range from a few feet to many feet in diameter. These green rings of stimulated turf may or may not be accompanied by adjacent areas of dead or declining grass. When the turf becomes stressed, the rings may become brown. During periods of heavy rainfall, mushroom or puffball fungi may appear adjacent to the rings and persist for a few days.

Management

Fairy rings are very difficult to control.

- Remove stumps and other wood material from the root zone before establishing a turfgrass area. Fairy rings will develop where wood is left in the root zone.
- Deep tilling and application of an approved fumigant have shown limited success.
- Symptoms may be masked by adequate irrigation or fertilization with nitrogen and/or iron.

- If fairy ring is causing the turf to decline, cultivate or apply wetting agents to encourage the penetration of water into the thatch and soil. Irrigate regularly as needed to keep the thatch and soil moist, but not wet.
- If fairy rings occur near trees over several growing seasons, it may be useless to attempt to eradicate the fungi. In this case, consider landscaping the areas underneath the trees with non-turfgrass plants.
- Certain fungicides may suppress fairy ring symptoms temporarily, but they will not control the disease on a long-term basis.

Microdochium Patch (Pink Snow Mold)

***Microdochium* patch** is a common disease of cool-season grasses, especially ryegrass and bentgrass. Although warm-season grasses are sometimes reported to be susceptible, infections of warm-season grasses are rare in the Southeast. The disease may spread by mycelial growth or movement of spores which are produced in enormous amounts on diseased tissue. The fungus causing this disease is very potent and may kill the grass in affected areas.

In cool-season grasses, disease occurs during cool, humid to cold, wet conditions. Prolonged periods of snow cover are not necessary for development of this disease, but provide ideal conditions for its development. Excessive nitrogen fertilization and infrequent mowing that prolong humid conditions in the turf canopy promote disease. Also, alkaline soil conditions (soil pH greater than 7.0) will favor *Microdochium* patch.

Stand Symptoms (Color Plate 5)

Circular patches 2 to 6 inches in diameter develop during prolonged periods of cool wet weather. If severe, spots merge to form large areas of diseased turf. The grass on the outer edge of the patches generally appears water-soaked (wet and slimy) with profuse gray or pink mycelia of the fungus present in high humidity.

Management

- Maintain balanced fertility levels and optimal soil pH based on soil tests.
- Mow frequently at appropriate cutting heights.
- Avoid fertilization during periods of slow turfgrass growth in winter.
- If severe disease problems occur, fungicide applications may be tried to see if they will prevent further disease or "cure" existing problems.

Gray Leaf Spot

Gray leaf spot is a very common disease of St. Augustinegrass. The disease may also cause problems in perennial ryegrass and tall fescue. The disease occurs in very hot, humid weather and is generally more severe in newly established turf areas, in shady locations, and in locations with poor air movement. High nitrogen fertilization creates succulent leaf tissue that promotes this disease. The fungus forms spores that are easily spread by wind and moisture or by equipment movement and other human activities. Areas of turf with poor soil drainage are also more prone to gray leaf spot.

Stand Symptoms

In hot, humid weather, turf infected with gray leaf spot looks scorched and ragged.

Plant Symptoms (Color Plates 6a and 6b)

Infections may occur on all above-ground plant parts and begin as small brown-to-tan leaf spots with a distinct brown-to-purple border or band surrounding the infected tissue. Lesions may become very numerous on leaves, and individual spots may expand to consume leaves completely and may girdle stolons of St. Augustinegrass.

Management

- Mow to recommended height. Infrequent mowing and high cutting height may favor disease.
- Improve air movement and light penetration in areas prone to chronic infections.
- Irrigate only during early morning hours to minimize duration of leaf wetness.
- Avoid excessive rates of nitrogen during periods favorable for disease development.
- Fungicides provide short-term (2 to 3 week) suppression of the disease in lawns.

Pythium Blight

***Pythium* blight** is caused by the fungus *Pythium aphanidermatum* and similar *Pythium* species. All cool-season grasses are susceptible to *Pythium* blight. Warm-season grasses may be affected, but are generally less susceptible. *Pythium* blight is a dreaded disease of bentgrass putting greens because damage can occur rapidly and is potentially severe. Large areas of turf can be damaged in a short time. Frequent monitoring of cool-season turf areas for *Pythium* blight activity in the summer is very important.

Pythium blight can be devastating to bentgrass or ryegrass during hot, wet, or very humid weather, especially when air movement is limited. *Pythium* blight may develop when low night temperatures exceed 65°F for several consecutive days. High nitrogen fertility increases susceptibility to *Pythium* blight. The disease spreads rapidly when spores, mycelia, or infected plant parts are moved by water, mowers, or traffic.

Stand Symptoms (Color Plate 7)

Round to irregular spots from 1 inch in diameter on closely mowed turf up to several inches in diameter on higher-cut turfgrass appear suddenly. If humidity is high and prolonged, a gray mycelium is frequently visible in the turf canopy associated with blighted leaf tissues.

Plant Symptoms

The leaves in affected spots are water-soaked, slimy to the touch, and copper colored, dark brown, or black when disease is active. As humidity and/or temperature decreases, spots appear straw-colored and lesions on leaves are tan, but without a distinct border between diseased and green tissue. Generally, leaves in the centers of diseased patches are completely blighted or appear "dead" (without distinct lesions).

Management

- Provide good surface and subsurface drainage.
- Removal of shrubs, tree limbs, etc., to increase air movement and light penetration will improve conditions commonly associated with chronic problems with *Pythium* blight.

- Installing fans near bentgrass putting greens will increase air circulation and reduce leaf wetness.
- Minimize nitrogen applications to cool-season turfgrasses when weather conditions are favorable for *Pythium* development.
- Fungicide-treated seed has improved control of damping-off and seedling blight.
- Fungicides provide good control when applied on a preventative basis during conditions that favor disease development.

Spring Dead Spot

Spring dead spot is a serious disease of bermudagrass. It is most severe in the northern-most range of bermudagrass, but commonly occurs wherever bermudagrass undergoes winter dormancy. Several fungi are possible causal agents of this disease. It is more common on sterile hybrid cultivars of bermudagrass than on common seeded types. Generally, the disease appears in bermudagrass turfs three to six years old or those that have developed a significant thatch layer.

Any factor that would tend to promote low-temperature injury in bermudagrass favors development of spring dead spot. Excessive nitrogen, soil compaction, and excessive thatch promote spring dead spot. Fertilization and liming practices that cause high soil pH (in the alkaline range) also favor spring dead spot.

Stand Symptoms (Color Plate 8)

As bermudagrass greens up in the spring, circles or patches of turf remain dormant and eventually die. These patches may be 2 to 3 feet in diameter. The dead areas may persist over the summer, with poor or weak colonization of patches by the stolons of healthy bermudagrass. Patches of diseased turf may persist and enlarge for several years, but they rarely exceed 3 feet in diameter.

Management

- In areas prone to harsh winters, select less susceptible cultivars. Bermudagrass cultivars with good cold tolerance also tend to be more resistant to spring dead spot.
- Aerify and dethatch regularly.
- Stop nitrogen applications to bermudagrass 6 weeks prior to the expected date of dormancy.
- During active bermudagrass growth, the use of fertilizers that acidify the root zone, such as ammonium sulfate, has been shown to decrease disease.
- Avoid application of dinitroaniline herbicides for preemergent crabgrass control. These products will slow bermudagrass recovery from spring dead spot damage.
- Preventive fungicide applications in the fall have shown uneven results and are not recommended except for high-value areas prone to the disease.

Nematodes

Nematodes are microscopic roundworms, ranging in size from about 1/50 to 1/8 inch long. "Vegetarian" nematodes must feed on living plants in order to complete their life cycle. As they feed, they cause damage to plants by puncturing the cells of the root system with a hollow feeding spear or stylet and feeding on the cell contents. Most species of nematodes that harm plants feed on or in the roots. They may feed in one spot, or they may constantly move through the roots. Nematodes usually reduce growth and plant health rather than killing plants. They may weaken the plant and make it susceptible to other disease agents.

Nematodes may develop and feed either inside or outside a plant. Their life cycle includes an egg, four larval stages, and an adult. The females of some species become fixed in the plant tissue. The only way to be sure of the presence and identity of nematodes is to send living turf roots and surrounding soil to a laboratory. Ask your County Cooperative Extension Service for directions on collecting plant and soil samples for analysis.

Turf-Damaging Nematodes

Sting nematodes (Figure 5-2A) are the most destructive species in the Southeast and may cause damage to any turfgrass grown in the region. Fortunately, sting nematode is limited to coarse-textured soils that are high in sand content. The Sandhills areas of the Carolinas and Georgia and sandy portions of coastal areas are commonly infested with sting nematodes.

Lance nematodes (Figure 5-2B) occur more frequently in older turfgrass areas such as old putting greens where other nematodes were controlled over the years with various nematicides. Because they feed internally, lance nematodes are very hard to control, even with nematicides. Lance nematodes also damage St. Augustinegrass.

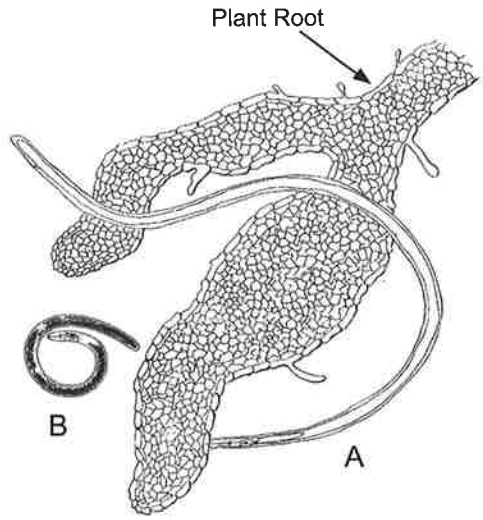


Figure 5-2. Sting (A) and lance (B) nematodes are the most destructive species for turfgrass in the southeast.

Stand Symptoms (Color Plate 9)

Diagnosis of nematode damage based on symptoms alone is not recommended. Symptoms only indicate nematodes as one possible cause of the damage. Turf that is heavily infested with one or more damaging nematode species may appear off color and bunchy, with various species of weeds invading weak or dead areas. Infested areas tend to wilt prematurely, even when adequate soil moisture is available.

Plant Symptoms

Excessive feeding damage causes short, stunted, and brown root systems.

Management

An integrated management program is necessary to manage nematode problems in turf. This requires use of several methods and procedures to suppress the nematodes in the soil and maintain the turfgrass in such a state that it can withstand some level of infestation. Take samples for nematodes before renovating or establishing turf on the site.

- Treatment prior to planting or replanting is recommended if potentially damaging nematode infestations are confirmed by sampling. There are chemical treatments that can be applied to soil prior to planting to reduce nematodes, weeds, and fungi. **These products are toxic to all living things, including plants and humans, and are intended for preplant use only. They are also restricted-use pesticides and thus must be applied with extreme care and only by certified pesticide applicators.** Following treatment, care should be taken to avoid recontamination of the site by contaminated equipment or by infested soil or sod or sprigs from infested soils.
- After establishment, the health of the turfgrass should be maintained by following the cultural recommendations in Chapter 2 and by reducing the stresses caused by insects, diseases, and weeds. Two nematicide products are currently available for control of nematodes in established turfgrasses. These products are highly toxic, and their use is limited to golf courses and other specialized facilities. These products should only be applied if nematode populations are above damage threshold levels based on a laboratory analysis. Nematicide applications in spring, when the turf roots are growing and nematodes are actively feeding, are most effective. In severe situations, a second application in late summer or fall may be needed to keep nematode populations in check.
- Finally, selection of a different species of turfgrass may provide a solution to certain nematode infestations. For instance, substituting St. Augustinegrass for centipedegrass in areas heavily infested with ring nematodes has been successful in some instances. Some of the hybrid bermudagrasses also tolerate certain nematode infestations to a degree. Choose a substitute grass only after careful consideration of the site requirements of the turfgrass (sun, partial shade, probability of winter injury, etc.) and the maintenance requirements of the grass.

Test Your Knowledge

1. Which of these factors is not a component of the disease pyramid?
a) soil moisture
b) sunlight
c) fungicide
d) soil fertility

2. Spring dead spot in bermudagrass
a) occurs after winter dormancy.
b) is worse where winters are mild.
c) is not a problem when thatch is left to accumulate.
d) is prevented by late fall fertilization.

3. What is a major advantage of systemic fungicides for management of turf diseases?
a) If applied to one part of the lawn, they spread throughout the entire lawn.
b) They usually provide broad spectrum activity.
c) Fungi are less likely to develop resistance to a systemic fungicide.
d) They translocate to protect newly formed tissue.

4. To reduce gray leaf spot in St. Augustinegrass
a) irrigate early in the morning to give the turf time to dry out completely before evening.
b) irrigate frequently.
c) apply extra nitrogen fertilizer weekly during the disease cycle.
d) mow infrequently.

5. Which of the following cultural practices increases the risk of several turf diseases?
a) infrequent irrigation.
b) frequent mowing.
c) excessive nitrogen fertilizer.
d) excessive air movement.

Answers: 1-c; 2-a; 3-d; 4-a; 5-c.

Resources

Web Sites

Clemson University Turfgrass Program: www.clemson.edu/extension/horticulture/turf/

North Carolina State University Turf Files: www.turffiles.ncsu.edu

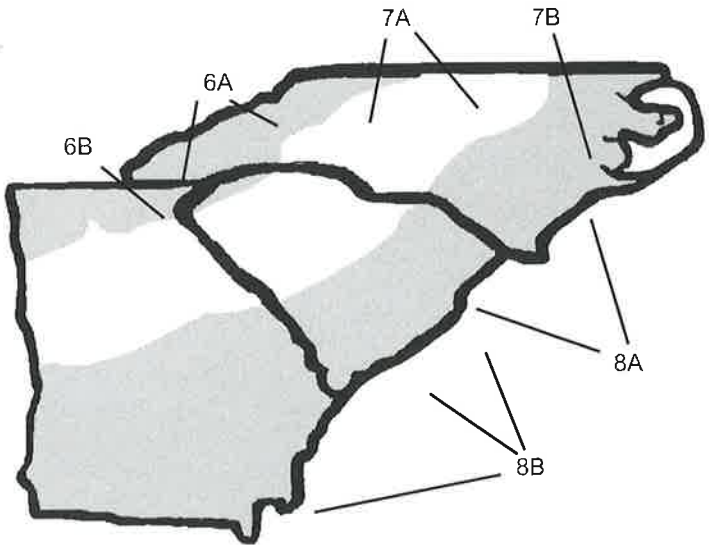
University of Georgia: www.commodities.caes.uga.edu/turfgrass/georgiaturf/index/index.html

National Turfgrass Evaluation Program provides results of turfgrass variety trials: www.ntep.org

Rhizoctonia Diseases of Turfgrass:

www.apsnet.org/edcenter/intropp/lessons/fungi/Basidiomycetes/Pages/Rhizoctonia.aspx

Cultural Management for Ornamental Plants



Erv Evans
James R. Baker
Wayne G. Buhler

Chapter 6

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Explain the use of the USDA Plant Hardiness Zone ratings.
2. List four site conditions that might contribute to plant stress.
3. Describe how to plant a container-grown shrub to maximize root growth.
4. List four reasons to use mulch around landscape plants.
5. Identify two pest problems that might be treated by pruning.

Terms to Know

Hardiness Zones

Microclimate

Chapter 6.

Cultural Management for Ornamental Plants

Landscapes usually have a variety of ornamental plantings. These include flowers and woody ornamentals, which may be ground covers, vines, shrubs, and trees. In general, shrubs are woody plants with one or more stems that grow to a height of 15 feet or less with foliage extending to the ground. Trees typically grow more than 15 feet tall and usually have only one main trunk.

Cultural management for ornamental plants involves many common sense ways to grow healthy plants. For detailed information regarding ornamental plant selection and care, see the Resources section at the end of this chapter.

Match the Plant and the Site

As you select plants for the landscape, it is important to match the plant's needs with the site conditions. Factors to consider include cold hardiness, heat tolerance, light requirement, soil characteristics, and pest susceptibility.

Hardiness

The primary guide to determining plant hardiness is the USDA Hardiness Zone Map (Figure 6-1). **Hardiness zones** are based on average minimum temperatures. A plant is said to be hardy if it can tolerate the lowest average winter temperatures that usually occur in a zone.

When trying to determine why a particular plant is failing, make sure that it is adapted to the site in the first place. Outside their hardiness zones, plants will be under stress that will make them more susceptible to pests.

Information about plant heat tolerance is harder to obtain. Spruce, white pine, and lilac often perform poorly in the piedmont and coastal plain regions because of the stress caused by long, hot summers. The warm night temperatures in the South also increase plant respiration and deplete food reserves. The American Horticultural Society has developed a Plant Heat Zone Map that includes 12 zones based on the number of days that temperature rises above 86°F. You can accurately predict which plant varieties will thrive in an area by consulting the USDA Hardiness Zone map and the Heat Zone map.

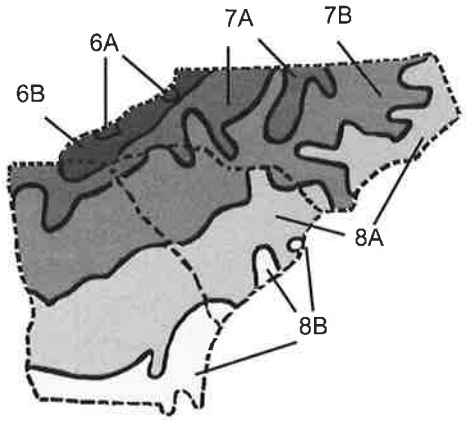


Figure 6-1. Stylized USDA Plant Hardiness Zone Map (2012). Zones are subdivided into A (colder) and B (warmer) sections. Any particular location within a zone may be warmer or colder due to microclimate variations.

Microclimates

In addition to the regional climate, plants are affected by the **microclimate** conditions in their immediate vicinity. The north side of a building will have colder but more constant temperatures than the south side. The microclimate under a tree canopy can be several degrees warmer in the winter than that in an open area and can be several degrees cooler in the summer. Plants under a building's eaves may receive almost no rain, while plants near a roof without gutters may receive several hundred inches of rainfall per year. Rocks, paved surfaces, and brick walls will reradiate heat at night and keep nearby plants warmer.

Sunlight/Shade

Plants vary in the amount of light they require. Before choosing plants for a landscape, observe how many hours of sun and shade a specific site receives during the day. Plants requiring full sun need at least 6 hours of direct sun. Many shade-loving plants can tolerate exposure to early morning sun, but putting heat-loving plants in light shade will delay and reduce their flower production. Pest problems can be caused by placing a plant in a site that does not provide adequate sun. For example, roses growing in shade are likely to develop black spot disease.

Light, temperature, and water are closely interrelated. Woody plants listed as preferring partial shade may tolerate more sun if temperatures are moderate and adequate water and mulch are provided.

Soil Moisture and Drainage

Frequent, heavy rains in combination with poorly drained soils will cause saturation (excessive soil moisture and limited air space in the soil), thus reducing plant growth and increasing the chances of root rot problems.

While most plants need to dry out slightly between waterings, they cannot tolerate standing water or drought for extended periods of time. Many hollies, azaleas, dogwoods, and junipers die because the soil has poor internal drainage and insufficient oxygen. Clay soils are more prone to poor drainage because they tend to hold more water and drain more slowly than sandy soils.

Check the planting site for good drainage.

1. Dig a hole 10 inches deep and fill it with water.
2. After it drains, refill it with water.
3. If this water drains in 8 to 10 hours, the site drains well enough for most plants.

For poorly drained sites, select plants that are tolerant of wet conditions or improve drainage with raised beds or drainage tile. Add organic matter, such as pine bark or compost to improve aeration, water movement, and drainage.

Soil pH

If soil test results indicate that nutrient or pH adjustments are needed for annual plants, the materials should be mixed into the soil uniformly because bedding plants have very shallow root systems. The soil pH for bedding plants should be between 5.5 and 6.5. Most woody plants will grow in soil with a pH range between 6.0 and 7.0. Plants such as Japanese pieris, azalea, blueberry, camellia, mountain laurel, and rhododendron grow best in soil with a pH of 5.0 to 5.5.

Adjust pH to meet plant needs.

To raise pH, apply lime.

To reduce pH, apply sulfur, iron sulfate, or aluminum sulfate.

If lime is needed, incorporate it into the soil before planting. Lime applied on the soil surface moves slowly (about 1 inch per year). Lime can be applied any month, but winter application is recommended.

Pest Susceptibility

Some plants are very susceptible to insect and disease problems. Red tip photinia has a high probability of developing *entomosporium* leaf spot disease. Japanese euonymus is likely to have problems with scale insects. Selection of plants that are less susceptible may reduce problems, but it will probably not eliminate them altogether. Remember that cultivars of a specific plant will vary in their susceptibility to a specific disease.

Inspect Plants

Make a serious effort to purchase only pest-free plants and always inspect transplants for diseases, insects, and weeds before putting them into a landscape. It is especially important to inspect the roots. Roots should be firm and straight. Avoid plants that have kinks in the major roots or that have roots encircling the pot. When selecting annual plants, do not buy plants that have been neglected or stored under stressful conditions (such as displays on hot, paved surfaces) for extended periods.

Starting with Bedding Plants

Choose plants with compact foliage, side branches, and good color. It may be tempting to select plants already in bloom, but younger, nonflowering plants are often the best choice because they establish more quickly in the landscape.

Place the plants outdoors in a partially shaded location until they can be planted. The small amount of soil in the containers will dry out quickly, so check the plants daily and provide water as needed.

Fertilizing

A soil test is the only way to determine whether phosphorus, potassium, calcium, or magnesium is needed or whether pH is in the right range for the plants selected. Application of too much fertilizer or unneeded fertilizer could result in salt injury to plants or cause nutrient imbalances. It is also environmentally unsound.

If a soil test is not made, incorporate 2 to 3 pounds of 10-10-10 fertilizer per 100 square feet of bed area. An alternative to 10-10-10 is a slow-release fertilizer such as 16-4-8 or 12-4-8. Dolomitic limestone can be used to raise pH and to supply needed magnesium.

During the growing season, make decisions about additional fertilizer applications by checking for adequate growth rate and healthy leaf color.

Nitrogen can be applied in two forms:

1. In a quick-release, water-soluble form using a liquid or granular fertilizer. If a quick-release fertilizer (such as 10-10-10) is used, apply 1 pound per 100 square feet every four to eight weeks throughout the season.
2. In a slow-release, granular form. Make only two applications: one incorporated into the bed just before planting and the second broadcast over the bed midway through the growing season. Do not exceed 4 to 6 pounds of nitrogen per 1,000 square feet.

Transplanting

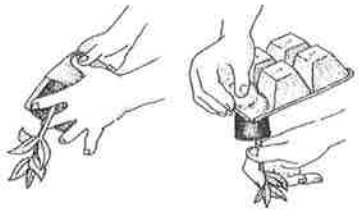


Figure 6-2. To remove plants from cell packs, turn the container upside down and squeeze the bottom of the container to force the root ball out of the pack.

Plants in cell packs or containers should be watered thoroughly and allowed to drain before removing them from the container. A damp root ball is less likely to fall apart. Do not pull plants from the container (Figure 6-2). Set the plants at the same depth or just slightly deeper than they were growing in the container. When filling the hole, firm the soil lightly and water thoroughly.

Space plants so they will fill in but not be crowded—crowding increases the likelihood of disease development. A good rule of thumb is to space plants 6 to 8 inches apart.

Mulch transplants after planting with a 2- to 3-inch layer of material such as pine bark mulch or compost. Apply only ½ inch of mulch at the base of the plant; excessive mulching at the plant base can cause disease problems.

How to Plant Trees and Shrubs

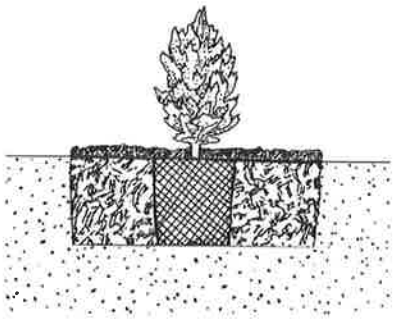


Figure 6-3. The planting holes for transplants should be no deeper than the pot, but two or three times wider to improve soil aeration and reduce compaction.

The proper installation of plants in the landscape involves much more than just digging holes and setting plants in them. The existing soil is often compacted and poorly drained. Tilling or digging to improve aeration and drainage is essential for satisfactory plant growth.

Preparing an entire bed instead of preparing individual holes will give roots a larger area to grow into before they encounter native soil. To achieve a 25 percent increase in organic matter, incorporate 3 inches of organic matter, such as pine bark mulch (not nuggets) or compost, into the top 12 inches of soil. Use organic matter that has been composted or aged. Incorporating uncomposted organic matter can create nutrient deficiency problems. Adding organic matter when preparing individual holes is not recommended.

The planting depth should keep the plant at the same depth after transplanting as it was in the container (Figure 6-3). Make the sides of the hole rough and irregular.

Planting in Poorly-Drained Sites

When planting in poorly drained or severely compacted sites, set the plant so the root ball is partially above the soil level. Dig the hole only two-thirds the depth of the root ball and mound soil around the root ball to create a gentle slope. The mound should be five times wider than the root ball. A disadvantage with this method of planting is that the top of the root ball may dry out quickly during dry weather.

Container-Grown Plants

Growing plants in containers has become the most popular method of growing plants for sale by the nursery industry. Late fall and early spring are considered ideal planting times because roots will have more time to grow into the surrounding soil before the stress due to new foliage growth and high temperatures occurs.

Always water plants thoroughly before transplanting. Remove the plant from the container by turning the plant upside down and giving the top edge of the container a sharp rap. Catch the root ball in your hands as it slips from the container. After the roots have been loosened or cut (Figure 6-4), carefully place the plant in the hole. Always pick the plant up by the root ball, never by the trunk or stem.

If a soil test indicates that lime is needed, mix it with the backfill. Fertilizer should not be added at planting because it can burn the roots. An exception would be the application of phosphorus which moves very slowly, or not at all, in the soil and plays a key role in root formation. It will not burn the roots.

After a tree or shrub has been planted, construct a ring of soil 2 to 3 inches high at the outside edge of the hole to form a water basin. This prevents water from running off the surface. The water basin can be removed after the plants become established. Plants in beds probably will not require a water basin.

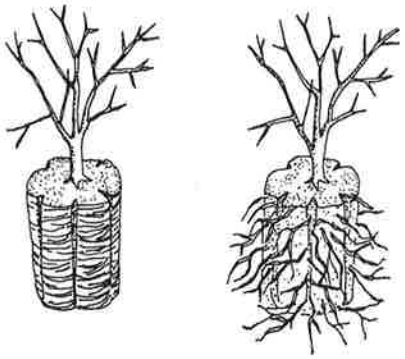


Figure 6-4. If the root mass is growing in a tight, compact circle, the roots should be loosened before planting. If the roots are only slightly encircled, you can loosen and spread them out by hand. Many gardeners cut the outer roots with a sharp knife by making vertical cuts approximately 2 inches into the root ball on two to four sides of the root ball.

Balled and Burlapped Plants

Balled and burlapped (B&B) plants have been grown in field nursery rows, dug with the soil intact, wrapped with burlap, and tied with twine. They transplant best during late fall and early winter, but can be successfully moved in the spring. The planting procedure is essentially the same as for container-grown plants.

Handle B&B Material Carefully

When selecting a B&B plant, be sure the ball is sound and has not been broken. Always pick the plant up by the soil ball—never by the trunk or stem. Be sure the soil ball does not dry out or get exposed to hot summer or freezing winter temperatures for an extended time before planting.

Unless it is a synthetic material or has been treated with a chemical preservative, leave the burlap on the root ball. Tan-colored, untreated, natural burlap is biodegradable. (Synthetic material will melt rather than burn when tested with a match.) The burlap on top of the root ball should be cut, rolled back, and covered with soil. If part of the burlap remains exposed above the soil line, it will act as a wick that draws moisture from the root ball.

After positioning the plant in the hole, remove any straps, ties, or strings from around the root ball. Wire baskets are often used to reinforce the root ball during shipping. Removing the entire wire basket may damage the root ball. It might be safer to cut and remove the top portion of the basket. B&B plants usually need little pruning at planting, but will need careful watering during dry weather.

Care of Newly Installed Plants

Watering

Until their roots grow into the surrounding soil, recently installed plants are subject to drought stress from (1) loss of roots in the transplanting process, and (2) differences in soil texture between the root ball and the surrounding soil that restrict water movement. If the root ball is dry, increase the amount and/or the frequency of watering. Do not let the transplanted root ball dry out because once the organic mix of container-grown plants gets dry, it is very difficult to rewet.

Pruning

Container-grown plants require only the removal of broken and damaged branches. B&B plants may require light pruning if the root system was drastically reduced during digging. Prune by removing entire small branches rather than cutting back the tips of many branches. Do not remove the lower branches of transplanted trees that will provide shade for the trunk and produce food for the tree.

Fertilizing

You should have the soil tested before planting and every two to three years thereafter. For fall-planted trees and shrubs, wait until spring to fertilize. For spring-planted plants, wait 6 to 8 weeks to fertilize. Apply a slow-release fertilizer in a light band along the perimeter of the planting hole. Remember that newly installed plants are under stress and should receive only a light application of fertilizer.

Tree Wraps

The benefits of tree wraps are unclear. They may provide some protection from cracking of newly transplanted, thin-barked trees if direct sun shines on the trunk. Tree wraps are normally applied in the fall and removed the following spring. If left on too long, they can encourage insect and disease problems.

Care of Established Trees and Shrubs

Symptoms of poor growth may be caused by inadequate soil aeration, excessive moisture, adverse climatic conditions, incorrect pH, or disease. Recently transplanted ornamentals often will not resume a normal growth rate until the original root system is reestablished.

Fertilizing

Trees and shrubs in the landscape do not necessarily need fertilizer every year. A moderate rate of growth and good, green color is desired for most woody plants. Excessive vigor, which is evident by lush green leaves and long shoot growth, is often undesirable. Such plants are more susceptible to injury by cold in winter, are more likely to be broken during wind and ice storms, and usually require more pruning than plants making moderate growth.

All too often landscapers assume that if a plant is not doing well they should fertilize to correct the situation. Fertilization may be helpful, but only after the problem causing poor growth has been corrected.

Fertilizer Rate

Fertilization rates should be based on soil test results; current and desired growth rate; plant age and type; location; or general guidelines (see Resources). The rate should also be influenced by rainfall and soil type. A wet season will normally increase the need to fertilize, especially in sandy soils. During periods of dry weather, reduce the amount of fertilizer. Fertilizer encourages water-demanding new growth and can injure roots of ornamentals under drought stress.

Plants growing in a restricted root zone will need less nitrogen. Plants with a fibrous root system, such as azalea, rhododendron, and blueberry, are very easily damaged by fertilizer. Light applications are recommended. Plant roots normally grow three times as far as their branches. Ornamentals located near a lawn that is fertilized regularly may not need additional fertilizer because many of their roots extend into the lawn area where they will absorb nutrients.

Time and Method of Application

Fertilize trees and shrubs in early spring or fall. Spring fertilizer application should be made before new growth starts. Fall fertilizer applications should be made approximately one month after the first killing frost. Do not apply fertilizer after mid-August because it may stimulate late growth that will not harden off before frost.

The fertilizer should be spread evenly over the entire root zone, which can extend two to three times the width of the branches (Figure 6-5). Sprinkle the fertilizer on top of the soil or mulch and water lightly. Because the fertilizer will quickly move through the mulch, there is no need to remove the mulch or to place the fertilizer below it.

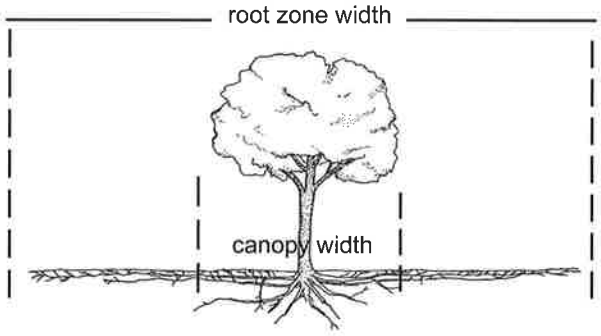


Figure 6-5. Tree roots are shallow and extend far beyond the leaf canopy. Spread fertilizer evenly over the entire root zone. Dumping fertilizer in one spot can burn or kill the roots.

Do not use weed-and-feed lawn fertilizer/herbicide combinations under trees or shrubs unless the label indicates that it is safe. Some plants, such as dogwoods, are very sensitive to the dicamba herbicide that is contained in many weed-and-feed lawn fertilizers.

Mulch

Mulches generally reduce stress on ornamental plants. Mulch conserves moisture, maintains uniform soil temperatures, prevents most weed seeds from germinating, and improves the appearance of landscape plantings. Organic mulches such as compost and shredded bark contribute to plant nutrition when the mulch decomposes into humus and releases nutrients. Keep organic mulch several inches away from trunks to help prevent crown rot diseases and vole feeding.

A 2- to 3-inch layer of mulch (after settling) is adequate to prevent most weed seeds from germinating and will allow air and water to penetrate the soil below. For maximum benefit, the mulched area should be extended to include as much of the root zone as possible.

Mulch can be applied any time of the year, although the best time is late spring after the soil has warmed. Early spring application will delay soil warming and possibly plant growth.

Mulching Materials

Some of the best mulching materials include **pine bark nuggets, pine straw, and compost.** On slopes, pine straw will remain in place better than most other materials.

Geotextiles and landscape fabrics are available for use as mulch. These materials will prevent the growth of most weeds (sedges and some grasses will grow through them) and will allow normal water and oxygen exchange. Fasten the material to the bare soil before or immediately after planting to prevent weeds from pushing the material up. Fit around shrubs by making an X cut and laying the flaps back. Landscape fabric covered with an organic material gives good results, but weeds can begin to grow in the layer of decomposing mulch. A coarse-textured mulch material, such as pine bark nuggets, will decay more slowly than fine-textured mulch.

Note: Although gravel, rock, black plastic, and rubber nuggets are used as mulches, replanting shrubs or removing these materials may be difficult. Rock materials and rubber nuggets will also absorb and re-radiate heat from the sun and thus increase water loss from plants and soil. Plastic mulch is not a good choice because it reduces the oxygen and water that reach the roots. This produces a very shallow root system and makes the plant more susceptible to drought stress.

Watering Plants

Watering is not as simple as waiting until a plant wilts or using some predetermined schedule. The need for water is influenced by a number of factors. Soils differ in how quickly they dry out after a rain or watering. A clay soil will not need watering as frequently as a sandy soil.

Different plants have different water needs, and some are quite drought tolerant. Plants with large leaves (hydrangea, rhododendron) or with shallow root systems (azalea, dogwood) are usually the first to suffer during drought periods. Shrubs under large trees are especially susceptible because of the large volumes of water taken up by tree roots. Plants are more likely to suffer from drought during their first two growing seasons after transplanting. Trees and shrubs transplanted in late spring or summer are most susceptible to drought because their roots have a shorter time to become established before summer. When there is a long period without rain during the summer, new plants should be watered at least once a week.

When to Water

It is important to water thoroughly and to allow the soil to dry between waterings. Frequent, light watering wastes water, does little to satisfy the water requirements of most plants, and leads to development of a shallow root system, which increases susceptibility to drought. By allowing the soil surface to dry out somewhat between waterings, major root development will be at greater depths where soil moisture is higher. For well-established woody plants, watering should be done every seven to ten days during prolonged dry spells. During cool seasons, less frequent watering is needed because evaporation from the leaves and soil is slower.

The best time to water is between 9 p.m. and 9 a.m. During this time there is generally less wind and temperatures are lower, so that less water is lost through evaporation. Irrigating during the evening after dew develops and before it dries in the morning does not increase disease development. Watering in late afternoon, however, lengthens the time the foliage is wet and can lead to disease development.

Pruning Trees and Shrubs

Correct pruning may help stop the spread of such pests as the azalea stem borer, dogwood twig borer, and the dogwood clubgall midge. Pruning out and destroying the infested twigs in late spring or early summer helps control the next generation of these pests. Pruning out infected plant parts can help save apples, crabapples, and pears from fire blight. As these diseases grow downward from the twigs, the wood in the stem becomes discolored. The pruning cut must be below the downward spread of the disease. Dip the cutting blade in a disinfectant (1 part chlorine bleach to 9 parts water) between each cut. Some plant diseases can be controlled by pinching off diseased parts such as flowers or leaves.

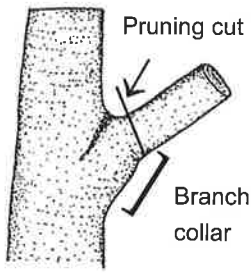


Figure 6-6. Make pruning cuts outside the branch collar.

When pruning to control the size or shape of trees and shrubs, where you make the pruning cut has a direct effect on plant health. Prune a branch to just outside the branch collar, or swelling at the base of a branch where the bark from the branch and trunk meet (Figure 6-6). The collar contains protective chemicals that guard the tree trunk from decay-causing microorganisms. When pruning cuts do not injure the branch collar, the wood heals all the way around.

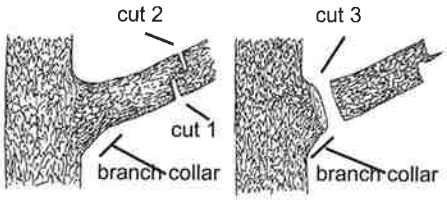


Figure 6-7. Make the first pruning cut below the branch, and then saw through at cut 2. Make a third cut close to the trunk, but leave the branch collar to heal.

If you must prune tree branches larger than 2 inches in diameter, make a series of three cuts to avoid tearing the bark (Figure 6-7). Remember to make the third cut just outside the branch collar. If a long stub is left, fungi begin to rot the stub, and the rot fungi can get into the trunk.

Wounds treated with a dressing heal no faster than untreated wounds, and dressings may actually favor decay-causing microorganisms.

Recognizing and Preventing Tree Problems

Trees are usually the most valuable and prominent features in any landscape. It is very easy to damage a tree unintentionally. When you operate any equipment in a landscape or prepare a site for landscape installation, take every precaution to protect the existing trees.

Prevent Lawn Mower and Weed-trimmer Damage

Injury and infection started by a lawn mower or weed trimmer can seriously threaten a tree's health. The most severe injury occurs when the tree bark is loose in early spring, and again in early fall. The site of injury is usually the root buttress, because it flares out from the trunk and gets in the path of the mower or weed-trimmer. Although large wounds are more serious, repeated small wounds can also add up to trouble. Use mulch around trees to prevent growth of weeds and grass. Otherwise remove weeds and grass by hand trimming or applying an appropriate herbicide.

Exposed roots need protection from pedestrian and vehicle traffic, including lawn mowers. Mulching exposed roots protects them physically as well as preventing direct sunlight from heating them. Cutting off surface roots or covering them with top soil is a temporary solution that can cause long-term damage to the tree.

Root Damage by Trenching

Digging trenches for installation of water, sewer, telephone, cable, gas lines, or for building foundations can damage the root system of nearby trees. The likelihood that the tree will recover and survive depends on the percentage of the total root system damaged, the overall health of the tree, time of year, and the type and age of the tree. To minimize potential damage, locate trenches in areas that will cause the fewest roots to be damaged or near areas that have already been trenched. If such injury cannot be avoided, tree limbs can be thinned out to reduce demand for water from the remaining roots. Mulch, aerate the soil, and lightly fertilize to promote root growth.

Test Your Knowledge

1. Before installing a new plant in the landscape you should check
a) the hardiness zone for which it is adapted.
b) the amount of sunlight it requires.
c) soil drainage.
d) all the above

2. What is NOT a good way to work with poorly drained planting sites?
a) till and add compost or pine bark.
b) add extra fertilizer.
c) adjust planting depth to leave part of the root ball above the surface and cover with mulch.
d) install raised beds.

3. It is best to plant woody shrubs and trees
a) in the fall.
b) after they break dormancy in the spring
c) below the soil surface to make watering easier.
d) in holes that are the same diameter as the pot.

4. When planting container-grown and balled and burlapped plants
a) expose them to sunlight to harden the stems.
b) keep the potting mix they are growing in moist.
c) add nitrogen fertilizer to the planting hole.
d) knock the potting mix away from the roots.

5. Plants with fibrous root systems near the surface of the ground
a) should never be planted near trees.
b) require more than 2-3 inches of mulch.
c) should be fertilized sparingly.
d) should be watered in late afternoon.

6. When pruning large branches
a) leave a 6-inch stub.
b) cut as close to the trunk as possible.
c) make three cuts to avoid tearing the bark.
d) treat the wound with a dressing to reduce exposure to air.

Answers. 1-d; 2-b; 3-a; 4-b; 5-c; 6-c

Resources

Web Sites (Plant Selection)

American Horticulture Society Plant Heat Zone Map: www.ahs.org/gardening-resources/gardening-maps

NCSU Department of Horticultural Science Portal: https://horticulture.ces.ncsu.edu/

University of Georgia Extension: http://extension.uga.edu/

Web Sites (Plant Care)

The following information is available at: https://horticulture.ces.ncsu.edu/
Bed Preparation and Fertilization Recommendations for Bedding Plants in the Landscape

Annual Flowers: Preparing the Soil

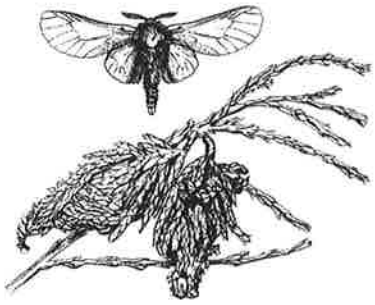
Fertilizing Deciduous Shade Trees in the Landscape

The following information is available at: http://extension.uga.edu/

Soil Preparation and Planting Procedures for Ornamental Plants in the Landscape

Pruning Ornamental Plants in the Landscape

Insect and Mite Pests of Ornamental Plants



Chapter 7

James R. Baker

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Tell the difference between damage caused by chewing insects and damage caused by sucking/piercing insects.
2. Recognize characteristic signs of damage caused by common pests of landscape plants.
3. Recognize the most common pests of landscape plants.
4. List three alternatives to synthetic insecticides.
5. Name pests that might be controlled by Bt in the caterpillar stage.
6. Name pests that might be controlled by horticultural oils and insecticidal soaps.

Terms to Know

horticultural oil

insecticidal soap

insect growth regulators

galls

honeydew

sooty mold

Chapter 7.

Insect and Mite Pests of Ornamental Plants

At one time or another, the hundreds of different ornamental plants used in landscapes are attacked by hundreds of different insects and mites. Fortunately, only 10 to 12 kinds of insects and mites are common pests in most landscapes. You should be able to recognize these common pests and know when they are likely to appear. Resources listed at the end of this chapter will help you to identify insect and mite pests. In addition, the Cooperative Extension Service provides services and training in pest identification.

Controlling Insects and Mites

- Review "Basic Principles of Integrated Pest Management" and "What's the Problem?" in Chapter 1 for general information on IPM and scouting.
- Review the information in Chapter 3 on "Using Traps to Monitor Insects" and "Biological Control."
- Review the information in Chapter 6 about cultural management practices that reduce plant stress and make plants less attractive to pests.

Pesticides

To use pesticides successfully:

- Know what pest is present.
- Know when it is most susceptible to control.
- Remember that pesticides may not work on all stages. With the azalea caterpillar, for example, eggs may not be killed, but the smaller young caterpillars are easy to control. Read the management recommendations for each pest.

Although some insecticides have been removed from the market or their uses have been restricted, many insecticides and miticides remain available for use on ornamental plants. Plant extracts such as pyrethrin and neem seed extract give some control of insect pests. **Insect growth regulators** prevent pests from hatching or molting properly. Synthetic pesticides include insect growth regulators as well as systemic and contact pesticides.

Horticultural oils and **insecticidal soaps** have a more physical action than other pesticides. When mixed with water and sprayed on pests, oils and soaps coat the pest and kill it. They disrupt the insect's ability to retain moisture and also soak into tiny openings and poison the insect's internal tissues. Horticultural oils are especially

useful for control of mites and aphids. Insecticidal soaps are effective for aphid, mite, and whitefly control.

Identifying Insect and Mite Pests

The most common insect and mite pests of landscape plants are described in the following sections. These pests are grouped as (1) chewing insects, (2) wood-boring insects, (3) sucking pests, and (4) gall makers. For each pest, there is a description, an explanation of its life cycle, a summary of the typical damage, and some suggestions for management options (cultural, biological, mechanical, or chemical).

Chewing Insects

Azalea Caterpillar

The azalea caterpillar feeds primarily on azaleas. Young azalea caterpillars are green. When they are about ½ inch long, they molt into purple striped caterpillars. They finally grow to about 2 inches long with black and yellow striped bodies and reddish heads and legs. The moths are light brown with darker brown stripes. Moths have a wingspan of almost 2 inches (Figure 7-1).

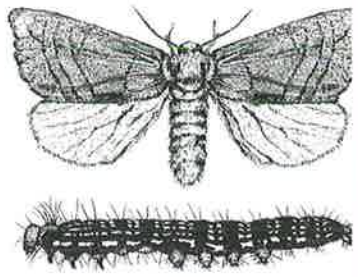


Figure 7-1. Azalea caterpillar and moth.

Life Cycle: Female azalea moths lay up to 100 eggs in masses on a leaf in early summer. Tiny azalea caterpillars hatch and feed together in a group. After the caterpillars mature, they crawl down into the soil to spend the rest of the fall, winter, and spring in the pupa stage.

Damage: Azalea caterpillars usually completely defoliate one stem or area before moving on to another part of the plant. As the caterpillars mature, they do more and more damage.

Management: Azalea caterpillars can be shaken from the shrub and trampled. *Bacillus thuringiensis* (Bt) should give adequate control of young caterpillars (but not older ones).

Japanese Beetle

The adult Japanese beetle is about ½ inch long and metallic green with coppery brown wing covers (Figure 7-2). Small tufts of white hairs occur at the sides and back. Grubs are white, curled, and have brown heads. Grubs are about 1 inch long with two rows of spines that form a "V" on the underside of the tail-end segment.

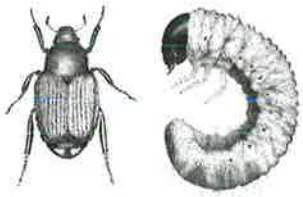


Figure 7-2. Japanese beetle and grub.

Life Cycle: During the summer, females deposit batches of 40 to 60 eggs 2 to 3 inches below the soil surface. They prefer damp soil. In warm, wet summers, eggs hatch in 2 weeks. In extremely dry weather, many eggs and tiny grubs perish. The new grubs feed until cold weather forces them into hibernation. The grubs overwinter in cells about 6 inches below the soil surface. In spring, they move almost to ground level, where they finish feeding and pupate. Peak emergence of adults occurs in July. One generation occurs each year.

Damage: The beetles attack the flowers and foliage of many plants.

Management: It is not a good idea to spray flowers for Japanese beetle control because pollinators such as honey bees or butterflies may be killed. Japanese beetle traps can do more harm than good because the traps attract more

beetles than they catch. Neem extracts repel but do not kill Japanese beetles. A disease of Japanese beetles, milky spore disease, is available as a biological control agent. Milky spore disease spores can be applied when the ground is not frozen, but it makes sense to apply it in early fall when the grubs are near the surface of the soil. Insecticides give adequate control of Japanese beetles, but several applications may be needed for complete control because the adult beetles are present for several weeks each summer.

Eastern Tent Caterpillars

Moths of the eastern tent caterpillar are brown to reddish-brown with two pale diagonal lines on the forewing (Figure 7-3). Eggs are laid in masses around twigs and covered with a foamy secretion that dries into a covering that looks like a brown foam pellet. The black caterpillars are somewhat hairy with gold, white, and blue markings and a white stripe down the back. The caterpillars grow to 2 inches long. The cocoon is about 1 inch long and is spun of white or yellowish-white silk.

Life Cycle: Eastern tent caterpillars hatch, begin to feed, and spin silken webbing in spring just at bud break. They soon weave a tent in a crotch on flowering peach, crabapple, or other related ornamental. As they grow, they spin successive layers on the tent. In good weather, they leave the tent several times each day to feed. In bad weather, the caterpillars remain in the tent. After feeding for about six weeks, the caterpillars leave the tent and spin white cocoons on fences, tree bark, buildings, or debris. In early summer, adult moths emerge from the cocoons to mate and lay eggs. The caterpillars develop inside the eggs, but they do not hatch until spring.

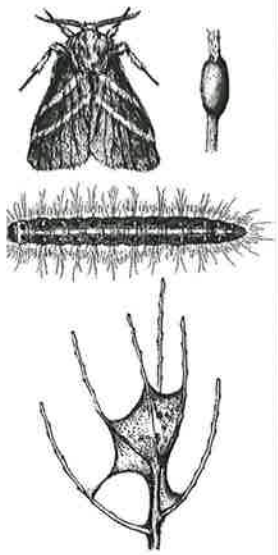


Figure 7-3. Eastern tent caterpillar.

Damage: Small trees may be completely defoliated. The silken tents become filled with caterpillars and frass.

Management: Eastern tent caterpillars can be controlled by destroying the tents with a stick or brush and discarding the young caterpillars. *Bacillus thuringiensis* should give adequate control of young caterpillars. Control of older caterpillars may not be needed as most of the damage has already been done by the time the tents are noticed.

Fall Webworms

The fall webworm caterpillars are hairy and grow to 1 3/8 inches long (Figure 7-4). Female moths are small and white. Some have black spots. Males moths are small, brown, and hairy with dark wings that become clear with age.

Life Cycle: Fall webworms hatch from groups of up to 900 eggs laid in the spring. After feeding for 4 or 5 weeks, the caterpillars crawl down, spin cocoons and pupate in mulch or soil. In July and August another generation of moths emerges from the cocoons to lay eggs on leaves for the fall generation. Fall webworms overwinter as pupae in cocoons hidden in mulch, litter, and soil.

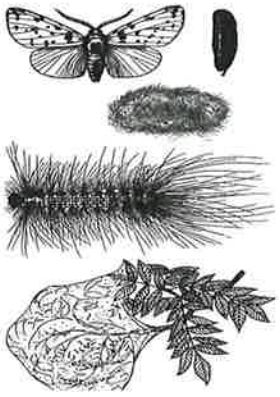


Figure 7-4. Fall webworm.

Damage: The new caterpillars spin webbing over leaves at the tips of branches and feed within the webs. The web is enlarged to enclose uneaten leaves until each web may become 2 to 3 feet long. Small trees may be entirely webbed. Fall webworms prefer pecan, persimmon, and sourwood, but also feed on other plants. The webbing is ugly, but their feeding usually does not damage the health of trees.

Management: Fall webworms can be controlled by destroying the tents and discarding the young caterpillars. *Bacillus thuringiensis* should give adequate control of young caterpillars, and synthetic pesticides are effective for larger fall webworms.

Bagworms

Bagworms are caterpillars that grow from 1/16 inch to almost 2 inches long. The caterpillars are rarely seen because they stay within a silken bag covered with pieces of the plant on which they feed (Figure 7-5). Female bagworm moths do not have wings or legs. Male moths are small, dark moths with dark wings that soon become clear.

Life Cycle: Winter is spent as eggs (500 to 1,000) inside the mother's bag attached to the plant stem. The new bagworms hatch in May and June and spin downward on silken threads. Although most young worms land on the original host plant, some may be blown for miles on the silk thread. In August, the caterpillars mature and molt into the pupal stage inside a silk bag that they cover with bits of leaves and attach to a twig by a sturdy silk band. During August and September, adult male moths emerge from their bags to mate. After mating, females lay their eggs inside their bags and die.

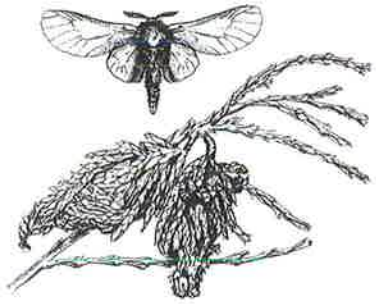


Figure 7-5. Bagworm moth and bag.

Damage: Large numbers of bagworms may cause excessive defoliation and may kill arborvitae and Leyland cypress within one or two seasons. Occasionally, the silk band girdles the twig as the twig enlarges.

Management: Leyland cypress is very susceptible to bagworms. Choose an alternative tree. To conserve biological control organisms, bagworm bags can be removed by hand during the winter and left outdoors away from the host plant. This allows tiny parasitic wasps that infest some of the bags to escape and attack eggs in other bags on other trees. Discard the bags before any surviving eggs hatch in April. Early in the growing season, *Bacillus thuringiensis* should give adequate control of young caterpillars. In late July through August, use a synthetic pesticide.

Wood-Boring Insects

The most damaging borers are the southern pine beetle and the Asian ambrosia beetle.

Southern Pine Beetles

Southern pine beetles are about 1/8 inch long, dark brown, cylindrical, and about the thickness of a pencil lead.

Life Cycle: Southern pine beetles become active in the spring about the time dogwoods bloom. Pairs of beetles attack the middle and upper trunk of stressed or damaged yellow pines (especially loblolly). If the tree has sufficient vigor, it exudes pitch, which oozes out the entrance hole onto the bark where it hardens. The beetles maintain a breathing hole, or "pitch tube" through the pitch. The pitch tube eventually becomes about the size of a piece of popcorn. Each pair of beetles chews an S-shaped tunnel 1 foot long between the bark and wood. The tunnels crisscross and girdle the tree. Eggs are deposited in niches along these tunnels. Grubs feed just under the bark until they pupate, and the new beetles emerge. The entire life cycle takes from 30 to 40 days (three to five generations per year). The last brood of the season overwinters in infested trees.

Damage: The beetles transmit the blue stain fungus that blocks water transport, kills the tree, and degrades the lumber (Figure 7-6). Southern pine beetles may become so numerous that they kill up to several hundred acres of pines.

Management: Once the pitch tubes are noticed on the trunks of pines, it is usually too late to save the tree with pesticides. Infested trees should be cut down and debarked or chipped to kill the developing southern pine beetle eggs and grubs. High value trees can be protected with pesticides during southern pine beetle outbreaks. Insecticidal barriers only prevent infestations, they do not clean up or rid infested trees of borers. Southern pine beetle treatments must reach and thoroughly soak the upper portion of trees to be effective. In landscapes, removal of infested trees is often the best option. Susceptible pines should be planted at least 25 feet apart.

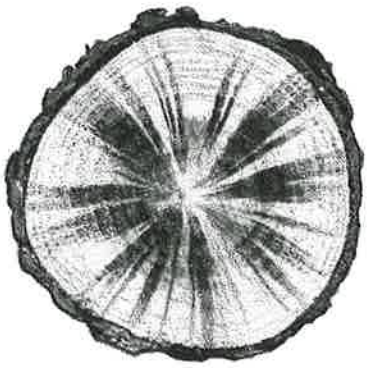


Figure 7-6. This tree was infected with blue stain fungus transmitted by southern pine beetle.

Asian Ambrosia Beetle

Asian ambrosia beetles are almost 1/8 inch long, blackish-brown, and short-legged. The eggs are oval and almost microscopic. The tiny grubs do not have legs.

Life Cycle: Eggs are laid in deep tunnels bored into the sapwood and heartwood. The young larvae hatch and chew out small egg "cradles" that radiate like teeth on a comb. The larvae apparently do not eat wood, but feed on a fungus (the "ambrosia") that grows on the surface of the wood in the tunnels and egg cradles. The adult beetles have special pouches in which they carry some of the fungi as they colonize new trees.

Damage: When ambrosia beetles attack, they bore straight into the sapwood and heartwood of diseased or stressed ornamental hardwood trees and shrubs. These tunnels are sometimes as much as 10 to 12 inches deep in a large tree. Fortunately the ambrosia fungus is not systemic or highly pathogenic, but large numbers of ambrosia beetles may kill branches or whole plants. Their entry holes can also serve as points of entry for more damaging fungi.

Management: Do not overfertilize or overwater small deciduous trees. Provide adequate irrigation in dry weather. The Asian ambrosia beetle attacks many deciduous trees, but seems to prefer plants such as cherries, magnolias, crapemyrtles, and styraxes with stem diameters larger than 1½ to 2 inches. Very few pesticides are effective for Asian ambrosia beetle control. Contact your local Cooperative Extension Center for control recommendations.

Sucking Pests

Piercing/sucking pests feed by sucking out liquids through tiny, straw-like mouthparts.

Aphids

Aphids are slow, fragile insects that vary from 1/16 to 1/4 inch long. They can be black, brown, yellow, red, gray, purple, or green. Aphids may or may not have wings. Their young are smaller than the adults and are always wingless. Aphids are the only insects with structures called cornicles that resemble exhaust pipes sticking out from both sides of the rear (Figure 7-7).

Life Cycle: During the growing season, aphids give birth to living young, but many species of aphids overwinter as eggs.

Damage: Aphids inject saliva into plants as they feed, which may distort future growth. Some aphids transmit plant viruses as well. Aphids excrete a sweet, sticky

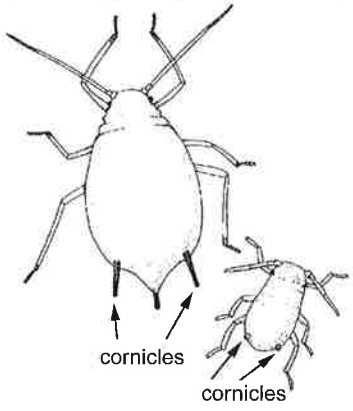


Figure 7-7. Aphid cornicles.

liquid called **honeydew**. When aphid numbers are large, honeydew often coats the upper surfaces of leaves and other objects below, making infested plants sticky. Honeydew attracts ants, flies, wasps, and other insects. In addition, dark fungi called **sooty molds** often grow in honeydew, further defacing plants.

Management: Naturally occurring predators and parasites often give adequate control of aphids. When lady beetles and lacewings are present with aphids, there is usually no need to spray. Aphids are susceptible to soaps and oils; systemic pesticides are rarely needed.

Azalea Lace Bugs

Azalea lace bugs are about 1/8 inch long and have clear, lacy wings with brown and black markings. Nymphs are almost colorless when they hatch, but soon turn black and spiny (Figure 7-8).

Life Cycle: The azalea lace bug usually spends the winter in the egg stage within the leaf tissue, although in moderate winters adults survive and continue to lay eggs. Nymphs hatch in the spring. Both immature and adult lace bugs are found most often on the undersides of leaves of azalea and rhododendron. They lay groups of eggs on the lower surface of leaves, usually along the midrib but completely hidden inside the leaf.

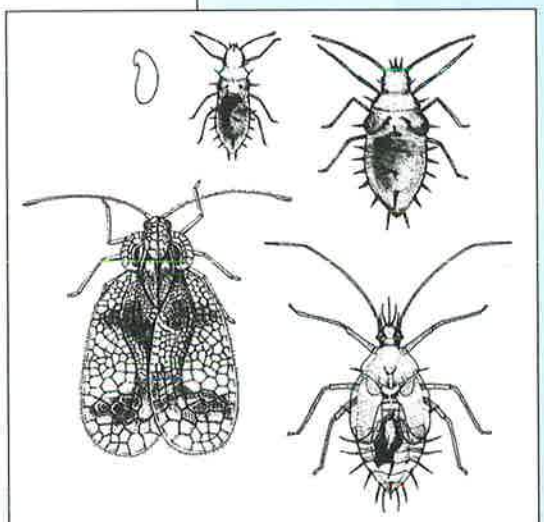


Figure 7-8. Azalea lace bug life cycle.

Damage: Lace bugs cause a blotched or spotted appearance of the upper leaf surface, and they leave behind spots of dark varnish-like excrement on the underside of the leaves. Infested leaves turn pale and may drop off prematurely. Most azaleas are susceptible to lace bugs. Although an attack by azalea lace bugs is not always fatal to azaleas, it can ruin their appearance, and damage done in spring can persist all season.

Management: Shortly after azaleas bloom, start looking for the first and most damaging generation of lace bug nymphs on the underside of the leaves. Control of this generation is most important for best season-long appearance. A bright red predatory bug, the azalea plant bug, may give some control later in the summer. Light infestations can be adequately controlled with contact insecticides. For high populations, use a systemic insecticide.

Armored Scales

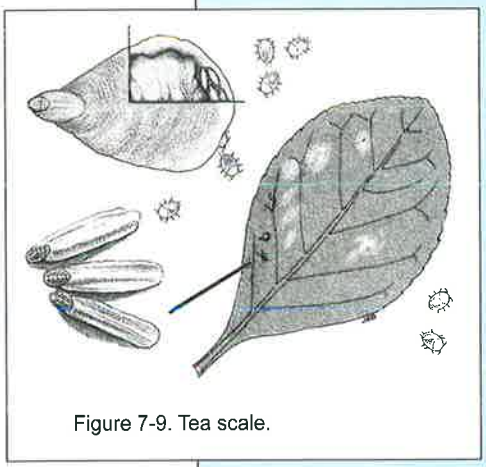


Figure 7-9. Tea scale.

Armored scales are usually very small insects that secrete a tiny fish-scale-like armor under which they grow and reproduce. The armor protects them from some pesticides. Armored scales include euonymus scales, camellia scale, tea scale, white peach scale, and others.

Life Cycle: Tea scale females have flat, hard, brown armor. The armor is oval or canoe-shaped and is about 1/16 inch long. Male armor is soft, white, and narrow with a ridge down the middle of the top. Each female lays 10 to 15 eggs under her armor. The first stage is a flat, yellow "crawler" that migrates to the newer leaves and soon settles down to feed (Figure 7-9). Male tea scales sometimes produce noticeable white fluff under the leaves of camellias and Chinese hollies. Crawlers hatch throughout the year, although less frequently in cold than in warm weather.

Damage: Leaves often develop yellow spots where the scales feed, and heavily infested leaves may drop prematurely.

Management: Although resistant to most pesticides, armored scales are susceptible to horticultural oils which can be applied throughout the year except when the foliage is new and tender or when plants are under drought stress.

Soft Scales

Soft scale insects include wax scales, cottony maple scales, and brown soft scales. The body is sometimes covered with flakes of clear wax or with white, sticky wax.

Life Cycle: Most soft scales start hatching in late May. New nymphs are pale yellow or green and translucent. They feed on stems or along leaf veins. Soft scales that feed on the leaves of deciduous plants crawl to the twigs in late summer where they feed for the rest of the fall, winter, and early spring. Most soft scales overwinter as females. Only one generation occurs each year (Figure 7-10).

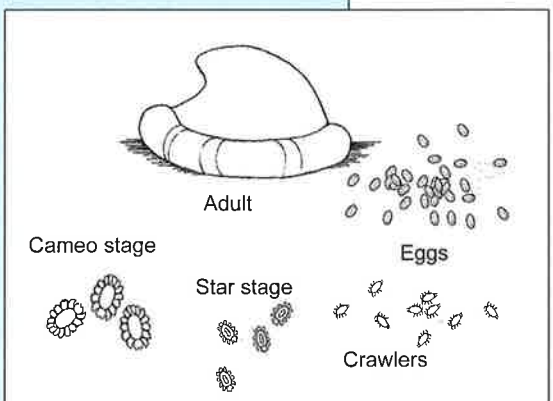


Figure 7-10. The wax scale has several life stages.

Damage: Unlike armored scales, soft scales excrete honeydew. When sooty molds grow on the honeydew, infested plants appear scorched and black. The flowers and leaves of heavily infested plants are usually smaller than normal. Twig dieback may occur.

Management: Only the crawlers of soft scales are susceptible to contact pesticides. Wax scales are not susceptible to contact pesticides after the wax covers the insect in late summer.

Spider Mites

Spider mites are small relatives of insects that resemble very tiny spiders. Spider mite adults are so small that they are barely visible. They spin fine, silk webs.

Life Cycle: Spider mites hatch from eggs and develop through active and resting stages. In hot weather, spider mites may develop to adulthood and begin laying eggs in just 5 days.

Damage: Spider mites feed on plants by piercing and sucking out liquids. A pale spot forms at each place they suck out liquid. After a heavy attack, an entire plant may become yellowed or die, and the mites may completely web over plants. Twospotted spider mites (Figure 7-11) do most damage during hot, dry weather. Spruce spider mites and the southern red mites are most active in the fall and spring. Their damage slows during the winter, and the mites seem to disappear during hot weather except in the mountains. The

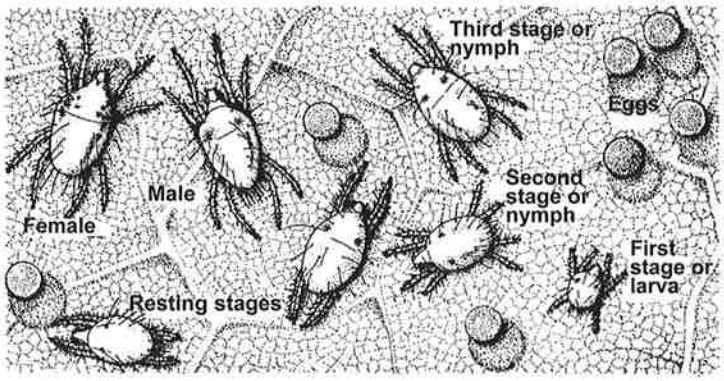


Figure 7-11. Twospotted spider mites have two black spots on top and can be green or yellow.

spruce spider mite is the most frequently reported pest of junipers, and southern red mites feed on hollies, azaleas, and other broadleaf shrubs.

Management: The eggs and resting stages are resistant to pesticides. Horticultural oils control spider mites and conserve natural predators that feed on spider mites. Predators can also be purchased for release onto small plant beds when spider mite populations are high.

Gall Makers

Gall makers are insects and mites that cause plants to form galls, which are abnormal growths that provide shelter and food for the pest (Figure 7-12). Galls may form on any part of the plant. Most galls are caused by tiny flies, mites, and wasps. Except for the boxwood leafminer, most gall makers seem to do no permanent damage to their host plants.

Boxwood Leafminers

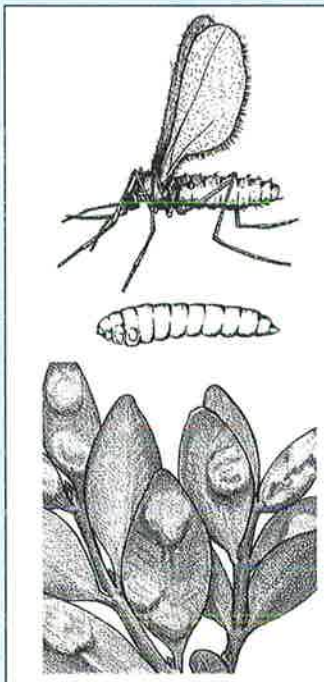


Figure 7-12. Boxwood leafminer adult, maggot, and galls.

Life Cycle: Boxwood leafminer adults are orange gall midges about 1/8 inch long. They swarm around or cling to infested boxwoods shortly after new growth has emerged in spring. After laying eggs inside the leaf, the flies die. Tiny, whitish maggots hatch and feed inside the leaf. As they grow, the maggots become bright yellow. Several maggots may develop in a single leaf. Their feeding causes galls that resemble blisters to form on the lower leaf surface (Figure 7-12). Boxwood leafminer maggots develop inside these blisters for almost a year. The next spring, the blisters form a thin translucent spot called the window, and the maggots develop into pupae. Fully developed pupae wriggle through the windows and hang down. Soon adult flies emerge from the pupae to begin a new generation. There is one generation per year.

Damage: Heavily infested boxwoods drop leaves prematurely and become unsightly.

Management: Boxwood leafminers do not seem to have effective predators and parasites. The systemic pesticides seem to give the best control, especially when applied to the soil. Late winter is the best time to apply systemic pesticides to the soil under boxwoods.

Test Your Knowledge

1. Horticultural oils are especially useful for control of which pests?

a) Caterpillars.
b) Plant bugs and stink bugs.
c) Mites, aphids, and armored scales.
d) Lace bugs and leafminers.

2. How many generations do Japanese beetles have each year?

a) One.
b) Three.
c) Five.
d) Five or more, depending on the weather.

3. When is the best time to use insecticides against soft scale insects?

a) During the adult stage when the scales do not move.
b) During the crawler stage.
c) During the egg stage.
d) After the scales are covered with wax. The wax absorbs pesticide.

4. Which of the following is a piercing-sucking insect?

a) Southern pine beetle.
b) Aphid.
c) Bagworm.
d) Leafminer.

5. What is the difference between the webs of eastern tent caterpillar and fall webworm?

a) The eastern tent caterpillar makes webs in a tree crotch; the fall webworm makes webs over leaves at the ends of branches.
b) The fall webworm makes webs in a tree crotch; the eastern tent caterpillar makes webs over leaves at the ends of branches.
c) Fall webworm larvae leave the web to feed; eastern tent caterpillars do not.
d) Eastern tent caterpillars make webs only in conifers; fall webworms make webs in hardwoods.

Answers: 1-c; 2-a; 3-b; 4-b; 5-a.

Resources

Web Sites

North Carolina State University, Ornamentals and Turf Insect Pest Management: http://ipm.ncsu.edu/ornamentals

University of Georgia, Integrated Pest Management for Turf, Lawns, and Ornamentals: http://commodities.caes.uga.edu/turfgrass/georgiaturf/PestMngt/index.html

Clemson University, Entomology Insect Information Series, Turf and Ornamental:

www.clemson.edu/cafls/departments/esps/factsheets/turforn/index.html

Weed Pests of Ornamental Plants

Chapter 8

James R. Baker
Mark Czarnota
Wayne G. Buhler

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Describe cultural control practices for ornamentals that will reduce weed problems.
2. Describe the ways that weed plants and seeds are introduced to plant beds.
3. Explain precautions to take when using herbicides in ornamental beds.
4. Explain the difference between selective and nonselective herbicides.

Terms to Know

soil fumigation

competition

Acknowledgment: With permission of the authors, this chapter draws extensively on material previously published in *Weed Management in Annual Color Beds*. 2007. J. C. Neal. NCSU Horticulture Information Leaflet. http://content.ces.ncsu.edu/weed-management-in-annual-color-beds.

Chapter 8.

Weed Pests of Ornamental Plants

Many kinds of plants become weed pests in landscapes. Both weed plants and seeds can be introduced to a site in sod, nursery stock (containerized and balled materials), and on equipment that brings them in from an infested site. Wind, water, birds, and other wildlife species also disperse weed seeds.

Developing a Weed Management Program

A successful weed management program involves three steps:

- Understanding weeds (identification and life cycle).
- Preparing the site by eliminating perennial weeds and sedges before planting.
- Using a combination of methods to maintain the site.

Understanding Weeds

The first step in developing a successful weed management program is identifying the weeds and learning about their life cycles. Some of the more common weeds of ornamentals are described at the end of this chapter. Refer to the Resources section for weed identification guides. Read the section entitled "Identifying Weeds" in Chapter 4 to review weed life cycles and methods of reproduction.

Site Preparation

The most important weed management tasks are done before planting. Good site preparation includes detecting perennial weeds and controlling them before planting. Once a planting bed is established, manual or mechanical control of perennial weeds is difficult and costly. It may be beneficial to treat the entire area with a broad spectrum herbicide. When a site is heavily infested with perennial broadleaf weeds or sedges, consider soil fumigation treatment.

Soil fumigants are applied as a gas, solid, or liquid, and they kill most organisms living in the soil. Because fumigants are highly toxic, it is important to carry out each stage of the fumigation process with care to ensure the safety of the fumigator and the effectiveness of the treatment. Always refer to the product label for details and precautions. Soil should be cultivated to a depth of 6 to 8 inches 7 to 10 days before and again immediately before fumigation. Fall is an excellent time to fumigate because soils are warm and proper moisture levels are easier to attain. Depending on the fumigant, you may need to wait 2 to 3 weeks after treatment before planting. After fumigating the site, avoid reintroducing weeds. Clean equipment such as a tiller or tractor before using it in the fumigated area. Do not add top soil (unless it has

also been fumigated). Use only "clean" composts. Control creeping perennial weeds in the surrounding beds and turf.

A soil test should be done to determine pH and nutrient content. Adjust pH and apply fertilizer to match the pH and nutrient needs of the species to be planted.

Weeds occupy open spaces. Designing the planting bed to use all the bed space will increase **competition** and keep the sunlight that weeds need for growth from reaching the soil surface. Purchase plants from nurseries that have a good reputation for providing healthy, pest-free plants. When ornamental plants are healthy and growing well, they shade out many weeds and prevent their growth.

Site Maintenance

Unfortunately there is no such thing as a maintenance-free landscape, but once perennial weeds are removed, other weed problems can be eliminated with minimal effort. One of the most important steps in preventing weeds in ornamentals is to apply a 2- to 4-inch layer of mulch. Mulches control weeds by depriving them of light. Organic mulches such as pine bark mulch, pine bark nuggets, and compost, or inorganic mulches such as gravel or stones may be used. When mulches are too fine, too thick, or begin to decompose, they stay wet between rains, allowing weeds to germinate and grow directly in the mulch. Landscape fabrics are often used in combination with mulches. They allow water and air to penetrate soil, but prevent weeds from emerging. Do not use black plastic under mulch because it prevents the free passage of water and air.

When small numbers of weeds are present, it may be most economical to remove them by hand or hoe (mechanical control). Weeds should be removed when they are young, before they compete with ornamentals and before they set seed. To prevent the spread of weed seeds, tools used to control weeds should be cleaned before they are taken to another job site.

Herbicides

Although herbicides are a valuable part of a weed-control program, the use of herbicides without preventive cultural and mechanical weed-control practices will not result in high quality, weed-free landscape plantings. Landscape herbicides may be grouped into various categories based on their general mode of action or time of application (see Table 4-1. Herbicide Terms to Know).

The proper herbicide for each situation will be dictated by the plant species located in the bed, weed species, and replanting plans. When using herbicides around ornamental plants or in beds intended for ornamentals, consider several factors:

- In ornamentals and turfgrass, nonselective herbicides can cause severe plant injury (phytotoxicity) if the spray solution touches the foliage or green bark of desirable plants. Do not use nonselective herbicides under windy conditions.
- Contact herbicides kill plants quickly, often within hours of application. Contact herbicides may be classified as selective or nonselective. They generally do not work as well as systemic herbicides for controlling perennial weeds.

- In contrast to the quick kill observed with contact herbicides, systemic herbicides kill plants over a period of days or a few weeks. Systemic herbicides are also classified as selective or nonselective.
- Preemergence herbicides form the base of a chemical weed control program in landscape sites and are used primarily to control annual grasses and broadleaf weeds. Due to their persistence in the soil, preemergence herbicides control susceptible weeds for an extended period, generally two to four months. Although the persistence of these herbicides in the soil is an advantage in terms of length of weed control, it may be a disadvantage if replanting operations are planned. Read the herbicide label to determine the length of time to wait before it is safe to replant the treated site.
- Postemergence herbicides have little, if any, residual soil activity. They are useful to control perennial grass and broadleaf weeds that are not controlled by preemergence herbicides.

Identifying Weeds

Examples of common grass, broadleaf annual, broadleaf biennial, and broadleaf perennial weeds that invade the landscape are described below, along with suggested control measures.

Grasses

Figure 8-1. Sandspur leaves are rough like sandpaper. The seeds are in sharp burs.

Summer Annual Grass

Sandspur, or sandbur (Figure 8-1), germinates in the spring, grows during the summer and early fall, and dies with the first heavy frost.

Sandspur tends to be a problem on sandy soils from the coastal plain to the Sandhills.

Pull by hand in small areas. Apply mulch 2 to 3 inches deep to ornamental bed areas to suppress germinating weed seeds. Preemergence herbicides can be applied in early spring and again in 60 days.

Summer Perennial Grass

Bermudagrass (Figure 8-2) is a creeping perennial that is dormant during the winter and buds out from underground roots (rhizomes) the following spring. It blooms throughout the summer.

In plant beds, ground cover fabrics will suppress (but not completely control) bermudagrass. Hand pulling is not effective because the underground rhizomes are hard to pull up completely. The rhizomes that escape from hand pulling soon shoot up more plants. Selective grass herbicides can be used to control bermudagrass in plant beds.

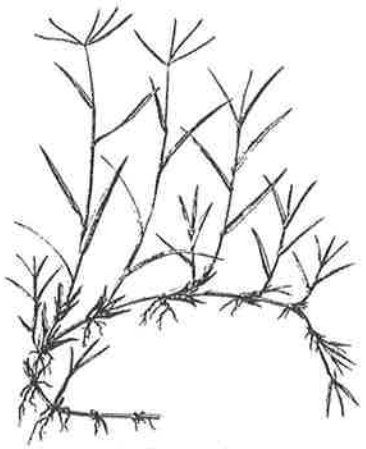


Figure 8-2. Bermudagrass seeds form on four or five very narrow fingers on the tip of a slender, leafless stalk.

Broadleaf Annuals

Figure 8-3. Leaves of Carolina geranium are deeply lobed.

Winter Annual

Carolina geranium or wild geranium (Figure 8-3) is also called cranesbill. Stems are hairy and reddish. Leaves are round, but deeply lobed. The leaves are often on long petioles. The purple to pink flowers have five petals.

Apply 2 to 3 inches of mulch to ornamental beds to smother seedlings. Larger plants can be pulled by hand. Herbicides are most effective on small plants.

Summer Annual

Horseweed is also called mare's tail. If it is not cut, horseweed grows a long single stem that branches at the top (Figure 8-4). It may grow to 6 feet or more. Horseweed has crowded, dark green, hairy leaves that are smaller toward the top of the stem. In plant beds, small infestations can be pulled by hand.

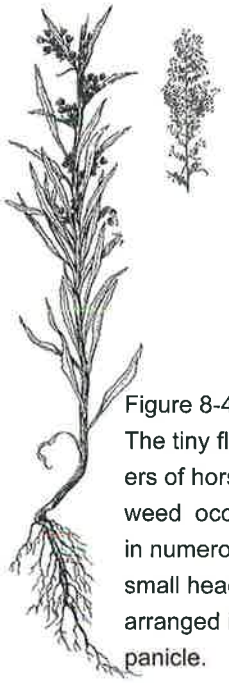


Figure 8-4. The tiny flowers of horseweed occur in numerous small heads arranged in a panicle.

Broadleaf Biennial

Bull thistle (also called common thistle) is a large, coarse, spiny winter biennial (Figure 8-5). During the first year, it grows into a flat rosette of leaves and sends down a large taproot. During the second year, it sends up a central stalk with "wings" running down the stalk from each side of each leaf. The branches are hairy, and the prickly leaves are hairy on the bottom and smooth on top. The attractive reddish or purple flowers form at the ends of short, prickly, winged stems from June through October. The flower heads are 1 to 2 inches in diameter and surrounded with spiny bracts. The seeds are readily blown about like dandelion seeds.

Hand pull in plant beds.

Figure 8-5. Nearly every part of the thistle plant is spiny.

Broadleaf Perennial

Woodsorrel (sometimes called oxalis) is most obvious during the cool season (Figure 8-6), but new seedlings also pop up during the summer. The small, bushy, yellow-green plant grows from a central taproot. The stems are slender and sometimes root at the nodes. It blooms from May to September. The 1/2 inch yellow flowers have five petals. One to four flowers appear at the end of each stem. The seed pods are about 1 inch tall and are on slender stalks. When dry, the pods break open suddenly if touched and throw the seed as far as 6 feet. Woodsorrel reproduces from stem pieces as well as from seed.

Hoe or hand pull from plant beds.

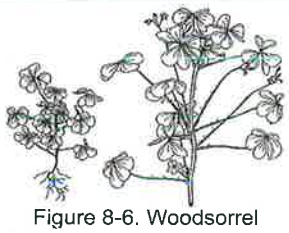


Figure 8-6. Woodsorrel leaves are up to 3/4 inch across and have three heart-shaped leaflets.

Dock is the common name of a group of 20 species of plants. Two of these, broadleaf dock and curly dock, are common weeds. Both develop a low, bunchy, flat-topped, rosette of leaves. The flower stalk rises from the center of the basal rosette (Figure 8-7).

In the landscape, spot treatments of contact herbicides are preferred because hand pulling usually breaks off the tap root from which another plant may grow.

Figure 8-7. Dock leaves get smaller and narrower toward the top of the flower stalk.

Figure 8-8. Poison ivy leaves are shiny and have three parts.

Poison ivy (Figure 8-8) is a common weed in fields, woods, and landscapes. It climbs up trees using hairy, aerial roots along the stem. The compound leaves have three shiny green leaflets. The edges of the leaflets vary. The flowers are yellowish green and inconspicuous, but the clusters of white, waxy fruit are readily eaten by birds and then spread into landscapes in their droppings. Poison ivy also spreads by rhizomes.

Pull or dig small plants by hand (wearing rubber gloves!). Larger plants can be cut and the stump painted or treated with a herbicide. Whole plants can be treated with a herbicide as long as no ornamental plants are nearby.

Test Your Knowledge

1. Mulches

a) should be applied in layers thicker than 4 inches.
b) should not be used in a landscape.
c) smother new weed seedlings by keeping out light.
d) are always organic.

2. Preemergence herbicides

a) control weeds after they germinate.
b) should be applied only in summer months.
c) persist in the soil for 2 months or more.
d) cannot be used in ornamental beds.

3. Postemergence herbicides

a) prevent weed seed from germinating.
b) control most plants after they emerge.
c) can damage plants when spray contacts green bark.
d) both b and c

4. Which of these weeds will sprout from rhizomes?

a) sandspur
b) woodsorrel
c) bermudagrass
d) bull thistle

5. Which of these weeds is a summer annual grass?

a) dock
b) bermudagrass
c) Carolina geranium
d) sandspur

Answers: 1-c; 2-c; 3-d; 4-c; 5-d.

Resources

Web Sites

North Carolina State University Weed Info Fact Sheets: http://weedinfosearch.ces.ncsu.edu/

Virginia Tech Weed Identification Guide: http://oak.ppws.vt.edu/~flessner/weedguide/

Texas A & M University Digital Flora of Texas, Vascular Plant Image Library http://botany.csdl.tamu.edu/FLORA/gallery.htm

Diseases of Ornamental Plants

Colleen Y. Warfield
James R. Baker

Chapter 9

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Name the four types of pathogens that cause the majority of plant diseases.
2. Explain the difference between protectant and systemic fungicides.
3. Define fungicide resistance and explain how to slow the development of resistance.
4. Know the general symptoms associated with common foliar and root diseases.

Terms to Know

bactericide
broad spectrum
pathogen
protectant (contact) fungicide
systemic fungicide
local penetrant (local systemic) fungicide
mode of action
solarization
resistance
leaf spot
scab
root rot
nematode
powdery mildew
blight
vascular wilt

Chapter 9.

Diseases of Ornamental Plants

Successful disease management for ornamentals requires much more than spraying pesticides. By the time disease symptoms appear or become severe, it is often too late to provide effective control. For this reason, prevention is not only the most important method of disease management, it is often the only effective control. To avoid plant diseases, review Chapter 6 for ways to grow healthy plants that are better able to withstand disease damage. With careful cultural management, most landscape plants can be grown using little or no pesticide.

In addition to disease, many factors cause plant problems with symptoms that resemble those caused by plant pathogens. Symptoms that are actually caused by overwatering, nutrient deficiencies, pesticide toxicity, air pollution, and improper plant selection are often incorrectly blamed on insects, mites, or plant pathogens.

Review the Disease Pyramid section of Chapter 5. Remember that disease occurs only in the presence of (1) a pathogen to cause the disease, (2) a susceptible host plant, (3) environmental conditions that favor disease development, and (4) time for infection to occur. Most plant pathogens require specific conditions to spread and infect plants. By modifying these conditions, you may be able to prevent the disease from spreading.

Types of Pathogens and Pesticides

The microorganisms that cause diseases are called **pathogens**. The most common pathogens that cause diseases of ornamental plants are fungi, bacteria, viruses, and nematodes.

- **Fungi** are responsible for most plant diseases in the landscape. They cause a variety of plant symptoms including leaf spots, wilts, dieback, root rots, and cankers. Although you need a microscope to see most fungi, some of them, such as powdery mildew and rust, are visible without magnification. Fungicides are applied for control of some fungal diseases.
- **Bacteria** are one-celled, microscopic organisms that can cause shoot blights, leaf spots, soft rots, and galls. Bactericides are used to control bacterial diseases, but in most cases once symptoms are seen, the damage is done, and it is difficult to stop disease development.
- **Viruses** are pathogens that are too small to see even with a microscope. Viruses can cause stunting, discoloration of leaves and flowers, or malformation of plant tissues. Viruses are most often introduced into a landscape on infected plants. Aphids, leafhoppers, or thrips spread many of the common plant viruses. No pesticides are available for virus control, although some insecticides control the insects that transmit viruses.

- **Plant parasitic nematodes** are microscopic roundworms. Various species attack roots (root parasitic nematodes), shoots (stem nematodes), or leaves (foliar nematodes). Nematodes that attack the roots can cause root galls, stubby roots, low vigor, discoloration, or decline of infected plants. Foliar nematodes cause a discoloration of leaf tissue and infested leaves drop off.

Fungicide Basics

Protectant Fungicides

Most of the pesticides applied to ornamentals are fungicides used to control fungal diseases. A few **bactericides** are used for control of bacterial diseases. Some fungicides work against specific pathogens, while others are effective against a wide variety of pathogens (**broad-spectrum fungicides**).

Most fungicides and bactericides are **protectants** that act like an exterior shield that protects the plant from certain fungi or bacteria for some period of time. When the fungus comes in contact with a protectant fungicide on the plant surface, it is prevented from entering the plant and causing infection. For this reason, protectant fungicides are also called contact fungicides.

Protectant fungicides do not enter the plant, but stay on the leaf and stem surfaces. Because protectant fungicides and bactericides are effective only on contact with the pathogen, it is important to coat the entire surface of the plant to provide a complete shield. This means that young, expanding leaves and twigs may need to be sprayed more often than mature tissues, since they may outgrow protection within 3 to 5 days after spraying.

The duration of protection that a protectant fungicide provides depends on many factors. As with any pesticide, rainfall or irrigation within a few hours after application washes away much of the pesticide residue and greatly reduces the protective value. Even after drying on the plant surface, residues of a protective fungicide may continue to be eroded by rain, dew, vaporization, or sunlight, thus reducing the protection.

Systemic Fungicides

Systemic fungicides are absorbed and translocated within the plant from the site of application to distant tissues. This means that systemic fungicides can prevent the development of disease at the site of uptake and in other regions of the plant. Almost none of the fungicides on the market today translocate throughout the entire plant. Most systemic fungicides are only translocated upward in the plant's water-conducting vessels (xylem). **Local penetrant** (also called local systemic) fungicides are absorbed into the immediate area of application, but are not translocated far from the site of uptake. Some local penetrant fungicides move through the leaf tissue from the upper surface to the underside of the leaf. These are useful when it is difficult to get good spray coverage on the bottom of the leaf.

Because they are absorbed by the plant and protected from wash-off and weathering, systemic fungicides have longer residual activity than protectant fungicides. Systemic fungicides also protect plant tissues such as crowns, roots, and newly formed tissues that are difficult to spray. They may also control fungi that have already entered the plant, although preventive applications of systemic fungicides are generally more effective than treatments applied after infection has occurred. The main problem with systemic fungicides is the development of pathogen resistance or tolerance.

Fungicide Resistance

The mechanism by which a fungicide or bactericide controls a plant pathogen is called its **mode of action**. Most fungicides target specific processes that the fungus needs in order to survive. If the fungus is no longer killed by the fungicide, the pathogen is said to have developed **resistance** to that fungicide. Fungi that have developed resistance to a fungicide will no longer be adequately controlled by that fungicide or any fungicide with the same mode of action.

Compared with systemic fungicides, protectant fungicides tend to affect fungi in multiple ways, which makes it more difficult for the fungi to develop resistance and "get around" the chemical. Because many systemic fungicides target just a single process in the fungus, the pathogen can more easily adapt its metabolism in order to survive and develop resistance.

It is very important to read the precautions on pesticide labels and follow the recommendations for managing resistance. This usually means limiting the number of consecutive applications of the same pesticide or limiting the total number of applications of the same pesticide in one season. Using fungicides that act in different ways on the pathogen will slow the development of resistance.

Soil Fumigants

Some chemical fumigants are used to sterilize soil by killing most fungi, bacteria, insects, nematodes, and weeds. Fumigation for disease control is generally limited to situations where populations of soil-borne pathogens have reached such high levels that susceptible plants can no longer be grown successfully. Fumigants are applied as a gas or a liquid injected into the soil and immediately covered with plastic or as granules that are incorporated into the soil (typically followed by irrigation) and then covered with plastic. Fumigants can be highly toxic to humans and must be used with strict safety measures. Fumigants are restricted use pesticides. Fumigants cannot be applied where plants are currently growing, so their use is generally limited to large, commercial landscape beds that are replanted each year or to areas where high-value ornamentals are being produced.

Types of Disease

Examples of the most common types of diseases of ornamental plants are described in the following pages. Management sections include preventive methods and other control techniques for each disease.

Leaf Spots

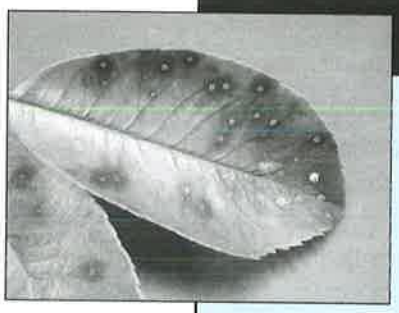


Figure 9-1. *Entomosporium* causes reddish spots on the leaves, sometimes surrounded by a yellow halo. Spots darken and enlarge as the leaves mature.

Leaf spots may be caused by pathogens, environmental conditions, cultural practices, and insects. Most ornamental plants are susceptible to one or more fungi that cause leaf spots. Leaf spot fungi generally cause circular or irregular lesions on the leaves (Figure 9-1). Lesions are typically brown, yellow, reddish, or purple and may have tan or light-colored centers of dead tissue bordered by a distinct margin. Raised, pinhead-sized, black dots may be observed within the dead tissue. These structures are fruiting bodies that contain large numbers of fungal spores. Fungal leaf spots typically show up first on older leaves during periods of warm, humid weather. Water must be present on leaf surfaces for 4 to 12 hours (depending on the pathogen) for most fungal spores to germinate and infect the plant.

Common fungal leaf spot diseases include *Entomosporium* (*Diplocarpon*) leaf spot of Indian Hawthorn and red-tip Photinia, black spot of roses, spot anthracnose on dogwood, shot-hole on cherry laurel, and *Cercospora* leaf spot of pansy.

Bacteria can also cause leaf spots. Leaf spots caused by bacteria often appear watersoaked and turn brown. The leaf spot may have a halo of yellow tissue surrounding the spot. English ivy, cherry laurel, and chrysanthemum are commonly infected by bacterial leaf spot pathogens. Blossoms and stems can also become infected and may wilt and then die.

Management

Keep the foliage of susceptible plants as dry as possible, especially during warm, humid weather. Water with drip irrigation or irrigate in the morning so that the foliage dries out during the day. Give plants enough space to allow good air circulation between plants. Remove and dispose of spotted, fallen leaves.

Fungicides or copper-based bactericides can be applied during periods of warm, wet weather to protect new growth.

Scab

Scab is a common fungal disease that causes defoliation and blemishes on fruit (Figure 9-2). While the fungus that causes scab on apple and crabapple is different from the fungus that causes scab on pyracantha, the diseases they cause are very similar.

Dull, olive-green, fungal growth that develops on the surface of leaves during the spring gives them a velvety appearance. Heavily infected leaves may turn yellow or reddish and drop prematurely. Infected fruit have circular rough spots on their surface and, in severe cases, the fruit can become completely covered with cracked, scabby, dark lesions.

The scab fungus overwinters in infected plant tissue and in infected fallen leaves and fruit on the ground. Spores from these tissues are splashed by rain or forcibly shot out of fungal fruiting

bodies onto young, emerging leaves the following spring. Young leaves that have moisture on them become infected. New spores that form on the infected tissue spread this disease throughout the growing season. Although apple scab does not do permanent damage, losing leaves two or three years in a row can weaken the tree.

Figure 9-2. Crabapples infected with scab develop rough spots on the surface. Leaves on infected trees often fall prematurely.

Management

Select resistant cultivars (see the Resources section at the end of this chapter). Rake and destroy the fallen leaves and fruit under infected trees.

The disease can be managed by fungicide applications made at 7- to 10-day intervals beginning when the leaf buds begin to swell in the spring and repeated until dry, warm summer conditions occur.

Root Rots

Several root and crown diseases commonly affect landscape trees and shrubs. These include *Armillaria* root rot, *Phytophthora* root rot, and black root rot caused by the fungus *Thielaviopsis*. Because plant roots transport water and nutrients to the rest of the plant, the symptoms of root disease are also likely to be seen on other parts of the plant as well (Figure 9-3). Most of the fungi that cause root diseases are naturally present in the soil, so that the most effective control is to keep plants vigorous with proper cultural care and to prevent the wet soil conditions that promote disease development.

***Phytophthora* root rot** is a common problem on azalea, rhododendron, camellia, and boxwood, and it can infect more than 900 other plant hosts. *Phytophthora* kills the roots and root crown of infected plants. All species of *Phytophthora* require extended periods of high soil moisture to cause disease, so avoid overwatering and poor drainage. Infected plants are often stunted, have small leaves, and the roots are brown and rotted. At the base of stems near the soil line, infected wood under the bark is brown instead of a healthy white. Leaves may wilt and plants may appear to die suddenly when hot, dry weather begins. The roots of resistant cultivars that have been stressed by drought or flooding become susceptible.

Figure 9-3. Wilting of the top portion of a plant usually indicates a problem with the root system. Leaves may wilt and turn downward on rhododendron plants infected with *Phytophthora* root rot.

Management

When setting out plants in a new landscape, select resistant cultivars (see the Resources section at the end of this chapter). Choose healthy, disease-free plants. Avoid plants that lack normal green color. Knock plants out of their pots and avoid plants with dark or discolored roots. In areas where root-rot-susceptible plants have died, replant with plants that are not susceptible to root rot.

Remove and destroy plants confirmed to be infected with *Phytophthora*. Always locate plants susceptible to root rot in well-drained areas. In heavy clay or poorly drained soils, plant in raised beds. Incorporate organic amendments such as pine bark to a depth of 8 to 12 inches.

There are no fungicides that can cure an infected plant; they will only delay an almost certain death. It is sometimes possible to treat uninfected nearby plants with a registered fungicide to protect them from infection.

Nematodes

Nematode infestations of the roots should be considered whenever a particular plant species shows a general decline or stunting and yellowing or bronzing of the foliage. Root rots and poor cultural care can cause very similar symptoms, so an accurate diagnosis is important. Japanese holly, juniper, aucuba, and boxwood are often infected by root-parasitic nematodes. Laboratory analysis of a soil sample is the only way to determine the presence and species of nematode associated with the problem. Contact your local County Extension Agent or the state department of agriculture for more information on testing for nematodes.

Although nematode root feeding causes plant stress, established woody plants are rarely killed by nematodes. However, a plant that is weakened by nematode damage can be more susceptible to infection by more aggressive pathogens. In a plant bed, nematode damage may be spotty because nematodes are usually not evenly distributed throughout the soil.

Foliar nematodes cause areas of discolored tissue between the major leaf veins (Figure 9-4). The infested tissue is initially chlorotic (discolored), but becomes dark brown with age. Heavily infested leaves will drop.

Management

Select top quality, resistant cultivars (see the Resources section at the end of this chapter).

Incorporate organic matter into the soil before planting to encourage the activity of other microorganisms that are natural enemies of nematodes. Tilled, moist soil can be treated through **solarization** (heating to very high temperatures that kill nematodes) by covering it with clear polyethylene for 6 to 8 weeks. Solarization works best on sandy soils in hot weather. Where the soil has extremely high numbers of plant parasitic nematodes, the soil can be replaced. This might be practical in planters and confined beds.

Keeping water off the foliage will help to reduce the population and spread of foliar nematodes, but there is no cure. The best management practice is to avoid introducing infested plants into the landscape.

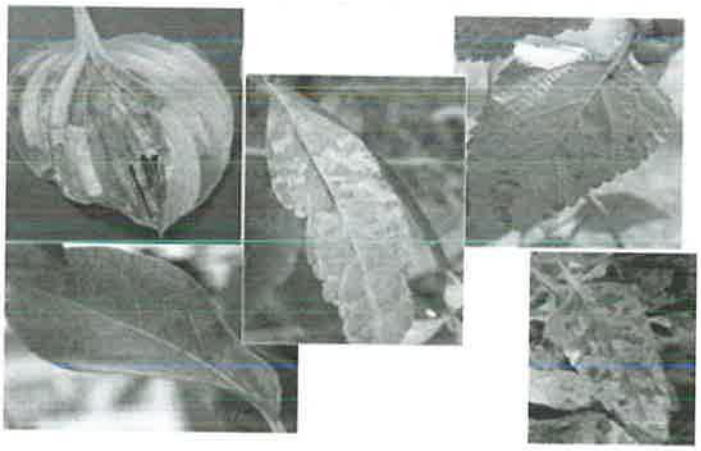


Figure 9-4. Foliar nematode injury. Over time, the affected cells turn from light green to yellow to brown. Heavily infested leaves will turn yellow and drop prematurely. Infested leaf tissue may also drop out, so that leaves have a tattered appearance.

Powdery Mildew

Many ornamental plants are susceptible to one or more species of **powdery mildew** fungi. The first signs of powdery mildew are patches of white powdery-looking fungal colonies on the leaf surfaces and stems. Infection is favored by cool nights with high relative humidity (above 85 percent) followed by warm dry days with temperatures between 70° and 80°F, but powdery mildew can occur in humid as well as dry locations. Unlike most other fungal leaf spot diseases, free water on the leaf surfaces will often minimize disease.

Figure 9-5a (left) and 9-5b (right). Powdery mildew can cause white patches on leaves, flowers, and stems. These white patches are typically found on the upper surface of the leaves, but can be found on the underside when infection is severe.

Crabapples, crapemyrtle (Figure 9-5a), dogwood, rose, euonymus, and zinnia (Figure 9-5b) are often infected with powdery mildew. Infected leaves may become puckered and distorted. New growth may become twisted and deformed, and infected flower buds do not open properly. Once powdery mildew growth is extensive, it is usually too late for fungicides to prevent damage.

Management

Selective pruning to increase air movement around the plant will help to reduce the humidity.

Pruning out heavily infected plant parts will reduce the amount of inoculum that can start new infections. When choosing new plants for the landscape, select resistant cultivars (see the Resources section at the end of this chapter). Powdery mildew grows best in the shade, so growing susceptible cultivars in sunny locations may help to prevent this disease.

Apply a registered fungicide as soon as new growth begins to emerge or when fungal growth is first observed. Continue to make regular fungicide applications until conditions are no longer favorable for infection.

Blights

Fire blight is an example of a bacterial blight disease that infects plants in the rose family such as apple, pear, hawthorn, and *Cotoneaster.* Fire blight is evidenced by a sudden wilting and blackening or browning of shoots, blossoms, or fruit. Infected shoots appear scorched, and dead leaves remain attached to the twigs (Figure 9-6). Cankers may form on the twigs and branches which may die back. Branches and trunks may become infected when the bacterium moves downward in the plant from infected flowers, twigs, and shoots.

The bacteria overwinter in plant tissue around cracked, sunken cankers on infected trees. During warm, wet, or humid weather, bacteria ooze from around the cankers. They are then spread to wounds or flowers by many species of flying or crawling insects, splashing rain, or pruning tools. Infection occurs through the blossoms. Once flowers are infected, the bacterium can be spread from one flower to another by bees and splashing water. Fire blight may kill susceptible cultivars if cankers develop in the main trunk.

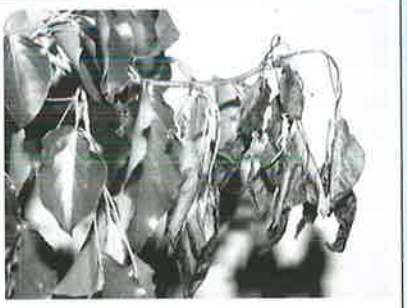


Figure 9-6. Fire blight disease can result in sudden wilting. Shoots, flowers, and fruit turn black or brown. Twigs and branches may curl over at the end into a shepherd's crook shape.

Management

Plant resistant cultivars and prune out all infected twigs and cankers before growth starts in the spring. Make cuts 4 to 6 inches below any evidence of dead tissue. During the growing season, make pruning cuts 12 inches below a canker or blighted tissue. Disinfect pruning tools frequently. Fertilize sparingly to minimize excessive succulent growth.

Timing of bactericide/antibiotic applications is critical for effective control. Applications of registered bactericides should begin several days before the first flower buds open and continue every 4 to 5 days until petal fall. Repeated use of antibiotics may result in the development of strains of the bacterium that are resistant and can no longer be controlled by the treatment.

Vascular Wilts

Various fungi and bacteria can cause vascular wilt diseases of ornamentals. Wilt diseases are usually fatal, and young plants can be killed quickly. Older plants may take several years to die. Dutch Elm disease, *Fusarium* wilt of mimosa, and Laurel wilt are examples of vascular wilt diseases (Figure 9-7). Symptoms of bacterial leaf scorch occur during mid to late summer and symptoms are very similar to those of other diseases and cultural problems, so ask a diagnostic laboratory for confirmation of this disease.

Figure 9-7. On oak, discoloration from bacterial leaf scorch moves from the edges of the leaf toward the center. A dull red or yellow band may appear between the healthy and dead areas of the leaf.

Wilt pathogens disrupt the vascular system that transports water and nutrients to different plant parts. The vascular tissues often turn brown and become clogged with fungal hyphae and spores, bacteria, or other substances produced by the plant in response to infection. The needles or leaves may begin to fade, turn yellow or brown, and then wilt.

Management

Preventive fungicide applications can be made to highly valued trees to help prevent Dutch Elm disease, but fungicides/bactericides are ineffective in controlling *Fusarium* wilt and bacterial leaf scorch.

Test Your Knowledge

1. **Stunting, small leaves, and nutritional deficiency symptoms are all associated with what type of disease?**
   a) leaf spot
   b) root rot
   c) root parasitic nematodes
   d) b and c

2. **Leaf spot diseases**
   a) are usually worse in wet or humid weather.
   b) cannot be prevented with fungicides.
   c) can be managed with overhead irrigation.
   d) are all caused by fungi.

3. **Root parasitic nematodes**
   a) cause a general decline or stunting.
   b) can be brought to the surface by using soapy water.
   c) are slender worms about 2 inches long.
   d) cause more damage under cool temperatures.

4. **Powdery mildew on crapemyrtle can be managed by several methods. Which of the following methods would NOT be effective?**
   a) Planting a resistant variety.
   b) Using a soil sterilant to kill the spores.
   c) Spraying with a registered fungicide when symptoms appear.
   d) Spacing plants to improve air circulation.

5. **Which of these statements about root rots is true?**
   a) A fungicide can be applied to cure infected plants.
   b) Root rots can be controlled by flooding the plant bed to drown the fungus.
   c) Roots infected with *Phytophthora* are yellow.
   d) Most root rots can be avoided with clean plants and good drainage.

Answers: 1-d; 2-a; 3-a; 4-b; 5-d.

Resources

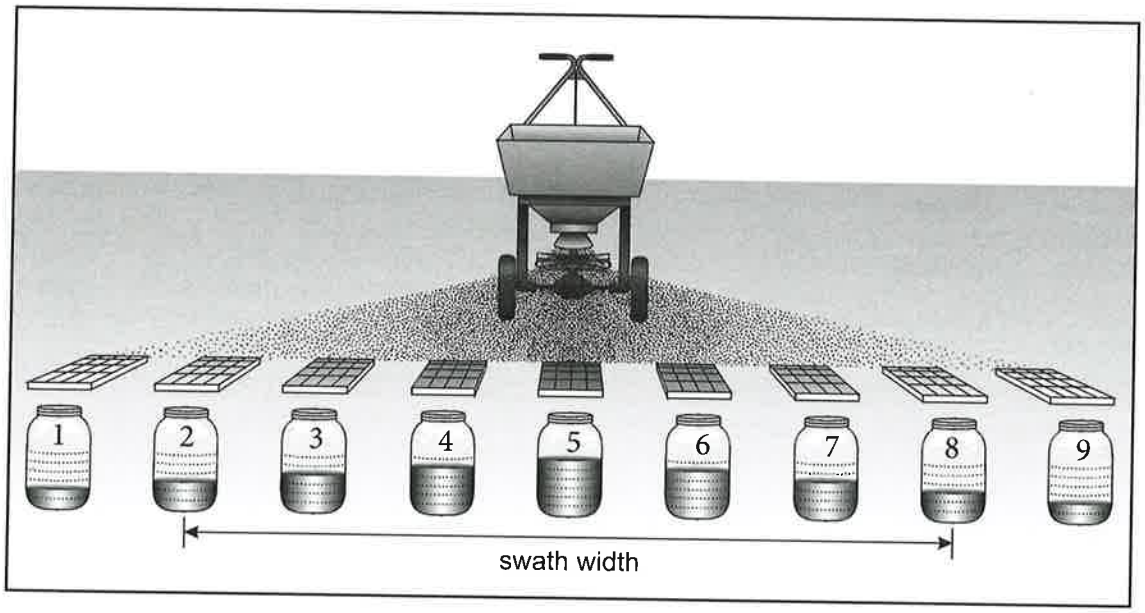
Web Sites

North Carolina State University Plant Pathology Ornamental Disease Information Notes: www.ces.ncsu.edu/depts/pp/notes/Ornamental/ornamental_contents.html

Alabama Cooperative Extension System. Common Diseases of Crapemyrtle. 2003. A.K. Hagan. ANR-1047: https://store.aces.edu/ItemDetail.aspx?ProductID=13942

University of Tennessee Agricultural Extension Service. https://extension.tennessee.edu/publications/Pages/default.aspx Dogwoods for American Gardens PB1670; Diseases of Shade and Ornamental Trees, SP546.

Applying the Correct Amount of Pesticide



Wayne G. Buhler

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Describe a method for figuring out the area of a treatment site.
2. List four times when equipment should be calibrated or recalibrated.
3. Know how to calibrate by area-to-be-treated or by sprayer volume.
4. Check nozzles on a boom sprayer for uniform output.
5. Adjust nozzles on a boom sprayer to produce uniform pattern.
6. Calculate your speed when driving a boom sprayer.
7. Determine the effective swath width for a rotary spreader.

Terms to Know

calibration

spray angle

application rate

swath width

spray overlap

nozzle body

diaphragm

strainer

nozzle tip

nozzle orifice

Chapter 10.

Applying the Correct Amount of Pesticide

To use pesticides successfully, you must apply the correct amount of pesticide over the target area in a uniform way. Errors in rate or uniformity may waste money, injure plants, damage the environment, fail to control pests, and result in fines for illegal application. In every situation, you should know, rather than guess, whether you are applying the correct amount of pesticide.

Measuring the Area To Be Treated

To apply the pesticide at the proper rate, you need to measure the area to be treated (Figure 10-1). Smaller sites are usually measured in square feet. Larger sites are measured in acres. Remember that an acre is 43,560 square feet (see Table of Measures, page 146). Accurate area measurements are very important when treating turf or large beds of ornamentals. Mistakes in measuring the area will result in costly errors from application of too much or too little pesticide. It is usually simple to measure the area of squares or rectangles such as home lawns or athletic fields. It may take several steps to measure the area of irregular sites such as golf courses or parks. One way to do this is to match each part of the irregular site to the closest geometric shape, then find the area of each part and add them up to get the total area to be treated (Figure 10-2).

Figure 10-1. Use a measuring wheel or tape to find dimensions of the area to be treated. Keep a record of the measurements for future reference.

Making Adjustments

If a driveway, mulched bed, dog pen, or building takes up space in the treatment area, determine the area that these sites occupy and subtract it from the total area. What you need to know is the size of the area that will actually be treated.

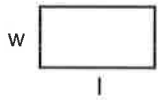
Area of Geometric Shapes

Circle: area = 3.14 x r^2

The area of a circle is the radius (r) squared and then multiplied by 3.14 (pi).

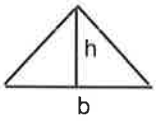
Rectangle: area = w x l

Multiply the width (w) by the length (l).



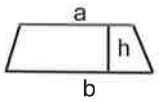
Triangle: area = $\frac{b \times h}{2}$

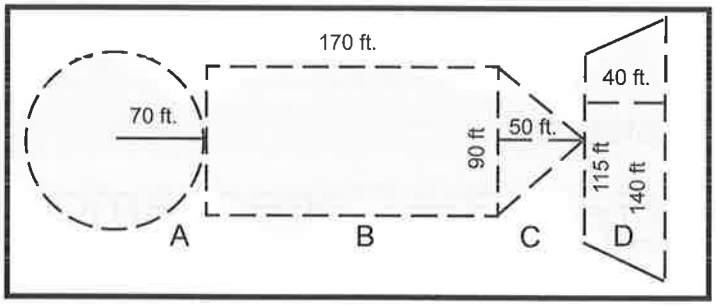
Multiply the base (b) by the height (h) and then divide by 2.



Trapezoid: area = $\frac{a + b}{2}$ x h

Multiply the average length of the parallel sides (a and b) by the height (h).





The area of the golf course hole above can be subdivided into a circle (A), a rectangle (B), a triangle (C), and a trapezoid (D). The total area is the sum of the individual areas, A + B + C + D.

A = 3.14 x 70 ft. x 70 ft. = 15,386 sq. ft.

B = 170 ft. x 90 ft. = 15,300 sq. ft.

C = $\frac{90 \text{ ft. x } 50 \text{ ft.}}{2}$ = 2,250 sq. ft.

D = $\frac{115 \text{ ft. + } 140 \text{ ft.}}{2}$ x 40 = 5,100 sq. ft.

Total = 38,036 sq. ft.

Figure 10-2. Using geometric shapes to measure irregular sites.

Calibration: Applying the Correct Amount

Calibration is the process of measuring output and adjusting your equipment to apply the right amount of pesticide to the target area. The person who will make the actual application should be the one to calibrate the equipment. Properly calibrated application equipment will:

- Deliver the right amount of pesticide.
- Apply it uniformly.

Every pesticide label will tell you the rate for applying the product. For some applications, the rate will be given as the amount of product per area (for example, 4 ounces per 1,000 square feet). For other applications, it may be the amount of product per volume (for example, 3 ounces per gallon) or a percent solution when mixed with water (for example, 2% solution).

When to Calibrate

The methods described here are practical, easy to learn, and use only basic tools. Before you begin, check to see that all equipment components are clean and in good working order. Every time you calibrate a piece of equipment, it is a good idea to keep a record of settings, rates, and operating conditions. Frequent calibration is critical with liquid pesticides because the flow rate increases as nozzles wear out with use.

Calibrate application equipment.

1. Before using it for the first time each year,
2. When changing the type of pesticide,
3. When changing the rate and speed at which it is applied,
4. When equipment is moved from one site to another. This is especially important with rotary spreaders because their settings are easily knocked out of place.

Safety

Once equipment has been used, it will have pesticide residue on it, and you should wear protective gloves and eyewear. If you will be mixing the pesticide with water, you can do the calibration with plain water. If the pesticide is a granule or is mixed with a carrier other than water (fertilizer, for example), you should use the actual pesticide or mixture for the calibration testing. Always wear the recommended protective equipment when working with pesticides.

Equipment Choice

The type of equipment to use for pesticide application depends on the size and type of the target area, the type of pest, and the pesticide formulation. For liquid pesticides, choose the correct nozzle tip size and type for your application needs (see "Nozzle Knowledge" page 130). Pesticide labels, equipment catalogs, and dealers have information that will help you select the right equipment. This chapter describes methods for calibrating the most common types of application equipment used in treating turfgrass and ornamentals.

Speed

Whether you are walking with a compressed air sprayer across a home lawn or driving a boom sprayer around a golf course, application rate is directly related to speed. Traveling faster will give a lower application rate, while slowing down will produce a higher rate (Figure 10-3).

Try to maintain a constant speed. If you walk faster going downhill and more slowly going uphill, the rate that you apply will vary. A walking speed of 2 to 3 mph is common when applying pesticides to turf. A speed of 4 to 6 mph is common for power-driven equipment.

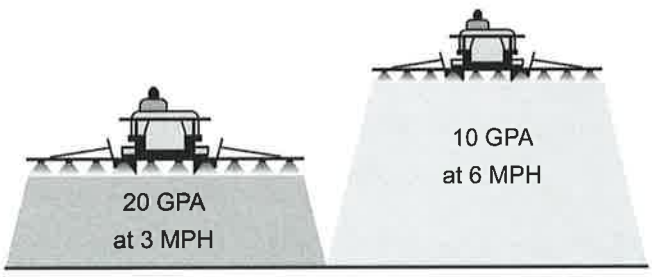


Figure 10-3. Doubling the speed applies only half as many gallons per acre (GPA).

Calibrating Handheld & Backpack Sprayers

Handheld sprayers and backpack sprayers operate on compressed air at pressures up to 30 pounds per square inch (psi). A hand-operated piston or diaphragm pump creates pressure in the tank and forces the solution out of the nozzle. The pressure drops as the solution is sprayed, and the tank must be re-pressurized frequently to maintain even pressure. If the sprayer has a pressure gauge, try to keep pressure within 10 psi of the initial pressure.

Calibrating by Area: Treating Small Turf Areas and Plant Beds

If you are applying pesticide to an area measured in square feet, calibrate the sprayer by staking out a 1,000-square-foot test plot (for example, 20 feet x 50 feet) on a surface similar to the treatment site.

Step 1—

- Fill the sprayer tank half full with water (no pesticide).
- Maintain the pumping pressure that you will use during application.
- Record the number of seconds it takes to spray the test plot evenly while walking at a comfortable, steady pace.
- It is a good idea to spray the test plot two or three times and figure the average time. Use the average time in your calibration.

Step 2—

- Stand still and spray into a container for the average time found in Step 1.
- The number of ounces collected equals the amount of spray delivered to 1,000 square feet.
- With this number you can calculate the amount of pesticide and water needed to treat the target area.

Example # 1:

Apply herbicide to a lawn 40 feet x 65 feet.

Labeled application rate: 2 ounces of herbicide are to be mixed with a sufficient amount of water to treat 1,000 square feet. This can be expressed as: 2 oz./ 1,000 sq. ft.

Area to be treated: 40 x 65 = 2,600 sq. ft. Test-plot time to cover 1,000 sq. ft. = 80 seconds.

Amount of water collected in 80 seconds: 57 oz. Sprayer output: 57 oz. per 1,000 sq. ft.

1. To determine the total spray mixture needed: Multiply the target area by the sprayer output.

$$2{,}600 \text{ sq. ft. } x \frac{57 \text{ oz.}}{1000 \text{ sq. ft.}} = \frac{148{,}200 \text{ oz.}}{1000} = 148.2 \text{ oz. (round off to 148).}$$

To solve this problem, first multiply 2,600 by 57 = 148,200.
Then divide 148,200 by 1,000 to get 148.2 total ounces.

2. To determine the amount of herbicide needed, multiply the target area by the labeled application rate.

$$2{,}600 \text{ sq. ft } x \frac{2 \text{ oz.}}{1000 \text{ sq. ft.}} = \frac{5{,}200 \text{ oz.}}{1000} = 5.2 \text{ oz. of herbicide.}$$

3. To treat the target area, a little more than 5 oz. of herbicide should be added to 143 oz. of water (148 - 5). Because there are 128 ounces in 1 gallon, this will mean adding 5 ounces of herbicide to 1.1 gal. water.

$$\frac{143}{128} = 1.1 \text{ gallons of water}$$

Calibrating by Volume: Treating Small Trees, Shrubs, and Ornamentals

A similar method works for calibrating the sprayer to treat individual plants or small groupings of plants. In this situation, however, you will find out how much water is used to treat an average plant. If the label says "spray to wet," spray as if you were painting the plant with spray paint. Try to avoid overapplication and minimize dripping of the pesticide off the plant.

Add water (no pesticide) to the tank and pressurize it. Then record the number of seconds it takes to spray a representative plant thoroughly. Now spray water into a container for that length of time. Use this number to calculate the amount of water and product needed.

Example # 2:

Apply insecticide to 18 azaleas in a plant bed.

Labeled rate = 3 ounces of insecticide per gallon of water. Number of plants to treat = 18
Seconds to spray one average plant = 12. Amount of water collected in 12 seconds = 10 oz.

1. To determine the total spray mixture needed, multiply the total number of plants to treat by the amount of water collected to treat one plant.
   18 x 10 oz. = 180 oz. Convert ounces to gallons: 180 / 128 = 1.4 gallons.
2. To determine the amount of insecticide needed, multiply the labeled rate by the total spray mixture.
   3 oz/gal. x 1.4 gal. = 4.2 oz.
3. Add a little more than 4 ounces of insecticide to 176 oz. of water (180 - 4) to treat 18 azaleas.

Spot Treatments and Percent Solutions

In some situations, such as spot spraying, calibration is not necessary. The product label may specify a mixture of 6 tablespoons of product per gallon of water to be sprayed to wet. Estimate how much solution will be needed to complete the job. Add about half the water needed for the treatment, stir while adding the pesticide, then add the rest of the water.

Many turfgrass and ornamental pesticides applied as spot treatments are mixed with water at a specific "percent solution." To create this solution, convert the percentage of concentrate to a decimal before calculating the amount of concentrate to mix with water (Table 10-1).

Table 10-1. Percentages and Solutions.

To convert percentages to decimals, divide the percentage number by 100 to get the decimal. This is equivalent to moving the decimal point two places to the left and adding zeros as needed.

100% = 1.00	50% = 0.5
10% = 0.10	5% = 0.05
1% = 0.01	0.5% = 0.005
0.1% = 0.001	

Example # 3:

Mix 3 gallons of a 2% pesticide solution in water.

1. Convert 2% to a decimal. $\frac{2}{100} = 0.02$
2. To determine the number of ounces of pesticide needed per gallon:
   Multiply the rate per gallon (0.02) by 128 (ounces in 1 gallon): 0.02 x 128 = 2.6 oz.
3. To determine the amount of pesticide needed: Multiply the amount of pesticide per gallon by total spray mixture: 2.6 oz. per gallon x 3 gallons = 7.8 oz.
4. Mix a little less than 8 ounces of pesticide with slightly less than 3 gallons of water.

Nozzle Knowledge*

Most nozzles have four major parts: the nozzle body, the cap, the strainer (screen), and the tip (Figure 10-4). Some may include a diaphragm.

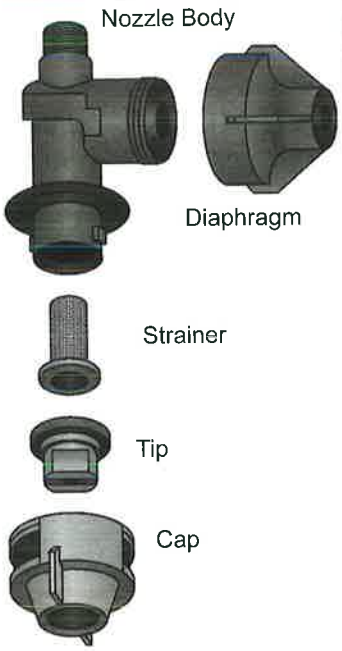


Figure 10-4. Nozzle parts.

Body—The nozzle body holds the strainer and tip in proper position. Several types of tips that produce a variety of spray patterns may be interchanged on a single nozzle body.

Cap—The cap is used to secure the strainer and the tip to the body. The cap should not be overtightened.

Strainer—The nozzle strainer is placed in the nozzle body to screen out debris that may clog the nozzle opening. The type of strainer needed depends on the size of the nozzle opening and the chemical being sprayed. If you are spraying a wettable powder suspension, choose a coarse screen size (50 mesh); for other formulations use a finer screen (100 mesh).

Diaphragm—Diaphragms may be attached to some nozzle bodies to help prevent nozzle dripping. Special nozzle screens are equipped with a check valve for the same purpose. Check valves or diaphragms should be used for small target areas and near environmentally sensitive areas where a sprayer must be stopped and started frequently.

Nozzle Tips—Tips break the liquid pesticide into droplets. They also distribute the spray in a predetermined pattern and control the rate of application.

Materials—Nozzle tips are made from brass, plastic or polymer, aluminum, stainless steel, hardened stainless steel, and ceramic. Although ceramic and hardened stainless steel tips cost more, they are more resistant to wear and will last longer when used with abrasive formulations such as wettable powders, so they may be less expensive in the long run.

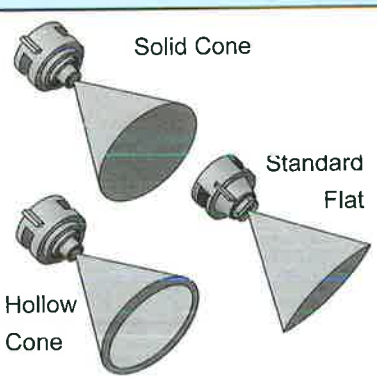


Figure 10-5. Common nozzle types.

Spray Pattern—Nozzle tips are classified according to the spray pattern they produce. Cone and flat fan shapes are most often used for applying pesticides to ornamentals and turf (see Figure 10-5). Solid stream nozzles are used in handgun sprayers to spray a distant target such as tree pests. Most hand-operated

sprayers are sold with adjustable nozzles that change their spray angle from a wide cone pattern to a solid stream when the nozzle collar is turned. These have limited value and should be replaced by nozzle tips that produce a consistent pattern and output.

- **Cone nozzles** produce circular patterns. They are well suited for applying insecticides or fungicides in situations where complete coverage of the leaf surfaces is extremely important. The hollow-cone nozzle delivers most of the material to the circumference of the circle. The solid-cone nozzle delivers droplets to the entire area of the circle. Cone nozzles are appropriate for a single-nozzle sprayer when moving the wand in a sweeping, overlapping motion from side to side.

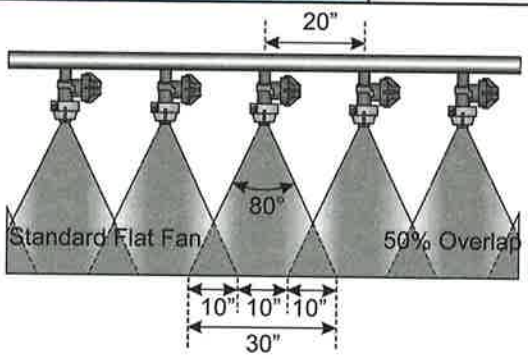


Figure 10-6. To spray uniformly with flat fan nozzles, adjust so that 30 to 50 percent of the spray pattern overlaps.

- **Flat fan nozzles** are well suited for herbicide applications. Standard flat fan tips are designed for broadcast spraying with a spray boom. They are positioned so that the released spray overlaps 30 to 50 percent for even product distribution across the boom (Figure 10-6). For band spraying in rows, even flat fan nozzles are available. They may also be used with a backpack (single nozzle) sprayer.

Spray Angle—Nozzles typically used for turfgrass applications have spray angles of 80 or 110 degrees. Tips with an 80° angle are more common, but wide-angle types (110°) can be positioned at lower nozzle heights to minimize drift or be spaced farther apart on a boom.

Nozzle Spacing—The distance between nozzle tips from center to center is the nozzle spacing. Typical range of spacings for application to turfgrass is from 10 to 20 inches (Figures 10-6 and 10-8).

Tip Orifice—The nozzle tip orifice or opening is the key factor affecting the sprayer output and droplet size. A nozzle's spray pattern is made up of numerous spray droplets of varying sizes. When operated under equal pressure, larger openings produce a higher output with larger droplets, while smaller openings produce a lower output with finer droplets. Although finer droplets are preferred for better coverage, they are more likely to drift. It is important to select a nozzle tip opening that, when operated within the pressure range specified by the manufacturer, will produce droplets large enough to minimize drift and small enough to provide coverage. Special features or nozzle subtypes such as "extended range" are available for some nozzle types that produce a greater percentage of large droplet sizes when operated over a wide range of pressures.

*For more detailed information on nozzle selection refer to *The Calibration of Turfgrass Boom Sprayers and Spreaders* (see Resources) or obtain a nozzle supplier's catalog.

Calibrating Spray Guns

A handheld spray gun operates off a truck-mounted pump and spray tank (Figure 10-7). The methods for calibrating spray guns are similar to those for calibrating compressed air sprayers, but developing a consistent walking speed, arm motion, and uniform spray pattern takes considerable practice. Your pace is about right if you hit a spot two or three times as you pass it. An overlap of one-half swath width (sprayed band) is needed for uniform coverage of parallel passes. Practice on a paved surface using water until your coverage pattern is even. Then set the pressure of the sprayer following the manufacturer's guidelines for the pump and nozzle before calibrating the sprayer.

Figure 10-7. Walking at a steady pace is the key to successful application with a hand-gun sprayer.

To calibrate a spray gun:

Step 1—Divide 1,000 square feet by your swath width to determine the distance of the test course.

Step 2—Spray the test course with water using the technique you will use for the application. Begin spraying just before you enter the course.

Step 3—Record the number of seconds it takes to spray the test course. Do this at least three times to get an average time to use for calibration.

Step 4—Spray into a bucket for the average number of seconds from Step 3. Measure this amount and convert to gallons.

Step 5—Amount of water collected is the spray gun output per 1,000 square feet. To determine output per acre, multiply output per 1,000 square feet by 43.56.

Example # 4.

Calibration of a spray gun.

1. For a swath width of 5 feet, mark a test course that is 200 feet long (1,000 sq. ft. divided by 5 = 200 ft.)
2. Average time in seconds to spray 200 ft. test course: $77 + 79 + 78 = \frac{234}{3} = 78.$
3. Gallons sprayed into bucket in 78 seconds: 5.25
4. Output = 5.25 gallons per 1,000 sq. ft. or 228.7 gallons per acre. (5.25 x 43.56)

Note: If your calibration output is not within 5 percent of the label rate, adjust your walking speed, nozzle, or pressure. Recalibrate until your output comes within 5 percent of the label rate.

Calibrating Boom Sprayers

Hydraulic sprayers that deliver pesticides through a boom with multiple nozzles are used for large-scale applications to golf courses, athletic fields, or parks. Hydraulic sprayers produce pressures up to 500 psi. Application rates can vary widely. Some materials are applied at a rate of 1 quart per 1,000 square feet. Others may be applied at 100 gallons or more per acre.

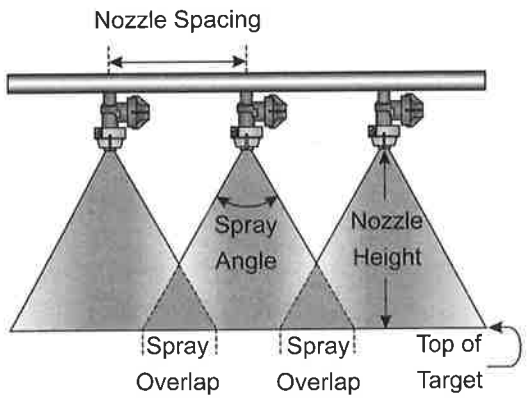


Figure 10-8. Nozzle-related terms.

Nozzle Height, Tip Selection, and Pressure Settings

The height of the nozzle above the ground determines the swath width or the effective sprayed area per nozzle (Figure 10-8). The height is usually 14 to 18 inches above the target surface. Raising the nozzle farther from the target makes spray drift more likely.

The flow rate, droplet size, and spray pattern depend on the nozzle tip and the pressure (see Nozzle Knowledge, page 130). The correct nozzle tip opening depends on the desired output at the speed and pressure you plan to use. Choose the right type and size of nozzle tip for each particular treatment. Small changes in tip size can significantly change nozzle flow rate. Nozzle manufacturers provide detailed charts of tip performance to help applicators choose the right tip for each job. Ask an equipment dealer for a catalog that lists available tips. Pesticide labels often provide recommendations for appropriate nozzles to use with the product.

Note that changes in pressure do not have the same direct influence on application rate that speed does. To double the spray output, the pressure must be increased by four times (Figure 10-9). This means that adjustments in pressure should be used only to make small changes in the nozzle flow rate.

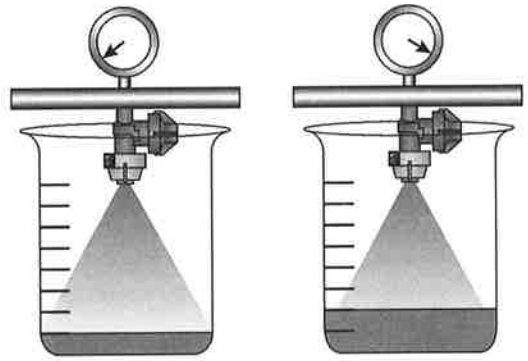


Figure 10-9. Pressure must be increased four times to double sprayer output. Adjust pressure only to make small changes in output.

Pre-Calibration Check: Spray Pattern

1. Check that all components are clean and working correctly and that nozzle tips are the correct type and size for the application.

2. Remove nozzles and screens and clean them in soapy water with a soft brush. Remove any deposits from the nozzle opening with compressed air or a tooth-pick (discard after use!). Never use a knife or metallic tool to clean nozzles. It will ruin them. Never try to unclog a nozzle by blowing through it.

3. Rinse the spray tank thoroughly in a place far away from any well or water source, and partially fill it with clean water.

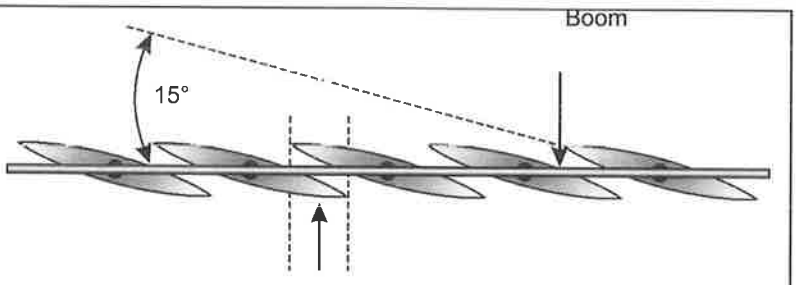


Figure 10-10. Overhead view of spray pattern.

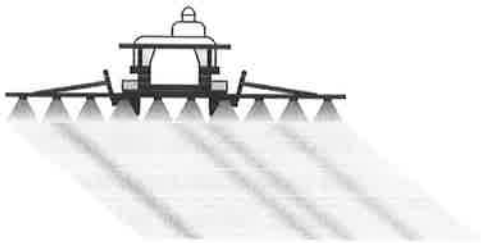


Figure 10-11. Streaks in the pattern show problems with nozzle height, alignment, or output.

4. Pressurize the sprayer and flush hoses and boom with plenty of water.

5. Reattach nozzle tips. Follow the nozzle supplier's catalog for the nozzle spacing, position, and height adjustments that will result in the spray pattern you need. Align flat fan nozzles at a slight angle to the boom (Figure 10-10). Newer nozzle caps are designed to obtain this angle when the tip is fastened in place on the nozzle body.

6. Spray water on a paved or bare surface and watch for streaks as the water dries (Figure 10-11). Wet streaks *directly under* the nozzles may result from damaged or worn nozzle tips, low operating pressure, or low boom height. Wet streaks *between* nozzles may result from incorrect alignment or boom height. Clogged nozzles may produce streaks *anywhere* in the spray pattern of the bad nozzle.

Pre-Calibration Check: Nozzle Flow Rate

The biggest challenge in using a boom sprayer is getting similar output from all nozzles. The flow rate varies with the pressure and size of the nozzle tip opening. Too much pressure produces inconsistent output and smaller droplets that are more likely to drift. Low pressure produces poor coverage and an uneven spray pattern. Perform this test with the sprayer operating at the manufacturer's recommended pressure for the nozzle type:

Step 1—Using a container marked in ounces, catch the output from each nozzle for 20 seconds. Write down the output from each nozzle.

Step 2—Add the amounts from each nozzle and divide by the number of nozzles to get the average output.

Step 3—If output from any nozzle is more than 10 percent above or below the average, clean or replace that nozzle. When output is too high, the nozzle is probably worn out and should be replaced. When output is too low, the nozzle may be clogged, and cleaning may bring it into the correct range.

Step 4—Repeat Step 1. Use the new results to figure a new average in Steps 2 and 3.

Nozzle output check.

Output Test 1			Output Test 2		
output per nozzle			output per nozzle		
Noz. oz.	Noz. oz.	Average = 15.4 (123 ÷ 8)	Noz. oz.	Noz. oz.	Average = 15.6 (125 ÷ 8)
#1 = 16	#5 = 16	Acceptable range = 13.9 to 16.9 (15.4 ± 1.54)	#1 = 15	#5 = 16	Acceptable range = 14 to 17.2 (15.6 ± 1.56)
#2 = 12	#6 = 15		#2 = 16	#6 = 15	
#3 = 15	#7 = 14	Nozzles 2 and 8 should be cleaned or replaced.	#3 = 15	#7 = 15	Output from all nozzles is now within the acceptable range.
#4 = 16	#8 = 19		#4 = 16	#8 = 17	

Calibration for Boom Sprayers

Once the proper nozzles are installed and tested, you need to calibrate the sprayer to deliver the product at the proper rate and volume of mixture. The label rate is commonly stated as an amount of product in a specified amount (gallonage) of water (for example, apply the pesticide at a rate of 2 pints per acre in a spray volume of 30 to 50 gallons of water per acre). To calibrate the gallons per acre (GPA) accurately, you need to know (1) the ground speed in miles per hour (MPH) and (2) the sprayer output in gallons per minute (GPM).

Measure Ground Speed

Don't rely on speedometers to determine actual speed. Follow the steps below to calculate speed in MPH.

Step 1—Mark a 200-foot course on a site that is typical of the surface and soil conditions of the area to be sprayed.

Step 2—Fill the spray tank one-half full with clean water. Test to determine which gear and RPM will allow the sprayer to maintain the desired pressure on the nozzles while maintaining a constant speed between 3 and 5 MPH.

Step 3—Drive the sprayer through the 200-foot course three times, recording the time of each run in seconds. Start far enough away from the course to reach the desired speed before passing the first marker.

Average the three test run times: (Time 1 + Time 2 + Time 3) / 3

Calculate the miles per hour:

MPH = (Distance (feet) x 60) / (Average Time (seconds) x 88)

Example # 5.

Measuring ground speed.

Test course length = 200 feet

Test run times in seconds: 31.5, 30.3, 29.2

$$\text{Average} = \frac{31.5+30.3+29.2}{3} = \frac{91}{3} = 30.3$$

$$\text{MPH} = \frac{200 \text{ feet} \times 60}{30.3 \text{ seconds} \times 88} = \frac{12{,}000}{2{,}666.4} = 4.5$$

Collect Output

While the sprayer is pressurized and standing still, use a container marked in ounces to collect output from the "quick check" nozzle (the nozzle with output closest to the average during the pre-calibration check). Using one "quick check" nozzle allows you to measure sprayer output quickly whenever the sprayer is used, but the more nozzles you collect from, the more accurate your calibration.

Step 1—Collect for 1 minute or collect for 30 seconds and multiply by 2. If you use more than one nozzle, average the output.

Step 2—Divide the number of ounces per minute (OPM) by 128 to find gallons per minute (GPM).

Step 3—Measure the distance in inches between the tips of adjacent nozzles. This is nozzle spacing or nozzle swath width (W).

Step 4—Determine sprayer output in gallons per acre (GPA) by inserting the values from Steps 2 and 3 and the MPH from your test course in this formula:

$$GPA = \frac{GPM \times 5{,}940}{MPH \times W}$$

If output is specified in gallons per 1,000 sq. ft. on the label, divide GPA by 43.56.

Example # 6.

Mix pesticide with water to treat 2.5 acres using a boom sprayer.

You already know: (A) Label rate: 5 pints per acre in a spray volume of 30 gallons per acre. (B) MPH = 4.5 (C) Nozzle spacing W = 20 inches, and (D) Avg. nozzle output = 56 OPM or 0.44 GPM (56/128)

1. To determine sprayer output in GPA:

$$\frac{0.44 \times 5{,}940}{4.5 \times 20} = \frac{2{,}613.6}{90} = 29$$

This output is within 5% of the label GPA (30 ± 1.5), so no adjustment is needed.

2. To determine the total spray mixture needed:
   Multiply the target area by the sprayer output: 2.5 acres x 29 gallons per acre = 72.5 gal.
3. To determine the amount of pesticide needed:
   Multiply the target area by the labeled rate. 2.5 acres x 5 pt. per acre = 12.5 pints.
4. To treat 2.5 acres, add 12.5 pints of pesticide to 70.9 gallons of water (72.5 gal. -12.5 pints).

Making Adjustments

If your sprayer's output is not within 5 percent of the GPA on the label recommendation, then adjust the pressure, speed, or nozzles according to the guidelines in Table 10-2.

Remember, sprayer calibration results are valid only for the speed, nozzles, pressure, and spray width (nozzle spacing) used during the calibration process. Changes in any one of these factors will require another calibration check.

Once you have calibrated your equipment, don't assume that it will continue to deliver the same rate during all future applications. Clogging, corrosion, and wear may change the delivery rate or the settings may gradually get out of adjustment. Take the time to check the calibration of your equipment regularly.

Table 10-2. Adjusting Boom Sprayer Gallons per Acre (GPA).	
IF measured output is **within 5 to 10 percent** of label GPA:	THEN increase pressure to deliver more spray or decrease pressure to deliver less spray.
IF measured output varies from label GPA **by 10 to 25 percent**:	THEN adjust travel speed. Slower speed delivers more spray. Faster speed delivers less spray. Measure speed under field conditions and use new speed in figuring GPA.
IF measured output varies from label GPA **by more than 25 percent**:	THEN change nozzles and repeat the pre-calibration check and calibration process.

Calibrating Granular Spreaders

The most common types of spreaders used to apply dry (granular) pesticides to turfgrass are drop spreaders and rotary spreaders. Choose a model that is easy to fill and clean. To calibrate either a drop spreader or a rotary spreader, you will need to (1) establish the swath width and distribution pattern and (2) determine the application rate.

Drop spreaders have a uniform pattern within the swath, low drift, and precise control of the edges. This makes them useful around small areas such as driveways and flowerbeds or near ponds and streams. Because the edge is abrupt, even a small error in steering will result in strips of untreated or overtreated grass. When used with large granules, a drop spreader may damage the coating. This can destroy the slow-release characteristics of products that depend on the coating to regulate the release of the active ingredient.

Rotary spreaders cover a wider area faster and are preferred for larger areas. Compared with drop spreaders, they are easier to push, have better ground clearance, and are not as easily knocked out of calibration. Generally, applications made with rotary spreaders are less uniform.

Calibration Factors

All granular spreaders should be calibrated by the person who will make the application. Calibration conditions should be similar to the application conditions, and the same product should be used.

Operator—The operator controls the walking speed, handle height, and pattern of travel. Always hold the handle at a height that keeps the rotator or rotating disk level. The operator must walk at the same comfortable, steady speed during the calibration test and during the treatment application. Practice until you can maintain a constant speed. Recalibrate the spreader if operators change.

Product—Particle size, shape, uniformity, density, and surface friction affect distribution and flow rate. Recalibrate the spreader whenever you change from one material to another.

Weather—Wind speed, temperature and humidity will affect the distribution pattern. If it is so windy that the material will not be applied uniformly, postpone application until conditions improve. Temperature and humidity will affect the flow rate of the material, and changes in weather from day to day will change the application rate even when the same product is used. Recalibrate when conditions change.

Calibrating Drop Spreaders

Test Site Selection

When you select a site to check calibration, make certain that it is an acceptable application site or plan to collect the granules so that they are not left on the ground. Turf can be damaged by repeated calibration test applications in the same area. Try to use multiple sites for calibration tests.

Swath Width and Distribution Pattern

If the distribution pattern is not even, you will apply too much product to some areas and not enough product to other areas.

For a drop spreader, the swath width is the measurement of the bottom of the hopper. The pattern should be uniform across the swath. Using the orifice setting for your spreader from the pesticide label instructions, make a short test run on a clean paved surface where you will be able to see the distribution pattern. If it is not even, you may need to clean the openings in the bottom of the hopper or correct the agitator operation.

Three Ways to Measure the Application Rate

Method 1—Catch-Pan. Attach a catch pan or small section of gutter with end caps to the bottom of the hopper. It should be wide enough to capture all the granules and attached in a way that does not interfere with the shut-off bar or rate-control linkage (Figure 10-12).

Step 1—Measure a straight test course that will give the equivalent of 100 square feet. For example, a drop spreader with a 3-foot swath width should cover a course 33 feet long (100 / 3 = 33). A spreader with a 2-foot swath width should cover a 50-foot course (100 / 2 = 50).

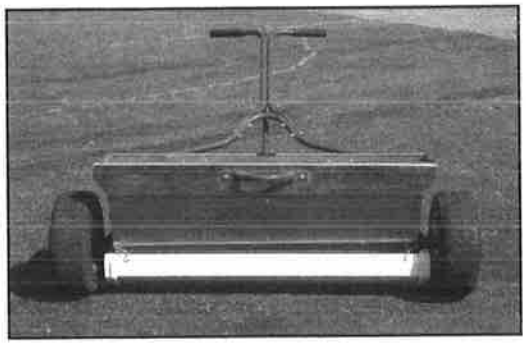


Figure 10-12. You can use a catch pan to calibrate a drop spreader.

Step 2—Fill the hopper half full with product and select a gate setting based on the pesticide label or spreader manual.

Step 3—Push the spreader over the test course. Begin walking at the desired speed before you cross the starting line. Turn on the flow of material as you cross the starting line. Turn it off when you cross the finish line. Weigh the amount of material captured in the pan. Convert ounces or grams to pounds (see Table of Measurements, page 146).

Step 4—To determine the spreader application rate in pounds per 1,000 square feet, multiply the weight by 10.

Step 5—Compare the spreader application rate to the pesticide label rate. If the spreader rate is not within 10 percent of the label rate, adjust the gate opening and repeat Steps 3 and 4 until it is. Note that even small changes in the settings can result in large changes in the flow of material.

Example # 7.

Calibrate a drop spreader with the catch-pan method.

Labeled rate: 2 lbs. product per 1,000 sq. ft.
Spreader swath width = 3 ft.
Test course length = 33 ft.
Amount collected in catch pan: 120 grams or 0.26 lbs. (120 grams / 454 grams per lb.)
Spreader rate per 1,000 sq. ft.: 0.26 x 10 = 2.6 lbs.
Adjust spreader by reducing gate opening until rate falls between 1.8 and 2.2 lbs. (2.0 lbs ± 10 percent).

Method 2—Sweep and Weigh. Instead of catching the material during application to the test course, you can lay out a course on a concrete surface or plastic sheet. Sweep up and weigh the material.

Method 3—Weigh Before and After. Place a known weight of granules in the hopper, conduct a calibration run over the test area, and reweigh the granules remaining in the spreader. The difference is the amount applied.

OR: If a large scale is available, load the spreader and weigh it. Conduct a calibration run over the 100 sq. ft. test area. Reweigh the spreader. The difference is the amount applied.

Example # 8.

Calibrate a drop spreader with the weigh-before-and-after method.

Put 2 pounds of granules in a drop spreader that has a swath width of 2 feet.
After applying the product to a 50-foot test course, you recover 1.75 pounds of granules from the spreader.
The calibrated rate is 0.25 pounds per 100 sq. ft., or 2.5 lbs. per 1,000 sq. ft.

Operating a Drop Spreader

Turning a drop spreader sharply will result in an uneven application pattern. When you treat an area in parallel passes, always turn off the spreader before making the turn to begin the next pass. Treat header strips at both ends of the area first (Figure 10-13). With a circular or irregular area, make an application to the boundary first. To prevent skips or overlap, make sure that the wheels slightly overlap the wheel tracks of the previous pass.

Figure 10-13. Create header strips for end turns.

Calibrating Rotary Spreaders

Swath Width and Distribution Pattern

Check the distribution pattern of a rotary spreader frequently. Some types of granules will travel farther and produce a different pattern than others. A good way to check the distribution pattern is to use a row of shallow boxes, trays, or pans in a line perpendicular to the direction of travel (Figure 10-14a). Use boxes that are identical in size, 1 to 2 inches deep, with an area of at least 1 square foot. You will need an odd number (7 or 9 will usually work well). A piece of cloth in the bottom of each box will keep the granules from bouncing out.

Step 1—Place one box in the center and space the remaining boxes on 2-foot centers on both sides. The boxes should cover a total width 1½ to 2 times the expected swath width.

Step 2—Pour some product into the spreader and follow the setting recommendation on the label. Make three passes over the boxes—always from the same direction.

Step 3—Record the weight of granules collected from each box, or pour granules into a jar or vial marked with the box number. When you line up the jars in the same order as the collection boxes, you will see the distribution pattern (Figure 10-14b). The center jar should have the most product, with amounts tapering off evenly to each side. If the pattern is not even on each side, follow the manual instructions for adjusting the spreader and then repeat Steps 2 and 3 until the spreader is applying material in the most uniform pattern possible.

Step 4—Find the jars to each side that have half the amount in the center jar. The distance between the boxes represented by these bottles is the effective swath width (Figure 10-15).

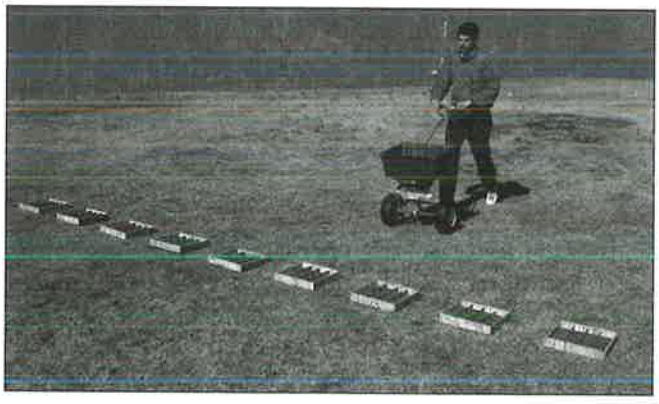


Figure 14a (left) and 14b (above). Collect material from spaced boxes to check distribution pattern and find swath width of rotary spreader.

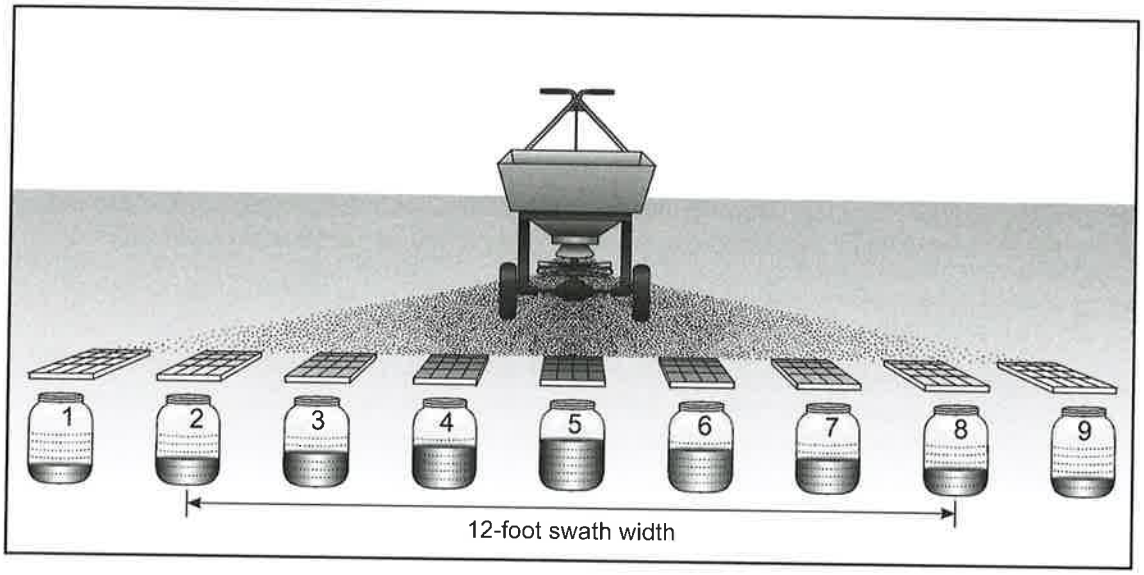


Figure 10-15. Rotary spreader distribution pattern and swath width measurement.

Example # 9.

Determine effective swath width for rotary spreader.

Spreader # 1	Spreader # 2
Depth of material in center jar = 2 inches	Depth of material in center jar = 3 inches
Depth of material in jars 2 and 8 = 1 inch	Depth of material in jars 2 and 8 = 1 inch.
Swath width = 12 feet (6 feet to each side of center).	Depth of material in jars 3 and 7 = 2 inches.
	Swath width = 10 feet (5 feet to each side)

An Alternative Method— A faster (but much less accurate) check on the uniformity of the distribution pattern and swath width can be done on a wide paved area. Measure the central two-thirds of the total swath to get a rough estimate of the effective swath width. Sweep up material from surface after test.

Reverse—When the spreader is operated backward, it delivers product at a different rate. If it is necessary to operate the spreader in reverse, the spreader must be calibrated in that direction.

Measuring Application Rate

Because the distribution pattern of a rotary spreader is rarely uniform, it is best to make two passes over a treatment site. Therefore, rotary spreader calibration should be based on applying one-half the label rate. Using the full label rate in two passes would result in application of a double dose of product.

Before and After Weight

Step 1—Weigh out enough product to load the spreader for a calibration test over a distance that can be easily converted to 1,000 square feet (Table 10-3).

Table 10-3. Distance and Effective Swath Width for Rotary Spreaders to Equal 1,000 Sq. Ft.

Effective Swath Width (feet)	Test Course Length (feet)
6	167
8	125
10	100
12	84
14	72

Step 2—Select a test setting to deliver one-half the labeled rate. (Note: Spreader settings are not linear, so using a number half the number recommended on the product label will not result in half the application rate. You may need to experiment with the equipment.)

Step 3—Apply the material over the measured distance and weigh the product remaining in the spreader. The difference in pounds should be within 10 percent of one-half the pesticide label rate.

Adjust the size of the gate opening until your application rate is in the right range.

Example # 10.

Calibrate a rotary spreader to apply a turf herbicide using two passes over the treatment site.

Label rate: 80 lbs. per acre,
Effective swath width = 12 ft.
Length of calibration course = 84 ft.
Beginning weight of product = 908 grams (2 lbs.)
End weight of product = 426 grams
Difference = 482 grams or 1.06 lbs. [482 grams divided by 454 grams (1 pound)]
The spreader is calibrated to apply 1.06 lbs. per 1,000 sq. ft.
Rate per acre = rate per 1,000 sq. ft x 43.56 or 1.06 lbs. x 43.56 = 46.2 lbs./acre
This rate is higher than the rate needed of 40 lbs./acre (one-half of 80 lbs./acre).
Adjust the spreader by reducing the gate opening until the rate falls within 10 percent of 40 pounds (between 36 and 44 pounds).

Determining How Much to Apply

After calibrating the spreader, determining the amount of product required for the application is straightforward. Label application rates are usually stated in pounds of product per acre or per 1,000 square feet. Whether you use acres or 1,000 square feet in your calculations, be consistent. Divide square feet by 43,560 to convert to acres; multiply acres by 43,560 to convert to square feet. To determine the amount of product to apply, multiply the area to be treated by the application rate.

Example # 11.

Determine the amount of granular insecticide needed to treat 2.5 acres.

Label rate: 3 lbs. per 1,000 sq. ft.

1. Convert acres to square feet.

   2.5 acres x 43,560 sq. ft. per acre = 108,900 sq. ft.

2. To get the total amount of product needed, multiply the area by the application rate.

$$108{,}900 \text{ sq. ft.} \times \frac{3 \text{ lbs}}{1{,}000 \text{ sq. ft.}} = \frac{326{,}700 \text{ lbs}}{1{,}000} = 326.7 \text{ lbs.}$$

Operating a Rotary Spreader

After the rotary spreader is calibrated to apply the product at half the labeled rate, there are two ways to make the application.

Right Angle Method—Make two passes at right angles to each other (Figure 10-16). Space passes at the effective swath width. For example, if the effective swath width is 8 feet, then after each pass, move the spreader over 8 feet from the center of the tire tracks to begin the next pass. When you use this method, you can fill the spreader with half the product. When you have completed all the passes in one half the pattern, you should have used all the material in the spreader. Close the spreader at each turn. Use a street, sidewalk, or similar border to guide your first pass.

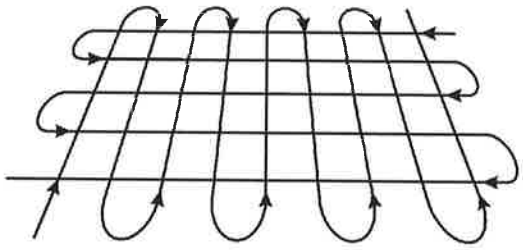


Figure 10-16. To use the right-angle method, make two passes at 90° from each other.

Use flags or stakes to mark the swath width. When the spreader is positioned in the starting location and direction of the first pass, pace off the effective swath width to the point where the second parallel pass will end and place a stake or flag. This will serve as a visual marking post for the return pass. As you come to the end of the first pass and reposition the spreader to line up with the first stake, place a second stake where the third pass will end. Continue moving the stakes at each end in this fashion until the area is completely treated.

Half-width Method—Use parallel passes spaced apart at one-half the swath width (Figure 10-17). For example, if the swath width is 10 feet, make each pass at 5-foot intervals.

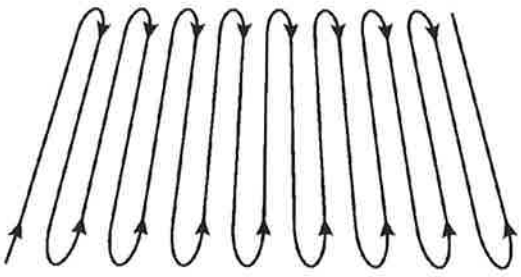


Figure 10-17. To use the half-width method, apply in parallel passes one-half the effective swath width apart.

Test Your Knowledge

1. When should equipment be calibrated?

a) When changing type of granular pesticide.
b) Before using it for the first time.
c) When changing the rate and speed at which the product is applied.
d) All the above.

2. If you double the speed of your application equipment, how will it affect the application rate of a boom sprayer?

a) The application rate is reduced by the square root.
b) The application rate is cut in half.
c) The application rate doubles.
d) The application rate does not change.

3. This type of nozzle is well suited for applying insecticides or fungicides in situations where complete coverage of the leaf surface is critical.

a) flat fan nozzle.
b) solid stream nozzle.
c) cone nozzle.
d) adjustable nozzle.

4. You want to make 2 gallons of a 4 percent solution of a broadleaf herbicide. How many ounces of herbicide are needed? (Round off to nearest ounce.)

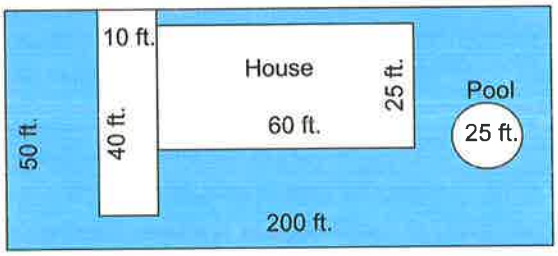
a) 4 oz.
b) 8 oz.
c) 10 oz.
d) 14 oz.

5. Determine the amount of granular insecticide needed to treat 2 acres assuming a label rate of 2 pounds per 1000 square feet. (Round to the nearest pound.)

a) 174
b) 348
c) 80
d) 35

6. You are applying fungicide to a lawn that measures 200 x 50 feet. In the middle of the lawn is a house that measures 60 x 25 feet and a swimming pool that has a 25 foot diameter. The drive measures 10 feet by 40 feet. The label application rate is 3 ounces of fungicide per 1000 square feet. How many ounces of fungicide will be needed to treat this yard? (Round your answer to the nearest ounce.)

a) 12 oz.
b) 23 oz.
c) 39 oz.
d) 48 oz.



7. How much total spray solution will be needed to treat the lawn in the question above if your sprayer is calibrated to deliver 4 gallons per 1,000 square feet? (Round answer to nearest gallon.)

a) 12 gal.
b) 16 gal.
c) 30 gal.
d) 36 gal.

Answers: 1-d; 2-b; 3-c; 4-c; 5-a; 6-b; 7-c.

Resources

Web Sites

The Pesticide Environmental Stewardship website: Calibration module. http://pesticidestewardship.org/calibration.

The Calibration of Turfgrass Boom Sprayers and Spreaders. 2001. Wayne G. Buhler. North Carolina Cooperative Extension Service. AG-628: www.turffiles.ncsu.edu/Files/Turfgrass/Articles/admin/2008/Calibration_of_Turfgrass_Boom_Sprayers_and_Spreaders_(AG-628).pdf

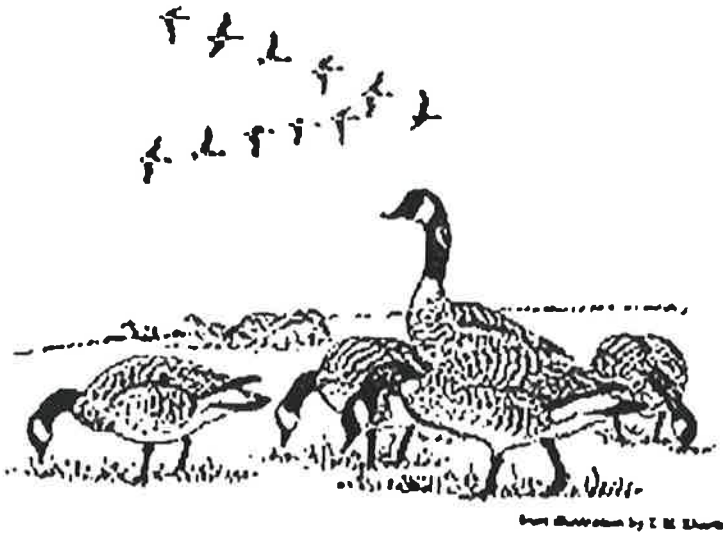
Table of Measurements and Conversions

Standard Measures	Metric Conversions
Length	
1 ft = 12 in	1 in = 25.4 mm = 2.54 cm
1 yd = 3 ft	1 ft = 304.8 mm = 30.48 cm
1 mi = 5,280 ft	1 yd = 914.4 mm = 91.44 cm = 0.914 m
1 mph = 88 ft/1 min	1 mi = 1,609 m = 1.61 km
	1 mm = 0.03937 in
	1 cm = 0.394 in = 0.0328 ft
	1 m = 39.37 in = 3.281 ft
	1 km = 3,281 ft = 0.621 mi
Area	
1 sq in = 0.007 sq ft	1 sq in = 6.45 sq cm
1 sq ft = 144 sq in	1 sq ft = 929 sq cm
1 sq yd = 1,296 sq in = 9 sq ft	1 sq yd = 8.361 sq cm = 0.8361 sq m
1 ac = 43,560 sq ft = 4,840 sq yd	1 ac = 4,050 sq m = 0.405 h
	1 sq cm = 0.155 sq in
	1 sq m = 1,550 sq in = 10.76 sq ft
	1 h = 107,600 sq ft = 2.47 ac
Volume	
1 tsp = 0.17 fl oz	1 fl oz = 29.5 ml = 0.0295L
1 tbs = 3 tsp	1 pt = 437 ml = 0.437L
1 fl oz = 2 tbs = 6 tsp	1 qt = 945 ml = 0.945L
1 cup = 8 fl oz = 16 tbs	1 gal = 3785 ml = 3.785L
1 pt = 2 cups = 16 fl oz	1 ml = 0.033 fl oz
1 qt = 2 pt = 32 fl oz	1 L = 33.8 fl oz = 2.112 pt = 1.057 qt = 0.264 gal
1 gal = 4 qt = 8 pt = 128 fl oz	
To convert liquid ounces to gallons, multiply by 0.0078125 (=.008)	
Weight	
1 oz = 0.0625 lb	1 oz = 28.35 g
1 lb = 16 oz	1 lb = 454 g = 0.4536 kg
1 ton = 2,000 lb	1 ton = 907 kg
1 gal of water = 8.34 lb	1 gal of water = 3.786 kg
	1 g = 0.035 oz
	1 kg = 35.27 oz = 2.205 lb

Abbreviations

ac	acre	in	inch	m	meter
cm	centimeter	kg	kilogram	min	minute
fl oz	fluid ounce	km	kilometer	ml	milliliter
ft	foot or feet	L	liter	mm	millimeter
g	gram	lb	pound	qt	quart
gal	gallon	mi	mile	sq	square
h	hectare (1h: 10,000 sq m)	oz	ounce	tbs	tablespoon
		pt	pint	tsp	teaspoon

Vertebrate Pests



James R. Baker

Learning Objectives

After study of the material in this chapter, you should be able to:

1. Describe how wildlife can damage the landscape.
2. Identify management techniques to prevent wildlife from becoming a nuisance.
3. Recognize limitations of pesticide use in managing wildlife.

Terms to Know

site or habitat modification

repellent

scare devices

apple sign test

Chapter 11.

Vertebrate Pests

Vertebrate pests present a management challenge. Pesticides cannot be used to control many pest animals, so management depends on preventing pest problems or keeping pests away from plants. In some cases, wildlife damage control agents may be hired to solve problems with animal damage in landscapes. Regulations on killing of non-game pest animals vary from state to state. Addresses and contact information for the state offices that handle Wildlife Depredation Permits are listed in the Resources section at the end of this chapter.

Canada Geese

In recent years, the Canada goose has become a nuisance in parks and residential landscapes, on golf courses, and along waterways. Geese graze on turfgrasses and produce up to a pound of droppings per day. Runoff from goose-infested areas may pollute ponds and increase nutrient loads, leading to algal blooms and fish kills. Because the Canada goose tends to come back to the same place year after year, it is best to try controlling them as soon as geese appear where they are not wanted. Swans cause the same kind of damage.

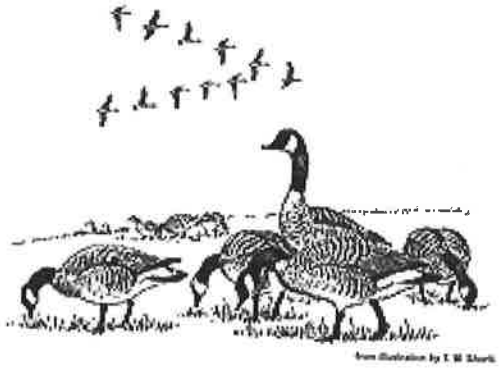


Figure 11-1. Large numbers of Canada geese create a nuisance.

After nesting, geese undergo a 4- to 5-week flightless period in June and July when they shed and re-grow their outer wing feathers. Severe problems often occur during this molting period when geese congregate on lawns next to ponds and lakes.

You may need to try a combination of management strategies to decrease nuisance problems with geese.

Stop Feeding

Feeding may attract large numbers of geese. It also teaches them not to be afraid of people, so that control becomes even more difficult. Once people stop feeding them, geese will disperse and go back to eating natural foods. Geese that depend on human handouts are less likely to migrate when severe winter weather arrives and are more vulnerable to disease.

Site Modification

Geese prefer to feed on short, green grass and other vegetation. Wherever possible, let grass or other vegetation around water bodies grow to its full height (10 to 14 inches). Where geese are a problem around ponds and along walkways, replace grass with shrubs or ground covers such as ivy or pachysandra. You can also plant grass species that are less appealing to geese, including some that go dormant in the winter. Geese tend to prefer Kentucky bluegrass and are less attracted to fescue. Minimize use of lawn fertilizers to reduce the nutritional value of grass to the birds.

Fencing and Wire Grids

A fence, hedge, or other physical barrier can keep birds from landing on ponds and walking to adjacent lawns to feed or rest. Fencing works best during the summer molt when geese are unable to fly and must walk between feeding and resting areas. To be effective, a fence must enclose the site completely. Fencing around large open areas such as athletic fields or ponds has little effect on free-flying birds. Fences should be solidly constructed and at least 30 inches tall (48 to 60 inches tall to block aggressive birds).

Because geese tend to land and take off from open water, a system of suspended wires over the water may help keep birds off ponds. Single strands of #14 wire or 80- to 100-pound test monofilament line can be arranged in a grid with 10 to 15 feet between wires. Each wire must be secured so that it remains 12 to 18 inches above the water surface. Perimeter fencing may be needed to keep geese from walking under the grid. To reduce the risk of birds flying into the wires, attach brightly colored flagging or other markers to make them visible.

Scare Devices

Scare tactics can be used temporarily to keep animals, like geese, out of the yard. Flash tape, noise makers, scary eyes, or scarecrows are most effective when they are moved to a new location every few days. Motion lights can startle when they first come on, but eventually, the animal gets used to the light. Flashing or strobe lights work best. A motion sensor on a garden hose that sprays when an animal triggers the sensor can be very effective. Although scare tactics may be temporarily effective, little scientific evidence exists on their long-term effectiveness.

Methods that Do Not Work

- Fountains or aerators in ponds do not scare geese and may even attract them.
- The use of poisons is illegal.
- Fake swans are not effective.
- Bird distress calls are not proven to work for geese.
- Scarecrows or dead goose decoys are ineffective for resident geese.
- Use of trained birds of prey to chase geese is labor-intensive and not a generally available option.
- No chemical contraceptives are available.
- The introduction of predators does not work because if the habitat were suitable for predators, they would already be present.

Repellents

The U.S. Environmental Protection Agency has approved the use of an anthraquinone-based repellent that may be applied to turf areas where geese are expected to feed or roost. Follow directions on the label and be aware of environmental conditions that impact effectiveness of the product.

Dogs

Dogs trained to harass geese but not harm them have been used to disperse geese from golf courses, parks, athletic fields, and corporate properties. Border collies or other breeds with herding instincts tend to work best. The dogs must be closely supervised, and leash laws or park rules must be followed unless special arrangements have been made. Initially, chasing must be done several times each day for several weeks, after which less frequent but regular patrols will be needed.

Hunting

Landowners may chase or disperse geese at any time without a permit as long as the birds are not physically harmed. Federal and state permits are required to capture, handle, or kill Canada geese or to disturb their nests or eggs. Hunting of resident Canada geese may be permitted during designated seasons when few migratory geese from Canada are present. State agencies that regulate hunting of Canada geese are listed in the Resources section.

Deer

Deer have become a widespread problem in landscapes. Where deer often cause major damage to ornamentals, switch to plants that deer do not like as well. Deer will avoid some plants until they are starving. For more information refer to the Resources section.

Repellents and Scare Devices

Repellents work best in combination with fencing and scare devices. Apply repellents at the first sign of deer damage to keep them from getting used to feeding on the landscape. Repellents may reduce feeding, but may not entirely stop it. Rain washes away some repellents, so you need to reapply them. New foliage that appears after treatment is unprotected. How well a repellent works depends on how hungry the deer are and whether other foods are available. When deer are very hungry, they may ignore both taste and odor repellents. Recent studies show that drilling a hole in a bar of soap and suspending it with a twist tie or soft twine reduces deer damage. For more information refer to the Resources section.

In rural settings, noisemakers, strobe lights, and sirens that go off at intervals are the most common scare devices. Scare devices are only effective for temporary control (1 to 2 weeks) because deer become accustomed to them.

Do not use mothballs. Mothballs (naphthlane) have been used by gardeners trying to control deer and rabbits. This practice is illegal and potentially dangerous. It is illegal to use any pesticide in a manner inconsistent with the product label. Deer and rabbits are not listed on the label for mothballs. Small childern and pets can be poisoned by eating mothballs.

Dogs

Invisible fencing can be used to keep a deer-chasing dog confined to the area of ornamental plants to be protected. At least in theory, this teaches the dog not to follow the deer out of the protected area.

Fencing

Fencing significantly reduces deer damage if installed and maintained properly. The most effective type is a high-tensile electric fence. Contact the North Carolina Wildlife Resources Commission for more information on fencing options.

Electrified Fences—Temporary, electrified fences smeared with peanut butter are simple and inexpensive and work well. Disconnect the lower wires if they are covered by snow.

Woven-Wire—Permanent fences provide the ultimate deer barrier. Fencing must be 9 or 10 feet tall to keep deer from jumping over it. Woven-wire fences are used for year-round protection of high-value crops subject to high deer pressures. Although these fences are expensive and difficult to construct, they are easy to maintain and usually last for 20 years.

Double (Offset) Fencing—Deer are apparently reluctant to jump double fencing. The protected area can be fenced with standard livestock or wire fencing with an electric fence 2 or 3 feet outside.

Hunting and Out-of-Season Shooting Permits

Where hunting is allowed, it can reduce deer damage in rural areas. A hunting license is required. If deer are causing problems during a nonhunting season, a special depredation permit may be issued in North Carolina by the Wildlife Resources Commission and in South Carolina and Georgia by the state Department of Natural Resources. In North Carolina, landowners may legally shoot deer out of season without a permit when the deer are in the act of damaging property and plants. Landscapers, however, must obtain a permit to kill deer on a client's property. The carcass must be buried on site if taken without a permit. In South Carolina, check with the Department of Natural Resources. In Georgia, contact the Department of Natural Resources, Wildlife Resources Division, Game Management Section Headquarters.

Moles

Three species of mole are found in the Southeast: the eastern mole, the hairy-tailed mole, and the star-nosed mole. All are shy, velvety, dark gray to black animals from 5 to 8 inches long. The head has a tapering snout, very small eyes, and no external ears. They feed on earthworms, white grubs, ants, beetles, and other subterranean insects as well as millipedes, slugs, snails, and earthworm cocoons. A mole can almost eat its own weight daily. Moles are harmless to people and pets.

Although moles do not feed on plants, their tunnels may damage roots. Young seedlings or transplants are especially vulnerable. Using their broad, clawed front feet, moles can tunnel up to 15 feet per hour. They dig two kinds of tunnels: surface runs and deeper galleries. A large network of surface runs can ruin the appearance of a lawn. In established lawns, the mower may skin the tops of the runs, which creates gaps in the turf and dulls the blades. Moles also make deep tunnels, throwing the excavated soil out of the opening. Moles burrow in fresh soil to seek food, but they also maintain older burrows and patrol them regularly to catch insects and worms. Moles are active throughout the year and are most active during rainy periods in summer.

Fencing

A sheet metal or hardware cloth fence may be used to protect areas. The fence should start at the ground surface and go to a depth of at least 12 inches then bend outward an additional 10 inches at a 90-degree angle.

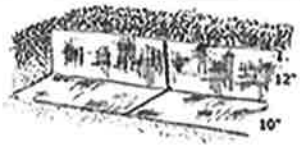


Figure 11-2. Subterranean mole fence.

Management

Foxes, owls, and cats feed on moles, but moles can be difficult to eradicate. Because moles are solitary, most lawns usually have only one or two. Control of grubs helps eliminate their food, but trapping is the only reliable method of control. It is not legal to poison all moles. In North Carolina, the eastern and hairy-taled mole may now be controlled with the use of a labeled pesticide. Pesticides used for mole control cannot be applied within 100 feet of a body of water nor at elevations greater than 4,000 feet. The star-nosed mole is a state listed species of Special Concern and has not been classified as a pest so management options are different. There is no open hunting or trapping season for star-nosed moles. A depredation permit from the NCWRC is required to trap star-nosed moles and is only issued when substatial damage has occured. For current information on the use of pesticides to control moles in South Carolina, contact the Department of Natural Resources. In Georgia, contact the Department of Natural Resources, Wildlife Resources Division, Game Management Section Headquarters.

Rabbits

Cottontails prefer to live in areas with woody and dense vegetation. They seek shelter in brush piles and holes in the ground or under buildings. Rabbits can severely damage or kill landscape plants throughout the year. During the growing season, they prefer to eat young, succulent, green vegetation, flowers, vegetables, and crops. In winter, they gnaw bark and nip off small branches to get the green, inner bark layer and buds of trees and shrubs. Rabbits are often active throughout the day and leave characteristic signs such as narrow, paired tracks and pea-sized droppings.

The presence of rabbits does not always result in economic loss or damage to the appearance of the landscape, so before starting a control program, compare the time and cost of control with the amount of damage caused by rabbits. A combination of methods is usually best for managing rabbit damage.

Habitat Modification

Cottontails live in areas with shrubs and other tall plants to protect them from severe weather and predators such as cats and dogs. Remove brush and rock piles, wood and board piles, weed patches, and other debris in which rabbits could hide.

Fencing

A 2-foot high fence of 1-inch mesh chicken wire keeps rabbits out of a garden or flower bed. Bury the bottom edge of the fence about 6 inches below ground. A double-strand electric fence (at 3 to 4 inches and 8 to 12 inches) or electrified plas-

tic-net fence should exclude rabbits from larger areas. The expected snow depth may determine the height at which fences should be built to ensure protection during the winter months. Place wire cylinders around the trunks of individual trees or shrubs to protect them from being clipped and girdled. Anchor the cylinders securely so rabbits cannot move or collapse them and gnaw through openings in the wire. Plastic and fabric cylinders are also available at yard and garden stores.

Scare Devices and Repellents

People have tried scarecrows, fake owls and snakes, pinwheels, pie pans spinning in the wind, and other devices to frighten rabbits out of gardens and away from plants. Rabbits get used to noise and artificial movement very quickly.

Repellents may provide temporary protection, but their effectiveness varies. Dried blood meal sometimes protects flower beds, but it could attract dogs. Repellents work best in spring and summer when rabbits can feed on alternatives to the treated plants. Taste repellents make plants distasteful and they work only on the treated parts, so taste repellents should be reapplied after each rain or as significant new growth occurs. Although odor repellents may repel rabbits from treated areas temporarily, they quickly become accustomed to them. Perimeter applications may keep rabbits out of gardens and flower beds. Wind disperses odor repellents, and frequent reapplications may be necessary.

Hunting and Trapping

In areas where hunting is allowed, licensed hunters can reduce local population levels. A permit is required for shooting or trapping rabbits out of season.

The short-term benefits of fewer rabbits will likely result in less damage during particular seasons (for example, fall trapping may reduce winter tree and shrub damage). Cottontails can be trapped with a variety of live traps. Box traps made of wood and commercially available wire cage traps (at least 7 inches high) are both effective.

Trapping is usually most effective during the winter and early spring, when rabbits are hungry. During winter months, cover wire cage traps with canvas to make them more attractive to rabbits and to protect captured rabbits from cold and injury. Do not set cage traps where pets or children can harass trapped animals. Consider installing boards or 1 foot-high fences to help funnel rabbits into the traps. Approach a trapped rabbit slowly and quietly to avoid alarming and potentially injuring the animal. Cover the trap with a light blanket or tarp to help keep the animal quiet until it can be humanely dispatched.

Skunks

Skunks are black with white stripes (eastern striped skunk) or spots (spotted skunk). Skunks are omnivorous, feeding primarily on plants and insects during the summer and on smaller mammals in winter. Skunks uproot and damage turf when they dig through the sod to feed on white grubs, ground bees, or yellow jackets. Skunks are active at dusk and throughout the night. Skunks sleep throughout the winter except during warm spells when they emerge to forage.

Management

Control of grubs will keep skunks from digging up turf. Skunks can also be controlled by trapping, but trapping may be a smelly business. Skunks may spray a disagreeable musk on unwary people who disturb them. Skunks may be trapped during the open trapping season with either live (Havahart) or kill traps (No. 1 or No. 1.5 steel). During the closed season, a permit to take animals causing depredation is required for trapping.

Voles

Voles are small rodents that normally live in field and scrub habitats and forage on vegetation. In flower and shrub plantings, however, voles may eat flower bulbs, girdle the stems of woody plants, and gnaw roots. Plants not killed outright may be invaded by diseases or die from water stress. Voles do most of their damage during the winter.

After successful treatment, meadow voles can be discouraged from repopulating the area by close mowing and removal of thatch. Pine voles can be excluded from plants with ¼-inch wire mesh guards. Remember that pine voles feed underground so the bottom of the wire fence must extend from 6 inches below ground to 18 or even 24 inches above ground.

The two most damaging species of voles are the meadow vole and pine vole. Both species are gray to brown and 3 to 5 inches long, and both occupy mole tunnels. One simple way to tell if you have voles is to look for quarter-sized entrance holes to the tunnels. If pine voles are living under a tree, their network of tunnels will be about 3 inches below the soil and it can be found by probing with a rod.

Pine voles

- Tunnel underground and feed on below-ground parts of trees and other plants.
- Sever trunks of small trees or shrubs from the roots just under the soil line, making it possible to pull the top of the plant out of the soil.
- Leave piles of soil (3 to 4 inches wide) near damaged plants.

Figure 11-3a. The pine vole's tail is about the same length as its hind leg.

Meadow voles

- Prefer green vegetation and dropped fruit, but feed on shrub roots and flower bulbs during the winter or when their populations are high.
- Live mainly above ground, and prefer grassy or weedy areas where their faint trails and small piles of droppings may be noticed in grass clippings or tall grass.
- Usually girdle young trees, shrubs, and saplings at the ground line. Close inspection of the damage will reveal narrow paired grooves left by their chisel-like teeth. (Rabbits also chew on young trees, but the girdling begins several inches above the soil line.)

Figure 11-3b. The meadow vole's tail is about twice as long as its hind leg.

The Apple-sign Test

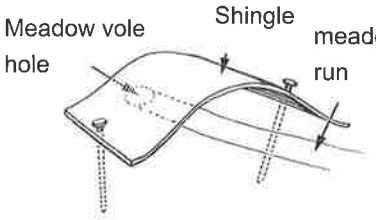


Figure 11-4. Construction of the apple-sign test.

Because moles feed on insects and not apples, you can use the apple-sign test to confirm the presence of voles. Place a shingle over a tunnel entrance. If you are monitoring for meadow voles, bow the shingle or prop it up so that it is 3 to 4 inches off the ground to allow access to the tunnel (Figure 11-4). Use brown shingles that blend in with the mulch or use pieces of 1- to 2-inch-thick lumber painted to match the background color of the planting. After 5 days, place a piece of apple under each shingle. After 24 hours, if the apple has been removed or eaten, you probably have a vole problem.

Traps and Baits

Use the apple-sign test each fall because voles do most damage to woody ornamentals during the winter. Baits or traps should be applied only where the presence of voles has been confirmed by the apple-sign test. In North Carolina, trapping of voles in a horticultural area is allowed with a permit from the North Carolina Wildlife Resources Commission. In South Carolina, check with the Department of Natural Resources. In Georgia, contact the Department of Natural Resources, Wildlife Resources Division, Game Management Section Headquarters. Traps are set in the tunnels (runs) leaving a hole above them so that they may be checked daily. Cover the hole above the bait or trap with a flower pot, board, or shingle.

Check state regulations to see what baits are available for use on voles. Baits should be placed in the runs and covered with a board or shingle to keep household pets from eating it.

Test Your Knowledge

1. Which of the following methods is not effective for discouraging geese and may even attract them?
a) Fountains in ponds.
b) Fencing around ponds.
c) Shiny mylar tape.
d) Noisemakers.

2. How effective are the scare devices sold to repel deer?
a) They are an effective, long-term solution if the noise does not cause other problems.
b) They are only effective for a few weeks
c) They are never effective.
d) Some types (exploders) are effective, but sirens do not work.

3. How tall must a fence be to keep deer from jumping over it?
a) 8 feet.
b) 9 or 10 feet.
c) 12 or 13 feet.
d) at least 14 feet.

4. What do moles eat?
a) Worms, grubs, slugs, and other, similar small animals.
b) Plant roots and tubers.
c) Decomposing leaves and grass.
d) All of the above.

continued on next page

5. When should you begin a control program for rabbits?

a) As soon as you see the first one.
b) When you see five or more.
c) When the damage exceeds the cost and time of controlling them.
d) By the time you see rabbits, it may be too late.

6. You observe narrow, paired grooves that girdle a young tree at the ground line. What kind of pest probably caused this damage?

a) Mole
b) Vole
c) Rabbit
d) Rat

Answers: 1-a; 2-b; 3-b; 4-a; 5-c; 6-b.

Resources

For questions regarding **wildlife damage management**, call the following toll free number and you will be automatically connected with your state Wildlife Services center: 1-866-487-3297.

For information about **permits and licenses** for trapping and hunting wildlife, refer to the following state Wildlife Resource Offices:

Georgia: Wildlife Resources Division, US Highway 278, Social Circle, GA 30025. (770-918-6400).

North Carolina: NC Wildlife Resources Commission, Archdale Building, 512 N. Salisbury St., Raleigh, NC 27699-1722 (919-707-0010).

South Carolina: Wildlife and Freshwater Fisheries Division, SC Department of Natural Resources. P.O. Box 167, Columbia, SC 29202. (803-734-3886).

Web Sites

Prevention and Control of Wildlife Damage. 1994. S. E. Hygnstrom, R. M. Timm, and G. E. Larson (eds.) University of Nebraska Cooperative Extension, Lincoln, NE, USDA APHIS/ADC, Great Plains Agricultural Council. http://icwdm.org/handbook/allPDF/complete%20Handbook.pdf

When Geese Become a Problem. 1999. New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources and U.S. Department of Agriculture Animal and Plant Health Inspection Service. www.dec.ny.gov/docs/wildlife_pdf/geese.pdf

DePerno, C., C. Moorman, L.K. Bradley, K. Moore. 2017. Wildlife, Chpt 20. In: K.A. Moore and L.K. Bradley (eds). North Carolina Extension Gardener Handbook. NC State Extension, Raleigh, NC. <http://content.ces.ncsu.edu/20-wildlife>

Notes

Notes

Notes