Biological insecticides need to be handled and applied with care in order to be effective. Since control is a result of the activities of living organisms, the source of the product and how it is shipped affect the viability of the organisms (48). In addition, soil conditions at the time of application must be favorable to the growth of the organisms. For example, entomopathogenic or insect-eating nematodes survive best in moist, loamy soils that have soil temperatures between 65° and 85° F. Since they are able to withstand high pressure, you can apply these biological control organisms using a sprayer or irrigation equipment (49). The ATTRA publication Biointensive Integrated Pest Management provides detailed information on biological control practices. It also contains extensive lists of suppliers for biopesticides and microbial pest control agents.

Table 4 (see Appendix) summarizes cultural and biological control measures for common turf insect pests.

Turf weeds. Weeds are plants growing in the wrong place. The type of lawn you are interested in having will define which plants are weeds. For example, for someone developing a natural lawn, white clover is an integral component of the turf. For people wanting a pure grass lawn, white clover is a weed. Using good turf management practices that favor the growth of desired species allows these plants to out-compete undesired species. Essential management practices for weed control include (22):

- Growing grass species appropriate for your region and your soil conditions
- Eliminating soil compaction
- Reducing wear on the lawn or turf
- Providing turf soil with appropriate and balanced levels of fertilization
- Overseeding with cool-season grasses to maintain grass growth in the fall and spring
- Watering turf deeply and infrequently during dry periods
- Ensuring proper drainage
- Increasing mowing height

Table 5 (see Appendix), which summarizes soil, weather, and management conditions that favor the growth of weeds. To reduce stress on turf

and decrease infestations from weeds, make management changes to alter these weed enhancing conditions.

Mowing to control weeds. Raising the mower height reduces the incidence of some common turf weeds. Research conducted at the University of Maryland showed that mowing turf at 3 inches, especially during the spring, provided as much control of crabgrass as did the use of herbicides (50). The higher cut reduced the stress on the turfgrass and they were able to choke out the crabgrass.

Mowing at a lower cut during seed set can help control annual bluegrass, crabgrass, goosegrass, foxtail, barnyardgrass, fall panicum, and dallisgrass. This technique must be carefully timed to coincide with early seed set. Attach a clippings bag to the mower to collect and remove seed heads. Also be careful not to mow so low that you stress the desired turf species (4).

When not mowing to collect and remove seed heads, leave the grass clippings on the soil to control weed growth. Clippings from a variety of different turf species contain allelopathic compounds that suppress the germination and growth of certain weeds (4, 47). Many tur grass roots also produce allelochemicals that suppress the growth of weed seeds. Raising the mowing height favors root growth and the production of these allelochemicals.

Corn gluten meal is effective in the pre-emergence control of various weed species, including crab grass, foxtail, pigweed and dandelion. This animal feed product controls weed growth by inhibiting root formation (51). Studies demonstrate that repeated applications increase the effectiveness of this natural herbicide. These studies show that corn gluten meal initially reduced weeds by 60 percent, by 80 percent the second year, and by 90 percent in the third year. The main drawback to using corn gluten meal is its high cost, which makes its use economically feasible only in small areas. The average cost is \$1.50/lb., with recommended applications rates of 40 to 65 pounds per 1,000 square feet (52). Since it contains 10% nitrogen, it should be managed as both a fertilizer and a herbicide. University of Iowa turfgrass researcher, Nick Christians has compiled a list of suppliers of corn gluten meal,



which is available at: <http://www.public.iastate.edu/~isurf/tech/ cgmwebsite.html>.

Vinegar has recently gained attention as an effective natural post-emergence herbicide. It works by degrading the waxy cuticle layer on weed leaves, resulting in desiccation. More frequent applications or applications with a stronger solution are needed to control weeds with very thick cuticle layers. While vinegar typically contains approximately 5% acetic acid, distillation can increase this concentration to 15%, and freeze evaporation can increase it to 30%. Research conducted by the USDA Agricultural Research Service demonstrated that vinegar at 10, 15, or 20% acetic acid concentrations killed 80 to 100% of giant foxtail, common lambsquarters, smooth pigweed, and velvetleaf (53). Some gardeners have seen increased effectiveness by adding lemon juice to the vinegar and applying it during the heat of the day (53).

Like corn gluten meal, vinegar is an expensive treatment for large areas. Approximate costs for broadcast application of vinegar are \$66.00 per acre for 20% acetic acid and \$99.00 per acre for 30% acetic acid (53).

While vinegar readily degrades in the soil and has no long-term impact on soil organisms (soil pH decreases at the time of application but returns to its original level in less than two days), it is caustic. When applying this material, you should wear a mask to avoid inhalation and gloves to prevent skin contact (55).

Summary

A lawn that is healthy requires less irrigation and resists pests and diseases. Establishing and maintaining a healthy lawn means reducing or eliminating conditions that put stress on the turf. A soft, microbially-rich soil allows for rapid water infiltration, good water and nutrient holding capacity, unimpeded root growth, efficient nutrient mineralization, and effective antagonistic control of pests and diseases. Regular additions of mature compost enhance soil quality while providing biological control of diseases and certain weeds. Raising mowing height to 2 ½ to 3 inches, keeping mower blades sharp, and returning mower clipping to the soil stimulates healthy turf growth and reduces the potential for diseases. Similarly, watering infrequently – but to the depth of root penetration – minimizes both turf stress and the environmental conditions that favor root diseases. A diversity of species within a lawn reduces insect and weed infestations. Natural lawns including clover, wildflowers, or groundcovers that are drought or shade tolerant add variety to a landscape while reducing maintenance time and expenses.

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Organizations

<u>Golf Course Superintendents Assoc. of America</u> 1421 Research Park Dr. Lawrence, KS 66049-3859 Telephone: 800-472-7878, 785-841-2240 http://www.gcsaa.org

The Golf Course Superintendents Association of America (GCSAA) supports research on environmentally sensitive turfgrass care. Their magazine, Golf Course Management, includes articles on least toxic pesticide use and practices, integrated pest management (IPM), biological control, wildlife and golf courses, water saving practices, and compost use in golf course management, among other topics.

Turfgrass Resource Center / Turfgrass Produc-

<u>ers International</u> 1855-A Hicks Rd. Rolling Meadows, IL 60008 Telephone: 800-405-8873, 847-705-9898. FAX: 847-705-8347 E-mail: info@TurfGrassSod.org Web page: http://www.TurfgrassSod.org



A member's Web page with information about turfgrass varieties, turf soil management, and lawn watering practices. Also includes a database of turfgrass specialists.

National Turfgrass Evaluation Program Kevin Morris, Executive Director National Turfgrass Evaluation Program 10300 Baltimore Ave. Bldg. 003, Rm. 218 Beltsville Agricultural Research Center-West Beltsville, MD 20705 Telephone: 301-504-5125 E-mail: kmorris@ntep.org

Web page: http://www.ntep.org/contact.htm The National Turfgrass Evaluation Program (NTEP) is one of the most widely-known turfgrass research programs in the world. NTEP currently evaluates seventeen turfgrass species in as many as forty U.S. states and six provinces in Canada. Their Web page provides annual evaluation results on turfgrass quality, color, density, resistance to diseases and insects, tolerance to heat, cold, drought, and traffic.

United States Golf Association Green Section

P.O. Box 708 Far Hills, NJ 07931 Telephone: 908-234-2300 USGA Publications: 1-800-336-4446 Web page: http://www.usga.org/green/ index.html

Golf course maintenance publications cover turf management, IPM for golf courses, landscape restoration, environmental issues for golf course management and construction, irrigation systems, waste water reuse, and bird conservation on golf courses.

NOFA Accredited Organic Land Care Professionals c/o NOFA Connecticut PO Box 386 Northford, CT 06472-0386 Web page: http://www.organiclandcare.net/ professionals.php

> They wrote the Standards for Organic Land Care. Their Web page also lists names of lawncare professionals in the Northeast who are NOFA Accredited Organic Land Care Professionals.

Resources Books

Least-toxic and Organic Lawn Care

Standards for Organic Land Care: Practices for Design and Maintenance of Ecological Landscapes. Organic Land Care Committee. 2001. 66 p. Northeast Organic Farming Association of Connecticut PO Box 3 Northford, CT 06472-0386.

Web page: <http://www.nofaic.org/store/ct/ index.php>

> This manual describes how to grow an organic lawn following an ecological stewardship philosophy for designing and maintaining landscapes. Written by landscape professionals, scientists, and citizen activists. It includes lists of preferred, allowed, and prohibited materials and practices for organic land care. Purchase of this manual includes the booklet A Citizen's Guide to Organic Land Care, which answers, in customer-friendly terms, the questions: what is an organic lawn? and what are the advantages of an organic lawn?

Organic Lawn Care

Bruneau, A.H., Fred Yelverton, L.T. Lucas, and Rick L. Brandenburg. 1997. Publication AG-562. North Carolina Cooperative Extension Service. 32 p.

Department of Agricultural Communications North Carolina State University Box 7603

Raleigh, NC 27695-7603

Practical information for homeowners. Maintenance schedules, sources of organic fertilizers, organic control strategies for insects and diseases, and recommended cultivars and planting dates for North Carolina.

Handbook of \$uccessful Ecological Lawn Care Sachs, Paul D. 1996. 290 p. Edaphic Press PO Box 107 Newbury, VT 05051 Telephone: 802-222-4277 *Well-researched handbook, written for professionals who install and maintain lawns. The* book is divided into two sections. The first, called In the Field, includes chapters on turfgrass dynamics, installing a new lawn, cultural practices, turfgrass pests, and soil testing and fertility. Part Two focuses on the business aspects of running a lawn care business. This book is comprehensive in its approach to the soil-turf complex.

Ecological Golf Course Management

Sachs, Paul D., and Richard T. Luff. 2002. 197 p. Wiley Publishers

Web page: <http://www.wiley.com/cda/sec/ 0,,10734,00.html>.

> A comprehensive publication on ecological turf management. It focuses on managing the health and welfare of all soil organisms from a singlecelled bacterium to fully developed turf plants. It also points out ways to exploit natural plant defense systems that have been largely ignored and to engage many of the powerful allies that live above and below ground.

Down-to-Earth Natural Lawn Care Raymond, Dick. 1993. 176 p. Storey Communications 25 Main St. Williamstown, MA 01267 Telephone: 800-793-9396 Natural lawn care for residents or landscape professionals.

Pest and Disease Control

Turfgrass Problems: Picture Clues and Management Options Eva Gussack and Frank S. Rossi. 2001. 214 p. Natural Resource, Agriculture, and Engineering Service (NRAES) Cooperative Extension 152 Riley-Robb Hall Ithaca, New York 14853-5701 Telephone: 607-255-7654 Fax: 607-254-8770 E-mail: nraes@cornell.edu. Web page: <http://www.nraes.org/publications/nraes125.html>

> A compact, spiral-bound guide with over 130 color photos designed to help readers identify turfgrass problems and implement appropriate management strategies. The guide covers problems of cool-season turfgrasses caused by nonliving (abiotic) or living (biotic) factors. Each problem discussion includes photos, a detailed

description, conditions under which the problem tends to occur, and non-chemical management strategies. Also includes chapters on scouting and sampling procedures and symptom timelines for when in the season problems are likely to occur.

IPM Handbook for Golf Courses

Schumann, G., P. Vittum, M. Elliott, and P. Cobb. 1998. 264 p. Wiley Publishers

Web page: <http://www.wiley.com/cda/sec/ 0,,10734,00.html>

> An excellent introductory handbook for golf course superintendents. Describes IPM and how it can be performed on golf courses. Chapters include site assessment, scouting and monitoring, cultural control strategies, biological and chemical control strategies.

Biological Control of Turfgrass Diseases Cornell Media Services Resource Center. 12 p. Ithaca, NY 14853 Telephone: 607-255-2080 Web page: http://www.cce.cornell.edu/publications/gardening.cfm Lists biological controls for turfgrass diseases and describe the use of organic fertilizers, sup-

pressive composts, and microbial fungicides.

IPM for Lawns.

Bio-Integral Resource Center. 1987. 70 p. PO Box 7414 Berkeley, CA 94707 Telephone: 510-524-2567

Web page: <http://www.birc.org/>

Bio-Integral Resource Center (BIRC) specializes in finding non-toxic and least-toxic, integrated pest management (IPM) solutions to urban and agricultural pest problems.

The Chemical-Free Lawn Schultz, Warren. 1989. 208 p. Rodale Press 33 E. Minor St. Emmaus, PA 18098 Telephone: 800-527-8200

Designed for homeowners. Includes information on assessing lawn problems, species and cultivars, seeding, sodding, sprigging, fertilizing, mowing, watering, and fighting weeds, insects, and diseases without chemicals.



Compendium of Turfgrass Diseases. 2nd ed. Smiley, Richard W. et al. 1992. 102 p. American Phytopathological Society 3340 Pilot Knob Rd. St. Paul, MN 55121-2097 Telephone: 612-454-7250

Management of Turfgrass Diseases. 2nd ed. Vargas, M.J., Jr. 1993. 320 p. Lewis Publishers 2000 Corporate Blvd. NW Boca Raton, FL 33431 Telephone: 800-272-7737

Managing Turfgrass Pests Watschke, Thomas L., Peter H. Dernoeden, and David Shetlar. 1994. 384 p. Lewis Publishers 2000 Corporate Blvd. NW Boca Raton, FL 33431 Telephone: 800-272-7737

Alternative Lawns

Easy Lawns: Low-Maintenance Native Grasses for Gardeners Everywhere Stevie Daniels (ed.). 1999. 111 p. Brooklyn Botanic Garden 1000 Washington Ave. Brooklyn, NY 11225 Telephone: 718-622-4433 Web page: http://www.bbg.org/gar2/topics/sustainable/handbooks/lawns/

> This book is a compilation of information on the establishment of no-mow and native grass prairie lawns. Each chapter focuses on low-maintenance lawn species and management practices for different regions of the country.

The Wild Lawn Handbook: Alternatives to the Traditional Front Lawn. Daniels, Stevie. 1995. 256 p. Macmillan

New York, NY

A practical guide for transforming grass lawns into beautiful alternative lawns using native grasses, ferns, mosses, wildflowers, low-growing shrubs, and perennials. Includes detailed instructions on choosing, installing and maintaining a wild lawn, including a chapter on landscaping ordinances. Gardening with Prairie Plants: How to Create Beautiful Native Landscapes Wasowski, Sally. 2002. 285 p. University of Minnesota Press Minneapolis, MN A beautifully illustrated guide to establishing prairie landscapes. Describes methods for designing, installing, and maintaining yards with prairie plants. Provides extensive and detailed profiles of prairie flowers and grasses and how to use them in prairie lawns.

Electronic database

Turfgrass Information Center Michigan State University 100 Library East Lansing, MI 48824-1048 Telephone: 517-353-7209 E-mail: tgif@pilot.msu.edu Web page: <http://www.lib.msu.edu/tgif/>. The Turfgrass Information Center (TIC) at Michigan State contains the most comprehensive collection of turfgrass educational materials publicly available in the world. The TIC maintains the Turfgrass Information File (TGIF), an on-line computer based bibliographic database of turfgrass research data. Subscriptions or flat rates available. See their Web site for more information.

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IP123



istics of good quality compost for turf				
Analysis				
few recognizable components of original material remain. Structure is light and crumbly.				
dark brown to black (but not dark black, which indi- cates overheating during the composting process)				
fine texture, particles smaller than 1/2 inch for incorporation, smaller than 1/8 for topdressing				
earthy aroma, no smell of ammonia or sulfur				
not warm to the touch				
30 to 50%				
15:1 to 20:1				
more than 25%				
color chromotography test between 50 and 80 for finished compost				
0.2 to 3.0 ppm				
< 300 ppm				
zero to trace				
6.5 to 8.5; pH 7 optimal				
lower than allowable limits				
conductivity less than 3 millimhos				
 10,000 to 20,000 species of bacteria per gram aerobic bacteria populations should be between 100 million to 10 billion CFU/gdw aerobic bacteria should outnumber anaerobic bacteria by ratio of 10:1 or more Pseudomanas bacteria populations should be between 1 thousand to 1 million CFU*/gdw nitrogen-fixing bacteria populations should be between 1 thousand to 1 million CFU/gdw yeasts and fungi populations should be between 1 to 10 thousand CFU/gdw actinomycete populations should be between 1 to 100 million CFU/gdw 				

* CFU/gdw is colony forming units per gram dry weight

Sources: 4, 5, 6, 40



	Nitrogen Sources	Phosphorus Sources	Potassium Sources
Preferred	 alfalfa meal compost compost tea	 compost compost tea green manures	 alfalfa meal compost compost tea
Allowed	 vegetable meal such as soybean meal, corn gluten meal, cotton seed meal, and peanut meal blood meal from U.S. sources fish emulsion or meal 	 greensand rock phosphate steamed bone meal from U.S. sources 	 greensand seaweed Sul-Po-Mag potassium sufate
Prohibited	leather mealChilean nitratesynthetic nitrogen fertilizers	• synthetic phosphorus fer- tilizers	muriate of potashsynthetic potassium fertilizers
	Do not use: • uncomposted manure, since it co • sewage sludge, since it may con	ontains weed seeds and pathog tain heavy metals and pathoger	ens 15



PEINDIX: Tab twn Grass arm-Season tasses thiagrass	le 3. Characteris Heat or Cold Tolerance Heat tolerent	tics of Commo Shade Moderate - Poor	n Turf Gr Drought Good -	asses Durability or Wear Poor -	Pest Resistance	Soil Preference Acid, sandy	Maintenance Level Low - Moderate	Establishment Method Seed, sod
agrass etgrass	Heat tolerent Heat tolerent	Moderate - Poor Poor- Very Poor Fair -Moderate	Good- Excellent Excellent Poor	Foor - Good - Excellent Poor	Diseases - Good Diseases - Good Nematodes- Poor Diseases - Good Nematodes-Poor Diseases - Moderate	Wide range Acid, wet	Low - Moderate Medium - High Low	seed, sou Sod, sprigs, plugs, seed Seed, sprigs
ipedegrass ugustinegrass	Heat tolerent Heat tolerent	Fair-Good Good- Very Good	Good Good - Poor	Poor Poor - Good	Nematodes-Poor Diseases - Good Nematodes-Good Diseases-Moderate	Acid, infertile Wide range	Low Medium	Seed, sod, sprigs, plugs Sod, plugs, sprigs
siagrass I-Season sses tucky	Heat tolerent Heat - moderate	Good	Good- Excellent Good	Good - Excellent Good	Nematodes-Poor Diseases - Good Diseases- moderate	Wide range Wide range	High Moderate -High	Sod, plugs Seed, sod
sgrass gh-stalk grass Fesue	Cold - moderate Heat - moderate Cold - moderate Heat - moderate Cold - moderate	Moderate Good - Very Good	Poor Very	Poor Good - Vour Cood	Diseases- moderate Diseases- moderate	Wide range	Moderate Low - Moderate	Seed, sod Seed, sod, plugs
Fescue nual grass	Northern Heat- poor Cold - moderate	Poor	Good- Very Good Poor	Good	Resistant to red thread Diseases- moderate	Acid soils	Low High	Sod, plugs, sprigs Seed
annial grass ive Grasses	Heat - moderate Cold - moderate	Good- Very Good	Good - Poor	Good	Allstar - high insect resistance		Low- Moderate	Seed, sod
alograss e Gamma	Heat-good Cold - moderate Heat-moderate Cold -good	Good	Very Good Good	Moderate Moderate	Disease-good Disease-good		Low Low	Seed, sod, plugs Seed, sod
s s rces: 56, 57, 5	Heat-moderate							Seed, sod

APPENDIX: Tabl	e 4. Cultural Practices f	or Turf Disease C	Control				
Disease	Grass species affected	Resistant varieties	Aeration	Mowing	Fertility	Watering/ Leaf wetness	Other
Anthracnose			increase aeration	 increase mowing height 	increase	 reduce leaf wetness 	
Brown patch	 Fescue Ryegrass Bluegrass Bermudagrass St. Augustinegrass 		increase aeration		 reduce N in late spring, summer adjust pH to 6 - 6.5 	 water deeply, infrequently water early in day reduce leaf wetness provide good drainage 	 topdress compost
Dollar spot	 Bluegrass Ryegrass Centipedegrass Bernudagrass Zoysiagrass 	available	increase aeration	 collect and compost clippings 	adequate fertilization necessaryraise pH	 water deeply, infrequently avoid drought stress water early in day reduce leaf wetness 	 prevelent in dry weather topdress compost
Fairy ring	All cool and warm season grasses		increase aeration		increase N, iron		 remove excess organic matter decrease thatch rototill or remove soil
Fusarium				 increase mowing height 	reduce N	avoid droughtreduce leaf wetness	reduce thatchprevelent in coolweather
Leaf spot	 All cool-season grasses Bermudagrass 	available		 increase mowing height especially in late spring and summer keep mower blades sharp 	reduce N	 water deeply, infrequently water early in day reduce leaf wetness 	 reduce thatch
Necrotic ring spot		available	increase aeration		minimize stress	 minimize stress 	reduce thatchtopdress compost
Powdery mildew	• Bluegrass	shade-tolerant cultivars	increase aeration	increase mowing height	reduce N	water deeply, infrequentlywater early in dayreduce leaf wetness	reduce shadeprevelent in coolweather
Pythium blight				do not mow when wet	reduce N	 do not water at night improve drainage	reduce shadetopdress compost
Pythium root rot			increase aeration	increase mowing height		• improve drainage	 reduce shade heavy fall compost application

APPENDIX: Table 4	. Cultural Practices f	for Turf Disease Co	ontrol - C	ontinued			
Disease	Grass species affected	Resistant varieties	Aeration	Mowing	Fertility	Watering/ Leaf wetness	Other
Red thread/pink patch	All cool-season grasses	available		collect and compost leaf clippings	increase fertility, pH	 water deeply, infrequently reduce leaf wetness 	 improve air movement prevelent in cool weather prevelent in dry weather topdress compost
Rust	 Fescue Ryegrass Bluegrass Zoysiagrass 	available		collect and compost leaf clippings	increase	 minimize stress maintain good soil moisture reduce leaf wetness 	reduce shadeprevelent in dry weather
slime molds	All cool and warm season grasses			collect and compost leaf clippings			 remove mold by brushing or washing turf reduce thatch prevelent in cool weather
Southern Blight	BluegrassRyegrass				fertilize properly	 water deeply, infrequently reduce leaf wetness 	 reduce thatch
Summer patch				increase mowing height	lower pH		
Stipe smut		smut-free seed			reduce N	minimize stress	
Fake-all patch	• St. Augustinegrass			increase mowing height	lower pH increase P, K decrease Ca	improve drainage	
Yellow patch					reduce N	 reduce leaf wetness 	reduce shade
Yellow tuft					reduce N increase iron	reduce leaf wetnessimprove drainage	
Sources: 12, 13, 22							

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Aethods for Turf Insect Pests and Other Athropods	methods Botanical Pesticides Biological Insecticides		 in July and early August Neem Bacillus popilliae (Milky spore) to control Japanese Beetles to control Japanese Beetles Beauveria bassiana Te effectiveness Entomopathogenic nematodes 	 Bacillus popilliae Entomopathogenic nematodes Beauveria bassiana 		to reduce habitat• Neem• Entomopathogenic nematodesction• Diatomaceous earth• Beauveria bassianar springfor adults• Beauveria bassiana		ies of grass , especially early in season	watering • Insecticidal soap	hly to remove bugs uring heat of the day		s to reduce habitat ainage conditions • Neem • Bacillus thuringiensis	λ
l Biological Contr	dophytes Cultural co		ailable for • withold v ol-season when eggs r • increasing hances milk			ailable for • remove th ol-season • reduce co asses • water dee		ailable for • resistant v ol-season • water regu usses	frequent 1	water thowater ligh		 ailable for a mow to 3 ible for a movie for a	• enhance fe
able 5. Cultural and	Geographical Lo- cations Affected En		 Northeast av Southeast coi Midwest gri Plains states Northwest Southwest 	SoutheastGulf states		Southeast av. Plains states coo		 Northeast av. Southeast co. Gulf states grain Southwest grain 		• Zone 8		 Northeast Southeast Gulf states Midwest Plains states Northwest 	• Northwest
APPENDIX: T	Insect Pest	Root feeders	White grubs	Mole crickets	Stem feeders	Billbugs	Juice suckers	Chinch bugs	Mites	Spittlebugs	Leaf eaters	Sod webworms	Crane flies

APPENDIX: Continued	Table 5. Cult	ural and Bio	ological Control Methods for Tu	urf Insect Pests and ()ther Athropods -
Insect Pest	Geographical Locations Affected	Endophytes	Cultural control methods	Botanical Pesticides	Biological Insecticides
Cutworms	• Northwest	available for cool-season grasses	 remove thatch to reduce habitat use pheromone traps to monitor time of egg laying mow and bag clippings to remove eggs from leaf tips 	 Neem Insecticidal soaps 	 Entomopathogenic nematodes Bacillus thuringiensis
Armyworms	SoutheastGulf states	available for cool-season grasses	 remove thatch to reduce habitat 	NeemInsecticidal soaps	 Entomopathogenic nematodes Bacillus thuringiensis
Other Arthropods					
Slugs and snails	Moist, humid climates		 eliminating wet areas in lawn setting out traps planting non-preferred plant species 	 Copper barriers Horsetail (Equisetum) extract Sawdust Woodash 	 Slug-attacking nematodes (available currently only in Britian)
Sources: 6, 13, 58,	59				

APPENDIX: Tab	ole 6. Condi	tions that F	avor Weed II	nfestations		
Weed	Soil moisture	Soil pH	Soil Compaction	Soil fertility	Mowing	Shade
Annual bluegrass	Poor drainage		High	High N	Too low	
Barnyardgrass	Poor drainage					
Birdsfoot Trefoil	Droughty conditions			Low N		
Black Medic	Droughty conditions			Low N		
Broadleaf Plantain		High	High			
Burdock					Infrequent	
Buttercup	Poor drainage					
Chickweed				High N	Too low	
Cinquefoil	Droughty conditions High surface moisture	Low		Low fertility		
Coltsfoot	Poor drainage	Low				
Common Mullein		Low		Low fertility		
Corn Chamomile	Poor drainage	High				
Corn Speedwell			High			
Crabgrass	Droughty conditions			Low N	Too low	
Creeping Bentgrass	Droughty conditions High surface moisture				Too low	
Creeping Speedwell						Too much shade
Creeping Thyme		High				
Curly Dock	Droughty conditions					





APPENDIX: Tabl	e 6. Conditi	ons that F	avor Weed In	festations - Co	ntinued	
Weed	Soil moisture	Soil pH	Soil Compaction	Soil fertility	Mowing	Shade
Dandelion		High			Too low	
English Daisy		Low				
Foxtail				Low fertility		
Goosegrass	Droughty conditions		High			
Hawkweed		Low		Low fertility		
Henbit				Low fertility		
Hop Clover		High				
Lady's Thumb	Poor drainage	Low				
Leafy Spurge	Droughty conditions					
Mallow				Low fertility		
Nutsedge	Poor drainage					
Pigweed	Droughty conditions					
Prostrate Knotweed	Droughty conditions		High			
Prostrate Spurge	Droughty conditions		High			
Red Sorrel		Low				
Speedwell	Droughty conditions			Low N	Too low	
Wild Parsnip				Low fertility		
Yarrow	Droughty conditions					
Yellow Woodsorrel	Droughty conditions					
Sources: 4, 13						

Sustainable Turf Care Executive Summary Barbara C. Bellows

The key to organic or least-toxic turf management is reducing turf stress. Turf experiences stress from heat, drought, wetness, compaction, nutrient deficiencies or imbalances, and disease and pest infestations. To minimizing stress on turf, you need to pay attention to the following principles:

- Establish and maintain a healthy soil environment
- Include a diversity of species in the lawn environment
- Use cultural practices that reduce stress on turf
- Understand and work with your local soil and climate conditions
- Use biological pest controls

Establish And Maintain A Healthy Soil Environment

A lawn that is healthy requires less irrigation and better resists pests and diseases. Mature compost provides turf plants with a balanced, slow-release source of nutrients. Compost can be tilled into the soil to renovate land for healthy turf growth or applied to existing turf as a topdressing. When topdressing, the best time to apply compost is in the spring or fall. Compost applied in the spring provides nutrients to the soil and turf during the main growing season, while compost applied in the fall helps prolong the growing season, strengthens roots for the dormant season, and promotes early spring growth. Other organic sources of plant nutrients include vegetable and alfalfa meals for nitrogen, rock phosphate and greensand for phosphorus, and alfalfa meal, greensand, and seaweed for potassium.

Besides serving as a complete source of nutrients for turf growth, compost provides food for soil organisms. These organisms help create a soft, porous, well-aerated soil. They also break down thatch and allow for more effective water and nutrient use.

Include A Diversity Of Species In The Lawn Environment

Turf composed of a single species is highly susceptible to becoming weedy and demands more nutrients and water than turf composed of a diversity of species (12). To minimize maintenance problems, use a combination of species appropriate for your location and for the specific conditions within the yard. Also, choose varieties that have resistance to common pests in the area and that do not have a high demand for nitrogen.

Adding legumes such as Dutch white clover, subterranean clover, or black medic can add nitrogen to the soil, increase drought-tolerance, and decrease diseases and weed infestations. When mixed evenly with turf grass species, the resulting lawn has a soft, natural look.

Slow growing or "no mow" lawn mixes provide another option for low-maintenance lawn care. A combination of hard fescue and creeping red fescue is suitable for the cooler, medium-rainfall areas of the upper Midwest and the northeastern United States, and southern Canada. Various sedges and rushes can be used in moister regions.

Wildflowers provide additional color and variety to a yard while also attracting beneficial insects and birds. When purchasing wildflower seeds, select mixtures that are either native to or well adapted to your local climate and soil conditions. Avoid inexpensive seed mixes that contain a high percentage of weedy, aggressive, annual species. Native, warm-season prairie grasses provide an excellent companion to prairie flowers.

Use Cultural Practices That Reduce Stress On Turf

Mowing and watering are normal lawn maintenance practices that can either be used to create a healthy lawn or misused to produce a highly stressed lawn. Raising the mowing height to 2 $\frac{1}{2}$ to 3 inches, keeping mower blades sharp, and returning mower clipping to the soil stimulates healthy turf growth, controls weeds, and reduces the potential for diseases. Watering infrequently, but to the depth of root penetration, stimulates healthy root growth, minimizes turf stress, and reduces environmental conditions that favor root diseases.

Overseeding allows you to rejuvenate a lawn and fill in bare spots where weeds might otherwise grow (18). Overseeding also allows you to slowly replace inappropriate or disease-prone varieties with more appropriate or more disease-resistant varieties. In mid-latitude areas, it will extend the length of time a lawn remains green into the fall. For lawn rejuvenation, overseeding may be done either in the spring (April or May) or in the fall (September or October).

Other cultural practices that help control turf grass diseases include aerating the soil and turf by raking, coring, or spiking. You can also stimulate the growth of microbial antagonists by applying natural supplements such as lime, ash, compost, liquid seaweed, or fish emulsion.

Biological Pest Control Methods

A light topdressing of high-quality mature compost applied every 30 days can provide effective control of some root pathogens and reduce weed infestation. Compost applications can suppress some soil borne fungal diseases as well as conventional fungicides. You can topdress solid compost or mix with 20 to 30% sand, then incorporated into the soil with an aerator or drag chains. Alternatively, you can apply compost tea – a liquid solution prepared from high quality compost – as a spray.

Various biological pesticides are labeled for turf. The fungus *Trichoderma harzianum* controls several diseases, such as brown patch, dollar spot, pythium root rot, and blight. A commercial mixture of four species of *Bacillus* bacteria provides remedial treatment of turf diseases. *Bacillus popilliae*, also known as milky spore, controls grubs of Japanese beetles and mole crickets. Two species of insect-eating nematodes can be used to control white grubs, billbugs, sod webworms, cutworms, and army worms. These pest predators survive best in moist, loamy soils that have soil temperatures between 65° and 85° F. Since they are able to withstand high pressure, they can be applied using a sprayer or irrigation equipment.

Perennial ryegrass and many types of fescue have a symbiotic relationship with special fungi or endophytes. Grass varieties that contain endophytes produce a bitter toxin that repels most insects and kills many of those that continue to feed. Besides protecting infected grasses from insect pests, endophytes also produce hormonelike substances that increase the growth and vitality of the grass. While endophyte-infected seed must be stored carefully and planted promptly to ensure the survival of the endophyte, once the endophyte-infected grass is planted, the endophyte grows and reproduces with the grass as long as the grass remains viable.

The easiest and most effective method of weed control is to increase species diversity in the lawn. By raising the mower height to 3 inches, especially during the spring, you can obtain the same level of crabgrass control as with herbicides. Leaving grass clipping on the lawn after mowing can control the germination and growth of certain weeds, because the clippings contain allelopathic compounds. Two organically-approved herbicides have demonstrated a high level of control. Corn gluten meal provides preemergence control of various weed species, including crab grass, foxtail, pigweed and dande-Concentrated vinegar, containing 10 to lion. 20% acetic acid, is an effective post-emergence herbicide that kills giant foxtail, common lambsquarters, smooth pigweed, and velvetleaf. Unfortunately, both of these products are only economical to use in small areas or as a spot-treatment.



