1989 Illinois Pest Control Handbook

Suggestions for Insect, Weed, and Plant Disease Management Including Pesticide Information

Cooperative Extension Service
University of Illinois
at Urbana-Champaign
College of Agriculture
in cooperation with the
Illinois Natural History Survey

Cooperative Extension Service
University of Illinois at Urbana-Champaign

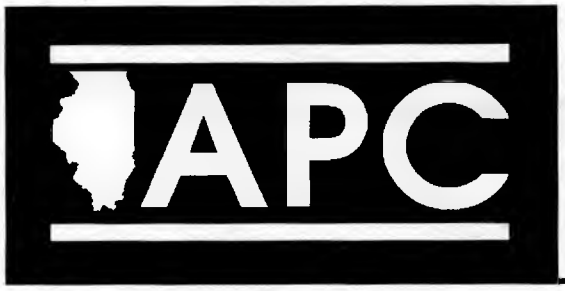
Helping You Put Knowledge to Work

The information in this handbook was prepared by specialists employed by the University of Illinois at Urbana-Champaign, College of Agriculture, the Cooperative Extension Service, the Illinois Natural History Survey, and the U.S. Fish and Wildlife Service. The suggestions herein are intended to provide guidelines for pest management in Illinois during the current calendar year only.

Because of changing laws and regulations, the Illinois Cooperative Extension Service assumes no liability for the recommendations for using pesticides that are included in this handbook. These recommendations are incomplete; therefore, they should be used only as guidelines. Complete instructions for the use of a specific pesticide are on the pesticide label. Read and follow the label directions and precautions before applying any pesticide. The pesticide user is responsible for applying pesticides according to label directions, as well as for problems that may arise through misapplication or misuse of the pesticide.

Not all pesticides registered for crop pests are included in this handbook. Effective pesticides that do not present an undue hazard to the user and the environment are suggested whenever possible. Trade names have been used for clarity, but their use does not constitute an endorsement by the University of Illinois, nor does it imply discrimination against other products.

Label changes, product cancellations, and changes in recommendations may have occurred since the publication of this handbook. Check with your county Extension adviser in agriculture if you are in doubt about a pesticide that you plan to use. Announcement of new registrations, label changes, and changes in recommendations will be made through newsletters and appropriate media sources.



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Acknowledgments

The compilation and publication of this handbook require considerable coordination and cooperation among several units in the College of Agriculture at the University of Illinois. Without the dedication of the individuals involved in this effort, the numerous papers and circulars it contains could never be published as a whole. Following is a list of the people responsible for the production of the *1989 Illinois Pest Control Handbook*.

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Where To Get Information

Many times throughout a growing season, you might need to contact someone for specific information that will help you make a decision related to pesticides or pest management. The following is a list of addresses and telephone numbers for people and organizations that might be able to provide some assistance.

Animal Damage Control

Ron Ogden, State Director
USDA-APHIS
Room 104, 600 East Monroe Street
Springfield, IL 62701
(217) 492-4308

Emergency Services and Disaster Agency

Oran Robinson, Hazardous Materials Officer
110 East Adams Street
Springfield, IL 62706
(217) 782-7860

Emergency Reporting
(800) 782-7860 (toll free within Illinois)

Environmental Protection Agency, Illinois

A.G. Taylor, Agricultural Adviser
2200 Churchill Road
Springfield, IL 62706
(217) 782-3960

Emergency Response
(217) 782-3637

Hazardous Waste Research and Information Center

David L. Thomas, Director
1808 Woodfield Drive
Savoy, IL 61874
(217) 333-8940

Illinois Department of Agriculture

State Fairgrounds
P.O. Box 19281
Springfield, IL 62794-9281
(217) 782-2172

Bill Anderson, Chief
Bureau of Plant and Apiary Protection
(217) 785-2427

Robert Schwarberg, Chief
Bureau of Laboratories
(217) 782-7655

Illinois Department of Public Health

Harvey Dominick, Chief
Section of Pesticides and Vector Control
Division of Environmental Health
Office of Health Protection
525 West Jefferson Street
Springfield, IL 62761
(217) 782-5830

Illinois Fertilizer and Chemical Association

Lloyd Burling, President
P.O. Box 186
St. Anne, IL 60964
(815) 427-6644

Dwight Dunbar, Vice President/Legislative Affairs
P.O. Box 357
Springfield, IL 62705
(217) 522-3734

Victor Thompson, Containment Regulations and Systems
P.O. Box 357
Springfield, IL 62705
(217) 522-3734

University of Illinois Agricultural Research and Demonstration Centers

Brownstown

John Sawyer, Superintendent
Route 2, Box 32A
Brownstown, IL 62418
(618) 427-5239

Dixon Springs

Stephen Ebelhar, Superintendent
Agronomy Division
Route 1
Simpson, IL 62985
(618) 695-2790

Illinois River Valley Sand Field

Stanley Sipp, Superintendent
Box 283
Kilbourne, IL 62655
(309) 538-4342

Northern

Lyle Paul, Superintendent
Route 1
Shabbona, IL 60550
(815) 824-2029

Northwestern

Mike Mainz, Superintendent
Route 3, Box 111
Monmouth, IL 61462
(309) 734-7459

Orr

Glenn Raines, Superintendent
Box 212
Perry, IL 62362
(217) 236-4911

University of Illinois, Cooperative Extension Service - State Offices

Agricultural Engineering

Agricultural Engineering Sciences Building
1304 West Pennsylvania Avenue
Urbana, IL 61801

Loren Bode, Pesticide Application
(217) 333-3000

John Siemens, Tillage
(217) 333-2854

Robert Wolf, Pesticide Applicator Training
(217) 333-9418

Agronomy

Turner Hall
1102 South Goodwin Avenue
Urbana, IL 61801
(217) 333-4424

Diane Anderson, Pesticide Applicator Training/Weed Science
Bill Curran, Integrated Pest Management/Weed Science
Don Graffis, Alfalfa Production
Bob Hoeft, Fertility
Ellery Knake, Weed Science
Marshal McGlamery, Weed Science
Emerson Nafziger, Crop Production and Physiology
Ted Peck, Soils
Gary Pepper, Soybean Production
David Pike, Pesticide Impact Assessment/Weed Science
Bill Simmons, Soil and Water Management

Entomology

172 Natural Resources Building
607 East Peabody Drive
Champaign, IL 61820
(217) 333-6650, 333-6651, 333-6652, or 333-6653

Don Kuhlman, Field Crop Insects and Pesticides
Mike Gray, Integrated Pest Management/Field Crop Insects
Phil Nixon, Pesticide Applicator Training/Household and Ornamental Insects
Roscoe Randell, Turf, Ornamental, Vegetable, and Fruit Insects
Kevin Steffey, Field Crop Insects and 4-H Entomology
Rick Weinzierl, Stored Grain and Livestock Insects

Eugene Killion, Honey Bees
502 East Jasper Street
Paris, IL 61944
(217) 465-4944

Horticulture

Plant Sciences Lab
1201 South Dorner Drive
Urbana, IL 61801

Tom Fermanian, Turfgrass
(217) 244-5147

John Gerber, Vegetable Crops
(217) 244-4232

John Masuinas, Vegetable Crops
(217) 244-4231

Dan Meador, Fruit Crops
(217) 333-1522

Tom Voigt, Turfgrass
(217) 333-7847

Dave Williams, Woody Ornamentals
(217) 333-2126

Plant Pathology
Turner Hall
1102 South Goodwin Avenue
Urbana, IL 61801
(217) 333-8414 or 333-7515

Darin Eastburn, Vegetable Crop Diseases
Walker Kirby, Field Crop Diseases
Mal Shurtleff, Turf and Ornamental Diseases

University of Illinois, Cooperative Extension Service - County Offices

Adams
330 South 36th Street
Quincy, IL 62301
(217) 223-8380

Bond
Lake & Harris Avenue, Box 129
Greenville, IL 62246
(618) 664-3665

Boone
930 West Locust
Belvidere, IL 61008
(815) 544-3710

Brown
109 West North
Mt. Sterling, IL 62353
(217) 773-3013

Bureau
Route 2, Box 21B
Princeton, IL 61356
(815) 875-2878

Calhoun
Box 336 South Park Street
Hardin, IL 62047
(618) 576-2293

Carroll
Route 1, Box 5
Mt. Carroll, IL 61053
(815) 244-9444

Cass
210 South Main Street
Virginia, IL 62691
(217) 452-7255

Champaign
1715 West Springfield, Box 3367
Champaign, IL 61821
(217) 352-3312

Christian
1120 North Webster
Taylorville, IL 62568
(217) 287-7246

Clark
Route 2
Marshall, IL 62441
(217) 826-5422

Clay
231 South Main, Box F
Louisville, IL 62858
(618) 665-3328

Clinton
P.O. Box 185
Breese, IL 62230
(618) 526-4551

Coles
P.O. Box 159
Charleston, IL 61920
(217) 345-7034

Cook
4200 West Euclid Avenue
Rolling Meadows, IL 60008
(312) 991-1160

Cook
17722 South Oak Park Avenue
Tinley Park, IL 60477
(312) 532-4369

Crawford
300 South Lincoln Street, Box 655
Robinson, IL 62454
(618) 546-1549

Cumberland
Route 121 East, Box 218
Toledo, IL 62468
(217) 849-3931

DeKalb
315 North Sixth Street
Dekalb, IL 60115
(815) 758-8194

DeWitt
P.O. Box 347
Clinton, IL 61727
(217) 935-5764

Douglas
RR 2, Box 2B
Tuscola, IL 61953
(217) 253-2713

Edgar
210 West Washington
Paris, IL 61944
(217) 465-8585

Effingham
1209 Wenthe Drive
Effingham, IL 62401
(217) 347-7773

Ford
100 North Hunt Street, Box 155
Melvin, IL 60952
(217) 388-7791

Fulton
Routes 97 & 100, Box 71
Lewistown, IL 61542
(309) 547-3711

Greene
RR 3, Box 129C
Carrollton, IL 62016
(217) 942-6996

Hamilton
Courthouse
McLeansboro, IL 62859
(618) 643-3416

Henderson
119 South Broadway, Box 540
Stronghurst, IL 61480
(309) 924-1163

Iroquois
123 South Fifth Street
Watseka, IL 60970
(815) 432-5416

Jasper
107 South Hutton Drive
Newton, IL 62448
(618) 783-2521

Jersey
RR 1, Box 16A
Jerseyville, IL 62052
(618) 498-4821

DuPage
421 North County Farm Road
Wheaton, IL 60187
(312) 682-7486

Edwards
350 North Seventh
Albion, IL 62806
(618) 445-2934

Fayette
118 North Sixth
Vandalia, IL 62471
(618) 283-2753

Franklin
P.O. Box 539
Benton, IL 62812
(618) 439-3178

Gallatin
Murphy Street, Box 487
Ridgway, IL 62979
(618) 272-4561

Grundy
220 West Main, Suite 301, Box 432
Morris, IL 60450
(815) 942-2725

Hancock
550 North Madison, RR 3, Box 114A
Carthage, IL 62321
(217) 357-2150

Henry
116 North East Street
Cambridge, IL 61238
(309) 937-2424

Jackson
P.O. Box 160
Murphysboro, IL 62966
(618) 687-1727

Jefferson
RR 3, Route 15 West
Mt. Vernon, IL 62864
(618) 242-0780

JoDaviess
State Bank Building, Box 1
Elizabeth, IL 61028
(815) 858-2273

Johnson
208 East Main, Box 158
Vienna, IL 62995
(618) 658-5321

Kankakee
KCC Campus, River Road, Box 2266
Kankakee, IL 60901
(815) 939-3626

Knox
180 S. Soangetaha Road, Box 1347
Galesburg, IL 61401
(309) 342-5108

LaSalle
Route 23 & Dayton Road, Box 489
Ottawa, IL 61350
(815) 443-0707

Lee
P.O. Box 119
Amboy, IL 61310
(815) 857-3525

Logan
P.O. Box 38
Lincoln, IL 62656
(217) 732-8289

Macoupin
210 North Broad Street
Carlinville, IL 62626
(217) 854-9604

Marion
1404 East Main, Route 50 East
Salem, IL 62881
(618) 548-1446

Mason
133 South High, Box 170
Havana, IL 62644
(309) 543-3308

McDonough
3022 West Jackson Street
Macomb, IL 61455
(309) 837-3939

Kane
535 Randall Road
St. Charles, IL 60174
(312) 584-6166

Kendall
4-C Bonnie Lane
Yorkville, IL 60560
(312) 553-5824

Lake
33020 North Highway 45
Grayslake, IL 60030
(312) 223-8627

Lawrence
1406 Locust Street, Box 657
Lawrenceville, IL 62439
(618) 943-5018

Livingston
1412 South Locust
Pontiac, IL 61764
(815) 844-3622

Macon
985 Pershing Road, Suite G4, Box 2219
Decatur, IL 62526
(217) 877-6042

Madison
900 Hillsboro, Box 427
Edwardsville, IL 62025
(618) 656-8400

Marshall-Putnam
300 Edward Street, Box 172
Henry, IL 61537
(309) 364-2356

Massac
1438 West Tenth
Metropolis, IL 62960
(618) 524-2270

McHenry
789 McHenry Avenue, Box 431
Woodstock, IL 60098
(815) 338-3737

McLean
402 North Hershey Road
Bloomington, IL 61704
(309) 663-8306

Mercer
206 Southeast Third Street
Aledo, IL 61231
(309) 582-5106

Montgomery
102 North Main Street
Hillsboro, IL 62049
(217) 532-3941

Moultrie
1102 West Jackson, Box 223
Sullivan, IL 61951
(217) 728-4318

Peoria
1716 North University
Peoria, IL 61604
(309) 686-6033

Piatt
427 West Marion, Box 407
Monticello, IL 61856
(217) 762-2191

Pope-Hardin
P.O. Box 97
Golconda, IL 62938
(618) 683-8555

Randolph
South St. Louis & Belmont, Box C
Sparta, IL 62286
(618) 443-4364

Rock Island
1188 John Deere Road
East Moline, IL 61244
(309) 796-0512

Sangamon
P.O. Box 8467
Springfield, IL 62791
(217) 782-4617

Scott
24 South Main Street
Winchester, IL 62694
(217) 742-9572

Menard
420 South Seventh Street, Box 275
Petersburg, IL 62675
(217) 632-7491

Monroe
P.O. Box 117
Waterloo, IL 62298
(618) 939-3434

Morgan
104 North Westgate Avenue
Jacksonville, IL 62650
(217) 243-7424

Ogle
Pines Road, Box 99
Oregon, IL 61061
(815) 732-2191

Perry
113 East South Street
Pinckneyville, IL 62274
(618) 357-2126

Pike
RR 3, Box 23
Pittsfield, IL 62363
(217) 285-5543

Pulaski-Alexander
124 North Oak Street
Mounds, IL 62964
(618) 745-6310

Richland
306 South Fair, Box 364
Olney, IL 62450
(618) 395-2191

Saline
21 1/2 West Robinson
Harrisburg, IL 62946
(618) 252-8391

Schuyler
710 Maple Avenue
Rushville, IL 62681
(217) 322-3381

Shelby
P.O. Box 168
Shelbyville, IL 62565
(217) 774-4321

St. Clair
116 South Charles, Box 331
Belleville, IL 62222
(618) 233-1047

Stark
302 South Downend Street
Toulon, IL 61483
(309) 286-5421

Stephenson
Highland Community College
Building A, Pearl City Road
Freeport, IL 61032
(815) 235-4125

Tazewell
1505 Valle Vista
Pekin, IL 61554
(309) 347-6614

Union
RR 2, Box 305B
Anna, IL 62906
(618) 833-6363

Vermilion
3803 North Vermilion
Danville, IL 61832
(217) 442-8615

Wabash
RR 1, Box 107
Mt. Carmel, IL 62863
(618) 262-5725

Warren
1000 North Main, Box 325
Monmouth, IL 61462
(309) 734-5161

Washington
P.O. Box 192, 135B East St. Louis
Nashville, IL 62263
(618) 327-8881

Wayne
119 Northeast Third, Box 647
Fairfield, IL 62837
(618) 842-3702

White
304 East Robinson
Carmi, IL 62821
(618) 382-2276

Whiteside
100 East Knox
Morrison, IL 61270
(815) 772-4075

Will
100 Manhattan Road
Joliet, IL 60433
(815) 727-9296

Williamson
906 East Reeves
Marion, IL 62959
(618) 993-3304

Winnebago
4311 West State Street
Rockford, IL 61102
(815) 987-7379

Woodford
P.O. Box 162
Eureka, IL, 61530
(309) 467-3789

University of Illinois, Cooperative Extension Service - Regional Offices

Region 1 (Northern)

Ann Carrick, Area IPM Adviser
P.O. Box 587
Dixon, IL 61021
(815) 288-3361

Region 4 (Central)

Rob Koethe, Area IPM Adviser
P.O. Box 8167
Springfield, IL 62791
(217) 782-6515

Region 7 (Southern)

Noel Troxclair, Area IPM Adviser
901 West Washington
Benton, IL 62812
(618) 439-7263

University of Illinois Plant Clinic (Plant Problem Diagnosis)

(By U.S. Mail - Do not put "University of Illinois" on letter.)

Plant Clinic
1401 St. Mary's Road
Urbana, IL 61801
(217) 333-0519

1989 Insect Pest Management Guide

FIELD and FORAGE CROPS

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POLICY STATEMENT

This publication is provided for use by people who desire insect management guidelines and suggestions for field and forage crops in Illinois. It is revised annually and is intended for use during the current calendar year only. The insecticides suggested in this publication should be used only to supplement a complete insect pest management program that also includes the use of cultural, mechanical, and biological control tactics.

Selection of the insecticides and the guidelines for insect management that are included in this circular was based on registrations from the U.S. Environmental Protection Agency (EPA) and research results from the Illinois Natural History Survey, the University of Illinois College of Agriculture, other land grant universities, and the United States Department of Agriculture. Not all insecticides registered for control of crop insect pests are included in this circular. Effective insecticides that do not present an undue hazard to the user or the environment are suggested whenever possible.

At the time this publication was in preparation, only currently registered insecticides were included. New registrations and changes in registration, labels, and recommendations will be announced through appropriate media sources and county Extension advisers.

The information in this circular is provided for educational purposes only. Trade names of insecticides have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

PEST MANAGEMENT PROGRAMS

Integrated pest management (IPM) is the selection of management tactics that promote favorable economic, ecological, and sociological outcomes. Sound management of pest populations should rely on a program that integrates the use of pesticides with cultural, mechanical, biological, genetic, and regulatory techniques only when the use of pesticides is necessary. The selection of a specific insecticide should be carefully targeted at the pest population. Insecticides should be used to prevent

Prepared by Donald E. Kuhlman, Kevin L. Steffey, and Michael E. Gray, Extension Entomologists

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 899 (revised annually) September 1988

yield loss only when an insect population has reached an economic threshold. Economic thresholds may be expressed as numbers of insects (for example, the average number of potato leafhoppers per sweep in an alfalfa field) or as a level of damage (for example, 5 to 10 percent of soybean pods injured within a field). Producers who utilize economic thresholds will reduce the number of unnecessary insecticide applications and management costs. Economic thresholds serve as initial guidelines to help producers make intelligent management decisions regarding their specific farm operations.

The use of economic thresholds requires that fields be scouted for insect populations, both beneficial as well as potentially harmful. A successful pest management program hinges on these population estimates. Recognizing various pests and their damage is becoming increasingly important from an economic and environmental perspective. Pest scouting has been accepted by many Illinois farmers, and scouting programs are currently offered by private consulting firms, farmer coops, pesticide dealers, and seed companies throughout the state. Services provided by many of these organizations range from soil testing to offering information on various pest populations, such as diseases, insects, nematodes, and weeds.

Table 1. Insecticide Classifications

Trade name	Common name	Classification
*Aastar	flucythrinate + phorate	restricted
*Ambush	permethrin	restricted
*Asana	esfenvalerate	restricted
Broot	trimethacarb	general
*Counter	terbufos	restricted
Cygon	dimethoate	general
Cythion	malathion	general
Diazinon	diazinon	general
Dipel	*Bacillus thuringiensis*	general
*Dyfonate	fonofos	restricted
Dylox	trichlorfon	general
*Furadan	carbofuran	restricted
Imidan	phosmet	general
*Lannate	methomyl	restricted[a]
Larvin	thiodicarb	general
Lorsban	chlorpyrifos	general
Malathion	malathion	general
*Mocap	ethoprop	restricted
*Nudrin	methomyl	restricted[a]
Orthene	acephate	general
*Penncap-M	methyl parathion (microencapsulated)	restricted
*Pounce	permethrin	restricted
*Pydrin	fenvalerate	restricted
Sevin	carbaryl	general
*Supracide	methidathion	restricted
*Thimet	phorate	restricted

[a] All formulations except water-soluble packages, 25% wettable powder, and granulars are restricted.

Asterisks (*) are used throughout this circular to indicate insecticides classified for "restricted" use.

The University of Illinois provides training for producers and members of their families through programs on campus and at many locations throughout the state. The following two programs are offered annually in Champaign-Urbana and provide intensive training in many facets of integrated pest management.

Fifteenth Annual Illinois Crop Protection Workshop
March 7 to 9, 1989

Field Crop Pest Management Scout Training School
March 20 to 22, 1989

If you are interested in obtaining more information concerning scout training, contact your county Extension adviser.

FEDERAL AND STATE LAWS

The U.S. EPA classifies pesticides for ***general*** or ***restricted*** use (Table 1).

Commercial applicators who apply restricted-use pesticides must be certified. Commercial applicators include persons applying a pesticide for hire and governmental personnel, chemical company representatives, and others involved in demonstrational, regulatory, and public health pest control. Certification as a commercial applicator requires passing written examinations administered either by the Illinois Department of Agriculture or the Department of Public Health.

Private applicators (farmers) who use restricted-use pesticides for the purpose of producing any agricultural commodity on property owned, rented, or otherwise controlled by them or their employer, or as exchange labor (no compensation) on the property of another must be certified by passing a written examination.

Certification via written examination and the issuing of permits or licenses are handled by the Illinois Department of Agriculture. Training programs for farmers (private applicators) and commercial pesticide applicators are conducted by the Cooperative Extension Service to prepare persons for certification. For additional information about training programs, consult your county Extension adviser in agriculture.

Special Local Need Registrations

Section 24(c) of the amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1972 allows states the right to register pesticides for use within the state to meet special local needs (SLN). The authority for state registration of pesticides is the Illinois Department of Agriculture. A special label, which lists the new 24(c) uses, is printed by the formulator. A copy of this label must be in the possession of the operator during application of the pesticides.

Groundwater Protection

The U.S. EPA has started requiring pesticide manufacturers to include groundwater statements on labels if the product has been detected in samples of groundwater associated with monitoring programs.

Most groundwater statements now on labels have identical wording: "*Pesticide X* is a chemical which can travel (seep or leach) through soil and can contaminate groundwater which may be used as drinking water. *Pesticide X* has been found in groundwater as a result of agricultural use. Users are advised not to apply *Pesticide X* where the water table (groundwater) is close to the surface and where the soils are very permeable, i.e., well-drained soils such as loamy sands. Your local agricultural agencies can provide further information on the type of soil in your area and the location of groundwater."

Groundwater statements that are present on labels help the applicator to choose appropriate treatments where soils are sandy or where extra precautions are needed to reduce the risk of groundwater contamination. Pesticide applicators should use alternative products in areas with sandy soils and shallow groundwater.

Currently, the only agricultural **insecticide** product that includes a groundwater statement on the label is Furadan.

The leaching potential of pesticides is affected by many properties, including how tightly they are adsorbed by soil particles, solubility, and persistence. Adsorptivity, solubility, and persistence properties of pesticides are usually not included on pesticide labels.

Endangered Species Act

In 1973, Congress passed the Endangered Species Act to protect America's endangered plants and wildlife. That act requires the U.S. EPA to ensure that these species are adequately protected from pesticides.

At the present time, it is working to develop an Endangered Species Protection Program in fulfillment of this mandate. The goal of this program will be to remove the potential hazard to endangered species posed by pesticide use. A concurrent goal of this agency is to avoid placing any unnecessary limitations on the use of many important pesticides.

Role of the EPA. The federal government has a clearly defined legal responsibility to protect native plants and animals from hazards posed by pesticides. The EPA's role, as defined by Congress, is to register pesticides and set conditions for their use. FIFRA, one of the EPA's principal statutes, charges the EPA with protecting the environment and health from "any unreasonable adverse effects" of pesticides. In addition, the Endangered Species Act requires all federal agencies to ensure that their actions do not jeopardize endangered species.

Responsibility of Growers in 1989. During 1988, comments that the EPA has received from the states, other federal agencies, and the public have made it clear that implementing the Endangered Species Protection Program would be far more complex and time-consuming than anticipated. It was not possible for the EPA to meet its original field implementation goal in 1988. The Endangered Species Protection Program has been delayed. Until the program is implemented, the EPA encourages *voluntary* actions by pesticide users to protect endangered species.

Program Implementation. Initially, the EPA envisioned a program that depended upon pesticide product labeling and endangered species habitat maps to achieve the goal of protecting endangered species from potential jeopardy. The EPA proposed that the program would apply to certain pesticide products registered for use on rangeland or pastureland; on selected crops (corn, cotton, soybeans, sorghum, wheat, oats, barley, or rye); in forests; or as mosquito larvicides. Because densely populated urban areas generally no longer support endangered species, pesticides used directly on people or pets and in, on, or around homes, schools, or day-care facilities are not to be subject to these limitations. In addition, forest-use pesticides injected into or individually sprayed on trees or used on seedbed orchards, nursery plantings, and ornamental trees and shrubs are not included in the Endangered Species Protection Program.

As originally designed, the program relied upon labeling the affected pesticides to direct pesticide users to obtain additional information before using the pesticide in listed counties. Pesticide users in those counties were to be required to obtain "Pesticide Use Bulletins for the Protection of Endangered Species" (county bulletins) for cropland or rangeland uses or to contact the Fish and Wildlife Service (FWS) for forestry or mosquito larvicide uses.

The county bulletins were to contain maps or habitat descriptions of the currently occupied habitats of endangered species and were to specify limitations on pesticide use to protect these species. Contact with the FWS was to have provided this same information. Generally, pesticide use was to be limited only in currently occupied habitats as defined by the FWS, together with the EPA and the states. If the labeling-and-bulletin approach is retained when the program is implemented, all affected pesticides will be included in the county bulletins.

Importance of Protecting the Endangered Species. Biological diversity is essential for a healthy environment. Removing a single species can directly or indirectly affect many others that rely on it during all or part of its life cycle. It has been estimated, for example, that the disappearance of one plant can take with it 30 other

species, including insects, higher animals, and even other plants.

Biologists know that today's danger to wildlife most often results from habitat destruction, environmental pollution, the introduction of nonnative organisms, and exploitation — all generally the direct result of human activity. Scientists also believe that certain pesticides may pose a threat to the survival of some of America's endangered species if used in their remaining habitats.

INSECTICIDE NOMENCLATURE

The chemical names used in this circular may be unfamiliar to you. These names are the common, coined chemical names and as such are not capitalized (for example, terbufos). Trade names are capitalized (for example, Counter). In the tables of suggestions for control, only the trade name is listed. In the table of limitations (Table 13), the trade names are listed first, with the common names in parentheses following the trade names.

PESTICIDE LABELS AND SAFETY

Certain precautionary steps should be taken when handling insecticides. The insecticides suggested in this publication can be poisonous to the applicators, the people most likely to suffer ill effects from insecticides. Farmers or applicators are expected to protect themselves, their workers, and their families from needless exposure.

When using insecticides, apply all the scientific knowledge available to make sure that there will be no illegal residue on the marketed crop. Such knowledge is condensed on the label. **Read the label carefully and follow the instructions. The label is the law.** The label should be recent and not from a container several years old. Do not exceed the maximum rates suggested. Observe the interval between application and harvest. Apply only to crops for which use has been approved. Keep records of pesticide use for each field. Record the product used, the trade name, the percentage content of the insecticide, the dilution, the rate of application per acre, and the date or dates of application.

Always handle insecticides with respect. Accidents and careless, needless overexposure can be avoided. Following these rules will prevent most insecticide accidents:

- When using any pesticide, regardless of its toxicity, wear at least a hat, long-sleeved shirt, long-legged trousers or a coverall garment, and socks and shoes.
- Wear rubber boots, rubber gloves, a rubber or vinyl apron, and goggles when handling insecticide concentrates.
- If at all possible, mix insecticides in a place out-of-doors where there are good light and ventilation.
- Keep your face turned to one side when opening, pouring from, or emptying insecticide containers.
- If you splash or spill an insecticide on yourself while mixing or loading, stop immediately, remove contaminated clothing, and wash yourself thoroughly with soap and water.
- Do not smoke, eat, or drink while handling or using insecticides.
- Do not put the water supply hose directly into the spray tank.
- Never leave a spray tank unattended while it is being filled.
- Do not leave puddles of insecticide mixture on impervious surfaces or apply insecticides near dug wells or cisterns.
- Do not blow out clogged nozzles or spray lines with your mouth.
- Avoid spraying near beehives, lakes, streams, pastures, houses, schools, playgrounds, hospitals, or sensitive crops whenever possible. If these areas must be sprayed, do not spray on windy days, and always spray downwind from the sensitive area.
- Do not apply insecticides when drift is likely to occur.
- Do not apply insecticides to fish-bearing or other waters.
- Do not apply insecticides to areas with abundant wildlife.
- To avoid killing bees, apply insecticides early in the morning or late in the evening when bees are not actively foraging. If at all possible, use the insecticide that is least toxic to bees. Before you begin application, warn beekeepers that you are applying insecticides.
- Change clothes and take a shower every day after insecticide application.
- If contamination occurs while using an insecticide, change clothes and shower immediately.
- Keep contaminated clothing away from the family laundry.
- Leave unused insecticides in their original containers with the labels on them.
- If at all possible, buy no more insecticide than you will use, thus eliminating problems with insecticide storage and disposal.
- Store insecticides out of the reach of children, irresponsible persons, and animals, preferably in a locked building marked for insecticide storage. Do not store insecticides near livestock feeds.
- Triple rinse, bury, or burn all empty insecticide containers or take them to an appropriate sanitary landfill.

Refer to the *Illinois Pesticide Applicator Study Guide* for more information concerning safe handling of pesticides and treatment of pesticide poisoning.

POISON RESOURCE CENTERS

The Poison Resource centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency

can call the toll-free telephone number for help. Personnel at the Poison Resource Center will provide first-aid information and refer callers to local treatment centers if necessary.

Poison Resource centers supplement, but do not replace, local emergency medical services. Do not delay calling local emergency medical personnel to request immediate assistance or transportation. If possible, have the pesticide container and label present when you call or reach a treatment center or hospital.

Chicago and northeast Illinois
1753 West Congress Parkway
Chicago, Illinois 60612
Telephone: 800-942-5969

Northern and central Illinois
530 N.E. Glen Oak
Peoria, Illinois 61603
Telephone: 800-322-5330

Central and southern Illinois
800 East Carpenter
Springfield, Illinois 62702
Telephone: 800-252-2022

POTENTIAL FOR SOIL INSECT PESTS IN CORN

There are many factors that affect soil insect populations and their potential to damage corn. The type of crop rotation greatly influences whether a soil insect problem will occur and what kind it will be. Weather, weeds, soil type, planting date, hybrid, tillage, and natural enemies also influence insect populations. Knowledge about damage caused by certain soil insects in particular fields during previous years may also be useful for anticipating problems.

Illinois Extension entomologists have estimated the probability of the occurrence of soil insect pests in corn on the basis of cropping sequence (Table 2). These estimates can serve as a guide to determine the relative risk of damage caused by soil insects.

Corn After Soybeans. The potential for soil insect problems in corn after soybeans is generally low, and the use of soil insecticides rarely pays. Corn rootworms rarely cause damage to corn after soybeans. In most fields, a lindane or diazinon + lindane planter-box seed treatment will be adequate to protect the seeds against attack by seedcorn beetles, seedcorn maggots, and wireworms. Scout the field for cutworm damage as the plants emerge from the soil.

White grubs are an occasional problem in corn after soybeans.

Corn After Corn. The potential for rootworm damage is moderate to severe wherever corn follows corn in Illinois. A rootworm soil insecticide may be needed in fields of corn after corn. If wireworms are a potential problem, select a soil insecticide that will control the wireworm/rootworm complex. Scout for cutworm damage.

Corn After Grass Sod. Wireworms and white grubs are potential problems. Apply a labeled soil insecticide at planting time. Scout for cutworm damage.

Corn After Sorghum. A planter-box seed treatment of diazinon or diazinon + lindane will protect the seeds against seedcorn maggots. Scout the fields for cutworms as the corn emerges. Corn rootworms are rarely a problem where corn follows sorghum.

Corn After Legumes. Cutworms, grape colaspis, grubs, and wireworms occasionally damage corn planted after

Table 2. Probability Estimates of Economic Soil Insect Damage in Corn and Suggestions for Management According to Cropping Sequence, Illinois

Crop preceding corn	Insect pest							Need for a soil insecticide	Recommended pest management practices
	Wireworm	Cutworm	Corn rootworm	White grub	Seedcorn maggot	Billbug	Grape colaspis		
Soybeans	1:100	1:25	1:1,000	1:500	1:150	1:1,000	1:1,000	very low	Use planter-box seed treatment; scout for cutworms; bait for wireworms.
Corn	1:200	1:100	2:3	1:1,000	1:50	1:1,000	1:5,000	mod-high	Scout for rootworm beetles; treat corn if population exceeds 0.75 per plant at any time during August.
Small grain	1:100	1:50	1:100	1:250	1:50	1:200	1:5,000	low	Bait for wireworms prior to planting; scout for cutworms.
Legume	1:25	1:25	1:50	1:150	1:10	1:50	1:4	low-mod	Bait for wireworms prior to planting; scout for cutworms.
Grass sod	1:10	1:25	1:500	1:10	1:25	1:50	1:1,000	mod-high	Use soil insecticide for wireworms and white grubs; if no-till, scout for foliar insect damage as corn emerges.

clover and alfalfa. In addition, adult northern corn rootworms are sometimes attracted to legumes or to blooming weeds in legumes for egg laying, particularly in years when beetles are forced to leave adjacent fields of drouth-stressed corn to seek food. A soil insecticide might be considered for this cropping sequence.

Corn After Small Grain. There is a slight potential for damage by wireworms, seedcorn beetles, and seedcorn maggots in corn after small grain, particularly wheat. In most instances, a diazinon + lindane planter-box seed treatment will be adequate. If wireworms are present, use a soil insecticide at planting time. Excessive weed cover in small grain stubble fields may have been attractive to northern corn rootworm beetles for egg laying as the beetles moved from adjacent fields of drouth-stressed corn.

CORN ROOTWORM SITUATION

Populations of northern and western corn rootworm beetles were extremely high in July, 1988. However, due to environmental factors and the condition of the corn crop, the numbers of rootworm beetles declined significantly in August. Although the potential for rootworm damage to corn following corn is greatest in the northern two-thirds of the state, moderate to severe damage to corn roots by larvae may occur in any field where corn follows corn in Illinois.

Rootworm Control Problems

Corn rootworm larval control with soil insecticides has been variable in Illinois during the past few years, in both farmers' fields and research trials. Instances of poor control have been observed with all rootworm soil insecticides over a wide geographical area with various soil types and weather conditions. An investigation of some of the problem fields has disclosed several factors that probably contributed to poor control with the insecticides. The factors that stand out but are not easily quantifiable include dry soil conditions during May, June, and July, above-average rootworm larval populations, and improper calibration of equipment (rates that were too low).

In many areas, lack of rain prevented the movement of the insecticide off the granular carrier to the area where rootworm larvae were feeding. Early planting also may have been a contributing factor in some fields because soil insecticides applied in April could have lost much of their potency by the time eggs hatched. Undoubtedly, several of these conditions in combination could have affected the performance of soil insecticides.

Unfortunately the factors that influence the performance of soil insecticides under field conditions are not well understood. Recent research indicates that the breakdown of some soil insecticides by soil microorganisms is accelerated after repeated applications of the same compound. The soil microorganisms use the insecticide as an energy source. As a result, the insecticide has a progressively shorter residual time in the soil. This seems to be most prevalent in fields where the same soil insecticide has been used for several consecutive years; however, the pattern is neither clear-cut nor predictable. In all probability, environmental conditions combined with accelerated degradation of the insecticides are causes for rootworm control problems.

Are the rootworms resistant to the soil insecticides? Although this has not been confirmed, some research data suggest that some slight change in susceptibility has occurred with some compounds. At this point, resistance to insecticides cannot be ruled out, but widespread control failures are not likely caused by resistance.

Extended Diapause

Since 1986 in the northern half of Illinois, a small number of fields of corn following soybeans were damaged by corn rootworm larvae. Entomologists have verified that the damage was caused by northern corn rootworms, some of which are known to undergo extended diapause (a period of suspended development) in the egg stage. Extended diapause is not known to occur in the western corn rootworm population, the predominant species of rootworms in Illinois.

Crop rotation and certain environmental conditions may favor the expression of extended diapause in northern corn rootworms, thereby enabling the eggs to survive two winters before hatching. Ordinarily rootworm eggs hatch the year after they are deposited.

Should a farmer use a corn rootworm soil insecticide on corn following soybeans to control corn rootworms in 1989? Although the answer is not a clear-cut "no," the percentage of cornfields following soybeans that have been economically damaged by corn rootworms has been extremely small. Based on a random survey of 890 fields of corn following soybeans in the northern half of Illinois, only 1 percent of the fields sampled had economic rootworm damage in 1986, 1987, and 1988. At this point there is little justification for using a soil insecticide in corn following soybeans. A few fields may sustain damage in 1989, but it is impossible to predict where these will be.

What scenerio might best describe how corn rootworm damage to corn following soybeans might occur in 1989 as a consequence of extended diapause in the northern corn rootworm population? Northern corn rootworm beetle numbers had to exceed 2 beetles per plant in a field of corn during August, 1987, in order to produce a sufficient number of diapausing eggs to cause larval damage to corn after soybeans in 1989.

Research entomologists in Illinois are conducting investigations into the phenomenon of extended diapause within the northern corn rootworm populations to determine the extent of this trait in Illinois.

Determining Potential for Damage in 1989

Corn growers should base the need for using a rootworm soil insecticide in 1989 on the abundance of rootworm beetles in cornfields during late summer of 1988. Generally, if beetle numbers reached or exceeded 0.75 per plant at any time during late July, August, or September, 1988, plan to apply a rootworm soil insecticide if the field is to be replanted to corn in 1989.

However, if the field scouted in 1988 was corn following any crop other than corn, the threshold (beetles per plant) is lower. The ratio of female to male beetles in first-year corn is usually higher than in continuous corn. The females apparently migrate into first-year cornfields, so most of the beetles found there are females. As a consequence, the threshold for determining whether to rotate away from corn or to use a soil insecticide in 1989 may be as low as 0.5 beetle per plant.

Fields of corn planted in late May or June, 1988, may have extensive rootworm damage if replanted to corn in 1989. During August and September, rootworm beetles are especially attracted to late-planted or late-maturing fields. Seeking fresh pollen and silks to feed on, the beetles lay millions of eggs in these fields. Planting the fields to a crop other than corn in 1989 is suggested to reduce the rootworm population.

SUGGESTIONS FOR ROOTWORM MANAGEMENT, 1989

During the past 10 years, the performance of rootworm soil insecticides has been variable. They have provided effective control at some locations and have been marginal or ineffective at others. An immediate solution to the problem of erratic rootworm soil insecticide performance is not readily available. Perhaps there is none. It is entirely possible that changes brought about by treating millions of acres of corn with soil insecticides over the past 20 years have introduced an era when rootworm control with current soil insecticides will be highly variable.

Looking to 1989, you should seriously consider crop rotation, particularly in fields where there is a high probability of rootworm damage. Other alternatives include applications of a soil insecticide at planting or at cultivation. Planting time treatments of a soil insecticide will be the predominant method of rootworm control. However, a cultivator application in early June near the beginning of rootworm egg hatch can be an effective option. If you use a soil insecticide at planting, plan to check fields in early to mid June to determine whether damage is occurring. If so, a cultivator application may be needed as a rescue treatment.

Crop Rotation

Crop rotation is an extremely effective way to prevent damage from northern and western corn rootworm larvae. If feasible, do not grow corn two years in succession in the same field. First-year corn following soybeans will generally not require a soil insecticide for rootworm control (see "Extended Diapause").

Although rootworm beetles can be found in "clean" or weed-free soybean fields, and may even lay a few eggs there, the number of eggs is not great enough to warrant the use of a soil insecticide on corn the following season. In a few instances, rootworm larval damage has occurred to corn planted after soybeans when the bean field had been heavily infested with volunteer corn or weeds during August of the preceding year. Adult northern and western corn rootworms were attracted to these fields to deposit eggs. As a result, root damage by larvae occurred the following season. Soybean fields that had 5,000 or more volunteer corn plants per acre in 1988 may warrant treatment for rootworm control in 1989 if they are planted to corn. Good weed control in soybeans will usually prevent rootworm damage in corn following soybeans.

Corn rootworm beetles deposit the vast majority of their eggs in cornfields. The larvae cannot survive on the roots of broadleaf crops (soybeans or alfalfa) or broadleaf weeds. Consequently, when a crop other than corn, soybeans for example, is planted in a field with soil containing millions of rootworm eggs, the rootworm larvae die from starvation.

Soil Insecticides

Our suggestions for rootworm control are based on research conducted by entomologists in Illinois and other states.

At Planting. Apply Aastar G, Broot 15GX, Counter 15G, Dyfonate II or 4EC, Furadan 15G or 4F, Lorsban 15G, Mocap 15G, or Thimet 20G at the suggested rate (see Table 3). IMPORTANT: Read the suggestions in the section on alternating rootworm soil insecticides.

The rates suggested in Table 3 should not be exceeded for rootworm control. Research has shown that increasing the rates of soil insecticide application does not improve rootworm control. Increasing the rate of the product will not solve rootworm control problems and may even accelerate the onset of resistance in the rootworm population.

Proper calibration, placement, and incorporation of rootworm soil insecticides will improve the likelihood of good control. See the section "Calibration for Granular Soil Insecticides" in this circular.

Insecticide Placement at Planting. The soil insecticides are labeled for application in a 7-inch band ahead of the planter press wheel or firming wheels. Counter 15G and Furadan 15G can also be applied in the seed

Table 3. Soil Insecticides for Rootworm Control, Illinois, 1989

Insecticide[a]	Time of application	Ounces of product per 1,000 ft. of row	Amount of product needed per acre			
			40″ rows	38″ rows	36″ rows	30″ rows
*Aastar G	At planting	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
Broot 15GX	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
*Counter 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
*Dyfonate II	At planting or cultivation	6	5.0 lb.	5.3 lb.	5.6 lb.	6.7 lb.
*Dyfonate 4E	At planting	2.5 fl. oz.	2 pints	2⅛ pints	2¼ pints	2¾ pints
*Dyfonate 4E	Preplant	Broadcast	3 quarts	3 quarts	3 quarts	3 quarts
*Furadan 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
*Furadan 4F	At planting or cultivation	2.5 fl. oz.	2 pints	2⅛ pints	2¼ pints	2¾ pints
Lorsban 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
Lorsban 4E	At cultivation	2.5 fl. oz.	2 pints	2⅛ pints	2¼ pints	2¾ pints
Lorsban 4E	Preplant	Broadcast	6 pints	6 pints	6 pints	6 pints
*Mocap 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
*Thimet 20G	At planting or cultivation	6	5.0 lb.	5.3 lb.	5.6 lb.	6.7 lb.

[a] Consult text for more information. LIQUID FORMULATIONS ARE HIGHLY TOXIC.
* Use restricted to certified applicators only.

furrow for rootworm control, and both have provided control equivalent to the level of control achieved by placement in a 7-inch band. Aastar, Broot, Dyfonate, Lorsban, Mocap, and Thimet should *not* be applied directly in the seed furrow. None of these products is labeled in this manner for rootworm control; and Aastar, Broot, Dyfonate, Mocap, and Thimet might cause crop injury if they are applied in furrow. All insecticides should be lightly incorporated with spring tines or drag chains mounted behind the planter units.

Soil insecticides will give 50 to 70 percent control of corn rootworm larvae, which is usually adequate to prevent economic levels of larval damage in most fields. But in some heavily infested fields enough larvae may survive to cause economic levels of root damage, and beetle populations may be large enough to interfere with pollination.

Planting-time treatments applied in early April may provide only marginal control. Consider a cultivator application in late May or early June in such fields, rather than a treatment at planting time.

Liquid Formulations. Dyfonate 4E or Furadan 4F may be mixed with water and applied as a spray in a 7-inch band ahead of the press wheel. They may also be mixed with liquid fertilizer and used with a split-boot applicator at planting.

Incompatibility or crop injury may be a problem with combinations of a liquid insecticide and a liquid fertilizer applied at planting. The insecticide *must* be compatible with the fertilizer. Conduct a test before planting to make certain that the two are physically compatible. Maintain agitation in the tank after mixing and during application to prevent separation. **Use caution when handling liquid insecticide formulations.**

At Cultivation. Apply Broot 15GX, Counter 15G, Dyfonate II, Furadan 15G or 4F, Lorsban 15G or 4E, Mocap 15G, or Thimet 20G on both sides of the row at the base of the plants just ahead of the cultivator shovels. Cover the insecticides with soil. The best time to apply a basal treatment of a soil insecticide by cultivator is in late May or early June, near the beginning of egg hatch.

A cultivation-time application of a soil insecticide is an alternative to a planting-time application or may be used as a "rescue" treatment if the planting-time insecticide fails to control rootworm larvae. In either case, you should dig up several plants and examine the roots and surrounding soil for rootworm larvae and damage. If you find 3 or more larvae per plant and the field was not treated at planting, a cultivator application is warranted. If the field was treated at planting and rootworm larvae and damage are obvious in June, plan to apply a cultivator treatment. "Obvious" rootworm damage is characterized by brown root tips and roots that have been tunneled in or chewed back toward the base of the plant.

Soil moisture may affect both application and effectiveness of cultivation-time treatments. Fields that are too wet may never be cultivated. On the other hand, the insecticide may not perform satisfactorily if the soil is too dry.

Suggestions For Alternating Rootworm Soil Insecticides. Avoid using the same soil insecticide for several consecutive years or in fields where there have been performance problems. The continuous use of one insecticide may enable soil microorganisms to break it down more rapidly or may hasten the onset of insecticide resistance. **Illinois entomologists encourage growers to consider alternating rootworm soil insecticides, rather than using one product for several consecutive years.**

Consider the following suggestions for alternating rootworm soil insecticides:

1. If performance of a soil insecticide has been poor in a particular field in recent years, do not use the same insecticide in that field in 1989.
2. Avoid using carbamates in consecutive years.
3. Avoid using the same organophosphate for several consecutive years.

Control of Rootworm Beetles to Prevent Egg Laying

Research conducted during the mid 1970s indicated that properly timed sprays to prevent rootworm beetles from laying eggs could eliminate the need for a soil insecticide the following year. However, the procedure is not foolproof. Factors beyond the control of the operator, such as beetle migration and weather, may minimize the treatment's effectiveness.

Growers who have experienced erratic rootworm control with soil insecticides the past few years and who are committed to a continuous corn program may look to beetle control as an alternative, or an addition, to soil insecticides at planting. Ideally, one properly timed spray should *replace* a soil insecticide. Unfortunately, some fields will require two sprays to combat extended beetle emergence and egg laying. Two sprays or a spray plus a soil insecticide the following season may hasten the onset of rootworm resistance to insecticides.

It is important to recognize that control programs to prevent egg laying and controlling beetles to prevent silk clipping do not overlap in time. Most eggs are laid from mid-August through early September, well after the time when treatments to prevent silk clipping would be necessary.

A rootworm beetle suppression program should be employed only if the fields are under the supervision of trained pest management personnel in weekly scouting programs. Careful field scouting is a requirement.

Summary: Planning Your Rootworm Management Program

A management plan for rootworms should be long range (not a year at a time) and include crop rotation, insecticide rotation, cultivator treatments, and scouting to determine the need for rootworm control.

1. Alternate corn with another crop when possible, particularly in fields where rootworm beetles averaged 0.75 or more per plant last summer, or if the soil insecticide did not give effective rootworm control in 1988.

2. If you intend to grow corn after corn and if rootworm beetles averaged 0.75 or more per plant in corn after corn or 0.5 beetle per plant in first-year corn last summer, apply a rootworm soil insecticide at planting time. Apply the rate suggested in Table 3 and consider our suggestions for alternating rootworm soil insecticides.

3. Consider a cultivation-time application of a rootworm soil insecticide if you intend to plant in early April or if your planting-time insecticide does not provide effective control.

4. Scout for rootworm beetles in July and August, 1989, to determine the potential for rootworm larval damage in 1990.

Scouting to Determine Rootworm Potential in 1990

The abundance of rootworm beetles in a cornfield in July and August is an indicator of potential rootworm problems the following year. You can determine the potential for rootworm damage in 1990 by counting western and northern corn rootworm beetles from mid-July through August, 1989, in this way:

1. Scout fields at least three times at 7- to 10-day intervals between mid-July and late August in fields to be replanted to corn.

2. Examine 5 plants selected at random in each of 10 areas of the field. Count all of the western and northern corn rootworm beetles on 50 plants each time. The counts take about 45 minutes in a 40-acre field.

3. As you approach a plant, move quietly to avoid disturbing the beetles. Count the beetles on the entire plant, including the ear tip, tassel, leaf surface, and behind the leaf axils.

4. Record the number of beetles you find per plant. If the average is more than 0.75 beetle per plant in corn after corn or 0.5 beetle per plant in first-year corn for any sampling date, plan to rotate away from corn or apply a rootworm soil insecticide to corn in 1990. If populations do not exceed an average of 0.5 beetle per plant for any sampling date, a soil insecticide will not be needed the following season.

Rootworm Life Cycle

Western and northern corn rootworm beetles deposit their eggs in the soil at the base of the corn plants or between rows during August and September. The eggs overwinter in the soil and begin hatching in late May. Egg hatch usually takes place over a period of 3 to 5 weeks. Consequently, in July and August all stages of the corn rootworm — egg, larva, pupa, and adult — may be found. The rootworm larvae feed on the roots of corn plants during June, July, and August. When a larva is fully grown (½ inch), it builds a cavity in the soil and goes into the pupal or resting stage. After 5 to 10 days, the beetle emerges from the soil. The development from egg hatch to adult emergence takes 27 to 40 days. After the females emerge from the soil and mate, 14 days or more elapse before they begin laying eggs. Rootworm beetles may deposit as many as 1,000 eggs; an average of 500 per female is probably common. Most egg laying in Illinois occurs after August 1.

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Rescue (or emergency) treatments to control outbreaks of cutworms include broadcast sprays of Ambush, Asana, Lorsban, Pounce, or Pydrin.

The keys to effective cutworm control with rescue treatments are the amount of surface moisture and the movement of the worms. Control may be poor, regardless of the insecticide used, if the topsoil is dry and crusted and the worms are working below the soil surface. When the soil is dry, the high rate of Ambush, Asana, Lorsban, Pounce, or Pydrin is recommended.

To determine the need for rescue treatments, scout the fields during plant emergence, particularly those fields considered to be high-risk. Early detection of leaf-feeding or of cutting by cutworms is vital. When the corn plants are beginning to emerge, check the fields for leaf-feeding, cutting, wilting, or missing plants. Small cutworm larvae (less than ½ inch) feed on the leaves and do not begin cutting plants until they are about half grown.

A control measure may be needed on corn if 3 percent or more of the plants are cut and cutworms are still present. A single cutworm will cut 3 or 4 plants if the plants are in the 2-leaf stage or smaller. After corn plants reach the 4-leaf stage, a single cutworm will cut only 1 or 2 plants during the remainder of its larval stage.

Planting-time treatments are relatively effective in controlling light to moderate infestations, but control may be unsatisfactory for heavy infestations particularly under dry soil conditions. Aastar G, Dyfonate II, Lorsban 15G, Mocap 15G, and Pounce 1.5G are labeled for control of cutworms in corn. Counter 15G and Furadan 15G are labeled for suppression of cutworms and are not as effective as the preceding insecticides.

Preemergent sprays of Ambush, Asana, Pounce, and Pydrin may be applied in fields where the probability of cutworm damage is great. Pounce 3.2EC can be broadcast or banded.

A preplant broadcast treatment of Lorsban 4E is registered for corn cutworm control at rates of 1 to 2 quarts per acre; the higher rate is suggested. The insecticide should be incorporated into the top 2 to 4 inches of soil immediately after application.

Replanting may be required if cutworm damage is severe. Before replanting apply Lorsban 4E as a broadcast spray at 3 to 4 pints per acre, and incorporate the insecticide into the top 2 to 4 inches of soil. Or you can apply a preemergent spray of Ambush, Asana, Pounce, or Pydrin after replanting.

WIREWORMS

During the past five years wireworm damage to corn has occurred with increasing frequency. Even so the proportion of fields of corn affected by wireworms in Illinois is small (less than 1 percent) and does not justify the widespread use of a soil insecticide on first-year corn after soybeans. A lindane or diazinon + lindane planter-box seed treatment may help deter the wireworms from attacking the seed but will not protect the seedling.

Wireworms may attack the seed or drill into the base of the stem below ground level, damaging or killing the growing point. Damage will show up as wilted, dead, or weakened plants and spotty stands. Wireworm larvae are yellowish-brown and wirelike; several species are known to attack corn. They live for two to five years in a field in the larval stage, feeding on the roots of grasses and crops. Their presence is often related to the crops or weeds that were in the field two to four years

before damage to the corn is apparent. Most reports of damage to corn have been in fields where corn follows soybeans or where there has been a corn-soybean-small grain rotation. The adult (a click beetle) prefers to deposit its eggs in small-grain stubble or in grassy fields.

Wireworms are usually most damaging in bottomlands or in poorly drained areas on upland soils. Low spots in the field often have the heaviest populations.

Attempts to control wireworms with an insecticide rescue treatment after the damage appears are not very successful. Therefore, if an infestation is known to be present, an insecticide should be applied at planting.

Checking for Wireworms

A technique using baits has been developed for evaluating wireworm potential before planting. The bait stations should be established 2 to 3 weeks before the anticipated planting date. Fields where small grain or grasses have been grown the preceding 2 or 3 years are the best candidates for bait stations.

Since wireworm infestations are usually not uniform within a field, it will be necessary to place the bait stations randomly throughout the field. One bait station per acre is desirable. If you cannot place one bait station per acre, be sure that your baiting program adequately represents all different areas of the field.

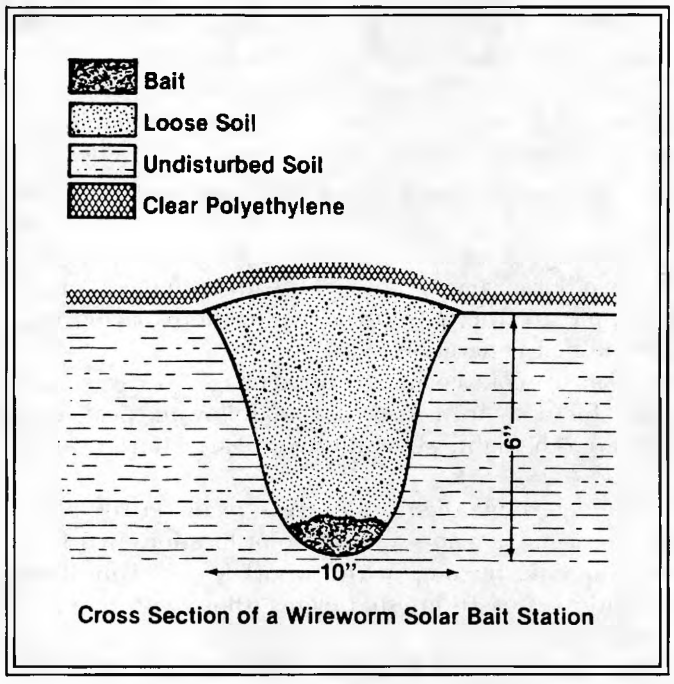
Follow this procedure for baiting:

1. Use a mixture of 1 cup of untreated wheat and 1 cup of untreated shelled corn at each station.

2. Bury the bait about 4 inches deep. It is also desirable to cover the ground over each bait station with an 18-inch square of clear plastic (see diagram). The plastic collects solar heat and speeds germination of the corn and wheat, which attracks overwintering wireworms.

3. Mark each station with a flag or stake.

4. Dig up the bait stations in 10 to 14 days and count the number of wireworms.



Cross Section of a Wireworm Solar Bait Station

Need for Treatment

If you find an average of one or more wireworms per bait station, use a labeled soil insecticide. In some instances, several wireworms may be found in one bait station and none in others. Wireworm infestations tend to concentrate in some locations. It may be possible to limit treatment to areas where the concentration of wireworms is heaviest.

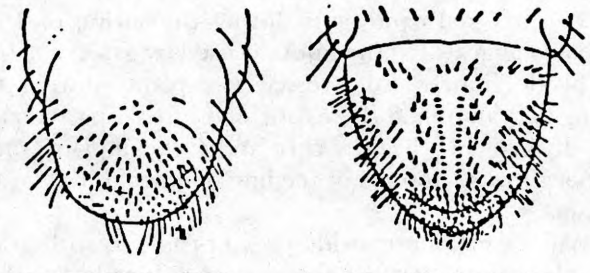
WHITE GRUBS

Several species of economically important white grubs have 3-year life cycles. Peak years of damage usually occur during the year following large flights of May beetles, the adult stage of white grubs. The beetles prefer to lay their eggs in ground covered with vegetation, such as weedy soybean fields and sod.

The C-shaped white grub larvae chew on the roots and root hairs of corn seedlings. During peak years of damage, the grubs feed all season long. Damage to a cornfield is most apparent in the spring. Symptoms of white grub injury visible aboveground are irregular emergence, reduced stands, and stunted or wilted plants. The damage is usually spotty throughout the field.

There are no effective rescue treatments for white grubs after the damage appears. However, if plants show symptoms of injury, dig around the root system of several corn plants. If white grubs are causing the problem and replanting is warranted, use a labeled soil insecticide.

One way to detect the presence of white grubs is to look for them during spring tillage operations. However, if you turn up grubs during spring tillage, be sure to identify them correctly by examining the pattern of



Last Abdominal Segment of Annual and True White Grubs

hairs on the underside of the last abdominal segment (see diagram). True white grubs (right), the species that may damage corn, have two parallel rows of hairs on the underside of the abdomen. Annual white grubs (left) have a more random pattern of hairs, and they rarely cause economic damage to corn. The presence of true white grubs during spring tillage operations might warrant application of a soil insecticide.

GRAPE COLASPIS

Grape colaspis larvae infested many acres of soybeans and corn in the spring of 1988. The majority of fields affected were soybeans planted after soybeans, but fields of soybeans and corn planted after red clover were also damaged. The government set-aside program forced some growers into atypical crop rotations, which in part were responsible for making grape colaspis more of a problem in 1988.

The grape colaspis overwinters as a small larva in the soil. In early spring, the larvae move toward the soil surface and feed on corn and soybean roots. They complete their larval development in mid-June to early July and then enter the pupal, or resting, stage. Adults emerge from the soil in late July and can be found during August in clover, alfalfa, soybeans, corn, and patches of smartweed. The eggs hatch in early fall.

The grape colaspis larva is about ⅛ to ⅙ inch long when fully grown and is shaped like a comma. It has a rather fat, white body and a yellow-brown head. The adult is a yellowish brown, elliptical beetle that resembles a northern corn rootworm. Unlike the northern corn rootworm, the wing covers of the grape colaspis are marked with longitudinal rows of ridges with evenly spaced punctures.

Grape colaspis larvae feed on the roots and root hairs of both corn and soybeans, preventing the plants from getting enough moisture and nutrients. They also scarify the roots and eat out narrow strips on the root. The first symptom of colaspis damage to corn is purpling and wilting of the leaves. Damaged soybean plants are wilted. If the infestation is severe enough, the leaves turn brown and die, and plant populations are reduced.

The dry soil conditions during the spring of 1988 probably aggravated the injury caused by grape colaspis. Herbicide injury also stressed the plants during the spring and amplified the expression of colaspis damage. Rapidly growing, healthy corn and soybean plants often do not show symptoms of feeding damage due to grape colaspis.

Will we encounter widespread problems with grape colaspis again in 1989? Because colaspis beetles lay their eggs in red clover and soybeans, the potential for damage is greatest in fields of soybeans and corn planted after soybeans or red clover. However, if growing conditions are ideal during the spring of 1989, grape colaspis probably will not be a prevalent problem.

The use of a soil insecticide to prevent damage from grape colaspis in 1989 is not warranted. In fact, none of the currently available soil insecticides is labeled for control of grape colaspis in either corn or soybeans. However, insecticides labeled for control of white grubs in corn (Aastar, Counter, Lorsban 15G and 4E, and Thimet) might protect the plants from extensive feeding. Of these products, only Lorsban and Thimet are labeled for use on soybeans.

There are no effective rescue treatments for grape colaspis after the damage appears. But if plants show symptoms of injury, dig around the root system of several plants. If grape colaspis larvae are causing the problem and replanting is warranted, consider applying an insecticide that is labeled for control of white grubs.

EUROPEAN CORN BORER

The European corn borer (ECB) usually has two generations a year in Illinois. In some years there may also be a partial third generation in southern and central Illinois. There are four stages in each generation: egg, larva, pupa, and adult (moth). The ECB overwinters as a full-grown larva in corn stalks, cobs, and plant residue.

First Generation

The ECB moths that lay eggs for the first generation begin to emerge in late May in southern Illinois and in mid-June to late June in the central and northern regions. The females lay most of their eggs in the evening and spend the daylight hours in fencerows and other protected areas (action sites).

First generation ECB larvae reduce yields by stalk-tunneling, which weakens the plant and destroys the tissue used to transport food within the plant.

Different corn hybrids have variable degrees of tolerance or resistance to leaf-feeding by first-generation borers. Consider this trait when selecting varieties.

Scouting Procedure. Corn that is planted early (the fields with the tallest corn) should be monitored closely from mid-June to early July for signs of whorl-feeding by corn borer larvae. The fields with the tallest corn in mid-June are the most attractive to moths laying eggs for the first generation.

Plan to scout cornfields for damage at least once a week for a 2- to 4-week period following peak corn borer moth flight, generally from early June to early July.

To determine the need to treat, examine 100 plants (20 consecutive plants at 5 different locations in a field) for shot-hole feeding in the whorl leaves. Unroll the whorl leaves of 10 infested plants (those with shot-hole feeding) and count the *live* corn borers per infested

plant. Calculate the percentage of plants infested and the average number of live borers per infested plant. Also note the location of the corn borer larvae. Those that are still in the whorl leaves can be controlled, while those that have bored into the stalk are protected from the insecticide. If all larvae have left the whorl leaves and bored into the stalk, it is too late to apply a treatment.

Treatment Guidelines. To decide whether it will be profitable to treat a field infested with first-generation corn borers, the following information is needed:

1. Average percentage of plants with whorl feeding.
2. Average number of larvae per infested plant.
3. Expected yield per acre.
4. Value of grain per bushel.
5. Cost per acre for insecticide treatment.

Enter these data into the worksheet below to calculate the gain or loss for applying an insecticide to control corn borers.

Second Generation

European corn borer moths laying eggs for the second generation are attracted to fields of corn that have recently tasseled or are in the pollen shedding or green silk stage. Late-planted fields of full-season hybrids are usually more attractive and are more likely to sustain economic damage.

Yield losses caused by second-generation ECB are primarily the result of physiological injury, although stalk breakage and ear droppage may become significant if harvest is delayed. Stalk tunneling by corn borers also increases the likelihood of stalk rot.

Scouting Procedure. To assess the need for controlling second-generation ECB, start checking for egg masses when moth flight is under way, usually around mid-July in southern Illinois and late July to mid-August in central and northern Illinois. Concentrate initial scouting efforts in late-planted fields where the probability of an economic ECB infestation is greatest.

Examine a minimum of 25 plants, selected at random throughout the field, and count the number of ECB egg masses that are found on each plant. European corn borer moths usually lay their eggs on the underside of the two or three leaves above or below the developing ear. However, you should check all leaves on the plant for egg masses. One technique is to remove the leaves one by one, starting at the bottom of the plant, and carefully scan them for egg masses. The eggs, which are deposited in masses of 15 to 30, overlap like the scales of a fish.

Egg masses are flat and about ¼ inch in diameter. Newly deposited eggs are white, then turn pale yellow, and become darker just before hatching. Eggs that are about to hatch have distinct black centers. These are the black heads of the larvae that are visible through the translucent eggshell. The eggs hatch in 3 to 7 days, depending on the temperature.

The female moth rests in grassy areas during the day. Noncrop areas that border cornfields may harbor large numbers of corn borer moths. Check these areas for moths as you enter the field to determine the potential for corn borer infestation.

Calm nights favor egg deposition by the moths. The

Management Worksheet for First-Generation Corn Borer

_____ % of 100 Plants Infested × _____ Average No. Borers/Infested Plant = _____ Borers/Plant
(determined by checking whorls from 10 plants)

_____ Borers/Plant × 5% Yield Loss/Borer = _____ % Yield Loss

_____ % Yield Loss × _____ Expected Yield (Bu/A) = _____ Bu/A Loss

_____ Bu/A Loss × $_____ Price/Bu = $_____ Loss/A

$_____ Loss/A × _____ % Control = $_____ Preventable Loss/A
(80% for granules)
(50% for sprays)

$_____ Preventable Loss/A − $_____ Cost of Control/A =
$_____ Gain (+) or Loss (−) per acre if treatment is applied

Management Worksheet for Second-Generation Corn Borer

_____ Number of Egg Masses/Plant × 2 Borers/Egg Mass* = _____ Borers/Plant
(cumulative counts, taken 7 days apart)

_____ Borers/Plant × 4 % Loss/Borer** = _____ % Yield Loss

_____ % Yield Loss × _____ Expected Yield = _____ Bu/A Loss

_____ Bu/A Loss × $_____ Price/Bu = $_____ Loss/A

$_____ Loss/Acre × 75 % Control = $_____ Preventable Loss/A

$_____ Preventable Loss/A − $_____ Cost of Control/A =
$_____ Gain (+) or Loss (−) per acre if treatment is applied

* Assumes survival rate of 2 borers/egg mass.
** Use 3% per borer per plant if infestation occurs after silks are brown. The potential economic benefits of treatment decline rapidly if infestations occur after corn reaches the blister stage.

absence of hard, beating rains during moth emergence also increases the potential for infestations.

Treatment Guidelines. To determine whether it will be profitable to treat a field to control second-generation corn borers, the following information is needed:

1. Average number of ECB egg masses per plant.
2. Crop maturity.
3. Expected yield per acre.
4. Value of corn per bushel.
5. Cost per acre for insecticide treatment.

For best results, treatment should be applied soon after egg hatch to kill the young larvae before they bore into the plant. The larvae begin tunneling into the stalks about 10 days after hatching. Occasionally, two treatments may be necessary for satisfactory control if egg laying extends over a 3- to 4-week period.

REDUCED TILLAGE AND NO-TILL CORN INSECT PESTS

Concern about insect problems should not keep growers from adopting conservation tillage practices. The soil-insect complex in corn, which is similar in many ways in conventional and reduced-tillage systems, can be readily controlled by applying soil insecticides at planting time. Outbreaks of insects feeding on foliage can usually be reduced with properly timed insecticide treatments. Close monitoring of fields to detect insect outbreaks is essential, regardless of the tillage system.

Weather conditions and the type of crop rotation determine to a great extent whether a soil insect problem will occur and what kind it will be. In some instances, tillage may also influence the kind and abundance of an insect pest. Some tillage operations favor specific pests. Others tend to reduce pest problems. The general expectation is that insect infestations will be more pronounced in a no-till system than in conventional or reduced-tillage systems.

No-Till Pests

Insect problems occur more frequently in no-till corn than in any other conservation tillage system and are often more serious. Crop residue left by the use of no-till practices provides a more stable environment for pest survival and development. Pests occurring under these conditions include *European corn borer, cutworms, armyworm, common stalk borer, wireworms, seedcorn maggots, billbugs, slugs,* and *mice.* Soil insecticides may be needed on no-till corn following corn (in rootworm area), grass sod, legumes, or following any crop in which grasses and broadleaf weeds are prevalent.

Soil Insect Control

Select a soil insecticide that will control the anticipated soil insect pest. Consult Table 5 for suggestions. If a soil insecticide is not applied at planting, a diazinon + lindane planter-box seed protectant will protect the seed against seedcorn maggots, seedcorn beetles, and light infestations of wireworms.

Crop residues from no-till and reduced-tillage systems may present some problems with the placement and incorporation of granular soil insecticides applied at planting. To be most effective, the soil insecticide

should be incorporated into the upper ½ inch of soil, and not just broadcast on the surface.

NOTE: Before using Broot, Dyfonate, Mocap, or Thimet on no-till corn, be sure that soil moisture is low enough to ensure closing of the seed furrow to prevent the insecticide granules from contacting the seed. Crop injury may occur with these products.

Aboveground Insect Pests

Aboveground insects may be more of a problem in no-till corn than under reduced or conventional tillage. Corn planted in grass sod or fall-seeded rye is vulnerable to attack by **armyworms.** The moths lay eggs on the grasses during April or early May. After vegetation is killed by a herbicide, the larvae move to the young corn seedlings and feed on them. Control is justified when 25 percent of the plants are being damaged. Rescue treatments are effective; a spray volume of 15 to 20 gallons per acre will improve coverage and control.

Instances of damage to corn by the **common stalk borer** have been greater in no-till corn than in other tillage systems. Moths of this insect deposit their eggs in late August and September on weeds, particularly quackgrass, giant foxtail, ragweed, and wirestem muhly. When a herbicide is applied in the spring to no-till corn in fields previously infested with host weeds, the newly hatched stalk borer larvae move from the dead vegetation and attack newly emerging corn plants. Rescue treatments may give erratic control of common stalk borer because the chemicals cannot reach the worms inside the stem. To reduce the potential for stalk borer damage in a subsequent season, it is essential to have good weed control within a field during August and September when moths are laying eggs.

SPIDER MITES

Spider mites seriously injured soybeans throughout much of Illinois in 1988. The mite species most commonly infesting soybean fields throughout the state was the twospotted spider mite. Mites are not insects but are closely related arthropods. Mites hatch from very small eggs, which with the aid of a magnifying glass can be seen on the undersurface of soybean leaves. Larvae with six legs emerge from the eggs and progress through two nymphal stages, each with eight legs. Following the last nymphal molt, the eight-legged adults emerge, representing the reproductive portion of the life cycle. The time necessary to complete a generation ranges from 1 to 3 weeks and depends on environmental conditions, mainly the temperature.

Mites have piercing and sucking mouthparts with which they puncture plant cells and remove plant juices. Once plant cells have been damaged, they do not recover. Foliage that becomes yellow and that has brown stippling with webbing on the undersurface of the leaves is characteristic of a mite infestation. Severe infestations may cause complete defoliation of soybean plants. Mites can move very easily throughout fields by ballooning, that is, by spinning webs and moving to a position on a leaf from which they can be blown aloft. Mites can also go from row to row by bridging or moving across leaves that are in contact when canopy closure is near completion.

Field margins are frequently the first areas of a field to be infested as mites move from nearby grasses and weeds. In order to manage spider mite populations in 1988, many producers initially treated infested border rows. This tactic was not altogether successful in some fields, and many farmers had to return to earlier treated fields to apply insecticides to the entire field. If not for the extended hot, dry period in 1988, the management tactic of treating border rows might have provided better results.

The outlook for 1989 is uncertain. We know that hot, dry weather increases the potential for spider mite problems. Twospotted spider mites overwinter in sheltered areas as adult females. We anticipate larger than normal populations of mites going into this winter, but this does not imply that spider mites will cause severe problems in 1989. If temperatures are moderate and rainfall is near normal, spider mites should not cause much concern in 1989. The economic threshold for twospotted spider mites is not clearly defined. When mites and symptoms of their feeding damage are observed, treatment is usually warranted. Treatment of border rows initially is still the recommended management strategy when mites and damage are present.

BEAN LEAF BEETLES

Bean leaf beetle populations were present in record numbers in many fields of soybeans throughout Illinois in August, 1988. This extraordinarily large population will overwinter as adults (beetles) under residue in fencerows, wooded areas, and other protected sites. The survival of the overwintering beetles depends on the severity of the winter. A mild winter increases the chances for a large population of beetles in the spring of 1989. In addition, if soybeans are planted early in 1989, the beetles will establish themselves early.

As temperatures warm above 55°F, the bean leaf beetles fly to alfalfa, clover, or seeds to feed. If soybeans are planted early in 1989, however, the beetles will abandon the forage fields or move directly from hibernation sites to colonize and feed on the leaves of the early emerging bean seedlings. Soybeans can withstand considerable leaf feeding during the vegetative (prebloom) stage, but treatment may be necessary if defoliation reaches 30 percent and at least one cotyledon per foot of row is destroyed.

In addition to feeding on the leaves, the adults lay eggs in the soil near the soybean plant. Egg hatch commences in late May, and the larvae feed on the roots and nodules of the soybeans during June. Adults of the first generation emerge in July. These beetles feed on the soybean foliage, lay eggs, and the new larvae emerge as second-generation adults during August and September. These adults do not lay eggs, although they stay in soybean fields as long as there are green leaves or tender pods to chew on. As soybeans mature, and temperatures fall, the beetles fly to winter hibernation sites.

The availability of early emerging soybeans is essential for the survival of bean leaf beetles coming out of winter hibernation sites. A large acreage of early planted soybeans generally results in the survival of large numbers of bean leaf beetles early in the season and even larger adult populations in August. Conversely, a severe winter and later-planted soybeans will reduce the rate of survival of bean leaf beetles in the spring and also the size of first- and second-generation populations.

Insecticide treatments are recommended during the critical pod-set and pod-fill stages when defoliation exceeds 20 percent. The greatest concern, however, is caused by the beetles' feeding on pods, which leaves scars on many pods. These scars predispose the pods to fungal infections. Beans within the damaged pod may be discolored, deformed, or moldy. A treatment is recommended when 5 to 10 percent of the pods are damaged.

ALFALFA INSECTS

Alfalfa weevils may cause moderate to severe damage to the first cutting of alfalfa in most areas of Illinois. In the southern counties, where egg laying takes place in the fall, alfalfa weevil larval damage occurs early in the spring. Damage to the first cutting in northern Illinois is more likely to occur if hay harvest is delayed. Otherwise the injury to alfalfa in the northern counties will occur on the stubble and new growth of the second cutting.

Numbers of alfalfa weevils are regulated to a large extent by winter weather. During a cold, open winter the mortality rate is high in overwintering weevil populations; during mild winters the mortality rate is low.

A parasitic wasp and a fungal disease may regulate weevil numbers in the spring. Although the wasp and the fungus will be present in alfalfa fields in 1989, we cannot yet predict their effect on weevil numbers. In general, wet weather promotes the spread of the fungal disease throughout the weevil population.

Alfalfa growers in southern and central Illinois should inspect their fields closely in April, May, and June. Early larval damage appears as pinholes in the growing terminals. As the larvae grow, they skeletonize the leaves, and damaged fields appear tattered. Growers in northern Illinois should look carefully for larval damage in May and June. All growers should examine the stubble after the first cutting, because larval and adult feeding can slow or halt new growth. Follow the suggestions in Circular 1136, *Alfalfa Weevil Pest Management Program,* to determine the need and proper timing of a treatment. If this circular is unavailable, a rule of thumb is to treat when 25 percent of the tips are being skeletonized. This threshold is 40 percent in northern Illinois where damage occurs later in the season.

Potato leafhoppers may cause moderate to severe damage to the second and third cuttings of alfalfa in all areas of Illinois. However, population levels are difficult to predict because the leafhoppers do not survive the winter in Illinois. They migrate from southern states into Illinois during May and June.

Damage first appears as a yellow, wedge-shaped area at the tip of the leaf. Many people confuse the damage with diseases or nutrient deficiency.

Damage may begin on the new growth as soon as the first hay crop is removed. Stunting and yellowing are signs of leafhopper injury. A swarm of leafhoppers at the time of the first cutting also indicates that there may be a problem in the new growth. The economic threshold for leafhoppers varies with the height of the alfalfa (see Table 4). A treatment is justified when the number of leafhoppers exceeds the economic threshold.

Table 4. Economic Thresholds for Potato Leafhoppers on Alfalfa

Alfalfa height (inches)	Average number of leafhoppers per sweep of sweep net
0-3	0.2
3-6	0.5
6-12	1.0
12 or taller	1.5

CALIBRATION FOR GRANULAR SOIL INSECTICIDES

Calibrate the applicators for granular soil insecticides before the planting season begins. In some instances, poor control is caused by applying rates that are too low. Proper calibration will help avoid this problem. Most soil insecticide bags have a list of suggested settings for the particular model of applicator. The settings are based on planting speed. The *beginning settings* are helpful, but be sure to check your actual application rate under your own operating conditions.

Follow these steps for calibrating the applicator:

1. Calibration of granular applicators for soil insecticides is usually based on ounces of product needed per 1,000 feet of row. Consult the insecticide label or Table

3 for labeled rates for rootworm control. These rates are expressed in ounces per 1,000 feet of row and in pounds of product per acre.

2. Consult the label or manufacturer's recommendation for an approximate application setting. Adjust the setting on each hopper.

3. Select an area for a test run, preferably in the field so that speed and traction conditions are constant. Measure off 1,000 feet.

4. Fill the hoppers and attach a plastic bag or container to each delivery tube to catch the granules from each hopper.

5. Drive the premeasured distance (1,000 feet) at the same speed to be used during the planting operation.

6. Weigh the material collected from each hopper. Use a scale that weighs in ounces (e.g., a postal scale or a diet scale).

7. Compare the weight (ounces) per bag against those given in Table 3. The following amounts of material should be collected:

Formulation, percent	Ounces collected per 1,000 feet
10	12
15	8
20	6

8. Recalibrate if the difference in the amount of insecticide applied during the calibration process is more than 10 percent over or under the rate suggested on the label.

PLANTER-BOX SEED TREATMENTS

Corn. Consider using a seed treatment in fields that do not receive a soil insecticide at planting time. A planter-box seed treatment containing diazinon will protect germinating corn against attack by seedcorn beetles and maggots. A lindane or diazinon + lindane planter-box seed treatment protects seed from attack by seedcorn maggots, seedcorn beetles, and wireworms. Lorsban 50-SL is labeled as a slurry treatment on seed before planting to protect germinating seed against injury by seedcorn maggots and beetles. NOTE: Excess dust from the seed treater may interfere with the electronic monitor in air planters.

Some seed may have already been treated with a combination of insecticide and fungicide. Addition of diazinon + lindane may cause planter units to gum up. Consult your seed or insecticide dealer to obtain specific information about seed treatment combinations.

Soybeans. Consider using a diazinon or diazinon + lindane seed protectant to prevent damage to germinating soybeans from seedcorn maggots. Follow the label directions for application. Potential damage is greatest during cool, wet springs when germination is slow.

CHEMICAL INJURY TO SOYBEANS

There have been instances of phytotoxicity to soybeans when organophosphate soil insecticides were used. The problems have occurred where growers started planting soybeans without first emptying the insecticide boxes. Organophosphate soil insecticides applied in soybean fields treated with Sencor or Lexone may cause injury to a soybean crop, according to information on the labels.

Table 5. Insecticides for Field Corn

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworms (True)	*Furadan 15G	8 oz. per 1,000 ft. row	Band, furrow	Apply as a planting-time treatment for early season control of armyworms in corn planted no-till in grass sod or small grains.
	*Ambush 2E	6.4-12.8 oz.	Broadcast	Seedling corn: Control is justified when 25 percent of the plants are being damaged. After pollen shed: Control is justified when the armyworms are eating leaves above ear level.
	*Asana 1.9EC	1.7-3.4 oz.		
	Dylox 80SP	10-20 oz.		
	Lorsban 4E	1-2 pt.		
	malathion 57%EC	1½-2 pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2-4 pt.		
Billbug	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	At planting.
	Lorsban 15G	8-16 oz. per 1,000 ft. row	Band	
	Lorsban 4E	4 pt.	Broadcast-PPI[c]	
	Lorsban 4E	2-3 pt.	Broadcast	Apply as a postemergence rescue treatment with ground equipment when damage appears.
Chinch bug	*Asana 1.9EC	1.7-3.4 oz.	Spray at base of plant.	Treat border rows at the start of migration from small grains. Use only ground equipment and apply 20 to 40 gallons of finished spray per acre.
	Lorsban 4E	2-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2-4 pt.		
Common stalk borer	*Ambush 2E	6.4-12.8 oz.	Broadcast	Apply postemergence sprays when young larvae are moving from weed hosts to corn. See labels for more specific instructions about effective control.
	*Asana 1.9EC	1.7-3.4 oz.		
	Lorsban 4E	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
Corn earworm	*Ambush 2E	6.4-12.8 oz.	Overall spray or directed toward ear zone	Justified only in seed corn fields. Treatments are rarely effective for the control of earworms after worms enter ear tips.
	*Asana 1.9EC	1.7-3.4 oz.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
Corn leaf aphid	Cygon 400	⅔-1 pt.	On foliage	Apply during late whorl to early tassel when 50% of plants have light to moderate infestations and plants are under drouth stress.
	Lorsban 4E	1-2 pt.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	2-3 pt.		
Corn rootworm beetles	*Ambush 2E	6.4-12.8 oz.	Overall spray or directed toward ear zone	To protect pollination, treat if there are 5 or more beetles per plant, pollination is not complete, and if silk clipping is observed. Apply Ambush or Pounce prior to the brown silk stage.
	*Asana 1.9EC	1.7-3.4 oz.		
	Cygon 400	⅔-1 pt.		
	Imidan 50WP	½-1 lb.		
	Lorsban 4E	1-2 pt.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-2 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2 pt.		
Corn rootworm larvae	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting. Broot 15GX, Counter 15G, Dyfonate II, Furadan 15G and 4F, Lorsban 15G and 4E, Mocap 15G, and Thimet 20G can also be applied at cultivation time.
	Broot 15GX	8 oz. per 1,000 ft. row	Band	
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Dyfonate II	6 oz. per 1,000 ft. row	Band	
	*Dyfonate 4E	6 pt.	Broadcast-PPI[c]	
	*Dyfonate 4E	2.5 fl. oz. per 1,000 ft. row	Band	
	*Furadan 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Furadan 4F	2.5 fl. oz. per 1,000 ft. row	Band	
	Lorsban 15G	8 oz. per 1,000 ft. row	Band	
	Lorsban 4E	6 pt.	Broadcast-PPI[c]	
	*Mocap 15G	8 oz. per 1,000 ft. row	Band	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	

Table 5. Insecticides for Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Cutworms	Lorsban 4E	2-4 pt.	Broadcast-PPI[c]	Incorporate into the top 2 to 4 inches of soil.
	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	Dyfonate II	6 oz. per 1,000 ft. row	Band	
	Lorsban 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Mocap 15G	8 oz. per 1,000 ft. row	Band	
	*Pounce 1.5G	8-16 oz. per 1,000 ft. row	Band	
	*Ambush 2E	6.4-12.8 oz.	PRE[d]	Lorsban 4E is labeled as a preemergent in conservation tillage corn. Pounce 3.2EC can be broadcast or banded.
	*Asana 1.9EC	1.7-3.4 oz.	PRE[d]	
	Lorsban 4E	1-2 pt.	PRE[d]	
	*Pounce 3.2EC	4-8 oz.	PRE[d]	
	*Pydrin 2.4EC	5⅓-10⅔ oz.	PRE[d]	
	*Ambush 2E	6.4-12.8 oz.	PE[e]	Apply as a postemergence rescue treatment when 3 percent or more of the plants are cut and larvae are still present.
	*Asana 1.9EC	1.7-3.4 oz.	PE[e]	
	Lorsban 4E	2-3 pt.	PE[e]	
	*Pounce 3.2EC	4-8 oz.	PE[e]	
	*Pydrin 2.4EC	5⅓-10⅔ oz.	PE[e]	
European corn borer, first generation	*Ambush 2E	6.4-12.8 oz.	On upper ⅓ of plant and into whorl	See "Treatment Guidelines" under European Corn Borer, first generation. Granular formulations are more effective than sprays when applied by air for control of first-generation borers. Sprays are most effective when directed by ground equipment over the row, rather than broadcast. Apply Dipel ES only by ground equipment or center pivot irrigation.
	Dipel 10G	10 lb.		
	Dipel ES	2 pt.		
	*Dyfonate II	5 lb.		
	*Furadan 15G	6.7 lb.		
	*Furadan 4F	2 pt.		
	Lorsban 4E	1½-2 pt.		
	Lorsban 15G	5-6.5 lb.		
	*Penncap-M	4 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pounce 1.5G	6.7-13.3 lb.		
European corn borer, second generation	*Ambush 2E	6.4-12.8 oz.	On foliage	See "Treatment Guidelines" under European Corn Borer, second generation. Apply Ambush 2E or Pounce 3.2EC prior to the brown silk stage.
	Dipel 10G	10 lb.		
	Dipel ES	2 pt.		
	*Dyfonate II	5 lb.		
	*Furadan 15G	6.7 lb.		
	*Furadan 4F	2 pt.		
	Lorsban 15G	5-6.5 lb.		
	Lorsban 4E	2 pt.		
	*Penncap-M	4 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pounce 1.5G	6.7-13.3 lb.		
Fall armyworm	Dylox 80SP	10-20 oz.	On foliage	Treat when 35% of plants have whorl damage and if worms are present. Ground sprays directed over the row are more effective than broadcast sprays. Treatments to control worms in ear tips are not effective.
	Lannate, Nudrin 90WSP	½ lb.		
	Lorsban 4E	2 pt.		
Flea beetles	*Ambush 2E	6.4-12.8 oz.	Over row as spray	When leaves on seedling plants are severely damaged and plants are being killed.
	*Asana 1.9EC	1.7-3.4 oz.		
	Lorsban 4E	2 pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2 pt.		
Grasshoppers	*Asana 1.9EC	1.7-3.4 oz.	On foliage	Treatment may be warranted when there are 7 or more grasshoppers per square yard. After pollen shed, control is justified when grasshoppers are feeding on leaves above ear level. The higher rates are suggested for control of adult grasshoppers.
	Cygon 400	1 pt.		
	*Furadan 4F	¼-½ pt.		
	Lorsban 4E	½-1 pt.		
	malathion 57%EC	1½ pt		
	*Penncap-M	1-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	1-3 pt.		

Table 5. Insecticides for Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Hop vine borer	None labeled	..	...	Postemergence sprays of Ambush, Asana, Pounce, Pydrin, or Lorsban may give some control if applied when damage first appears.
Japanese beetle	Sevin XLR Plus	2 pt.	On foliage	During the silking period to protect silks if there are 3 or more beetles per ear and pollination is not complete.
Picnic, sap beetles	Lannate 90WSP malathion 57%EC Sevin XLR Plus	¼-½ lb. 1½ pt. 2 pt.	On foliage	Justified only in seed corn fields when beetles are causing significant injury to ear tips.
Seedcorn beetles	*Aastar G *Counter 15G *Dyfonate II Lorsban 15G *Thimet 20G	8 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 6 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 6 oz. per 1,000 ft. row	Band Band, furrow Band Furrow Band	At planting.
	diazinon diazinon + lindane Lorsban 50-SL	See label See label See label	On seed On seed On seed	Use formulations that are prepared as seed treaters.
Seedcorn maggots	*Aastar G *Counter 15G *Dyfonate II *Furadan 15G Lorsban 15G *Thimet 20G	8 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 6 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 6 oz. per 1,000 ft. row	Band Band, furrow Band Furrow Furrow Band	At planting.
	diazinon diazinon + lindane Lorsban 50-SL	See label See label See label	On seed On seed On seed	Use formulations that are prepared as seed treaters. Seed treatments should be considered for fields that do not receive a soil insecticide at planting.
Sod webworm	*Aastar G Lorsban 4E	8 oz. per 1,000 ft. row 1-2 pt.	Band Broadcast	At planting. At time of initial attack.
Southwestern corn borer	*Ambush 2E *Dyfonate II *Furadan 15G *Furadan 4F Lorsban 15G Lorsban 4E *Penncap-M *Pounce 3.2EC *Pounce 1.5G	6.4-12.8 oz. 5 lb. 6.7 lb. 2 pt. 6.5 lb. 2 pt. 4 pt. 4-8 oz. 6.7-13.3 lb.	On foliage	Direct granules over row. Apply when 25% of the plants have egg masses or larvae on leaves. Early planted corn usually escapes damage. Sprays are most effective when directed over the row, rather than broadcast. Apply Ambush 2E or Pounce 3.2EC prior to the brown silk stage.
Spider mites	Cygon 400 Diazinon AG 500	1 pt. 1 pt.	On foliage	Begin control if the majority of plants are infested with mites severe enough to cause some yellowing or browning of the lower leaves before dent stage.
Symphylans	*Counter 15G *Dyfonate 4E Lorsban 15G Lorsban 4E *Mocap 15G	8 oz. per 1,000 ft. row 4 pt. 8 oz. per 1,000 ft. row 2-4 pt. 8 oz. per 1,000 ft. row	Band, furrow Broadcast-PPI Band Broadcast-PPI Band	At planting.
Thrips	malathion 57%EC	1½ pt.	On foliage	When severe wilting and yellowing of leaves are noticed.
White grubs	*Aastar G *Counter 15G Lorsban 15G Lorsban 4E *Thimet 20G	8 oz. per 1,000 ft. row 8 oz. per 1,000 ft. row 8-16 oz. per 1,000 ft. row 4 pt. 6 oz. per 1,000 ft. row	Band Band, furrow Furrow Broadcast-PPI Band	At planting. Furadan 15G is labeled to aid in the control of white grubs, and Mocap 15G is labeled for their suppression.

Table 5. Insecticides for Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Wireworms	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	Dyfonate II is labeled for suppression of wireworms.
	*Dyfonate 4E	8 pt.	Broadcast-PPI[c]	
	*Furadan 4F	2.5 oz. per 1,000 ft. row	Furrow	
	*Furadan 15G	8 oz. per 1,000 ft. row	Band, furrow	
	Lorsban 15G	16 oz. per 1,000 ft. row	Band, furrow	
	Lorsban 4E	4 pt.	Broadcast-PPI[c]	
	*Mocap 15G	8 oz. per 1,000 ft. row	Band	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	
	lindane	See label	On seed	Use formulations that are prepared as seed treaters.
	diazinon + lindane	See label	On seed	
Woollybear caterpillars	None labeled	. .	. . .	Silk clipping caused by caterpillars does not generally warrant control.

* Use restricted to certified applicators only.
[a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.
[c] PPI Pre-plant incorporated.
[d] PRE Preemergent application.
[e] PE Postemergent application.

Table 6. Insecticides for Soybeans

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Bean leaf beetle	*Ambush 2E	3.2-6.4 oz.	On foliage	**Seedlings:** Treat if 20% of the plants are cut and the stand has gaps of 1 foot or more; or treat if at least 1 cotyledon per foot of row is destroyed. This level of damage usually requires 5 or more beetles per foot of row. **Before bloom:** when defoliation reaches 30% and there are 5 or more beetles per foot of row. **Bloom to pod fill:** when defoliation reaches 20% and there are 16 or more beetles per foot of row. **Seed maturation:** when 5 to 10% of the pods are damaged, the leaves are green, and there are 10 or more beetles per foot of row.
	*Asana 1.9EC	1.7-3.4 oz.		
	Cygon 400	1 pt.		
	Larvin 3.2F	18-30 oz.		
	Lorsban 4E	1-2 pt.		
	Orthene 75S	⅔ lb.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓ oz.		
	Sevin XLR Plus	1-2 pt.		
Blister beetles	Sevin XLR Plus	1-2 pt.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Corn earworm	*Ambush 2E	6.4-12.8 oz.	On foliage	Damage occurs when larvae feed on pods. Apply control if populations exceed 1 per foot of row and 5 to 10% of the pods are damaged.
	*Asana 1.9EC	1.7-3.4 oz.		
	Larvin 3.2F	10-16 oz.		
	Orthene 75S	1⅓ lb.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
Cutworms	*Asana 1.9EC	1.7-3.4 oz.	Broadcast	Scout as plants are emerging. Treat if 20% of plants are cut, stand has gaps of one foot or more, and cutworms are present.
	Larvin 3.2F	20-30 oz.		
	Lorsban 4E	2 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		

Table 6. Insecticides for Soybeans (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Grasshoppers	*Asana 1.9EC	1.7-3.4 oz.	On foliage	When migration into fields begins and defoliation or pod feeding reaches economic levels. When defoliation reaches 30% before bloom and 20% between bloom and pod fill. When 5 to 10% of the pods are damaged. The higher rates are suggested for control of adult grasshoppers.
	Cygon 400	1 pt.		
	*Furadan 4F	¼-½ pt.		
	Lorsban 4E	½-1 pt.		
	Orthene 75S	⅓-⅔ lb.		
	*Penncap-M	1-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	1-3 pt.		
Green cloverworm	*Ambush 2E	3.2-6.4 oz.	On foliage	When defoliation occurs during blooming, pod set, and pod fill. Usually requires 12 or more half-grown worms per foot of row and 20% defoliation to justify treatment.
	*Asana 1.9EC	0.85-1.7 oz.		
	Dipel	See label		
	Larvin 3.2F	10-16 oz.		
	Lorsban 4E	½-1 pt.		
	Orthene 75S	⅔ lb.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR Plus	1-2 pt.		
Japanese beetle adults	*Asana 1.9EC	1.7-3.4 oz.	On foliage	When defoliation reaches 20% during bloom and pod fill.
	*Penncap-M	3-4 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2 pt.		
Loopers	*Ambush 2E	3.2-6.4 oz.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Asana 1.9EC	1.7-3.4 oz.		
	Larvin 3.2F	18-30 oz.		
	Orthene 75S	⅔-1⅓ lb.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Dipel	See label		
Mexican bean beetle	*Ambush 2E	3.2-6.4 oz.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Asana 1.9EC	0.85-1.7 oz.		
	Cygon 400	1 pt.		
	*Furadan 4F	1 pt.		
	Larvin 3.2F	18-30 oz.		
	Lorsban 4E	1 pt.		
	Orthene 75S	⅔ lb.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR Plus	1-2 pt.		
Potato leafhopper	*Ambush 2E	3.2-6.4 oz.	On foliage	When leafhoppers are numerous and the edges of the leaves appear burned.
	*Asana 1.9EC	0.85-1.7 oz.		
	Cygon 400	1 pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR Plus	2 pt.		
Seedcorn maggot	diazinon	See label	On seed	At planting time. Use formulations that are prepared as seed treaters.
	diazinon + lindane	See label	On seed	
Spider mites	Cygon 400	1 pt.	On foliage	When symptoms of injury appear and mites are present.
	Dimethoate 400	1 pt.		
	Lorsban 4E	½-1 pt.		
Stink bugs	*Asana 1.9EC	1.7-3.4 oz.	On foliage	When adult bugs or large nymphs reach 1 per foot of row during pod fill.
	Lorsban 4E	2 pt.		
	Orthene 75S	1-1⅓ lb.		
	*Penncap-M	2-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		

Table 6. Insecticides for Soybeans (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Thistle caterpillar	Sevin XLR Plus	3-4 pt.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Thrips	*Penncap-M Sevin XLR Plus	2-3 pt. 2 pt.	On foliage	If seedlings are being seriously damaged and some plants are being killed.
Webworms	Sevin XLR Plus	2-3 pt.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Whitefly	None labeled	..	...	High infestations are occasionally present on double-crop soybeans, but are rarely economic.
Woollybear caterpillars	*Ambush 2E *Asana 1.9EC Larvin 3.2F Lorsban 4E *Pounce 3.2EC *Pydrin 2.4EC	3.2-6.4 oz. 0.85-1.7 oz. 10-16 oz. 1-2 pt. 4 oz. 2⅓-5⅔ oz.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.

* Use restricted to certified applicators only. [a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

Spraying blossoming soybeans can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your County Extension Office.

Table 7. Insecticides for Alfalfa
To avoid injury to bees, do not spray alfalfa during bloom or if weeds are blooming.

Insect	Insecticide[a,b,c]	Amount of product per acre[c]	Placement	Timing of application, comments
Alfalfa caterpillar	*Ambush 2E Dipel Dylox 80SP *Pounce 3.2EC Sevin XLR Plus	3.2-12.8 oz. See label 8-10 oz. 2-8 oz. 2 pt.	On foliage	When damage to foliage is obvious and there are at least 10 nonparasitized larvae per sweep.
Alfalfa weevil (spring treatment for larvae)	*Ambush 2E *Furadan 4F Imidan 50WP Lorsban 4E[d] *Penncap-M *Pounce 3.2EC *Supracide 2E	6.4-12.8 oz. ½-1 pt. 2 lb. 2 pt. 2-3 pt. 4-8 oz. 2 pt.	On foliage	Refer to Circular 1136. Or when 25% to 40% of tips are being skeletonized and if there are 3 or more larvae per stem, treat immediately. Do not apply sprays during bloom. Instead, cut and remove the hay. Two treatments may be necessary on first cutting. Watch regrowth for signs of damage, and treat if feeding damage is apparent.
Alfalfa weevil adults	*Furadan 4F Imidan 50WP Lorsban 4E[d] *Penncap-M	1-2 pt. 2 lb. 1-2 pt. 2-3 pt.	On foliage	As a stubble spray when regrowth of the plants is delayed due to weevil feeding damage.
Aphids	*Ambush 2E Cygon 400 *Furadan 4F Lorsban 4E[d] malathion 57%EC *Penncap-M *Pounce 3.2EC *Supracide 2E	3.2-12.8 oz. ½-1 pt. ½ pt. ½ pt. 1½ pt. 2 pt. 2-8 oz. 2 pt.	On foliage	When aphids average 100 or more per sweep and lady beetle larvae and adults, parasites, and diseases are not abundant.

Table 7. Insecticides for Alfalfa (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Blister beetles	Sevin XLR Plus	1-2 pt.	On foliage	Although blister beetles rarely cause economic damage to alfalfa, their presence in hay could injure horses if the horses ingest the beetles.
Cutworms	*Ambush 2E	3.2-12.8 oz.	On foliage	When seedling plants or regrowth is being damaged.
	Dylox 80SP	10-20 oz.		
	Lorsban 4E[c,d]	2 pt.		
	*Pounce 3.2EC	2-8 oz.		
	Sevin XLR Plus	2-3 pt.		
Fall armyworm	Dylox 80SP	20 oz.	On foliage	Usually in late summer or early fall on new seedlings or established stands.
	Lorsban 4E[d]	2 pt.		
	Sevin XLR Plus	2 pt.		
Grasshoppers	Cygon 400	½-1 pt.	On foliage	When grasshoppers are small, before damage is severe, and there are 15 to 20 per square yard. The higher rates are suggested for control of adult grasshoppers.
	*Furadan 4F	¼-½ pt.		
	Imidan 50WP	3-4 lb.		
	Lorsban 4E[d]	½-1 pt.		
	*Penncap-M	1-3 pt.		
	Sevin XLR Plus	1-3 pt.		
Leafhoppers	*Ambush 2E	3.2-12.8 oz.	On foliage	Treatment is justified at these combinations of alfalfa height and leafhopper numbers:
	Cygon 400	½-1 pt.		
	Dylox 80SP	10-20 oz.		
	*Furadan 4F	1 pt.		
	Imidan 50WP	2 lb.		
	Lorsban 4E[d]	1-2 pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	2-8 oz.		
	Sevin XLR Plus	2 pt.		
	*Supracide 2E	2 pt.		

Alfalfa height (inches)	Leafhoppers per sweep
0-3	0.2
3-6	0.5
6-12	1.0
12 or taller	1.5

Plant bugs	*Ambush 2E	6.4-12.8 oz.	On foliage	When tip damage is obvious and nymphs and adults average 3 per sweep on alfalfa less than 3 inches tall, or 5 per sweep on alfalfa taller than 3 inches.
	Cygon 400	½-1 pt.		
	Dylox 80SP	20 oz.		
	*Furadan 4F	2 pt.		
	Lorsban 4E[d]	1-2 pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
	Sevin XLR Plus	2 pt.		
Spittlebug	*Ambush 2E	6.4-12.8 oz.	On foliage	When spittle masses are found and nymphs average more than 1 per stem.
	Imidan 50WP	2 lb.		
	Lorsban 4E[d]	1-2 pt.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
Webworms	*Ambush 2E	3.2-12.8 oz.	On foliage	If damage appears.
	Dylox 80SP	20 oz.		
	*Pounce 3.2EC	2-8 oz.		
	Sevin XLR Plus	2-3 pt.		

* Use restricted to certified applicators only. [a] See Table 13 for insecticide restrictions.

[b] Before applying insecticides, be certain to clean all herbicides out of equipment. During bloom, apply very late in day or, if possible, avoid application during bloom.

[c] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

[d] Young, tender, rapidly growing alfalfa may show some phytotoxic symptoms when treated with Lorsban 4E.

Spraying blossoming alfalfa can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your County Extension Office.

Table 8. Insecticides for Grain Sorghum

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Chinch bug	Lorsban 4E[c]	2 pt.	At plant base	Use only ground equipment and apply 20 to 40 gallons of finished spray per acre.
	Sevin XLR Plus	2-4 pt.		
Corn earworm	Lannate, Nudrin 90WSP	¼-½ lb.	Over row	When there is an average of 2 worms per head.
	Lorsban 4E	2 pt.		
	Sevin XLR Plus	2-4 pt.		
Corn leaf aphid	Cygon 400	½-1 pt.	Over row	Corn leaf aphids rarely cause economic damage unless populations are heavy and drouth conditions exist.
	Lorsban 4E[c]	½-1 pt.		
	malathion 57%EC	1½ pt.		
Cutworms	Lorsban 15G	8 oz. per 1,000 ft. row	Band	At planting.
	Lorsban 4E[c]	2 pt.	Broadcast	When seedling plants are being cut.
	Sevin XLR Plus	4 pt.	Broadcast	
Fall armyworm	Lannate, Nudrin 90WSP	¼-½ lb.	Over row	When there is an average of 2 worms per head. Leaf feeding or whorl damage is seldom economic.
	Lorsban 4E[c]	2 pt.		
Grasshoppers	Cygon 400	1 pt.	Over row	Treatment may be warranted when there are 7 or more per square yard. The higher rates are suggested for control of adult grasshoppers.
	Lorsban 4E[c]	½-1 pt.		
	Sevin XLR Plus	1-3 pt.		
Greenbug	Cygon 400	½-1 pt.	Over row	When greenbug damage is sufficient to cause death of more than 2 normal-sized leaves before the hard-dough stage. CAUTION: Some sorghum varieties are sensitive to organophosphate insecticides.
	Lorsban 4E[c]	½-1 pt.		
	malathion 57%EC	1½ pt.		
	*Counter 15G	8 oz. per 1,000 ft. row	Band	At planting.
	*Furadan 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	
Sorghum midge	Lorsban 4E[c]	½ pt.	Over row	Apply during bloom when 50% of heads have begun to bloom and there are 1 or more midge adults (flies) per head.
	Sevin XLR Plus	1½-2 pt.		
Webworms	Lorsban 4E[c]	2 pt.	Over row	When 5 or more larvae per head are found.
	Sevin XLR Plus	2-4 pt.		
White grubs	*Counter 15G	8 oz. per 1,000 ft. row	Band	At planting.
Wireworms	*Counter 15G	8 oz. per 1,000 ft. row	Band	At planting.
	*Furadan 15G	8 oz. per 1,000 ft. row	Furrow	
	lindane	See label	On seed	Use seed treatment formulations.
Yellow sugarcane aphid	Cygon 400	1 pt.	Over row	Sprays should be applied at first sign of damage to seedling sorghum; 5 to 10 aphids per leaf.
	Lorsban 4E[c]	½-1 pt.		
	*Furadan 15G	8 oz. per 1,000 ft. row	Band, furrow	At planting.

* Use restricted to certified applicators only.

[a] See Table 13 for insecticide restrictions.

[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

[c] To avoid phytotoxicity, do not treat plants that are under extreme heat and drouth stress.

Table 9. Insecticides for Small Grains (Barley, Oats, Rye, Wheat)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworm	Lannate, Nudrin 90WSP	¼-½ lb.	On foliage	When there are 6 or more nonparasitized armyworms (¾-1¼ inch long) per linear foot of row and before extensive head cutting occurs. Do not use Penncap-M on rye.
	*Penncap-M	2-3 pt.		
	Sevin XLR Plus	2-3 pt.		
Cereal leaf beetle	*Furadan 4F	½ pt.	On foliage	When there are one or more small larvae per stem or flag leaf. Apply Furadan before heads emerge from the boot.
	*Lannate 90WSP	¼-½ lb.		
	malathion 57%EC	1½ pt.		
	Sevin XLR Plus	2 pt.		
Fall armyworm	Sevin XLR Plus	2-3 pt.	On foliage	During fall when damage to new growth is apparent.
Grasshoppers	Cygon 400	¾ pt.	On foliage	During fall when damage is apparent, treat field borders and noncrop areas to stop migration. The higher rates are suggested for control of adult grasshoppers. Do not apply Penncap-M to rye.
	*Furadan 4F	¼-½ pt.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-3 pt.		
	Sevin XLR Plus	1-3 pt.		
Greenbug, English grain aphid, oat bird-cherry aphid	Cygon 400	½-¾ pt.	On foliage	Aphids damage plants indirectly by transmitting disease. Once yellowing is noticeable, it is usually too late to treat. Use Cygon on wheat only. Do not apply Penncap-M to rye.
	Lannate 90WSP	¼-½ lb.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-2 pt.		
Wheat stem maggot	None	..	...	No chemical control. Damage shows as white heads when field is still green.

* Use restricted to certified applicators only.
[a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

Table 10. Insecticides for Grass Pasture

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworms	malathion 57%EC	2 pt.	On foliage	As needed. Do not apply when weeds are blooming.
	*Penncap-M	2-3 pt.		
	Sevin XLR Plus	2-3 pt.		
Grasshoppers	malathion 57%EC	1½ pt.	On foliage	When there are 15 to 20 per square yard. The higher rates are suggested for control of adult grasshoppers. Do not apply when weeds are blooming.
	*Penncap-M	1-3 pt.		
	Sevin XLR Plus	1-3 pt.		

* Use restricted to certified applicators only.
[a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

Table 11. Insecticides for Noncrop Areas

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Grasshoppers	*Asana 1.9EC	0.85-1.7 oz.	On foliage	When grasshopper nymphs average 15 to 20 per square yard along roadsides and fence rows. Apply treatments while hoppers are small and before they migrate into row crops. The higher rates are suggested for control of adult grasshoppers. Do not spray areas adjacent to water or where runoff is likely to occur.
	Diazinon AG 500	1 pt.		
	Imidan 50WP	3-4 lb.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-3 pt.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR Plus	1-3 pt.		

* Use restricted to certified applicators only. [a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

To avoid injury to bees, do not apply sprays to noncrop areas if weeds are blooming.

Table 12. Insecticides for Sunflowers

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworm	Sevin XLR Plus	3-4 pt.	Over row	When defoliation reaches 25%.
Cutworms	Lorsban 4E	2-3 pt.	Over row	When 10% of the seedlings are damaged.
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	3 pt.		
Fall armyworm	Sevin XLR Plus	3-4 pt.	Over row	When defoliation reaches 25%.
Grasshoppers	*Furadan 4F	¼-1 pt.	Over row	When defoliation reaches 25%. Use higher rates for adult grasshoppers.
	Lorsban 4E	1 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	1-3 pt.		
Seed weevils	*Furadan 4F	1 pt.	Over row	When there are 10 to 12 adults per plant.
	Lorsban 4E	1-1½ pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	*Supracide 2E	2 pt.		
Stem weevil	*Furadan 4F	1 pt.	Over row	When there are 2 or more beetles per plant.
	Lorsban 4E	1-1½ pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	2-4 pt.		
	*Supracide 2E	2 pt.		
Sunflower beetle	*Furadan 4F	¼-½ pt.	Over row	When defoliation reaches 25%.
	Lorsban 4E	1-1½ pt.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR Plus	2-4 pt.		
Sunflower moth larvae	*Furadan 4F	1 pt.	Over row	Apply first treatment when a field has reached 20 to 25% bloom and moths are present.
	Lorsban 4E	1-1½ pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR Plus	3-4 pt.		
	*Supracide 2E	2 pt.		

* Use restricted to certified applicators only. [a] See Table 13 for insecticide restrictions.
[b] The formulation of the product most commonly used in Illinois is listed. If you use another formulation, READ THE LABEL to determine the amount of product per acre.

Spraying blossoming sunflowers can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your County Extension Office.

Table 13. Harvest Restrictions: Limitations in Days Between Application of the Insecticide and Harvest of Crop and Restrictions on Use of Insecticides for Field Crop Insect Control (These are only guidelines. Read the label for more detailed information.)

(Blanks denote that the product may not be labeled or suggested for that specific use in Illinois)

Insecticide	Field corn		Grain Sorghum	Forage crops		
	Grain	Ensilage		Alfalfa	Clover	Pasture
*Aastar G (phorate + flucythrinate)	A	60	...	...	...	...
*Ambush 2E (permethrin)[a,b]	B	B	...	C	...	...
*Asana 1.9EC (esfenvalerate)	21,D	21,D	...	...	...	...
Broot 15GX (trimethacarb)	90	90	...	...	...	...
*Counter 15G (terbufos)	A	30,E	F	...	...	...
Cygon 400 (dimethoate)[b]	14,G	14,G	28,G	10,H	...	...
Diazinon AG 500	A	A	7	10	10	0
Dipel (*Bacillus thuringiensis*)	A	A	...	...	...	...
*Dyfonate II, 4E (fonofos)[a,b]	30	30	...	...	...	...
Dylox 80SP (trichlorfon)	I	I	...	0,I	0,I	...
*Furadan 15G, 4F (carbofuran)[a,b]	30,J,K	30,J,K	75	L	...	...
Imidan 50WP (phosmet)	14	14	...	7,H	...	...
Lannate 90WSP (methomyl)[a,b]	A	3	14	...	...	...
Lorsban 15G, 4E (chlorpyrifos)	35,M	14,M	60,N	21,P	...	...
Malathion 57% EC	5	5	7	0	0	0
*Mocap 15G (ethoprop)	A	A	...	...	...	...
Nudrin 90WSP (methomyl)[a,b]	A	0	14	0	...	...
*Penncap-M (microencapsulated methyl parathion)[a,b]	12	12	...	15	...	15
*Pounce 3.2EC, 1.5G (permethrin)[a,b]	Q	Q	...	C	...	...
*Pydrin 2.4EC (fenvalerate)[a,b]	21,R	21,R	...	...	...	...
Sevin XLR Plus (carbaryl)	0	0	21	7	0	5
*Supracide 2E (methidathion)[a,b]	...	...	...	10,T	...	...
*Thimet 20G (phorate)	30,U	30,U	...	...	...	...

Insecticide	Barley	Oats	Rye	Wheat	Soybeans	Sunflowers
*Ambush 2E (permethrin)[a,b]	...	...	...	...	60,V	...
*Asana 1.9EC (esfenvalerate)	...	...	...	...	21,W	...
Cygon 400 (dimethoate)[b]	...	...	...	60	21	...
Dipel, Thuricide, Bactur, SOK (*Bacillus thuringiensis*)	...	...	...	...	0	...
*Furadan 15G, 4F (carbofuran)[a,b]	X	X	...	X	21,Y	28,Z
Lannate 90WSP (methomyl)[a,b]	7	7	7	7	...	...
Larvin 3.2F (thiodicarb)	...	...	...	...	28,AA	...
Lorsban 15G, 4E (chlorpyrifos)	...	...	...	...	28,BB	42,CC
Malathion 57% EC	7	7	7	7	0	...
Nudrin 90WSP (methomyl)[a,b]	7	7	7	7	...	...
Orthene 75S (acephate)	...	...	...	...	14,AA	...
*Penncap-M (microencapsulated methyl parathion)[a,b]	15	15	...	15	20,DD	...
*Pounce 3.2EC (permethrin)[a,b]	...	...	...	...	60,V	...
*Pydrin 2.4EC (fenvalerate)[a,b]	...	...	...	...	21,EE	28,EE
Sevin XLR Plus (carbaryl)	...	...	...	21	0	60
*Supracide 2E (methidathion)[a,b]	...	...	...	...	...	50,AA

Read the label for more detailed information.

A. No specific restriction when used as recommended.

B. Apply prior to the brown silk stage.

C. Do not apply more than 0.2 pound active ingredient per cutting. When rates of 0.1 pound active ingredient per acre or less are used, application may be made on day of harvest. When rates greater than 0.1 pound active ingredient per acre are used, do not apply within 14 days of harvest. For aerial application, do not apply within 100 yards of aquatic habitats. For ground application, do not apply within 20 yards of aquatic habitats.

D. Do not exceed 0.25 pound of active ingredient per acre per season for field and seed corn. Do not exceed 0.5 pound of active ingredient per acre per season for popcorn.

E. Only 1 postemergence incorporated treatment or 1 cultivation-time treatment may be used in addition to treatment at planting time.

F. Only one application per year may be used.

G. Make no more than 3 applications per year. Do not apply to corn during the pollen-shed period if bees are actively foraging in the treated area. Do not apply to sorghum after heading.

H. Apply only once per cutting; do not apply during bloom.

I. Three applications may be made per season on corn, and 3 applications may be made per cutting of alfalfa or grasses. Can be applied up to harvest.

J. Do not make a foliar application if Furadan 15G was applied at more than 8 ounces per 1,000 linear feet of row (6.7 pounds per acre with 40-inch row spacing) at planting. Do not make more than 2 foliar applications of Furadan 15G per season.

K. Do not make more than 2 applications of Furadan 4F per season at the 1½ to 2-pint use rate. Do not make more than 4 applications per season at the 1-pint use rate. Do not apply Furadan 4F on seed corn less than 14 days prior to detasseling or rogueing. If prolonged, intimate contact with corn or sorghum foliage will result, do not reenter treated field within 14 days of application without wearing proper clothing. For all other situations do not renter fields less than 24 hours following application unless appropriate clothing is worn.

L. Make no more than 2 applications per season. Do not apply more than once per cutting. Do not use more than 1 pint per acre in the second application. Apply only to fields planted to pure stands of alfalfa. When using no more than ¼ pound per acre, allow 7 days between application and harvest. When using ¼ to ½ pound per acre, allow 14 days between application and harvest. When using ½ to 1 pound per acre, allow 28 days between application and harvest. Do not move bees to alfalfa fields within 7 days of application.

M. For soil insect control, do not exceed the equivalent of 16 ounces of Lorsban 15G per 1,000 feet of row or 13.5 pounds of Lorsban 15G per acre per crop season. For foliar insect control, do not exceed the equivalent of 16 ounces of Lorsban 15G per 1,000 feet of row or 13 pounds of Lorsban 15G per acre per crop season. Do not apply more than a total of 15 pints of Lorsban 4E per acre per season. Do not allow livestock to graze in treated areas nor harvest treated corn silage as feed for meat or dairy animals within 14 days after last treatment. Do not feed treated corn fodder to meat or dairy animals within 35 days after last treatment.

N. The treated crop is not to be used for forage, fodder, hay, or silage within 30 days after application of 1 pint of Lorsban 4E per acre or within 60 days after application of rates above 1 pint per acre. Do not treat sweet varieties of sorghum. Do not apply more than 3 pints of Lorsban 4E per acre per season. Do not make more than one application of Lorsban 15G per season.

P. Do not apply more than once per cutting. Do not cut or graze treated alfalfa within 7 days of application of ½ pint of Lorsban 4E per acre, within 14 days after application of 1 pint per acre, or within 21 days after application of rates above 1 pint per acre. Do not make more than 4 applications per year.

Q. Apply Pounce 3.2EC prior to the brown silk stage. Do not apply more than 0.4 pound active ingredient of Pounce 1.5G per acre after the brown silk stage. Do not exceed a total of 1.0 pound active ingredient per acre per season.

R. Do not exceed 1.0 pound of active ingredient per acre per season for field and seed corn. Do not exceed 2 pounds of active ingredient per acre per season for popcorn.

S. Do not allow foraging and do not cut for hay within 14 days of last application by ground. Aerially treated pastures may be grazed or cut for hay on the day of treatment. Apply a maximum of 2 applications per year. Allow at least 14 days between applications.

T. Make no more than 1 foliage and 1 stubble application per alfalfa cutting.

U. Do not make more than one application over the plant.

V. Do not graze or feed soybean forage or hay. Do not apply more than 0.4 lb. active ingredient per acre per season.

W. Do not feed or graze livestock on treated plants. Do not exceed 0.2 pound of active ingredient per acre per season.

X. Apply before heads emerge from boot. Do not make more than 2 applications per season. Do not feed treated forage to livestock.

Y. Do not use Furadan 4F as a foliar application if Furadan 10G, Furadan 15G, or Furadan 4F was applied to soybeans at planting time. Do not make more than 2 foliar applications per season. Do not graze or feed foliar-treated forage to livestock or cut for silage or hay.

Z. No more than 4 applications per season.

AA. Do not graze or feed treated crop to livestock.

BB. Do not apply more than 6 pints of Lorsban 4E per acre or 3 pounds of chlorpyrifos (active ingredient) per acre per season. Do not apply last treatment within 28 days before harvest or apply last 2 treatments closer than 14 days apart. Do not allow livestock to graze in treated areas or otherwise feed treated soybean forage, hay, and straw to meat or dairy animals. On determinate soybeans do not apply more than one application after pod set.

CC. Do not apply more than 9 pints of Lorsban 4E per acre per season. Do not allow livestock to graze in treated areas.

DD. Do not make more than 2 applications per season.

EE. Do not feed or graze livestock on treated plants. Do not exceed 0.8 pound active ingredient per acre per season.

* Use restricted to certified applicators only.

[a] Workers should be warned in advance of treatments. Workers may not enter fields treated with the insecticides without wearing protective clothing for the intervals indicated. They may not enter a field treated with other insecticides without protective clothing until the spray has dried or the dust has settled. Protective clothing includes a hat, long-sleeved shirt, full length pants, and shoes and socks.

[b] Sprays to be applied only by experienced operators wearing proper protective clothing.

Table 14. Relative Toxicities of Commonly Used Agricultural Insecticides

Trade name	Chemical class[b]	Chemical name	Toxicity to mammals[a]		Toxicity to		
			Acute oral	Acute dermal	Birds	Fish	Bees
*Aastar	OP,P	Phorate + flucythrinate	high	high	moderate	very high	moderate
*Ambush	P	permethrin	low	low	low	very high	high
*Asana	P	esfenvalerate	moderate	low	low	very high	high
Broot	C	trimethacarb	moderate	low	moderate	moderate	. . .
*Counter	OP	terbufos	high	high	high	very high	. . .
Cygon	OP	dimethoate	moderate	moderate	moderate	very low	very high
Diazinon	OP	diazinon	moderate	moderate	high	high	high
Dipel, Bactur, Topside, Thuricide, SOK	. . .	*Bacillus thuringiensis*	very low	very low	very low	very low	very low
*Dyfonate	OP	fonofos	high	moderate	high	very high	. . .
Dylox	OP	trichlorfon	low	low	low	very low	low
*Furadan	C	carbofuran	high	moderate	high	moderate	high
Imidan	OP	phosmet	moderate	low	moderate	moderate	very high
Lannate WSP, Nudrin WSP	C	methomyl	high	moderate	low	moderate	high
Larvin	C	thiodicarb	moderate	low	low	moderate	moderate
Lorsban	OP	chlorpyrifos	moderate	moderate	moderate	very high	high
Malathion	OP	malathion	low	low	low	moderate	high
*Mocap	OP	ethoprop	moderate	high	moderate	. . .	moderate
Orthene	OP	acephate	moderate	moderate	moderate	low	high
*Penncap-M	OP	microencapsulated methyl parathion	moderate	low	moderate	very low	high
*Pounce	P	permethrin	low	low	low	very high	high
*Pydrin	P	fenvalerate	moderate	low	low	very high	very high
Sevin	C	carbaryl	low	low	very low	very low	high
*Supracide	OP	methidathion	high	moderate	moderate	high	high
*Thimet	OP	phorate	high	high	moderate	very high	moderate

* Use restricted to certified applicators only.

[a] Relative toxicities based on acute oral and acute dermal LD_{50} values of technical insecticide. Toxicities of formulated materials vary.

[b] OP = organophosphate, P = pyrethroid, C = carbamate.

Always read the label before applying insecticides.

WORKER REENTRY PERIODS IN FIELDS WHERE INSECTICIDES HAVE BEEN APPLIED

Most insecticide labels contain a statement about the length of time that should elapse before a person enters a treated field. The following is a summary of minimum field reentry times for insecticides commonly used in field crops. Follow label directions and do not enter treated fields without protective clothing until the reentry period has passed. Protective clothing is defined on most insecticide labels as a hat or other suitable head covering, a long-sleeved shirt and long-legged trousers or a coverall type garment, shoes, and socks.

Insecticide	*Reentry statement on label*
Aastar G	Do not enter treated areas without protective clothing until treatments have been completed.
Ambush 2E	Wait until spray is dry.
Asana 1.9EC	After spray has dried.
Broot 15G	After dust has settled in treated field.
Counter 15G	Do not enter treated area without protective clothing until treatments have been completed.

Insecticide	*Reentry statement on label*
Cygon 400	Wait four days, unless protective clothing is worn.
Diazinon AG 500	After spray is dry.
Dyfonate 4EC	Wait 24 hours unless protective clothing is worn.
Dyfonate 20G	Wait 24 hours unless protective clothing is worn.
Furadan 4F Furadan 15G	If prolonged intimate contact with corn and sorghum will result, do not reenter treated field within 14 days without proper protective clothing. For all other situtions, do not reenter field less than 24 hours following application.
Imidan	After spray has dried.
Lannate 90WSP	After spray has dried.
Larvin 3.2F	After spray has dried.
Lorsban 4E	Wait 24 hours, unless protective clothing is worn.
Lorsban 15G	None specified on label.
Malathion 57EC	After spray has dried.
Mocap 15G	After chemical has been mixed in soil.
Nudrin 90WSP	After spray has dried.
Orthene 75SP	After spray has dried.
Penncap-M	48 hours.
Pounce 3.2EC	After spray has dried.
Pydrin 2.4EC	After spray has dried.
Sevin XLR Plus	After spray has dried.
Supracide 2E	Wait 48 hours.
Thimet 20G	Do not enter treated areas until soil treatment is completed; 7 days for foliar application.

AVAILABLE PUBLICATIONS

Additional sources of information regarding insect management in field and forage crops are available from your county Extension office or from Extension Entomology, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820; telephone (217)333-6652.

Insect Fact Sheets

Fact sheets (designated by NHE numbers) that discuss nonchemical control methods and give descriptions of specific insects and their life history and biology have been prepared for most of the insects that attack field and forage crops in Illinois. Color picture sheets are also available in this series. Individual fact sheets and color picture sheets are $.25 each.

Insect Pest Management Guides

Other insect pest management guides available are Circular 897, *Insect Pest Management Guide: Commercial Vegetable Crops;* Circular 898, *Insect Pest Management Guide: Livestock and Livestock Buildings;* Circular 900, *Insect Pest Management Guide: Home, Yard, and Garden;* and Circular 1242, *Insect Pest Management Guide: Stored Grain.* Copies of these circulars are available from the Office of Agricultural Publications, address below.

Illinois Pest Control Handbook

All of the above-mentioned circulars, other references regarding management of insects, weeds, plant diseases, and vetebrate pests (including rats and mice), and pesticide application guidelines are bound together annually in the *Illinois Pest Control Handbook.* This is a valuable reference for pesticide dealers and applicators, farm managers, and anyone who frequently must answer questions about pest control. This publication can be obtained from the Office of Agricultural Publications, 54 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois, 61801; telephone (217) 333-2007.

Conference Proceedings

The proceedings of the Illinois Agricultural Pesticides Conference '89 are available from Extension Entomology (see address and telephone listed previously). This 200-page reference contains about 40 articles concerning recent research information about insect, weed, and plant disease control and about recent advances in pesticide application technology.

Insect, Weed, and Plant Disease Survey Newsletter

The *Insect, Weed, and Plant Disease Survey Bulletin* is issued weekly from April through August. This series of newsletters provides a timely look at the agricultural insect, weed, and plant disease situation, along with suggested control measures. New developments in pesticide application are also included. To subscribe to this valuable newsletter, contact the Agricultural Newsletter Service, 116 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801; telephone (217) 333-2666.

1989 Insect Pest Management Guide

STORED GRAIN

Grains produced in Illinois may be stored for periods of a few weeks to a few years before feeding or processing. The profitability of such storage depends not only upon marketing concerns, but also upon maintenance of grain quality. It is important to remember that the harvest and storage of grain does not signal an end to the possibility of losses caused by insects and pathogens.

Successful management of stored-grain insects is possible only when proper storage practices are carried out. Insecticides and fumigants should be viewed as supplements to, not replacements for, sound storage methods. Used properly, however, insecticides and fumigants can help to limit insect losses in stored grains without endangering the pesticide applicator or resulting in excessive pesticide residues that threaten the health of consumers (livestock or humans) of treated grain or grain products.

This publication provides recommendations for cultural and chemical control of stored-grain insects. It is revised annually; always use the current year's issue. Registration changes that occur between revisions will be announced to appropriate media sources and county Extension offices.

USING INSECTICIDES AND FUMIGANTS

The U.S. Environmental Protection Agency has designated certain pesticides for "restricted" use. The grain fumigants aluminum phosphide, chloropicrin, and methyl bromide are restricted-use pesticides. *Commercial* applicators must be certified in order to apply restricted-use pesticides. Elevator employees responsible for grain treatment at their place of employment must be certified under the category "Grain Facility Pest Control Applicator." Commercial fumigation professionals who treat stored grain or grain products at farms, elevators, warehouses, etc. must be certified by the Illinois Department of Public Health. A *private* applicator who wishes to purchase or apply restricted-use pesticides "for the purpose of protecting any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must obtain certification by passing an examination administered by the Illinois Department of Agriculture. **Regulations recently enacted by the Illinois Department of Agriculture mandate that private applicators must obtain special certification to purchase and apply grain fumigants. To obtain certification for fumigant application, individuals must first pass the private applicator exam and then pass a grain storage and fumigation exam.**

Those who apply pesticides should be aware that the pesticide user is always responsible for the results of pesticide applications. To avoid accidents and maximize the effectiveness of any application, always read the pesticide label and follow all directions and safety precautions. Be sure that the pesticide is specifically labeled for the pest, site, and application method planned. **Remember: The label is the law.**

Poison Resource Centers. The Poison Resource Centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency can call the toll-free telephone number for help. Personnel at the Resource Center will provide first-aid information and refer callers to local treatment centers if necessary.

Poison Resource Centers supplement, but do not replace, local emergency medical services. Do not delay calling local emergency medical personnel to request immediate assistance or transportation. If possible, have the pesticide container and label present when you call or reach a treatment center or hospital.

Chicago and northeast Illinois
1753 West Congress Parkway
Chicago, Illinois 60612
Telephone: 800-942-5969

Northern and central Illinois
530 N.E. Glen Oak
Peoria, Illinois 61603
Telephone: 800-322-5330

Central and southern Illinois
800 East Carpenter
Springfield, Illinois 62702
Telephone: 800-252-2022

NOTE: The information that follows is provided for educational purposes only. Reference to commercial products or trade names does not constitute an endorsement by the University of Illinois and does not imply discrimination against similar products. Trade names

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
Prepared by Richard A. Weinzierl, Extension Entomologist CIRCULAR 1242 November 1988

are presented for reasons of clarity only. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

INSECTS ATTACKING STORED GRAIN

Several types of insects inhabit stored grain. Exact identification of these insects often is difficult because most stored-grain pests are extremely small (1/16 to 1/4 inch in length), and many separate species are very similar in appearance. Presenting identification information for the many species of stored-grain pests is not the purpose of this publication; materials containing such information are included in the reference listing at the end of this circular. It is important, however, to recognize the different groups of insects that live in stored grains because management considerations may differ according to the insects' characteristics.

Weevils and Other Insects that Feed Inside Kernels

The most damaging insect pests of stored grain are those that develop within grain kernels. These insects are referred to as internal pests or primary pests. Adults deposit eggs on or in whole kernels, and larvae develop hidden within kernels. Damage caused by internal pests makes grain more suitable for infestation by insects that feed externally on grain or grain debris.

The common primary pests of grains in Illinois are the weevils — rice weevil, maize weevil, and granary weevil. The grain weevils are small (between 1/16 and 1/8 inch in length), but recognizable as a group because the head bears a prolonged snout. Another primary pest found in wheat, but only rarely in corn, is the lesser grain borer. Recognition of this pest is possible because the adult lesser grain borer's head projects downward, not forward, from the anterior portion of the body. These insects may be found in any portion of the grain mass within a bin; they are not restricted to portions near the surface.

The larval stages of the Angoumois grain moth also feed within grain kernels. This insect can infest grain in the field; storage infestations are limited to near the surface of the grain mass.

Beetles that Develop and Feed Outside Grain Kernels

Most insects commonly collected in stored grain in Illinois are beetles that range in size from 1/16 inch to over 1/2 inch in length. Adults of most species are reddish brown to black in color, and their forewings are hardened to form a "shell" over the body. Larvae of common species are cylindrical and cream-colored; some bear fine hairs. Species frequently collected in Illinois grain bins include the sawtoothed grain beetle, flat grain beetle, rusty grain beetle, foreign grain beetle, hairy fungus beetle, larger black flour beetle, red flour beetle, and confused flour beetle.

Like the weevils, beetles that feed and develop outside grain kernels are not limited in distribution to the grain surface, but instead inhabit any portion of a grain mass. They feed on several different grains, but their buildup in any grain usually results from an abundance of broken kernels (fine material) or fungal growth on moist grain. Their dependence on fines or fungal growth accounts for the description of these insects as "secondary" pests, "bran bugs," or "fungus feeders." Concentrations of stored-product beetles cause an increase in grain moisture and temperature, and such changes favor continued population growth.

Surface-Feeding Caterpillars

Caterpillars that feed in stored grain inhabit primarily the outer portions of the grain mass (usually the grain surface, but also the bottom of the grain mass just above perforated drying floors or aeration ducts). These caterpillars reach approximately 3/4 inch in length and are cream-colored. They produce fine, silken webbing as they move about near the grain surface. Mature larvae pupate within a silky cocoon. Adult moths fly and mate in the bin headspace where they may be seen resting on the bin walls and roof.

The Indianmeal moth is the most common surface-feeding caterpillar in stored grain in Illinois. The adult Indianmeal moth has a wingspan of about 3/4 inch; the outer half of each front wing is reddish brown or copper-colored. Malathion resistance appears to be common in Illinois populations of Indianmeal moth. Other surface-feeding caterpillars include the Angoumois grain moth (which feeds within kernels), the Mediterranean flour moth, and the meal moth.

Other Stored-Grain Insects

Additional pests that sometimes infest stored grains include psocids (booklice) and grain mites. These soft-bodied pests feed on grain-rotting fungi. An abundance of psocids or grain mites often indicates a more important problem of mold-related deterioration of the grain.

Remember that not all insects in grain are pests. Parasitic wasps, larvae of a predaceous fly species, and predaceous Hemipterans (true bugs) attack certain grain pests. In addition, many field insects are inadvertently transported to grain bins where they cause no damage.

PREVENTION OF INSECT INFESTATIONS

Sources of Infestations

Some stored-grain insects can infest maturing grain crops in the field. Although some field infestations probably occur in Illinois, the extent of field-originated storage problems appears to be minor.

The most common sources of stored-grain insects are old grain, grain spills, feeds, seed, and grain debris. Insects often move to new grain from carry-over grain, from small amounts of grain not cleaned from "empty" bins, from feed supply buildings, and from grain debris beneath perforated floors of bins. Most pest species can fly at least short distances to reach new grain.

Sanitation

To minimize the migration of stored-product insects from current food sources to new grain, thorough cleanup practices are necessary. At least 2 weeks before storing new grain, clean all grain and grain debris from within and around grain bins. Be thorough; sweep or vacuum bin floors. Also remove and feed or destroy any grain and grain debris in combines, wagons, augers, etc. If grain debris is not removed from the combine, collect and feed or destroy the first few bushels of grain that pass through the combine.

Bin Sprays and Empty-Bin Fumigation

Insects may remain in certain bin locations even after a thorough cleanup is completed. Hard-to-clean sites that harbor insect pests include cracks and crevices in bin walls and the plenum beneath nonremovable perforated floors. Applying an insecticide or a fumigant in an empty bin can supplement (but not replace) physical cleanup efforts.

Apply an insecticide to the walls, ceiling, roof, and floor of all bins that will be used to store grain for more than a few weeks. Use:

- 4 fl oz malathion 57% EC in 2 gal water;

or

- 1 qt methoxychlor 25% EC in 2 gal water;

or

- 12 oz methoxychlor 50% WP in 2 gal water;

or

- 4 fl oz Reldan 4E (chlorpyrifos-methyl) in 3 gal water.

Spray all bin surfaces to the point of runoff, and be sure to thoroughly treat all cracks and crevices and around doors. Directing extra spray to and through perforated flooring will provide some control of insects living in grain debris in the subfloor plenum, but satisfactory control of insects in this space requires fumigation (or removal of the false floor to allow complete cleanup of debris in the plenum).

Fumigating empty bins to control insects in the subfloor plenum may be necessary if summer-harvested grain (wheat, etc.) is to be stored in the bin 1 month or longer or if fall-harvested crops (corn, soybeans, or grain sorghum) will be stored beyond May or June of the year following harvest. Empty bin fumigation is usually not necessary where grain will be treated with a protectant insecticide at the auger as it is binned. The fumigant chloropicrin (trade names are Chlor-o-pic, Larvacide 100, and Quasar) is labeled and effective for empty bin fumigation.

Chloropicrin is a restricted-use pesticide that is extremely toxic. The U.S. Environmental Protection Agency recently revised fumigant regulations to require the use of a canister respirator (gas mask) or self-contained breathing apparatus (SCBA) if applicators are exposed to chloropicrin. Fumigators also must measure fumigant gas concentrations to determine that the fumigant has dissipated sufficiently before unprotected persons can enter the fumigated space. Follow specific label directions concerning respiratory protection equipment and gas detection devices. Failure to follow all label instructions is unsafe and illegal. If you are uncertain about the safe use of a fumigant, contact the manufacturer for detailed recommendations.

Use chloropicrin only on relatively calm days when the outside air temperature is 65°F or higher. Before applying chloropicrin, use tape and polyethylene sheeting to seal the side door and all bin openings below the level of the side door. Be sure to seal fan openings and the unloading auger shaft. Post warning placards according to label directions. Always have a partner present when applying this or any other fumigant.

To fumigate the subfloor plenum of empty bins, pour in chloropicrin from a ventilation door on the bin roof. Wear a canister respirator equipped with a fresh canister when applying chloropicrin and climbing down from the bin roof. Use 1 quart per 250 square feet of floor area. Chloropicrin forms a pungent tear gas that settles in the lower portion of the bin. This gas will kill all stages of stored-grain insects beneath the subfloor, but chloropicrin will not spread to the upper portions of the bin to kill insects suspended in grain debris remaining on bin walls. Wait at least 24 hours before airing out the bin.

Filling the Bin

Effective insect management in stored grain starts with good grain storage practices. Use a grain cleaner to minimize the amount of fine material that is binned along with the grain. Many species of stored grain insects cannot survive in the absence of broken kernels and grain debris. Use of a grain spreader evenly distributes remaining fine material and helps to level the grain surface. Once the bin is full, if fine material is concentrated in a central core beneath the auger spout, removal of one or a few loads from the bin will extract this core of fines. Do not add new grain on top of old because insects will rapidly move from the infested grain to the new crop. Do not overfill bins; the levelled grain surface should be at least a few inches below the lip of the bin. Levelling the grain surface is important for uniform airflow and for effective insecticide or fumigant application.

Store only dry grain. Maintaining moisture levels that prevent the growth of storage fungi is sufficient where fall-harvested grain is to be stored only through the winter, but grains that will be stored 1 month or longer during warm, summer weather should be dried to 12-13 percent moisture. This moisture content is unfavorable for most grain insects; it also allows prolonged persistence of protectant insecticide residues.

Aerate to cool stored grain as soon as possible. Temperatures below 50°F prevent insect feeding and reproduction. Cooling grain to just above freezing will kill some stages of many grain insects. Aeration also results in uniform temperatures that prevent moisture migration problems within a bin. Most grain storage

references recommend aerating to maintain grain temperatures within 15°F of average outdoor temperatures. These references also usually discourage the use of aeration to cool grain below freezing.

Grain Protectants

Application of insecticides directly to grain to prevent insect infestation is warranted if grain is to be stored more than 3 to 6 weeks at grain temperatures above 60° to 70°F. Summer-harvested grains that are to be stored 1 month or more and fall-harvested grains that are to remain in storage beyond May or June of the year following harvest should be treated with a protectant insecticide. Incorporating a surface treatment is adequate for short-term protection. However, uniform application to all grain at the auger is necessary for long-term protection. Where grain protectant insecticides are applied at labeled rates, grain can be processed or fed to livestock with no waiting period.

In order to protect against stored-grain beetles and weevils throughout the entire mass of grain within a bin, a protectant insecticide must be applied uniformly to all grain as it is augered into the bin. Drip-on or spray-on applicators can be mounted on the auger to apply liquid formulations. Dusts can be applied using an auger-mounted applicator, or they can be spread over a truck or wagon just before unloading. Protectant insecticides should not be applied to grain before high-temperature drying. Once grain is in the bin, surface or "cap-off" applications of protectant insecticides are effective only against the insects that are feeding at the grain surface. A surface dressing or "cap-off" treatment may be used to give some control of insects entering the top of the grain mass. Surface treatments often provide adequate protection where previously uninfested grain is to be stored at warm temperatures for a month or two. For longer storage at warm temperatures, adequate control requires treating the entire grain mass at the auger as the grain is binned. Table 1 summarizes uses for registered grain protectants.

Crop-specific recommendations for the use of protectant insecticides are:

Corn. It is not necessary to apply any insecticide to new-crop corn that will be removed from storage by May or June of the following spring. For storage periods of 1 year or longer, apply Actellic or malathion at the loading auger using rates listed in Table 1. Reldan is not registered for use on corn. Do not apply insecticides before high-temperature drying because extreme heat will result in rapid volatilization and reduction in residues. For malathion residues to persist on corn at effective levels through the summer following harvest, corn must be dried to approximately 12 percent moisture. Data indicate Actellic residues will persist for a similar period on grain stored at 14 percent moisture.

Malathion will not control Indianmeal moth. Where malathion is applied at the auger as corn is binned, incorporate *B.t.* in the top 4 to 6 inches of the grain once the bin is filled and levelled or by May of the following spring to prevent infestation by Indianmeal moth larvae.

Long-term storage programs usually allow "rotating" corn in storage — shipping out old corn and replacing it with the new crop each year. Annual rotation of stored corn helps to avoid buildup of insect infestations. Where annual rotation is practiced, topdress treatments of malathion plus *B.t.* or Actellic alone applied in April or May usually provide adequate control without treating the entire grain mass.

Soybeans. Only Indianmeal moth will infest soybeans stored at moisture levels that prevent mold growth. To protect against Indianmeal moth infestation, rake in surface applications of *B.t.* once the bin is filled and levelled or by May of the following year. No other protectant insecticides are registered for application to stored soybeans.

Wheat. Wheat is especially vulnerable to insect infestation because it is harvested in midsummer when stored-product insects are active within and outside storage facilities. Warm temperatures in summer-harvested wheat also contribute to the rapid development and reproduction of insects within bins.

Apply malathion or Reldan at the loading auger to all wheat that is to be stored for 1 month or more. Where malathion is used, also incorporate *B.t.* in the top 4 to 6 inches of grain to prevent Indianmeal moth infestations. Reldan controls Indianmeal moth and the weevils and "secondary" beetles that infest grain.

Sorghum. For storage periods of 1 year or longer, apply Actellic, malathion, or Reldan at the loading auger, but not before high-temperature drying. For malathion residues to persist at effective levels through the summer following harvest, grain must be dried to 12 percent moisture content; Actellic and Reldan should persist for 12 months or more on 14 percent moisture sorghum. Where malathion is applied, also rake in surface applications of *B.t.* once the bin is filled and levelled or by May to control Indianmeal moth. Where sorghum has not been treated at the auger as it was binned, topdress applications of Actellic, Reldan, or malathion plus *B.t.* usually will provide adequate protection for one summer's storage if application is made by April or May.

Insecticide Resistance in Stored-Grain Insects

Insecticide resistance is an important worldwide problem that is especially common (on an international scale) in stored-product insects. In Illinois, resistance to malathion is widespread among Indianmeal moth populations throughout the state. Some Illinois populations of the red flour beetle are resistant to malathion, but the range and intensity of this resistance problem in Illinois are not well known. Populations of the hairy fungus beetle collected in northern Illinois are resistant to both Actellic and malathion; the geographical range of resistant populations of this species is not known.

Table 1. Insecticides Registered for Use to Protect Stored Grain. Grains treated with protectant insecticides at labeled rates as specified below can be fed to livestock or processed for feed or food uses with no waiting period.

Insecticide	Registered for use on:	Rate/1,000 bu	Restrictions; Comments
malathion 57% EC, 6% D, 4% D, and 2% D	corn, wheat, oats, barley, rye, sorghum, sunflower	1 pt 57% EC in 2-5 gal water; 10 lb 6% dust; 15 lb 4% dust; or 30 lb 2% dust. Use the same amount/1,000 sq ft of grain surface as a "cap-off" treatment *if the entire grain mass is not treated.*	Do not apply to soybeans. Malathion will not control Indianmeal moth. Dry grain to 12% moisture in order for malathion to persist for 1 year or more. Do not apply prior to high-temperature drying. Cap-off treatments do not provide control of insects already active beneath the treated layer.
chlorpyrifos-methyl (Reldan 4E, 3%D)	wheat, oats, barley, sorghum	barley — 9.2 fl oz; oats — 6.2 fl oz; sorghum — 10.7 fl oz; wheat — 11.5 fl oz. Apply in 1 to 5 gal water. Use 10 lb 3% dust/1,000 bu. Use 1.6 to 3.0 fl oz 4E or 7 lb 3% dust/1,000 sq ft of grain surface as a "cap-off" treatment *if the entire grain mass is not treated.*	Do not apply to corn or soybeans. Controls weevils, "bran bugs," and Indianmeal moth. Dry grain to 14% moisture in order for chlorpyrifos-methyl to persist for 1 year or more. Do not apply prior to high-temperature drying. Cap-off treatments do not provide control of insects already active beneath the treated layer.
Bacillus thuringiensis (Bactospeine, Dipel, SOK-Bt, and Thuricide)	corn, soybeans, wheat, oats, barley, rye, sorghum, sunflower	Rate depends on product concentration. Follow label directions.	Use to control Indianmeal moth larvae. Controls only larval stages; must be ingested. Apply to the top 4 to 6 inches of grain as it is augered into the bin or incorporate by raking once the bin is filled.
pirimiphos-methyl (Actellic 5E)	corn (including popcorn), sorghum	8.6 to 11.5 fl oz in 5 gal water. Use 3 fl oz in 2 gal water/1,000 sq ft surface area as a "cap-off" treatment *if the entire grain mass is not treated.*	Do not apply to soybeans, wheat, barley, or oats. Controls weevils, "bran bugs," and Indianmeal moth. Dry grain to 14% moisture for pirimiphos-methyl to persist for 1 year or more. Do not apply before high-temperature drying. Cap-off treatments do not provide control of insects already active beneath the treated layer.
methoprene (Diacon, 65.7% a.i.)	corn, wheat, sorghum, barley, oats	wheat — 7.7 fl oz; corn and sorghum — 7.1 fl oz; barley — 6.1 fl oz; oats — 4.1 fl oz. Apply in 5 gal water.	Do not apply to soybeans. Prevents normal development of immature stages of insects but will not kill adult insects. Apply as a preventative. Do not apply more than once per crop.
pyrethrins plus piperonyl butoxide	corn, wheat, oats, barley, rye, sorghum, sunflower	Rate depends on product concentration. Follow label directions.	Do not apply to soybeans. Short-term residual activity. Useful mainly as a surface spray to control larval and adult Indianmeal moths as well as other pests at the grain surface.

Special Review of Dichlorvos

Resin strips containing the insecticide dichlorvos (DDVP, Vapona) have been used for several years in grain storages to control the adult Indianmeal moth in the storage headspace. Originally known as "No-Pest Strips," these insecticide devices have been sold under several trade names.

As a result of studies commissioned by the National Toxicology Program, the U.S. Environmental Protection Agency (U.S. EPA) has recently classified dichlorvos as a probable human carcinogen. The U.S. EPA has initiated a "Special Review" of dichlorvos to evaluate the benefits and risks associated with its use in a variety of pest control situations. The results of that review will determine the future of dichlorvos registrations and uses.

Until further information clarifies the risks associated with the use of dichlorvos, and until the Special Review results in continuation or cancellation of current registrations, grain handlers are advised to discontinue the use of dichlorvos for stored-product insect control.

New Registration for Methoprene

The U.S. EPA recently approved registration of the insect growth regulator methoprene (trade name Diacon) for use on stored grains (but not soybeans). Methoprene is a compound similar to the naturally occurring juvenile hormones of insects. Its acute toxicity to mammals is very low. The active ingredient methoprene interferes with the growth and maturation of immature stages of insects. It will not control adult insects already present in grain, but it will prevent immature stages

from developing to adults and reproducing. Insects listed on the Diacon label include the Indianmeal moth, cigarette beetle, lesser grain borer, sawtoothed grain beetle, merchant grain beetle, red flour beetle, and confused flour beetle.

Current labeling for Diacon allows its use as an empty-bin spray and as a direct spray on grain as it is augered or conveyed into storage; no instructions for surface topdress application are included on the Diacon label. Because methoprene does not kill adult insects, this compound should not be used to provide rapid control of existing infestations.

SAMPLING STORED GRAIN

Stored grain should be monitored regularly to determine grain moisture content and temperature and to detect any insect infestations. Sample stored grain for insects at least monthly from November through April and at least twice monthly from May through October. Pay particular attention to the grain surface and the central core of the grain mass, but also sample additional locations and depths. Be sure to examine grain from any locations where temperature or moisture readings are substantially higher than average. Deep bin probes and sectioned grain triers are most commonly used for withdrawing samples from beneath the grain surface. Probe traps and sticky pheromone traps also are available for monitoring insects within the grain mass and flying moths, respectively. Sampling equipment is available from most bin sales and service companies.

CONTROLLING ESTABLISHED INFESTATIONS

When insects are found in stored grains, a logical question is "Are there enough insects present to warrant control?" Unfortunately, this question is hard to answer. The importance of an insect infestation is determined not only by insect numbers, but also by type of grain, insect species, time of year, grain temperature and moisture, the planned duration of storage, market potential, and local elevator quality and dockage guidelines. Revised (1988) Federal Grain Inspection Service (FGIS) standards for grain insect infestation are presented in Table 2, but local elevators usually enforce more stringent standards. Insect-damaged kernels also may result in price discounts. Consider too that insect populations and their damage can increase rapidly.

Table 2. The Number of Live Insects (per Kilogram of Grain) Required for FGIS Designation as "Infested"

Crop	Insect density for designation as "infested"
Wheat, Rye, Triticale	• More than 1 live weevil, or • One live weevil plus any other live stored grain insect pest, or • No live weevils, but 2 or more other live pest insects.
Corn, Barley, Oats, Sorghum, and Soybeans	• More than 1 live weevil, or • One live weevil plus 5 or more other live pest insects, or • No live weevils, but 10 or more other live pest insects.

When insects are detected in stored grain, consider several possible management practices. Sometimes the most profitable action can be to clean and sell the grain immediately without any chemical treatment. Immediate sale can be especially appropriate where early stages of insect infestations are detected before insect numbers reach elevator detection or discount levels. During cool weather, aerating to cool the grain to below 50°F can prevent insect activity and allow an extended period of safe storage.

Sometimes insect problems may be limited primarily to the surface or central core of stored grain. If Indianmeal moth is the only problem, light infestations can be controlled by using *B.t.*, Actellic, or Reldan as outlined in Table 1. Unincorporated surface treatments of *B.t.*, Actellic, or Reldan will not control Indianmeal moth larvae already present a few inches below the grain surface. Where abundant webbing indicates a severe infestation, webbing should be raked from the surface before treating; fumigation may be necessary in these situations. Where "bran bugs" are confined primarily to a central core of fine material, removing 1 or 2 loads of grain to extract that core can allow safe storage of the remaining grain.

Where infested grain can be moved to a clean bin, transfer and treatment with a protectant insecticide (see Table 1) is recommended. If possible, use a grain cleaner during the transfer process. Protectant insecticides will not immediately kill immature insects within grain kernels, but residues will eventually provide control and protect against reinfestation for a period dependent upon grain moisture and temperature.

Infested grain that cannot be treated successfully in any other way should be fumigated. The U.S. Environmental Protection Agency has prohibited the use of fumigants containing ethylene dibromide (EDB), ethylene dichloride (EDC), carbon bisulfide, or carbon tetrachloride.

Suspension of most liquid fumigant registrations, coupled with increased safety concerns and protective equipment requirements for remaining fumigants, signals the fact that fumigation of farm-stored grain is a potentially dangerous and difficult operation. Hiring a professional fumigator is recommended, especially for fumigation of bins with capacities greater than 5 to 10 thousand bushels.

Fumigation Steps

Persons not trained and certified specifically in the use of grain fumigants should not attempt to fumigate stored grain. The steps outlined below provide general guidelines, but not complete directions.

1. Level the surface of the grain, break up any caked or crusted areas, and remove any surface webbing.
2. Use tape and plastic sheeting to thoroughly seal

all cracks and holes in the bin; seal the side door, unloading auger shaft, and fan openings. If the grain surface will not be tarped, also seal the eaves and roof hatches. Leave only the necessary access openings to seal after fumigant application. If the grain surface is to be tarped, tuck the plastic tarp along one edge of the structure so that it can be rolled out easily once the fumigant has been applied.

3. Spray the outside surface of the bin with malathion (4 fl oz 57% EC/gal water), chlorpyrifos-methyl (4 fl oz Reldan 4E/3 gal water), or methoxychlor (1 qt 25% EC or 12 oz 50% WP/2 gal water).

4. Learn and follow all safety precautions. Always work in pairs; an observer should be present *outside* of the bin. The U.S. Environmental Protection Agency recently revised fumigant regulations. New labeling requires the use or availability of a self-contained breathing apparatus for respiratory protection during one or more stages of the fumigation process. Fumigators also must measure fumigant gas concentrations to determine that the fumigant has dissipated sufficiently before unprotected persons can enter the fumigated space. Follow specific label directions concerning respiratory protection equipment and gas detection devices. Failure to follow all label instructions is unsafe and illegal. If you are uncertain about the safe use of a fumigant, contact the manufacturer for detailed recommendations.

5. Choose a calm, warm day when the grain temperature is above 60°F. Apply a liquid or solid fumigant. Only those fumigants containing aluminum phosphide are registered for use on soybeans.

Chloropicrin (Chlor-o-pic, Larvacide 100, and Quasar) is a restricted-use liquid fumigant labeled for probe and surface application to stored grain. Protective clothing and respiratory equipment must be worn during application. Use 2.5 lb/1,000 bushels of wheat, barley, or rice; 3.0 lb/1,000 bushels of corn; 3.5 lb/1,000 bushels of oats; or 4.5 lb/1,000 bushels of grain sorghum. To provide successful control, chloropicrin must be applied by probes into the grain mass and uniformly onto burlap bags spread over the grain surface. Wait at least 72 hours before airing out; fumigated grain must be thoroughly aerated before processing or feeding.

Chloropicrin's use as a grain fumigant is scheduled to be discontinued. Its use as an empty-bin fumigant will not be altered by this action.

Dry fumigants containing aluminum phosphide include Detia, Fumitoxin, Gastoxin, Phostek, and Phostoxin. Aluminum phosphide is a restricted-use fumigant. A special application probe is required to place aluminum phosphide tablets or pellets in the grain mass. Use 180 tablets or 300 pellets per 1,000 bushels of bin capacity. Do not allow water to come in contact with tablets or pellets; wear neoprene or cotton gloves to prevent perspiration from reaching the dry material. During application, fumigant concentrations must be monitored using detector tubes to determine the need for respiratory protection.

6. Following application, finish tarping the grain surface or seal the access door that served as an exit from the bin. Place warning signs as directed by the fumigant label.

7. Wait at least 72 hours before airing out bins following aluminum phosphide or chloropicrin application; follow label directions. After aeration, fumigant concentrations must be measured before warning placards can be removed and before the grain can be fed or processed.

An additional fumigant that is effective and registered for application to stored grain is methyl bromide. Safety concerns and equipment requirements limit the use of methyl bromide to application by professional fumigators.

The atmospheric gases carbon dioxide and nitrogen (alone or in combination) can be used successfully as grain fumigants. These gases are supplied for fumigation by stationary or portable generators or delivered in pressurized tanker trucks. The fumigant gas must be introduced into a storage in a manner that displaces the original air volume; then an adequate concentration (usually around 40 to 60 percent by volume) must be maintained for a period of 4 to 10 days (longer in cool grain). For these reasons, thorough sealing is especially important. Fumigation with atmospheric gases leaves no toxic residues once the treated commodity is aerated, but it is important to remember that carbon dioxide concentrations reach toxic levels in work areas during application. Applicators and other workers must wear respiratory protection (a self-contained breathing apparatus) during periods of exposure. Fumigation using atmospheric gases is currently conducted by only a few professional fumigators and by a few large grain companies that maintain equipment at their storage sites. Where available, fumigation with carbon dioxide and/or nitrogen can be cost-competitive and effective.

Once it is aired out, fumigated grain is subject to reinfestation. Surface application of a protectant insecticide should precede or follow fumigation if storage is to continue.

"Nonchemical Controls"

Diatomaceous earth is an abrasive and slightly sorptive dust that damages an insect's body covering and causes death by dehydration. Applied at high rates (120 to 300 lb/1,000 bushels of grain), diatomaceous earth is a fairly effective protectant against several stored-grain insects. For long-term protection, diatomaceous earth must be applied at the auger as grain is binned so that it is distributed evenly throughout the grain mass within a storage. Incorporating surface treatments should provide some control of insects active in the treated layer. Problems associated with the use of diatomaceous earth as a grain protectant include increased wear to grain-moving equipment, the generation of great amounts of airborne dust during grain handling, and possible reductions in grain grade and test weight. Some buyers

refuse to accept grain treated with diatomaceous earth. One successful and practical use of diatomaceous earth has been its addition to small seed packets to prevent infestation by stored-product pests.

One or more companies are marketing a program that calls for periodic releases of beneficial insects (predators and parasites of pest species) for pest management in stored grains. Although considerable research has been directed at this practice, questions concerning the ability of beneficial releases to lower pest populations to levels required by current grading standards remain unanswered. Published studies conducted in on-farm storages have not achieved adequate levels of control. Farmers and grain handlers who purchase beneficial insects for stored-grain pest management are urged to monitor results very closely.

Where management efforts must be limited to "nonchemical" methods of control, sound cultural practices (sanitation, adequate drying, cleaning, aeration, and annual rotation of the commodity) are extremely important.

SPECIAL CONSIDERATIONS FOR STORED SEEDS

Seed corn in bulk storage (in cribs, bins, granaries, etc.) can be protected from insect damage by using the storage practices and protectant insecticides discussed previously. These practices include proper sanitation, drying, cleaning, and temperature management (aeration) and the use of protectant insecticides such as pirimiphos-methyl (Actellic), malathion, *B.t.*, and pyrethrin plus piperonyl butoxide. Where fumigation of bulk-stored seed corn is necessary, aluminum phosphide fumigants or carbon dioxide can be used effectively without affecting seed germination. Methyl bromide and chloropicrin reduce or destroy seed germination.

In bagged seed corn (usually not treated with any insecticides) several stored-grain insects may be a problem, but the Indianmeal moth is the most common. Although bulk seed treatments using Actellic or *B.t.* provide residual control of Indianmeal moth larvae, such treatments must be applied before or during bagging. Small quantities of valuable seed can be protected by cool storage or by adding diatomaceous earth to seed packets.

To limit the invasion of untreated, bagged seed corn, warehouses can be fogged periodically during the summer using pyrethrins plus piperonyl butoxide. Using proper warehouse sanitation methods, maintaining cool temperatures, and excluding pests (by using screens, tight-fitting doors and windows, caulking, etc.) also are important. Bagged seed can be effectively fumigated using aluminum phosphide fumigants. Hiring a professional fumigator is advised.

REFERENCES

Stored Grain Insects. 57 pp. USDA Agricultural Handbook No. 500. Available for $4.50 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Fact Sheets available from Agricultural Entomology, University of Illinois, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

NHE 62 — *Angoumois Grain Moth*
NHE 63 — *Indianmeal Moth*
NHE 64 — *Granary and Rice Weevil*
NHE 65 — *Grain and Flour Beetles*

Picture Sheet X798.01, Stored Grain Insects and Molds. Available for purchase from Vocational Agriculture Services, University of Illinois, 1401 South Maryland Drive, Urbana, IL 61801.

Pesticide Applicator Training Packet — Grain Facility Pest Control. Available for $6.00 from the Office of Agricultural Entomology, University of Illinois, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

Illinois Pesticide Applicator Training Manual for Seed Treatment — SP39-1. Available for $2.00 from the Office of Agricultural Entomology, University of Illinois, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

1989 Insect Pest Management Guide

LIVESTOCK and LIVESTOCK BUILDINGS

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Special Review of Dichlorvos

Many insecticide products containing dichlorvos (DDVP) are registered and commonly used to control pests of livestock. Among such products are Ciovap (dichlorvos plus crotoxyphos), Ravap (dichlorvos plus stirofos), resin strips known as "No-Pest Strips" and "Farm Strips," Vapona (liquid concentrates and dry bait), and dichlorvos horse wormers.

As a result of studies commissioned by the National Toxicology Program, the U.S. Environmental Protection Agency (U.S. EPA) has recently classified dichlorvos as a probable human carcinogen. The U.S. EPA has initiated a special review of dichlorvos to evaluate the benefits and risks associated with its use in a variety of pest-control situations. The results of that review will determine the future of dichlorvos registrations and uses.

Until further information clarifies the risks associated with the use of dichlorvos, and until the special review results in continuation or cancellation of current registrations, livestock producers are advised not to purchase products containing dichlorvos. Although the use of dichlorvos according to label directions during the special review is legal, curtailing this use reduces any risks to human health during this process. For that reason, all listings of dichlorvos uses have been deleted from the 1989 issue of this publication.

Successful pest management is an essential part of efficient and profitable livestock production. Although pest-related losses are often inconspicuous, flies, lice, mites, and ticks can cause significant reductions in meat, milk, wool, and egg production. Several livestock pests also transmit important diseases.

Effective management of livestock pests should include the use of cultural, mechanical, and biological control tactics as well as the application of chemical insecticides. Insecticides should be viewed as supplements to, not replacements for, sanitation and sound cultural practices. Used properly, insecticides efficiently reduce pest populations without injuring livestock or threatening the safety of either the pesticide applicator or the ultimate consumer of animal products.

This publication provides recommendations for safe and effective use of livestock insecticides. It is revised annually; always use the current year's issue. Registration changes that occur between revisions will be announced to appropriate media sources and county Extension offices. If you have questions about the use of insecticides for livestock insect management, consult your county Extension adviser.

Selection of the insecticides listed on the following pages was based on EPA registrations and on efficacy data reported by entomologists of the University of Illinois College of Agriculture, the Illinois Natural History Survey, and other midwestern universities. If listed insecticides fail to provide pest control, please contact your county Extension adviser or the Entomology Extension office at the University of Illinois.

Additional sources of information. In the tables, leaflets outlining the life history, biology, and habits of livestock pests are indicated by the letters "NHE" and the leaflet number. Request these leaflets at your county Extension office or from Entomology Extension, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820. Additional pest management

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 898 (revised annually) October 1988
Prepared by Richard A. Weinzierl, Extension Entomologist

publications available from the Office of Agricultural Publications (54 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801) include Circular 899, *1989 Insect Pest Management Guide: Field and Forage Crops;* Circular 900, *1989 Insect Pest Management Guide: Home, Yard, and Garden;* Circular 925, *Insect Pests of Cattle;* Circular 897, *1989 Insect Pest Management Guide: Commercial Vegtetable Crops;* and Circular 1136, *Alfalfa Weevil Pest Management Program.*

Using livestock insecticides. The pesticide user is always reponsible for the results of insecticide applications to his livestock and crops, as well as for problems of pesticide drift and contamination. All users should observe the following rules.

- Read the label and follow directions and safety precautions. Be sure that the insecticide is specifically labeled for the pest and animal in question and the application method planned. THE LABEL IS THE LAW.
- Use face masks or respirators and protective clothing during spraying. Avoid breathing spray mist or dust.
- If pesticides are spilled on the skin or clothing, wash thoroughly with soap and water and change clothes.
- Do not eat, drink, or smoke when handling pesticides.
- Provide adequate ventilation when applying pesticides.
- Do not exceed registered rates of application. Improper or excessive applications can endanger livestock and result in illegal residues in meat and milk.
- Obey the preslaughter interval listed on the label.
- Avoid drift to adjacent cropland, yards, woodlots, lakes, or ponds. Some materials may injure or kill fish, wildlife, and crops.
- Do not treat animals that are sick, overheated, or stressed from shipping, dehorning, castration, recent weaning, and other causes.
- Avoid contamination of feed, mangers, water, milk, and milking equipment.
- Do not spread treated manure on crops that are not listed on the pesticide label.
- Accurately record all pesticide usage. Include the pesticide's trade name, formulation, dilution, application rate, and date of treatment.
- Store pesticides in their original, labeled containers, safely locked away from children, pets, and livestock.
- Dispose of empty pesticide containers promptly and properly according to specified recommendations. Do not breathe smoke from burning containers.
- Contact a physician at once in all cases of suspected poisoning. Symptoms of organophosphate poisoning include blurred vision, abdominal cramps, and tightness in the chest.

Poison Resource Centers. The Poison Resource Centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency can call the toll-free telephone number for help. Personnel at the Resource Center will provide first-aid information and refer callers to local treatment centers if necessary.

Poison Resource Centers supplement, but do not replace, local emergency medical services. Do not delay calling local emergency medical personnel to request immediate assistance or transportation. If possible, have the pesticide container and label present when you call or reach a treatment center or hospital.

Chicago and northeast Illinois
1753 West Congress Parkway
Chicago, Illinois 60612
Telephone: 800-942-5969

Northern and central Illinois
530 N.E. Glen Oak
Peoria, Illinois 61603
Telephone: 800-322-5330

Central and southern Illinois
800 East Carpenter
Springfield, Illinois 62702
Telephone: 800-252-2022

Preventing livestock poisoning. Every year livestock animals die after consuming pesticide granules, wettable powders, or dusts that have been spilled on trucks, wagons, or soil surfaces. Animals consume the pesticide alone or with feed grains or forage placed on the contaminated surface. Prevent livestock poisoning by properly containing and disposing of spilled pesticides and by storing all pesticides in locked facilities that are inaccessible to domestic and wild animals, as well as to children.

NOTE: The information in the following tables is for educational purposes only. Reference to commercial products or trade names does not constitute an endorsement by the University of Illinois and does not imply discrimination against other similar products. Trade names are presented for reasons of clarity only. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

Beef Cattle and Nonlactating Dairy Cattle

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE (NHE 18) $1/16$ to $1/8$ inch long. Biting lice are reddish, flattened, and active. Sucking lice are gray to blue and sluggish. Heavy populations cause poor growth, general unthriftiness, and anemia. Symptoms are rough, patchy hair coats and a dirty appearance. Lice are most troublesome when cattle are crowded in shelters during winter months.	Self-treatment devices such as back rubbers, face rubbers, and dust bags effectively control lice when used in conjunction with systemic insecticides applied from August through October for grub control. The systemics kill lice that are present on animals during the fall; the self-treating devices then hold louse populations below economic levels throughout the winter. Place rubbing devices and dust bags where cattle will use them. For back rubbers and face rubbers, mix insecticides with No. 2 fuel oil, No. 2 diesel fuel, or an oil recommended on the insecticide label. Mineral oil is less irritating than fuel oil. Do not use waste oil or motor oil. Keep dust bags dry. Service self-treating devices at least once per month.			
	Back rubber or face rubber (oilers)	Co-Ral 11.6% EC (coumaphos)	1 gal/13 gal fuel or mineral oil.	0 days. Do not apply with oral drenches, with other internal medications such as phenothiazine, or with natural or synthetic pyrethroids, synergists, or organophosphates.
		malathion 57% EC	0.5 pt/1.5 gal fuel or mineral oil.	0 days.
	Dust bag	Products listed for use in dust bags can also be applied by hand-dusting. Follow label directions.		
		Co-Ral 1% D (coumaphos)	10 lb dust/bag. Use 1 bag/10-20 head.	0 days.
		Ectiban or Permectrin 0.25% D (permethrin)	10 lb dust/bag. Use 1 bag/10-20 head.	0 days.
		Rabon 3% D (stirofos)	4-8 lb dust/bag. Use 1 bag/10-20 head.	0 days.
	Spray	Apply sufficient spray to thoroughly wet each animal. Use up to 1 gallon finished spray per animal. Do not contaminate feed or water.		
		Co-Ral 11.6% EC or 25% WP (coumaphos)	2 qt 11.6% EC or 2 lb 25% WP/100 gal water.	0 days. Do not treat calves less than 3 months old or sick, convalescent, or stressed cattle. Do not spray within 10 days after shipping, weaning, or disease exposure. Do not spray in nonventilated areas. Do not apply in conjunction with other organophosphates, pyrethroids, synergists, or phenothiazine.
		Delnav 15% EC or 30% EC (dioxathion)	1 qt 15% EC or 1 pt 30% EC/25 gal water.	0 days. Do not treat more often than every 14 days. Do not use on dairy cattle or in dairy barns. Restricted-use.
		Ectiban 5.7% EC (permethrin)	1 qt/100 gal water.	0 days. Repeat treatment 14-21 days after first application. Do not treat more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for control of lice on beef cattle. Check product labels for dilution and application rates.)		
		malathion 57% EC	1 gal/100 gal water.	0 days. Do not apply to lactating dairy cattle or within 14 days of freshening. Do not treat calves less than 1 month old.
		Rabon 50% WP or 24% EC (stirofos)	4 lb 50% WP/75 gal water or 1.5 gal 24% EC/100 gal water.	0 days. Beef cattle only.
		methoxycholor 25% EC or 50% WP	2 qt 25% EC or 2 lb 50% WP/25 gal water.	0 days. Repeat treatment 14-21 days after first application. Do not use on dairy cattle or in dairy barns.
		Taktic 12.5% EC (amitraz)	1 qt/100 gal water. Use up to 2 gal spray per fully grown animal.	0 days. Apply spray within 6 hours after mixing. Repeat application in 10-14 days.
	Pour-on or spot-on	Fall applications of systemic pour-ons and spot-ons such as Co-Ral (coumaphos), Warbex (famphur), Tiguvon (fenthion), Neguvon (trichlorfon), and Prolate (phosmet) for grub control also reduce louse populations. These treatments may not provide season-long louse control through the winter. Follow label directions concerning reuse after grub treatment cut-off dates. Products listed below effectively control lice, but do not provide grub control.		
		Dursban 44 (chlorpyrifos)	2 cc/100 lb body weight	14 days. Beef cattle only. Apply as spot treatment. Do not exeed 16 cc/animal. Do not treat calves under 3 months old or bulls over 8 months old. Do not treat purebred continental or exotic breed cattle such as Charolais, Chianina, Simmental, and Gelbveih. Do not retreat within 30 days. Do not use on cows within 21 days prior to calving or 14 days after calving.

Beef Cattle and Nonlactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE, cont.	Pour-on or spot-on, cont.	Lysoff 7.6% EC (fenthion)	1 pt/1 gal water. Use 1 fl oz/100 lb body weight.	21 days; 35 days if 2 applications are made. Do not apply within 28 days of freshening of dairy cattle. Pour evenly along back line. Do not treat calves under 3 months old or sick, convalescent, or stressed livestock. Do not use with other cholinesterase-inhibiting insecticides or drugs.
	Injection	Ivomec 1% (ivermectin)	Ready to use. 1 cc/110 lb body weight.	35 days. Inject subcutaneously. Use aseptic procedures. Do not use on dairy cattle of breeding age.
CATTLE GRUBS Larvae ("grubs") bore through the skin and migrate within the host to the skin of the back. Light infestations cause little or no reduction in the rate of gain or in feed efficiency. Hide damage can be economically important if cattle are slaughtered during the spring or early summer following grub emergence. The hairy, yellow and black adult flies, slightly smaller than honey bees, annoy grazing cattle.	Timing of grub control treatments is important. Systemic insecticides applied as pour-ons, spot-ons, or sprays travel within the animal's bloodstream and should be applied to control grubs 6 to 8 weeks before they migrate to the animal's back. Late treatments may cause host-parasite reactions with symptoms of bloat, hindquarter paralysis, or death. Systemic insecticides should be used on native beef cattle herds in August or September in southern Illinois, and in September or October in the northern half of the state. For native cattle, treat only summer-pastured cattle in areas with histories of grub problems. Animals in confinement are not attacked by ox warble flies (heel flies). Heel fly season and grub treatment dates are earlier for cattle grazed in southern states. Cattle feeders should either know the origin of feeder cattle to determine grub treatment dates or should purchase only cattle that have received grub treatments. Do not apply systemic insecticides in conjunction with or immediately after phenothiazine, with pyrethrins or synthetic pyrethroids or their synergists, or with other organophosphate insecticides. Do not treat cattle under stress from castration, dehorning, weaning, shipping, illness, or overexertion. Do not treat calves less than 3 months old.			
	Pour-on	Apply pour-ons using a long-handled dipper supplied by the manufacturer. Apply to the back line from the shoulder to the hip.		
		Co-Ral 4% (coumaphos)	Ready to use. Apply 0.5 fl oz/100 lb body weight.	0 days. Do not apply within 14 days of freshening of dairy cattle.
		Neguvon 8% (trichlorfon)	Ready to use. Apply 0.5 fl oz/100 lb body weight. Do not exceed 4 fl oz/animal.	21 days. Do not apply within 7 days of freshening of dairy cattle.
		Prolate (GX-118) 11.6% E (phosmet)	1 gal/2 gal water. Apply 1 fl oz/100 lb body weight. Do not exceed 8 fl oz/animal.	21 days. Do not apply to dairy animals.
		Tiguvon 3% (fenthion)	Ready to use. Apply 0.5 fl oz/100 lb body weight.	35 days. Do not apply within 28 days of freshening of dairy cattle.
		Warbex 13.2% (famphur)	Ready to use. Apply 0.5 fl oz/100 lb body weight. Do not exceed 4 fl oz/animal.	35 days. Do not apply within 21 days of freshening of dairy cattle. Do not use on Brahmans or Brahman crossbreeds.
	Spot-on	To apply spot-ons, use the applicator system provided by the manufacturer. Apply the material to a single location on the back midline.		
		Spotton 20% (fenthion)	Ready to use. Apply 4 cc/300 lb body weight. Do not exceed 20 cc/animal.	45 days. Do not treat dairy cattle of breeding age.
	Spray	Use high-pressure sprays (250-350 psi) to apply 3 to 4 quarts of finished spray per animal. Because few farm sprayers generate sufficient pressure for proper application, veterinarians and commercial applicators with appropriate livestock spray equipment should be contacted to apply grub sprays. Use a pencil stream of spray directed at right angles to the sides and back. Treat 10 or fewer animals at one time. Do not contaminate feed or water.		
		Co-Ral 25% WP or 11.6% EC (coumaphos)	12-16 lb 25% WP or 8-12 qt 11.6% EC/100 gal water.	0 days. Do not apply within 14 days of freshening of dairy cattle.
		Prolate (GX-118) 11.6% EC (phosmet)	2 gal/100 gal water.	21 days. Beef cattle only.
	Injection	Ivomec 1% (ivermectin)	Ready to use. 1 cc/110 lb body weight.	35 days. Inject subcutaneously. Use aseptic procedures. Do not use on dairy cattle of breeding age.

Beef Cattle and Nonlactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
MANGE MITES Microscopic mites live on the skin or burrow into it. Lesions vary with mite species. Infestations are greatest when cattle are crowded in shelters during winter months.	Chorioptic mange is the most prevalent mite-induced disorder of Illinois cattle. Infested cattle may or may not develop lesions; lesions usually occur as localized nodules that exude serum. They are most numerous from the tailhead to the hind heels. Insecticides listed previously for louse control on beef cattle also control chorioptic mange mites. Cattle scabies (psoroptic mange) is a quarantinable disease. Its symptoms are lesions that occur first on the withers, over the back, and at the tailhead. Small wounds cause itching, and rubbing leads to abscesses, especially on the shoulders and rump. Mites move to edges of scabs, causing lesions to enlarge and coalesce. Scabs may cover much of the body. Where cattle scabies is detected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, Illinois 62706, (217) 782-4944.			
TICKS 8-legged adults of most species are reddish brown and less than ¼ inch long. Engorged females may exceed ½ inch in length. Ticks are blood feeders and disease vectors.	Ticks rarely pose an economic threat to cattle in Illinois. Problems are most likely where cattle graze in brushy or wooded areas.			
	Spray	Apply sufficient spray to thoroughly wet each animal; use up to 1 gallon finished spray per animal. Do not contaminate feed or water.		
		Co-Ral 25% WP or 11.6% EC (coumaphos)	4 lb 25% WP or 1 gal 11.6% EC/100 gal water.	0 days. Do not treat calves less than 3 months old or sick, convalescent, or stressed cattle. Do not spray within 10 days after shipping, weaning, or disease exposure. Do not spray in nonventilated areas. Do not apply in conjunction with phenothiazine, pyrethroids, synergists, or systemic organophosphate insecticides.
		Ectiban 5.7% EC (permethrin)	1 qt/100 gal water.	0 days. Do not apply more than once every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for control of ticks on cattle. Check product labels for dilution and application rates.)		
		malathion 57% EC	1-2 gal/100 gal water.	0 days. Do not apply to dairy cattle within 14 days of freshening. Do not treat calves less than 1 month old.
		Taktic 12.5% EC (amitraz)	1 qt/100 gal water. Use up to 2 gal spray per fully grown animal.	0 days. Apply spray within 6 hours after mixing. Repeat application in 10-14 days.
MOSQUITOES Annoyance may cause cattle to bunch in or near buildings and reduce their grazing.	Mosquito populations are greatest near low, wet areas, ponds, or slow-moving streams. Reduction of mosquito breeding sites is necessary for long-term control. The insecticides listed below provide some short-term relief for treated animals, but frequent applications are not economical or recommended.			
	Spray (to animals)	Ectiban 5.7%	1 qt/100 gal water.	0 days. Do not apply more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of mosquitoes and horse flies on cattle. Check product labels for dilution and application rates.)		
		pyrethrin (0.1%) plus synergist	Mist 1-2 fl oz/ animal.	0 days. Do not contaminate feed or water. Do not wet skin.
HORSE FLIES, DEER FLIES (NHE 60) Large flies that feed on the back, shoulders, neck, and head. Blood feeding annoys cattle and reduces grazing and weight gain. Wounds attract other flies.	Adequate and practical control methods for horse flies and deer flies on pastured beef cattle are not available. Insecticide applications provide some relief but do not provide long-term control. Place cattle in barns or sheds to protect them from horse flies and deer flies.			
	Spray	Ectiban 5.7%	1 qt/100 gal water.	0 days. Do not apply more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of mosquitoes and horse flies on cattle. Check product labels for dilution and application rates.)		
		pyrethrin (0.5-1.0%) plus synergist	0.5% oil is ready to use; apply 2 fl oz/animal 3 times per week. Mix 1 gal 1% EC/10 gal water; apply 1 to 2 pt/ animal every 3 days.	0 days. Apply to head, back, sides, belly, and legs. Do not contaminate feed or water.

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES (HORN FLIES, FACE FLIES, STABLE FLIES) **Horn flies** (NHE 59) are smaller than house flies but are similarly colored and marked. They have piercing mouthparts and are blood feeders. Horn flies congregate about the back, shoulders, and horns; on hot days they are mostly on the shady side of the animal or on the belly. Horn flies seldom follow animals into barns or sheds. **Face flies** (NHE 106) resemble house flies but are slightly larger and darker. Only females frequently visit cattle. They feed on secretions about the eyes, nose, and mouth. **Stable flies** (NHE 61) resemble house flies but have a piercing proboscis that protrudes from the front of the head. Stable flies are blood feeders that often attack the lower portion of the front legs. Stable flies attack both pastured and feedlot cattle.	**Threshold Infestations and Adequate Levels of Control:** Horn fly infestations of up to 100 to 200 flies per animal produce little or no effect on the rate of gain. In Illinois, control programs utilizing dust bags or oilers often reduce horn fly infestations to 10 to 50 flies per animal. The use of dust bags or oilers provides adequate and economical control of horn flies and usually does not favor rapid development of insecticide resistance (as do ear tags). Available data do not support any estimates of what constitutes an economically damaging number of face flies or an acceptable level of face fly control. Although face flies annoy cattle, even heavy infestations do not cause reductions in the rate of gain. Face flies can transmit the pathogen that causes pinkeye, but pinkeye outbreaks also occur in the absence of face flies. Research indicates that as few as 1 to 5 stable flies per leg can reduce cattle performance in some conditions. Nonetheless, there are no effective insecticide applications for reducing stable fly attacks on pastured cattle. Although sprays directed at animals' legs may provide temporary relief, no long-term control is accomplished. Moving cattle into shelters reduces annoyance by horn flies and face flies, but it does not deter stable fly attack.			
	Back rubber or face rubber (oilers)	Mix insecticides with No. 2 fuel oil, No. 2 diesel fuel, or a label-recommended mineral oil. Mineral oils are less irritating than fuel oils. Do not use waste oil or motor oil. Service the rubbing device at least one per week. Self-treating devices are effective only if they are used regularly. Place rubbing devices in the entryways to water or mineral feeders to ensure usage. Effective horn fly control can be achieved with forced-use oilers; partial control of face flies is provided by these devices. Oilers do not control stable flies.		
		Co-Ral 11.6% EC (coumaphos)	1 gal/13 gal fuel or mineral oil.	0 days.
		Delnav 15% EC or 30% EC (dioxathion)	2 qt 15% EC or 1 qt 30% EC/5 gal fuel or mineral oil.	0 days. Beef cattle only.
		Ectiban 5.7% EC (permethrin)	1 qt/10 gal diesel oil.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
		Permectrin II 10% EC (permethrin)	1 qt/20 gal fuel or mineral oil.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
	Dust bag	Dust bags are effective only if they are used regularly. Place them in the entryways to water or mineral feeders to ensure use. Keep dust bags dry and well charged; service at least once per week. Forced-use dust bags that contact the animal's face provide effective horn fly control and significant reductions in face flies; dust bags do not effectively control stable flies.		
		Co-Ral 1% D (coumaphos)	10 lb/bag.	0 days.
		Ectiban or Permectrin 0.25% D (permethrin)	10 lb/bag.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
		malathion 4% plus methoxychlor 5% D	1 10-lb bag/ 10-15 animals.	0 days. Beef cattle only.
		Rabon 3% D (stirofos)	4-8 lb/bag.	0 days.
	Feed additive	Feed additives prevent the development of face fly and horn fly larvae in cattle dung. Stable flies do not develop in fresh dung and are not controlled by feed additives. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not also receive boluses or feed additives. Animals must consume the recommended dosage for the feed additive to be effective.		
		Altosid 0.02% (methoprene)	0.25-0.5 lb/100 lb body weight/ animal/month.	0 days. Feed mineral mix or block from May to September.
		Rabon 97.3% or 7.76% Oral Larvacide (stirofos)	70 mg a.i./100 lb body weight/day.	0 days. Use from May through September. Mix with complete feeds, concentrates, or protein supplements.
	Bolus	Boluses release an active ingredient that prevents the development of face fly and horn fly larvae in treated dung. Stable flies do not develop in fresh dung and are not controlled by bolus use. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not receive boluses or feed additives.		
		Vigilante 9.5% bolus (diflubenzuron)	1 bolus/550 lb body weight.	0 days. Use standard balling gun. Do not administer to animals weighing less than 300 pounds. No more than 2 boluses per animal. Boluses can be divided in half to achieve correct rate.

Beef Cattle and Nonlactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES, cont.	Ear tag or ear tape	Ear tags and tapes impregnated with pyrethroid insecticides such as fenvalerate, flucythrinate, or permethrin effectively control horn flies (in the absence of resistance) and provide some control of face flies. They do not control stable flies. One tag or tape per cow will effectively control non-resistant horn fly populations for up to 20 weeks. Midseason control failures indicate horn fly resistance. Using 2 tags per cow and 2 tags per calf will improve face fly control; maximizing tagging rate will not overcome horn fly resistance. Attach tags in late May or early June after fly populations have begun to increase. Remove tags in September or October. Tags containing the organophosphates diazinon (Terminator tag) or pirimiphos-methyl (Tomahawk tag) effectively control horn flies (including pyrethroid-resistant horn flies), but they are somewhat less effective than pyrethroid tags for face fly control. Two tags per cow will provide horn fly control for approximately 16 weeks. Attach tags in late May or early June after fly populations have begun to increase. Remove tags in September or October. Tags containing cypermethrin (a pyrethroid) plus Dursban (an organophosphate) plus a synergist also are available (Max-Con tags). These tags do not effectively control pyrethroid-resistant horn flies. Horn fly populations in several locations throughout Illinois have developed resistance to pyrethroids in ear tags. To slow the development of resistance or manage pyrethroid-resistant horn flies: 1. Delay applying pyrethroid tags until early-season horn fly infestations have reached 100-200 flies per animal. 2. Use sprays, dust bags, or oilers containing an organophosphate (coumaphos, dioxathion, or stirofos) or a chlorinated hydrocarbon (methoxychlor) for fly control in some herds. Using dust bags or oilers provides the most economical control of horn flies. Use organophosphate-impregnated tags in some herds, but do not switch to complete reliance on any single tag. Do not use pyrethroid tags every year or on every herd; alternate with other treatment methods. 3. Do not use sprays or dusts of pyrethroids to control flies not controlled by pyrethroid tags. 4. Remove tags as soon as possible where resistance is evident (more than 100 horn flies per animal). Continuous exposure to pyrethroid tags prevents a decline in the level of resistance in the horn fly population.		
		fenvalerate 8% tag (Ectrin, Insecta-Shield, Ear Tag Plus, Starbar, Vet Shack)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		flucythrinate 7.5% tag (Guardian)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		permethrin 10% tag (Atroban, Apollo, Expar, Insecta-Gard, Gard Star, Fearing Du-flex, Gen-Sal, Permectrin)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		permethrin 0.9 g tape (Ectiban)	1 tape per animal.	0 days. Remove in fall or before slaughter.
		diazinon 20% tag (Terminator)	2 tags per animal.	0 days. Do not apply to calves less than 3 months old. Do not apply to lactating dairy cattle. Remove in fall or before slaughter.
		pirimiphos-methyl 20% tag (Tomahawk)	2 tags per animal.	0 days. Do not apply to lactating dairy cattle. Remove in fall or before slaughter.
	Spray	Sprays directed to animals should not contaminate feed or water. Do not use sprays containing fenvalerate or permethrin to control resistant horn flies that are not controlled by pyrethroid ear tags.		
		Co-Ral 11.6% EC or 25% WP (coumaphos)	2 qt 11.6% EC or 2 lb 25% WP/ 100 gal water. Completely wet skin to runoff.	0 days. Do not apply to dairy cattle within 14 days of freshening.
		Delnav 15% EC or 30% EC (dioxathion)	1 qt 15% EC or 1 pt 30% EC/25 gal water.	0 days. Do not use more often than every 14 days. Do not use on dairy cattle or in dairy barns. Restricted-use.
		Ectiban 5.7% EC (permethrin)	1 qt/100 gal water. Thoroughly wet animals.	0 days. Repeat as needed, but not more often than once every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for control of pasture flies on cattle. Check product labels for dilution and application rate.		
		methoxychlor 25% EC or 50% WP	2 qt 25% EC or 2 lb 50% WP/25 gal water.	0 days. Do not use on dairy cattle or in dairy barns.
		Rabon 50% WP (stirofos)	4 lb/75 gal water. Use ½ to 1 gal/animal.	0 days. Beef cattle only.

Lactating Dairy Cattle

Insecticides listed in this section are registered for use on lactating dairy cattle. Most insecticides listed for use on beef cattle can be applied to nonlactating dairy cattle if the specified interval between application and freshening is observed. Follow all label directions.

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE (NHE 18) 1/16 to 1/8 inch long. Biting lice are reddish, flattened, and active. Sucking lice are gray to blue and sluggish. Heavy populations cause reduced milk production and anemia. Symptoms are rough, patchy hair coats and a dirty appearance. Most troublesome in winter.	Dust bag	Place dust bags at milkroom exits. Keep bags charged and dry, and service at least once per month. (Co-Ral 1% dust and Ectiban and Permectrin 0.25% dusts can be used for direct hand-dusting; follow label directions.)		
		Co-Ral 1% D (coumaphos)	10 lb dust/bag.	0 days.
		Ectiban or Permectrin 0.25% D (permethrin)	10 lb dust/bag. Self-treating.	0 days.
	Spray	Apply sufficient spray to thoroughly wet each animal; use up to 1 gallon finished spray per animal. Do not contaminate feed, water, milk, or milking equipment.		
		Co-Ral 11.6% EC or 25% WP (coumaphos)	1 qt 11.6% EC or 1 lb 25% WP/100 gal water.	0 days. Do not treat calves less than 3 months old.
		Ectiban 5.7% EC (permethrin)	1 qt/100 gal water.	0 days. Repeat application 14-21 days after first treatment.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of lice on dairy cattle. Check product labels for dilution and application rates.)		
		Taktic 12.5% EC (amitraz)	1 qt/100 gal water. Use up to 2 gal per fully grown animal.	0 days. Apply spray within 6 hours after mixing. Repeat application in 10-14 days.
CATTLE GRUBS	No pesticides are currently registered for control of cattle grubs on lactating dairy cattle.			
MANGE MITES Microscopic mites live on or within skin. Lesions vary with mite species. Infestations are greatest when cattle are crowded in shelters during winter.	Mange caused by chorioptic mites (barn itch mites) is the most common mite-induced disorder of Illinois dairy cattle. Infested cattle may or may not develop lesions; lesions usually appear as localized nodules that exude serum. Lesions are most prevalent from the tailhead to the hind heels. Insecticides listed for louse control on dairy cattle also control chorioptic mange. Cattle scabies (psoroptic mange) is a quarantinable disease. Its symptoms are lesions that occur first at the withers, over the back, and at the tailhead. The wounds itch, and rubbing leads to absesses, especially on the shoulders and rump. Mites move to edges of scabs, causing lesions to enlarge and coalesce. Scabs may cover much of the body. Where cattle scabies is detected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, Illinois 62706, (217) 782-4944.			
TICKS 8-legged adults of most species are reddish brown and less than 1/4 inch long. Engorged females may exceed 1/2 inch in length. Ticks are blood feeders and disease vectors.	Ticks are rarely economically important on Illinois dairy cattle. Problems are most likely where cattle graze in brushy or wooded areas.			
	Spray	Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Do not apply more often than once every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of ticks on dairy cattle. Check product labels for dilution and application rates.		
		Taktic 12.5% EC (amitraz)	1 qt/100 gal water. Use up to 2 gal per fully grown animal.	0 days. Apply spray within 6 hours after mixing. Repeat application in 10-14 days.
MOSQUITOES Blood feeding. Annoyance may cause cattle to remain in buildings and reduce their grazing.	Mosquito populations are greatest near low, wet areas, ponds, and slow-moving streams. Reduction of mosquito breeding sites is necessary for long-term control. The insecticides listed below provide some short-term relief for treated animals, but frequent applications are not economical or recommended.			
	Spray (to animals)	Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt per animal.	0 days. Do not apply more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of mosquitoes on dairy cattle. Check product labels for dilution and application rates.)		
		pyrethrin (0.03-0.10%) plus synergist (0.5-1.0%)	Ready to use. Mist 1-2 fl oz/animal.	0 days. Do not wet skin. Do not contaminate feed, water, milk, or milking equipment. Repeat as necessary.

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES (HORN FLIES, FACE FLIES, STABLE FLIES) **Horn flies** (NHE 59) are smaller than house flies but are similarly colored and marked. They have piercing mouthparts and are blood feeders. Horn flies congregate about the back, shoulders, and horns; on hot days they are mostly on the shady side of the animal or on the belly. Horn flies seldom follow animals into barns or sheds. **Face flies** (NHE 106) resemble house flies but are slightly larger and darker. Only females frequently visit cattle. They feed on secretions about the eyes, nose, and mouth. **Stable flies** (NHE 61) resemble house flies but have a piercing proboscis that protrudes from the front of the head. Stable flies are blood feeders that often attack the lower portion of the front legs. Stable flies attack both pastured and feedlot cattle.	**Threshold Infestations and Adequate Levels of Control:** In Illinois, control programs utilizing dust bags or oilers often reduce horn fly infestations to 10 to 50 flies per animal. The use of dust bags or oilers provides adequate and economical control of horn flies and usually does not favor rapid development of insecticide resistance (as do ear tags). Available data do not support any estimates of what constitutes an economically damaging number of face flies or an acceptable level of face fly control. Although face flies annoy cattle, even heavy infestations do not cause reductions in milk production. Face flies can transmit the pathogen that causes pinkeye, but pinkeye outbreaks also occur in the absence of face flies. Research indicates that as few as 1 to 5 stable flies per leg can reduce milk production in some conditions. Spraying cattle's legs as they exit the milkroom provides temporary relief, but no long-term control is accomplished. Moving cattle into shelters reduces annoyance by horn flies and face flies, but it does not deter stable fly attack.			
	Back rubber or face rubber (oilers)	Mix insecticides with No. 2 fuel oil, No. 2 diesel fuel, or a label-recommended mineral oil. Mineral oils are less irritating than fuel oils. Do not use waste oil or motor oil. Service the oiler at least once per week. For self-treating devices to be effective, cattle must use them frequently. Place oilers in the entryways to water or mineral feeders or in the milking room exit. Well-used back rubbers or face rubbers will control horn flies and provide some face fly control. They will not control stable flies.		
		Co-Ral 11.6% EC (coumaphos)	1 gal/13 gal fuel or mineral oil.	0 days.
		Ectiban 5.7% EC (permethrin)	1 qt/10 gal oil.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
		Permectrin II 10% EC (permethrin)	1 qt/20 gal fuel or mineral oil.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
	Dust bag	For self-treating devices to be effective, cattle must use them regularly. Place dust bags in the entryways to water or mineral feeders or in the milking room exit. Keep dust bags dry; service at least once per week. Dust bags will control horn flies and provide some reduction in face fly problems. They will not control stable flies. (NOTE: Insecticide dusts listed below can also be used for direct hand-dusting; follow label directions.)		
		Co-Ral 1% D (coumaphos)	10 lb/dust bag.	0 days. Do not treat calves less than 3 months old.
		Ectiban or Permectrin 0.25% D (permethrin)	10 lb/dust bag.	0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags.
		Rabon 3% D (stirofos)	4-8 lb/dust bag.	0 days.
	Spray	It is important that the following sprays do not contaminate feed, water, milk, or milking equipment. Do not use sprays containing fenvalerate or permethrin to control resistant horn flies that are not controlled by pyrethroid ear tags.		
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Re-treat as needed, but not more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for pasture fly control on dairy cattle. Check product labels for dilution and application rates.)		
		pyrethrin (0.1%) plus synergist	Ready to use. Apply 1-2 fl oz/animal.	0 days. Repeat as needed.
	Feed additive	Feed additives prevent the development of face fly and horn fly larvae in cattle dung. Stable flies do not develop in fresh dung and are not controlled by feed additives. Face flies and horn flies migrate considerable distances, so larval control in the dung of a single herd may not substantially reduce fly populations if other herds in the area do not also receive boluses or feed additives. Animals must consume the recommended dosage for the feed additive to be effective.		
		Rabon 97.3% or 7.76% Oral Larvicide (stirofos)	70 mg a.i./100 lb body weight/day.	0 days. Feed in complete feeds, concentrates, or protein and mineral supplements from May to September.

Lactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES, cont.	Bolus	Boluses release an active ingredient that prevents the development of face fly and horn fly larvae in treated dung. Stable flies do not develop in fresh dung and are not controlled by bolus use. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not receive boluses or feed additives.		
		Vigilante 9.5% bolus (diflubenzuron)	1 bolus/550 lb body weight.	0 days. Use standard balling gun. Do not administer to animals weighing less than 300 pounds. No more than 2 boluses per animal. Boluses can be divided in half to achieve correct rate.
	Ear tag or ear tape	Ear tags and tapes impregnated with pyrethroid insecticides such as fenvalerate, flucythrinate, or permethrin effectively control horn flies (in the absence of resistance) and provide some control of face flies. They do not control stable flies. One tag or tape per cow will effectively control non-resistant horn fly populations for up to 20 weeks. Midseason control failures indicate horn fly resistance. Using 2 tags per cow and 2 tags per calf will improve face fly control; maximizing tagging rate will not overcome horn fly resistance. Attach tags in late May or early June after fly populations have begun to increase. Remove tags in September or October. Tags containing the organophosphate Rabon (stirofos) provide fly control for approximately 6 weeks after application. The organophosphates diazinon (Terminator tags) and pirimiphos-methyl (Tomahawk tags) should **not** be used on lactating dairy cattle. Horn fly populations in several locations throughout Illinois have developed resistance to pyrethroids in ear tags. To slow the development of resistance or manage pyrethroid-resistant horn flies: 1. Delay applying pyrethroid tags until early season horn fly infestations have reached 100-200 flies per animal. 2. Use sprays, dust bags, or oilers containing an organophosphate (coumaphos, dioxathion, or stirofos) or a chlorinated hydrocarbon (methoxychlor) for fly control in some herds. Using dust bags and oilers provides the most economical control of horn flies. Do not use pyrethroid tags every year or on every herd; alternate with other treatment methods. 3. Do not use sprays or dusts of pyrethroids to control flies not controlled by pyrethroid tags. 4. Remove tags as soon as possible where resistance is evident (more than 100 horn flies per animal). Continuous exposure to pyrethroid tags prevents a decline in the level of resistance in the horn fly population.		
		fenvalerate 8% ear tag (Ectrin, Insecta-Shield, Ear Tag Plus, Starbar, Vet Shack)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		flucythrinate 7.5% tag (Guardian)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		permethrin 10% ear tag (Atroban, Apollo, Expar, Insecta-Gard, Gard Star, Fearing, Permectrin)	1-2 tags per head.	0 days. Remove in fall or before slaughter.
		permethrin 0.9 g ear tape (Ectiban)	1 tape per animal.	0 days. Remove in fall or before slaughter.
		stirofos 13.7% tag (Rabon)	1-2 tags per head.	0 days. Remove in fall or before slaughter.

Hogs

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
MANGE MITES (AND LICE) Microscopic mites feed on or within skin and cause mange.	Although mange mites and lice are blamed for substantial losses in swine production, controlled studies indicate that otherwise healthy pigs suffer little or no reduction in the rate of gain or feed efficiency when infested with mange mites and lice. Managing lice and mange mites remains an important step in swine production, but keeping every animal louse-free and mange-free through the time of sale and slaughter is probably **not** economically justified. Mange mites and lice are spread by direct contact among animals. They may survive off the host animal for short periods in bedding, but they do not infest animals other than swine. Prevent mange outbreaks by isolating and treating any new animals — especially boars — before adding them to the herd. Thoroughly clean and disinfect pens before using them to hold uninfested animals. To prevent infestation of newborn pigs, treat boars before the breeding season and treat sows 30 to 45 days before farrowing. It is often necessary to treat all animals in contact with those infested by mange mites or lice. It is also wise to isolate carrier animals to prevent the unnecessary spread of these pests from animal to animal.			

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
MANGE MITES cont. **Sarcoptic mange** usually starts at the head and then spreads back; infested skin becomes dry, scurfy, or leathery. Rubbing may lead to raw or scabby areas. **Demodectic mange** is characterized by hard, round swellings on or below the skin surface.	The insecticides listed below will help to control sarcoptic mange. There is no satisfactory chemical control for the hog follicle mites that cause demodectic mange. Isolate hogs with demodectic mange. Kill and destroy severely infested animals; market for slaughter the animals that are severely attacked. Clean and disinfect pens, sheds, and other infested areas before moving in uninfested animals. Follow label precautions against the simultaneous use of organophosphate sprays, dusts, or pour-ons with similar medications used for internal parasite control. Do not contaminate feed or water.			
	Spray	Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Spray animals thoroughly.	5 days. Repeat application after 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for control of hog lice and mange. Check product labels for dilution and application rates.)		
		Ectrin 10% WDL (fenvalerate)	1 qt/50 gal water. Spray each animal thoroughly.	1 day. Repeat application in 14 days if necessary.
		lindane 12.4% EC or 20% EC	3 pt 12.4% EC or 1 qt 20% EC/100 gal water. Spray animals thoroughly.	30 days. Treat twice at a 7-day interval. Do not treat pigs less than 3 months old. Do not treat sows within 2 weeks before farrowing or 3 weeks after farrowing. Restricted-use.
		malathion 57% EC	1 qt/15 gal water. Treat animals, bedding, and walls thoroughly.	0 days. Do not treat pigs less than 1 month old. Repeat treatment after 10 days.
		Taktic 12.5% EC (amitraz)	1 qt/50 gal water. Spray animals, bedding, and walls thoroughly.	1 day. Apply spray within 6 hours after mixing. Repeat application in 7-10 days.
	Dust	malathion 4-5% D	Thoroughly cover animals over 1 month old. Also treat pens and bedding. Use ¼-½ tbsp/pig for pigs less than 1 month old.	0 days. Repeat as needed. Gives only partial control of mange mites.
LICE Up to ⅛ inch long. Hog lice are bluish black in color. They suck blood from infested animals.	Insecticides listed for controlling mange mites on hogs will also control lice. Do not contaminate feed or water. Follow label precautions against the simultaneous use of organophosphate sprays, dusts, or pour-ons with medications used for internal parasite control.			
	Spray	Co-Ral 25% WP (coumaphos)	2 lb/100 gal water. Spray each animal thoroughly.	0 days. Do not treat animals less than 90 days old. Apply a second spray 10-14 days after first.
		methoxychlor 50% WP	8 lb/100 gal water. Spray each animal thoroughly.	0 days. Make second application 14 days after first if needed.
	Dust	Co-Ral 1% D (coumaphos)	1 oz/animal.	0 days. Dust especially around shoulders and back. Repeat as needed, but not more than once every 10 days.
		Ectiban or Permectrin 0.25% D (permethrin)	1 oz/animal.	5 days. Make second application 14 days after first.
		Rabon 3% D (stirofos)	3-4 oz/animal; 1 lb/150 sq ft of bedding for severe infestations.	0 days. Do not re-treat for 14 days.
	Pour-on	Ectrin 10% WDL (fenvalerate)	1 qt/25 gal water. Pour 4 fl oz/animal on head and back midline.	1 day. Add wetting agent according to label directions. Repeat application in 14 days if necessary.
		Tiguvon 3% Pour-On (fenthion)	0.5 fl oz/100 lb body weight.	14 days. May be used on gestating and lactating sows. Do not re-treat within 35 days.

Sheep

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
KEDS, LICE (NHE 53) **Sheep keds** (also called sheep ticks) are flattened, wingless, reddish brown flies about the size of house flies. **Lice** reach 1/16 to 1/8 inch in length. Biting lice are flattened and yellowish to reddish in color. Sucking lice are oval and bluish gray.	Spray	Apply enough spray to thoroughly cover each animal. Do not contaminate feed or water.		
		Co-Ral 25% WP (coumaphos)	*Lice:* 2 lb/100 gal water. *Keds:* 4 lb/100 gal water.	15 days. Do not treat lambs less than 3 months old.
		diazinon 50% WP	0.5 lb/100 gal water. Use 1 gal/animal.	14 days. Use high pressure and volume. Do not treat lambs less than 2 weeks old.
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Repeat application in 14 days. Do not treat more often than every 14 days.
		Ectrin 10% WDL (fenvalerate)	1 qt/100 gal water. Wet each animal with up to 1 qt of spray.	2 days. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall.
		malathion 57% EC	1 gal/100 gal water.	0 days. Do not treat lambs less than 1 month old.
		Marlate 50% WP (methoxychlor)	8 lb/100 gal water. Spray each animal thoroughly.	0 days.
	Dip	Co-Ral 25% WP (coumaphos)	*Lice:* 2 lb/100 gal water. *Keds:* 4 lb/100 gal water.	15 days. Do not dip lambs less than 3 months old.
	Dust	Co-Ral 0.5% D	Follow label directions.	15 days. Treat once after shearing. Do not treat lambs less than 3 months old.
		diazinon 2% D	1½ oz/animal.	14 days. Do not treat lambs less than 2 weeks old.
		malathion 4-5% D	1-2 oz/animal.	0 days. Repeat application in 2-3 weeks if needed. Do not treat lambs less than 1 month old.
		Marlate 50% WP (methoxychlor)	1 tbsp/animal.	0 days. Treat only once.
	Pour-on	Ectrin 10% WDL (fenvalerate)	2 qt/25 gal water. Pour 4 fl oz/animal down midline of back.	2 days. Add wetting agent according to label directions. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall.
WOOL MAGGOTS Cream-colored maggots are larvae of blow flies. Maggots live in wet, matted wool near the rear of the animal and in matted wool surrounding wounds.	Spray	Reduce wool maggot attacks by tagging sheep (shearing under the tail and between the hind legs), docking, and castrating before May. Practice good sanitation. Shear around and direct sprays to the infested areas.		
		Co-Ral 25% WP (coumaphos)	4 lb/100 gal water. Use 1 gal/animal.	15 days. Do not treat lambs less than 3 months old.
		diazinon 50% WP	0.5 lb/100 gal water. Use 1 gal/animal.	14 days. Do not treat lambs less than 2 weeks old.
SCAB MITES (SCABIES, WET MANGE)	Sheep scab is a quarantinable disease. Infested animals shed wool; skin becomes roughened and crusted. Where infestations are suspected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, Illinois 62706, (217) 782-4944.			
HORN FLIES (NHE 59) **FACE FLIES** (NHE 106)	Spray	Co-Ral 25% WP (coumaphos)	2 lb/100 gal water.	15 days. Do not treat lambs less than 3 months old.
		Marlate 50% WP (methoxychlor)	2 lb/100 gal water.	0 days. Repeat treatment every 3 weeks as needed.
		pyrethrin (0.05-0.10%) plus synergist (0.5-1.0%)	1-2 fl oz/animal.	0 days. Apply daily to head, neck, and front legs as a fine mist. Do not wet hair or skin.

Goats

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE (NHE 53)	Spray	Ectrin 10% WDL (fenvalerate)	1 qt/100 gal water. Wet each animal with up to 1 qt of spray.	2 days. Do not apply to lactating goats. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall.
	Pour-on	Ectrin 10% WDL (fenvalerate)	1 qt/25 gal water. Pour 4 fl oz/animal down midline of back.	2 days. Do not apply to lactating goats. Add wetting agent according to lable directions. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall.
FACE FLIES (NHE 106), **HORN FLIES** (NHE 59), **STABLE FLIES** (NHE 61) **HORSE FLIES, DEER FLIES** (NHE 60)	Spray	pyrethrin (0.05-0.10%) plus synergist (0.5-1.0%)	1-2 fl oz/animal.	0 days. Apply to head, neck, and front legs as a fine mist. Do not wet hair or skin.

Poultry

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE, NORTHERN FOWL MITES (BIRD TREATMENT) (NHE 54)	Spray	Co-Ral 25% WP (coumaphos)	*Lice:* 6 oz/5 gal water. *Mites:* 3 oz/5 gal water. Use 1 gal/100-125 birds, or 0.5 fl oz/bird.	0 days. Do not treat more than once per week. Do not treat within 10 days of vaccination or stress.
Chicken lice are flat-bodied, straw-colored, 1/16-inch-long lice with chewing mouthparts. They feed on feathers and skin flakes, irritating birds. Severe infestations reduce egg production.		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1 gal/100 birds.	0 days. Treat vent area thoroughly.
		malathion 57% EC	1 fl oz/gal water. Use 1 gal/100-125 birds.	0 days. Repeat treatment in 4-8 weeks or when necessary.
		Permectrin II 10% EC (permethrin)	1 qt/50 gal water. Use 1 gal/100 birds.	0 days. Treat vent area thoroughly.
		Rabon 50% WP (stirofos)	6.5% oz/5 gal water. Use 1 gal/100 birds or 1 fl oz/bird using at least 100-125 psi.	0 days. Do not treat more than once every 14 days.
Northern fowl mites are dark red to black blood feeders that build up in the vent area. Mature mites are roughly 1/25 inch long. Feathers around the vent appear grayish or black from accumulation of mites, mite eggs, and excrement. Severe infestations reduce egg production and can cause death. Northern fowl mites are most troublesome in winter.		Sevin 50% WP or 80% SP (carbaryl)	6 oz 50% WP or 4 oz 80% SP/5 gal water. Use 1 gal/100 birds.	7 days. Repeat treatment in 4 weeks if necessary.
	Dust	Ectiban or Permectrin 0.25% D (permethrin)	Use 1 lb/100 birds.	0 days. Apply with shaker or hand duster. Treat vent area thoroughly.
		malathion 4-5% D	Use 1 lb/100 birds.	0 days. Apply with shaker or hand duster.
		Rabon 3% D (stirofos)	Use 1 lb/300 birds.	0 days. Apply with hand or power duster. Do not treat more than once every 14 days.
		Sevin 5% D (carbaryl)	Use 1 lb/100 birds.	7 days. Apply with shaker or hand duster. Do not treat more than once every 4 weeks.
	Strip	Permectrin 10% strip (permethrin)	1 or 2 strips per cage of up to 9 hens.	0 days. For northern fowl mite control.

Poultry, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE, CHICKEN MITES, NORTHERN FOWL MITES (POULTRY HOUSE AND LITTER TREATMENT) (NHE 54) **Chicken mites** (or roost mites) are bright to dark red and 1/25 inch long. They hide in cracks and crevices during the day and feed on birds at night. They are most prevalent in spring, summer, and fall, not in winter.	Spray	Co-Ral 25% WP (coumaphos)	6 oz/5 gal water. Use 1 gal/1,000 sq ft.	0 days. Apply thoroughly to litter, walls, ceilings, floors, roosts, nests, and adjacent areas. Force spray into all cracks and crevices.
		malathion 57% EC	2 fl oz/gal water. Use 1 gal/1,000 sq ft.	0 days. Apply liberally to litter, walls, ceilings, floors, roosts, nests, and adjacent areas. Force spray into cracks and crevices.
		Rabon 50% WP (stirofos)	0.5 lb/6 gal water. Use 1-2 gal/1,000 sq ft.	0 days. Apply thoroughly to litter, walls, roosts, cracks, crevices, and interiors.
		Sevin 50% WP or 80% SP (carbaryl)	2 lb 50% WP or 1.5 lb 80% SP/5 gal water. Use 1-2 gal/1,000 sq ft.	7 days. Apply spray to walls, bedding, litter, and roosts. Force spray into cracks and crevices. Repeat as needed. Avoid contamination of nests, eggs, feed, and water.
	Dust	malathion 4-5%	1 lb/50-60 sq ft.	0 days. Apply liberally to litter, walls, ceilings, roosts, nests, and adjacent areas.
		Rabon 3% D or 50% WP (stirofos)	1 lb 3% D or 2.5 oz 50% WP/100 sq ft.	0 days. Treat litter evenly and thoroughly.
		Sevin 5% D (carbaryl)	1 lb/40 sq ft.	7 days. Apply to litter, roosts, and adjacent areas. Do not apply to eggs or nests. Do not treat more than once every 4 weeks.
DARKLING BEETLES (LESSER MEALWORMS) Cream-colored larvae infest decaying organic matter or moldy feeds. Can serve as intermediate hosts for poultry pathogens. Sometimes nest in and damage building insulation.	Spray	Rabon 50% WP (stirofos)	2 lb/25 gal water. Use 1-2 gal/1,000 sq ft.	0 days. Apply evenly and thoroughly to litter, walls, center posts, and foundation walls.
		Sevin 80% SP or 40% or 43.4% suspensions (carbaryl)	62.5 lb 80% SP or 50 qt 40% or 43.4% suspensions/ 100 gal water. Use 2 gal/1,000 sq ft.	7 days. Apply evenly and thoroughly to litter or floor surface. Do not appy directly to poultry, nests, or eggs. Repeat as needed.
	Dust	Sevin 5% D (carbaryl)	1 lb/40 sq ft.	7 days. Do not apply to eggs or nest litter. Do not treat more than once every 4 weeks.
BED BUGS Flat, reddish brown, blood-sucking insects that feed at night. Rarely seen on birds during daylight.	Spray	Sevin 50% WP, 80% SP, or 40% or 43.4% suspensions (carbaryl)	8 lb 50% WP, 5 lb 80% SP, or 4 qt 40% or 43.4% suspensions/ 100 gal water. Use 1-2 gal/1,000 sq ft.	7 days. Apply thoroughly to walls, litter, and roost surfaces. Force spray into cracks and crevices. Do not apply directly to poultry, nests, or eggs. Repeat as needed.
	Dust	Sevin 5% D (carbaryl)	1 lb/40 sq ft.	7 days. Apply even to litter. Do not treat more than once every 4 weeks. Do not apply to eggs or nest.

Horses

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
MANGE MITES Burrowing in skin causes pain and itching. Most prevalent in winter.	Spray	Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Repeat application in 14 days. Do not treat more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of mites on horses. Check product labels for dilution and application rates.)		

Horses, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE 1/16 to 1/8 inch in length. Biting lice are yellow to red. Sucking lice are brownish to blue-gray. Head and neck, withers, and tailhead develop a scurfy appearance. Rubbing may create raw areas.	Spray	Co-Ral 25% WP or 11.6% EC (coumaphos)	0.5 lb 25% WP or 1 pt 11.6% EC/25 gal water. Treat animal thoroughly.	0 days.
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Repeat application in 14 days. Do not treat more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of lice on horses. Check product labels for dilution and application rates.)		
		malathion 57% EC or 25% WP	6.5-10 fl oz 57% EC or 0.75 lb 25% WP/ 5 gal water. Treat animal thoroughly.	0 days.
TICKS Seldom a problem unless horses graze in brushy or wooded areas.	Spray	Co-Ral 25% WP or 11.6% EC (coumaphos)	1 lb 25% WP or 1 qt 11.6% EC/25 gal water. Treat animal thoroughly.	0 days. Repeat as necessary.
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Do not treat more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of ticks on horses. Check product labels for dilution and application rates.)		
		malathion 57% EC or 25% WP	6.5-10 fl oz 57% EC or 0.75 lb 25% WP/ 5 gal water. Treat animal thoroughly.	0 days.
HORSE BOTS Flies are nearly as large as honey bees. They deposit eggs on the forelegs, throat, or muzzle, area; fly activity severely annoys horses. Eggs are ingested; larvae (bots) develop within the horse's alimentary canal.	Feed additive	Anthon 90% Powder (trichlorfon)	5 g/250 lb body weight mixed with feed. Treat from mid-October to mid-December.	Nonfood use. Repeat after 3 to 4 months. Withdraw all feed 12-18 hours prior to and 3 hours after treatment. Do not treat colts under 4 months of age, mares in the last month of gestation, or horses to be used for food.
	Oral paste	Eqvalan 1.87% (ivermectin)	Ready to use. Follow directions on prefilled syringe.	Nonfood use.
		Equibot or Combot (trichlorfon)	Ready to use. Follow directions on prefilled syringe.	Nonfood use.
	Stomach tube	Consult with a veterinarian for treatment with carbon disulfide, or piperazine + carbon disulfide (Parvex Plus).		
	Preventive spray	malathion 57% EC	During fall months, sponge legs, under jaw, and chest of animal with a warm 0.5% malathion solution.	0 days. Eggs will be stimulated to hatch and the larvae will be prevented from borrowing into the animal. Re-treat when more eggs accumulate. Do not use bare hands; use specially prepared gloves or rubber gloves.
SCREWWORMS, BLOW FLIES Maggots develop in wounds.	Spray	Co-Ral 25% WP (coumaphos)	1.3 oz/gal water. Treat wound lightly but thoroughly.	0 days.
		Co-Ral 3% Spray Foam (coumaphos)	Ready to use. Spray thoroughly so that foam completely covers wound.	0 days.
	Dust	Co-Ral 5% D (coumaphos)	Ready to use. Treat wound lightly but thoroughly.	0 days.

Horses, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
HORN FLIES, FACE FLIES, STABLE FLIES, HORSE FLIES, DEER FLIES, BLACK FLIES, MOSQUITOES	Spray	Co-Ral 25% WP or 11.6% EC (coumaphos)	0.5 lb 25% WP or 1 pt 11.6% EC/25 gal water. Treat animal thoroughly.	0 days.
		malathion 57% EC or 25% WP	6.5-10 fl oz 57% EC or 0.75-1.25 lb 25% WP/5 gal water. Treat animal thoroughly.	0 days.
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Do not treat more often than every 14 days.
		(Additional permethrin formulations including emulsifiable concentrates of Insectrin, Permaban, and Permectrin II are registered for the control of biting flies on horses. Check product labels for dilution and application rates.)		
		Ectrin 10% WDL (fenvalerate)	4 fl oz/3 gal water. Mist 8 fl oz spray per animal. Direct at face, head, shoulders, and legs.	Do not treat animals intended for slaughter.
		pyrethrin plus synergist	Ready to use.	0 days. Apply as a mist spray. Do not wet the hide. Repeat as needed.
		Rabon 1% Spray-n-Wipe (stirofos)	Apply 1-2 fl oz to flanks, belly, and back.	0 days.
	Dust	Co-Ral 1% D (coumaphos)	2 oz/animal.	0 days. Apply to the head, neck, shoulders, back, and tailhead. Repeat as needed.
		malathion 4% D	4 tbsp/animal.	0 days. Apply evenly along back line. Repeat at 10-14 day intervals.
	Wipe-on	Rabon 2% Gel Wipe-on (stirofos)	1-2 fl oz/animal.	0 days. Apply as directed every 2-3 days if needed.

FLY CONTROL IN LIVESTOCK BUILDINGS AND FEEDLOTS

Filth fly species that commonly inhabit livestock dwellings, feedlots, and nearby buildings include the house fly, stable fly, little house fly, and several blow fly species. These flies develop in a variety of moist, organic wastes including manure, spilled feed, decaying vegetation, and garbage. Common breeding sites are around feed bunks, at the edges of feeding floors, under fences, along stacks of hay or straw, and in accumulations of manure.

Although stable flies are biting flies that take blood meals from cattle, horses, and hogs, most other flies associated with confined livestock are nuisance pests, not blood feeders. Neither stable flies nor nonbiting nuisance flies spend much time on their animal hosts, so successful fly control around confined livestock does not center on animal treatments. The use of dust bags, oilers, or ear tags provides little or no control of flies in or around buildings. Sprays directed to the legs and belly of cattle, horses, and hogs (apply as recommended in preceding sections for horn fly control on individual livestock species) may provide short-term relief from stable fly attack, but such applications are not likely to significantly reduce the overall fly problem.

Thorough sanitation is the most important step in successful fly control. Weekly removal of manure, decaying hay and straw, and spilled feeds disrupts fly breeding sites frequently enough to prevent the development of fly larvae. Removing wastes beneath feeders and along fences is especially important. If manure is temporarily piled before spreading, cover it with black plastic to prevent flies from entering or leaving this potential breeding site. If manure is not removed weekly, leaving an 8-inch-thick manure residue at each cleanup may help to maintain populations of insect predators and parasites that limit fly populations. Poultry producers who do not remove manure weekly can maintain predator and parasite populations by removing manure from beneath only one row of cages at each cleanup.

Insecticide applications may be necessary in addition to good sanitation. Unless otherwise indicated, premise treatments listed below can be used in beef, dairy (other than milking rooms), swine, sheep, goat, poultry, and horse facilities. Separate recommendations for fly control in milking rooms are provided.

Fly Control

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC.	Space spray from mist blower or fogger	To minimize control failures caused by insecticide resistance, do not apply a single insecticide repeatedly throughout an entire season. Alternate applications of pyrethroids (permethrin products) and an organophosphate (naled). Space sprays (aerosols) provide rapid control of adult flies present at the time of application. Close doors and windows to reduce air movement during treatment. Daily to twice-weekly applications may be necessary where space sprays are the only treatments used. Animals may be present during application, but space sprays should not be applied directly to livestock. Do not apply space sprays in areas where animals have been treated directly with an insecticide during the previous 24 hours. Do not contaminate feed or water or use in milking rooms.		
		Dibrom 36% EC or 1% Ready-to-use Spray (naled)	1 qt 36% EC/40 gal water. Apply throughout building. Use 1 fl oz of 1% Ready-to-use Spray/ 3,000 cu ft.	0 days.
		Ectiban 5.7% EC (permethrin)	*Misting:* Use 4 fl oz/1,000 cu ft. *Overhead system:* 1 qt/12.5 gal fuel or mineral oil; use 4 fl oz/1,000 cu ft.	0 days.
		Permectrin II 10% EC (permethrin)	*Misting:* Use 4 fl oz/1,000 sq ft. *Overhead system:* 1 qt/12.5 gal fuel or mineral oil; use 4 fl oz/1,000 cu ft.	0 days.
		pyrethrins plus synergist	Follow label directions.	0 days.
	Surface residual spray	To minimize control failures caused by insecticide resistance, do not apply a single insecticide repeatedly throughout an entire season. Alternate applications of pyrethroids (permethrin, fenvalerate) and organophosphates (fenthion, dimethoate, stirofos). Surface sprays applied to walls, ceilings, partitions, posts, etc. kill flies at their resting sites and provide residual activity for 1-7 weeks. Products (or the listed concentrations of these products) recommended for use as residual sprays should not be applied directly to animals. Thoroughly spray surfaces to the point of runoff. Do not contaminate feed or water, and do not use residual sprays in milking rooms.		
		Baytex 45% EC (fenthion)	3 qt/25 gal water. use 1 gal/500 sq ft.	0 days. Residue persists 3-5 weeks.
		Cygon 23.4% EC (dimethoate)	1 gal/25 gal water. Use 1-2 gal/1,000 sq ft.	0 days. Remove all animals before spraying. Keep them out for at least 4 hours. Do not use in dairy barns or poultry houses. Residue persists 2-4 weeks.
		Ectiban 25% WP or 5.7% EC (permethrin) (Atroban, Insectrin, Overtime, Permaban, and Permectrin II are other permethrin products registered for use as surface residual sprays.)	6 oz 25% WP/11 gal water or 1 qt 5.7% EC/12.5 gal water. Use 1 gal/750 sq ft.	0 days. Residue persists 3-7 weeks.
		(Pounce is another permethrin product that can be used as a residual spray. It is classified for restricted use; do not apply Pounce directly to poultry or livestock.)		

Fly Control, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC., cont.	Surface residual spray, cont.	Ectrin 10% WDL (fenvalerate)	1 qt/10 gal water. Use 1 gal/750 sq ft.	0 days for swine buildings. Use only in swine buildings and in horse barns where horses are not to be slaughtered. Residue persists 3-7 weeks.
		Rabon 50% WP (stirofos)	4-8 lb/25 gal water. Use 1-2 gal/1,000 sq ft.	0 days. Residue persists 2-4 weeks.
	Bait	Baits may enhance house fly control; they do not attract stable flies. Bait applications of insecticides used in surface residual sprays can be prepared by adding sugar or corn syrup to the spray tank mixture. Follow directions on individual product labels. Dry baits can be sprinkled in areas where flies congregate. Do not place dry baits in areas where birds or animals will contact the bait. Do not contaminate feed or water.		
		Dipterex 1% Dry Bait (trichlorfon)	4 oz/1,000 sq ft.	0 days.
		Golden Malrin 1% Dry Bait (methomyl)	4 oz/1,000 sq ft.	0 days.
	Manure spray	Manure sprays control fly larvae that are developing in treated feces. Migration of adult flies from nearby areas can occur if any breeding sites remain untreated. Manure sprays are recommended only where manure cannot be removed on a weekly basis. Apply sprays at rates that wet the manure surface; soaking is not necessary. Repeat applications as necessary, but not more often than every 7 days. Do not apply where mammals or birds will come in contact with the manure. Do not apply treated manure to crops not listed on the insecticide label.		
		Cygon 23.4% EC (dimethoate)	0.5 pt/5 qt water. Apply as a coarse spray.	0 days.
		Larvadex 5% SC (cyromazine)	1 qt/25 gal water. Use 1 gal/100 sq ft manure, pit, or lagoon surface.	0 days.
		Rabon 50% WP or 24% EC (stirofos)	4 lb 50% WP or 1 gal 24% EC/25 gal water. Use 1 gal/ 100 sq ft manure.	0 days.
	Feed additive	Feed additives used to prevent the development of fly larvae in feces provide minimal control of flies in livestock buildings. Feed additives do not reach house fly and stable fly larvae that develop in sites other than fresh manure. Good sanitation more effectively prohibits larval development. Animals must consistently consume recommended dosages for feed additives to be effective against fly larvae in manure.		
		Larvadex 0.3% Premix (cyromazine)	1 lb/ton of feed. Mix thoroughly.	Poultry only. Feed to laying hens only; not for broilers or poultry producing eggs for hatching purposes. Continuous use of cyromazine has led to fly resistance in research trials.
		Moorman's 0.02% IGR (methoprene)	0.25-0.5 lb/100 lb body weight/animal/ month.	0 days. Feed mineral mix or block from May through September. Beef cattle and dairy cattle only.
		Rabon 7.76% or 97.3% Oral Larvacide (stirofos)	70 mg a.i./100 lb body weight/day.	0 days. Use from May through September. Mix with complete feeds, concentrates, or protein supplements. For beef cattle, dairy cattle, or hogs only.

Fly Control, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC., cont.	Biological agents	Several companies sell parasitic wasps for use in controlling flies around livestock buildings and feedlots. These predaceous wasps attack only flies; they do not sting (or bite) other insects, animals, or humans. Adult wasps (less than 1/10 inch long) deposit eggs on or inside fly larvae or pupae. Developing wasps kill the immature flies. Suppliers usually recommend wasp releases (several thousand wasps per release) before and during the fly season. Most biological control programs recommend periodic (but not complete) removal of manure, effective water management, and control of weeds around feedlots and buildings. Some suppliers also recommend certain insecticide applications to supplement the control provided by biological agents. In many instances it is difficult to assess the separate impacts of parasitic wasps, sanitation practices, and insecticide applications. Although wasp releases have been shown to be effective for fly control in certain poultry housing, research data do not support other uses of currently available biological controls for flies. If biological control agents are to significantly contribute to fly control programs, integration with sanitation and chemical control practices is essential.		
CONTROL OF FLIES IN MILKING ROOMS	Although effective fly control is essential in dairy barns and milkrooms, small amounts of pesticides can be detected in milk, and their presence is often illegal. To control flies and avoid residue problems, the following steps are recommended: 1. Use good sanitation and recommended insecticides in dairy barns to reduce the number of flies entering the milkroom. 2. Use sticky fly strips where appropriate. 3. Use tight screens (14-16 mesh) on milkroom doors and windows. Copper, aluminum, bronze, plastic, or rust-resisting screens are best. 4. Use a mist or aerosol spray of 0.06-0.1% pyrethrin plus piperonyl butoxide oil-based fly sprays in the milkroom when other methods do not give adequate fly control. To prevent milk contamination, cover all milking utensils, cans, bulk tanks, and containers before spraying.			
RATTAILED MAGGOTS	The rattailed maggot is the larval stage of a syrphid fly. The 1¼ inch long maggot has a cylindrical body about ¾ inch long and a tail-like breathing tube that extends ½ inch from the posterior of the body. The adult fly is a beelike hover fly that is not a pest on or around livestock or humans. Rattailed maggots live in highly polluted water such as that in livestock lagoons and manure pits. When larvae are ready to pupate, they migrate from lagoons and pits to adjacent, drier areas. They become pests when they enter feed, egg cartons, and milking rooms. To limit rattailed maggot development, eliminate floating solids within pits and keep pit sidewalls clean. Agitate the pit contents or pump the pit weekly. Although insecticides are of limited value in managing rattailed maggots, application of Ravap or Larvadex to the pit surface provides some control. Use 1 pint Ravap 28.7% EC per 3½ gallons fuel oil and apply 1 gallon of the spray mixture per 100 square feet of pit surface. (Do not agitate the pit contents after application.) Repeat applications as needed, but not more often than every 7 days. Use 1 quart Larvadex 5% SC per 25 gallons water and apply ½ to 1 gallon of finished spray per 100 square feet of pit surface. Limit rattailed maggot migration by constructing a soil barrier between the pit and the milking room. Migrating larvae will burrow into the loose soil to pupate instead of continuing their migration into milking rooms, etc.			

Diatomaceous earth. The insecticidal activity of a range of chemically inert dusts, including diatomaceous earth, results from their abrasiveness and/or their sorptive characteristics. To understand how these dusts kill insects, it is important to recognize that an insect's body covering, the cuticle, contains fat layers that make the cuticle nearly water-proof and prevent water loss. Sorptive dusts absorb fats, disrupting the cuticle's waterproof nature. Abrasive dusts damage the insect's water barrier by actually scratching or cutting the cuticle. Where inert dusts are effective as insecticides, dehydration usually causes the insect's death.

For animal ectoparasite control, sorptive and/or abrasive dusts have been used somewhat successfully for reducing populations of lice, fleas, and some mites on a range of animal species and humans. Although most trials have evaluated silica aerogels, diatomaceous earth was used effectively to control cattle-biting lice in a study conducted in the 1930s. Silica aerogels were used at a rate of 1 to 2 ounces of dust per cow; diatomaceous earth was applied at a rate of 3 ounces per cow. Based on available evidence, it is likely that although diatomaceous earth will not work as well as currently available chemical insecticides, if applied thoroughly and repeatedly, it should provide some control of lice, fleas, and certain mites. Because of the skin-burrowing habits of swine mange mites, producers should not expect diatomaceous earth to control this pest.

Advertisements claim that diatomaceous earth used as a feed additive will provide control of internal parasites and also control fly larvae in animal manure. Sales materials also include claims of controlling adult flies by aerosol, dust bag, or hand-dusting applications of diatomaceous earth to barns and animals. No reliable data support these claims of fly control. Negative data and an understanding of fly breeding and migration lead to the conclusion that little or no fly control is likely to be achieved by using diatomaceous earth.

1989 Insect Pest Management Guide

COMMERCIAL VEGETABLE CROPS

Restricted-use insecticides are identified with an asterisk (*).
You must be certified as a pesticide applicator to use restricted-use pesticides.
See your county Extension adviser in agriculture for information.

COMMERCIAL VEGETABLE GARDENERS find it impossible to produce vegetables profitably unless they can control insects at maximum efficiency and minimum cost. Today's cook will not accept unsightly or wormy vegetables; not only are wormy fruits and vegetables unappetizing, but the waste from trimming increases food costs. Thus the commercial grower must produce a quality product that is acceptable and safe to the consumer. Careful use of the right insecticides will make this possible.

Insect pest-management programs, which include the wise selection of cultural, mechanical, biological, and chemical methods, are suggested for the major insect pests of vegetable crops. Insecticides, though, are still the most efficient means of managing most insects.

This suggested insecticide guide has been prepared for use by Illinois commercial vegetable farmers; it is not for home gardeners, who should use only those insecticides that are extremely safe to handle, apply, and store. Furthermore, the commercial vegetable grower must use a wider variety of insecticides than the home gardener in order to obtain maximum insect control at the least cost.

In using insecticides, always read the label and carefully follow the instructions. Do not exceed maximum rates suggested; observe the interval between application and harvest, and apply the product only to crops for which use has been approved. Make a record of the product used, the trade name, the percentage content of the insecticide, the dilution, the rate of application per acre, and the dates of application.

Some of the insecticides suggested here can be poisonous to the applicator. In using them, the commercial grower is expected to use precautions to protect himself or herself, all workers, and any family members from undue or needless exposure.

In using this guide, always refer to the table on the next page, which lists the limitations and restrictions on use. These limitations apply to the vegetables as human food. If you use any portion of a vegetable for livestock food (tops, stalks, etc.), refer to product labels for instructions on the intervals required between application and feeding.

The chemical names used in these tables may be unfamiliar to you. These names are the common chemical names and as such are not capitalized. Trade names are capitalized. In the table of limitations the common names are listed first and trade names are listed in parentheses following the common name. Throughout the tables of suggestions, however, trade names are usually used. In case you have a question, refer to the table of limitations.

These suggestions are subject to change without notification during the growing season.

Check with your county Extension adviser if you are in doubt about the insecticide you plan to use. We will make announcements of label changes through newsletters and the news media to keep you up to date.

Requested label clearances for a few uses of insecticides, carriers, and solvents are uncertain for 1989, since many requests have not been officially cleared. Anticipating needed changes in labeling, we began modifying these suggested uses a few years ago.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. Anyone who wishes to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Contact your county Extension adviser in agriculture for details on this program.

A few insecticides have been classified at this time. More will be classified later.

Suggestions for the effective use of insecticides from a practical standpoint are based on available data. Soil textures, pH of the soil, rainfall, slope of the field, wind velocity at planting, method and accuracy of application, and other unpredictable factors affect efficiency.

Prepared by Roscoe Randell, Extension Entomologist

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 897 (revised annually) November 1988

LIMITATIONS FOR FIELD VEGETABLES IN DAYS BETWEEN APPLICATION AND HARVEST AND OTHER RESTRICTIONS ON USE OF INSECTICIDES IN ILLINOIS

(Blank spaces indicate that the material is not suggested for the specific use in Illinois)

Insecticide	Beans	Peas	Broccoli	Brussels sprouts	Cabbage	Cauliflower	Horseradish	Radish	Turnip	Onions	Eggplant	Peppers	Tomatoes
acephate (Orthene)	14											7	
*Asana		3,A,B		3C	3C	3C					7D	7D	1E
Bacillus thuringiensis[2]			0	0	0	0							0
carbaryl (Sevin)	0		3	3	3	3	3	3	3, 14F		0	0	0
*carbofuran (Furadan)												21G	
chlorpyrifos (Lorsban)			H	H	H	H		H		H, I			
diazinon			5		7	5		10	10	10			1
dimethoate (Cygon)	0A	0A	7		3	7			14			0	7
*fonofos (Dyfonate)			H		H	H				H, I			
*ethion										H			
*fenvalerate (Pydrin)[3]		3A,C	3		3	3							1E
malathion	1		3	7	7	7	7	7	3	3	3	3	1
*methomyl (Lannate, Nudrin)	1	1, 5F	3	3	1	3						10	2
*mevinphos (Phosdrin)			1	3	1	3			3				
*Monitor			21	21	35	28							
naled (Dibrom)			1	1	1	1			4				
*permethrin (Ambush, Pounce)			1J	1J	1J	1J	22						
*phorate (Thimet)	C												
rotenone											1	1	1
trichlorfon (Dylox)				21	21	21			28A			21	21

Insecticide	Potatoes	Collards	Kale	Lettuce	Spinach	Swiss chard	Sweet corn	Cucumbers[1]	Melons[1]	Pumpkins[1]	Squash[1] Winter	Squash[1] Summer
*Asana	7D						1E	3K	3K	3K	3K	3K
Bacillus thuringiensis[2]		0	0	0	0							
carbaryl (Sevin)	0	14	14	14	14	14	0	0	0	0	0	0
*carbofuran (Furadan)	14J						7L,21F	C	C	C	C	C
chlorpyrifos (Lorsban)							35F, M					
diazinon		10	10	10	10	12	H	7	3		3	7
dimethoate (Cygon)	0	14	14	14	14	14			3			
*fonofos (Dyfonate)							H					
*fenvalerate (Pydrin)[3]	7K						1E		3	3	3	3
malathion	0	7	7	14	7	7	5	1	1	3	1	1
*methomyl (Lannate, Nudrin)	6			10	7		0 (3F)	3	3			3
*mevinphos (Phosdrin)		3	3	2	4							
*Mocap							H					
naled (Dibrom)		4	4	1	1	1						
*permethrin (Ambush, Pounce)	7K						1N		1J	1J		
*phorate (Thimet)	H						C					
*terbufos (Counter)							C					
trichlorfon (Dylox)		28P	21	28P						3Q		

* Use restricted to certified applicators only.

[1] Apply insecticides late in the day after the blossoms have closed to reduce bee kill.

[2] The trade names are Bactur, Dipel, Thuricide, and Sok Bt.

[3] Only root crops indicated on label can be planted following application. For all other root crops, wait 12 months before planting.

REENTRY INTERVALS FOR WORKER PROTECTION

Insecticide	Days
Guthion, Dyfonate, Dibrom, Orthene, Lorsban, Thimet, Ethion	1
Lannate, Nudrin, Monitor, Parathion	2
Furadan	
(sweet corn)	14
(other crops)	1

Workers must wear protective clothing if they enter treated fields before the time intervals shown at the left. They must also wear protective clothing for all other insecticides applied if the spray has not dried or the dust has not settled.

A. Do not use tops for feed or food.
B. Do not exceed 0.1 lb a.i. per acre.
C. Do not exceed 0.4 lb a.i. acre.
D. Do not exceed 0.35 lb a.i. per acre.
E. Do not exceed 2 lb a.i. per acre.
F. If tops or stover are to be used for feed.
G. Not more than twice per season.
H. Soil applications at planting time only.
I. Do not use on green onion crop.
J. Not more than 8 times per season.
K. Do not exceed 0.25 lb a.i. per acre.
L. Not more than 4 applications per season.
M. Not more than once per season.
N. Not more than 6 applications per season.
P. Not after edible portions or heads begin to form.
Q. Not more than 3 times per season.

ASPARAGUS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Asparagus beetles (NHE-49)	Early and mid-season on spears and ferns	Sevin[1] malathion[1]	1½ 1	Spears and ferns	As needed. Spray fern growth in late summer if beetles are present.
Cutworms (NHE-38)	Early and midseason	*Ambush, Pounce	0.01-0.02	Spears	As needed.

* Use restricted to certified applicators only.
[1] One-day restriction between last application and harvest.

BEANS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Seed maggots (NHE-27)	All season	diazinon 50% WP[1]	3/5 oz/bu	Seed	Treat seed no longer than 3 months before planting.
		Lorsban 25% WP[1]	2 oz/bu	Seed	
		*Thimet G	1½	Soilband	Place on either or both sides of row at planting but not in contact with seed.
Bean leaf beetles (NHE-67)	Early and late season	Sevin malathion	1 1	Foliage	When feeding first appears and weekly for 2 or 3 applications as needed.
Leafhoppers (NHE-22) and Plant bugs (NHE-68)	All season	Sevin Cygon malathion *Lannate, Nudrin	1 0.3 1 0.45	Foliage	Before plants become yellow and stunted. Repeat applications at weekly intervals as necessary.
		*Thimet G	1½	Soilband	As for seed maggot.
Mexican bean beetles	Midseason and late season	Sevin malathion	½ 1	Foliage	When occasional leaves show lacework feeding.
		*Thimet G	1½	Soilband	As for seed maggot.
Aphids (NHE-47)	All season	Cygon malathion	0.3 1	Foliage	Usually applied when a few aphids can be found on each plant, but before leaves begin to curl and deform.
		*Thimet G	1½	Soilband	As for seed maggot.
Blister beetles (NHE-72)	Midseason and late season	Sevin	1½	Foliage	As needed.
Corn earworms (NHE-33) Corn borers	Late season	Orthene Sevin *Lannate, Nudrin	⅔ 1½ 0.45	Foliage	As needed, but usually after August 20. Worms may be present before bloom.
Mites	Midseason and late season	Cygon	0.3	Foliage	As needed, but especially during drouth periods particularly if carbaryl has been used on crops.
		*Thimet G	1½	Soilband	As for seed maggot.

* Use restricted to certified applicators only.
[1] No restrictions when used as recommended.

PEAS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Caterpillars, including loopers	June	*Lannate, Nudrin *Asana *Pydrin	½-1 0.025-0.05 0.1	Foliage	Before harvest if worms are present.
Aphids	May-June	Cygon	⅓	Foliage	As needed.

* Use restricted to certified applicators only.

CABBAGE AND RELATED COLE CROPS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Cabbage maggots[1] (NHE-44)	All season	diazinon	3	Broadcast	Disk in just before planting. Use only for cabbage, cauliflower, and broccoli.
		Dyfonate	2		
		diazinon G	1	Furrow	At time of planting; on turnips a drenching spray of 1 lb. diazinon should be applied 30 days following treatment.
		diazinon	4 oz per 50 gal transplant water	Furrow	6 fl. oz. transplant water per plant.
		Lorsban	3 oz 4E per 1,000 ft of row		Transplant drench to cabbage, broccoli, and cauliflower.
		Lorsban	1 oz 4E per 1,000 ft of row		Radishes only.
Aphids (NHE-47) Thrips (NHE-48)	All season	Cygon	0.3	Foliage	When aphids appear, but before leaves begin to curl.
		malathion	1		
		*phosdrin	¼		
		*Monitor	1		
Cabbage loopers (NHE-45); diamond-back moth larvae; imported cabbage worms	All season	*Bacillus thuringiensis*	See rates on label	Foliage	When small worms first appear, and about every 5 to 7 days thereafter. Thorough spray coverage of foliage is important.
		*Pydrin	0.1-0.2		
		*Asana	0.025-0.05		
		*Lannate, Nudrin	0.45-0.9		Use only *B. t.* formulations if diamond-back moth resistance is present.
		*Monitor	1		
		*Ambush, Pounce	0.1-0.2		
Cutworms	At planting	*Asana	0.025-0.05	Base of plants	As needed.
		*Pydrin	0.1-0.2		
		Dylox	1		
Flea beetles and leafhoppers	All season	Sevin	1½	Foliage	As needed.
		*Asana	0.025-0.05		
		*Pydrin	0.1-0.2		

NOTE: EC = Emulsion concentrate; WP = wettable powder.
* Use restricted to certified applicators only.
[1] Maggots are resistant to diazinon in some areas of Illinois.

COLLARDS, KALE, LETTUCE, SPINACH, SWISS CHARD

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Aphids (NHE-47)	All season	diazinon	½	Foliage	As needed.
		Cygon	0.3		
		*Phosdrin	¼		
		Dibrom	1		
Cutworms	On seedling plants	Dylox[1]	1	Base of plant and soil	When first damage appears.
Leafhoppers	All season	Sevin	1½	Foliage	When first leafhoppers appear, and as needed.
		Cygon	0.3		
		malathion	1		
Caterpillars (NHE-45)	All season	*Bacillus thuringiensis*	See rates on label	Foliage	When small worms first appear and every 5 to 7 days thereafter.
		*Lannate, Nudrin[2]	0.45		
		Dibrom	1		
Leaf miners	All season	diazinon	½	Foliage	When first miners are observed.
		Cygon	0.3		
Flea beetles	All season	Sevin	1	Foliage	As needed.

* Use restricted to certified applicators only.
[1] Do not use on spinach or Swiss chard.
[2] Use limited to lettuce and spinach only.

CUCUMBERS AND OTHER VINE CROPS[1]

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Striped and spotted cucumber beetles (NHE-46)	Seedling to mature plants	Sevin *Furadan G	1 2	Foliage Soil	When beetles first appear; as often as necessary thereafter. Apply Furadan at planting or transplanting.
Aphids (NHE-47)	All season	diazinon Cygon[2] malathion	½ 0.3 1	Foliage	When aphids become noticeable.
Squash bugs (NHE-51)	All season	*Ambush, Pounce[4] Dylox[3]	0.2 1	Foliage	Do not appy until first eggs are found hatching (about June 15 to July 15); controls only nymphs.
Leafhoppers	July-August	*Asana *Pydrin malathion Cygon[2] *Ambush, Pounce[4]	0.025-0.05 0.1-0.2 1 0.3 0.1-0.2	Foliage	As needed.
Squash vine borers	June-September	Sevin *Pydrin *Asana	1 0.1-0.2 0.025-0.05	Base of stem for 3 ft.	Weekly applications when vines begin to run—usually 5 applications.
Pickle worms	August-September	Sevin *Pydrin *Asana	1 0.1-0.2 0.025-0.05	Foliage	Weekly applications, beginning in late August.
Mites	July-September	Cygon	0.3	Foliage	As needed.
Cutworms (NHE-77)	April-June	Sevin *Asana *Pydrin *Ambush, Pounce[4]	2 0.05 0.2 0.1-0.2	Base of plants	As needed.

* Use restricted to certified applicators only.
[1] Spray vine crops with insecticide only late in the day after blossoms have closed to reduce bee kill.
[2] Do not use Cygon on cucumbers.
[3] Pumpkin is the only vine crop for which Dylox can be used for squash bug control.
[4] Pumpkin and cantaloupes only.

ONIONS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Onion maggots (NHE-50)	All season	diazinon WP *ethion WP	½-1 for 40-50 lb of seed 1 for 40-50 lb of seed	Seed	Seed treatment for set onions only. Use lighter dosage of diazinon on sandy, highly mineral soils.
		diazinon G *Dyfonate *ethion G Lorsban G	½-1 1 ½-2 1	Furrow	Use 1 lb. active ingredient per acre for rows 12″ apart; ¾ lb. for rows 18″ apart; ½ lb. for rows 24″ apart. Up to twice these amounts are needed for ethion on muck soils. Do not use Dyfonate, or Lorsban on green onions.
		diazinon	2	Broadcast	Preplanting; disk into upper 1 to 2 inches of soil. Supplement with foliage spray below.
		diazinon malathion	⅓ 1	Foliage	Supplemental to soil treatment. Make first application when first adult flies are seen; make another 1 week later. From then on only as necessary.
Thrips (NHE-48)	Midseason and late season	diazinon malathion	½ 1	Foliage	When injury first appears and every 10 days as necessary.

* Use restricted to certified applicators only.

PEPPERS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Aphids (NHE-47)	May-July	Cygon	0.3	Foliage	Only when aphids are present. Add to borer spray when it is being used.
		*Lannate, Nudrin	0.45		
		Orthene	½		
Corn borers	Late season	Sevin	2	Foliage and fruit	When fruit is present on plant. Apply every 5 days when borers are present.
		Orthene	1		
		*Furadan	2-3	Soilband to transplant	Make 2 applications; first, 3 weeks after transplant, second, 5 weeks later.
Flea beetles	Early season	*Asana	0.025-0.05	Foliage	When shiny, jumping beetles are present.
		Pydrin	0.1-0.2		
		Orthene	½		

* Use restricted to certified applicators only.

POTATOES

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Flea beetles	May-July	Sevin	1	Foliage	When damage first appears on the leaves. Repeat as needed.
		*Furadan G	3	In furrow	Planting time.
		*Furadan F	1	Foliage	As needed.
		*Asana	0.025-0.05	Foliage	As needed.
		*Pydrin	0.1	Foliage	As needed.
		*Lannate, * Nudrin	0.45	Foliage	As needed.
		Ambush, * Pounce	0.1	Foliage	As needed.
Colorado potato beetles; cutworms; potato leafhoppers (NHE-22)	May-July	Sevin	2	Foliage	As needed.
		*Furadan G	3	In furrow	Planting time.
		*Furadan F	1	Foliage	As needed.
		Cygon	0.3	Foliage	As needed.
		*Asana	0.025-0.05	Foliage	As needed.
		*Pydrin	0.1	Foliage	As needed.
		*Ambush, Pounce	0.1	Foliage	As needed.
		*Thimet G	2-3	Soilband	Place on either or both sides of row at planting, but not in contact with seed. Use the lower rate on sandy soils, the heavier rate on heavy soils. Do not use on muck soils.
Aphids (NHE-47)	All season	Cygon	0.3	Foliage	As needed.
		*Lannate, Nudrin	0.45		
		*Thimet G	2-3	Soilband	Same as for leafhoppers.
Blister beetles (NHE-72)	All season	Sevin	1½	Foliage	As needed.
Wireworms (NHE-43) White grubs (NHE-23)	All season	*Thimet G	2-3	Soil	Preplanting, disk in; or use as soilband at planting.
Grasshoppers (NHE-74)	July-September	Sevin	¾	Foliage	As needed, control in fencerows, roadsides, ditch banks, etc., before migration.
		Cygon	0.3		

* Use restricted to certified applicators only.

SWEET CORN

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Corn rootworm (NHE-26)	June-July	*Counter G	1	Furrow	Rootworm control may be needed if the field was in corn the previous year and was not sprayed.
		*Dyfonate G	1	Row	
		*Furadan G	1	Furrow	
		Lorsban G	1	Row	
		*Mocap G	1	Row	
		*Thimet G	1	Row	
Cutworms (NHE-38)	April-June	*Asana	0.025-0.05	Base of plants	When first damage appears.
		Lorsban 4E	1½	Broadcast	
		Pydrin	0.1-0.2		
Flea beetles (NHE-36)	April-July	Sevin[1]	1½	Foliage	As necessary.
		*Furadan G	1	Furrow	At planting.
Japanese beetles (NHE-32)	July-September	Sevin[1]	1	Ear zone	As necessary.
First-generation corn borers	May-June	Sevin[1]	2	Foliage	If needed make first application in late whorl stage. Repeat in 5 to 7 days.
		*Pounce, Ambush	0.1-0.2		
Second-generation corn borers	July-September	*Ambush, Pounce	0.1-0.2	Tassel	*Processing corn:* Observe light traps for borer adults. When there are 50 or more trapped per night and 1500 or more heat units (base 50) have accumulated, spray at row tassel and every 5 to 7 days until 10 to 12 days of harvest. *Fresh market corn:* Apply first spray at row tassel and additional corn earworm treatments will control corn borers.
		*Furadan[2]	0.5	Ear zone	
Corn earworm	June-September	*Lannate Nudrin	0.45	Ear zone	*Fresh market corn:* Treat at first silk and every 2 to 4 days for 4 to 6 applications. *Processing corn:* Observe pheromone traps, if more than 10 moths per night, apply a borer spray during early silking period and repeat if necessary.
		*Ambush, Pounce	0.1-0.2		
		*Pydrin	0.1-0.2		
		*Asana	0.025-0.05		
Sap beetles (NHE-10) Picnic beetles	July-September	Sevin[1]	2	Foliage	When adults first appear in field; usually between pollen-shedding and silk-drying.
		diazinon	1		
		malathion	1		
Corn leaf aphids (NHE-29)	July-September	malathion	1	Foliage	As needed to produce attractive ears for fresh market.
Fall armyworms	July-September	*Lannate, Nudrin	0.45	Foliage	Apply to ear zone when whorl feeding is evident.

* Use restricted to certified applicators only.
[1] During pollen shed, apply Sevin as late in the day as possible (preferably after 4 p.m.) to reduce bee kill.
[2] Corn borer control only.

TOMATOES AND EGGPLANT

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Cutworms (NHE-77)	Early and midseason	Sevin	2	Base of plants or foliage	As needed.
		*Asana	0.025-0.05		
		*Pydrin	0.1-0.2		
		Dylox	1		
Flea beetles	May-June	Sevin	2	Foliage	Apply every week as long as needed.
		*Asana	0.025-0.05		
Aphids (NHE-47)	May-July	diazinon	½	Foliage	As needed, but before leaves curl.
		Cygon[1]	0.3		
		malathion	1		

* Use restricted to certified applicators only.
[1] Use cleared only on tomatoes.

TOMATOES AND EGGPLANT, continued

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Cabbage loopers	July-September	*Bacillus thuringiensis*	See rates on label	Foliage	When loopers are present.
		*Asana	0.025-0.05		
		*Pydrin	0.1-0.2		
		*Lannate, Nudrin	0.45-0.9		
Corn earworms Corn borers Hornworms	July-September	Sevin	2	Foliage	Add to weekly applications of fungicide sprays beginning at first fruit set when first small worms appear.
		*Asana	0.025-0.05		
		*Pydrin	0.1-0.2		
		*Lannate, Nudrin	0.45-0.9		
Mites	July-September	Cygon[1]	0.3	Foliage	As needed.
Blister beetles (NHE-72)	June-September	Sevin	1½	Foliage	As needed.
Fruit flies and picnic beetles	August-October	Sevin diazinon	2 ½	Foliage	When flies or beetles first appear.

* Use restricted to certified applicators only.
[1] Use cleared only on tomatoes.

FOR ADDITIONAL INFORMATION

You can obtain the following circulars on insect control from the Office of Agricultural Publications, University of Illinois, 54 Mumford Hall, 1301 W. Gregory Drive, Urbana, Illinois 61801.

Circular 899, *1988 Insect Pest Management Guide — Field and Forage Crops*

Circular 900, *1988 Insect Pest Management Guide — Home, Yard, and Garden*

Circular 1076, *1988 Turfgrass Pest Control*

Leaflets describing the life history, biology, and habits of some of the insects mentioned can be obtained from the offices of county Extension advisers or by writing to Entomology Extension, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, Illinois 61820. These are indicated by an NHE number in the tables. Individual fact sheets are 25 cents each.

FOR YOUR PROTECTION

Always handle insecticides with respect. The persons most likely to suffer ill effects from insecticides are the applicator and his or her family. Accidents and careless, needless overexposure can be avoided. Here are a few easy rules that, if followed, will prevent most insecticide accidents:

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of reach of children, irresponsible persons, or animals — preferably in a locked cabinet.
6. Triple-rinse and bury or burn all empty insecticide containers or take them to an approved sanitary landfill.
7. Do not put the water-supply hose directly into the spray tank.
8. Do not blow out clogged nozzles or spray lines with your mouth.
9. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply insecticides to fish-bearing or other water supplies.
12. Do not apply insecticides, except in an emergency, to areas with abundant wildlife or to blossoming crops visited by bees. Avoid drift onto blossoming crops or onto bee hives.
13. Do not apply insecticides near dug wells or cisterns.
14. Do not spray when weather conditions favor drift.
15. Observe all precautions listed on the label.
16. To avoid bee kill, apply insecticides after bee activity has been completed for the day; use the least toxic materials. *Warn beekeepers that you are appying insecticides.*

1989 Insect Pest Management Guide

HOME, YARD, and GARDEN

MUCH HAS BEEN SAID ABOUT THE EFFECTS of pesticides, particularly insecticides, on the health and well-being of the American people. However, as you are also aware, insects can destroy your property or make your life uncomfortable. Destruction of crop residues, varietal selection, handpicking, fertilization, tree pruning, irrigation, screening, and other practices may reduce the number of insects with which you must contend. Occasionally, you can avoid or at least reduce the destruction caused by some pests without using an insecticide. For many insects, though, you must rely on an insecticide to provide the satisfactory management you want.

SAFE USE OF INSECTICIDES

By using insecticides and other pest-management tools carefully, you can enjoy reasonable freedom from insects without endangering yourself, your family, or your pets. You must recognize, however, that insecticides are designed to destroy one group of animals — insects — and can be harmful to other animals, including man himself, if used without regard for normal safety precautions. Each insecticide user must handle, apply, and store insecticides safely in order to benefit from them without suffering from their dangers.

This publication lists certain insecticides with which to control insect pests of food, fabrics, structures, man and animals, lawns, shrubs, trees, flowers, and vegetables. We have tried to suggest only the safest and most available materials. You may prefer to employ the services of a professional exterminator or custom applicator rather than to become involved in the selection and application of insecticides.

INSECTICIDES AND THEIR NAMES

The names used in the tables are the common, coined chemical names, not the trade names, and as such may not be familiar to you. For instance, the common name for *Cygon* is *dimethoate.* If there is no coined chemical name, the trade name is used but is capitalized. A table giving common, trade, and chemical names appears at the end of this circular.

CLASSIFICATION OF INSECTICIDES

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. Only a few insecticides have been classified for restricted use at this time. No insecticides in this circular, except those listed for termites, have a restricted-use classification. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial applicator by the State of Illinois. Contact your county Extension adviser in agriculture for details about that program.

Requested label clearances for a few uses of some insecticides, carriers, and solvents are uncertain for 1988, since many requests have not yet been officially cleared. Consequently, labels may be cancelled, and the product removed from the market at any time. Anticipating this, we took a conservative attitude a few years ago and began modifying suggested uses in these annually revised guides. We have attempted to anticipate any further label changes in 1989, but occasionally there are still use cancellations. Check with your local county Extension adviser if you are not sure about the insecticide you plan to use. We will make announcements about label changes through the news media and newsletters in an attempt to keep you up to date.

Suggestions for the use of insecticides, effective from a practical standpoint, are based on available data. Many factors affect efficiency of control. Please report details of control failures to us.

In using the tables in this circular, *always read the footnotes* before using the insecticides. The footnotes list precautions and other pertinent information.

The suggestions given in this circular are subject to change without notification during the year.

SOURCES OF INFORMATION ON INSECTS

Fact sheets describing the life history, habits, and damage of specific insects and the nonchemical methods of control can be obtained from your county Extension adviser or by writing to Entomology Extension, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, Illinois 61820. These fact sheets are indicated by an NHE number in the tables.

INTEGRATED PEST MANAGEMENT FOR HOMEOWNERS

Pest control should be conducted in as safe a manner as possible. Reducing the use of insecticides and other pesticides through integrated pest management (IPM) is one way to accomplish this goal. The two main components of IPM are scouting for pests and utilization

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of a variety of pest population control methods. These include mechanical, biological, cultural, and chemical tools, use of resistant varieties, and prevention.

Scouting

Scouting is the process of finding the suspected pest, identifying it, and determining whether the pest is present in great enough numbers to justify control.

Finding the suspected pest. Indirect evidence may or may not indicate the presence of a pest. For instance:

— Holes in leaves may be caused by late frost damage, not by chewing insects.
— Piles of sawdust in the home may be construction debris sifting through cracks or the consequence of mouse activity rather than the trail of carpenter ants or other wood-destroying insects.

It is important to find the insects or other pests actually responsible for the damage observed. Do not assume guilt through association with the damage.

Identification. Once found, the suspect pest must be identified. In some situations an insect that is present in great numbers may not be the cause of damage.

— Lady beetle larvae and adults and other aphid-destroying insects are often found in large numbers in the midst of damage caused by aphids.
— Large numbers of ants in the lawn rarely damage the lawn and have little relationship to the number of ants that enter the home.

Identification is also important because some kinds of insects are more damaging than others. Once you know what kind of insect is present, you can better judge whether or not the potential damage justifies control measures. Knowing the identity of a pest also helps you learn about the insect's biology, enabling you to use other IPM tools to control the insect.

Pest population size. Knowing the number of pests present will help you estimate their impact and whether there is sufficient cause to spend time and money on control. Different numbers of pests may be damaging in different situations. For instance:

— One cockroach in a home is usually sufficient cause to start some kind of control measure, but a few in an outbuilding will probably not invade the home and would not need to be controlled.
— A small number of white grubs in a vegetable garden may cause heavy damage to root crops such as potatoes, carrots, and onions, but cause no yield loss to nonroot crops such as tomatoes, beans, and cabbage.

IPM Tools

Various control measures may be used on a pest population. Individual IPM tools may be more or less successful, depending on the situation and the biology of the pest. A good IPM program will usually combine two or more of these tools to control the pest.

Mechanical control. The use of mechanical devices to keep out or kill pests. These methods are frequently too labor intensive to be profitable commercially. However, in the relatively small areas of home landscapes, garden plots, and houses, mechanical devices may be very useful.

— Handpicking: removing insect pests by hand. Useful in controlling Colorado potato beetle adults and larvae, tomato hornworms, eastern tent caterpillars, fall webworms, and bagworm eggs.
— Barriers: keeping pests from reaching an area where damage can be caused. Tin cans and other barriers around young tomato plants can be used to keep out cutworms. Screening windows can keep out flies and other winged pests.
— Devices: using mechanical devices to control insects. For example, flyswatters to kill flies or other home-invading pests and red sticky balls to capture apple maggots.

Ultrasonic devices have not been shown to be effective in repelling insect pests.

Biological control. The use of other living organisms to control a pest. Naturally occurring predators, parasites, and diseases are very effective in reducing pest populations. When we increase the numbers of these natural enemies, we are practicing biological control.

— Augment habitat to increase favorable conditions for the natural enemy so that it can become more numerous. Allow fallen leaves and other debris to accumulate in such areas as the base of shrubs to provide overwintering sites for lady beetles and other predatory insects. Leave vegetation that harbors mite predators beneath fruit trees to help control mite pests on the trees.
— Introduce more natural enemies into the area. For example, spray *Bacillus thuringiensis kurstaki* to control cabbage looper, imported cabbage worm, eastern tent caterpillar, and cankerworms; introduce minnows or other fish into ornamental pools to control mosquitos.

Cultural control. Controlling pests by changing the methods used to grow or maintain the plants, animals, or buildings that are attacked.

— Planting time: Early plantings of sweet corn will reduce damage by corn earworm. Planting zucchini squash early will allow more of the crop to be harvested before damage by squash vine borer occurs.
— Habitat changes: Good sanitation in the home will reduce cockroach numbers. Proper fertilization and growing conditions for shade trees help prevent borer infestations.

Chemical control. The use of chemical insecticides is an integral part of many IPM programs. Pesticides are commonly used for economical control of the pest population. Properly timed insecticide applications fre-

quently provide adequate control so that additional applications are not necessary.

Resistant varieties. Pest problems can be avoided or lessened by growing plant varieties or raising animals that are not heavily attacked by the pest in question.

— Plant birch varieties such as whitespire or heritage that are resistant to bronze birch borer.
— Butternut squash is more resistant to squash vine borer than are acorn or blue hubbard squashes. Zucchini squash appears to be the most susceptible summer squash variety.

Prevention. Pest problems can be avoided by keeping an insect pest out of the area where the crop is being grown. This is normally accomplished by governmental agencies with the assistance and cooperation of the public.

— Efforts made in keeping gypsy moth out of Illinois.
— Efforts made in keeping Mediterranean fruit flies and Africanized honey bees out of the U.S.A.

Another form of pest prevention is simply avoiding the food plants of particular pests. Careful selection of landscape or garden plants can prevent pest problems that might otherwise be difficult to control.

NAMES OF INSECTICIDES

Below is a list of the common names of insecticides used in the tables, followed by the commercial trade name and the chemical name. Some products may be available under a variety of trade names not listed below. Be sure to read the label. The label on the container always lists these products by the common name or chemical name.

Common name	Trade name	Chemical name
acephate	Orthene	O, S-dimethyl acetylphosphoramidothioate
Bacillus thuringiensis	Dipel, Thuricide, SOK-BT	
carbaryl	Sevin	1-naphthyl methylcarbamate
chlorpyrifos	Dursban	O, O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate
DEET	Off, Cutter's	N, N-diethyl-m-toluamide
diazinon	Spectracide	O, O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
dimethoate	Cygon	O, O-dimethyl S-(N-methyl carbamoyl methyl) phosphorodithioate
hydrazone	Combat	Tetrahydro-5,5-dimethyl-2(1H)-pyrimidinone (3-[4-(trifluoromethyl)phenyl]-1-(2-[4-trifluoromethyl)phenyl]-ethenyl)-2-propenylidene)hydrazone
hydroprene	Gencor	Ethyl-3,7,11-trimethyl dodeca-2,4 dienoate
malathion	Cythion	diethyl mercaptosuccinate, S-ester with O, O-dimethyl phosphorothioate
methoprene	Precor, Pharorid	Isopropyl-11-methoxy-3,7,11 trimethyl-2,4 dodecadienoate
naled	Dibrom	1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate
propoxur	Baygon	2-(1-methylethoxy) phenyl methylcarbamate
pyrethroids		
d-trans allethrin		allyl homolog of cinerin I
d-phenothrin	Sumithrin	3-phenoxybenzyl d-cis & trans 2,2-dimethyl-3-(2-methylpropenyl) cyclopropanecarboxylate
pyrethrin	Pyrenone	principally from plant species *Chrysanthemum cinariaefolium*
resmethrin	Chryson, SBP-1382	(5-benzyl-3-furyl) methyl 2,2 dimethyl-3-(2-methylprophenyl) cyclopropanecarboxylate
tetramethrin	Neo-Pynamin, Phthalthrin	(1-cyclohexene-1,2-dicarboximido)-methyl 2,2-dimethyl-3-(2-methylpropenyl)-cyclopropanecarboxylate
tetrachlorvinphos	Rabon	2-chloro-1-(2,4,5,-trichlorophenyl) vinyl dimethyl phosphate

CONVERSION TABLE FOR SMALL QUANTITIES

1 level tablespoon = 3 level teaspoons	1 pint = 2 cups
1 fluid ounce = 2 tablespoons	1 quart = 2 pints or 32 fluid ounces
1 cup = 8 fluid ounces or 16 tablespoons	1 gallon = 4 quarts or 128 fluid ounces

VEGETABLE INSECTS

Insects	Crop	Insecticide	Suggestions
Aphids (NHE-47) Mites (NHE-58) Thrips	Most garden crops	malathion	Apply on foliage to control the insects. Aphids and leafhoppers transmit plant diseases; early control is important. Mites web on the underside of leaves; apply insecticide to underside of leaves early before extensive webbing occurs.
Blister beetles (NHE-72) Cutworms (NHE-77) Flea beetles (NHE-36) Grasshoppers (NHE-74) Leafhoppers (NHE-22) Picnic beetles (NHE-40)	Most garden crops	carbaryl	For cutworms, attach collars of paper, aluminum foil, or metal at planting for small numbers of plants, or apply insecticide to base of plants at first sign of cutting. Control grasshoppers in garden borders when hoppers are small. For picnic beetles, pick and destroy overripe or damaged vegetables.
All cabbage worms (NHE-45)	Cabbage and related crops, salad crops, and leafy vegetables	*Bacillus thuringiensis*[1]	Presence of white butterflies signals start of infestation. Control worms when small. It is almost impossible to raise cole crops in Illinois without controlling these pests.
Hornworms (NHE-130) Fruitworms	Tomatoes	carbaryl *Bacillus thuringiensis*[1]	Handpicking usually provides satisfactory control of hornworms.
Earworms (NHE-33)	Tomatoes and sweet corn	carbaryl	Apply to late-maturing tomatoes 3 to 4 times at 5- to 10-day intervals from small-fruit stage. Apply at fresh-silk stage to early and late corn every 2 days 4 to 5 times.
Colorado potato beetles	Eggplant, potatoes, tomatoes	carbaryl	Apply as needed. Insects usually present only in late May and June.
Potato leafhoppers (NHE-22)	Potatoes, beans	carbaryl or malathion	Apply 3 to 4 times at weekly intervals starting in late May or early June. Late potatoes and beans require additional treatments. Most serious pest of potatoes and beans in Illinois.
Bean leaf beetles (NHE-67)	Beans	carbaryl	Leaves are riddled in early plantings. Apply once or twice as needed.
Mexican bean beetles	Beans	carbaryl	Except for southern Illinois, only a pest of late beans. Apply insecticide to underside of leaves.
Cucumber beetles (NHE-46)	Vine crops	carbaryl	Apply as soon as beetles appear in spring. When blossoming begins, apply insecticide late in the day so as not to interfere with pollination by bees.
Squash vine borers (NHE-8)	Squash	carbaryl	Make weekly applications to crowns and runners when plants begin to vine. Apply late in day.
Corn borers	Sweet corn	carbaryl	Apply 4 times every 3 days to whorl and ear zone of early corn when feeding appears on whorl leaves.
Soil insects (including grubs, wireworms, root maggots)	All crops	diazinon	Mix 6 fluid ounces of 25% diazinon emulsion in enough water to cover 1,000 sq. ft., usually 2 to 3 gallons. Rake into soil.

Days Between Application and Harvest

	Collards, kale, and other leafy crops	Beans	Lettuce	Cabbage and related crops	Sweet corn	Onions	Vine crops[2]	Tomatoes	Pumpkin	Eggplant	Peas	Potatoes
carbaryl	14	0	14	3	0	..	0	0	0	0	0	0
malathion	7	1	14	7	5	3	1	1	3	3	3	0

Amount of Insecticide for Volume of Spray for Vegetable Insects

	1 gal.	6 gal.	100 gal.	Commercial dust
carbaryl 50% W.P.	2 tbl.	¾ cup	2 lb.	5%
malathion 50-57% E.C.	2 tsp.	4 tbl.	1 qt.	4%

E.C. = emulsion concentrate; W.P. = wettable powder. An emulsion concentrate is a chemical pesticide dissolved in a solvent to which an emulsifier has been added. It can then be mixed with water to the desired strength before being used.

[1] No time limitations. Sold as Dipel, Thuricide, Bactur, SOK-BT, and others. [2] Apply insecticides late in the day after blossoms have closed to avoid bee kill.

FLOWER INSECTS

Insect	Insecticide[1]	Dosage	Suggestions
Ants, soil-nesting wasps, and sowbugs (NHE-79, 93, 111) White grubs	diazinon 25% E.C.	1 cup per 1,000 sq. ft.	Drench into soil.
Aphids, mealybugs, spittlebugs, lacebugs, scales (NHE-7, 114)	malathion 50-57% E.C. acephate 15.6% E.C.	2 tsp. per gal. water 4 tsp. per gal. water	Spray foliage thoroughly. Repeat treatments may be needed.
Blister beetles (NHE-72)	carbaryl 50% W.P.	2 tbl. per gal. water	Spray foliage. Repeat treatments may be needed.
Cutworms (NHE-77)	diazinon 25% E.C. diazinon 5% granules	6 oz. per 2-3 gal. water 2½ lb. per 1,000 sq. ft.	Spray 1,000 sq. ft. soil at base of plants. Do not spray on plant foliage. Small numbers of plants can be protected with collars of paper, aluminum foil, or metal.
Earwigs (NHE-142)	carbaryl 50% W.P.	2 tbl. per gal. water	Spray foliage as needed. Do not spray blooms.
Grasshoppers (NHE-74)	carbaryl 50% W.P. malathion 50-57% E.C.	2 tbl. per gal. water 2 tsp. per gal. water	Spray foliage and also adjacent grassy or weedy areas.
Iris borer	dimethoate (Cygon 2E)	4 tsp. per gal. water	Apply when irises are in bloom, but not on blooms and make only one application. Add a small amount of liquid detergent to spray mix to improve coverage on leaves.
Leaf-feeding beetles Leaf-feeding caterpillars Plant bugs and leafhoppers	carbaryl 50% W.P. acephate 15.6% E.C.	2 tbl. per gal. water 4 tbl. per gal. water	Spray foliage. Repeat treatments if needed.
Slugs (NHE-84)	metaldehyde bait Mesurol 2% bait		Apply as a bait to soil. Remove old leaves, stalks, poles, boards, and other debris where slugs like to hide and lay eggs.
Springtails (NHE-70)	malathion 50-57% E.C. malathion 4% dust	2 tsp. per gal. water	Spray foliage and soil. Apply to base of plants.
Stalk borers (NHE-24)	Same as for leaf-feeding beetles		Spray foliage thoroughly and frequently.
Thrips	Same as for leaf-feeding beetles		Spray foliage carefully.
White flies (NHE-136)	pyrethrin 0.1% resmethrin	aerosol spray	Spray foliage thoroughly. Repeat in 5 days.

E.C. = emulsion concentrate; W.P. = wettable powder.

[1] Use only one insecticide from those listed. Do not use oil-base sprays on plants. Do not use malathion on African violets. Do not use carbaryl on Boston ivy. Do not use diazinon on ferns. Repeated use of carbaryl foliage sprays may cause mite or aphid infestations to increase and to become damaging. Do not use insecticides during full bloom. Do not use dimethoate on chrysanthemums.

TREE AND SHRUB INSECTS

Insects	Insecticide[1]	Suggestions[2]
Aphids (NHE-7)	acephate diazinon malathion	Spray foliage thoroughly with force when aphids become numerous. Repeat as needed.
Bagworms (NHE-6)	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray foliage thoroughly. Apply June 15. Later sprays are less effective. For late spraying, use *Bacillus thuringiensis.*
Borers Bronze birch (NHE-143)	dimethoate	Spray trunk and limbs thoroughly in late May and early June. Repeat in 3 weeks or apply 6-inch band of concentrate to trunk.
Flatheaded apple tree Oak	chlorpyrifos	Spray trunk and/or limbs in mid-May and repeat 4 weeks later. Keep trees healthy and vigorous and avoid trunk wounds.
Ash (NHE-145) Lilac (NHE-145) Peach tree	chlorpyrifos	Spray trunk and limbs in mid-June and repeat 4 weeks later. Keep the tree healthy and vigorous and avoid wounds or injury to the trunk.
Cankerworms (NHE-95)	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray foliage when feeding or worms are first noticed in spring.
Eastern tent caterpillars	Same as for cankerworms	Spray when nests are first noticed. Remove nests and destroy.
Elm leaf beetles (NHE-82)	acephate carbaryl	Spray as soon as damage is noticed.

[1] Use only one insecticide of those listed. [2] Treatment dates listed are for central Illinois. In southern Illinois, apply 2 weeks earlier; in northern Illinois, 2 weeks later. [3] Trade names: Dipel, Thuricide, Bactur, SOK-BT, and others.

TREE AND SHRUB INSECTS (continued)

Insects	Insecticide[1]	Suggestions[2]
European pine shoot moths and Nantucket pine moths (NHE-83)	dimethoate	Spray ends of branches thoroughly in late June for European species and in mid-May for Nantucket species.
Fall webworms	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray when first webs appear; clip off and destroy infested branches or burn out webs.
Galls (NHE-80, 81) Elm cockscomb Hickory Maple bladder	diazinon malathion	Spray foliage thoroughly when buds are unfolding. Sprays after galls form on leaves are ineffective.
Hackberry blister	acephate diazinon malathion	Spray foliage thoroughly in late May. Kills psyllids in galls. Sprays after galls form on leaves are ineffective.
Cooley spruce Eastern spruce	diazinon malathion	Apply in late September or October or early spring just before buds swell.
Green-striped mapleworms	Same as for cankerworms	Spray as soon as damage is noticed.
Leaf miners Boxwood Hawthorn Oak	diazinon malathion acephate	Spray foliage thoroughly when miners first appear. Repeat treatment in 10 to 12 days. Use acephate only on oak.
Birch Holly	dimethoate	Repeat treatment in 3 weeks.
Mealybugs	acephate malathion	Spray foliage thoroughly and with force. Repeat in two weeks.
Mimosa webworms (NHE-109)	acephate malathion *Bacillus thuringiensis*[3]	Spray foliage thoroughly when first nests appear (June, July). A repeat treatment for second-generation larval feeding may be needed (August).
Oak kermes	malathion	Spray foliage thoroughly about July 1 to kill the crawlers.
Periodical cicadas (NHE-113)	carbaryl	Spray all branches thoroughly when adults appear. Repeat in 7 to 10 days.
Sawflies	carbaryl	Spray as soon as worms or damage is evident.
Scales (NHE-100, 114, 146)	diazinon malathion acephate	Spray foliage thoroughly in early April for *Fletcher* and *European elm scale;* in late May for *pine needle* and *sweet gum scale;* in early June for *scurfy, oystershell,* and *euonymous scales;* in early July for *cottony maple, Juniper,* and *dogwood scales;* in mid-July for *spruce bud scale;* and again in August for *oystershell scale.*
Cottony maple (NHE-144), Putnam, San Jose, Tulip tree	dormant oil diluted according to label	Apply when plants are still dormant in late winter. Do not use on evergreens. For tulip tree scale, a malathion spray in late September or in early spring is also effective.
Sycamore lace bugs Plant bugs	acephate carbaryl malathion	Spray when nymphs appear, usually in late May.
Thrips	Same as for aphids	Mainly on privet. Spray foliage thoroughly.
Yellow-necked caterpillars	acephate carbaryl malathion	Spray foliage when worms are small (July).
Zimmerman pine moths (NHE-83)	chlorpyriphos dimethoate	Spray trunk and branches in mid-April for young larvae and/or mid-August for adults and young larvae.

[1] Use only one insecticide from those listed. [2] Treatment dates listed are for central Illinois. In southern Illinois, apply 2 weeks earlier; in northern Illinois, 2 weeks later. [3] Trade names: Dipel, Thuricide, Bactur, SOK-BT, and others.

Amount of Insecticide Needed for Volume of Spray for Tree and Shrub Insects

	1 gal.	6 gal.	100 gal.		1 gal.	6 gal.	100 gal.
acephate (Orthene) 15.6% E.C.[1]	4 tsp.	1 cup	2 qt.	diazinon 25% E.C.[4]	2 tsp.	4 tbl.	1 qt.
carbaryl (Sevin) 50% W.P.[2]	2 tbl.	¾ cup	2 lb.	dimethoate (Cygon 2E)[3]	2 tsp.	4 tbl.	1 qt.
chlorpyrifos (Dursban 2E.)	2 tsp.	4 tbl.	1 qt.	malathion 50-57% E.C.[5]	2 tsp.	4 tbl.	1 qt.

E or E.C. = emulsion concentrate; W.P. = wettable powder.

[1] Do not use on flowering crab, sugar maple, redbud, American elm, Lombardy poplar, or cottonwood. [2] Do not use on Boston ivy. [3] Do not use on chrysanthemums. [4] Do not use on ferns or hibiscus. [5] Do not use on canaert red cedar.

LAWN INSECTS

Insects	Insecticide[1]	Dosage per 1,000 sq. ft.[2]	Suggestions
White grubs (NHE-104, 147)	diazinon 25% E.C. 5% G.	1 cup 2½ lb.	Apply as spray or granules to small area and then water in thoroughly before treating another small area. Grub damage will usually occur in late August and in September.
Ants (NHE-111) Cicada killer and other soil-nesting wasps (NHE-79, 150)	diazinon 25% E.C. 5% G. chlorpyrifos 5 or 6% E.C.	¾ cup 2 lb. 1 cup	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest and cover with soil.
Sod webworms (NHE-115)	carbaryl 50% W.P. diazinon 25% E.C. 5% G. chlorpyrifos 5 or 6% E.C.	½ lb. ¾ cup 2 lb. 8 fl. oz. (1 cup)	As sprays, use at least 2.5 gal. of water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader. Webworms usually damage lawns in late July and in August.
Millipedes and sowbugs (NHE-93)	carbaryl 50% W.P. diazinon 25% E.C. chlorpyrifos 5 or 6% E.C.	½ lb. ¾ cup 1 cup	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
Armyworms Cutworms	carbaryl 50% W.P. chlorpyrifos 5 or 6% E.C.	2 oz. 1 cup	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
Chinch bugs	chlorpyrifos 5 or 6% E.C. diazinon 25% E.C. 5% G.	1 cup ¾ cup 2 lb.	Spray infested areas where chinch bugs are present.
Aphids (NHE-148)	acephate 15.6% E.C.	4½ fl. oz.	Spray grass thoroughly.
Chiggers	diazinon 25% E.C.	1 tbl.	Spray grass thoroughly.
Slugs (NHE-84)	Mesurol 2% bait		Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.
Bluegrass billbugs	chlorpyrifos 5 or 6% E.C.	1 to 2 cups	Apply as a spray in spring to lawn damaged in previous year. Drench at high rate in July if damage is observed.

E.C. = emulsion concentrate; W.P. = wettable powder; G. = granules.

[1] Use only one insecticide from those listed. [2] To determine lawn size in square feet, multiply length times width of lawn and subtract non-lawn areas including house, driveway, garden, etc. Do not allow people or pets on the lawn until the spray has dried.

HOUSEHOLD INSECTS

Insects	Insecticide[1]	Suggestions for control
Ants (NHE-111) Carpenter ants (NHE-10)	*Outdoors:* diazinon 25% E.C. *Indoors:* chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U. hydrazone baits propoxur baits boric acid R.T.U.	**Chemical.** Use 5 tablespoons of diazinon 25 E.C. per gallon of water to spray completely around outside foundation and the adjacent 1 ft. of soil. Apply a R.T.U. spray to baseboards, cracks, and door thresholds. Apply boric acid in out-of-reach areas only. **Non-chemical.** Keep foods in tightly sealed containers or in the refrigerator. Most ants prefer sweets and fats. Practice good sanitation. Avoid leaving dirty dishes or other food particles where they are accessible to ants. Caulk cracks and crevices in house foundation.
Ants, Pharaoh	methoprene baits boric acid baits	**Chemical.** *Indoors:* Place baits near ant food and water sources and in other areas where ants are found. Treat for several weeks, replacing bait as it becomes dry. **Non-chemical.** Follow suggestions above for other ants. Apply petroleum jelly or double-sided tape to furniture legs to keep ants off of furniture.
Boxelder bugs (NHE-9)	diazinon 25% E.C. carbaryl 50% W.P.	**Chemical.** Spray boxelder bugs on tree trunks, foundation walls (diazinon only), under eaves, and other areas where they gather. Use carbaryl on foliage where beetles are feeding. **Non-chemical.** Spraying with soapy water may be effective. Keep screens, and other openings in good repair. Caulk all seams around windows and doors. Indoors remove the bugs by vacuuming.
Carpet beetles, clothes moths (NHE-87)	chlorpyrifos R.T.U. diazinon R.T.U.	**Chemical.** Spray storage areas, edges of carpeting, baseboards, cracks and crevices. **Non-chemical.** Destroy all badly infested materials. If insulation is of plant or animal origin remove it from the structure. Check for any dead animal or bird carcasses that may be in wall voids, chimneys, or fireplace areas. Keep accumulation of lint to a minimum and vacuum thoroughly in areas where hair and other natural fibers gather. Remove all bird, insect, and rodent nests in the fall before cool weather. Place cleaned or washed woolens in insect-free chests that are tightly sealed or in plastic bags. Dry cleaning and laundering kills these pests.
Carpenter bees	carbaryl 5% dust diazinon R.T.U.	**Chemical.** Dust and spray entrances to nest with insecticide. Do not plug entrance. **Non-chemical.** In the fall, fill the holes and paint or varnish the entire wood surface.
Centipedes, millipedes, sowbugs (NHE-93)	*Outdoors:* diazinon 25% E.C. *Indoors:* chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U.	**Chemical.** Apply 5 tablespoons of diazinon 25% E.C. per gallon of water as an outside foundation spray. If millipedes are abundant, treat entire lawn according to label. *Indoors:* Use R.T.U. spray according to label. **Non-chemical.** Correct situations where moist habitats occur such as crawl spaces, poorly drained areas, and piles of trash, mulch, or compost. Remove indoors by vacuuming.
Chiggers (NHE-127)	diazinon 25% E.C. DEET R.T.U.	**Chemical.** Treat lawns, roadsides, and areas not mowed. For personal protection, a repellent such as DEET will prevent attack. **Non-chemical.** Eliminate or mow breeding sites, especially briars, weeds, and other thick vegetation where there is an abundance of moisture and shade. Wear protective clothing such as a long-sleeved shirt and trousers, shoes, and socks. Tuck pant legs into boots or socks. Avoid sitting on the ground either in the lawn or brushy areas. Take a warm soapy shower or bath immediately after returning from any infested areas.
Clover mites (NHE-2)	pyrethroid R.T.U.	**Chemical.** *Indoors:* Spray with pyrethroid. **Non-chemical.** Eliminate grass and other vegetation in a 1 ft. band all the way around the house. Also make sure window and door seams are properly caulked and sealed to prevent entry by the mites. *Indoors:* Mites can be removed by vacuuming.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules. (SEE THE PESTICIDE DILUTION TABLE.)

[1] Whenever possible, purchase specially prepared, ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table. You need to know only the formulation of the insecticide when using the dilution table.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Cluster flies (NHE-1)	pyrethroid R.T.U.	**Chemical.** Fog lightly in rooms with pyrethroid. Repeat spray as needed. **Non-chemical.** Seal cracks and openings around windows, eaves and siding. Use fly screen over air intake vents or air conditioning systems. Seal off attic openings with screen or caulking. *Indoors:* Remove flies by vacuuming.
Cockroaches German (NHE-3) Brown-banded (NHE-4) American and Oriental (NHE-5)	chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U. boric acid R.T.U. hydroprene R.T.U. hydrazone bait propoxur bait	**Chemical.** Spray roach runways and hiding places. Treat under sink, refrigerator, cabinets, on baseboards, etc. Treatment throughout home may be needed to control brown-banded roaches. May be supplemented with boric acid applied into out-of-sight and out-of-reach voids under cabinets and appliances. **Non-chemical.** Practice proper sanitation by keeping food properly sealed or stored in the refrigerator. Keep trash covered. Do not allow dirty dishes to accumulate. Clean frequently under refrigerators and stoves where food particles may accumulate. Eliminate hiding places such as piles of newspapers, boxes and papers. Caulk cracks and crevices. Do not leave pet food out overnight.
Crickets (NHE-137) Field House Camel	*Outdoors:* diazinon 25% E.C. *Indoors:* chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U. propoxur bait	**Chemical.** Use 5 tablespoons of diazinon 25% E.C. per gallon of water to spray completely around outside foundation and the adjacent 1 ft. of soil. Apply an R.T.U. spray to baseboards, cracks, and door thresholds. **Non-chemical.** Cracks and crevices around windows, doors, and in the foundation should be properly sealed and caulked. *Indoors:* Remove crickets by vacuuming. House lights attract both field and house crickets. Keep garbage cans clean and empty frequently. Keep firewood at least 1-2 feet away from the foundation. Apply a 6-inch band of ashes around the wood pile. Eliminate sources of moisture by fixing leaky pipes and modifying damp areas.
Drain flies (NHE-91)	pyrethroid R.T.U.	**Chemical.** Use chemicals only after solving sanitation problems. Pour boiling water or rubbing alcohol into overflow drain to eliminate maggots. **Non-chemical.** Practice proper sanitation. Clean out overflow drains, drain traps, and basement drains. Keep screens in good repair.
Earwigs (NHE-142)	*Outdoors:* diazinon 25% E.C. *Indoors:* chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U. propoxur bait	**Chemical.** Apply 5 tablespoons of diazinon 25% E.C. per gallon of water as an outside foundation spray. *Indoors:* Use R.T.U. spray according to label. **Non-chemical.** Remove unessential plant debris, mulch, and boards from around buildings. Establish a zone of bare concrete or soil which will dry out. *Indoors:* Remove by vacuuming. Caulk cracks and crevices around windows, doors, and in the foundation.
Elm leaf beetles (NHE-82)	carbaryl 50% W.P.	**Chemical.** Spray with carbaryl on nearby Chinese elm trees to control elm leaf beetle larvae and adults. **Non-chemical.** Seal cracks and crevices around windows and other openings to prevent entry. *Indoors:* Remove by vacuuming.
Fleas (NHE-107)	naled carbaryl 5% dust methoprene R.T.U. pyrethroid R.T.U.	**Chemical.** Replace flea collars on pets about every 3 months. Some pets are allergic. Dust pets directly as needed. Dust areas inside and outside the home where pets rest. For infestations in the home, spray edges of carpets and rugs, and floors where fleas are observed. Follow label directions. Vacuum rugs and upholstered furniture thoroughly approximately 30 minutes after spraying.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules. (SEE THE PESTICIDE DILUTION TABLE.)

[1] Whenever possible, purchase specially prepared, ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table. You need to know only the formulation of the insecticide when using the dilution table.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Fleas (cont.)	diazinon 25%E.C.	**Chemical.** Apply to lawn. **Non-chemical.** Frequently launder pet bedding and rugs where pets frequent with hot soapy water. Vacuum thoroughly to remove lint and dust around baseboards and cracks where flea eggs and larvae accumulate. Eliminate vegetation that will serve as a harborage for the native mammal population (carriers of fleas). Prevent pets from resting under the house and exclude mammals by screening attic and eave entrances. Thoroughly clean furniture in areas pets tend to frequent.
Flies (NHE-16) Houseflies Gnats, Midges	*Outdoors:* malathion 50-57% E.C. *Indoors:* pyrethroid R.T.U.	**Chemical.** Use 4½ tablespoons of malathion 50-57% E.C. per gallon of water to spray around garbage cans and other resting sites. Apply fine mist or fog of pyrethroid. **Non-chemical.** Proper sanitation is important. Dispose of refuse frequently and prevent the accumulation of rotting or decaying vegetation. Keep screens in good repair. Fly strips and fly swatters can also be effective.
Honey bees (NHE-141)	carbaryl 5% dust diazinon R.T.U. pyrethroid R.T.U.	**Chemical.** Drill holes through siding to inject insecticide, if necessary. Remove nests and honey and destroy them. Treat nests at dusk or dawn. **Non-chemical.** Caulk cracks and crevices during the winter or early spring to prevent nest building. Seal off attic openings, air intake vents, and air conditioning systems with fly screen.
Lice (NHE-105) Human Head Crab Body	Kwell 1% shampoo pyrethrin R.T.U.	**Chemical.** Dust lightly over body hair. Repeat in 2 weeks if needed. Do not get in eyes. Consult a physician. **Non-chemical.** Practice proper personal hygiene. Avoid using other individuals' combs, hats, towels, or hair brushes. Bedding and clothing should be changed and washed frequently. Sanitation of locker rooms, and proper laundering will help reduce the incidence of lice. Crab louse is usually transmitted through intimate sexual contact.
Mites, Human Human scabies Human itch mite (NHE-135)	Kwell 1% lotion available only by a physician's prescription pyrethrin R.T.U.	**Chemical.** Consult a physician. **Non-chemical.** Consult a physician.
Mosquitoes (NHE-94,132)	*Outdoors:* malathion 50-57% E.C. *Bacillus thuringiensis israelensis* *Indoors:* pyrethroid R.T.U.	**Chemical.** Spray tall grass, around doorways, and other resting sites. Use a repellent like DEET when entering mosquito-infested areas. Apply fine mist or fog of pyrethroid. **Non-chemical.** Keep screens in good repair. Flues and chimneys should be covered during the summer months. Eliminate resting places such as tall grass, weeds, shrubbery, and vines from around the home. Eliminate rain-water-collecting items such as old tires, pans, cans, and buckets. Weekly, drain plastic swimming pools and bird baths. Provide for proper water drainage around the foundation of the home. When visiting mosquito-infested areas, wear protective clothing to prevent bites. If small garden ponds are present use Top minnows *Gambusia sp.* *"Bug zappers" and ultrasonic devices have not proven to be extremely effective in controlling mosquitoes and other noxious flying insects.*
Pantry and Cereal Pests (NHE-11) Grain beetles Indian meal moth Flour beetles	diazinon R.T.U. propoxur R.T.U. chlorpyrifos R.T.U. pyrethroid R.T.U.	**Chemical.** Force spray into cracks and crevices; allow to dry; cover shelves with clean, fresh paper. Do not contaminate food or utensils with insecticide. **Non-chemical.** Discard infested packages. Thoroughly clean and vacuum food cabinets and shelves. Keep dry food in tightly sealed containers. Keeping nonhuman food at 32°F for 3-4 days will kill eggs and larvae.
Powder-post beetles (NHE-85)	chlorpyrifos 42% E.C.	**Chemical.** Use 2 tablespoons of chlorpyrifos 42% E.C. per gallon of water to paint or spray infested unfinished wood. Follow label directions. **Non-chemical.** Avoid buying furniture or wood products that have not been stained, varnished or properly dried. Properly paint or varnish new wood items to seal pores and to prevent egg laying.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules. (SEE THE PESTICIDE DILUTION TABLE.)

[1] Whenever possible, purchase specially prepared, ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table. You need to know only the formulation of the insecticide when using the dilution table.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Silverfish (NHE-86)	diazinon R.T.U. propoxur R.T.U. chlorpyrifos R.T.U. boric acid R.T.U.	**Chemical.** Spray runways, baseboards, closets, and places where pipes go through the walls. Repeat treatments in 2 weeks if needed. Apply boric acid in out-of-reach areas only. **Non-chemical.** Alter the physical environment of the infested area by reducing the humidity. Reduce harborage sites by caulking cracks and crevices. Eliminate their food source by storing books, papers, and linens in tightly sealed containers or cabinets.
Spiders (NHE-17, 116)	*Outdoors:* diazinon 25% E.C. *Indoors:* chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U.	**Chemical.** Use 5 tablespoons of diazinon 25% E.C. per gallon of water to spray completely around outside foundation and the adjacent 1 ft. of soil. Apply R.T.U. spray to baseboards, cracks, and door thresholds. *Do not use diazinon E.C. inside.* **Non-chemical.** Keep screens and other openings in good repair. Caulk all seams around windows and doors. Spiders are considered beneficial as they are predators of insects and other small animals. *Indoors:* Remove by simply vacuuming.
Springtails (NHE-70)	*Outdoors:* diazinon 25% E.C.	**Chemical.** *Outdoors:* Spray soil next to the house, especially grassy moist areas. **Non-chemical.** Eliminate moist areas around the home where mulch and rotting vegetation are present. Keep outside light use to a minimum. Keep screens and doors in good repair. Allow potting soil of houseplants to dry out between waterings.
Swimming pool insects (NHE-103)	Do *not* add insecticides to pool water	**Chemical.** None. **Non-chemical.** Keep outside light to a minimum. Maintain proper chlorine balance in the pool. Cover pool when not in use.
Termites (NHE-57)	chlorpyrifos 42% E.C. (Dursban T.C.) fenvalerate 24.5% E.C. (Tribute) permethrin (Dragnet 36.8% E.C.) (Torpedo 25.6% E.C.) cypermethrin 25.3% E.C. (Demon T.C.)	**Chemical.** Fenvalerate, cypermethrin, and permethrin are restricted-use pesticides. Control by pest control operator (exterminator) recommended. **Non-chemical.** Remove termite tubes connecting the soil to wood sources. Eliminate wood-to-soil contacts. Ventilate damp areas such as crawl spaces for proper drying. Use treated wood when landscaping or constructing outside structures. Cedar and redwood are somewhat resistant; termites prefer hardwoods.
Ticks (NHE-56) Brown dog tick Wood tick	tetrachlorvinphos 50% W.P. malathion 50-57% E.C. carbaryl 50% W.P. carbaryl 5% dust tetrachlorvinphos 3% dust	**Chemical.** Apply spray to lawns, fencerows, roadsides, and areas not regularly mowed. Dust pets directly as needed, according to label instructions. Dust baseboards, cracks, and crevices around pet bedding. **Non-chemical.** Keep vegetation, weeds and brush, mowed and clean. Avoid areas where ticks are known to be present. Wear long-sleeved shirt and trousers when visiting infested areas. Vacuum baseboards and other cracks and crevices thoroughly to destroy eggs and immatures.
Wasps (NHE-141) Hornets Yellowjackets	carbaryl 5% dust diazinon R.T.U. pyrethroid R.T.U.	**Chemical.** For nests below ground, apply diazinon according to label and seal opening with soil. Spray aboveground wasp and hornet nests in partitions with carbaryl. Drill holes through siding to inject insecticide, if necessary. Remove nests and destroy them. Treat nests at dusk or dawn. **Non-chemical.** Keep garbage cleaned up and properly covered. Avoid indiscriminate killing of wasps, hornets, and yellowjackets, as they are considered beneficial. If picnicking, keep food properly covered or sealed. Avoid areas where yellowjackets are prevalent. Keep overripe fruit and vegetables cleaned up and away from human activity. Caulk cracks and crevices during the winter or early spring to prevent yellowjacket nests but do not caulk opening of active nest.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules. (SEE THE PESTICIDE DILUTION TABLE.)

[1] Whenever possible, purchase specially prepared, ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table. You need to know only the formulation of the insecticide when using the dilution table.

PESTICIDE DILUTION TABLE FOR HOUSEHOLD INSECTS

When preparing a spray of a desired percentage you need to know only the formulation of the particular product (examples: Sevin 50% wettable powder; Diazinon 25% emulsion concentrate). For instance, if you were preparing a 0.5% diazinon solution for spraying the foundation of the home, you would mix 5 tablespoons of diazinon 25% E.C. into each gallon of water. The formulations of insecticides in the table may be purchased from hardware stores, pest control establishments, lawn and garden centers, and other sources. For some jobs, such as spraying outdoors to control flies or mosquitoes, a gallon or more of properly diluted spray is required. To obtain the percent concentration suggested for controlling a particular insect, add the amount of pesticide suggested in the table to one gallon of water.

The formulations below are suggested for control of household insects. *Do not* use this table for vegetable, flower, tree, shrub, or lawn insects.

Pesticide formulation	Amt. of insecticide needed per gal. of spray — Desired concentration				
	0.03%	0.25%	0.5%	1.0%	2.5%
carbaryl 50% W.P.	. .	2 tbsp.	4 tbsp.	8 tbsp.	. .
chlorpyrifos 42% E.C.	. .	. .	. .	5 tbsp.	. .
diazinon 25% E.C.	. .		5 tbsp.	10 tbsp.	. .
malathion 50-57% E.C.	. .	. .	7 tsp.	4½ tbsp.	10 tbsp.
tetrachlorvinphos 50% W.P.	. .	. .	4 tbsp.	. .	. .

(*tbsp.* = *tablespoon; tsp.* = *teaspoon*)

FOR YOUR PROTECTION

1. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet.
2. If you use a bait around or in the home, place it after the children have retired and pick it up in the morning before they get up. Furthermore, place it out of their reach. At present we do not encourage the use of baits for insect control.
3. Avoid breathing insecticide sprays and dusts over an extended period. This is particularly true in enclosed areas such as crawl spaces, closets, basements, and attics.
4. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
5. Wear rubber gloves when handling insecticide concentrates.
6. Do not smoke while handling or using insecticides.
7. Leave unused insecticides in their original containers with the labels on them and in locked cabinets.
8. Triple-rinse empty pesticide containers. Wrap each container in several layers of paper. Dispose of the containers one at a time through the municipal solid-waste-disposal system.
9. Do not leave puddles of spray on impervious surfaces.
10. Do not apply insecticides to fish ponds.
11. Do not apply insecticides near dug wells or cisterns.
12. Observe all precautions listed by the manufacturer on the label.

Insecticide Formulations and Toxicities

The following list of insecticides is intended as a reference for their trade and common names, toxicities, formulations, and manufacturers. In addition to the insecticides recommended in the Insect Pest Management Guides, we have included some that have label approval but are not in the Illinois recommendations and some that are still experimental compounds.

The index of trade names of insecticides, listed alphabetically, will allow you to find quickly the appropriate common name. Within the body of the reference, the approved common names are also listed alphabetically in the left-hand column. Trade names, formulations, toxicities, signal words, and manufacturers are listed for each product.

The use of product names does not constitute an endorsement by the University of Illinois. Ultimate reliance must be placed on directions and information supplied by manufacturers or on product labels.

Oral and dermal toxicity values are expressed as LD_{50}, which indicates the size of the dose that is lethal to 50 percent of the test animals. LD_{50} is expressed as milligrams (mg) of actual insecticide per kilogram (kg) of body weight of the test animal--mg/kg. Most of the oral and dermal LD_{50} values we have used on our list are printed in the 8th edition of *The Pesticide Manual: A World Compendium,* published in 1987 by the British Crop Protection Council (Lavenham Press Ltd.). Oral and dermal LD_{50} values reported from other sources sometimes differ markedly, depending on the carrier of the toxicant, the ratio of isomers in the sample, and the species, sex, age, and degree of fasting of the test animals. Acute oral toxicity values are usually obtained by feeding technical-grade product to white rats or rabbits; acute dermal values are determined by skin absorption tests on rats or rabbits. However, white mice, guinea pigs, dogs, and other animals are sometimes used for these tests. Whenever possible, we have used the data reported for either white rats or rabbits. Because test results vary, an LD_{50} may be expressed as a range of values rather than a single value.

By multiplying the LD_{50} value by 0.003, you can approximate the ounces of actual insecticide required to be lethal to one of every two 187-pound men or other warm-blooded animals. As an example, an oral LD_{50} value for malathion is 1,200 mg/kg; thus, if a group of men each weighing 187 pounds ate 3.6 ounces (1,200 times 0.003) of actual malathion per man, half of them would probably die. The dermal-toxicity-LD_{50} value of malathion is approximately 4,000 mg/kg, or, for a 187-pound man, 12 ounces. If you check the list of insecticides, you will find some highly toxic chemicals with LD_{50} values from 1 to 10 mg/kg. For the average-size man, fatal doses of those chemicals would be in the range of 0.003 to 0.03 ounce.

LD_{50} values are approximate, but they serve as a guide for comparing the toxicities of insecticides as well as an indication of their comparative acute toxicities to other warm-blooded animals and man. Acute toxicity values

expressed as LD_{50} are classified according to their relative danger when being used. An acute oral LD_{50} of 500 mg/kg or higher is rated as low toxicity; an LD_{50} rating of 50 to 500 is moderate; and 50 or less is high.

When available, ratings of insecticide toxicity to fish, birds, and honey bees are also given. Those for bees can be interpreted readily as follows: (1) high--kills bees on contact and by residues; bees should be removed from area of application; (2) moderate--kills bees if applied over them; limited damage with correct dosage, timing, and method of application; (3) low--can be used around bees with few precautions and a minimum of injury. However, the relative toxicities of insecticides to fish and birds must be interpreted from the available data. The primary test species for fish are rainbow trout and bluegills, but goldfish, golden orfe, carp, bass, catfish, guppies, harlequin fish, minnows, and mosquito fish have also been used by a number of different laboratories. The primary test species for birds are bobwhite quail, ringneck pheasants, and mallard ducks, but chickens, Japanese quail, canaries, ducks, pigeons, blackbirds, starlings, and partridges have also been used. As a consequence, the data for toxicity of various insecticides to fish and birds should be viewed as relative ratings.

Factual errors arising during the transcription of the information from *The Pesticide Manual* are our responsibility. Please draw our attention to any errors or omissions in the following list so that we can make corrections to our next annual revision.

Remember, this is NOT a list of recommended insecticides, nor is it to be used in determining what insecticide to use to control a particular insect. This list is a reference to compare common names of insecticides with trade names and to determine their relative toxicities and general use.

INDEX: INSECTICIDE TRADE NAMES

Trade name	Common name
Aastar	combination of phorate and flucythrinate
Abate	temephos
Actellic	pirimiphos-methyl
Agrox D-L Plus	combination of captan, diazinon, and lindane
Alleviate	allethrin
Altosid	methoprene
Ambush	permethrin
Ammo	cypermethrin
Anthon	trichlorfon
Arrivo	cypermethrin
Asana	esfenvalerate
Atroban	permethrin
Avid	avermectin
Azodrin	monocrotophos
Bactimos	*Bacillus thuringiensis* var. *israelensis*
Bactospeine	*Bacillus thuringiensis* var. *kurstaki*
Baygon	propoxur
Baytex	fenthion
Baythroid	cyfluthrin
Bidrin	dicrotophos
Black Leaf 40	nicotine
Bolstar	sulprofos
Brigade	bifenthrin
Broot	trimethacarb
Capture	bifenthrin
Carzol	formetanate
Chlor-O-Pic	chloropicrin
Ciodrin	crotoxyphos
Ciovap	combination of crotoxyphos and dichlorvos
Co-Ral	coumaphos
Combot	trichlorfon
Comite	propargite
Counter	terbufos
Cygon	dimethoate
Cymbush	cypermethrin
Cythion	malathion
Dasanit	fensulfothion
DDVP	dichlorvos
De-Fend	dimethoate
Delnav	dioxathion
Deltic	dioxathion
Demon	cypermethrin
Derris	rotenone
Detia	aluminum phosphide
Diacon	methoprene
Diazinon	diazinon
Dibrom	naled
Dimecron	phosphamidon
Dimilin	diflubenzuron
Dipel	*Bacillus thuringiensis* var. *kurstaki*
Dipterex	trichlorfon
Di-Syston	disulfoton
DNOC	dinitro compounds
Doom	*Bacillus popilliae*
Dragnet	permethrin
Dursban	chlorpyrifos
Dycarb	bendiocarb
Dyfonate	fonofos
Dylox	trichlorfon
D·Z·N	diazinon
Ecopro	temephos
Ectiban	permethrin
Ectrin	fenvalerate
EDC	ethylene dichloride
Elgetol	dinitro compounds
Entex	fenthion
Equibot	trichlorfon
Eqvalon	ivermectin
Expar	permethrin
Famphos	famphur
Ficam	bendiocarb
Force	tefluthrin
Fumitoxin	aluminum phosphide
Furadan	carbofuran
Gammasan	lindane
Gastoxin	aluminum phosphide
Gencor	hydroprene
Germate Plus	lindane + diazinon
Grasshopper spore	*Nosema locustae*
Guardian	flucythrinate
Guthion	azinphos-methyl
HCN	hydrocyanic acid
Imidan	phosmet
Insectrin	permethrin
Isotox	lindane
Ivomec	ivermectin
Javelin	*Bacillus thuringiensis* var. *kurstaki*
Karate	lambda-cyhalothrin
Karathane	dinocap
Kelthane	dicofol
Knox Out	diazinon
Lannate	methomyl
Larvin	thiodicarb
Larvacide	chloropicrin
Larvadex	cyromazine

Trade name	Common name
Lorsban	chlorpyrifos
Lysoff	fenthion
Marlate	methoxychlor
Mavrik	fluvalinate
Mesurol	methiocarb
Metasystox-R	oxydemeton-methyl
Metho-gas	methyl bromide
Mocap	ethoprop
Monitor	methamidophos
Moorman's IGR	methoprene
Morestan	oxythioquinox
Neguvon	trichlorfon
Nemacur	fenamiphos
Neo-Pynamin	tetramethrin
Nudrin	methomyl
Off	deet
Oftanol	isofenphos
Omite	propargite
Orthene	acephate
Overtime	permethrin
Pay-Off	flucythrinate
PDB	paradichlorobenzene
Penncap-M	methyl parathion (encapsulated)
Pentac	dienochlor
Permaban	permethrin
Permectrin	permethrin
Pharorid	methoprene
Phosdrin	mevinphos
Phostek	aluminum phosphide
Phostoxin	aluminum phosphide
Phthalthrin	tetramethrin
Plictran	cyhexatin
Pounce	permethrin
Pramex	permethrin
Precor	methoprene
Premgard	resmethrin
Prolate	phosmet
Proxol	trichlorfon
Pryfon	isofenphos
PT470 Regulator	fenoxycarb
Pydrin	fenvalerate
Pynamin	allethrin
Pyrenone	pyrethrins
Pyrid	fenvalerate
Quasar	chloropicrin
Rabon	tetrachlorvinphos
Ravap	combination of dichlorvos and tetrachlorvinphos
Reldan	chlorpyrifos-methyl
Respond	resmethrin
Safrotin	propetamphos
Savit	carbaryl
Scourge	resmethrin
Scout	tralomethrin
Sevin	carbaryl
SOK-BT	*Bacillus thuringiensis* var. *kurstaki*
Spectracide	diazinon
Spotton	fenthion
Spur	fluvalinate
Supracide	methidathion
Synerid	erythrosine-B
Synthrin	resmethrin
Systox	demeton
Taktic	amitraz
Talstar	bifenthrin
Tedion	tetradifon
Teknar	*Bacillus thuringiensis* var. *israelensis*
Temik	aldicarb
Tempo	cyfluthrin
Terminator	diazinon
Tetralate	combination of tetramethrin and resmethrin
Thimet	phorate
Thiodan	endosulfan
Thuricide	*Bacillus thuringiensis* var. *kurstaki*
Tiguvon	fenthion
Tomahawk	pirimiphos-methyl
Topside	*Bacillus thuringiensis* var. *kurstaki*
Torpedo	permethrin
Trigard	cyromazine
Trithion	carbophenothion
Triumph	miral
Turcam	bendiocarb
Vapona	dichlorvos
Vectobac	*Bacillus thuringiensis* var. *israelensis*
Vendex	hexakis
Vigilante	diflubenzuron
Vydate	oxamyl
Warbex	famphur
Zectran	mexacarbate
Zolone	phosalone

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
acephate (Chevron)	Orthene	75SP	L	H	M	866-945	>2,000	caution
aldicarb (Rhone-Poulenc)	Temik	10G, 15G	-	H	M	1	5	danger
allethrin (Stauffer, Fairfield Am.)	Alleviate, Pynamin	many	H	L	L	685-1,100	>2,500	caution
aluminum phosphide (Degesch Am.)	Detia, Fumitoxin, Gastoxin, Phostek, Phostoxin	55% tablets, pellets	-	-	-	AV[d] 2,000 ppm		danger
amitraz (NOR-AM)	Taktic	12.5% EC	-	L	-	800	>1,600	warning
avermectin (Merck)	Avid	EC	M	H	M	650	2,000	caution
azinphos-methyl (Mobay)	Guthion	2S, 2L, 50WP	VH	H	M	16	>250	danger
Bacillus popilliae (Reuter, Fairfax Biological)	Doom	WP	EL	EL	EL	NT[e]	NT	caution
Bacillus thuringiensis var. *israelensis* (Abbott Labs, Biochem, Sandoz)	Bactimos, Teknar, Vectobac	F, G, L, WP	EL	EL	EL	NT	NT	caution
Bacillus thuringiensis var. *kurstaki* (Abbott Labs, Biochem, Tuco, Sandoz, NOR-AM, Reuter)	Bactospeine, Dipel Javelin, SOK-Bt, Thuricide, Topside	many	EL	EL	EL	NT	NT	caution
bendiocarb (NOR-AM)	Dycarb, Ficam, Turcam	29 and 76WP, 1D, 25% oil suspension	-	H	-	40-156	566-600	warning
benzyl benzoate	...	30L	-	-	-	500-5,000	...	caution
bifenthrin (FMC)	Brigade, Capture, Talstar	10WP, EC	VH	H	L	54	>2,000	warning
carbaryl (Rhone-Poulenc)	Sevin	XLR, 4-oil, 80S, 50W, 4F, Bait	VL	H	VL	850	>4,000	caution warning
carbofuran (FMC, Mobay)	Furadan	3G, 5G, 10G, 15G, 4F	M	H	M	8-14	>2,550	warning danger
carbophenothion (ICI)	Trition	EC	VH	H	-	20-79	1,850	warning
chloropicrin (Great Lakes, Niklor, IMC)	Chlor-o-pic, Larvacide 100, Quasar	liquid fumigant	-	-	-	AV 20 ppm CV 0.1 ppm		danger
chlorpyrifos (Dow)	Dursban, Lorsban	2E, 4E, 15G, 50W, 50SL, others	VH	H	H	135-163	2,000	caution warning
chlorpyrifos-methyl (Dow)	Reldan	4E	-	-	-	1,630-2,140	>2,000	warning
coumaphos (Bayer AG)	Co-Ral	25WP, pour-on, EC, D, F	M	M	H	13-963	860-1,000+	warning danger

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
crotoxyphos (DuPont, SDS Biotech)	Ciodrin	EC, D, oils	H	M	-	53	384	danger
cyfluthrin (Mobay)	Baythroid, Tempo	0.05G, 2E	VH	H	L	500-1,200	>5,000	caution
cyhexatin (Dow)	Plictran	50W	VH	L	-	540	>2,000	warning
cypermethrin (FMC, ICI)	Ammo, Arrivo, Cymbush, Demon	EC, WP	VH	H	L	251-4,123	>2,400	warning
cyromazine (CIBA-Geigy)	Larvadex, Trigard	0.3% feed premix, 75WP (insect growth regulator)	L	VL	-	3,387	>3,100	caution
deet (McLaughlin-King)	Off	in alcohol	-	-	-	2,000	10,000	caution
demeton (Mobay)	Systox	2E, 6E	M	M	M	2-12	14	danger
diazinon (CIBA-Geigy, Pennwalt)	D·Z·N, Knox Out, Spectracide, Terminator eartags	4E, 14G, 50W, AG500, 2F, ear tags	H	H	H	300-400	>2,150	caution warning
dichlorvos (CIBA-Geigy, SDS Biotech, DuPont)	DDVP, Vapona, others	many	M	H	M	56-108	75-210	danger
dicofol (Rohm and Haas)	Kelthane	1.6EC, 35WP	M	L	L	668-842	1,870	caution warning
dicrotophos (DuPont, CIBA-Geigy)	Bidrin	8M	-	H	H	17-22	111-181	danger
dienochlor (Sandoz)	Pentac	4F, 50WP	-	L	L	>3,160	>3,160	warning
diflubenzuron (Uniroyal)	Dimilin, Vigilante	25W, 4G, Bolus	VL	VL	VL	>4,640	>2,000	caution
dimethoate (Am. Cyanamid)	Cygon	400(4E), 2.67E	VL	H	M	180-336	>800	warning
dinitro compounds (Pennwalt)	DNOC, Elgetol, others	WP, F, flakes, salts	-	-	-	37-50	80-200	danger
dinocap (Rohm and Haas)	Karathane	WP, LC, D	-	-	L	980-1,190	>4,700	caution
dioxathion (NOR-AM)	Delnav, Deltic	EC	H	L	VL	23-43	63-235	danger
disulfoton (Mobay, Sandoz)	Di-Syston	8E, 15G	M	M	M	3-12	20	danger
endosulfan (FMC)	Thiodan	2EC, 3EC, 50WP	VH	M	M	80-110	359	warning danger
erythrosine-B (Hilton-Davis)	Synerid	bait	-	-	-	6,700-7,000	-	caution
esfenvalerate (DuPont)	Asana	1.9EC	H	H	L	75	>2,000	danger
ethion (FMC, Rhone-Poulenc)	Ethion	8E, 5G, 4M, superior 70 oil, 25WP	H	M	VL	24	915	warning

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
ethoprop (Rhone-Poulenc)	Mocap	10G, 15G, 6E	H	M	M	62	26	warning danger
ethylene dichloride (PPG Industries)	EDC	liquid fumigant	-	-	-	670-890 AV 1,000 ppm	...	danger
eugenol (several)	...	attractant	-	-	-	500-5,000	...	...
famphur (Am. Cyanamid)	Famphos, Warbex	pour-on	-	H	H	48	2,730	danger
fenamiphos (Mobay)	Nemacur	EC, G	H	-	-	15-19	500	danger
fenoxycarb (R. Maag AG)	Pt470 Regulator	aerosol	-	-	-	>10,000	>2,000	warning
fensulfothion (Mobay)	Dasanit	15G, spray concentrate	H	H	H	5-11	3-30	danger
fenthion (Mobay)	Baytex, Entex, Lysoff, Tiguvon, Spotton	pour-on, spray concentrate	H	H	VH	190-615	330-500	warning
fenvalerate (DuPont)	Ectrin, Pydrin, Pyrid	2.4EC, 6.48EC, 10L, eartags	VH	H	L	451	>5,000	caution warning
flucythrinate (Am. Cyanamid)	Guardian, Pay-Off	2.5EC, eartags	VH	H	L	67-81	>1,000	danger
fluvalinate (Sandoz)	Mavrik, Spur	2E, 23.3F	VH	-	-	260-280	>20,000	danger
fonofos (ICI)	Dyfonate	4E, 10G, 20G	-	M	M	11-24	159	danger warning
formetanate (NOR-AM)	Carzol	92WP	M	M	L	21	>5,600	danger
geraniol (several)	...	attractant	-	-	-	...	...	...
gyplure (National Chemical)	Disparlure	attractant	-	-	-	...	...	...
hexakis (DuPont)	Vendex	50WP, 4L	-	-	-	2,630	>2,000	danger
hydrocyanic acid (several)	HCN	fumigant	-	-	-	4 AV 40 ppm, CV 10 ppm	...	danger
hydroprene (Sandoz)	Gencor	EC	-	-	-	>5,100	>5,100	caution
isofenphos (Mobay)	Oftanol, Pryfon	G, EC	H	-	H	28-39	>1	danger
ivermectin (Merck)	Eqvalon, Ivomec	RTU injectable, RTU paste	M	H	M	650	2,000	caution
lambda-cyhalothrin (ICI)	Karate	EC	H	-	-	56-79	632	...
lead arsenate (Drevel, Mechema Chemical)	...	...	-	H	L	1,050	>2,400	danger

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b] Fish	Bee	Bird	Acute LD_{50}[c] Oral	Dermal	Signal word
lindane (Rhone-Poulenc)	several	many	H	H	M	88-270	900-1,000	warning
malathion (Am. Cyanamid, Rhone-Poulenc)	Cythion, Malathion, others	57EC, ULV, others	M	H	L	2,800	4,100	caution
metaldehyde (several)	several	bait	-	-	-	630	...	caution warning
methamidophos (Chevron, Mobay)	Monitor, others	4L	-	H	-	30	50-110	danger
methidathion (CIBA-Geigy)	Supracide	2E	H	H	M	25-54	1,546	danger
methiocarb (Mobay)	Mesurol	75WP, bait, powder	H	H	L	100	350-400	warning
methomyl (DuPont)	Lannate, Nudrin	90SP, 1.8L, 2.4LV	M	H	L	17-24	>5,000	danger
methoprene (Sandoz)	Altosid, Diacron, Moorman's IGR, Pharorid, Precor	EC, bait	VL	L	VL	>34,600	3,500	caution
methoxychlor (Hopkins, Prentiss)	Marlate	many	H	L	VL	6,000	2,820	caution
methyl bromide (Great Lakes Chemical)	Metho-gas, others	liquid fumigant	-	-	-	AV 200 ppm CV 20 ppm		danger
methyl parathion (Monsanto)	many	EC, WP, D	M	H	H	14-24	67	danger
methyl parathion, encapsulated (Pennwalt)	Penncap-M	2F	VL	H	H	270-480	5,400	warning
mevinphos (DuPont)	Phosdrin	4EC, 10.3WS	H	H	H	3-12	4-90	danger
mexacarbate (Rhone-Poulenc)	Zectran	2E, 25W	-	H	-	24	...	warning danger
MGK-R11 (McLaughlin-Gormley-King)	...	repellent	-	-	-	2,500	...	caution
MGK-R326 (McLaughlin-Gormley-King)	...	repellent	-	-	-	5,230-7,230	...	caution
miral (CIBA-Geigy)	Triumph	EC	H	H	H	40-60	118-3,100	warning
monocrotophos (CIBA-Geigy, DuPont)	Azodrin	5M	H	H	-	14	336	danger
naled (Chevron)	Dibrom	8E, oil	H	H	L	430	1,100	danger
nicotine (Black Leaf)	Black Leaf 40, others	40S	-	-	L	50-60	50	danger
Nosema locustae (Reuter)	Grasshopper spore	WP, bait	EL	EL	EL	NT	NT	caution

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b] Fish	Bee	Bird	Acute LD_{50}[c] Oral	Dermal	Signal word
oxamyl (DuPont)	Vydate	2L	-	M	-	5	710	danger
oxydemeton-methyl (Mobay)	Metasystox-R	2E	VH	M	M	65-80	250	warning
oxythioquinox (Mobay)	Morestan	25WP	-	L	-	2,500-3,000	>500	caution
paradichlorobenzene (PPG-Industries)	PDB	fumigant (crystals, liquid)	-	-	-	500	2,000	warning
parathion (Mobay, Monsanto)	several	EC, WP, D, oils	H	H	H	4-13	7-21	danger
permethrin (FMC, ICI)	Ambush, Atroban, Dragnet, Ectiban, Expar, Insectrin, Overtime, Permaban, Permectrin, Pounce, Pramex, Torpedo	many	VH	H	L	430-4,000	>2,000	warning danger
phorate (Am. Cyanamid)	Thimet, Aastar	20G	VH	M	M	2-4	2-6	danger
phosalone (Rhone-Poulenc)	Zolone	3EC, 25WP	H	M	-	120-170	1,500	warning
phosmet (ICI)	Imidan, Prolate	50WP	H	H	L	113	>5,000	warning
phosphamidon (CIBA-Geigy)	Dimecron	8L, soluble concentrates	L	H	VH	17	374	danger
piperonyl butoxide (Fairfield Am., Prentiss)	...	synergist	VH	-	-	7,500	>7,950	caution
pirimiphos-methyl (ICI)	Actellic, Tomahawk	EC, ear tags	-	-	-	2,050	>2,000	caution
propargite (Uniroyal)	Comite, Omite	6.55EC, 6E, 30W	H	L	L	220	>300	danger
propetamphos (Sandoz)	Safrotin	EC, WP	-	-	-	119	2,825	caution
propoxur (Mobay)	Baygon, others	1.5E, 2% bait, 70WP	-	H	L	90-128	800-1,000	warning
pyrethrum (Fairfield Am., Prentiss)	...	flower extract	H	L	VL	1,500	>1,800	caution
resmethrin (Fairfield Am.)	Premgard, Respond, Scourge, Synthrin	many	VH	H	VL	>2,500	3,000	caution
rotenone (Fairfield Am. Prentiss)	Derris, others	many	VH	L	L	132-1,500	1,000-3,000	caution
sulprofos (Mobay)	Bolstar	EC	-	-	-	304	>1,200	warning
tefluthrin	Force	1.5G	VH	[illegible]	-	22-35	148-1,480	...
temephos (Am. Cyanamid)	Abate, Ecopro	4E, G	L	M	M	8,600-13,000	>4,000	caution

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name (manufacturer)	Trade name	Formulations[a]	Toxicity to[b] Fish	Bee	Bird	Acute LD_{50}[c] Oral	Dermal	Signal word
terbufos (Am. Cyanamid)	Counter	15G	H	M	H	2-5	7	danger
tetrachlorvinphos (DuPont, SDS Biotech)	Rabon	50WP, 75WP, 3D, EC	-	H	VL	4,000-5,000	>2,500	caution
tetradifon (Duphar)	Tedion	EC, WP, smokes	M	L	VL	>14,700	>10,000	caution
tetramethrin (Fairfield Am.)	Neo-Pynamin, Phthalthrin	25EC	-	-	-	>5,000	>5,000	caution
thiodicarb (Monsanto, Rhone-Poulenc)	Larvin	3.2F	-	M	-	66	>2,000	warning
tralomethrin (Am. Hoechst)	Scout	EC	VH	-	L	99-3,000	>2,000	caution
trichlorfon (Mobay, NOR-AM, Tuco)	Anthon, Combot, Dipterex, Dylox, Equibot, Neguvon, Proxol, others	many	L	L	M	560-630	>2,000	warning
trimethacarb (Rhone-Poulenc)	Broot	15GX	-	M	-	178-232	>2,000	caution

[a]Formulations: D, dust; E, EC, emulsifiable concentrate; F, flowable; G, granules; L, liquid solution; LC, liquid concentrate; LV, low volume; M, miscible; RTU, ready to use; S, solution; SL, slurry; SP, soluble powder; ULV, ultra low volume; W, WP, wettable powder; WD, water dispersion; WS, water soluble; XLR, extra long residual.
[b]Toxicity to fish, bees, and birds: L, low; M, moderate; H, high; EL, extremely low; VH, very high; VL, very low.
[c]LD_{50} - based on technical grade, not formulated product.
[d]AV - acute vapor (1 hr); CV - chronic vapor (40 hr).
[e]NT- no evidence of acute or chronic toxicity to mammals.

1989 Weed Control for Corn, Soybeans, and Sorghum

This guide is based on the results of research conducted by the University of Illinois Agricultural Experiment Station, other experiment stations, and the United States Department of Agriculture (USDA). Consideration has been given to the soils, crops, and weed problems of Illinois.

The effectiveness of herbicides is influenced by rainfall, soil factors, weed spectrum, method of application, and formulation. Under certain conditions, some herbicides may damage the crop to which they are applied. In some cases, herbicide residues in the soil may damage crops that are grown later; and some herbicides may move outside the target area, affecting desirable plants.

Precautions

When selecting a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. You can reduce risks by taking the following precautions:

- Apply herbicides only to those crops for which use has been approved.
- Clean tanks thoroughly when changing herbicides, especially when using a postemergence herbicide. Use a 1-percent ammonia wash to clean any traces of 2,4-D or dicamba from the tank before spraying soybeans. Some herbicide labels provide cleaning suggestions.
- Correctly calibrate the sprayer, and check the nozzle output and adjustment before adding the herbicide.
- Use recommended rates. Applying too much herbicide is costly and, in addition, can damage crops and cause illegal residues. Using too little herbicide can result in poor weed control.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or between treatment and harvesting of crops, as well as recommended intervals between application and subsequent planting of crops.
- Guard against drift injury to nearby susceptible plants, such as ornamentals and vegetables, as well as agronomic crops. Mist or vapors from 2,4-D and dicamba sprays may drift several hundred yards. Whenever possible, operate sprayers at low pressure with tips that deliver large droplets. Spray only on calm days or make sure that the wind is not moving toward susceptible crop plants and ornamentals. Use special precaution with Command.
- Applicators should use appropriate precautions to protect themselves and others from exposure to herbicides.
- Be sure that animals or persons not directly involved in the operation are not present in the area. Use special precautions near residential areas.
- Several herbicide labels carry the following groundwater warnings under either the environmental hazard or the groundwater advisory section. "X is a chemical that can travel (seep or leach) through soil and enter groundwater which may be used as drinking water. X has been found in groundwater as a result of its use as a herbicide. Users of this product are advised not to apply X where the soils are very permeable (that is, well-drained soils such as loamy sands) and the water table is close to the surface."
- Check the herbicide label for the proper method of container disposal. Triple rinse, puncture, and haul metal containers to an approved sanitary landfill. Haul paper containers to a sanitary landfill, or burn them in an approved manner.

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Urbana, Illinois Circular 1277 (revised annually) November 1988

- Promptly return unused herbicides to a safe storage place. Store them in the original containers away from unauthorized persons, particularly children.
- Because formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide has been developed to help you use herbicides as effectively and safely as possible. Because no guide can remove all the risk involved, however, the University of Illinois and its employees assume no responsibility for the results of using herbicides, even if they have been used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Cultural and mechanical control

Good cultural practices that aid in weed control include adequate seedbed preparation, adequate fertilization, crop rotation, planting on the proper date, use of the optimum row width, and seeding at the rate required for optimum stands.

Planting in relatively warm soil can help the crop emerge quickly and compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans. If weed control is adequate during that period, corn and soybeans will usually compete quite well with most of the weeds that begin growing later.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. If herbicides alone cannot give adequate weed control, however, then keep rows wide enough to allow for cultivation. Some of the newer herbicides are improving the chances of achieving adequate control without cultivation.

If a preemergence or preplant herbicide does not appear to be controlling weeds adequately, use the rotary hoe while weeds are still small enough to be controlled. Use the rotary hoe after weed seeds have germinated but before most weeds have emerged. Operate it at 8 to 12 miles per hour, and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small weeds. Cultivate shallowly to prevent injury to crop roots.

Herbicides can provide a convenient and economical means of early weed control and allow for delayed and faster cultivation. Furthermore, unless the soil is crusted, it may not be necessary to cultivate some fields if herbicides are controlling weeds adequately.

Herbicide incorporation

Soil-applied herbicides are incorporated to minimize surface loss, reduce dependence upon rainfall, and provide appropriate placement of the herbicide. Herbicides such as Sutan+ and Eradicane are incorporated soon after application to minimize surface loss from volatilization. Treflan and Sonalan are incorporated to minimize loss due to photodecomposition and volatilization. Triazine herbicides such as atrazine and Bladex and acetamide herbicides such as Lasso and Dual may be incorporated to minimize dependence upon timely rainfall; but because these herbicides are not lost as quickly from the soil surface, the timing of incorporation is less critical.

Incorporation should place the herbicide uniformly throughout the top 1 or 2 inches of soil for the best control of small-seeded annual weeds that germinate at shallow depths. Slightly deeper placement may improve the control of certain weeds from deep-germinating seed under relatively dry conditions. Incorporating too deeply, however, tends to dilute the herbicide and may reduce the effectiveness. The field cultivator and tandem disk place most of the herbicide at about one-half the depth of operation. Thus for most herbicides, the suggested depth of operation is 3 to 4 inches.

Thorough incorporation with ground-driven implements requires two passes. Single-pass incorporation can result in streaked weed control, especially in moist soils. It can also cause concentrated zones of herbicide, which are conducive to crop injury. Single-pass incorporation may be adequate with some herbicides that tend to move laterally in the soil. It may also be adequate with some equipment, especially if rotary hoeing, cultivation, or subsequent herbicide treatments are used to improve weed control. If the first pass sufficiently covers the herbicide to prevent surface loss, the second pass can be delayed until immediately before planting.

The depth and thoroughness of incorporation depend upon the type of equipment used, the depth and speed of operation, the texture of the soil, and the amount of soil moisture. Field cultivators and tandem disks are commonly used for incorporation; however, disk-chisels and other combination tools are being used in some areas.

Field cultivators

Field cultivators are frequently used for herbicide incorporation. They should have three or more rows of shanks with an effective shank spacing of no more than 8 to 9 inches (a spacing of 24 to 27 inches on each of three rows). The shanks may be equipped with points or sweeps. Sweeps usually give better incorporation, especially when soil conditions are a little too wet or dry for optimum soil flow and mixing. Sweeps for C-shank cultivators should be at least as wide as the effective shank spacing.

The recommended operating depth for the field cultivator is 3 to 4 inches. It is usually sufficient to operate the field cultivator only deep enough to remove tractor tire depressions. The ground speed should be

at least 6 miles per hour. The field cultivator must be operated in a level position so that the back shanks are not operating in untreated soil, which would result in streaked weed control. Two passes are recommended to obtain uniform weed control. If single-pass incorporation is preferred, the use of wider sweeps or narrower spacing with a 3- to 5-bar harrow or rolling baskets pulled behind will increase the probability of obtaining adequate weed control.

Tandem disks

Tandem disk harrows invert the soil and usually place the herbicide deeper in the soil than most other incorporation tools. Tandem disks used for herbicide incorporation should have disk blade diameters of 20 inches or less and blade spacings of 7 to 9 inches. Larger disks are considered primary tillage tools and should not be used for incorporating herbicides. Spherical disk blades give better herbicide mixing than do conical disk blades.

Tandem disks usually place most of the herbicide in the top 50 to 60 percent of the operating depth. For most herbicides, the suggested operating depth is from 3 to 4 inches. Two passes are recommended to obtain uniform mixing with a double disk. A leveling device (harrow or rolling baskets) should be used behind the disk to obtain proper mixing. Recommended ground speeds are usually between 4 and 6 miles per hour. The speed should be sufficient to move the soil the full width of the blade spacing. Lower speeds can result in herbicide streaking.

Combination tools

Several new tillage tools combine disk gangs, field cultivator shanks, and leveling devices. Many of these combination tools can handle large amounts of surface residue without clogging and yet leave considerable crop residue on the soil surface for erosion control. Results indicate that these combination tools may provide more uniform one-pass incorporation than does a disk or field cultivator, but one pass with them is generally no better than two passes with the disk or field cultivator.

Chemical weed control

Plan your weed-control program to fit your soils, tillage program, crops, weed problems, and farming operations. Good herbicide performance depends on the weather and on wise selection and application. Your decisions about herbicide use should be based on the nature and seriousness of your weed problems. The herbicide selectivity tables at the end of this guide indicate the susceptibility of our most common weed species to herbicides.

Corn or soybeans may occasionally be injured by some of the herbicides registered for use on those crops. To reduce injury to crops, apply the herbicide uniformly, at the time specified on the label, and at the correct rate. (See the section entitled "Herbicide rates.") Crop tolerance ratings for various herbicides are also given in the tables at the end of this guide. Unfavorable conditions such as cool, wet weather, delayed crop emergence, deep planting, seedling diseases, soil in poor physical condition, and poor-quality seed may contribute to crop stress and herbicide injury. Hybrids and varieties also vary in their tolerance to herbicides and environmental stress factors. Once injured by a herbicide, plants are prone to disease.

Crop planting intentions for next season must also be considered. Where atrazine or simazine are used, you should not plant spring-seeded small grains, small-seeded legumes and grasses, or vegetables the following year. Be sure that the application of Treflan or similar herbicides for soybeans is uniform and sufficiently early to reduce the risk of injury to wheat or corn following soybeans. Note that certain cropping restrictions apply for Command, Scepter, Classic, Preview, and Lorox Plus. Refer to the herbicide label for information about cropping sequence and appropriate intervals to allow between different crops.

Names of some herbicides

Trade	Common (generic)
AAtrex, Atrazine	atrazine
Ala-Scept	alachlor plus imazaquin
Amiben	chloramben
Assure	quizalofop
Banvel	dicamba
Basagran	bentazon
Bicep	metolachlor plus atrazine
Bladex	cyanazine
Blazer, Tackle	acifluorfen
Bronco	alachlor plus glyphosate
Buctril	bromoxynil
Buctril/atrazine	bromoxynil plus atrazine
Bullet	alachlor plus atrazine
Butyrac 200, Butoxone	2,4-DB
Cannon	alachlor plus trifluralin
Classic	chlorimuron
Cobra	lactofen
Command	clomazone
Commence	clomazone plus trifluralin
Dual	metolachlor
Eradicane	EPTC plus safener
Eradicane Extra	EPTC plus safener and extender
Evik	ametryn
Extrazine II	cyanazine plus atrazine
Fusilade 2000	fluazifop-P
Gramoxone Super	paraquat
Laddok	bentazon plus atrazine
Lariat	alachlor plus atrazine
Lasso, several others	alachlor
Lexone	metribuzin

Lorox, Linex ..... linuron
Lorox Plus ..... chlorimuron plus linuron
Marksman ..... dicamba plus atrazine
Option ..... fenoxaprop
Poast ..... sethoxydim
Prelude ..... paraquat plus metolachlor
Preview ..... chlorimuron plus metribuzin
Princep, Simazine, Caliber 90 ..... simazine
Prozine ..... pendimethalin plus atrazine
Prowl ..... pendimethalin
Ramrod ..... propachlor
Reflex ..... fomesafen
Rescue ..... naptalam plus 2,4-DB
Roundup ..... glyphosate
Salute ..... metribuzin plus trifluralin
Scepter ..... imazaquin
Sencor ..... metribuzin
Sonalan ..... ethalfluralin
Squadron ..... pendimethalin plus imazaquin
Surflan ..... oryzalin
Sutan+, Genate Plus ..... butylate plus safener
Sutazine, Rhino ..... butylate plus atrazine
Tandem ..... tridiphane
Tornado ..... fomesafen plus fluazifop
Treflan ..... trifluralin
Tri-Scept ..... trifluralin plus imazaquin
Turbo ..... metribuzin plus metolachlor
Vernam ..... vernolate

Some herbicides have different formulations and concentrations under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

Herbicide combinations

Herbicides are often combined to control more weed species, reduce carryover, or reduce crop injury. Numerous combinations or mixtures of herbicides are sold as premixes, while others are tank-mixed. Tank-mixing allows you to adjust the ratio of herbicides to fit local weed and soil conditions, while premixes may overcome some of the compatability problems found with tank-mixing. If you use a tank-mix, you must follow restrictions on all products used in the combination.

Problems may occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP), water-dispersible liquid (WDL), or water-dispersible granule (WDG) formulations. These problems can sometimes be prevented by using proper mixing procedures. Fill tanks at least one-fourth full with water or liquid fertilizer before adding herbicides that are suspended. If using liquid fertilizers, check compatibility in a small lot before mixing a tankful. The addition of compatibility agents may be necessary. Wettable powders, WDGs, or WDLs should be added to the tank and thoroughly mixed before adding ECs. Emulsify ECs by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often enough to prevent accumulation of material on the sides and the bottom of the tank.

The user can apply two treatments of the same herbicide (split application) or can use two different herbicides, provided such uses are registered. The use of one herbicide after another is referred to as a sequential or overlay treatment. Sequential treatment may be done in a number of ways. For example, a preplant application may be followed by a preemergence application, or a soil-applied treatment may be followed by a postemergence treatment. One herbicide may be broadcast, the other banded or directed.

Herbicide rates

Herbicide rates vary according to the time of application, soil conditions, the tillage system used, and the seriousness of the weed infestation. Sometimes lower rates are specified for preemergence application than for preplant incorporated application. Postemergence rates may be lower than preemergence rates if the herbicides may be applied at either time. Postemergence rates often vary depending upon the size and species of the weeds and whether or not an adjuvant is specified. Rates for combinations are usually lower than rates for herbicides used alone.

The rates for soil-applied herbicides usually vary with the texture of the soil and the amount of organic matter the soil contains. For instance, light-colored, medium-textured soils that have little organic matter require relatively lower rates of most herbicides than do dark-colored, fine-textured soils that have medium to high organic-matter content. For sandy soils, the herbicide label may specify "do not use," "use a reduced rate," or "use a postemergence rather than soil-applied herbicide," depending on the herbicide and its adaptation and on crop tolerance.

The rates given in this guide are, unless otherwise specified, broadcast rates for the amount of formulated product. If you plan to band or direct herbicides, adjust the amount per crop acre according to the percent of the area actually treated. Many herbicides have several formulations with different concentrations of active ingredient. Be sure to read the label and make necessary adjustments when changing formulations.

Postemergence herbicide principles

Postemergence herbicides applied to growing weeds generally have foliar rather than soil action; however, some may have both. The rates and timing of applications are based on weed size and climatic conditions. Weeds can usually be controlled with a lower application rate when they are small and tender. Larger weeds often require a higher herbicide rate or the addition of a spray additive, especially if the weeds have developed under droughty conditions. Herbicide penetration and action are usually greater with warm

temperature and high relative humidity. Rainfall occurring too soon after application (1 to 8 hours, depending on the herbicide) can cause poor weed control.

Translocated herbicides are most effective at lower spray volumes (5 to 20 gallons per acre), whereas contact herbicides require more complete coverage. Foliar coverage increases as water volume and spray pressure are increased. Spray nozzles that produce small droplets also improve coverage. For contact herbicides, 20 to 40 gallons of water per acre are often recommended for ground application, and a minimum of 5 gallons per acre is recommended for aerial application. Spray pressures of 30 to 60 psi are often suggested with flat-fan or hollow-cone nozzles to produce small droplets and improve canopy penetration. These small droplets are quite subject to drift.

The use of an adjuvant such as a surfactant, crop-oil concentrate, or fertilizer solution may be recommended to improve spray coverage and herbicide uptake. These spray additives will usually improve weed control but may increase crop injury. Spray additives may be needed, especially under droughty conditions or on larger weeds.

Crop size limitations may be specified on the label to minimize crop injury and maximize weed control. If weeds are smaller than the crop, basal-directed sprays may minimize crop injury because they place more herbicide on the weeds than on the crop. If the weeds are taller than the crop, rope-wick applicators or recirculating sprayers may be used to place the herbicide on the top of the weeds and minimize contact with the crop. Follow the label directions and precautions for each herbicide.

Conservation tillage and weed control

Conservation tillage refers to tillage methods that provide efficient crop production along with adequate control of soil erosion caused by wind and water. Erosion is controlled by protecting the soil surface with plant residue. The amount of tillage is less than that used in conventional moldboard plowing. Chisel plowing, ridge tilling, or no tillage may be used; several other systems are also available.

With reduced tillage systems, there is often a greater reliance upon herbicides for weed control. With these systems, herbicides cannot be incorporated without covering much of the residue that is necessary for effective erosion control. Early applications of preplant, preemergence, or postemergence herbicides are alternatives to incorporation.

Early preplant herbicides may be applied several weeks before planting. Early application may reduce the need for a contact herbicide at planting. However, early preplant application may require additional herbicides (preemergence or postemergence) or cultivation for satisfactory weed control.

Compared with preplant incorporated herbicides, preemergence herbicides require less tillage, but their performance is more dependent upon timely rainfall. Preemergence herbicides, however, have performed better than herbicides that are poorly incorporated. With conservation tillage, a higher application rate of surface-applied herbicides may be required for satisfactory weed control, especially in fields with considerable weed infestation or crop residue. However, do not use a higher rate than that stated on the label. Use great care when selecting herbicides and choosing application rates.

Postemergence herbicides, which are not influenced by crop residues or soil action, may be a logical choice with some conservation tillage systems. Postemergence herbicide rates are generally the same regardless of the tillage system used. However, the effectiveness of postemergence herbicides is greatly influenced by climatic conditions and weed size.

No-till and double-crop

Corn, sorghum, and soybeans may be planted without seedbed preparation, either in last year's crop residue (no-till) or as a second crop after small-grain harvest or forage removal (double-crop). Because it conserves soil, soil moisture, and time, no-till planting has greatly improved the probability of success with double-cropping.

Several precautions should be observed in no-till cropping systems. Crop seed should be planted to the proper depth and adequately covered to avoid possible contact with herbicide sprays. (Several herbicide labels give the planting depths that are necessary to avoid possible injury.) Preemergence applications may give better weed control than preplant applications because the planting process can expose untreated soil that contains viable weed seed. The total reliance on chemical weed control and the large amounts of crop residue present under no-till cropping systems may require that the higher labeled rates of soil-applied herbicides be used to obtain acceptable weed control. However, some phases of a no-till system may require little or no increase in herbicide rates or costs.

Control of existing vegetation in reduced tillage programs

Existing vegetation may be a perennial sod (grass, legume, or legume-grass), an annual cover crop, or weeds. Perennial legume sods often can be controlled before planting corn or sorghum by preplant applications of 2,4-D and Banvel. For shallow-rooted clovers, triazines may give adequate control if moisture is sufficient. But for deeper-rooted alfalfa, on the other hand, 2,4-D and Banvel tanslocate better to the roots. Banvel may be used in the fall (but not in spring) before planting soybeans. Some perennial grass sods can be controlled with Roundup. Fall applications are usually more effective than early spring applications. If a cutting of forages is removed before no-till plant-

ing, sufficient regrowth of the forage must occur before herbicides are applied.

Existing vegetation of small annual weeds that are less than 2 inches tall can often be controlled by residual herbicides that have postemergence activity. Bladex, atrazine, Sencor, Lexone, Preview, Lorox, Lorox Plus, and Scepter have both preemergence and postemergence activity. Postemergence activity is often increased by the addition of surfactants or the use of liquid fertilizer as a carrier instead of water.

Early preplant application of labeled residual herbicides can often prevent existing vegetation from being a problem before the crop is planted. Applications that are made too early may need an additional preemergence or postemergence herbicide application to increase the period of weed control. See the section entitled "Preplant not incorporated" for more information. If the annual vegetation is more than 2 to 3 inches tall, a burndown or translocated herbicide may be needed. Many postemergence herbicides do not have significant residual activity. Gramoxone Super or Roundup is often used with preemergence herbicides to control existing vegetation.

Gramoxone Super (1½ to 2½ pints per acre) plus a *nonionic* surfactant may be used to "knock down" existing foliage before crop emergence. Smartweed, giant ragweed, "marestail," and fall panicum may not be controlled. At least 40 gallons of spray per acre is suggested to ensure adequate coverage of the foliage. Gramoxone Super may be applied with certain liquid fertilizers. *Do not apply* with suspension or high-phosphate liquid fertilizers.

Prelude is a premix of paraquat plus metolachlor (Dual) for preplant use in corn, soybeans, or grain sorghum (which must have Concep II seed treatment).

Roundup (3 to 8 pints per acre) is another alternative for control of existing vegetation before crop emergence in situations where fall panicum, smartweed, or certain perennial weeds are a problem. Roundup can translocate to the roots to give better control of perennials. Use 10 to 40 gallons of spray volume per acre. Roundup plus 2,4-D may be used in some situations to improve broadleaf control.

For control of small annual weeds, Roundup may be used at a rate of 12 to 16 ounces per acre plus 0.5-percent nonionic surfactant in 5 to 10 gallons of spray solution per acre. Do not mix the Microtech formulation of Lasso with Roundup.

Bronco is a formulated mixture of glyphosate (Roundup) plus alachlor (Lasso). Application rates are 4 to 5 quarts per acre. Bronco may be applied in 10 to 30 gallons of water or in 10 to 50 gallons of 28-percent or 32-percent liquid nitrogen solutions. Applications with a nitrogen solution should be made only for control of annual weeds that are less than 6 inches tall.

Roundup, Gramoxone Super, and Bronco are registered for use in combination with the preemergence herbicides indicated in Table 1. See the sections entitled "Herbicides for corn" and "Herbicides for soybeans" for more information about these products.

Table 1. Registered No-Till Herbicide Combinations

	Alone	Combination			
		Dual	Lasso	Surflan	Prowl
Soybeans					
Amiben	GR	GR	GR	GR	GR
Lorox, Lorox Plus	GBR	GR	GR	GR	G
Lexone, Preview	GBR	GR	GR	GR	G
Scepter	GBR	GR	GR	—	GR
Sencor	GBR	GR	GR	GR	G
Turbo	GR	—	—	—	—
Corn					
Atrazine	GBR	GR	GR	—	—
Bladex	GBR	GR	GR	—	—
Princep	GBR	GR	GR	—	—
Extrazine II	GR	GR	GR	—	—
Atrazine + Princep	GBR	GR	GR	—	—
Bicep	GR	—	—	—	—

Knockdown herbicides:
G = Gramoxone Super (paraquat)
R = Roundup (glyphosate)
B = Bronco = Roundup + Lasso
— = Not registered

Banvel may be used in the fall or spring before planting corn to control annual and perennial broadleaf weeds. It is more effective on smartweed than is Gramoxone Super or 2,4-D. Banvel may be used in the fall (*but not in the spring*) before planting soybeans.

2,4-D may be used in the fall or spring before planting corn. It is more effective than Banvel on dandelion. A combination of 2,4-D and Banvel is often appropriate to broaden the spectrum of control and reduce costs. The combination is more effective than Roundup in the spring on alfalfa.

The status of 2,4-D applications in the spring prior to planting soybeans has been somewhat controversial. The Sencor label indicates 30 days prior to planting, and the Surflan label indicates that you should not plant any crop for 3 months, or until the chemical has disappeared from the soil. The guidelines regarding use of 2,4-D with Poast have been in a state of flux; users are referred to 2,4-D labels, which may not be very explicit in this regard.

Buctril or Buctril plus atrazine is also a possibility to give early postemergence control of weeds prior to planting corn or up until the time of corn emergence.

Herbicides for corn

Herbicides mentioned in this section are registered for use on field corn. Some are also registered for silage corn. See Table 2 for registered combinations. Herbicide suggestions for sweet corn and popcorn may be found in Circular 907, *1989 Weed Management Guide for Commercial Vegetable Growers,* which appears in the *'89 Illinois Pest Control Handbook.* Growers producing hybrid seed corn should check with the contracting

Table 2. Registered Herbicide Combinations for Preplant Incorporated (PPI), Preemergence (Pre), or Early Postemergence (EPoE) Application in Corn

	Atrazine	Bladex	Extrazine II	Princep	Atrazine + Princep
PPI only					
Eradicane	1	1	1	1	—
Genate Plus	1	1	1	—	—
Sutan+	1	1	1	1	—
PPI or Pre or EPoE					
Used alone	1,2,3	1,2,3	1,2,3	1,2	1,2
Dual.....	1,2,3	1,2	1,2	1,2	1,2
Lasso	1,2,3	1,2	1,2	2	—

1 = Preplant incorporated
2 = Preemergence
3 = Early postemergence
— = Not registered

company or the producer of inbred-seed about tolerance of the parent lines.

Preplant not incorporated

Interest in early preplant application is increasing, especially with the trend toward reduced tillage. Bladex, Banvel, and atrazine have postemergence as well as residual activity. Early weeds such as smartweed can be controlled while they are small, and emergence of other weeds can be curtailed.

With **AAtrex, Dual,** or **Bicep**, preplant surface application may be made using a two-thirds rate as early as 45 days before planting, followed by a one-third rate at planting. A single application may be made within 30 days before planting.

Lariat (alachlor plus atrazine) may be used as a preplant plus preemergence 60/40-percent split application on medium- to fine-textured soils. The preplant application may be made up to 30 days before planting. The rate is 5 to 6 quarts per acre.

Bladex may be applied early preplant at labeled rates; but if Bladex is applied earlier than 15 days before planting, a split application or use of another herbicide at or after planting is suggested. **Extrazine II** may also be applied 15 to 30 days before planting corn.

Banvel (dicamba) applied before planting no-till corn can control emerged and actively growing broadleaf weeds. Use one pint per acre for medium- and fine-textured soils and one-half pint on coarse soils with over 2-percent organic matter. When planting into a legume sod (alfalfa or clover), apply one-half to one pint of Banvel after 4 to 6 inches of regrowth of the legume. A follow-up postemergence treatment may be needed.

Marksman (dicamba plus atrazine) may be used as a preplant treatment in no-till corn. The rate is 3.5 pints per acre on medium- and fine-textured soils that have at least 2-percent organic matter. See the postemergence section for more information.

2,4-D may be used to control existing vegetation in minimum-tillage and no-till situations before planting corn. Many preplant tank-mixes labels allow for 1 to 2 pints of 2,4-D LV ester per acre, but see the specific label for details.

Buctril, or a tank-mix or premix of Buctril plus atrazine, may be used before planting field corn or grain sorghum, up until just before crop emergence to control emerged annual broadleaf weeds. Apply Buctril alone at 1.0 to 1.5 pints per acre, or Buctril mixed with atrazine at 0.5 to 1.2 pounds of active ingredient.

Roundup may be used preplant to corn or sorghum at three-fourths to one pint (12 to 16 fluid ounces) per acre to control small annual weeds. Use 5 to 10 gallons of water per acre plus a nonionic surfactant. Roundup may be mixed with Banvel or 2,4-D.

Preplant incorporated herbicides

Some herbicides may be applied prior to planting and incorporated. The time of application will depend upon the label directions and field conditions. Herbicides with sufficient residual activity may be applied early preplant. If these herbicides are applied too early, however, weed control may not last as long as desired after planting. Incorporation should distribute the herbicide uniformly throughout about the top 2 inches of soil. *Do not apply preplant herbicides too early or incorporate them too deeply.*

Sutan+, Genate Plus (butylate), Eradicane, and Eradicane Extra (EPTC) contain crop safening agents. Crop injury is unlikely but may occur when growing conditions are unfavorable or when certain hybrids are used. Eradicane Extra also contains an extender to lengthen weed control. These herbicides control annual grass weeds and at higher rates can control or suppress some problem grasses. The rate for Sutan+ and Genate Plus is 4¾ to 7⅓ pints per acre. The rate for Eradicane 6.7E is 4¾ to 7⅓ pints per acre. The rate for Eradicane Extra 6E is 5⅓ to 8 pints per acre. Use the higher rates for heavy infestations of shattercane and yellow nutsedge and for johnsongrass.

Application close to planting time is generally preferred to provide the maximum duration of weed control. These herbicides should be incorporated into the soil soon after application, although 4 hours may elapse before incorporation with the high rate and a dry soil.

Sutan+, Genate Plus, Eradicane, or Eradicane Extra may be tank-mixed with atrazine or Bladex to improve broadleaf control. The atrazine rate is 2 to 3 pints of 4L or equivalent amounts of 80W or 90WDG per acre. The Bladex rate is 3 to 4 pints of 4L or 2 to 2½ pounds of 80W per acre. Three-way combinations with atrazine plus Bladex are also registered. These herbicides (either alone or in combination) may be applied with liquid fertilizer or impregnated on dry, bulk fertilizer. Refer to the labels for specific information.

Sutazine and Rhino (butylate plus atrazine) con-

tain different ratios of active ingredients. Sutazine+ 6ME contains 4.8 pounds of butylate and 1.2 pounds of atrazine per gallon. The rate is 5.5 to 10.5 pints per acre. Rhino 6E contains 4.3 pounds of butylate and 1.7 pounds of atrazine per gallon, and the rate is 6.0 to 11.7 pints per acre.

Preplant or preemergence herbicides

Incorporation of the following herbicides is optional, depending upon the weeds to be controlled and the likelihood of rainfall. Incorporation of these herbicides should be shallow but thorough.

AAtrex, Atrazine (atrazine), or Princep (simazine) may be applied anytime during the 2 weeks before planting or soon after planting. If rainfall is limited, incorporation may aid performance. Corn tolerance of atrazine and simazine is good, but carryover to subsequent crops may occur.

Princep controls fall panicum and crabgrass better than atrazine does but is less effective in controlling cocklebur, velvetleaf, and yellow nutsedge. Princep is less soluble and more persistent than atrazine; thus Princep is usually applied preplant. Princep plus atrazine may be used in 1:1 or 2:1 combinations; the total rate is the same as for atrazine used alone.

The rate for atrazine used alone is 2½ to 3¾ pounds of atrazine 80W, 4 to 6 pints of 4L, or 2.2 to 3.3 pounds of AAtrex Nine-0. Atrazine controls annual broadleaf weeds better than it does grasses, and it is often used at reduced rates in tank-mix combinations to improve broadleaf weed control. The rate for atrazine in some combinations is 1½ to 2 pounds of atrazine 80W, 2 to 3 pints of atrazine 4L, or 1.1 to 1.8 pounds of AAtrex Nine-0. These rates may not provide adequate control of cocklebur, morningglory, and velvetleaf but can reduce the risk of carryover.

You can minimize carryover injury by mixing and applying the herbicides accurately, by applying them early, by using the lowest rates consistent with good weed control, and by tilling the soil to dilute the herbicide. The risk of carryover is greater after a cool, dry season and on soils with a pH over 7.3.

If you use atrazine at more than 3 pounds of active ingredient per acre (lb a.i./A) or if you apply after June 10, plant only corn or sorghum the next year. If you use atrazine in the spring and must replant, then plant only corn or sorghum that year. Do not plant small grains, small-seeded legumes, or vegetables in the fall or the following spring. Soybeans planted the year after an application of atrazine can also be affected by carryover, especially if you use Sencor or Lexone.

Bladex (cyanazine) has shorter soil persistence than atrazine, but atrazine has better corn tolerance. Rates of Bladex must be selected accurately on the basis of soil texture and organic-matter content to reduce the possibility of corn injury. The rates per acre for Bladex alone are 1.5 to 6.0 pounds of 80W, 1.35 to 5.3 pounds of 90DF, or 1.25 to 4.75 quarts of 4L. You can lessen the risk of corn injury by using reduced rates of Bladex in combination with other herbicides.

Bladex provides better control of most annual grasses than does atrazine but is weaker than atrazine on several broadleaf weeds, particularly pigweed.

Extrazine II contains cyanazine (Bladex) and atrazine. It is available as 90DF and 4L formulations and can be used preplant incorporated, preemergence, or in tank-mix combinations similar to Bladex. (See Table 2.) Rates must be adjusted carefully to the soil texture and organic-matter content.

Bladex may be tank-mixed with Genate Plus, Sutan+, or Eradicane for preplant incorporation or with Lasso or Dual for preplant or preemergence application. *Bladex and Extrazine II are restricted-use pesticides.*

Lasso (alachlor) or Dual (metolachlor) may be preplant incorporated or applied preemergence at planting time. Preplant incorporation of these herbicides can improve control of yellow nutsedge and can lessen dependence upon rainfall. Incorporation should distribute the herbicide evenly throughout the top 2 inches of soil.

Lasso and Dual control annual grasses and help control yellow nutsedge. You can improve broadleaf weed control by using atrazine, Bladex, or both in either a preplant or a preemergence combination.

Lasso may be applied anytime during the week before planting corn and shallowly incorporated, or it may be used after planting but before the crop and weeds emerge and within 5 days after the last tillage operation. The rate is 2 to 4 quarts of Lasso 4E or 16 to 26 pounds of Lasso 15G per acre.

Dual may be applied and shallowly incorporated within 45 days before planting, or it may be used soon after planting. The rates are 1½ to 4 pints of Dual 8E or 6 to 16 pounds of Dual 25G per acre.

Lasso or Dual plus atrazine may be preplant incorporated or applied after planting until corn is 5 inches tall and grass weeds have not passed the two-leaf stage. *Do not apply with liquid fertilizer after the crop emerges.* The suggested rate is 1½ to 4 quarts of Lasso or 1¼ to 2½ pints of Dual 8E plus 1½ to 2½ pounds of atrazine 80W, 1 to 2 quarts of atrazine 4L, or 1.1 to 2.2 pounds of AAtrex Nine-O per acre. Dual is also cleared in a combination with atrazine plus Princep.

Bicep 6L is a 5:4 premix of metolachlor (Dual) plus atrazine used at 1½ to 3 quarts per acre. **Lariat 4L** is a 5:3 premix of alachlor (Lasso) plus atrazine used at 2½ to 4½ quarts per acre.

Dual or Lasso plus Bladex may be applied before planting and incorporated, or either combination may be applied preemergence at planting. The rate is 2 to 4 quarts of Lasso 4E or 1¼ to 2½ pints of Dual 8E plus 1 to 3¾ pounds of Bladex 80W or 1 to 3 quarts of Bladex 4L per acre. Adjust the rate carefully according to soil texture and organic-matter content.

Preemergence herbicides

Ramrod (propachlor) may be applied alone before the crop or weeds emerge or with atrazine after the corn is planted but before grasses reach the two-leaf stage and corn emerges. Ramrod performs well on soils with more than 3-percent organic matter.

Because Ramrod is irritating to the skin and eyes, observe the label precautions. Corn tolerance is good. Ramrod controls annual grasses and pigweed. The rate is 4 to 6 quarts of Ramrod 4L or 20 to 30 pounds of 20G per acre.

Banvel (dicamba) may be applied immediately after planting, at the rate of one pint per acre on medium- to fine-textured soils having at least 2-percent organic matter. Do not apply preemergence to coarse-textured soils or any soils having less than 2-percent organic matter (4 percent on Lasso label). Banvel may be applied preemergence to early postemergence in tank-mix combinations with atrazine, Bladex, Lasso, Dual, or Prowl. **Marksman** is a premix of dicamba (Banvel) with atrazine. Refer to the labels for rates, timing, and precautions when using these combinations.

Prowl (pendimethalin) may be used in corn only after planting: do not incorporate. Corn should be planted at least 1½ inches deep. Prowl can control annual grasses, pigweed, and lambsquarters. The Prowl rate is 1½ to 4 pints alone or 1½ to 3 pints in combination with atrazine or Bladex. **Prozine 70DF** is a 1:1 premix of pendimethalin (Prowl) plus atrazine used at 3 to 4¼ pounds per acre. The tank-mixes and premix may be applied after corn emergence but before the crop reaches the four-leaf stage and weeds reach the one-inch stage. Avoid postemergence application when corn is under stress from cool, wet weather. Do not apply postemergence in liquid fertilizer.

Postemergence herbicides

Lasso, Dual, Ramrod, or Prowl may be combined with atrazine for application after planting to very early postemergence. The same is true for Lasso or Dual combined with Banvel. To obtain satisfactory control, apply before grasses reach the two-leaf stage. Early postemergence applications should be made using water, not liquid fertilizer, as a carrier. For more information, see the section on "Postemergence herbicide principles."

Atrazine may be applied when grass weeds are no more than 1½ inches high. Many annual broadleaf seedlings are more susceptible than grass weeds and may be treated until they are 4 inches tall. For control of some broadleaf weeds, 1.2 pounds active ingredient of atrazine may be sufficient. In most cases, this rate should be increased to 2 pounds for control of annual grass weeds.

The addition of oil-surfactant mixes or surfactants has generally increased the effectiveness of postemergence atrazine. Crop-oil concentrates, COCs (80-percent oil and 20-percent surfactant), are used at the rate of one quart per acre.

An atrazine-and-oil mix sometimes injures corn that has been under stress from prolonged cold, wet weather or other factors. Do not use more than 2½ pounds of atrazine 80W, 2 quarts of atrazine 4L, or 2.2 pounds AAtrex Nine-O per acre if you mix with oil or an oil concentrate. *Do not add 2,4-D to the atrazine-oil treatment, or severe injury may result.* Mix the atrazine with water first, and add the oil last. If atrazine is applied after June 10, do not plant any crop except corn or sorghum the next year.

Bladex (cyanazine) may be applied until the fifth leaf of corn is visible and before grass weeds exceed 1.5 inches in height. The rate is 1.5 to 2.5 pounds Bladex 80W or 1.1 to 2.2 pounds Bladex 90DF per acre. *Do not use Bladex 4L postemergence.* Either a tank-mix (Bladex and atrazine) or a premix (Extrazine II) may also be applied postemergence.

Do not apply Bladex alone or with atrazine (tank-mix or premix) postemergence either in cold, wet weather or to corn that is stressed. Injury to corn is more likely under these conditions. Under droughty conditions, certain agricultural surfactants or vegetable oils may be added to Bladex 80W and 90DF. Do not use these spray additives with Extrazine II. Do not use petroleum crop oils or apply Bladex or Extrazine II with liquid fertilizers. Do not apply Bladex or Extrazine II to corn grown for seed. *Bladex and Extrazine II are classified as restricted-use pesticides.*

Tandem (tridiphane) may be used with atrazine, Bladex, or both for postemergence control of both annual grass and broadleaf weeds in field corn. These combinations should be applied when annual grass weeds are in the one- to three-leaf stage and actively growing. The rates per acre are 1 to 1½ pints of Tandem plus 1½ to 4 pints of atrazine 4L (equivalent rates of 80W or 90DF) or 1 to 2½ pounds of Bladex 80W (equivalent rates of 90DF). *Do not use Bladex 4L in combination with Tandem.* Crop-oil concentrate (2 pints per acre) should be used with the tank-mixes that do not contain Bladex. Combinations containing Bladex should not be applied to corn under stress from cold or wet weather, to corn with more than four true leaves, or if rain is expected within 3 hours. Special programs are labeled for control of larger grasses, woolly cupgrass, and wild proso millet. See the Tandem label for more information on these programs.

Banvel (dicamba) may be applied early postemergence when corn is in the spike to five-leaf stage or up to 8 inches tall. The rate is one pint of Banvel per acre on medium- and fine-textured soils or one-half pint on coarse-textured soils. Corn tolerance is better and the potential for drift is less with the early treatment. Banvel may be tank-mixed with Lasso, Dual, Bladex (not 4L), or atrazine and applied early postemergence. See the label for rates, timing, and specific precautions.

Banvel may also be applied at one-half pint per acre

to corn more than 8 inches tall but less than 36 inches tall. Weeds should be less than 12 inches tall for best control. Use drop nozzles on corn over 8 inches tall (Banvel alone or with 2,4-D) to improve corn tolerance and improve spray coverage to the weeds. Do not apply Banvel within 15 days of tassel emergence.

Do not apply Banvel where soybeans are growing nearby if corn is more than 24 inches tall, soybeans are more than 10 inches tall, or the soybeans have begun to bloom. Observe all label precautions concerning spray pressure, spray volume, nozzle selection, wind speed, and temperature in order to minimize risk of vapor or spray drift to nearby susceptible crop or ornamental plants.

A preharvest treatment of Banvel plus 2,4-D can help control hemp dogbane. Apply after the brown silk stage in corn but at least 7 days before harvest, at the rate of one-half pint of Banvel with one pound acid-equivalent 2,4-D LV ester or amine per acre if current label covers this application. Nearby soybeans must be fully podded, with leaves turning yellow. The hemp dogbane must have green leaves and roots with pink buds. Do not apply near homesteads or residential districts.

Marksman is a 1:2 premix of dicamba (Banvel) and atrazine that may be applied when corn is in the spike to five-leaf stage. The rate is 3½ pints per acre on medium- or fine-textured soils that contain over 2-percent organic matter. Marksman may be tank-mixed with Bladex (not 4L), Dual, Lasso, or 2,4-D for very early postemergence application. See the label for rates, timing, and precautions. Drift precautions are the same as with Banvel.

If weeds are drought-stressed, the addition of an approved agricultural surfactant to Banvel or Marksman will improve coverage and control. Do not use adjuvants containing penetrants such as petroleum or crop oils because corn injury can be severe.

2,4-D is effective in controlling many broadleaf weeds in corn. If corn is more than 8 inches tall, use drop nozzles to decrease the possibility of injury to the corn. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

The suggested broadcast rate is one-third to one-half pint of ester or one pint of amine for formulations with 3.8 pounds of 2,4-D acid-equivalent per gallon. Use equivalent rates with other formulation concentrations. Use proportionately less 2,4-D when using directed nozzles.

Do not apply 2,4-D to corn from the tasseling stage to the dough stage. After the hard dough to dent stage, you may apply 1 to 2 pints of certain 2,4-D formulations by air or high-clearance equipment to control some broadleaf weeds that may interfere with harvest or to suppress certain perennial weeds. Do not forage or feed fodder for 7 days after treatment.

The ester forms of 2,4-D can vaporize and injure nearby susceptible plants. This vapor movement is more likely with high-volatile esters than with low-volatile esters. Spray particles of either the ester or the amine form can drift and cause injury.

Corn is often brittle for 7 to 10 days after application of 2,4-D and thus is susceptible to stalk breakage from high winds or cultivation. Other symptoms of 2,4-D injury are stalk bending or lodging, abnormal brace roots, and failure of leaves to unroll. Injury problems are unlikely once corn has reached the brown silk stage.

High temperature and high humidity can increase the potential for 2,4-D injury, especially if corn is growing rapidly. If it is necessary to spray under these conditions, it may be wise to reduce the rate by about 25 percent. Corn hybrids differ in their sensitivity, and the probability of injury increases when corn is under stress.

Buctril (bromoxynil) may be used to control broadleaf weeds in field and silage corn. It is important to treat when the weeds are small. For ground applications, use at least 10 gallons of water per acre, a spray pressure of 30 psi, and flat-fan nozzles.

Buctril will not volatilize and cause the drift injury associated with 2,4-D or Banvel. Under some conditions, Buctril may cause temporary burning of corn leaves. Do not add a surfactant or crop oil to Buctril used alone or in combination.

Buctril 2E rates are 1 to 1½ pints per acre when corn and weeds are in the three- to eight-leaf stage. Buctril may be applied to corn from the three-leaf stage to tassel emergence; if the rate of 1½ pints per acre is used, Buctril cannot be applied until the four-leaf stage. Use the higher rate on larger corn and weeds. Although most annual broadleaf weeds are controlled, larger pigweed and velvetleaf may require the higher rate or a combination with atrazine.

Buctril may be tank-mixed with atrazine 4L at one-half to one quart per acre (or equivalent rates of 80W or 90DF). **Buctril/atrazine 3L** is a 1:2 premix used at 1½ to 3 pints per acre. The rate varies with the size of the corn and weeds. Do not apply before the three-leaf stage of corn or after the corn is 30 inches tall.

Laddok (bentazon plus atrazine) is registered for postemergence broadleaf weed control in corn. Laddok does not control grasses. Corn has good tolerance to Laddok.

Laddok is effective mainly through contact action, therefore, weeds must be thoroughly covered with spray. Laddok rates range from 2.5 to 3.5 pints per acre. Always add UAN (urea ammonium nitrate) solution or an oil concentrate to Laddok. For ground application, use one gallon per acre of UAN solution; and, for aerial application, use one-half gallon per acre. If UAN solution is not used, a nonphytotoxic oil concentrate should be added to the spray tank.

Use the oil concentrate if Canada thistle or yellow nutsedge is to be treated. For ground application, use no more than 2 pints per acre of the oil concentrate;

and, for aerial application, use no more than 1 pint per acre.

To suppress Canada thistle, apply 3½ pints per acre of Laddok, applied from the time that plants are 8 to 10 inches tall until the bud stage. A single application of Laddok at 3½ pints per acre can suppress yellow nutsedge.

Laddok provides better control of velvetleaf, annual morningglory, lambsquarters, and pigweed than does Basagran alone and will create less risk of carryover than does atrazine alone.

Basagran (bentazon) may be used alone or with atrazine for postemergence broadleaf weed control in corn. Basagran is cleared for use alone at 1.0 to 1.5 pints per acre or in combination with atrazine at 0.6 to 1.0 pound of 80W, 0.6 to 0.9 pound of 90DF, or 1.0 to 1.5 pints of 4L per acre. Add 28-percent UAN solution (0.5 to 1.0 gallon per acre) or crop-oil concentrate (1 quart per acre) to the spray tank under all conditions. Basagran should be applied when weeds are small and actively growing and when the corn is at the growth stage of one to five leaves. Corn has good tolerance to Basagran.

Roundup (glyphosate) may be applied as a spot treatment in corn prior to silking. For applications made on a spray-to-wet basis, use a 1- to 2-percent solution of Roundup in water. Avoid contact of spray with the corn.

Postemergence soil-applied herbicides

Some soil-applied herbicides may be applied to the soil as a postemergence treatment in corn. It may be necessary to use drop nozzles to avoid interference from corn leaves and ensure uniform application to the soil.

Prowl (pendimethalin) or Treflan (trifluralin) may be applied to the soil and incorporated after field corn is 4 inches tall (for Prowl) or 8 inches tall (for Treflan) and up to the time of the last cultivation. The field should be cultivated to control existing weeds and cover the roots at the base of the corn before application. The herbicide should then be thoroughly and uniformly incorporated into the top inch of the soil with a sweep-type or rolling cultivator. Prowl may not require incorporation if irrigation is used or rainfall occurs soon after application. Prowl or Treflan may be combined with atrazine.

These Prowl or Treflan treatments may help control late-emerging grasses such as shattercane, wild proso millet, fall panicum, or woolly cupgrass.

Lasso (alachlor) may be used, either alone or with atrazine, as a soil-applied postemergence treatment to help control midseason annual grass weeds in *corn that is grown for seed.* Application should preferably be made after cultivation—before weeds emerge and before the crop is 40 inches tall.

Dual (metolachlor) or Bicep (metolachlor plus atrazine) may be used for postemergence "lay-by" treatments in corn. For Dual, as much as 3 pounds of active ingredient per acre may be used in a single application, up to a total of 6 pounds of active ingredient in one year. With Bicep, as much as 3 quarts of 6L may be used per acre.

Directed postemergence herbicides

Directed sprays are sometimes needed for emergency situations, especially when grass weeds become too tall to be controlled by cultivation. Weeds, however, are often too large for directed sprays to be effective. Directed sprays cannot be used on small corn because a height difference between corn and weeds is needed to keep the spray off the corn. Corn leaves that come into contact with the spray can be killed, and injury can affect yields. *Consider these to be emergency treatments.*

Lorox or Linex (linuron) may be applied as a directed spray after corn is at least 15 inches tall (freestanding) but before weeds are 8 inches tall, preferably when weeds are no more than 5 inches tall. Linuron controls broadleaf and grass weeds.

The broadcast rate is 1¼ to 3 pounds of linuron 50W or 50DF or 1¼ to 3 pints of 4L per acre, depending on weed size and soil type. Add Surfactant WK at the rate of 1 pint per 25 gallons of spray mixture. Cover the weeds with the spray, but keep it off the corn as much as possible.

Evik 80W (ametryn) is registered for directed use when corn is more than 12 inches tall and weeds are less than 6 inches tall. Evik should not be applied within 3 weeks of tasseling. The rate is 2 to 2½ pounds Evik 80W per acre (broadcast) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves.

Gramoxone Super (paraquat) may be applied as a directed spray after corn is 10 inches tall but before weeds are 4 inches tall. The rate is 1½ pint per acre in 20 to 40 gallons of water. Add 1 quart of nonionic surfactant per 100 gallons of spray volume. Control of broadleaf weeds such as smartweed can be improved by adding 1 to 2 pints per acre of atrazine 4L (or equivalent rates of 80W), Bladex, or Princep. Observe all label precautions. *Gramoxone Super is a restricted-use pesticide.*

Herbicides for sorghum

Many herbicides used to control weeds in corn may also be used in sorghum.

Bronco (alachlor plus glyphosate) may be used alone or with atrazine where grain sorghum is to be planted directly into a cover crop or in the residue of the previous crop. Bronco can control emerged annual weeds and may control or suppress many emerged perennial weeds, as well as give preemergence grass

control. Grain sorghum seed must be treated with Screen (flurazole), as it is when Lasso is used.

Gramoxone Super (paraquat) can control annual weeds where grain sorghum is to be planted into the residue of the previous crop. **Prelude** (paraquat plus metolachlor) may be used on grain sorghum that has been treated with Concep II. *Gramoxone Super and Prelude are restricted-use pesticides.*

Atrazine may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids, with application made preemergence or postemergence. A preplant surface application may be made using a single application within 30 days of planting or a two-thirds plus one-third split application within 45 days of planting. Plant the seed at least one inch deep. Do not use preplant or preemergence on soils with less than 1-percent organic matter. Atrazine can cause injury to sorghum if rainfall occurs before or shortly after sorghum emergence.

Injury may also occur when sorghum is under stress from unusual soil or weather conditions or when rates are too high. The rate of application for preplant and preemergence is 2 to 3 pounds of atrazine 80W per acre. The postemergence rate is 4 to 6 pints 4L per acre without crop oil or 2.4 pints 4L (broadleaf control only) with crop oil or crop-oil concentrate. Use equivalent rates of atrazine 80W or AAtrex 90DF formulations. Rotational crop recommendations and weed control are the same as for atrazine used in corn. Failure to control fall panicum has been a major problem.

Ramrod (propachlor) may be used alone or in combination with atrazine or Bladex for sorghum. Ramrod can improve grass control; but rates must not be skimpy, especially on soils that are relatively low in organic matter. Do not graze or feed forage to dairy animals.

Lasso (alachlor) alone or plus atrazine may be preplant incorporated or used preemergence for grain sorghum if seed is treated with Screen (flurazole). This use also applies to Lariat and to Bronco.

Dual (metolachlor) or Bicep (metolachlor plus atrazine) may be used for sorghum if seed has been treated with Concep II. These herbicides will control grasses better than will atrazine applied alone. An early preplant treatment of Dual or Bicep may be used in a similar manner as for corn, but it is still necessary to use seed that has been treated with Concep II.

Basagran (bentazon) is registered for postemergence broadleaf weed control in sorghum in a similar manner as for corn. (See the section entitled "Herbicides for corn.") Because sorghum through the early boot stage is quite tolerant of Basagran, adding a 28-percent UAN solution or crop-oil concentrate is considered relatively safe. Do not apply Basagran to grain sorghum that is heading or blooming.

Laddok (bentazon plus atrazine) is registered for postemergence broadleaf weed control in sorghum in a similar manner as for corn. (See the section entitled "Herbicides for corn.") Adding 28-percent UAN solution or crop-oil concentrate is considered relatively safe. Do not apply Laddok to grain sorghum that is heading or blooming. Laddok use rates range from 2.5 to 3.5 pints per acre.

For best results in sorghum, cultivate 7 to 14 days after application.

2,4-D may be applied postemergence for broadleaf control in sorghum that is from 4 to 24 inches tall. Use drop pipes on nozzles if sorghum is more than 8 inches tall. Rates are similar to those for corn. (See the section entitled "Herbicides for corn.")

Banvel (dicamba) may be applied postemergence to sorghum up to 21 days after emergence but before sorghum is 15 inches tall. The rate is one-half pint per acre. Do not graze or feed treated forage or silage before the mature grain stage. Sorghum can be injured by Banvel, and seed development can be affected.

Buctril (bromoxynil) can control small broadleaf weeds in grain sorghum from the three-leaf up to the boot stage. A tank-mix with atrazine or the Buctril/atrazine mixture may be used. See the label for rates, timing, and weed sizes.

Prowl (pendimethalin) may be applied to grain sorghum from the 4-inch growth stage until the last cultivation, primarily for control of late-season annual grass weeds. For more information, see the subsection on postemergence soil-applied herbicides under "Herbicides for corn."

Roundup (glyphosate) may be applied as a spot treatment in sorghum (milo) prior to heading. For applications on a spray-to-wet basis, use a 1- to 2-percent solution of Roundup in water. With motorized spot treatments from which less complete coverage of weeds may result, use a 5-percent solution. Avoid contact with the sorghum.

Herbicides for soybeans

Consider the kinds of weeds expected when you plan a herbicide program for soybeans, especially when growing soybeans in narrow rows. The herbicide selectivity table lists herbicides and their relative weed control ratings for various weeds. (See the table at the end of this guide.)

Although soybeans may be injured by some herbicides, they usually outgrow early injury with little or no effect on yield if stands have not been significantly reduced. Significant yield decreases can result when injury occurs during the bloom to pod-fill stages. Excessively shallow planting can increase the risk of injury from some herbicides. Accurate rate selection for soil type is essential for herbicides containing metribuzin (Lexone, Preview, Salute, Sencor, or Turbo) or linuron (Linex, Lorox, or Lorox Plus). Do not apply these herbicides after soybeans begin to emerge, or severe injury can result. Always follow label instructions. See Table 3 for some preplant and preemergence tank-mix combinations.

Table 3. Registered Herbicide Combinations for Preplant Incorporated (PPI) or Preemergence (Pre) Use in Soybeans

	Treflan	Amiben	Sencor or Lexone	Preview	Lorox or Linex	Sencor + Scepter	Scepter	Sencor + Command	Command	Dual	Lasso
PPI											
Sonalan	—	1	1	1	—	1	1	1	1	—	—
Treflan	—	1	1	1	—	1	1	1	1	1	1
Command	1	—	1	1	—	—	1	—	—	1	1
Salute	—	—	—	—	—	—	1	—	1	—	—
Commence	—	—	1	1	—	—	1	—	—	—	—
PPI or Pre											
Dual	1	1,2	1,2	1,2	2	1,2	1,2	1	1	—	—
Lasso	1	1,2	1,2	1,2	2	1,2	1,2	1	1	—	—
Prowl	—	1,2	1,2	1,2	2	1,2	1,2	1	1	—	—
Surflan[a]	—	2	2	—	2	—	—	—	—	—	—
Turbo	—	—	—	—	—	—	1,2	—	1	—	—

1 = Preplant incorporated
2 = Preemergence
— = Not registered
[a] Not for preplant incorporation

Preplant not incorporated

Early preplant application may be used in many conservation tillage programs — such as no-till, ridge-till, or mulch-till — to minimize existing vegetation problems at planting and thus reduce the need for knockdown herbicides. Lorox or Linex (linuron) and Sencor or Lexone (metribuzin) have both postemergence and residual activity, but postemergence activity varies with climatic conditions. If weeds have emerged before preplant application, the use of a foliar knockdown herbicide such as Gramoxone Super or Roundup may be necessary. (See the subsection about no-till and double-crop programs under "Conservation tillage and weed control.")

Several preemergence herbicides are registered for application before planting soybeans.

Surflan (oryzalin) may be applied anytime before planting no-till soybeans. Surflan may be applied in fully tillered wheat before heading, and soybeans may then be planted no-till into wheat before harvest or in wheat stubble immediately after harvest.

Surflan has been labeled for tank-mixing with 2,4-D prior to 90 days before planting to control established winter weeds for no-till. To control existing vegetation, Gramoxone Super or Roundup combinations with Surflan plus Sencor, Lexone, or Lorox may be applied before planting no-till soybeans. Surflan plus Lexone may be applied as much as 30 days before planting.

Dual (metolachlor) may be applied within 30 days before planting soybeans or as a split application using a two-thirds rate as early as 45 days before planting, followed by a one-third rate at planting.

Either Turbo alone or Sencor with Lasso or Dual may be applied up to 30 days before planting soybeans when using a sequential (split) preemergence application: the first made early, followed by the second at planting.

Some foliar postemergence herbicides may also be used before planting soybeans.

Roundup (glyphosate) may also be used preplant in soybeans to control small annual weeds. The rate is 12 to 16 fluid ounces (¾ to 1 pint) per acre in 5 to 10 gallons of water, with the addition of a surfactant.

Poast (sethoxydim) may be applied before planting soybeans, with no time interval restriction. Poast plus 2,4-D LV (low-volatile ester) as a tank-mix has been labeled for use before soybean planting. Refer to the most recent label for current registration information and for the specified time period between application and planting. Suggested use rates per acre have been ½ pint of Poast and 1 pint of 2,4-D (½ pound acid-equivalent) with 2 pints of crop-oil concentrate in 5 to 10 gallons of spray solution.

2,4-D has been registered for preplant application to control broadleaf weeds in some no-till programs. Refer to the most recent labels for the current registration and the time interval between application and planting.

Preplant incorporated herbicides

Incorporation is required for Treflan, Sonalan, and Vernam. Incorporation of Command is required to reduce movement outside the target area. Incorporation is optional for Amiben, Dual, Lasso, Preview, Prowl, Sencor, Lexone, and Scepter when used alone or in some combinations. Lorox and Surflan should not be incorporated.

Incorporation improves performance if rainfall is limited and increases the effectiveness of Dual or Lasso in controlling nutsedge. Incorporation should distribute the herbicide evenly in the top 1 to 3 inches of soil. Deep incorporation or very early application of the herbicide can significantly reduce weed control. For more information, see the section entitled "Herbicide incorporation."

Treflan, Prowl, and Sonalan are dinitroaniline herbicides for preplant incorporation before planting soybeans. Treflan and Sonalan must be incorporated, but

incorporation is optional with Prowl. However, variable weed control and soybean injury can result if Prowl is not incorporated. See the label for incorporation instructions.

Treflan, Prowl, and Sonalan control annual grasses, pigweed, and lambsquarters, and may provide some control of smartweed and annual morningglory. Prowl partially controls velvetleaf, while Sonalan suppresses black nightshade at the higher rates. Control of most other broadleaf weeds requires combinations (see Table 3) or sequential treatments with other herbicides.

Soybeans are sometimes injured by dinitroaniline herbicides. Plants that have been injured by incorporated treatments may be stunted and have swollen hypocotyls and shortened lateral roots. Usually, such injuries are not serious. At the level of the soil surface, plants injured by preemergence applications may have stem calluses, which can cause lodging and yield loss.

Corn, sorghum, and small grains can be injured if they are grown after a soybean crop that has been treated with a dinitroaniline herbicide. The symptoms are poor germination and stunted, purple plants with poor root systems. To avoid carryover, use no more than the recommended rates of dinitroaniline herbicides and be sure that application and incorporation are uniform. The likelihood of carryover increases with double-cropping or late application and after a cool, *dry season.* Adequate tillage may help dilute herbicide residue, which helps alleviate a carryover problem.

Treflan (trifluralin) may be applied alone anytime in the spring prior to planting. However, tank-mixes may specify a period closer to soybean planting. Incorporate trifluralin within 24 hours after application, or within 8 hours if the soil is warm and moist. The Treflan rate per acre is 1 to 2 pints 4E or MTF (multiple temperature formulation) — or equivalent rates of Pro-5 or 10G. A slightly higher rate may be specified for shattercane control. A lower rate may be specified in some tank mixtures. Many different herbicides may be tank-mixed with Treflan to improve broadleaf weed control (see Table 3).

Cannon (alachlor plus trifluralin) may be applied at 3 to 5 quarts per acre no more than 7 days prior to planting. Incorporate Cannon into the upper 2 inches of soil within 24 hours after application. For annual grasses only, the rate of 3 quarts per acre is suggested; for fine-textured soils, however, use 4 to 5 quarts per acre. Cannon may be tank-mixed with Command, Lexone, Sencor, Preview, Canopy, or Scepter for additional control of broadleaf weeds.

Sonalan (ethalfluralin) may be applied at 1½ to 3 pints per acre within 3 weeks before planting and should be incorporated within 2 days after application. There is a greater risk of soybean injury from Sonalan than with Treflan, however Sonalan is less likely to carry over and injure corn the following year. Sonalan may be tank-mixed with many herbicides to improve broadleaf control (see Table 3).

Sencor or Lexone (metribuzin) plus Treflan, Sonalan, or Prowl may be tank-mixed and applied within 14 days before planting. Incorporate uniformly into the top 2 inches of soil. The rate of Sencor or Lexone in these combinations is one-half to one pint of 4L or one-third to two-thirds pound of 75DF. Use the usual rate, or slightly less, of the dinitroaniline herbicide (see labels).

The application of Sencor or Lexone may also be split, with one part being incorporated and the other part applied to the surface preemergence. Although this method requires two applications, it can provide better broadleaf control and less injury than incorporating the same total amount of Sencor or Lexone in a single application.

Salute 4E is a premix of trifluralin (Treflan) plus metribuzin used at 1½ to 3 pints per acre. It may be applied up to 3 weeks prior to planting and must be incorporated within 24 hours. Do not apply to coarse soils with less than 1-percent organic matter. Salute may be tank-mixed with Scepter or Command to improve control of certain problem broadleaf weeds.

Command (clomazone) is used at 1½ to 2 pints per acre. It can provide excellent control of velvetleaf and annual grasses. At full rates, Command should also control lambsquarters, smartweed, jimsonweed, and common ragweed. Command may be tank-mixed with Scepter or Preview to improve control of pigweed and cocklebur. Command may also be tank-mixed with Sencor, Lexone, Treflan, Sonalan, Prowl, Lasso, or Dual to improve control of pigweed. See Table 3 for tank-mixes in which Command is used at reduced rates for velvetleaf control.

Commence 5.25L is a premix of Command and Treflan that is used at 1¾ to 2⅔ pints per acre. Commence may be tank-mixed with Preview, Scepter, Sencor, or Lexone.

Command or Commence should be incorporated immediately after application unless the soil is dry, in which case it must be incorporated within 8 hours. Spray particles or vapors drifting outside the target area can cause chlorosis or bleaching of sensitive plants. Do not apply within 100 feet of ornamentals, trees, vegetables, alfalfa, or small grains; within 1,000 feet of subdivisions or towns; or within 1,000 feet of nurseries, greenhouses, and vegetable or fruit production areas.

Do not plant wheat, oats, rye, or alfalfa in the fall or spring of the year following application of Command or Commence. Field corn, sweet corn, popcorn, sorghum, and certain vegetables may be planted 9 months after application of Command or Commence. Refer to the label for restrictions on corn grown for seed. Cover crops may follow, but stand reductions can occur. *Uniform, accurate application and incorporation are needed to minimize risk of carryover.* Some tank-mixes allow reduced rates. Carryover injury will appear as whitened or bleached plants after emergence. Corn may show symptoms early but usually has outgrown them.

Amiben (chloramben) may be incorporated with Treflan, Sonalan, or Prowl. The rate is 4 to 6 quarts of Amiben 2S or 2.4 to 3.6 pounds of 75DS per acre. Amiben may also be applied and incorporated with Treflan or Prowl plus Sencor or Lexone as a three-way combination. However, Amiben alone can control annual grass and several broadleaf weeds, so combinations are not always essential.

Vernam (vernolate) may be applied within 10 days before planting and incorporated immediately. The Vernam rate per acre is 2.3 to 3.5 pints of 7E or 20 to 30 pounds of 10G. Vernam controls annual grasses and pigweed and sometimes provides fair control of velvetleaf, yellow nutsedge, and annual morningglory. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Tank-mixes with Treflan, Prowl, or Sonalan allow the use of a lower rate of Vernam and reduce the risk of injury to soybeans.

Preplant or preemergence herbicides

Prowl (pendimethalin) may be applied before or after planting soybeans. It may be applied up to 60 days preplant alone, 30 days preplant with Scepter, or 7 days preplant with Sencor or Lexone. Preplant treatments should be incorporated within 7 days unless adequate rainfall occurs to incorporate the herbicide. For Prowl used alone, rates are 1 to 3 pints per acre, slightly lower for tank-mixes. Prowl may be applied preemergence in tank-mixes with several herbicides to improve broadleaf weed control (see Table 3). Prowl can cause stem callousing when applied preemergence, which can lead to soybean lodging.

Lasso (alachlor) or Dual (metolachlor) may be used preplant or after planting to control annual grasses and pigweed. They can also help control yellow nutsedge and black nightshade. They may be combined with Command (preplant incorporated), with Amiben, Lexone, Sencor or Scepter (incorporated or preemergence), or with Lorox (preemergence only) to improve broadleaf weed control.

Lasso may be applied up to one week before planting or after planting but before emergence. Lasso alone may be applied up to the unifoliate stage of soybeans. The Lasso rate is 2 to 4 quarts per acre of 4E or 4L (Microtech), or 16 to 26 pounds of 15G. A slightly lower rate may be specified for combinations.

Dual may be applied early preplant up to 30 days prior to planting or as a split preplant-plus-preemergence application up to 45 days prior to planting. The rate per acre is 1½ to 3 pints of 8E or 6 to 12 pounds of 25G. A slightly lower rate may be specified for combinations.

Amiben (chloramben) can control annual grasses and many broadleaf weeds in soybeans when used at the full rate. Do not expect control of cocklebur or annual morningglory. Control of velvetleaf and jimsonweed is often erratic. See Table 3 for some of the tank-mix combinations. Amiben occasionally injures soybeans, but usually the damage does not affect yield. Injured plants may be stunted and have abnormal, shortened roots. If rain does not occur within 3 to 5 days of an Amiben preemergence application, a rotary hoe should be used over the field. Amiben is best suited to soils that have more than 2.5-percent organic matter.

The broadcast rate for Amiben alone is 20 to 30 pounds of 10G, 4 to 6 quarts of 2S, or 2.4 to 3.6 pounds of 75DS per acre. The Amiben rate in combination is 3 to 6 quarts of 2S (1.8 to 3.6 pounds of 75DS) per acre. Use the higher rate where black nightshade, velvetleaf, or common ragweed is a problem weed.

Sencor or Lexone (metribuzin) may be applied anytime during the 1 to 2 weeks before planting and may be incorporated with Command, Commence, Dual, Lasso, Prowl, Sonalan, or Treflan. Incorporation should distribute the herbicide evenly throughout the top 2 inches of soil. Sencor or Lexone may be applied preemergence by itself or with Amiben, Dual, Lasso, Prowl, or Surflan.

Sencor or Lexone can control many annual broadleaf weeds but does not control annual morningglory. Control of giant ragweed, jimsonweed, and cocklebur is marginal at the reduced rates necessary to minimize soybean injury.

Accurately adjust the rates according to soil conditions. *Do not apply to sandy soil that is low in organic matter.* Combinations allow for reduced rates and thus reduce risk of soybean injury. The combination rate of Sencor or Lexone is one-half to one pint of 4L or one-third to two-thirds pound of 75DF. You can use higher amounts as a split preplant and preemergence application. The higher amounts can improve broadleaf control but also increase the risk of soybean injury.

One symptom of soybean injury is yellowing (chlorosis) of the lower leaves at about the first-trifoliolate stage or later; it may be followed by browning of leaves and death of plants, depending upon the severity of the injury. Seedling diseases, weather stress, and atrazine carryover may increase the possibility of soybean injury. Injury may be greater on soils with a pH over 7.5. Accurate, uniform application and incorporation are essential. Some soybean varieties are more sensitive than others. Injury has sometimes occurred when organophosphate insecticides such as Thimet, Counter, Dyfonate, Lorsban, or Mocap were left in applicators used for corn planting and were then inadvertently applied to soybeans that were being treated with metribuzin.

Turbo 8EC is a premix of metolachlor (Dual) and metribuzin to be applied preplant incorporated or preemergence at the rate of 1½ to 3½ pints per acre. Preplant application may be made up to 14 days before planting. Turbo may be tank-mixed with Scepter or Command to improve control of certain problem broadleaf weeds.

Preview 75DF is a premix of metribuzin (Lexone) and chlorimuron (Classic) used at 6 to 10 ounces per acre. It controls cocklebur, jimsonweed, velvetleaf, and wild sunflower better than metribuzin alone (see the table at the end of this guide). It may be applied preplant incorporated or preemergence. Do not apply after crop emergence. Combinations with other herbicides can improve grass control (see Table 3). *To avoid potential carryover injury, do not apply Preview to soils with a pH greater than 6.8.*

Minimum recropping intervals after application of Preview are 4 months to wheat or barley, 10 months to field corn or alfalfa, and 12 months to grain sorghum or clover. Delay planting another month if application is made after June 15. See the current labeling for climatic effects on recropping. Applying Scepter or Classic the same year as Preview may change the recropping intervals (see the labels).

Scepter (imazaquin) is used at two-thirds pint per acre (one gallon for 12 acres) applied within 30 days before planting or immediately after planting. Incorporation is not required but improves weed control under low-rainfall conditions, and it may also improve control of velvetleaf and giant ragweed. Postemergence application can control cocklebur and pigweed and is made with 0.25-percent surfactant. Do not apply within 90 days of harvest.

Scepter can control most annual broadleaf weeds if adequate rainfall is received but is somewhat weak on control of velvetleaf and annual grasses (see the table at the end of this guide). Grass control is improved by tank-mixing with Prowl, Treflan, Sonalan, Dual, or Lasso.

Squadron 2.33L is a 6:1 premix of pendimethalin (Prowl) and imazaquin (Scepter) used at 3 pints per acre.

Tri-Scept 3E is a premix of trifluralin and imazaquin in a 6:1 ratio. The rate is 2⅓ pints per acre. It must be incorporated.

Soybeans sometimes show temporary yellowing and growth retardation from applications of Scepter, Tri-Scept, or Squadron. Uniform, accurate application is extremely important to reduce the risk of carryover. If Scepter is incorporated, strive for uniform distribution. Carryover injury to corn appears as stunting, root inhibition, and interveinal chlorosis or purpling of the leaves.

There is significant concern about soil residues of Scepter affecting other, subsequent crops such as corn and wheat. For all of Illinois, do not plant corn grown for seed, sweet corn, or popcorn the year following application of a full rate of Scepter or premixes containing imazaquin (Scepter). If rainfall is adequate, wheat may be planted 4 months or more after application in the major wheat-producing area of southern Illinois. But, generally, other small grains and small-seeded legumes should not follow during the next year.

North of a line extending from Peoria west along State Route 116 and east along U.S. Route 24, do not plant corn, wheat, or small-seeded legumes the year following application — either preplant incorporated or preemergence — of Scepter at the rate of two-thirds pint or its equivalent in Squadron or Tri-Scept.

New labeling may indicate for Illinois south of this line that corn should not follow the next season after the use of two-thirds pint per acre of Scepter (either preplant incorporated or preemergence) when rainfall is limited to 15 inches or less from the time of application until November 1. Such label changes should be considered when making herbicide use and recrop decisions. It is generally not advisable to use Preview, Lorox Plus, or Classic the same year as Scepter because of the increased risk of carryover effects.

Those operators who used Scepter or a product containing imazaquin in 1988 should check with their supplier and the most recent labeling for guidelines before planting corn in 1989.

Preemergence herbicides

Surflan (oryzalin) can control annual grasses, pigweed, and lambsquarters if rainfall is adequate. Rotary hoe to control emerging weeds if adequate rain does not fall within 7 days after application. Surflan may be used as an early preplant application for no-till soybeans. Do not use on soils that have more than 5-percent organic matter. The rate is ¾ to 1½ quarts AS per acre (aqueous suspension) used alone and varies in some combinations. Surflan may be tank-mixed with Amiben, Lorox, Lexone, or Sencor to improve control of broadleaf weeds. Surface application may be made within 2 days after planting, prior to emergence. Surflan can cause stem callusing, which can lead to soybean lodging.

Lorox or Linex (linuron) is best suited to silt loam soils that contain 1- to 3-percent organic matter. *Do not apply to very sandy soils.* Linuron controls broadleaf weeds better than grass weeds. It does not control annual morningglory, and control of cocklebur, velvetleaf, and jimsonweed is variable. Accurate, uniform application and proper rate selection are necessary to minimize the risk of crop injury. Tank-mix combinations allow the use of a reduced rate of linuron to decrease the risk of soybean injury, but this reduced rate may also decrease the degree of weed control.

Linuron is registered in tank-mix combinations with Amiben, Lasso, Dual, Prowl, or Surflan to improve grass control. The rate of linuron in these combinations is 1 to 1⅔ pounds of 50DF or 1 to 1⅔ pints of 4L on silt loam soils that have less than 3-percent organic matter.

Lorox Plus 60DF is a premix of linuron (Lorox) plus chlorimuron (Classic) that is used at 12 to 18 ounces per acre. Lorox Plus controls cocklebur, jimsonweed, and velvetleaf better than linuron alone (see the table at the end of this guide). Tank-mixing with Lasso, Dual, Prowl, or Surflan can improve grass control.

Lorox Plus should be applied after planting but before soybeans emerge. Do not apply to soils with organic matter less than 0.5 percent.

To minimize potential carryover injury, *do not apply Lorox Plus 60DF to soils with a pH greater than 6.8.* Allow a minimum recropping interval of 4 months to small grains and 10 months to field corn or sorghum. Add one month if application is made after June 15. See the current labeling for climatic effects upon recropping. If applied the same year as Lorox Plus, Scepter will change and Classic may change the recropping intervals (see the current labels).

Postemergence herbicides

Research suggests that soybean yields will probably not be reduced if weeds are controlled within 3 to 4 weeks after the soybeans are planted. Postemergence herbicides are most effective when their use is part of a planned program and when they are applied while the weeds are young and tender; they should not be considered simply as emergency treatments. It is especially important that treatments are timely when using postemergence herbicides in narrow-row soybeans. It is important to know what specific weeds are present in the field and the size of those weeds. Select herbicides and rates accordingly. Usually, smaller weeds are easier to control.

Registered combinations are shown in Table 4. For more information about conditions affecting application, see the section entitled "Postemergence herbicide principles" and refer to labels.

Basagran (bentazon) can control cocklebur, jimsonweed, prickly sida, and velvetleaf; but it is weak on pigweed, lambsquarters, annual morningglory, and black nightshade. It may be used for control of yellow nutsedge and Canada thistle but does not control annual grasses.

The rate for Basagran is 1 to 2 pints per acre, depending on the weed size and species. Specifics on weed size and rates are indicated on the label. Application, however, preferably should be made when weeds are small (1 to 3 inches tall) and actively growing. These conditions usually exist when the soybeans are in the unifoliolate to second-trifoliolate stage or within 2 to 3 weeks of planting. Spraying during warm, sunny weather can also improve performance. Do not spray if rain is expected within 8 hours. Use at least 20 gallons of water per acre and 40- to 60-psi spray pressure to provide complete weed coverage. The higher spray pressure provides more thorough weed coverage and better control. Adding a crop-oil concentrate (COC) to Basagran may increase performance on most weeds but may cause some soybean injury. The addition of 2 fluid ounces of 2,4-DB (Butyrac 200) to Basagran may help control annual morningglory. Do not add crop oil when mixing with 2,4-DB. Do not mix or apply Basagran with other pesticides or liquid fertilizer except as specified on the product label.

A 28-percent UAN (urea ammonium nitrate) solution—commonly referred to as 28-percent nitrogen solution—may be added to the spray mixture instead of crop-oil concentrate for improved velvetleaf control. The UAN solution may be added to the tank with Basagran plus Blazer or Tackle when velvetleaf is the primary target weed. Do not use brass or aluminum nozzles when spraying Basagran and 28-percent nitrogen solution.

Basagran may be applied as a split application of one pint plus one pint per acre to improve control of lambsquarters, giant ragweed, wild sunflower, and yellow nutsedge. Apply the first pint of Basagran before weeds reach the maximum size or leaf stage as indicated on the label. Apply the second pint 7 to 10 days after the first application.

Blazer or Tackle (acifluorfen) should be applied when broadleaf weeds are in the 2- to 4-inch stage and actively growing. Weeds controlled include annual morningglory, pigweed, jimsonweed, and black nightshade. Control of cocklebur and morningglory can be improved by adding 2 fluid ounces of 2,4-DB. Apply the mixture when cocklebur and morningglory measure no more than 10 or 12 inches. Surfactant addition is recommended when combining Blazer and 2,4-DB, but not with Tackle plus 2,4-DB.

The rate is 1 to 3 pints of Blazer 2L or Tackle per acre. Blazer requires the addition of a nonionic surfactant at a minimum of 1 pint per 100 gallons of spray. Tackle requires the addition of a nonionic surfactant at a minimum of 1 quart per 100 gallons. Tackle may be tank-mixed with 28-percent UAN or 10-34-0 to improve performance on troublesome weeds. Fertilizer solutions may also be added to Tackle plus Basagran and Tackle plus Rescue tank-mixtures. The rate of surfactant may be increased to 2 to 4 pints per acre to improve control of small escaped grasses.

Because Blazer and Tackle are contact herbicides, leaf burn often occurs; however, the crop usually recovers within 2 to 3 weeks. Do not spray if rain is expected within 4 to 6 hours.

Basagran plus Blazer or Tackle provides a means of broadening the spectrum of control because Blazer or Tackle is better on pigweed and annual morning-

Table 4. Registered Postemergence Herbicide Combinations for Broadleaf Weed Control in Soybeans

	Amiben	Basagran	Blazer	2,4-DB	Scepter	Classic
Alanap	X	—	—	X	—	—
Amiben	..	—	X	X	—	—
Basagran	—	..	X	X	X	X
Blazer	X	X	..	X	X	—
Classic	—	—	X	—	—	..
Cobra	—	—	—	X	X	X
Reflex	—	X	—	X	—	—
Rescue	—	—	X	—	—	—
Tackle	—	X	—	X	—	—

X = Registered
— = Not registered

glory, while Basagran is better on cocklebur. The rate is 1 to 2 pints of each product in the combination. Addition of an adjuvant (crop-oil concentrate or surfactant) is suggested. To improve velvetleaf control with Blazer or Tackle plus Basagran, use 28-percent UAN or 10-34-0 liquid fertilizer additives at labeled rates to replace the surfactant or crop-oil concentrate (COC). Do not add COC when using fertilizer additives. A mixture of Blazer plus Basagran plus 2,4-DB amine (2 fluid ounces) may be used to improve control of cocklebur and morningglory under dry weather conditions. Do not add crop-oil concentrate or any other additives when using 2,4-DB with Basagran plus Blazer. Refer to individual product labels for specifics.

Storm 4S and Galaxy 3.67S. Storm is a 2:1 premix and Galaxy a 4.5:1 premix of the active ingredients bentazon (Basagran) and acifluorfen (Blazer). The recommended rate of Storm (1½ pints per acre) is equivalent to 1 pint of Basagran and 1 pint of Blazer. Galaxy at 2 pints per acre is equivalent to 1½ pints of Basagran and ⅔ pint of Blazer.

Storm and Galaxy herbicides are intended for selective postemergence control of broadleaf weeds. They are effective mainly through contact action; therefore, the weeds must be thoroughly covered with spray. Early application makes it easier to obtain thorough spray coverage of weeds and gives better control than later application. Delay in application, which permits weeds to exceed the maximum size stated, will result in inadequate control. Cultivation before or during the application is not recommended. Cultivation may put weeds under stress, thus making control more difficult to obtain.

With Storm or Galaxy, use at least 20 gallons of water per acre and a minimum pressure of 40 psi.

Either crop-oil concentrate or 28-percent UAN should be added to the spray tank with Storm or Galaxy. For Storm, oil concentrate should be added at a maximum of one pint per acre for ground or aerial application. For Galaxy, oil concentrate should be added at a maximum of 2 pints per acre for ground application or 1 pint per acre maximum for aerial application. The standard use rate of one-half to one gallon of UAN per acre is recommended for ground application of Storm or Galaxy.

Cobra 2E (lactofen) is applied at 12½ fluid ounces per acre with or without crop-oil concentrate (COC) at ½ to 1 pint per acre. Apply Cobra when weeds are small, usually before the four- to six-leaf stage. One gallon per acre of 28-percent UAN may be substituted for COC under favorable growing conditions; or a nonionic surfactant may be used at one quart per acre. Weeds controlled include cocklebur, jimsonweed, pigweed, common ragweed, and black nightshade. Control of annual morningglory and velvetleaf can be enhanced by using the higher rate with COC on weeds with no more than four leaves. Smartweed may be suppressed, but do not expect control of lambsquarters. Cobra can help on burcucumber, copperleaf, prickly sida, ragweeds, tall waterhemp, and venice mallow.

Cobra is a contact herbicide and can cause soybean leaf burn that is intensified at the higher use rate when applied with an adjuvant. The crop usually recovers 2 to 3 weeks after application. Cobra should not be applied if rain is expected within 30 minutes.

Cobra may be tank-mixed with Classic (0.38 to 0.5 ounces per acre), Scepter, or 2,4-DB (2 fluid ounces per acre). Surfactant X 77 is added at 1 quart per 100 gallons of spray solution. Classic improves control of cocklebur, smartweed, and wild sunflower. The 2,4-DB can enhance control of morningglory. Scepter can enhance control of pigweed and cocklebur.

Apply Cobra only once during the season, no later than 90 days before harvest.

Reflex 2LC (fomesafen) may be used to control broadleaf weeds at ¾ to 1 pint, north of Interstate 70, or at 1¼ pints per acre, south of I-70. Use a minimum of 10 gallons of spray per acre and add either crop-oil concentrate at 1 percent (1 quart per 25 gallons) or nonionic surfactant at 0.25 to 0.50 percent by volume. Reflex should control pigweed, black nightshade, jimsonweed, smartweed, and common ragweed up to the four-leaf stage at the high rate. Reflex may be tank-mixed with Basagran at 1 to 2 pints per acre to improve control of velvetleaf and giant ragweed; with 2 to 3 fluid ounces of Butyrac 200 to improve control of annual morningglory, giant ragweed, and cocklebur; or with ½ to ¾ ounce of Classic or ⅓ pint of Scepter to improve cocklebur control. Do not apply Reflex beyond 3 weeks after soybean emergence. It can be tank-mixed with Fusilade or sequentially applied after Fusilade. **Tornado** is a premix of Fusilade plus Reflex. Do not spray if rain is expected within 4 hours of application. *See a current label concerning recrop restrictions.*

Classic (chlorimuron) may be used for postemergence broadleaf weed control at one-half to three-fourths ounce 25DF per acre. Use the higher rate on larger weeds. Use at least 10 gallons of water per acre plus nonionic surfactant at 0.25 percent of spray volume (v/v). Crop-oil concentrate (COC) at 1 percent v/v may replace the surfactant to improve weed control but may increase soybean injury. Classic may cause temporary yellowing and retardation of soybean growth. This will generally be evident 5 to 7 days after application to soybeans that have been under stress. Do not apply Classic if rain is expected within one hour.

Control of cocklebur, jimsonweed, wild sunflower, redroot pigweed, and yellow nutsedge is good. Pigweed control varies with rate and species. Check the label for weed sizes and rates. Velvetleaf control is improved with the use of 28-0-0 (UAN), or 10-34-0 plus COC or surfactant. Split applications approximately 14 to 21 days apart will improve control of burcucumber, giant ragweed, and annual morningglory. Do not apply more than 1½ ounces of Classic

25DF per acre for the season. Do not apply Classic within 60 days of harvest.

Do not apply Classic to soils with a pH greater than 6.8. Allow a minimum recrop interval of 3 months to plant small grains and 9 months to plant field corn, sorghum, alfalfa, or clover. If Classic is applied sequentially after Preview or Lorox Plus, the recrop interval may change (see Classic label). If Scepter is used in the same season as Classic, the recrop interval does change. Carryover injury to corn is possible and may appear as stunting, root inhibition, and interveinal chlorosis or purpling of leaves.

Amiben (chloramben) may be used for postemergence application on soybeans in the cracking to fourth-trifoliolate stage, but only within 33 days after planting. This treatment can be especially helpful in controlling velvetleaf; but smartweed, common ragweed, and pigweed may also be controlled or suppressed. Velvetleaf may be 1 to 8 inches tall, and the others may be 1 to 3 inches tall. For ground applications, 10 to 20 gallons of water per acre, a spray pressure of 30 psi, and flat-fan nozzle tips are suggested. Use 6 quarts of Amiben 2S or 3.6 pounds of Amiben 75DF plus 1 quart of crop-oil concentrate per acre. Amiben may be tank-mixed with Butyrac 200, Alanap, or Blazer, and applied postemergence. See the Amiben label for specific information.

Rescue (naptalam plus 2,4-DB) may be used for midseason to late-season postemergence control of cocklebur, giant ragweed, and wild sunflower; it may also suppress annual morningglory. Apply 2 to 3 quarts per acre after soybeans are about 14 inches tall or after first bloom. Rescue may be tank-mixed with Blazer (1 to 1½ pints per acre) or Tackle (1 pint per acre) to improve control of morningglory, jimsonweed, pigweed, and common ragweed and to provide faster knockdown of weeds. Crop-oil concentrate or a nonionic surfactant should be added at the manufacturer's recommended rate. Fertilizer solutions may be used as spray adjuvants; for example, 10-34-0, may be used at one quart per acre, or 28-percent UAN is also effective. Tackle is labeled for use with either a nonionic surfactant, crop-oil concentrate, or 28-percent UAN. The water volume per acre is 10 to 25 gallons for ground application and at least 5 gallons for aerial application.

If rain occurs within 6 hours, effectiveness may be reduced. Activity may not be very noticeable until 10 to 14 days after application; maximum activity should occur 20 to 30 days after application. Crop injury such as leaf twisting and terminal droop may occur. To avoid possible yield losses, do not apply Rescue to soybeans under stress from drought, disease, or injury from another herbicide. *Do not apply Rescue within 60 days of harvest.*

Scepter (imazaquin) may be used postemergence in soybeans, primarily for control of pigweed and cocklebur. A Scepter rate of one-third pint per acre may be adequate and can reduce the risk of residual effects on subsequent crops if applied uniformly and accurately, sufficiently early in a season with adequate rainfall. However, certain recrop restrictions may still apply.

Assure (quizalofop) can control a broad spectrum of annual and perennial grasses in soybeans. At 10 ounces per acre, Assure is quite effective on volunteer corn that is 6 to 18 inches tall. The same rate is used for shattercane 6 to 12 inches tall. For giant foxtail that is 2 to 8 inches tall, use 14 ounces of product per acre. Fall panicum, volunteer wheat, and sandbur may be treated when they are 2 to 6 inches tall with 14 ounces per acre. Assure is also effective on wild proso millet and woolly cupgrass.

Add crop-oil concentrate or nonionic surfactant when using Assure. Use at least 10 gallons of water for ground application or 3 gallons for aerial application. Do not apply if rain is expected within an hour. Avoid drift to highly sensitive crops such as corn, sorghum, and wheat. Do not apply within 80 days of harvest, and do not apply after pod set. Do not rotate to crops other than soybeans for 120 days.

If Assure is mixed with Basagran or Classic, increase the rate of Assure by 4 ounces. It is best to use a postemergence herbicide for broadleaf weeds first and then wait about 7 days before applying Assure.

For spot spraying, use 1.0 fluid ounce (2 tablespoons) of Assure and 1.25 fluid ounces (2.5 tablespoons) of crop-oil concentrate or 0.3 fluid ounce (2 teaspoons) of nonionic surfactant.

Poast (sethoxydim) can control many annual and some perennial grasses in soybeans. Apply three-fourths pint per acre to control giant or green foxtail, barnyardgrass, and fall panicum up to 4 inches tall and volunteer corn up to 12 inches tall, or one pint per acre on grasses up to 8 inches tall. Use one-half pint per acre for wild proso millet that is 4 to 10 inches tall. Apply 1½ pints per acre as a rescue treatment if grasses are actively growing (see label for species and sizes). Always use 2 pints per acre of crop-oil concentrate or Dash (special adjuvant) with Poast. Fertilizer additives are recommended for volunteer corn and volunteer cereals. Volunteer cereals less than 6 inches tall (not tillered or overwintered) can be controlled with 1½ pints per acre.

The addition of 28-percent UAN (one gallon per acre) or spray-grade ammonium sulfate (2½ pounds per acre) may improve grass control. Components should be added slowly, with agitation, in the following sequence: (1) fertilizer additive, (2) Dash or crop-oil concentrate, and (3) Poast. After using fertilizer additives, rinse the entire spray system with water to reduce corrosion.

The spray volume is 5 to 20 gallons per acre for ground applications or at least 5 gallons per acre for aerial applications. Lower volumes often result in more consistent grass control. Use only standard high-pressure, hollow-cone, or flat-fan nozzles at 40 to 60 psi. Do not cultivate within 5 days before or 7 days after

application. Do not apply Poast to grasses under stress from hot, dry weather or herbicide injury. Do not apply if rainfall is expected within one hour.

Poast plus Basagran may be tank-mixed. If Dash (one quart per acre) plus 28-percent UAN solution (one gallon per acre) are used, the rate of Poast is one pint per acre. Use 1½ pints of Poast per acre if crop-oil concentrate (COC) is used. Apply the tank-mix before broadleaf or grass weeds exceed maximum specified sizes. Tackle may also be added at 1½ to 2 pints per acre, or Blazer may be added.

Poast plus Blazer or Tackle may be tank-mixed. Use one pint of Poast for fall panicum or giant foxtail that is 3 to 8 inches tall. For other annual grasses listed on the Poast label use 1½ pints per acre. For the combination, the rate for Blazer is 1½ to 2 pints per acre, while the rate for Tackle is 1½ to 3 pints per acre. Use crop-oil concentrate (at one quart per acre) and not fertilizer additives with this tank-mix. Sequential application is necessary for perennials and may be more economical for control of annuals.

Fusilade 2000 (fluazifop-P) may be used for post-emergence control of annual and perennial grass weeds in soybeans. Apply only to actively growing grasses before they tiller. The rate is 1½ pints per acre when giant foxtail is 2 to 6 inches tall and other annual grass weeds are 2 to 4 inches tall. Use three-fourths pint per acre when volunteer corn is 12 to 24 inches tall, shattercane is 6 to 12 inches tall, or wild proso millet is 6 to 12 inches tall. For control of volunteer cereals, apply one pint per acre before plants are 2 to 6 inches tall. To control wirestem muhly, apply 1½ pint per acre when plants are 4 to 12 inches tall. Fusilade can also control johnsongrass and quackgrass, but sequential applications may be needed. (See the section entitled "Specific weed problems.")

The spray volume should be at least 10 gallons per acre for ground application and 5 gallons per acre for aerial application. Add either crop-oil concentrate at 1 percent by volume (1 gallon per 100 gallons of spray) or a nonionic surfactant at 0.25 percent of spray volume. For aerial application, add one pint of crop-oil concentrate or surfactant per acre. Apply before soybeans bloom. A tank-mix of Fusilade with Reflex, Tackle, or Blazer is labeled for use. Sequential applications of Fusilade with Basagran, Blazer, Tackle, or Classic are also approved. *Do not tank-mix Fusilade with other postemergence herbicides intended for control of broadleaf weeds except as specified.*

Option (fenoxaprop) may be used postemergence at 0.8 pint plus 1 quart of crop-oil concentrate per acre when giant foxtail is 3 to 6 inches tall or volunteer corn is 10 to 26 inches tall. Use 1.2 pints per acre for 3- to 6-inch tall barnyardgrass or fall panicum. Wirestem muhly (3 to 6 inches tall) or johnsongrass (10 to 16 inches) can be controlled with 1.2 pints per acre. Repeat application may be necessary for control of johnsongrass. Crop-oil concentrate is required for the control of wirestem muhly, yellow foxtail, and crabgrass; is optional for the control of shattercane or johnsongrass seedlings; and should not be used for rhizome johnsongrass control. Rainfall within one hour of application may reduce grass control. Option may be tank-mixed or applied sequentially with Basagran, Blazer, or Tackle.

Roundup (glyphosate) may be applied through several types of selective applicators—recirculating sprayers, wipers, or rope-wicks. This application is particularly useful for control of volunteer corn, shattercane, and johnsongrass. Roundup may also suppress hemp dogbane and common milkweed. Weeds should be at least 6 inches taller than the soybeans. Avoid contact with the crop. Equipment should be adjusted so that the lowest spray stream or wiper contact is at least 2 inches above the soybeans. For equipment calibration, refer to the Roundup label. For recirculating sprayers and wipers, use the rates given on the label. For rope-wick applicators, mix 1 gallon of Roundup in 2 gallons of water. A spot treatment with Roundup is also a good option in many fields. For application made on a spray-to-wet basis, use a 1- to 2-percent solution of Roundup in water. For motorized spot treatments in which coverage of weeds may be less than complete, use a 5-percent solution. Avoid contact of the spray with the soybeans. Add a dye for increased visibility.

Soybean harvest aid

Gramoxone Super (paraquat) may be used for drying weeds in soybeans just before harvest. For indeterminate varieties of soybeans (most of the varieties planted in Illinois), apply when 65 percent of the seed pods have reached a mature brown color or when seed moisture is 30 percent or less. For determinate varieties, apply when at least one-half of the leaves have dropped and the rest of the leaves are turning yellow.

The rate is 11 to 21 ounces of Gramoxone Super per acre. Use the high rate on cocklebur. The total spray volume per acre is 2 to 5 gallons for aerial application and 20 to 40 gallons for ground application. Add 1 quart of nonionic surfactant per 100 gallons of spray. Do not pasture livestock within 15 days of treatment, and remove livestock from treated fields at least 30 days before slaughter.

Specific weed problems

Yellow nutsedge

Yellow nutsedge is a perennial sedge with a triangular stem. It reproduces mainly by tubers, which begin sprouting about May 1 in central Illinois. For the most effective control, soil-applied herbicides should be incorporated into the top 2 inches of the soil.

For soybeans, a delay in planting until late May allows time for two or three tillage operations to destroy many nutsedge sprouts. These operations help deplete food reserves in nutsedge tubers. Row cultivation is

helpful. Preplant-incorporated applications of Dual, Lasso, or Vernam will also help.

Lasso (alachlor) preplant incorporated at 1½ to 4 quarts per acre can often give good control of nutsedge.

Dual (metolachlor) may be applied at the rate of 2 to 3 pints per acre to control nutsedge. Preplant incorporated treatment is preferred to treatment at the preemergence stage.

Vernam 6.7E (vernolate) applied preplant at 3½ pints per acre is effective against yellow nutsedge. Immediate incorporation is necessary with Vernam.

Basagran (bentazon) applied postemergence can also help control nutsedge in soybeans. When nutsedge is 6 to 8 inches tall, three-fourths to one quart per acre may be applied. If needed, a second application may be made 7 to 10 days later. The addition of 28-percent UAN or a crop-oil concentrate improves Basagran performance.

Classic, at one-half to three-fourths ounce of product, can provide some control when nutsedge is 2 to 4 inches tall.

For corn that is planted relatively early, preplant tillage before nutsedge sprouts is of little help in controlling nutsedge. Timely cultivation gives some control, but a program of herbicides plus cultivation has provided the most effective control of nutsedge.

Several preplant treatments are available. **Eradicane Extra** at 5⅓ to 8 pints or **Eradicane, Sutan+**, or **Genate Plus** at 4¾ to 7⅓ pints per acre is effective for control of yellow nutsedge in corn. Any of these products should be incorporated immediately. **Lasso** or **Dual** applied in corn at the same rates as for soybeans can also be quite effective.

The combinations of Lasso, Dual, Sutan+, Genate Plus, Eradicane, or Eradicane Extra incorporated with atrazine may improve control of nutsedge while also controlling broadleaf weeds.

Bladex (cyanazine) or **atrazine** may be used as a postemergence spray to control emerged yellow nutsedge when it is small. Split applications of atrazine plus crop-oil concentrate (COC) have been more effective than single applications. **Basagran** may be used in corn in a manner similar to that for soybeans. **Lorox or Linex (linuron)** as a directed postemergence spray has also given some control.

Johnsongrass

Johnsongrass can reproduce both from seeds and by rhizomes. Both chemical and cultural methods are required to control johnsongrass rhizomes.

Much of the rhizome growth occurs after the johnsongrass head begins to appear. Mowing, grazing, or cultivating to keep the grass less than 12 inches tall can reduce rhizome production significantly.

Control of johnsongrass can also be improved with tillage. Fall plowing and disking bring the rhizomes to the soil surface, where many of them are winter-killed. Disking also cuts the rhizomes into small pieces, making them more susceptible to chemical control.

Johnsongrass rhizomes may be controlled or suppressed with the use of certain herbicides in various cropping programs. Several herbicides can provide control of johnsongrass seedlings in soybeans or corn. (See the table at the end of this guide.)

Treflan (trifluralin) or Prowl (pendimethalin) used in a 3-year soybean program has been fairly successful in controlling rhizome johnsongrass. Either one may be used at 1½ to 2 times the normal rate for 2 years; in the third year, either it is used at the normal rate or another suitable herbicide is used before a regular cropping sequence is resumed. Thorough preplant tillage and incorporation are necessary for satisfactory control. Be certain not to plant crops such as corn or sorghum the year following application of these herbicides at the higher rates.

Fusilade 2000 (fluazifop-P) can control 8- to 18-inch tall johnsongrass. Apply 1½ pints per acre before the boot stage of growth. If new shoots or regrowth occur, make a second application of one pint per acre when johnsongrass is 6 to 12 inches tall. Add crop-oil concentrate at 1 percent of volume or add nonionic surfactant at 0.25-percent volume.

Assure can control johnsongrass from seed or rhizomes. Applying 10 ounces of product per acre is recommended when seedling johnsongrass is 2 to 8 inches tall. For rhizome johnsongrass, apply 26 ounces of product per acre when johnsongrass is 10 to 24 inches tall. If regrowth occurs, a second 14-ounce application may be made when johnsongrass is 6 to 10 inches tall.

Poast (sethoxydim) can control 15- to 25-inch tall johnsongrass in soybeans. Apply 1½ pints of Poast plus 1 quart of Dash or crop-oil concentrate and 1 gallon of 28-0-0 (UAN) or 2½ pounds of ammonium sulfate per acre. A spray volume of 5 to 10 gallons per acre is suggested for best control. If regrowth occurs, apply one pint of Poast per acre when johnsongrass is 6 to 12 inches tall.

Option (fenoxaprop) can control 10- to 25-inch tall johnsongrass in soybeans. Apply 19 fluid ounces of Option per acre when johnsongrass is 10 to 20 inches tall. Do not add crop-oil concentrate.

Eradicane Extra can help control rhizome johnsongrass in corn when used at a rate of 8 pints per acre with a tillage program; Eradicane 6.7E or Sutan 6.7E can provide partial control (suppression) at 7⅓ pints per acre.

Roundup (glyphosate) may be used as a spot treatment to control johnsongrass in corn, soybeans, or sorghum. Apply a 1-percent solution when johnsongrass has reached the boot to head stage and is actively growing. Use of Roundup in rope-wick applicators or recovery-type sprayers is effective for control of johnsongrass in soybeans.

Roundup may be applied in small-grain stubble when johnsongrass is in the early head stage. Fall

applications should be made before the first frost. At least 7 days should be allowed after treatment before tillage.

Quackgrass

Quackgrass is a perennial grass with shallow rhizomes. In Illinois, it is found primarily in the northern part of the state.

Atrazine is quite effective when used as a split application in corn. Apply 2 quarts of atrazine 4L per acre in the fall or spring and plow 1 to 3 weeks later. Apply another 2 quarts per acre as a preplant or preemergence treatment. Postemergence application is usually less effective. A single treatment with 3 to 4 quarts per acre may be applied either in the spring or fall 1 to 3 weeks before plowing, but the split application usually gives better control of annual weeds. Use equivalent rates of other formulations. If more than 3 pounds of atrazine active ingredient is applied per acre, plant no crops other than corn or sorghum the next year.

Eradicane Extra may be used to suppress quackgrass in corn if more flexibility in cropping sequence is desired. A rate of 5⅓ pints per acre of Eradicane Extra may be used on light infestations, while 8 pints per acre is suggested for heavier infestations. Some risk of injury to corn occurs, especially at the higher rate. A tank-mix with atrazine should improve control. If Eradicane 6.7E is used, the rate range is from 4¾ to 7⅓ pints per acre for suppression.

Fusilade 2000 (fluazifop-P) may be used for quackgrass control in soybeans at 1½ pints per acre. Apply when quackgrass is 6 to 10 inches tall. If regrowth occurs, a second application of one pint per acre may be made. Best results are obtained with Fusilade and most other treatments if rhizomes are cut up by preplant tillage to stimulate maximum emergence of grass shoots. Always add crop-oil concentrate or nonionic surfactant to Fusilade.

Assure is quite effective for control of quackgrass, with 20 ounces per acre applied when quackgrass is 6 to 10 inches tall. If needed, a second application of 14 ounces may be made when quackgrass is 6 to 10 inches tall.

Poast (sethoxydim) may be used in soybeans to control quackgrass that is 6 to 8 inches tall. Use 2½ pints of Poast plus 1 quart of Dash or crop-oil concentrate per acre. Always add 28-percent UAN or ammonium sulfate for best control. If regrowth occurs or new plants emerge, apply one pint per acre of Poast when the grass is 6 to 8 inches tall.

Roundup (glyphosate) may be used for controlling quackgrass before planting corn, sorghum, or soybeans. Apply 1 to 3 quarts per acre when quackgrass is 8 inches tall and actively growing (fall or spring). For annual cropping systems, apply 1 quart per acre in 5 to 10 gallons of spray with surfactant added. Delay tillage for at least 3 days after application.

Wirestem muhly

Wirestem muhly is primarily a problem in northern and western Illinois. It is a perennial that reproduces by seeds and scaly rhizomes. The rhizomes are often moved by chisel plows, field cultivators, and shovel cultivators. Many farmers report that delayed seedbed preparation, where possible, can provide some control of wirestem muhly; but wirestem muhly does not start growth until late spring.

Roundup (glyphosate) may be used early preplant (early June) or after harvest when wirestem muhly is at least 8 inches tall and actively growing. Do not till before fall or spring applications. The rate is 1 quart of Roundup in 5 to 10 gallons of water per acre, with surfactant added at 2 to 4 quarts per 100 gallons. Use flat-fan nozzles. After applying, wait 3 days before tilling.

Fusilade (fluazifop) may be used to control wirestem muhly in soybeans. The rate is 1½ pints per acre when wirestem muhly plants are 4 to 12 inches tall.

Assure is effective for control of wirestem muhly, with 16 ounces per acre applied when muhly is 4 to 8 inches tall. If needed, a second application of 14 ounces may be made when muhly is 4 to 8 inches tall.

Poast (sethoxydim) can control 6-inch wirestem muhly in soybeans. Use 1½ pints per acre plus 1 quart of either Dash or crop-oil concentrate per acre. The addition of 28-percent UAN or ammonium sulfate will improve control.

Option (fenoxaprop) can control 3- to 6-inch wirestem muhly in soybeans. Use 1.2 pints plus 1 quart of crop-oil concentrate per acre.

Canada thistle

Canada thistle is a perennial weed that has a large amount of food reserves in its root system. Canada thistle has several varieties, which differ not only in appearance but also in their susceptibility to herbicides.

2,4-D may give fairly good control of some strains. Rates will depend on where the thistle is growing. For example, higher rates may be used in grass pastures or in noncrop areas than may be used in corn.

Banvel (dicamba) often is a little more effective than 2,4-D and may be used alone or in combination with 2,4-D. Banvel may be used as an after-harvest treatment in wheat, corn, or soybean fields and is labeled for use in fallow fields. Rates vary from 1 to 2 quarts of Banvel, alone or in tank-mix combinations with 2,4-D or Roundup. Fall treatments should be applied before killing frosts. For best results, thistles should be fully emerged and actively growing. Fields treated in the fall with Banvel may be planted to corn, sorghum, or wheat the next season; soybeans may be planted if rates of fall-applied Banvel are not excessive.

Atrazine and oil that are applied postemergence have been fairly effective in controlling Canada thistle

in corn. Make the application before thistles are 6 inches tall.

Buctril plus atrazine can provide partial control of Canada thistle if applied when the thistles are at the 8-inch to bud stage of growth. Apply Buctril at the rate of one pint per acre plus atrazine at 1.2 pounds of active ingredient per acre; or apply Buctril at 1.5 pints of Buctril plus atrazine at 0.5 to 1.5 pounds of active ingredient per acre.

Basagran (bentazon) may be used for control of Canada thistle in soybeans or corn when the thistles are 8 to 12 inches tall. Apply three-fourths to one quart per acre in a single application; or, for better control, make two applications of three-fourths to one quart per acre each, 7 to 10 days apart. Laddok is effective in corn.

Roundup (glyphosate) may be used at 2 to 3 quarts per acre when Canada thistle is at or beyond the early bud stage. Fall treatments must be applied before frost for best results. After applying Roundup, allow at least 3 days before tillage.

Additional information

Not all available herbicides and herbicide combinations are mentioned in this guide. Some are relatively new and are still being tested. Some are not considered to be well adapted to Illinois or are not used very extensively. For additional information about field crop weed control, consult your county Extension adviser or write to the Department of Agronomy, University of Illinois at Urbana-Champaign, N-305 Turner Hall, 1102 South Goodwin Avenue, Urbana, Illinois 61801.

Table 5. Relative Effectiveness of Herbicides on Major Weeds

This table gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used also will influence results. G = good; F = fair or variable, and P = poor.

	Grasses									Broadleaf weeds										
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Volunteer corn	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Sunflower, wild	Velvetleaf
SOYBEANS																				
Preplant																				
Command	G	G	G-F	G	G	F	F	P	P	P	P-F	F	G	P	P	F-G	P	F	P	G
Commence	F-G	G	G	G	G	G	G	F	P	P	P-F	F	F	P	G	F	P	F	P	G
Sencor[2], Lexone + dinitroaniline	F	G	G	G	G	G	G	F	P	P-F	F-P	F-G	G	P	G	F	F	G	F	F-G
Treflan, Sonalan	F-G	G	G	G	G	G	G	F	P	P-F	P	P	G	P-F	G	P	P	P-F	P	P
Vernam	F	G	G	G	G	G	G	P-F	F	P-F	P	P	F	P	G	P	P	P	P	F
Preplant or preemergence																				
Amiben	F-G	G	F-G	F-G	F-G	F	F	P	P	P	P	P-F	G	F-G	G	F-G	F	F-G	P	F
Lasso, Dual	G	G	G	G	G	P-F	P-F	P	F-G	P	P	P	F	F-G	G	P-F	P	P-F	P	P
Lasso or Dual + Lorox[1], Linex[1]	F	G	G	G	G	P	P	P	P-F	P	F	F	G	F-G	G	F-G	F	G	F	F
Lasso or Dual + Sencor[3] or Lexone	F	G	G	G	G	P	P	P	F	P	F-P	F-G	G	F-G	G	F	F	G	F	F-G
Lorox[1], Linex[1]	F	F	F	F	F	P	P	P	P	P	F	F	G	F	G	F-G	F	G	F	F
Lorox Plus	F-G	F	F	F	P	G	G	P	P	F	G	G	G	F	G	F-G	F-G	G	F-G	F
Preview	F-G	F	F	F	P	P	P	P	F	F	G	G	G	F-P	G	F-G	F-G	G	G	F-G
Scepter	G	F-G	F	F	P-F	F	F	F	F	F	G	F	G	F-G	G	G	F-G	G	G	F
Scepter + Lasso or Dual	G	G	G	G	G	F	F	F	F-G	F	G	F	G	G	G	G	F-G	G	G	F
Scepter + Prowl[4], Treflan, or Sonalan	G	G	G	G	G	G	G	F	F	F	G	F	G	F-G	G	G	F-G	G	G	F
Sencor, Lexone	F	F	F	F	F	P	P	P	P	P	F-P	F-G	G	P	G	F-G	F	G	F	F-G
Surflan[1], Prowl	F-G	G	G	G	G	G	G	F	P	P-F	P	P	G	P	G	P	P	P-F	P	P-F
Postemergence																				
Assure, Fusilade, Option, Poast	G	G	G	G	G	G	G	G	P	P	P	P	P	P	P	P	P	P	P	P
Basagran	F-G	P	P	P	P	P	P	P	F	P-F	G	G	F-P	P	P	F	F-G	G	G	F-G
Blazer, Tackle	F	P-F	P	P-F	P	P	P	P	P	F-G	F	G	F-P	F-G	G	F-G	F	G	F	P-F
Classic	F-G	P	P	P	P	P	P	P	F	F	G	G	P	P	F-G	F	F	G	G	F
Cobra	F	P	P	P	P	P	P	P	P	F	F-G	G	F-P	F-G	G	F-G	F-G	F-P	F	F
Reflex	G	P-F	P	P	P	P	P	P	P	F	F	G	F-P	F-G	G	F-G	F	F-G	F	P-F
Rescue	F-G	P	P	P	P	P	P	P	P	F	G	F	F-P	P	F-G	P	G	P	G	P
Storm, Galaxy	F-G	P	P	P	P	P	P	P	F	F-G	G	G	F-P	F-G	G	F-G	F-G	G	G	F-G
2,4-DB	P-F	P	P	P	P	P	P	P	P	F-G	G	P-F	F	P	F	F	F	P	F	P

[1] Do not use for preplant incorporation.
[2] Salute = Sencor + Treflan
[3] Turbo = Sencor + Dual
[4] Squadron = Prowl + Scepter

Table 5. Relative Effectiveness of Herbicides on Major Weeds (continued)

	Grasses								Broadleaf weeds										
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Sunflower, wild	Velvetleaf
CORN																			
Preplant																			
Butylate, EPTC	F-G	G	G	G	G	F-G	F-G	F-G	P	P	P	P-F	F	G	P	P	P	P	F
Butylate, EPTC + atrazine, Bladex	F-G	G	G	G	G	F-G	F-G	F-G	F-G	F-G	G	G	G	G	G	F	G	F-G	F-G
Princep + atrazine	G	F-G	F-G	F	F	P-F	P-F	P	F-G	F-G	G	G	G	G	G	G	G	G	F
Preplant or preemergence																			
Atrazine	G	F-G	F	P	P	P	P	F	G	F-G	G	G	G	G	G	G	G	F-G	F-G
Bladex	F-G	F-G	F-G	F-G	G	P	P	P	F	F-G	G	G	G	P-F	G	F-G	G	F-G	F-G
Bladex + atrazine[1]	F-G	F-G	F	F	F-G	P	P	P	F-G	F-G	G	G	G	G	G	F-G	G	F-G	F-G
Lasso, Dual	F-G	G	G	G	G	P-F	P-F	F-G	P	P	P	F	F-G	G	P-F	P	P-F	P	P
Lasso or Dual + atrazine or Bladex	F-G	G	G	G	G	P	P	F-G	F-G	F	G	G	G	G	G	F	G	F-G	F
Prowl[2] + atrazine[3] or + Bladex	F	G	G	G	G	F	F	P	F-G	F	G	G	G	G	G	F	G	F-G	F-G
Postemergence																			
Grass or broadleaf																			
Atrazine + oil	F-G	F-G	G	P	P	P	P	F	G	G	G	G	G	G	G	F-G	G	G	G
Bladex	F-G	G	G	F	F-G	P	P	F	F	F-G	G	G	G	P-F	G	F	G	F	F-G
Tandem + atrazine	F-G	G	G	F	P	F	F	F	G	G	G	G	G	G	G	G	G	G	G
Broadleaf only																			
Banvel	F-G	P	P	P	P	P	P	P	G	G	G	G	G	G	G	G	G	G	F
Basagran	G	P	P	P	P	P	P	F	P-F	G	G	F-P	P	P	F	F	G	G	F-G
Buctril	F-G	P	P	P	P	P	P	P	G	G	G	G	G	F	G	F	G	F-G	F
Laddok	G	P	P	P	P	P	P	F-G	G	G	G	G	G	G	G	G	G	G	G
2,4-D	F	P	P	P	P	P	P	P	G	G	F	G	F	G	G	G	F-P	G	F-G

[1] Bladex + atrazine premix = Extrazine II
[2] Do not use Prowl for preplant incorporation.
[3] Prowl + atrazine premix = Prozine

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1989 Weed Control in Small Grains, Pastures, and Forages

Good weed control is necessary for maximum production of high-quality small grains, pastures, and forages in Illinois. When properly established, these crops can usually compete effectively with weeds so that the need for herbicide applications is minimized. Weeds, however, can sometimes become significant problems and warrant control. For example, wild garlic is considered the worst weed problem in wheat in southern Illinois. Because its life cycle is similar to that of winter wheat, wild garlic can establish itself with the wheat, grow to maturity, and produce large quantities of bulblets by wheat-harvest time. Economic considerations make it necessary to attempt some control of wild garlic in winter wheat.

In pastures, woody and herbaceous perennials can become troublesome. Annual grasses and broadleaf weeds such as chickweed and henbit may cause problems in hay crops. Through proper management, many of these weed problems can be controlled effectively.

Several herbicide labels carry the following groundwater warnings under either the environmental hazard or the groundwater advisory section. "X is a chemical that can travel (seep or leach) through soil and enter groundwater which may be used as drinking water. X has been found in groundwater as a result of its use as a herbicide. Users of this product are advised not to apply X where the soils are very permeable (that is, well-drained soils such as loamy sands) and the water table is close to the surface."

Small grains

Good weed control is critical for maximum production of high-quality small grains. Often, weed problems can be dealt with before the crop is established. For example, many broadleaf weeds are controlled effectively in the late fall after corn or soybean harvest with 2,4-D, Banvel (dicamba), or Roundup (glyphosate).

Tillage helps control weeds. Although generally limited to preplant and postharvest operations, tillage can destroy many annual weeds and help suppress certain perennials. Good cultural practices such as proper seeding rate, optimum soil fertility, and timely planting help to ensure the establishment of an excellent stand and a crop that is better able to compete with weeds.

Winter annual grasses such as downy brome and cheat are very competitive in winter wheat. Illinois wheat producers are often limited to preplant tillage operations for control of these species as few herbicides have label clearances for annual grass control in winter wheat. If a severe infestation of downy brome or cheat exists, planting an alternative crop or spring crop may be best.

If annual broadleaf weeds later become a problem, a recommended herbicide may be needed. Postemergence herbicides such as 2,4-D, MCPA, Banvel, and Buctril (bromoxynil) can provide good control of susceptible species (Table 1). Herbicides must be applied during certain growth stages of the crop to maintain crop safety and for optimum weed control. Refer to Figure 1 for a description of the growth stages of small grains.

Some perennial broadleaf weeds, however, may not be controlled satisfactorily at the low herbicide rates used in small grains; and higher rates are not advisable because they can cause serious injury to crops. To control perennial weeds, translocated herbicides such

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Table 1. Effectiveness of Herbicides on Weeds in Small Grains

This table gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Rate of herbicide used will also influence results. E = excellent, G = good, F = fair or variable, and P = poor.

Weed	Life cycle	Susceptibility to herbicide				
		2,4-D	MCPA	Banvel, 0.125 lb rate	Buctril, Brominal	Harmony
Dandelion	perennial	G	F	F	P	P-F
Horseweed (marestail)	annual	F	F	E	F	G
Lambsquarters, common	annual	E	E	E	G	G
Mustard, wild	annual	E	E	P	F	G
Nightshade, eastern black	annual	F	F	G	G	P
Pennycress, field	annual	E	E	P	F	G
Pigweed spp.	annual	E	E	E	F	G
Ragweed, common	annual	E	G	E	F	F
Ragweed, giant	annual	E	G	E	F	P
Shepherdspurse	annual	E	E	F	F	G
Smartweed	annual	P	F	G	G	G
Velvetleaf	annual	G	G	F	F	F-G
Wild buckwheat	annual	P	F	E	G	G
Wild garlic	perennial	F	F	P	P	G
Wild lettuce	annual	E	G	F	F	F

Table 2. Weed Control in Small Grains

Herbicide	Broadcast rate/acre	Remarks	Restrictions
Oats and wheat			
2,4-D, 3.8 lb a.i. (amine)	½ to 1½ pt	Winter wheat more tolerant than oats. Apply in spring after full tiller but before boot stage. Do not treat in fall. Use lower rate of amine if underseeded with legume. Some legume damage may occur. May be used as preharvest treatment at 1 to 2 pints per acre during hard-dough stage.	Do not forage or graze within 2 weeks after treatment. Do not feed treated straw to livestock.
MCPA (amine)	¼ to 3 pt	Less likely than 2,4-D to damage oats and legume underseeding. Apply from 3-leaf stage to boot stage. Rate varies with crop and weed size and presence of legume underseeding.	Do not graze dairy animals on treated areas for 7 days after treatment.
Banvel, 4 lb a.i.	4 fl oz	Do not apply to small grains with legume underseeding. In fall-seeded wheat, apply before jointing stage. In spring-seeded oats, apply before oats exceed 5-leaf stage.	Do not graze or harvest for dairy feed before ensilage (milk) stage.
Buctril 2E	1 to 2 pt	Apply Buctril alone to fall-seeded small grains in the fall or spring, but before the boot stage. Weeds are best controlled before the 3- to 4-leaf stage. Buctril may be applied at 1 to 1½ pints per acre to small grains underseeded with alfalfa.	Do not graze treated fields for 30 days after application.
Wheat only			
2,4-D, 3.8 lb a.i. (ester)	½ to ¾ pt	Do not apply to wheat with legume underseeding. Apply in spring after full tiller but before boot stage. For preharvest treatment, apply 1 to 2 pints per acre during hard-dough stage. For control of wild garlic or wild onion, apply 1 to 2 pints in the spring when wheat is 4 to 8 inches high, after tillering but before jointing; these rates may injure the crop.	Do not forage or graze within 2 weeks after treatment. See current label for additional restrictions.
Harmony 75DF	⅓ to ⅔ oz	Apply to the crop after the 2-leaf stage, but before the boot stage. Wild garlic should be 6 to 12 inches tall, with 4 to 6 inches of new growth. Nonionic surfactant at 0.25% v/v or 1% v/v crop-oil concentrate should be included in the spray mixture unless liquid fertilizer is used as the carrier.	Do not plant to any crop other than wheat or barley within 30 days after application. Do not apply to cereals underseeded with legumes.

Table 3. Effectiveness of Herbicides on Weeds in Grass Pastures

This table gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Rate of herbicide used will also influence results. E = excellent, G = good, F = fair or variable, P = poor, and N = none.

Weed	Life cycle	Susceptibility to herbicide			
		2,4-D	Banvel	Crossbow	Roundup
Burdock, common	biennial	E	E	E	G
Daisy, oxeye	perennial	F	E	E	G
Dandelion	perennial	E	E	E	F
Dock, curly	perennial	P-F	E	E	G
Goldenrod spp.	perennial	F	G	F	E
Horseweed (marestail)	annual	G	E	E	E
Ironweed	perennial	F	G	G	E
Milkweed, common	perennial	P	F	F	F
Multiflora rose	perennial	F	G	E	G
Nettle, stinging	perennial	G	G	G	G
Pennycress, field	annual	E	F	G	E
Plantain spp.	perennial	E	G	E	G
Poison hemlock	biennial	G	E	E	G
Ragweed, common	annual	E	E	E	E
Ragweed, giant	annual	E	E	E	E
Snakeroot, white	perennial	F	G	G	G
Sorrel, red	perennial	N	E	E	E
Sowthistle	perennial	F	G	E	G
Thistle, bull	biennial	E	E	E	E
Thistle, Canada	perennial	F	E	E	G
Thistle, musk	biennial	E	G	G	E
Water hemlock, spotted	perennial	G	E	E	G

as 2,4-D, Banvel, or Roundup, in combination with tillage after corn or soybean harvest but before establishing small grains, may be the best approach.

Wild garlic continues to be a major weed problem in winter wheat. Harmony (DPX-M6316), now registered for use in winter wheat, has given good control of wild garlic in University of Illinois research trials. When applied in the spring at 0.33 to 0.66 ounce of 75 DF per acre, Harmony effectively controls wild garlic aerial bulblets and some underground bulbs as well. Harmony also controls common lambsquarters, smartweed, and many species of mustard. See Tables 1 and 2 for additional weed control information for Harmony.

A decision to use postemergence herbicides for broadleaf weed control in small grains should be based on several considerations:

1. *Nature of the weed problem.* Identify the species present and consider the severity of the infestation. Also note the size of the weeds. Weeds are usually best controlled while small.
2. *Stage of the crop.* Most herbicides are applied after full tiller until the boot stage. Do not apply herbicides from the boot stage to the hard-dough stage of most small grains. (See Figure 1 for a description of growth stages of small grains.)
3. *Presence of a legume underseeding.* Usually 2,4-D ester formulations and certain other herbicides listed in Table 2 should not be applied because they may damage the legume underseeding.
4. *Herbicide activity.* Determine crop tolerance and weed susceptibility to herbicides by referring to Tables 1 and 2. The lower rates in Table 2 are for more easily controlled weeds and the higher rates for the more difficult to control species. Tank-mixes may broaden the weed spectrum and thereby improve control; check the herbicide label for registered combinations.
5. *Economic justification.* Consider the cost of the treatment in terms of potential benefits such as the value of increased yield, improved quality of grain, and ease of harvesting the crop.

Table 2 outlines current suggestions for weed control options in wheat and oats, the two small grains most commonly grown in Illinois. Always consult the herbicide label for specific information about the use of a given product.

Grass pastures

Unless properly managed, broadleaf weeds can become a serious problem in grass pastures. They can compete directly with forage grasses and reduce the nutritional value and longevity of the pasture. Certain species, such as white snakeroot and poison hemlock, are also poisonous to livestock and may require special consideration.

Perennial weeds are probably of greatest concern. They can exist for many years, reproducing from both seed and underground parent rootstocks. Occasional mowing or grazing helps control certain annual weeds, but perennials can grow back from underground root reserves unless long-term control strategies are implemented.

Table 4. Broadleaf Weed Control in Grass Pastures

Herbicide	Rate/acre	Remarks	Restrictions
2,4-D, 3.8 lb a.i. (amine or low-volatile ester)	2 to 4 pt	Broadleaf weeds should be actively growing. Higher rates may be needed for less susceptible weeds and some perennials. Spray bull or musk thistles in the rosette stage (spring or fall) while they are actively growing. Spray perennials such as Canada thistle in the bud stage. Spray susceptible woody species in spring when leaves are fully expanded.	Do not graze dairy animals within 7 days after treatment. Do not apply to newly seeded areas or after heading begins. Do not apply to grass when it is in boot to milk stage.
Banvel, 4 lb a.i.	Annuals: ½ to 1½ pt Biennials: ½ to 3 pt Perennials: 1 to 2 pt (suppression) Perennials: 1 to 6 qt (control) Woody brush: 1 to 2 pt (suppression) Woody brush: 1 to 8 qt (control)	Use lower rates for susceptible annuals when they are small and actively growing and for susceptible biennials in the early rosette stage. Use higher rates for larger weeds, for less susceptible weeds, for established perennials in dense stands, and for certain woody brush species.	Refer to label for specific timing restrictions for lactating dairy animals. Remove meat animals from treated areas 30 days before slaughter.
Crossbow	Annuals: 1-2 qt Biennials and herbaceous perennials: 2 to 4 qt Woody perennials: 6 qt	Apply to foliage during warm weather when brush and broadleaf weeds are actively growing. When applying as a spot spray, thoroughly wet all foliage. Be cautious of vapor and particle drift, as Crossbow may injure susceptible crops growing nearby. See herbicide label for more specific rate recommendations.	Remove livestock from treated forage at least 3 days before slaughter during the year of treatment. Do not graze lactating dairy animals on treated areas for one year following treatment. Do not harvest grass for hay from treated areas for one year following treatment.
Roundup	2% solution (spot treatment)	Controls a variety of herbaceous and woody brush species such as multiflora rose, brambles, poison ivy, quackgrass. Spray foliage of target vegetation completely and uniformly, but not to point of runoff. Avoid contact with desirable nontarget vegetation. Consult label for recommended timing of application for maximum effectiveness on target species.	No more than 1/10 of any acre should be treated at one time. Further applications may be made in the same area at 30-day intervals. Allow 14 days after application before grazing or harvesting forage.
Spike Brush Bullets	4-16 bullets/100 sq ft (See label rates for specific species.)	For control of brush and woody plants in rangeland and grass pastures. Requires sufficient rainfall to move herbicide into root zone. May kill or injure desirable legumes and grasses where contact is made. Injury is minimized by applying when grasses are dormant.	Do not apply on or near field crops or other desirable vegetation. Do not apply where soil movement is likely. Refer to label for additional restrictions.
Spike 20P	10-20 lb	Remarks and restrictions are the same as for Brush Bullets above.	

Certain biennials can also flourish in grass pastures. The first year, they exist as a prostrate rosette, so that even close mowing does little to control their growth. The second year, biennials produce a seedstalk and a deep taproot. If these weeds are grazed or mowed at this stage, root reserves can sometimes enable the plant to grow again, thereby increasing its chance of surviving to maturity.

In general, the use of good cultural practices such as maintaining optimum soil fertility, rotational grazing, and periodic mowing can help keep grass pastures in good condition and more competitive with weeds. Where broadleaf weeds become troublesome, however, 2,4-D or Banvel may be used. Roundup may also be used as a spot treatment, and Crossbow (2,4-D plus triclopyr) is labeled for control of broadleaf and woody plant species in permanent grass pastures. Certain formulations of Spike (tebuthiuron) may also be used in grass pastures for brush and woody plant control. (See Tables 3 and 4 for additional information.)

Proper identification of target weed species is important. As shown in Table 3, weeds vary in their susceptibility to herbicides. Timing of herbicide application may also affect the degree of weed control. Annuals and biennials are most easily controlled while young and relatively small. A fall or early spring treatment works best if biennials or winter annuals are the main weed problem. Summer annuals are most easily controlled in the spring or early summer. Apply translocated herbicides to control established perennials when the weeds are in the bud to bloom stage. Perennials are most susceptible at this reproductive phase because translocated herbicides can move downward with food reserves to the roots, potentially killing the entire plant.

For control of woody brush, apply 2,4-D, Banvel,

or Crossbow when the plants are fully leafed and actively growing. Where regrowth occurs, a second treatment may be needed in the fall. During the dormant season, oil-soluble formulations of 2,4-D, Banvel or Crossbow may be used in fuel oil. Spike controls many woody perennials and should be applied to the soil in the spring. Spike requires rainfall to move it into the root zone of target species.

The weed control options in grass pastures are shown in Table 4. Be cautious with any pesticide and always consult the herbicide label for specific information about the use of a given product.

Forage legumes

Weed control is very important in managing forage legumes. Weeds can severely reduce the vigor of legume stands and thus reduce yield and forage quality. Good management begins with weed control practices that prevent weeds from becoming serious problems.

Establishment. To minimize problems, prepare the seedbed properly so that it is firm and weed-free. Select an appropriate legume variety. If you use high-quality seed and follow the recommendations for liming and fertility, the legume crop may crowd out many weeds and reduce the need for herbicides.

In fields where companion crops such as oats are used to reduce weed competition, seed the small grain at half the rate for grain production to ensure that the legumes will become established with minimum stress. If the legume is seeded without a companion crop (direct seeded), the use of an appropriate herbicide is suggested.

Balan (benefin) and Eptam or Genep (EPTC) are registered for preplant incorporation for legumes that are not seeded with grass or small-grain companion crops. These herbicides will control most annual grasses and some broadleaf weeds. In fall plantings, the weeds controlled include winter annuals such as downy brome and cheat. In spring legume plantings, the summer annual weeds controlled include foxtails, pigweeds, lambsquarters, crabgrass, and fall panicum.

Eptam or Genep can help suppress johnsongrass and quackgrass seedlings, yellow nutsedge, and shattercane, in addition to many annual grasses and some broadleaf weeds. Neither one will effectively control mustards, smartweed, or established perennials. Balan, Eptam, and Genep, *must* be thoroughly incorporated soon after application to avoid herbicide loss. They should be applied shortly before the legume is seeded, so they remain effective as long as possible into the growing season.

Weeds that emerge during crop establishment should be evaluated for their potential to become problems. If they do not reduce the nutritional value of the forage or if they can be controlled by mowing, they should not be the primary target of a postemergence herbicide. For example, winter annual weeds do not compete vigorously with the crop after the first spring cutting. Unless they are unusually dense or production of weed seed becomes a concern, these weeds may not be a significant problem. Some weeds such as dandelions are palatable and may not need to be controlled if the overall legume stand is dense and healthy; but undesirable weeds must be controlled early to prevent their establishment.

Poast (sethoxydim) may be applied to seedling alfalfa for control of annual and some perennial grass weeds after weed emergence. Grasses are more easily controlled when small, and alfalfa is tolerant to Poast at all stages of growth. Butyrac or Butoxone (2,4-DB) controls many broadleaf weeds and may be applied postemergence in many seedling forage legumes. Buctril (bromoxynil) may now be used to control broadleaf weeds in seedling alfalfa. Be sure to apply Buctril while weeds are small. (See Table 6 for specific weed control ratings.)

Established legumes. The best weed control in established forage legumes is maintenance of a dense, healthy stand via proper management techniques. Chemical weed control in established forage legumes is often limited to late fall or early spring applications of herbicide. Sencor or Lexone (metribuzin), Sinbar (terbacil), and Velpar (hexazinone) are applied after the last cutting in the fall or in the early spring. These herbicides control many broadleaf weeds and some grasses, too. Kerb (pronamide) is used for grass control and is applied in the fall after the last cutting. 2,4-DB controls many broadleaf weeds in established alfalfa; 2,4-DB should be applied when the weeds are small and actively growing. Refer to Tables 5 and 6 for additional remarks and weed control suggestions.

Once grass weeds have emerged, they are particularly difficult to control in established alfalfa. Poast herbicide may be used in established alfalfa for control of annual and some perennial grasses. Optimum grass control is achieved if Poast is applied when grasses are small and before the weeds are mowed.

Table 5 outlines current suggestions for weed control options in legume forages. The degree of control will often vary with weed size, application rate, and environmental conditions. Be sure to select the correct herbicide for the specific weeds to be controlled (Table 6). Always consult the herbicide label for specific information about the use of a given product.

Acreage Conservation Reserve Program

The Acreage Conservation Reserve Program (ACR) continues to occupy substantial farmland in Illinois. Investing in good weed control on ACR land may help alleviate some problem weeds when rotating back to row crops. For example, perennial broadleaf weeds such as hemp dogbane and common milkweed may be controlled or suppressed under small-grain production or when a perennial grass or legume species is grown. In addition, mowing or alternative herbicide options may be available. Whether using tillage, mowing, herbicides, or combinations, the best approach is to remain flexible and utilize cost-effective methods that fit your weed problems and management system.

Table 5. Weed Control in Forages

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks	Restrictions
PURE LEGUME FORAGES					
Seedling year					
Balan 1.5EC	Alfalfa, birdsfoot trefoil, red clover, ladino clover, alsike clover	Preplant incorporated	3 to 4 qt	Apply shortly before seeding. Do not use with any companion crop of small grains.	Do not use on soils high in organic matter.
Eptam 7E,10G or Genep 7E	Alfalfa, birdsfoot trefoil, lespedeza, clovers	Preplant incorporated	3½ to 4½ pt 30 lb	Apply shortly before seeding. Do not use with any companion crop of small grains.	Do not use on white Dutch clover.
Buctril 2E	Alfalfa only	Postemergence	1 to 1½ pt	Apply in the fall or spring to seedling alfalfa with at least 2 trifoliate leaves. Apply to weeds at or before the 4-leaf stage or 2 inches in height (whichever is first). May be tank-mixed with 2,4-DB for improved control of kochia and pigweed.	Do not apply when temperatures are likely to exceed 70°F at application or for the 3 days following application or when the crop is stressed. Do not add a surfactant or crop oil. Do not harvest or graze spring-treated alfalfa within 30 days and fall-treated alfalfa within 60 days following treatment (60 days if tank-mixed with 2,4-DB).
Butyrac 200 or Butoxone 2,4-DB	Alfalfa, birdsfoot trefoil, ladino clover, red clover, alsike clover, white clover	Postemergence	1 to 3 qt (amine) 3 to 4 pt (ester)	Use amine or ester formulation when weeds are less than 3 inches tall or less than 3 inches across if rosettes. Use higher rates for seedling smartweed or curly dock. Do not use on sweet clover.	Do not harvest or graze for 60 days following treatment.
Furloe 4EC	Alfalfa Certain clovers and birdsfoot trefoil	Postemergence	1 to 3 qt 1 to 2 qt	Apply after the 4-leaf stage in alfalfa. Used mainly for chickweed control.	Do not harvest or graze for 40 days.
Kerb 50W	Alfalfa, birdsfoot trefoil, crown vetch, clovers	Postemergence	1 to 3 lb	In fall-seeded legumes, apply after legumes have reached trifoliate stage. In spring-seeded legumes, apply next fall.	Do not graze or harvest for 120 days following application.
Poast 1.5E	Alfalfa only	Postemergence	¾ to 1½ pt	Alfalfa is tolerant of Poast at all stages of growth. Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB harvest and grazing restrictions.	Do not apply Poast within 7 days of grazing, feeding, or harvesting undried forage, or within 20 days of harvesting dry hay. Do not apply more than a total of 5 pints of Poast per acre in one season. Apply by ground equipment only.
Established stands					
Butyrac 200 or Butoxone	Alfalfa only	Growing	1 to 3 qt (amine) 3 to 4 pt (ester)	Use amine or ester formulation. Spray when weeds are less than 3 inches tall or less than 3 inches wide if rosettes. Fall treatment of fall-emerged weeds may be better than spring treatment. Do not apply to sweet clover.	Do not harvest or graze for 30 days following application.
Furloe 4EC	Alfalfa Certain clovers and birdsfoot trefoil	Growing and dormant	1 to 3 qt 1 to 2 qt	Apply when moisture is sufficient to move herbicide into root zone. Used mainly for chickweed control.	Do not harvest or graze for 40 days following application.
Kerb 50W	Alfalfa, birdsfoot trefoil, crown vetch, clovers	Growing or dormant	1 to 3 lb	Apply in the fall after last cutting, when weather and soil temperatures are cool.	Do not harvest or graze for 120 days.

Table 5. Weed Control in Forages (continued)

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks	Restrictions
Sencor or Lexone	Alfalfa only	Dormant	¾ to 2 pt (4L) ½ to 1⅓ lb (75 DF) ¾ to 2 lb (50 WP)	Apply once in the fall or spring before new growth starts. Rate is based upon soil type and organic-matter content.	Do not use on sandy soils or soils with pH greater than 7.5. Do not graze or harvest for 28 days.
Sinbar 80W	Alfalfa only	Dormant	½ to 1½ lb	Apply once in the fall or spring before new growth starts. Use lower rates for coarser soils.	Do not use on sandy soils with less than 1% organic matter. Do not plant any crop for 2 years.
Velpar L	Alfalfa only	Dormant	1 to 3 qt	Apply in the fall or spring before new growth exceeds 2 inches in height. Can also be applied to stubble after hay crop removal but before regrowth exceeds 2 inches.	Do not plant any crop except corn within 2 years of treatment. Corn may be planted 12 months after treatment, provided deep tillage is used. Do not graze or harvest for 30 days.
Poast 1.5E	Alfalfa only	Postemergence	¾ to 1½ pt	Alfalfa is tolerant of Poast at all stages of growth. Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions.	Do not apply Poast within 7 days of grazing, feeding, or harvesting undried forage, or within 20 days of harvesting dry hay. Do not apply more than a total of 5 pints of Poast per acre in one season. Apply by ground equipment only.
Gramoxone Super	Alfalfa only	Dormant	2½ to 4 pt	Apply after last fall cutting or before sping growth is 1 inch tall. Weeds should be succulent and growing at the time of application. Weeds germinating after treatment will not be controlled. Add surfactant as label indicates.	A restricted-use herbicide. Do not apply if fall regrowth following the last fall cutting is more than 6 inches tall. Do not harvest or graze for 60 days.
Roundup	Alfalfa or clover	Growing	2% solution (spot treatment)	Apply to actively growing, susceptible weeds. Avoid contact with desirable, nontarget vegetation because damage may occur. Refer to label for recommended timing of application for maximum effectiveness on target species.	No more than 1/10 of any acre should be treated at one time. Further applications may be made in the same area at 30-day intervals. Do not graze or harvest for 14 days.
MIXED GRASS-LEGUME FORAGES Established stands					
Sencor or Lexone	Alfalfa-grass mixtures	Dormant	¾ to 1½ pt (4L) ½ to 1 lb (75 DF) ¾ to 1½ lb (50 WP)	Apply once in the fall or spring before new growth starts. Rate based on soil type and organic matter content. Higher rates may injure grass component.	Do not use on sandy soils or soils with pH greater than 7.5. Do not graze or harvest for 28 days.
Roundup	Alfalfa or clover-grass mixture	Growing	2% solution (spot treatment)	Apply to actively growing, susceptible weeds. Avoid contact with desirable, nontarget vegetation because damage may occur. Refer to label for recommended timing of application for maximum effectiveness on target species.	No more than 1/10 of any acre should be treated at one time. Further applications may be made in the same area at 30-day intervals. Do not graze or harvest for 14 days.

Table 6. Effectiveness of Herbicides on Weeds in Legume and Legume-Grass[a] Forages

This table gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Rate of herbicide used will also influence results. E = excellent, G = good, F = fair or variable, P = poor, and N = none.

	Balan	Genep, Eptam	Butyrac, Butoxone	Furloe	Kerb	Paraquat, Gramoxone	Sencor, Lexone[a]	Sinbar	Velpar	Roundup[a]	Poast	Buctril
Barnyardgrass	G	G	P	P	F	F	F	F	G	E	E	N
Chickweed, common	P	P	P	G	F	G	G	G	G	E	N	P
Crabgrass	G	G	P	P	F	F	F	G	G	E	E	N
Dandelion	P	P	F	P	P	F	G	P	G	G	N	P
Dock, curly	P	P	P	P	P	F	P	P	P	G	N	P
Downy brome	G	G	P	G	G	G	G	G	F	G	E	N
Fall panicum	G	G	P	P	P	F	F	P	P	E	E	N
Field pennycress	P	P	G	P	P	G	G	G	G	E	N	G
Foxtails	G	G	P	P	F	F	F	G	G	E	E	N
Henbit	P	G	P	P	F	G	G	G	F	G	N	F
Lambsquarters	G	G	F	P	P	F	G	G	G	E	N	G
Mustard, wild	P	P	E	P	P	G	G	G	G	E	N	F
Nightshade[b]	P	F	F	F	P	F	G	P	P	G	N	G
Orchardgrass	P	P	P	P	F	F	F	F	G	F	P-F	N
Pigweed	G	G	F	P	P	F	G	F	G	E	N	F
Quackgrass	P	F	P	P	G	P	F	F	F	G	F	N
Ragweed, common	P	P	G	P	P	F	G	F	F	E	N	G
Shepherdspurse	P	P	G	P	P	G	G	G	G	E	N	G
Smartweed	P	P	P	F	P	F	F	F	F	E	N	G
Yellow nutsedge	P	F	P	P	P	P	P	P	P	F	N	P

[a] Sencor, Lexone, and Roundup are labeled for use in mixed legume-grass forages. No other herbicides are cleared for this use.
[b] Control of different species may vary.

Clover, alfalfa, or other forage legumes may be one of the best options for ACR acres. The cover helps conserve soil, improves soil structure, and adds nitrogen. Clover and alfalfa can be very economical, particularly if grown for at least two consecutive years. The use of a herbicide for legume establishment can allow a vigorous legume stand and alleviate the need for weed control measures later. If annual broadleaf weeds become a problem, applying 2,4-DB or mowing is another helpful option. Herbicides for use on forage legumes on ACR acres include those registered for commercial production fields and are listed in Table 5. In addition, Treflan (trifluralin) or Prowl (pendimethalin) may be used preplant incorporated to control annual grasses and some small-seeded broadleaf weeds. Some stand reduction may occur with Treflan or Prowl, but good weed control can compensate to allow for excellent establishment of the legume. Fusilade (fluazifop), Option (fenoxaprop), and Poast (sethoxidim) may be used for grass control postemergence on forage legumes on ACR land. With many of these products, haying and grazing are not allowed, therefore be sure to follow all restrictions imposed by the pesticide label.

Oats are commonly grown as a cover crop on set-aside acres. Oat seed is inexpensive and easy to obtain. If the Agricultural Stabilization and Conservation Service (ASCS) does not require clipping before seed maturity, oats can reseed themselves for fall cover. Wheat, rye, and barley are other small-grain cover crop possibilities.

Sowing clean oat, wheat, rye, or barley seed is the first step to minimizing weed problems. Small grains generally provide relatively good cover until they mature or the area is mowed; then weeds can soon proliferate. However, winter wheat or rye may be sown in the spring, and without the overwintering period (vernalization), little or no seed production occurs and a dense cover remains. Hoelon (diclofop) is one of the few options for control of grass weeds in wheat. Annual broadleaf weeds can be controlled by mowing and by the use of the herbicides listed in Table 2. Tillage prior to small-grain planting will help control established weeds.

Planting a small-grain/legume combination is another option for set-aside. Utilizing the small grain as a nurse or companion crop may help reduce weed pressure and alleviate the need for herbicides. If weeds become a problem, refer to Table 5 for more information in selecting the appropriate herbicide. In addition to those herbicides listed in Table 5, Buctril may also be used to control broadleaf weeds in seedling alfalfa-grass mixes on Conservation Reserve Program acres. Refer to current label rates and restrictions.

Sorghum-sudan grass can make a rapid, vigorous cover that also effectively suppresses many weeds. Although herbicides are rarely needed in sorghum-sudan grass stands, mowing and tillage may be difficult; and viable seed sometimes causes weed problems the next year.

Acreage Conservation Reserve land offers a unique opportunity for controlling problem weeds such as perennials and keeping other more common weeds in check. By managing ACR land this year, controlling weeds in future row crops will be less difficult and more profitable.

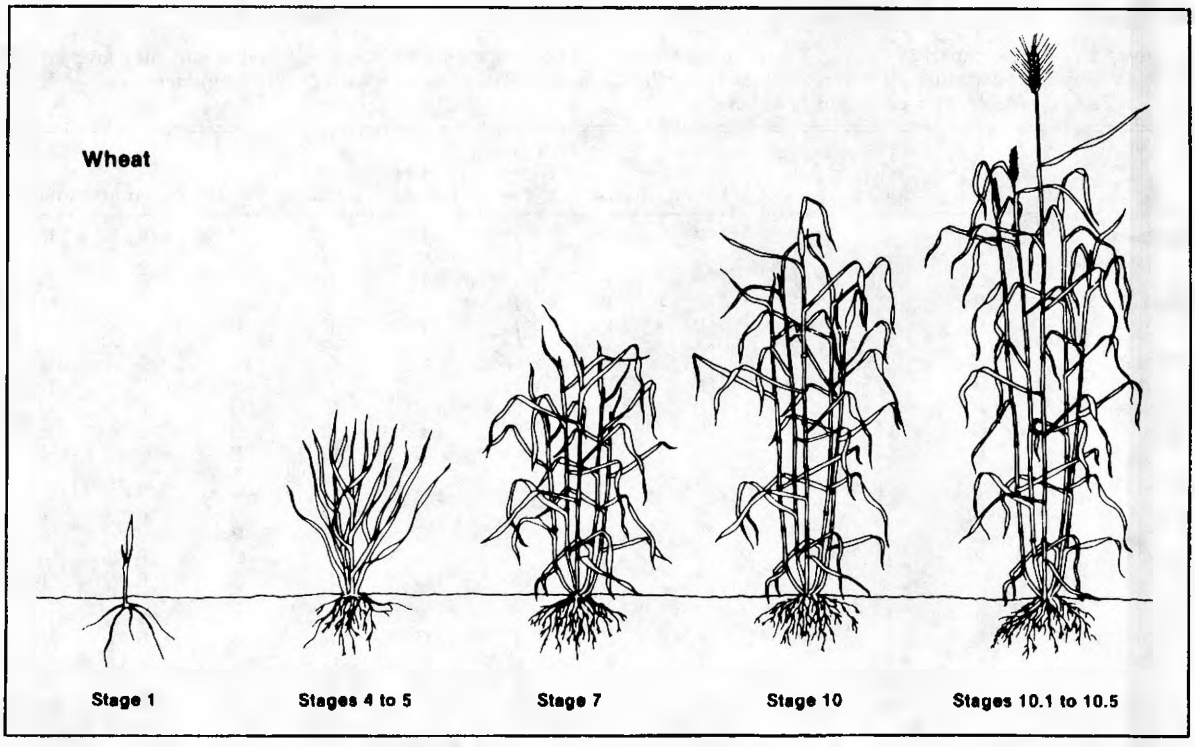

Figure 1. Growth stages of small grains.

Seedling

Stage 1. The coleoptile, a protective sheath that surrounds the shoot, emerges. The first leaf emerges through the coleoptile, and other leaves follow in succession from within the sheath of the previously emerging leaf.

Tillering

Stages 2 to 3. Tillers (shoots) emerge on opposite sides of the plant from buds in the axils of the first and second leaves. The next tillers may arise from the first shoot at a point above the first and second tillers or from the tillers themselves. This process is repeated until a plant has several shoots.

Stages 4 to 5. Leaf sheaths lengthen, giving the appearance of a stem. The true stems in both the main shoot and in the tillers are short and concealed within the leaf sheaths.

Jointing

Stage 6. The stems and leaf sheaths begin to elongate rapidly, and the first node (joint) of the stem is visible at the base of the shoot.

Stage 7. Second node (joint) of stem is visible. The next-to-last leaf is emerging from within the sheath of the previous leaf but is barely visible.

Stage 8. Last leaf, the "flag leaf," is visible but still rolled.

Stage 9: Preboot stage. Ligule of flag leaf is visible. The head begins to enlarge within the sheath.

Stage 10: Boot stage. Sheath of flag leaf is completely emerged and distended because of enlarging but not yet visible head.

Heading

Stages 10.1 to 10.5. Heads of the main stem usually emerge first, followed in turn by heads of tillers in order of their development. Heading continues until all heads are out of their sheaths. The uppermost internode continues to lengthen until the head is raised several inches above the uppermost leaf sheath.

Flowering

Stages 10.5.1 to 10.5.3. Flowering progresses in order of head emergence. Unpollinated flowers result in barren kernels.

Stage 10.5.4: Premilk stage. Flowering is complete. The inner fluid is abundant and clear in the developing kernels of the flowers pollinated first.

Ripening

Stage 11.1: Milk stage. Kernel fluid is milky white because of accumulating starch.

Stage 11.2: Dough stage. Kernel contents are soft and dry (doughy) as starch accumulation continues. The plant leaves and stems are yellow.

Stage 11.3. The kernel is hard, difficult to divide with the thumbnail.

Stage 11.4. Ripe for cutting. Kernel will fragment when crushed. The plant is dry and brittle.

Weed Management Guide 1989
FOR COMMERCIAL VEGETABLE GROWERS

The University of Illinois and its agents assume no responsibility for results from the use of herbicides, whether or not they were used in accordance with suggestions, recommendations, or directions of the manufacturer or any governmental agency.

WEEDS POSE one of the most important threats to the income of vegetable growers in the United States, causing millions of dollars in losses as a result of lower yields, poorer quality, and reduced efficiency. Herbicides are only part of a complete weed control program that should include mechanical control, mulches, crop rotation, and herbicides as needed. As you decide which weed control methods and which labeled herbicides to use, take into account past weed infestations, the present crop, planned future crop rotations, soil types, and pesticide prices.

In some instances, a weed control program may include only mechanical control, but in other instances, herbicides will be required to supplement mechanical control. Use a cultivator or a sharp hoe to cut weeds off while breaking up the soil crust. Do not till too deeply, or shallow-rooted crops may be injured and a fresh supply of weed seeds may germinate.

Plastic mulches, besides controlling weeds, will conserve moisture and increase the soil temperature, which can improve early season crop growth. Only herbicides labeled for the crop should be used between rows of mulch. Care should be used if a herbicide is applied under the mulch because crop injury can occur. Treflan, Prowl, Sonalan, and other herbicides that volatilize should not be applied under mulches or row covers.

Crop rotation should also be considered an integral part of vegetable-crop weed control. By rotating fields among different families of crops (for example, between muskmelon and soybeans), problems with diseases, insects, or weeds can sometimes be avoided. A wider spectrum of herbicides is generally available for use in agronomic crops, so weed problems that cannot be controlled in vegetable crops may be controlled in agronomic crops. You should scout your area to determine the existing weed problems, and if these weeds are difficult to control in planned future crops, you should consider other crops.

Several herbicides are often labeled for a crop. The choice of which of these herbicides to use is yours. Scouting your area to determine which weeds are present will allow you to select the herbicide that will give you the best results. Tank mixes can be used to give broader spectrum control. Check the labels for the specific tank mixes that are allowed.

All the herbicides labeled for a given crop are not necessarily listed below. Also, because revisions may change some herbicide uses, always read and follow carefully the directions on a current herbicide label before using any product. If you are unfamiliar with a herbicide, conduct a small evaluation under your environmental conditions and cultural practices before using the herbicide extensively.

Always Read and Understand the Herbicide Label Before Using the Product

Reading the herbicide label carefully is the most profitable use of your time spent in weed control. Information on the label will direct you to the correct uses, application methods, and rates. Following label directions will result in the best possible control with minimal crop injury. The label contains restrictions on use and discusses environmental and soil conditions

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that affect crop injury and influence the effectiveness of weed control. *Do not use any herbicide unless the label states that it is cleared for your particular use and crop.*

The label also states whether the herbicide is a restricted-use or general-use pesticide. Restricted-use pesticide labels contain a statement that the products are restricted, and that only licensed applicators can buy them and supervise their application. At present the only restricted-use herbicides labeled for vegetable crops are Bladex and Gramoxone. Any person who uses a restricted-use herbicide must be licensed as a private or commercial applicator by the Illinois Department of Agriculture. Consult your county Extension adviser for information about this program.

The information in this circular is current as of the date of publication. Watch for notices of changes in the EPA registration of herbicides in the *Illinois Vegetable Farmer's Letter* or the *Insect, Weed, and Plant Disease Survey Bulletin.* Contact your county Extension adviser or Vegetable Crops Extension, University of Illinois, 1103 W. Dorner Drive, Urbana, Illinois 61801, for subscription information.

Growers with Several Vegetable Crops

Growers with several vegetable crops in a small area should consider using a low-percentage granular herbicide. *Check the herbicide label closely for rates and application techniques. Application must be uniform and accurate or crop injury can occur.* Consult Table 1 for a herbicide that can be used on your crop. Be sure to follow the label directions that pertain to each crop on which the herbicide will be applied.

Stale Seedbed Treatment

Roundup, dalapon, or Gramoxone can be applied outside the normal growing season to control emerged weeds. Weeds should be growing actively and the application must be made before the crop has emerged. If you are applying Roundup to control perennial weeds, it is recommended that Roundup be applied before working the soil. Once Roundup has been applied, it must be allowed to translocate throughout the perennial weed for several days or incomplete control may result. Follow Roundup label directions carefully for the rates and timing of application. If perennial weeds are not a major problem, you can eliminate early flushes of weeds by preparing the soil 10 to 14 days before planting and then applying Roundup, dalapon, or Gramoxone to all weeds that emerge. Plant the crop with minimal reworking of the soil. Never apply Roundup or Gramoxone to an emerged crop because severe crop injury or death will occur.

Roundup and Gramoxone will control most annual broadleaf and grass weeds. Neither herbicide has any soil residual activity, so other weed control measures will be necessary during the growing season. Gramoxone will also suppress perennials by killing their shoots, but it should not be expected to control regrowth of perennial weeds from rhizomes or other underground storage organs. Roundup is better for controlling perennials, because it will kill shoots and translocate to destroy underground parts. Roundup will only suppress some particularly hard-to-control perennials such as bindweed, hemp dogbane, and milkweed. To obtain control of these perennials, applications of high rates or repeat applications of glyphosate (within label guidelines), or mechanical removal may be necessary.

How to Use This Circular

There are four tables in this circular. First, use Table 1 to determine the herbicides that are labeled for use in your crop. If you are not certain of the herbicide name, both the common name and the trade names of all herbicides in this circular are listed in Table 4. Once you have determined which herbicides are available and the weeds present, use Table 2 to determine which of the labeled herbicides will provide the best control. Then consult Table 3 for restrictions, precautions, and other considerations that may limit your use of a particular herbicide. These tables are not intended to replace careful reading of a current herbicide label. **ALWAYS READ THE LABEL BEFORE APPLYING ANY PESTICIDE.**

Table 1. Herbicides Labeled for Use in Vegetable Crops

	AAtrex, others (atrazine)	Alanap (naptalam)	Amiben (chloramben)	Balan (benefin)	Basagran (bentazon)	Bladex (cyanazine)	Brominal (bromoxynil)	Chem Hoe (propham)	Command (clomazone)	2,4-D amine	Dacthal (DCPA)	Dalapon 85, others (dalapon)	Devrinol (napropamide)	Dual (metolachlor)	Enide (diphenamid)	Eptam, Genep (EPTC)	Eradicane Extra (EPTC + safener + extender)	Furloe (chlorpropham)	Fusilade 2000 (fluazifop-butyl)	Genate Plus, Sutan + (butylate + safener)	Goal (oxyfluorfen)	Gramoxone (paraquat)	Karmex, others (diuron)	Kerb (pronamide)	Lasso (alachlor)	Lexone, Sencor (metribuzin)	Linex, Lorox (linuron)	Poast (sethoxydim)	Prefar (bensulide)	Princep, others (simazine)	Prowl (pendimethalin)	Pyramin (pyrazon)	Ramrod (propachlor)	Randox (CDAA)	Rhonox, others (MCPA)	Ro-Neet (cycloate)	Roundup (glyphosate)	Sinbar (terbacil)	Sonalan (ethalfluralin)	Surpass (vernolate)	Surflan (oryzalin)	Thistrol (MCPB)	Tillam (pebulate)	Treflan (trifluralin)
Asparagus			X							X		X	X						X		X	X			X		X		X						X	X						X
Broccoli											X		X								X	X						X								X						X
Cabbage											X		X								X	X						X						X		X						X
Carrot																		X	X			X			X										X						X
Cauliflower											X		X								X	X						X								X						X
Collard											X											X														X						X
Cucumber		X	X								X											X						X	X													
Dry Beans			X		X						X			X		X																			X		X					X
Eggplant											X		X									X						X														
Greens											X											X						X								X						X
Horseradish											X																									X						
Lettuce				X				X														X		X				X	X							X						
Lima Bean			X		X						X			X				X							X											X		X				X
Muskmelon		X	X								X											X						X	X													
Okra															X																					X						X
Onion							X				X							X	X		X	X														X						
Peas					X			X				X		X								X										X		X		X				X		X
Pepper			X								X		X		X							X						X														X
Popcorn	X				X					X				X			X			X					X		X			X					X			X				
Potato											X	X		X	X	X						X				X					X					X				X		X
Pumpkin			X						X													X						X	X				X									
Snap Beans			X		X						X	X		X		X						X														X						X
Squash			X								X											X						X	X							X						
Sweet Corn	X				X	X				X				X			X			X					X					X	X		X			X			X			
Table Beet																																X			X	X							
Tomato			X								X	X		X	X							X			X		X	X								X					X	X
Turnip											X	X										X														X						X
Watermelon		X									X											X						X	X													

Table 2. Weed Susceptibility to Herbicides Labeled for Use in Vegetable Crops

Herbicide	Weeds controlled	
	Grasses	Broadleaves
AAtrex, others (atrazine)	barnyardgrass, foxtail, crabgrass	cocklebur, jimsonweed, lambsquarters, mustard, annual morningglory, nightshade, pigweed, purslane, ragweed, velvetleaf
Alanap (naptalam)		carpetweed, chickweed, cocklebur, hairy galinsoga, lambsquarters, purslane, ragweed
Amiben (chloramben)	barnyardgrass, foxtail, crabgrass, goosegrass, seedling johnsongrass, wild proso millet	carpetweed, chickweed, lambsquarters, mustard, nightshade, pigweed, purslane, ragweed, smartweed, velvetleaf
Balan (benefin)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane

Table 2. Weed Susceptibility to Herbicides Labeled for Use in Vegetable Crops (continued)

Herbicide	Weeds controlled	
	Grasses	Broadleaves
Basagran (bentazon)		Canada thistle, purslane, lambsquarters, ragweed, galinsoga, jimsonweed, smartweed, velvetleaf, wild mustard, cocklebur
Bladex (cyanazine)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass	carpetweed, cocklebur, chickweed, purslane, morningglory, jimsonweed, lambsquarters, nightshade, pigweed, ragweed, velvetleaf, wild mustard
Brominal (bromoxynil)		mustard, cocklebur, pennycress, jimsonweed, annual morningglory, nightshade, lambsquarters, smartweed, pigweed
Chem Hoe (propham)	annual bluegrass, downy brome, volunteer small grains	common chickweed, stinging nettle
Command (clomazone)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	purslane, ragweed, jimsonweed, lambsquarters, smartweed, velvetleaf
2,4-D amine		carpetweed, dandelion, dock, galinsoga, pigweed, jimsonweed, lambsquarters, morningglory, plantain, ragweed, smartweed, thistle, wild mustard
Dacthal (DCPA)	crabgrass, foxtail, barnyardgrass, goosegrass, annual bluegrass, seedling johnsongrass	carpetweed, lambsquarters, common chickweed, purslane
Dalapon 85 or Dowpon M (dalapon)	barnyardgrass, foxtail, bluegrass, bermudagrass, crabgrass, johnsongrass, quackgrass, witchgrass	
Devrinol (napropamide)	barnyardgrass, weedy brome, crabgrass, foxtail, goosegrass, seedling johnsongrass	chickweed, purslane, common groundsel, prostrate knotweed, lambsquarters, pigweed, prickly lettuce
Dual (metolachlor)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass	nightshade, carpetweed, galinsoga, pigweed
Enide (diphenamid)	annual bluegrass, crabgrass, barnyardgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, groundsel, knotweed, lambsquarters, pigweed, purslane, smartweed
Eptam or Genep (EPTC)	annual bluegrass, crabgrass, barnyardgrass, foxtail, goosegrass, shattercane, witchgrass	annual morningglory, carpetweed, chickweed, lambsquarters, nightshade, purslane
Eradicane Extra (EPTC + safener + extender)	annual bluegrass, crabgrass, barnyardgrass, goosegrass, seedling johnsongrass, volunteer small grains, foxtail	annual morningglory, nightshade, carpetweed, lambsquarters, purslane, pigweed, velvetleaf
Furloe (chlorpropham)	annual bluegrass, witchgrass	black nightshade, carpetweed, knotweed, curled dock (seedling), purslane, smartweed, shepherdspurse, mustard
Fusilade 2000 (fluazifop-butyl)	bermudagrass, goosegrass, johnsongrass, wild proso millet, barnyardgrass, fall panicum, foxtail, crabgrass, witchgrass, volunteer cereals	
Genate Plus or Sutan+ (butylate + safener)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, seedling johnsongrass	
Goal (oxyfluorfen)		eveningprimrose, pigweed, common groundsel, purslane, black nightshade, shepherdspurse
Gramoxone (paraquat)	Most annual grasses and broadleaves. See stale seedbed discussion.	
Karmex, others (diuron)	barnyardgrass, crabgrass, annual bluegrass, foxtail	pigweed, purslane, ragweed, chickweed, mustard, pennycress, velvetleaf
Kerb (pronamide)	barnyardgrass, brome, annual bluegrass, panicum, foxtail, goosegrass, volunteer small grains	carpetweed, chickweed, henbit, knotweed, purslane, lambsquarters, nightshade, morningglory
Lasso (alachlor)	barnyardgrass, crabgrass, foxtail, goosegrass, fall panicum, witchgrass	carpetweed, pigweed, galinsoga, nightshade, purslane
Lexone or Sencor (metribuzin)	downy brome, crabgrass, foxtail, seedling johnsongrass	pigweed, purslane, ragweed, chickweed, jimsonweed, lambsquarters, pepperweed, shepherdspurse, smartweed, prickly sida

Table 2. Weed Susceptibility to Herbicides Labeled for Use in Vegetable Crops (continued)

Herbicide	Weeds controlled	
	Grasses	Broadleaves
Linex or Lorox (linuron)	barnyardgrass, crabgrass, fall panicum, goosegrass	annual morningglory, carpetweed, groundsel, lambsquarters, mustard, cocklebur, pigweed, prickly sida, purslane, smartweed, velvetleaf
Poast (sethoxydim)	bermudagrass, goosegrass, johnsongrass, quackgrass, wild proso millet, barnyardgrass, fall panicum, foxtail, crabgrass, witchgrass, volunteer cereals	
Prefar (bensulide)	crabgrass, foxtail, fall panicum, goosegrass	
Princep, others (simazine)	annual bluegrass, crabgrass, foxtail, goosegrass, fall panicum, witchgrass	carpetweed, galinsoga, nightshade, pigweed, purslane
Prowl (pendimethalin)	barnyardgrass, crabgrass, fall panicum, foxtail	carpetweed, lambsquarters, pigweed, purslane
Pyramin (pyrazon)		lambsquarters, pigweed, ragweed, shepherdspurse, purslane, nightshade, mustard, henbit, smartweed
Ramrod (propachlor)	barnyardgrass, crabgrass, foxtail, goosegrass, fall panicum	carpetweed, pigweed, purslane
Randox (CDAA)	annual bluegrass, crabgrass, barnyardgrass, foxtail	carpetweed, pigweed, purslane
Rhonox, Weedone MCPA, others (MCPA)		lambsquarters, wild mustard, ragweed, yellow rocket, purslane, pepperweed, cocklebur, Canada thistle, dandelion, shepherdspurse
Ro-Neet (cycloate)	annual bluegrass, crabgrass, volunteer barley, foxtail, barnyardgrass	nightshade, henbit, lambsquarters, purslane, redroot pigweed, shepherdspurse
Roundup (glyphosate)	Most annual and perennial grasses and broadleaves. See discussion of stale seedbed treatment.	
Sinbar (terbacil)	crabgrass, foxtail, seedling johnsongrass, barnyardgrass, annual bluegrass	chickweed, lambsquarters, wild mustard, pepperweed, shepherdspurse, dandelion, knotweed, pigweed, purslane, plantain, ragweed, henbit, jimsonweed
Sonalan (ethalfluralin)	annual bluegrass, crabgrass, barnyardgrass, foxtail, goosegrass, fall panicum, seedling johnsongrass, shattercane, witchgrass	wild buckwheat, carpetweed, chickweed, lambsquarters, pigweed, nightshade, purslane
Surpass (vernolate)	barnyardgrass, crabgrass, foxtail, goosegrass, wild proso millet	annual morningglory, purslane, lambsquarters, pigweed, velvetleaf, carpetweed
Surflan (oryzalin)	barnyardgrass, crabgrass, penicum, foxtail, seedling johnsongrass	carpetweed, lambsquarters, pigweed, purslane, prostrate spurge
Thistrol (MCPB)		Canada thistle, lambsquarters, pigweed, smartweed, sowthistle, annual morningglory
Tillam (pebulate)	barnyardgrass, crabgrass, foxtail, goosegrass	lambsquarters, pigweed, purslane, shepherdspurse
Treflan (trifluralin)	annual bluegrass, crabgrass, barnyardgrass, foxtail, seedling johnsongrass, goosegrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane

HERBICIDE RATES AND GUIDELINES FOR USE IN VEGETABLE CROPS

All herbicide rates given in Table 3 are in the amount of product per broadcast acre. You should adjust amounts accordingly for banded applications. Preemergence applications should be made before weeds emerge or after any weeds are removed. Postemergence applications should be made after weeds have emerged. Stale seedbed treatments should be made only if weeds have emerged but no crop plants are present.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops

Herbicide	Rate of product per broadcast acre	Remarks
	ASPARAGUS	
Preemergence		
Amiben (chloramben)	6 qt of 2S or 30 lb of 10G, or 3.6 lb of 75DS	Seedling asparagus only. Irrigate after application.
Devrinol (napropamide)	4-6 lb of 50WP	Rainfall or irrigation is necessary for activity. Established beds only.
Karmex, others (diuron)	2-4 lb of 80WP	Do not apply to young plants during the first year. Two applications per year can be made. See label restrictions.
Lexone or Sencor (metribuzin)	1.3-2.5 lb of 75DF	Established beds only.
Princep, others (simazine)	2-4 lb of 80WP	Established beds only.
Sinbar (terbacil)	1.5-3 lb of 80WP	With direct seeded asparagus, spray activated carbon over rows. High organic soils inactivate Sinbar.
Treflan (trifluralin)	1-1.5 pt of 4EC, or 2-4 pt of MTF	See label for incorporation instructions. Established beds only.
Postemergence		
2,4-D amine	See label	Apply to actively growing weeds.
Dalapon 85 or Dowpon M (dalapon)	10-20 lb	Spot treatment or direct spray under fern growth.
Fusilade 2000 (fluazifop-butyl)	16-48 fl oz of 1EC	NONBEARING ASPARAGUS ONLY. Use crop oil concentrate or a nonionic surfactant. See label for amount.
Poast (sethoxydim)	1.5-2 pt of 1.5EC	NONBEARING ASPARAGUS ONLY. Use crop oil concentrate or a nonionic surfactant. See label for amount.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment. Apply at least 1 week before spears emerge, or delay until after harvest.
	CARROT	
Preemergence		
Furloe (chlorpropham)	6 qt of 4EC	Apply in 20 gal or more of water per acre.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Must be incorporated.
Postemergence		
Fusilade (fluazifop-butyl)	1-1.5 pt of 1EC	Use crop oil concentrate or nonionic surfactant. Up to 2 applications can be made per year.
Lexone or Sencor (metribuzin)	½ pt of 4F	Carrots must have at least 5-6 leaves. Weeds must be small.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
	COLE CROPS (Broccoli, Brussels Sprout, Cabbage, Cauliflower, and Turnip)	
Preemergence		
Dacthal (DCPA)	8-11 lb of 75WP	Not effective on high organic soils. Can be sprayed directly over transplants.
Devrinol (napropamide)	2-4 lb of 50WP	Can apply to transplants or direct-seeded plants. Should incorporate shallowly.
Goal (oxyfluorfen)	1.25 to 2.5 pt of 1.6EC	Apply to soil after final tillage but before transplanting. May cause foliar injury. Do not apply to brussels sprout.
Randox (CDAA)	4-6 qt of 4EC	For use on cabbage only.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Direct-seeded cole crops exhibit marginal tolerance to Treflan. Stunting can occur under stress. Must be incorporated.
Postemergence		
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	CORN (Sweet and Popcorn)	
Preemergence		
AAtrex, others (atrazine)	2-4 lb of 80WP, or 4-6 pt of 4L, or 2.2-3.3 lb of Nine-O	Land treated with atrazine should not be planted with any vegetable the next year or injury may occur.
Bladex (cyanazine)	1.5-6.0 lb of 80WP, or 1.3-5.3 lb of 90DF, or 1.25-4.75 qt of 4L	Land treated with Bladex should not be planted with any vegetable the next year or injury may occur.
Dual (metolachlor)	1-3 pt of 8EC	Can be applied to the surface before planting or incorporated.
Eradicane Extra (EPTC + safener + extender)	4-8 pt of 6.7EC	Will suppress wild proso millet. Must be incorporated. Contains an extender that may lengthen the period of control.
Genate Plus or Sutan + (butylate + safener)	4.75-7.33 pt of 6.7EC	Especially useful on sandy soils. Must be incorporated.
Lasso (alachlor)	2-4 qt of 4EC	
Princep, others (simazine)	3.75-5 lb of 80WP, or 6-8 pt of 4L	Do not plant vegetables the year after application. Do not graze treated area.
Prowl (pendimethalin)	1.5-4 pt of 4EC	Do not incorporate. For use on processing varieties. Do not apply prior to planting.
Ramrod (propachlor)	6-9 lb of 65WP, or 4-6 qt of 4L	Not cleared for popcorn.
Surpass (vernolate)	4-7 pt of 6.7EC	Do not use if soil contains more than 10% organic matter. Incorporate.
Postemergence		
AAtrex, others (atrazine)	4-6 pt of 4L, or 2.5-3.75 lb of 80WP, or 2.2-3.3 lb of Nine-O	Can be applied with crop oils. Preemergence applications preferred. See label precautions.
Basagran (bentazon)	1.5-2 pt of 4S	Apply when weeds are small. Consult label for specific directions.
2,4-D amine	See label	Apply to actively growing weeds, preferably before corn is 6 inches tall. See label restrictions.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
	CUCURBITS (Cucumber, Muskmelon, and Watermelon)	
Preemergence		
Alanap (naptalam)	6-8 qt of 2L	A second application can be made prior to vining. Normally tank mixed with Prefar.
Amiben (chloramben)	6 qt of 2S, or 3.6 lb of 75DS	Use only with seed protected with activated carbon. Do not use on watermelon. Follow label directions carefully.
Dacthal (DCPA)	6-14 lb of 75WP	Apply when the crop is at the 4-5 true leaf stage. For use on direct-seeded cucurbits only.
Prefar (bensulide)	5-6 qt of 4EC	Incorporate or irrigate in. Can tank mix with Alanap. Do not plant other than label-specified crops for 18 months after application.
Postemergence		
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
	DRY BEANS (White, Navy, Kidney, Pinto, Lima, and Adzuki)	
Preemergence		
Amiben (chloramben)	2.4-3.6 lb of 75DS or, 20-30 lb of 10G	
Dacthal (DCPA)	8-11 lb of 75WP	
Dual (metolachlor)	1.5-3 pt of 8EC	
Eptam or Genep (EPTC)	2.5-3.5 pt of 7EC	Do not use on adzuki beans, cowpeas, lima beans, or other flat pod beans. Incorporate immediately.
Furloe (chlorpropham)	4 qt of 4EC	Lima beans only. Seed must be planted at least 1 inch deep.
Lasso (alachlor)	2.5-3 qt of 4EC	Only for lima beans and red kidney beans. May delay maturity of red kidney beans in cool, wet weather.
Sonalan (ethalfluralin)	1.5-3 pt of 3EC	Must be incorporated.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Must be incorporated.
Postemergence		
Basagran (bentazon)	1.5-2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first trifoliate leaf has expanded.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	EGGPLANT	
Preemergence		
Dacthal (DCPA)	6-14 lb of 75WP	Apply 4-6 weeks after transplanting or when direct-seeded plants are 4-6 inches tall. Cultivate if weeds have emerged before applying.
Devrinol (napropamide)	2-4 lb of 50WP	Transplanted eggplant only.
Postemergence		
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
	GREENS (Chicory, Collard, Kale, Mustard, Spinach, Turnip Greens)	
Preemergence		
Dacthal (DCPA)	6-14 lb of 75WP	For use on collards, kale, and mustard and turnip greens. Not effective on high organic matter soils.
Furloe (chlorpropham)	1-2 qt of 4EC	Spinach only. Use lower rates in cool, wet weather.
Treflan (trifluralin)	1-1.5 pt of 4EC or MTF	Must be incorporated.
Postemergence		
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Spinach or mustard greens only. Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	Collards only. See discussion of stale seedbed treatments.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	HORSERADISH	
Preemergence		
Dacthal (DCPA)	6-14 lb of 75WP	Apply uniformly to soil at planting time.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	LETTUCE	
Preemergence		
Balan (benefin)	3-4 qt of 1.5EC	Direct-seeded lettuce only. Must be incorporated.
Chem Hoe (propham)	3.75-6 qt of 4L	Rainfall or irrigation is required within a few days after application.
Kerb (pronamide)	2-4 lb of 50WP	Moisture is necessary to activate. Label rates vary depending on variety.
Prefar (bensulide)	5-6 qt of 4EC	Can be applied to head and leaf lettuce. Must be incorporated.
Postemergence		
Chem Hoe (propham)	3.75-6 qt of 4L	Apply when lettuce has 4 or more leaves. Irrigate to move herbicide into the root zone.
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	OKRA	
Preemergence		
Enide (diphenamid)	3.3 lb of 90WP	Apply at planting.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Must be incorporated immediately after application.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
	ONION	
Preemergence		
Dacthal (DCPA)	6-14 lb of 75WP	Can be applied at planting or at layby. Emerged weeds will not be controlled.
Furloe (chlorpropham)	4-8 qt of 4EC, or 30-40 lb of 20G	Do not use on sandy soils. Use lower rate in cool, wet weather. Seeded onions only.
Postemergence		
Brominal (bromoxynil)	0.5-0.75 pt of 4ME	Apply when onions have 2-5 true leaves. Sensitivity of onions is affected by variety and environment.
Furloe (chlorpropham)	4-8 qt of 4EC, or 30-40 lb of 20G	Apply after onions are 6 inches tall and have 3 true leaves. Apply as a directed spray. Do not use on sandy soils.
Fusilade 2000 (fluazifop-butyl)	16-48 fl oz of 1EC	Onions for dry bulbs only. Use crop oil concentrate or nonionic surfactant. Do not harvest within 45 days of application.
Goal (oxyfluorfen)	0.6 pt of 2EC	Do not apply until onions have 2 true leaves. Best control achieved when weeds are in the 2-4 leaf stage.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	PEAS	
Preemergence		
Chem Hoe (propham)	4 qt of 4L, or 27 lb of 15G	Incorporate after application.
Dual (metolachlor)	1.5-3 pt of 8EC or 6-12 lb of 25G	Can be incorporated. See label for restrictions.
Ramrod (propachlor)	6-7.5 lb of 65WP	Do not use on sandy soils. For green processing peas only.
Treflan (trifluralin)	1-1.5 pt of 4EC or MTF	Must be incorporated. Can tank mix with Surflan. May suppress root rot.
Postemergence		
Basagran (bentazon)	1.5-2 qt of 4S	Apply when weeds are small. Pea injury can occur. See label precautions.
Rhonox, Weedone MCPA, others (MCPA)	See label	Treat when weeds are 4-6 inches tall. Peas may be injured.
Dalapon 85 or Dowpon M (dalapon)	1 lb	Apply when peas are 3-6 inches tall and weeds are small. See label restrictions.
Thistrol (MCPB)	2-6 pt of 2EC	Apply when peas have developed 6-12 nodes and weeds are less than 3 inches tall.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	PEPPER	
Preemergence		
Amiben (chloramben)	30-40 lb of 10G	Apply to established peppers when foliage is dry.
Dacthal (DCPA)	6-14 lb of 75WP	Apply 4-6 weeks after transplanting or when direct-seeded plants are 4-6 inches tall.
Devrinol (napropamide)	2-4 lb of 50WP	Can be applied to direct-seeded plants or transplants. Incorporate.
Enide (diphenamid)	3.3 lb of 90WP	May be applied to direct-seeded plants or transplants.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Incorporate. Apply to transplants only.
Postemergence		
Poast (sethoxydim)	1.5-2 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
	POTATO	
Preemergence		
Dacthal (DCPA)	6-14 lb of 75WP	Apply at planting, drag off, or at layby.
Dual (metolachlor)	1.5-3 pt of 8EC	Apply preemerge, incorporated, or at layby. Do not use on muck soils.
Enide (diphenamid)	4.4 lb of 90WP	Hilling or other treatment that brings untreated soil to surface will reduce effectiveness.
Eptam or Genep (EPTC)	3.5-7 pt of 7EC	Incorporate immediately after applying. The variety Superior is sensitive.
Lexone or Sencor (metribuzin)	0.6-1.33 lb of 75DF	Make a single application prior to emergence.
Linex or Lorox (linuron)	1.5-2.5 pt of 4L, or 1-4 lb of 50WP or 50DF	Apply after planting but before potato emergence. Plant "seed" 2 inches deep.
Prowl (pendimethalin)	1.5-3 pt of 4EC	Incorporate lightly. Do not use on muck soils.
Surflan (oryzalin)	1.33 lb of 75WP, or 0.75-1 qt of 4AS	Use on white-skinned varieties only. Do not use on soils with more than 5% organic matter.
Treflan (trifluralin)	1-2 pt or 4EC or MTF	Apply after planting and incorporate uniformly.
Postemergence		
Lexone or Sencor (metribuzin)	0.5-1 pt of 4L, or 0.3-0.67 lb of 75DF	Do not use on smooth-skinned white- or red-skinned potatoes. Apply only if 3 successive days of sun have occurred prior to application. Apply before weeds are 1 inch tall.
Stale Seedbed		
Dalapon 85 or Dowpon M (dalapon)	3-10 lb	See discussion of stale seedbed treatment. Apply before potatoes emerge and when grass is small. Do not apply when planting red skinned varieties or White Rose.
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	PUMPKIN AND SQUASH	
Preemergence		
Amiben (chloramben)	1.5-2 gal of 2S, or 30-40 lb of 10G, or 3.6-4.8 lb of 75DS	Weed control can be erratic on soils with less than 1% organic matter. Can be broadcast or banded. Apply to seeded squash or pumpkins only.
Command (clomazone)	1.5 to 2 pt of 4EC	Pumpkins only. Requires incorporation. May cause some temporary bleaching of pumpkin plants.
Dacthal (DCPA)	6-14 lb of 75WP	Not effective on soils with greater than 5% organic matter. Use on summer and winter squash only. Apply when plants are well established and have 4-5 leaves.
Prefar (bensulide)	5-6 qt of 4EC	Incorporate or irrigate in. See label restrictions.
Ramrod (propachlor)	4-6 qt of 4L	USE ON PROCESSING PUMPKINS ONLY. Do not apply to jack-o-lantern types. Do not apply to sandy soils.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
Postemergence		
Poast (sethoxydim)	1-1.5 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
	SNAP BEANS OR GREEN BEANS	
Preemergence		
Amiben (chloramben)	4-5 qt of 2S, or 2.4-3 lb of 75DS	
Dacthal (DCPA)	6-14 lb of 75WP	Not effective on soils with more than 5% organic matter. Do not feed treated plants to livestock.
Dual (metolachlor)	1.25-2.5 pt of 8EC	
Eptam or Genep (EPTC)	3.5 pt of 7EC	Do not use on flat-podded beans. Must be incorporated.
Treflan (trifluralin)	1-1.5 pt of 4EC or MTF	Must be incorporated.
Postemergence		
Basagran (bentazon)	1.5-2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first trifoliate has fully expanded. Some injury to beans may occur.
Stale Seedbed		
Dalapon 85 or Dowpon M (dalapon)	8 lb	See discussion of stale seedbed treatment. Wait 4-5 weeks before planting.
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	TABLE BEET	
Preemergence		
Pyramin (pyrazon)	3-3.5 qt of 4.2FL	Rainfall or irrigation is needed for activation.
Ro-Neet (cycloate)	2-2.7 qt of 6EC	Must be incorporated. Use on mineral soils only.
Postemergence		
Pyramin (pyrazon)	3.5 qt of 4.2FL	Timing is very important. Treat when beets have 2 expanded leaves and weeds have 2-4 leaves.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	TOMATO	
Preemergence		
Amiben (chloramben)	2.4-3.6 lb of 75DS, or 4-6 qt of 2S, or 30-40 lb of 10G	Direct-seeded plants must be protected by activated charcoal. Or apply when tomatoes are established.
Dacthal (DCPA)	6-14 lb of 75WP	Apply when direct-seeded plants are established and 4-6 inches tall or when transplanted plants have been established for 4-6 weeks.
Devrinol (napropamide)	2-4 lb of 50WP	Must be incorporated.
Enide (diphenamid)	4.4 lb of 90WP	Incorporate or irrigate in. Can be applied over the top of transplants.
Lexone or Sencor (metribuzin)	0.5-1 pt of 4L, or 0.33-0.66 lb of 75DF	Apply to transplanted tomatoes only. May be incorporated.
Prefar (bensulide)	4-5 qt of 4EC	Incorporate or irrigate in. Do not plant other than specified crops for 18 months after treatment.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
Tillam (pebulate)	2.66-4 qt of 6EC	Do not use Tillam with row covers.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Must be incorporated. For direct-seeded plants apply at blocking or thinning as a directed spray between rows.
Postemergence		
Lexone or Sencor (metribuzin)	0.5-0.75 pt of 4L, or 0.33-0.67 lb of 75DF	Plants must be established; see label. Apply only if 3 successive days of sun have occurred prior to application.
Poast (sethoxydim)	1.5-2 pt of 1.5EC	Use crop oil concentrate or nonionic surfactant.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.

Table 4. Common and Corresponding Trade Names that Appear in This Circular

Common name	Trade name
alachlor	Lasso
atrazine	AAtrex, others
benefin	Balan
bensulide	Prefar
bentazon	Basagran
bromoxynil	Brominal
butylate + safener	Genate Plus, Sutan +
CDAA	Randox
chloramben	Amiben
chlorpropham	Furloe
clomazone	Command
cycloate	Ro-Neet
cyanazine	Bladex
2,4-D amine	several names
dalapon	Dalapon 85, Dowpon M
DCPA	Dacthal
diphenamid	Enide
diuron	Karmex, others
ethalfluralin	Sonalan
EPTC	Eptam, Genep
EPTC + safener + extender	Eradicane Extra
fluazifop-butyl	Fusilade 2000
glyphosate	Roundup
linuron	Linex, Lorox
MCPA	Rhonox, Weedone MCPA, others
MCPB	Thistrol
metolachlor	Dual
metribuzin	Lexone, Sencor
napropamide	Devrinol
naptalam	Alanap
oryzalin	Surflan
oxyfluorfen	Goal
paraquat	Gramoxone
pebulate	Tillam
pendimethalin	Prowl
pronamide	Kerb
propachlor	Ramrod
propham	Chem Hoe
pyrazon	Pyramin
sethoxydim	Poast
simazine	Princep, others
terbacil	Sinbar
trifluralin	Treflan
vernolate	Surpass

Herbicide Drift

Certain herbicides, if not used correctly, can cause injury to nontarget plants. Herbicides such as Command, dicamba, and 2,4-D can drift up to a mile and cause serious damage to grapes, tomatoes, peppers, other vegetables, fruit trees, and ornamental plants. Before spraying Command, dicamba, or 2,4-D, survey the area for desirable plants. Spray only on calm days and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use an amine formulation of 2,4-D to reduce vapor drift. Spray Command, dicamba, and 2,4-D when the temperature is expected to be lower than 80°-85°F for several days after treatment. Avoid applying Command to wet soils.

Spray Tank Residuals

Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Storing Pesticides

Keep pesticides in a separate area, room, or building used only for storage purposes. The storage area should be dry and ventilated. Keep all entrances to the area locked at all times to protect children, other people, and animals. **Caution:** Do not store herbicides together with insecticides. Remove only the pesticide that will be used in one day, and after use return the pesticide to the storage area. Do not allow Amiben Liquid, Basagran, Blazer, Gramoxone, Lasso EC, Lorox L, or Ramrod to freeze.

Disposing of Pesticides and Containers

Surplus pesticides. If possible use surplus pesticide mixtures by applying them to labeled crops or areas

that have the same pest. Never drain surplus pesticides in any location where they can contaminate ground or surface water supplies. Avoid creating surplus tank mixes by accurately measuring the treatment area and mixing the correct amount of pesticide. If a large amount of surplus pesticide is generated, contact the Illinois EPA Division of Land Pollution Control to locate a nearby landfill that has a supplemental permit for toxic waste or to obtain other instructions about disposal.

Pesticide containers. All empty containers, regardless of their type, should be rinsed three times before disposal. Rinse water should be dumped in the tank. Triple-rinsed containers should be punctured or broken to facilitate drainage and to prevent reuse for any purpose. Containers should then be hauled to a sanitary landfill for disposal. Private applicators can bury containers singly in open fields, with regard for the protection of surface and subsurface water. However, commercial applicators must dispose of containers in an approved landfill.

Illinois regulations permit the burning of combustible containers provided that they are burned on the premises where they were used, that they are burned at least 1000 feet from residential areas, that the burning will not cause undue visibility or environmental hazards, and that no reasonable alternative disposal method exists. Local and county regulations must also be observed; check before burning to determine that burning is permitted in your area.

Do not breathe smoke from burning pesticide containers, and do not burn containers used for 2,4-D or other herbicides whose vapors may damage nearby plants.

1989 Herbicides for Commercial Tree Fruits

D. Meador and C. Doll

The suggestions in this publication comply with the regulations of the U.S. Department of Agriculture and the Environmental Protection Agency in effect at the time this publication was assembled. Since such regulations are subject to change, consult the most recent product label for use restrictions. *Do not use any herbicide unless the label states that it may be used on the crop to be treated.*

This guide is provided for your information. The University of Illinois and its agents assume no responsibility for results from using herbicies, whether or not they are used according to suggestions, recommendations, or directions of the manufacturer or any governmental agency.

CAUTION

Rates are for full coverage per acre. For spot or band treatments, reduce rates in proportion to the area actually treated.

Some products are not registered for use on sandy soils; others call for reduced rates on sandy soils. See labels.

Crop	Weeds Controlled	Treatment (overall basis) and comments
Apples, pears, cherries, peaches plums (prunes) bearing and nonbearing	Annual broadleaf and grass weeds	Casoron or Norosac granular (4%) at 150 lb per acre. Apply under trees in winter or early spring. For best results material should be lightly incorporated. Regrowth usually occurs in later summer. Avoid overdosage on young trees.
		Surflan (75%) at 2 2/3 lb to 5 1/3 lb per acre. Apply under trees in spring prior to weed emergence; use low rate for short-term control and high rate for long-term control. Allow soil to settle around young plants prior to treatment.

Crop	Weeds Controlled	Treatment (overall basis) and comments
Apples, pears cherries, peaches, plums (prunes) *continued*		Devrinol (50%) at 4 lb on sandy or light soils, 8 lb on heavy or dark-colored soils, in 20 to 100 gal of water per acre. Apply under trees in spring on weed-free soil or supplement with a postemergence herbicide. If no rainfall occurs within 48 hours after treatment, irrigate to incorporate.
		Solicam (80%) at 2 1/2 lb on light-colored soils, 5 lb on heavy or dark-colored soils, in 20 to 100 gal of water per acre. Apply to soil surface from fall to early spring before weeds emerge. Peaches must be established at least 6 months. Pears and plums must be established at least 12 months. Do not use on coarse textured soils such as sand, loamy sand, or gravelly sand. Avoid spray contact with fruit or foliage.
		Karmex (80%) or Princep (80%) at 2 1/2 lb on sandy or light-colored soils, 4 lbs on heavy or dark-colored soils, in 100 gal of water per acre. Apply under trees in spring. Use on weed-free areas, or supplement with a post-emergence herbicide. *Trees must be established at least 1 year.*
	Most annual broadleaf and grass weeds. Perennial weeds, top growth control only.	Grammoxone (paraquat-1.5 lb/gal) at 1 1/3 to 2 2/3 qt in 100 gal of water per acre. Apply as directed spray when weeds are growing rapidly and before they reach maturity. Repeat applications will be necessary to give sustained control. Use low pressure to produce a coarse spray. Add wetting agent to spray solution at 0.25% by volume for best results. *Caution: do not allow spray to contact leaves, fruit, or limbs of trees. Handle concentrates carefully.*

Crop	Weeds Controlled	Treatment (overall basis) and comments
All above except peaches	Most annual and certain perennial broadleaf and grass weeds.	Roundup at 1 to 2 qt in 10 to 40 gal of water per acre. Apply when weeds are in bud stage and growing actively. Application too early is not as effective in killing perennial weeds. *Caution: do not allow spray to contact any part of the tree since severe damage may result. Do not apply within 14 days of harvest.*
Apples, pears apricots, peaches and plums	Annual and perennial grass weeds.	Dowpon M (85%) at 10 lb in 100 gal of water per acre. Apply under trees when grass is 4 to 6 inches high in spring. *Do not use on trees younger than 4 years.* Do not apply within 30 days of harvest.
Apples and peaches	Most annual broadleaf and grass weeds.	Sinbar (80%) at 2 lb on light-colored soils, 4 lb on heavy or dark-colored soils in about 100 gal water per acre. Apply under trees once in spring. *Trees must be established 3 years or more.* Do not replant areas to crops within 2 years of last application. Use on weed-free soil or supplement with postemergence material. Do not use on extremely sandy soils.
Apples and pears	Many annual broadleaf and certain perennial broadleaf weeds.	Dacamine 4D at 1 to 2 qt in 100 gal of water per acre. Apply as directed spray when weeds are in prebud to early bud stage. *Caution: do not allow spray to contact leaves, fruit, or limbs of trees.* Useful to control broadleaf perennial weeds that escape earlier treatments. Use coarse spray to avoid drive.
Nonbearing fruit trees	Most annual and perennial grasses.	Poast 1.5E at 1 to 2 pt plus crop oil concentrate at 1 qt in 25 gal of water per acre; or Fusilade plus crop oil concentrate at 1 qt in 25 gal of water per acre. Apply as a directed spray when grass is actively growing. *Do not apply to trees that will be harvested within 1 year after application.*

CAUTIONS

If you are applying herbicides for the first time or are trying a new herbicide, learn on a small area.

Avoid spray drifts. Use low pressure (30 to 60 pounds per square inch) with nozzles close to the ground. Spray when wind velocity is low.

Calibrate equipment to apply the correct amount of material per acre. Excessive amounts may cause damage to fruit plants. Lesser amounts may not give control. Uniform application is essential.

Clean sprayers after applying herbicides. Use detergent and water (2 cups in 25 gallons) or ammonia and water (1 quart in 25 gallons) to clean out wettable-powder sprays. Emulsifiable liquids should first be washed out with kerosene, then with detergent and water or ammonia and water. Do not allow drain solutions to run into streams or other water sources.

For herbicide suppestions in home fruit plantings, see Circular 1144, *Controlling Weeds in Home Fruit Plantings*.

1989 Herbicides for Commercial Small Fruit Crops

D. Meador, C. Doll, and J. Courter

The suggestions in this publication comply with the regulations of the U.S. Department of Agriculture and the Environomental Protection Agency in effect at the time this publication was assembled. Since such regulations are subject to change, consult the most recent product label for use restrictions. *Do not use any herbicide unless the label states that it may be used on the crop to be treated.*

This guide is provided for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides, whether or not they are used according to suggestions, recommendations, or directions of the manufacturer or any governmental agency.

CAUTION

Rates are for full coverage per acre. For spot or band treatments reduce rates in proportion to the area actually treated.

All rates are for silt and/or clay loam soils. Some residual herbicides **SHOULD NOT** be used on sandy soils. Others can be used on sandy soils at reduced rates. See label.

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Nonbearing blackberries, blueberries, grapes	Fusilade 2000 1E	1 to 2 pt	Annual and perennial grass herbicides. Use as a directed spray to actively growing grass 2 to 8 inches tall. Apply in 5 to 25 gpa water with 1 percent COC (2 pt/25 gpa) or 0.25 percent nonionic surfactant (1/2 pt/25 gpa). Do not apply within 12 months of harvest.
	or		
	Poast 1.5E	1 to 2 pt	

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Blackberries and raspberries	Princep 80W or Princep 4G or Sinbar 80W	2.5 to 5 lb 50 to 100 lb 1 to 2 lb	For plantings at least 1 year old. Apply in early spring before weeds emerge and before canes leaf out. On mowed-off Heritage, apply before new shoots emerge. Apply to soil surface at base of plants in a band along each side of the row. If winter weeds are a problem in established plantings, use half dosage in late fall and again in early spring. Treated area should not be disturbed or have untreated soil piled over it by cultivating equipment.
	Surflan 75W or Devrinol 50W	2.5 to 5 lb 8 lb	May be applied to new plantings after the ground settles and in a band over or along the row of established plantings in the spring before weeds emerge. Devrinol must be incorporated with 1/2 inch of rain or irrigation within 24 hours after application.
	Casoron 4G or Norosac 4G	100 lb	Use 4 percent granules. Apply any time from late fall to early spring to kill existing grass and weeds and to reduce growth of young weeds into early summer.
	Enide 90W	4.4 to 6.6 lb	Apply as a band application on new plantings of raspberries and blackberries. May be applied in the spring on established raspberries. Do not apply on raspberries within 60 days of harvest or on blackberries within 12 months of harvest.

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Blackberries and raspberries, *continued*	Gramoxone 1.5 (paraquat)	1.3 to 2.7 qt	Apply in spring before emergence of new canes or shoots.
Raspberries	Poast 1.5E	1 to 2 pt	A grass killer. Apply in 5 to 25 gallons of water per acre when grass is actively growing. Add 2 pints of oil concentrate per acre. Do NOT apply to raspberries within 45 days of harvest.
Blueberries	Princep 80W or Princep 4G or Sinbar 80W	2.5 to 5 lb 50 to 100 lb 2 to 4 lb	See remarks under blackberries and raspberries. Apply in early spring. Princep and and Sinbar may be applied on crops established at least 1 year.
	Surflan 75W or Devrinol 50W	2.5 to 5 lb 8 lb	May be applied to new plantings after the soil settles and to bearing and nonbearing plants. See remarks under blackberries.
	Casoron 4G or Norosac 4G	100 lb	See remarks under blackberries and raspberries.
	Gramoxone 1.5 (paraquat)	1.3 to 2.7 qt	See remarks under blackberries and raspberries.
Grapes	Karmex 80W or Princep 80W	2 to 6 lb 2.5 to 6 lb	Use in vineyards established at least 3 years. Apply in early spring to soil under trellis in a band 30 inches wide.

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Grapes, *continued*	Devrinol 50W or Surflan 75W	8 lb 2.5 to 5 lb	May be applied to newly planted vines after the soil settles and to nonbearing and bearing vines. Devrinol must be incorporated within 24 hours by 1/2 inch of rain or irrigation or by shallow cultivation.
	Gramoxone 1.5E (paraquat)	1.3 to 2.7 qt	Apply as a postemergent spray when annual grasses and weeds become a problem. Keep spray off foliage. Use the surfactant suggested by the manufacturer.
	Casoron 4G or Norosac 4G	100 to 150 lb	Use 4 percent granules. Apply from late fall to early spring to kill established weeds and grass. Residual effect to kill germinating weeds and grass will last until warm weather.
	Roundup 4EC	1 to 5 qt	Use as a directed spray in vineyards established at least 3 years or for site preparation prior to planting for control of emerged annual and perennial weeds. Keep spray off green foliage, green bark, and suckers.
Strawberries	Dacthal 75W	8 to 12 lb	Preemergence action. May be applied immediately after planting or during the growing season to weed-free soil except when blossoms of fruit are present on beds to be harvested. Effective weed control usually lasts 4 to 8

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Strawberries *continued*			weeks. Treatment may be repeated. Weak against velvetleaf, ragweed, smartweed, and nutsedge. Incorporate with 1/2 inch of rain or irrigation or shallow cultivation.
	Poast 1.5E	1 to 2 pt	A grass killer. Apply in 10 to 25 gallons of water per acre when grass is actively growing. Add 2 pints of oil concentrate per acre. Do NOT apply within 30 days of harvest. See label.
	Devrinol 50W	8 lb	Devrinol retards root development of runner plants; therefore it should not be applied until the desired number of runner plants is well rooted in both new plantings and in renovated plantings. An application in late fall just before mulching should last through harvest. May be incorporated with 1/2 inch of rain or irrigation within 24 hours.
	Enide 90W	6.6 lb	On new beds Enide may be applied to weed-free soil after the plants are established. On established beds it is most effective at renovation time and in late fall just before mulching. Incorporate with 1 inch of rain or irrigation. No more than 2 applications can be made per year. Do not apply within 60 days of harvest.

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Strawberries *continued*	Gramoxone 1.5 (paraquat)	1.3 qt	Use as directed spray to weeds between rows. Use shields to protect strawberry plants. No more than 3 sprays can be made per season. Do not apply within 21 days of harvest.
	Sinbar 80WP	4 to 8 oz	Apply no more than 1 pound per year. May be applied at renovation if leaves are removed by mowing before spraying. Or apply to fully dormant plants from late fall to late winter. May apply 1/2 pound at renovation and again in late fall. Application rate must be accurate and must be adjusted to soil type and soil organic matter content. See label. Excess rates may cause serious injury. Growers using Sinbar for the first time should limit application to a small part of their plantings.
	Tenoran 50W	8 lb	Postemergence action against young weeds less than 2 inches tall (many broadleaf and some grass weeds). Also has residual properties for preemergence action aginst germinating seeds. Delay application on new plantings until plants are established. Make no more than two applications per year. Do not apply within 60 days of harvest. See label for mixing and application instruction.

Crop	Chemical or trade names and formulations	Amount of product per treated acre	Remarks
Strawberries, *continued*	2,4-D amine Formula 40	1 to 1.5 qt	Postemergence action. To control many broadleaf weeds in established plantings apply in 25 to 50 gal of water per acre in late fall or early spring when strawberries are dormant. 2,4-D may also be applied at renovation time after last picking but before runners form. Do not use unless some crop injury is acceptable.

CAUTIONS

If you are applying herbicides for the first time or are trying a new herbicide, learn on a small area.

Avoid spray drifts. Use low pressure (30 to 60 pounds per square inch) with nozzles close to the ground. Spray when wind velocity is low.

Calibrate equipment to apply the correct amount of material per acre. Excessive amounts may cause damage to fruit plants. Lesser amounts may not give control. Uniform application is essential.

Clean sprayers after applying herbicides. Use detergent and water (2 cups in 25 gallons) or ammonia and water (1 quart in 25 gallons) to clean out wettable-powder sprays. Emulsifiable liquids should first be washed out with kerosene, then with detergent and water or ammonia and water. Do not allow drain solutions to run into streams or other water sources.

For herbicide suggestions in home fruit planting, see Circular 1144, *Controlling Weeds in Home Fruit Plantings.*

Controlling Weeds in Home Fruit Plantings

GRASSY AND BROADLEAFED WEEDS in home fruit plantings reduce yields, are unsightly, and may harbor injurious insects and mice. This publication is designed to aid home fruit growers in controlling these pest plants.

WEED CONTROL METHODS

Weed control methods available for the home fruit grower include using organic mulches, mowing, cultivating, hand hoeing, pulling weeds, and using herbicides. Usually a combination of these methods is the most practical approach.

MULCHING

Both tree fruits and small fruits, except strawberries, thrive under mulch culture (for strawberries, a modified mulch culture is suggested for winter protection). Organic mulches such as straw, hay, grass clippings, sawdust, hardwood bark, and chopped corn cobs are preferred. These mulches smother weeds, conserve moisture, reduce soil temperature fluctuations, and add organic matter to the soil. Keep the mulches about 6 inches deep. Because mulches may harbor mice, which damage fruit plants, use traps or bait or a good cat to keep mice under control.

CULTIVATING, HOEING, AND PULLING WEEDS

Cultivation is usually the most practical method of controlling the weeds and grass that grow in the aisles between rows of brambles, grapes, and strawberries. Hand hoeing and weed pulling will occasionally be needed to remove weeds that escape other control methods.

MOWING

The area between fruit trees usually is kept in bluegrass sod. Mowing is the most practical means of keeping weeds under control in this area. Mowing is also useful in the aisles between rows of grapes, blueberries, and brambles.

This circular was prepared by Daniel B. Meador, Associate Professor of Pomology Extension, and C. Chris Doll, Area Extension Adviser in Fruits and Vegetables.

HERBICIDES

Herbicides (chemical weed killers) can be used safely in home fruit plantings if the directions are followed carefully. Residual-type herbicides must be applied in the correct amount per area. Exceeding the recommended rate may damage fruit plants; using less than the recommended rate may not control weeds. Do not use residual-type herbicides on sandy soils.

ECONOMICS OF CHEMICAL WEED CONTROL

Chemical weed control probably is not practical for home gardeners with small plantings of fruit plants. Mulching, cultivation, hoeing, and weed pulling are the most practical weed control methods for small plantings.

Gardeners with larger plantings may find chemical weed control economically feasible. Farm families may currently be using some of the suggested herbicides in their farming operations and thus may already have them on hand.

Most of the herbicides suggested are packaged in 4- or 5-pound bags for wettable powders or in gallon containers for liquids. Purchasing that much herbicide represents a considerable investment. Herbicides will retain their effectiveness over several years, however, if they are stored in a dry area.

SUGGESTED HERBICIDES

The herbicides suggested in this circular are wettable powders (W), granules (G), or liquid emulsifiable concentrates (EC). Wettable powders and liquids are mixed with water for application. Granular herbicides are applied in the dry form.

Oryzalin (Surflan), simazine (Princep), DCPA (Dacthal), and diphenamide (Enide) are residual-type herbicides. Like most residual types, they work primarily against germinating weeds but have little or no effect on existing weeds. Any existing weeds should be removed by cultivation or killed with a contact-type herbicide before applying residual herbicides.

Dichlobenil (Casoron) is a residual herbicide that also has excellent eradicative action (kills existing weeds). It is volatile in hot weather and loses its effectiveness by early summer. When applied in late fall, winter, or early spring, Casoron kills existing weeds and acts as a residual herbicide against germinating weeds. It is especially useful in cleaning out weedy patches of raspberries, blackberries, and blueberries.

Residual herbicides do not become active until they are incorporated into the top layer of the soil. A half-inch of rain or irrigation water is sufficient for incorporation. These herbicides will be effective against new weed seedlings for varying lengths of time. Cultivation destroys their effectiveness. None of the residual herbicides is effective against all species of weeds; some hand hoeing and weed pulling will be necessary. Do not use residual-type herbicides on sandy soils.

Paraquat (Gramoxone), a nonselective contact-type herbicide, burns any foliage it contacts. It is useful under fruit trees and grapevines where the weeds can be sprayed without getting any spray material on the leaves of the fruit plants. Paraquat has been listed as a restricted pesticide by the Environmental Protection Agency; therefore, sale and use are limited to certified private applicators.

Amine 2,4-D is a growth-regulator-type herbicide that is effective against many species of broadleafed weeds. It can be used under apple and pear trees as needed; at certain times of the year, it can be used on strawberries.

Glyphosate is marketed as Roundup (4 pounds per gallon EC) and under other trade names in less concentrated form, one of which is fully diluted for use. Glyphosate is a non-selective growth-regulator-type herbicide that is effective against annual and perennial grasses and weeds. Keep glyphosate off the foliage of fruit trees.

WHERE TO BUY

Farm supply stores frequently carry paraquat, Princep, Dacthal, Surflan, Roundup, and amine-type 2,4-D. In areas where vegetables and fruits are produced commercially, these stores may also carry Enide and Casoron.

Garden centers and seed stores frequently carry Dacthal and amine-type 2,4-D. Some of them may also have Princep, Enide, Casoron and formulations of glyphosate.

WEED CONTROL PROGRAMS

FRUIT TREES

Young fruit trees need to be protected from competition by weeds for five years after planting. Organic mulches, cultivation, or herbicides may be used.

If the mulch program is to be used, apply the mulch soon after planting. Cover all the soil within 2 feet of the trunk. As the trees grow, the mulch may be extended to cover the area under the branches. If the mulch is maintained, cultivation or herbicides will not be needed.

If newly planted trees are not mulched, the soil within 2 feet of the trunk should be cultivated shallowly during the first growing season. The cultivated area may be larger if desired.

After the first growing season, cultivation or mulching may be continued or herbicides may be applied. The residual herbicides Princep or Surflan should be applied in the spring to bare soil or to areas where the existing weeds have been killed with paraquat or Roundup. The herbicide may be applied to a circular area extending 3 feet from the trunk, or to an area 4 feet square with the tree in the center, or to a 3- to 4-foot-wide strip down the tree row.

Starting with the sixth growing season, mulching or herbicide application may be continued, or closely mowed grass can be allowed to grow under the trees. A 12-inch-wide gravel or sand collar around each tree prevents the growth of weeds and grass next to the trunk and eliminates the possibility of mower injury to the trunk.

Apples and Pears

Princep 4G.....	3½ ounces treats 100 square feet
	2 pounds, 4 ounces treats 1,000 square feet
Princep 80 W	1 teaspoon treats 34 square feet
	1 tablespoon treats 102 square feet
Surflan 75 W	1 teaspoon treats 31 square feet
	1 tablespoon treats 93 square feet
Paraquat.....	See section on paraquat (page 154)
Amine 2,4-D	See section on 2,4-D (page 154)
Casoron 4G.....	5½ ounces treats 100 square feet
	3 pounds, 7 ounces treats 1,000 square feet
Roundup	See section on Roundup (page 154)

Peaches, Cherries, Plums, and Apricots

Princep 4G..... Same as apples
Princep 80 W ..... Same as apples
Surflan 75 W ..... Same as apples
Paraquat..... See section on paraquat (page 154)
Casoron 4G..... Same as apples
Roundup ..... See section on Roundup (page 154)

Suggestions and restrictions. Princep or Surflan: Apply in spring or early summer to bare ground, or apply soon after paraquat or Roundup has been used to control existing foliage. Do not apply on trees established less than one year. Make only one application per year.

Casoron: Apply in late fall, winter, or early spring. Make only one application per year.

BLACKBERRIES, RASPBERRIES, AND BLUEBERRIES

During the first growing season after planting, these plants should be mulched or cultivated. Mulching is preferred because it reduces the need for watering. However, the mulch must not be so deep that it prevents the new shoots from coming through. This is especially important for blackberries and red raspberries, which send up new shoots several inches from the main plant. During the second growing season and subsequent seasons, mulching or cultivation may be continued or herbicides may be used.

Casoron is especially useful to clean out existing weeds. It is also effective against germinating weeds until hot weather.

Surflan or Princep should give fairly good weed control throughout the growing season. In southern Illinois, foxtail and fall panicum may grow through the herbicide band in late summer.

Princep 4G..... 3½ ounces treats 100 square feet
2 pounds, 4 ounces treats 1,000 square feet
Princep 80 W ..... 1 teaspoon treats 34 square feet
1 tablespoon treats 102 square feet
Surflan 75 W ..... 1 teaspoon treats 31 square feet
1 tablespoon treats 93 square feet
Casoron 4G..... 3½ ounces treats 100 square feet
2 pounds, 4 ounces treats 1,000 square feet

Suggestions and restrictions. Princep and Surflan: Apply to weed-free soil in the spring before berry plants leaf out. Do not apply to plants established less than one year. Make only one application per year.

Casoron: Apply in late fall, winter, or early spring to plants established at least 6 months. Make only one application per year.

GRAPES

Grapes should be mulched or cultivated during the first three growing seasons. During the fourth and subsequent growing seasons, mulching or cultivation may be continued, or Surflan, Princep, or Casoron may be applied to a 3- to 4-foot wide strip down the row. Apply Surflan or Princep in the spring. Casoron should be applied in late fall, winter, or early spring. Paraquat and Roundup may be applied during the growing season as needed for weed knockdown.

Princep 4G..... 4½ ounces treats 100 square feet
3 pounds, 7 ounces treats 1,000 square feet

Princep 80 W ..... 1 teaspoon treats 34 square feet
1 tablespoon treats 102 square feet
Surflan 75 W ..... 1 teaspoon treats 31 square feet
1 tablespoon treats 93 square feet
Paraquat..... See section on paraquat (page 154)
Casoron 4G..... 5½ ounces treats 100 square feet
3 pounds, 7 ounces treats 1,000 square feet
Roundup ..... See section on Roundup (page 154)

STRAWBERRIES

Immediately after planting, Dacthal can be applied. It is more effective against grasses than against broadleafed weeds and is effective for about six to eight weeks. When Dacthal loses its effectiveness, clean the patch by cultivation and hoeing and apply again or switch to Enide. Enide has a much longer effective period than Dacthal and is likewise more effective against grass than against broadleafed weeds.

From planting time until runners start to form, many growers find cultivation and hoeing to be the most economical and successful weed control program. When the runner plants begin to root in late June or July, cultivation must be reduced; at this time, either Dacthal or Enide may be applied. If Dacthal is used, it can be applied again in September. If Enide is applied, it should be effective until late fall.

The effectiveness of Dacthal and Enide is destroyed by cultivation. After application of either of these materials, use a hand hoe or hand pulling to remove any weeds that were missed. Do not cultivate until just before you are ready to make another herbicide application.

In late November just before mulching, apply Enide. This application should give control through the harvest season. If dandelions and other perennial weeds are present, amine 2,4-D may also be applied.

At renovation time, immediately after harvest, when the rows have been narrowed and weeds in the aisles have been destroyed by cultivation, apply Dacthal or Enide. Enide should be effective until late fall. If Dacthal is applied, apply again in six to eight weeks. If broadleafed weeds are present in the rows at renovation time, amine 2,4-D may be applied.

Follow with an application of Enide just before mulching, as suggested above. In subsequent years, apply herbicides at renovation time and in late November before mulching.

Dacthal 5G ..... 6½ ounces treats 100 square feet
4 pounds treats 1,000 square feet
Dacthal 75 W ..... 1 teaspoon treats 16 square feet
1 tablespoon treats 48 square feet
Enide 90 W ..... 1 teaspoon treats 32 square feet
1 tablespoon treats 96 square feet
Amine 2,4-D..... See section on 2,4-D (page 154)

Suggestions and restrictions. Do not apply Dacthal when blossoms or berries are present. Do not apply Enide within 60 days before harvest, and do not apply more than twice a year. Amine 2,4-D may be applied immediately after harvest or in late fall but not at other times.

APPLYING WETTABLE POWDER RESIDUAL HERBICIDES

To be effective against germinating weeds without substantially injuring fruit plants, an exact amount of the herbicide must be spread evenly on an exact area of the soil. Recommendations for wettable powder herbicides in this circular give amounts in teaspoons or tablespoons to be spread evenly over square foot areas (length × width). For smaller areas, use ½ teaspoon or ¼ teaspoon measures and calculate the area to be covered by dividing the area for 1 teaspoon by 2 or by 4, respectively. For larger areas, multiples of 1 tablespoon may be used.

For most wettable powder applications a sprayer is the most convenient equipment. Use a flat fan type nozzle. For small areas a sprinkling can may be satisfactory.

The first step in application is adjusting the equipment to fit the situation. First, look up the amount of material required for a given area (see the section for each crop). Next, stake out the given area. If 1 tablespoon of material is suggested for 50 square feet, stake out an area of 50 square feet. Then make a trial run with the sprayer using water *only*. Try 1 quart of water. Spray evenly over the staked out area until all of the water is used. After the first trial run you may wish to increase or decrease the amount of water. After you have adjusted the amount of water to an amount convenient for covering the staked out plot, you are ready to apply the residual herbicide.

Measure the required amount of herbicide using a measuring teaspoon or tablespoon. Regular teaspoons and tablespoons used for eating and serving food do *not* measure accurately. Do not pack the material into the measuring spoon. Dip the measuring spoon into the material, overfilling the spoon. Then use a spatula or knife to remove the excess material, leaving the measuring spoon level full.

Place the measured amount of herbicide and the measured amount of water in the sprayer. Close the sprayer and shake vigorously to mix. Shake the sprayer while spraying to keep the materials mixed. Spray all of the material evenly on the staked out area.

Example: Applying Enide 90 W to strawberries. The recommended rate is 1 tablespoon per 96 square feet. If the rows are 3½ feet wide, stake out an area 3½ feet by 27 feet. Make a trial run with water only, using 1 quart of water. If 1 quart of water is convenient for coverage of the staked out area, put 1 tablespoon of Enide 90 W and 1 quart of water in the sprayer, shake thoroughly to mix, and spray evenly over the staked out area, using all of the spray mixture.

APPLYING GRANULAR RESIDUAL HERBICIDES

In granular formulations, the herbicide is incorporated onto an inert material and made into small granules. A fertilizer spreader or seeder is used to spread the material evenly over a specified area.

A lawn fertilizer spreader that drops the material in a band is convenient for applying granular materials under fruit trees and on strawberry beds. To calibrate this type of spreader, spread a sheet of plastic on a smooth area such as a driveway. Then run the spreader over a measured distance and determine the amount of material spread over the square foot area covered.

Example: Applying Dacthal 5G to strawberries. The recommended rate is 6½ ounces for 100 square feet or 4 pounds per 1,000 square feet. Set the dial for 4 pounds per 1,000 square feet; but since materials vary in density, test to determine the actual delivery rate. Spread a plastic sheet on the driveway, mark off 10 feet, and spread a 10-foot strip. Sweep up the material and weigh. If the material delivered weighed 3 ounces and the width of the band was 3 feet, then the rate was 3 ounces spread on 30 square feet (10 ft. long × 3 ft. wide). This would be a rate of 10 ounces per 100 square feet, which is too much. Reduce the size of the delivery holes and try another test strip. Continue adjusting and measuring delivery on the test strip until 2 ounces are delivered on the 30-square-foot test strip.

The cyclone-type spreader or seeder is more difficult to calibrate because walking speed is a part of the calibration. Rather than calibrate the spreader and speed of walking, a different approach is suggested. Set the opening to deliver the material slowly so that you must make two or more trips over the area to apply the given amount of material. Determine the number of square feet to be treated and calculate the amount of granular material needed. Put this amount of material in the spreader and go over the area to be treated until all of the material is used up.

APPLYING PARAQUAT, 2,4-D, AND ROUNDUP

PARAQUAT

Use 1 tablespoon of paraquat plus 1 teaspoon of a wetting agent per gallon of water. Wet the weed and grass foliage. Keep off foliage of fruit plants. The wetting agent may be a regular spreading agent or a liquid dishwashing agent such as Lux, Vel, etc. Paraquat may be applied more than once during the growing season.

Because paraquat has been listed as a restricted pesticide by the Environmental Protection Agency, purchase and use are limited to certified private applicators.

2,4-D

Use 1 tablespoon of amine 2,4-D plus 1 teaspoon of wetting agent (see the preceding paragraph) per gallon of water. Wet the foliage of broadleafed weeds under apple and pear trees, but keep off apple and pear foliage. In strawberry beds, wet the foliage of both broadleafed weeds and strawberry plants.

Tomatoes and grapes are extremely sensitive to vapors from 2,4-D sprays. During the growing season, do not spray 2,4-D near these plants — keep at least 100 feet away.

ROUNDUP AND OTHER FORMULATIONS OF GLYPHOSATE

Apply as a wipe on weeds under fruit trees and grape vines. Can also be applied as a spray under apple, pear, and cherry trees and under grape vines. Remove any suckers before spraying. Keep off fruit plant foliage. See label for directions.

PRECAUTIONS

1. Choose a calm day to apply herbicides. Winds cause drift to other plants and other areas and prevent even coverage.
2. Use low pressure in the tank or pump.
3. Use flat fan weed spray nozzles.
4. Read and follow all precautions listed on the product label.

Controlling Weeds in the Home Garden

A weed is a plant growing where it is not wanted. Weeds compete with desirable plants for water, soil nutrients, sunlight, and gaseous components of the air needed for growth. Many weeds also harbor diseases and insects that may attack plants around the home.

Three general methods of weed control can be used in the home garden: (1) cultivation and mechanical removal (hoeing, pulling); (2) mulching (smothering of weeds); and (3) herbicides (weed killers). Usually, one or more of these methods is used.

CULTIVATION AND MECHANICAL REMOVAL

Cultivation and mechanical removal are the safest and most common method for controlling weeds in small home gardens. Since only those weeds that are actually present can be controlled, the process must be repeated several times throughout the growing season. It may be difficult to control weeds adequately with this method during vacations or busy work periods.

Shave off deeply rooted weeds with a sharp hoe while gently breaking up the soil crust. Deep tillage can cause severe injury to shallow-rooted plants and can bring deeply buried weed seeds to the surface where they can germinate. Keeping equipment sharp and in good condition will help to reduce injury to desirable plants. Hoe carefully around your plants, and hand pull weeds close to the plants.

Weeds in small areas can be controlled by wheel hoes or hand hoes; in large gardens use power equipment such as rototillers and garden-type tractors. This equipment should be set shallow when used in a garden for weed control. Avoid cultivating too close to crop plants in order to prevent root injury.

MULCHING

Mulching controls weeds by preventing light from reaching the weed seeds or seedlings. This method will control many annual weeds--those that germinate from seed each year. Perennial weeds (those that sprout each year from belowground plant parts) usually must be removed by cultivation or hoeing.

The advantages of mulching include moisture conservation, prevention of soil crusting, reduction of erosion, increased spring soil temperatures, and the ability to keep edible aboveground plant portions clean.

Revised by D.J. Williams
1988 Revision of
Circular 1051

ORGANIC MULCHES

The organic materials used most frequently for mulching include plant residues such as straw or hay (free of weed seeds); crushed corncobs; various nut hulls; leaf and grass composts; peat; wood products such as sawdust, wood chips, shredded bark, and shavings; and well-rotted animal manures. Use the most economical mulch available. A combination of several thicknesses of newspaper (use papers with black ink, not colored ink) covered by organic materials has shown promise as a type of summer mulch. For good results, apply these materials to a depth of four to six inches.

Applying in natural mulch materials may require considerable hand labor. Most organic materials are bulky and must be hauled to the place of use, but this is not a serious problem in small gardens.

As organic mulches decompose, they return organic matter and some plant nutrients to the soil and improve soil tilth. Added benefits are the prevention of soil compaction, conservation of soil moisture, erosion control on slopes, cooler summer soil temperatures, and added attractiveness of the garden.

When organic materials are used, you may need to add nitrogen fertilizer to prevent a deficiency of nitrogen in the mulched crop. With alfalfa, clover, or other legume mulches, however, excess nitrogen is released during decomposition.

Organic mulch materials	Nitrogen required for decomposition (pounds per ton of mulch)
Cocoa pods	6.0
Corncobs (ground)	22.5
Hay, grass clippings	7.6
Peanut hulls	8.5
Sawdust (fresh)	26.0
Wheat straw	17.6

SYNTHETIC MULCHES

Common synthetic mulches include polyethylene, paper, paper-polyethylene combinations, black polypropylene mats, fiberglass mats, wax-coated papers, and aluminum and steel foils.

Polyethylene film is used in a thickness of 1 to 1 1/2 mils (1 mil = 0.001 inch) and a width of three to six feet. Black polyethylene is preferable for the home vegetable garden because it prevents light from reaching the weed seedlings. It is generally not practical to use transparent polyethylene as a full-season mulch because weeds develop under the polyethylene.

To install, press the edges of the mulch down into furrows and cover them firmly with soil. A push-type, one-wheel cultivator works well to open and close furrows. The mulch may also be installed by using a rake or shovel to cover the edges with soil. Do not throw excess soil on top of the mulch.

It is better to apply synthetic mulches in crop rows than to attempt to cover the entire area. The area between the rows of polyethylene mulch must be carefully cultivated or hoed.

Use of polyethylene mulch will increase spring soil temperatures and hasten the development of some crops.

HERBICIDES

It is not a good practice to use herbicides in small ornamental and vegetable gardens containing several crop species because different flowers, vegetables, and weeds vary in their tolerance to herbicides. Some herbicides may remain in the soil longer than one growing season and may kill or injure some species the following year (especially if excessive rates are used). Ideally, a specific herbicide should be used for each crop species, but most people have small areas of several species in their gardens, and it would often be impractical and expensive to buy the several herbicides that would be needed.

Application must be carefully controlled when a herbicide is used on small areas. The tendency is to apply additional amounts if the quantity measured out "looks" as if it is not enough. A low percentage granular formulation is suggested for small garden areas. *CAUTION: Check the container label very carefully for rates of material to use and application techniques. Applications must be accurate and uniform. Excessive amounts may cause injury to the present or subsequent crops.*

If a gardener prefers not to remove weeds by hand in the home garden, Dacthal, Amiben, Treflan, Genep, or Eptam can be used on several species. These herbicides may not be the most effective for a large planting of the individual fruit or vegetable species. Herbicides for these large plantings are listed in Extension Circular 907, *Weed Management Guide for Commercial Vegetable Growers*, in *1988 Herbicides for Commercial Small Fruits*, and *1988 Herbicides for Commercial Tree Fruits*, all of which are revised annually and appear elsewhere in this *Handbook*.

Trade name	Common name	Chemical name
Dacthal	DCPA	dimethyl 2,3,5,6-tetrachloroterephthalate
Roundup, Kleenup	glyphosate	*N*-(phosphonomethyl)glycine
Treflan, Preen	trifluralin	α, α, α-trifluoro-2,6 dinitro-*N*-*N*-dipropyl-p-toluidine
Devrinol	napropamide	*N*,*N*-Diethyl-2-(1-napthalenyloxy)-proprionamide
Amiben, Weedone Garden Weeder, Ornamental Weeder	chloramben	3-amino-2,5-dichlorobenzoic acid
Eptam, Genep	EPTC	ethyl *N*,n-dipropylthiol-carbamate
Dalapon 85, Dowpon M (and others)	dalapon	2,2 dichloropropionic acid

Herbicides may be sold under several trade names. If you cannot identify the trade names on the container, look on the label for the common name or the chemical name of the active ingredients. The trade names listed in this publication are for products commonly used in Illinois. Products of identical content that are marketed under other trade names may be equally effective.

DCPA

DCPA is a preemergence herbicide that controls very small weed seedlings soon after the weed seeds germinate. It does not control weeds that have emerged prior to application. The herbicide action is most effective if rainfall occurs or the soil is irrigated within two to three days after application of the herbicide. Weeds that have already emerged should be removed before DCPA is applied.

DCPA is the best *multipurpose* herbicide for home-garden use. It is available as a 75 percent wettable powder and as a 5 percent granular formulation. DCPA can be used for annual grass control in lawns, on a number of species of flowers, and on strawberries, broccoli, brussels sprouts, cauliflower, cabbage, dry and snap beans, cucumbers, squash, melons, collards, kale, mustard greens, turnips, garlic, onions, potatoes, sweet potatoes, yams, tomatoes, eggplants, peppers, and horseradish.

Do not use DCPA on beets, bugle weed, button pink, carnation, geum, germander, mesembryanthemum, pansy, phlox, sweet william, and telanthera.

A one-time application to all species is not always possible in a garden of flowers or vegetables because some plants are susceptible to injury when they are in early growth stages. It is preferable to use DCPA at seeding or transplanting time if the species is adapted for it. When application must be delayed, remove emerged weeds and then apply Dacthal to prevent further weed development. Consult the container label for the appropriate application time.

DCPA is effective in controlling annual grasses that are a problem in the spring. Broadleaf weeds must be removed mechanically.

Trifluralin

Because trifluralin is used in soybean production in Illinois, it is widely available. It can be purchased as a liquid with four pounds of active ingredient per gallon for large areas or in a low-percentage granular form for smaller areas.

Trifluralin can be used for weed control in green, lima, and dry beans, broccoli, brussels sprouts, cabbage, cauliflower, carrots, kale, mustard greens, okra, peas, peppers, tomatoes, turnip greens, apricots, cherries, grapes, peaches, and plums. Established trees, some ornamentals, and many established flowers will tolerate trifluralin. Do not use trifluralin on ground covers, sweet corn, strawberries, bramble fruits, or blueberries, because injury may result.

Trifluralin must be moved into the soil soon after application in order to prevent loss of the chemical from the soil surface. A rototiller or similar equipment should be used to mix trifluralin with the soil to a three- to four-inch depth. When it is impractical to mix trifluralin with the soil

mechanically, all emerged weeds should be removed and the herbicide should be incorporated into the soil by rainfall or sprinkle irrigation.

The correct amount of trifluralin to use depends on the type of soil to which it is being applied. The appropriate amounts are shown on the container label.

Trifluralin is quite effective on annual grasses, but many broadleaf weeds will need to be removed mechanically.

Napropamide

Napropamide is a preemergence herbicide. It should be incorporated into the soil by mechanical means or irrigation. Control existing weeds before applying napropamide.

Napropamide can be used in asparagus, tomatoes, peppers, strawberries, tree fruits, nuts, shrubs, and shade trees. It will control annual grasses such as barnyardgrass, crabgrass, fall panicum, and goosegrass. Broadleaf weeds that can be controlled by napropamide include carpetweed, purslane, lambsquarters, and pigweed.

Chloramben

Chloramben is available to many Illinois gardeners because it is used in soybean production. It should be applied to the soil surface before weed seeds germinate. The herbicide action is most effective if rainfall occurs or the soil is irrigated within two to three days after application of the herbicide.

Chloramben is available as a liquid with two pounds of active ingredient per gallon for large areas and as a low-percentage granular material for small areas. It can be used on lima beans, pumpkins, squash, sweet potatoes, transplanted tomatoes and peppers, and on young asparagus beds when they will not be harvested that season. Chloramben can be used on cucumbers, green beans, and muskmelons, but some injury may occur to these vine crops. Do not use chloramben on other vegetable or fruit crops.

As indicated on the container label, a number of annual flowers and established shrubs will tolerate chloramben. Chloramben controls a wider range of annual grass and broadleaf weeds than do DCPA, trifluralin, or EPTC, but it is not as effective on common purslane, which is often a problem in home gardens.

Chloramben is quite soil mobile and should not be used on gardens in sandy soil.

EPTC

EPTC can be purchased as a liquid with seven pounds of active ingredient per gallon for large gardens or as a 10 percent granular material for smaller areas. It can be used for weed control in green beans, dry beans, and Irish potatoes.

EPTC must be mixed with or watered into the soil immediately after application to prevent loss of the chemical from the soil surface. A rototiller or similar equipment should be used to mix EPTC with the soil to a three- to four-inch depth. When it is impractical to mix EPTC with the soil mechanically, all germinated and growing weeds should be removed, and the herbicide should be incorporated into the soil by rainfall or sprinkle irrigation.

EPTC is quite effective on annual grasses, but most broadleaf weeds will need to be mechanically removed.

Perennial Weed Control

Cultivation and mulching do not control most perennial weeds. Perennials can be controlled by removing the top growth to deplete the food (carbohydrate) supply in the underground storage tissues. This method may suppress the growth of perennial weeds, but completely eradicating the weeds with this method requires frequent recutting of the top growth.

Glyphosate (Roundup, Kleenup) must be applied to the foliage of green, actively growing plants to be effective. It has no soil activity, so it can be applied in the early spring. It can also be applied in the fall, after the edible plants have been removed from the garden, but while the perennial weeds are still growing. Do not apply glyphosate to (or let it drift onto) desirable or edible plants since it is nonselective. Be sure to read the label for complete application instructions.

Glyphosate can be used to control perennial weeds in vegetable gardens where labeled vegetable species will be grown. It must not be applied where nonlabeled vegetable species are to be grown. If gardeners in areas that are infested with perennial weeds are willing to restrict their choice of crops for one year, this method can effectively reduce the weeds. To find out which species are labeled, check the glyphosate label or ask your Extension adviser.

PRECAUTIONS

General

Phenoxy herbicides (2,4-D and others) and dicamba (Banvel) are used to control broadleaf weeds in corn, turf areas, and roadways. Most flowers, shrubs, shade trees, small fruits, tree fruits, and vegetables are susceptible to injury by these herbicides. When applying these materials, be sure that direct spray, drifting spray, or fumes do not reach susceptible plants.

Use the amine formulation of 2,4-D, which is less volatile and does not drift as easily as the esters, and apply it under calm conditions and temperatures below 80°F to 85°F. A sprayer used to apply phenoxy herbicides or dicamba on grass should not be used to apply other pesticides on gardens. Phenoxys usually cannot be cleaned out of sprayers thoroughly enough to avoid injury to broadleaf plants.

Soil Deactivation

If a garden area becomes contaminated with a persistent herbicide or a soil sterilant, this area can be decontaminated by applying activated carbon to inactivate the herbicide. See Horticulture Fact Sheet VC-15-81, *Testing for and Deactivating Herbicide Residues.*

Disposal of Pesticide Containers and Surplus Pesticides

Use pesticides safely. Read the label. If pesticides are handled or applied improperly, or if unused containers are disposed of improperly, injury can occur to humans, domestic animals, desirable plants, pollinating insects, and fish or other wildlife. Water supplies can also become contaminated. Use pesticides

only when needed, and handle them with care. Follow the directions, and heed all precautions on the container labels.

Store all pesticides in a cool, dry, locked storage area so that they are not accessible to children, unknowledgeable persons, or animals. Do not dispose of pesticides through sewage systems or where they can run off into drainage ditches or bodies of water. Haul them or have them hauled to a sanitary landfill for burial.

Never place aerosol cans on a stove or heater or near any source of heat that might exceed 120°F. Store in a cool place--not in the hot sun. Have empty aerosol cans hauled away and buried by experienced disposal crews. *Do not incinerate aerosol cans*.

Classification of Herbicides

The U.S. Environmental Protection Agency classifies herbicides for *general use* or *restricted use*. An Illinois resident wishing to use a herbicide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Your county Extension adviser in agriculture can give you details on this program. None of the herbicides discussed in this article have been classified for restricted use.

Controlling Weeds in Noncrop Areas

D. Anderson and M. McGlamery

Total vegetation management is the application of nonselective chemicals or nonselective rates of selective chemicals as a means of controlling all vegetation in such noncrop areas as parking lots, drive-in theater lots, driveways, and certain industrial sites.

Herbicides can be classified by their length of control. Those with little or no residual activity are the fumigants and the contact herbicides. Fumigants are volatile materials that can affect existing growth and the viability of weed seeds. Contact herbicides, such as paraquat, control only the existing vegetation that the spray contacts.

Amitrole, dalapon, 2,4-D, and DSMA give residual control for four months or less. Longer, semipermanent control is provided by some inorganic salts, such as sodium borate and sodium chlorate. Organic compounds that provide semipermanent control are bromacil, diuron, tebuthiuron, and the triazines (atrazine, simazine, and prometon).

Total vegetation management is desirable along fences, beneath asphalt pavement, along railroads, and around buildings as a means of preventing the growth of weeds that are unsightly or weeds that present a fire hazard. As an alternative to chemical control in some noncrop areas, it may be preferable to establish desirable, competitive vegetation to discourage weed growth and to provide protective soil and wildlife cover. Herbicides with little or no residual activity can be used for temporary control until desirable vegetation is established.

PRECAUTIONS AND GENERAL PROCEDURES

Several precautions must be observed when nonselective chemicals are used. Know what weeds are to be controlled and select the correct chemical for those particular problems. Survey the area, noting any desirable vegetation in the immediate or adjacent areas that could be affected by spray drift, chemical runoff, or herbicide leaching into the root zone.

Appropriate precautions should be taken to prevent damage to desirable plants. The risk of injury with some of these materials may be too great to allow their use in some areas. Be certain that you are familiar with the product and be aware of the risks before using any of these herbicides. Some treatments should be made only by professional applicators.

The type of vegetation to be controlled will affect your choice of a chemical. For example, perennial grasses can be controlled with dalapon, amitrole, pronamide, asulam, or DSMA; woody perennials can be controlled with picloram, triclopyr, 2,4-D, or Krenite. Deep-rooted vines, such as bindweed, can be controlled with dicamba or picloram.

Application timing is very important. The best time to apply nonselective, soil-residual herbicides is early in the spring before herbaceous weeds have emerged. If vegetation is dense, it may be necessary to mow or cut existing vegetation. For a later application, add a contact or translocated foliar herbicide, or mix the herbicides with diesel fuel to speed topkill. Follow label recommendations. After existing vegetation is under control, the rate of the soil herbicides can be reduced for maintenance applications.

Adjust application rates according to the soil type or the desired length of control. When you want to control growth for two or three years, several maintenance applications are better than one initial treatment at a high application rate.

HERBICIDES FOR NONCROPLAND

Inorganic Herbicides

1. **Sodium chlorate** has both foliar and root activity. The rate is 500 to 1,000 pounds per acre. This compound presents an *extreme fire hazard*, so fire retardants, such as calcium chloride or the borates, are often added to reduce the hazard. Altacide is sodium chlorate with a fire retardant. Another drawback to sodium chlorate is that it may be toxic to livestock that seek its salty taste.

2. **Sodium borate** (Borox, Polybor) has primarily root activity. Very high rates are required (1 to 2 tons per acre), so it is often used only as a granular carrier for organic compounds.

3. **Sodium arsenite** is a *highly toxic* compound. It is not usually recommended because safer products are now available. Sodium arsenite is formulated as a 9.5-pound-per-gallon liquid. The rate is 55 to 110 gallons per acre.

4. **Ammonium sulfamate**, or AMS, (Ammate X-NI) is formulated as 95 percent soluble crystals for control of woody plants and herbaceous weeds. It is sometimes used for brush control where volatility drift of growth-hormone-type herbicides would be a hazard. The rate is 60 to 100 pounds per acre. Ammonium sulfamate is corrosive to metals. Ammate X-NI is no longer manufactured but is available for sale and use until stock is depleted.

Organic Herbicides for Long-Term Control

1. **Asulam** (Asulox) is a 3.34-pound-per-gallon formulation that is used at the rate of 1 to 2 gallons per acre. Asulam controls grasses more effectively than it controls broadleaf weeds.

2. **Bromacil** (Hyvar-X) has both foliar and soil activity. It is formulated as an 80 percent wettable powder (WP) and a 2-pound-per-gallon liquid. Urox-'B' is a 4-pound-per-gallon liquid of bromacil. The rate of active ingredient is 5 to 15 pounds per acre.

3. **Bromacil + diuron** (Krovar I) is formulated as an 80 percent wettable powder or dry flowable, 1:1 combination of bromacil:diuron. It is used to control shallow-germinating weeds and deep-rooted perennials. The rate is 6 to 30 pounds per acre. Krovar II is a 2:1, bromacil:diuron dry flowable formulation.

4. **Simazine** (Princep) is formulated as an 80 percent WP, a 4-pound-per-gallon liquid, and a 4 percent granule (G). It has little foliar activity but has longer residual control than atrazine. The rate is 5 to 40 pounds per acre of the 80 percent WP.

5. **Atrazine** is an 80 percent WP, a 4-pound-per-gallon liquid, or a 90 percent water-dispersible granule (WDG). Atratol 8P is 8 percent atrazine on a chlorate-borate pellet, and Atratol 90 is a 90 percent WDG. The rate is 5 to 40 pounds per acre of the 80 percent WP, 0.25 to 1 pound per 100 square feet of the pellet, or 0.12 to 1 pound per 1,000 square feet of the water-dispersible granule.

6. **Prometon** (Pramitol) is available as a 2-pound-per-gallon liquid (Pramitol 25E) and a 5 percent pellet (Pramitol 5PS). Prometon has more foliar activity than atrazine. The rate for the liquid is 5 to 30 gallons per acre. The pellet rate is 12.5 to 75 pounds per acre or 0.5 to 2 pounds per 100 square feet.

7. **Hexazinone** (Velpar) is available as a 90 percent water-soluble powder (WSP), a 25 percent liquid (L), and a 75 percent granular formulation (G). Apply 2 to 5 pounds WSP or 1 to 2 1/2 gallons L per acre for contact kill and short-term control. Hexazinone is highly water soluble and may move in runoff to damage vegetation in adjacent areas.

8. **Tebuthiuron** (Spike) is available as an 85DF and a 20 or 40 percent granule (20P or 40P, respectively). For optimum results, applications should be made just before resumption of active seasonal growth in the spring and/or periods of rainfall at rates of 4.75 to 18.75 pounds per acre of 85DF, 5 to 30 pounds per acre of 20P, or 2.5 to 15 pounds per acre of 40P.

9. **Diuron** (Karmex) is an 80 percent WP or DF. The rate is 10 to 60 pounds per acre. It is sometimes mixed with bromacil (described earlier in 3).

10. **Dichlobenil** (Casoron) is available as a 50 percent WP and as 4 percent granules. It is used more commonly for nursery weed control than for soil sterilization. The rate is 10 to 40 pounds per acre of the 50 WP.

11. **Amizine** is amitrole plus simazine, which combines the foliar activity of amitrole with the residual activity of simazine. The suggested rate for general vegetation control is 20 pounds of Amizine per acre in 100 gallons of water or 9 gallons of Liquid Amizine per acre in a minimum of 50 gallons of water. Amizine and Liquid Amizine are restricted-use pesticides.

12. **Chlorsulfuron** (Telar) is a 75 percent DG that is most effective when applied postemergence, but it is also labeled for preemergence application. The rate is 1/4 to 3 ounces per acre.

13. **Sulfometuron** (Oust) is a 75 percent DG that is labeled for preemergence and postemergence application to young weeds. The rate is 1 to 12 ounces per acre.

14. **Imazapyr** (Arsenal) is formulated as a 2-pound acid equivalent-per-gallon aqueous solution that is taken up by both foliage and roots. It controls annual and perennial grasses and broadleaves, and controls brush species at the higher rates. Labeled rates range from 2 to 6 pints per acre. Arsenal

can be applied preemergence or postemergence, but postemergence application is the method of choice, especially to control perennials. Arsenal usually provides residual soil activity after a postemergence application. Prevent drift to desirable plants. Do not apply Arsenal to irrigation ditches, and do not allow runoff to cropland. Arsenal is corrosive to mild steel, brass, and copper. (Imazapyr is a proposed common name.)

Many of the granular or pelleted materials are organic herbicides formulated on sodium borate or borate-chlorate granules. They are applied dry, which makes them convenient for spot treatment or application on small areas.

Care should be taken not to apply bromacil, hexazinone, and tebuthiuron too close to trees and shrubs. Because of root uptake, these herbicides can be lethal to desirable species. Oaks are especially sensitive.

Organic Herbicides for Short-Term Control

1. **Amitrole** (Amizol, Amitrol-T) is a translocated herbicide that is especially effective on poison ivy and Canada thistle and on perennial grasses, such as quackgrass. Amizol is a 90 percent soluble powder that is applied at a rate of 2 to 5 pounds per acre in 50 to 100 gallons of water. Amitrole plus ammonium thiocyanate is available as Amitrol-T in a 2-pound-per-gallon liquid. The application rate is 1 to 4 gallons per acre. Amizol and Amitrol-T are restricted-use pesticides. (Amitrole plus simazine is available as Amizine; see Organic Herbicides for Long-Term Control, above).

2. **Dalapon** (Dowpon-M, Dalapon 85) is a foliage-applied, translocated grass herbicide. It is available with TCA (Dowpon-C, Revenge) for longer residual control. The rate is 10 to 15 pounds per acre of the 85 percent soluble powder. Use of a surfactant improves control. Perennial grass may require more than one application.

3. **TCA** (Sodium-TCA Weed Killer) is a root-absorbed grass killer that remains active in the soil longer than dalapon. It is a 90 percent soluble powder used at 50 to 150 pounds per acre.

4. **MSMA** is available as Daconate, a 6-pound-per-gallon liquid with a surfactant included. It is used for perennial grass control at 0.5 to 1.5 gallons per acre. More than one application may be necessary.

5. **DSMA** is available either as a liquid or as a soluble powder. It can be used for spot treatment of johnsongrass. The rate is 3 to 9 pounds per acre of the soluble powder or 1 to 2 gallons per acre of the liquid.

6. **Paraquat** (Gramoxone Super) is a 1.5-pound-per-gallon contact herbicide with no residual activity. The volume of water should be adjusted for the amount of vegetation. The rate is 1 to 3 quarts per acre. Paraquat requires the addition of a surfactant. Paraquat is restricted to use by certified applicators.

7. **Glyphosate** (Roundup) is a 4-pound-per-gallon translocated herbicide that is nonpersistent. Unlike paraquat, it will translocate to control perennial weeds. The rate is 1 to 5 quarts per acre.

HERBICIDES FOR BROADLEAF WEED AND BRUSH CONTROL

1. **Dicamba** (Banvel) is available as a 4-pound-per-gallon formulation. The rate is 1 to 4 quarts per acre. Formulated mixtures with other herbicides are also available. Banvel presents a drift hazard to nearby soybeans, tomatoes, and desirable broadleaf plants.

2. **Picloram** (Tordon) is a broadleaf weed and woody plant herbicide that does not affect grass species. Picloram is formulated as liquid Tordon K (2 lb/gal); Tordon 101, 101R, and RTU herbicides (mixtures of picloram and 2,4-D); and Access herbicide (mixture of picloram and triclopyr esters). Tordon K and Tordon 101 herbicides are designed for application to foliage and stems. Often in combination with triclopyr for maximum weed and brush control. Access herbicide is best suited for basal-bark applications. As with all mobile herbicides, picloram should not be used in areas of rapid permeability. Picloram is restricted for use by certified applicators only.

3. **Fenac** can be used for the control of deep-rooted, perennial broadleaf weeds. It is formulated as a 1.5-pound-per-gallon liquid. The application rate is 2 to 15 gallons per acre.

4. **2,4-D** is a broadleaf herbicide with little soil activity. Amine formulations present less hazard to nearby sensitive plants than esters because amines volatilize at higher temperatures. The common formulation is a 4-pound-per-gallon liquid. Mixtures of 2,4-D and dalapon are often used for short-term control of both broadleaf and grass weeds.

5. **Dichlorprop** or **2,4-DP** (Weedone 2,4-DP) gives better control of some woody plants than 2,4-D. Commercial mixtures of dichlorprop plus 2,4-D (Weedone 170 and Weedone CB) are available for broader-spectrum control.

6. **Bromacil** (Hyvar X or Hyvar X-L) is a 2-pound-per-gallon liquid for basal spraying of brush. A 10 percent pellet (HABCO-10B) is also available.

7. **Fosamine** (Krenite) is available as 2 different 4-pound-per-gallon formulations. When Krenite is applied within two months of autumn leaf discoloration, no symptoms are evident until the following spring, when the plants fail to refoliate. Because Krenite does not translocate, it can be used for chemical trimming. The rate is 1.34 to 3 gallons per acre.

8. **Triclopyr** (Garlon 4, Garlon 3A) is available in 3- or 4-pound-per-gallon formulations, in a formulated mix with 2,4-D (Crossbow), and in a mix with picloram (Access) for basal-bark applications. Triclopyr is a broad-spectrum broadleaf herbicide with no activity in grasses when used at recommended rates. It can be applied in foliar, basal-bark, or cut-surface applications to control many trees, brush species, and herbaceous broadleaf plants.

Long-Term Residual Control: Spray Applications

Many of these chemicals are wettable powders (WPs) and will require thorough agitation before application. A rate range is given to account for different soils and the different types of weeds to be controlled. Initial applications are often made at the higher rate, with subsequent treatments at the lower rate.

It is not always prudent to try to achieve control for more than one season with one application. Instead, use a lower rate and reapply annually.

Herbicide	Rate of formulation per acre		
	Annuals	Shallow perennials	Deep perennials
AAtrex (80W)	6 to 12.5 lb	12.5 to 25 lb	25 to 50 lb
Amizine (60W)	6 lb	12 lb	20 lb
Asulox (3.3 lb/gal)	1 to 2 gal	1 to 2 gal	...
Casoron (50W)	8 to 12 lb	12 to 25 lb	25 to 40 lb
Hyvar X (80W)	3 to 6 lb	7 to 12 lb	15 to 30 lb
Hyvar X-L (2 lb/gal)	1.5 to 3 gal	3 to 6 gal	6 to 12 gal
Karmex (80W or 80DF)	5 to 20 lb	20 to 40 lb	20 to 60 lb
Krovar I (80W or 80DF)	4 to 6 lb	7 to 18 lb	19 to 40 lb
Oust (75WDG)a	3 to 5 oz	6 to 12 oz	6 to 12 oz
Pramitol 25E (2 lb/gal)	5 to 7.5 gal	7.5 to 15 gal	15 to 30 gal
Princep (80W)	6 to 12.5 lb	12.5 to 25 lb	25 to 50 lb
Sodium chlorate	300 to 500 lb	500 to 750 lb	750 to 1,300 lb
Spike (85W)	5 to 10 lb	10 to 20 lb	...
Telar (75 WDG)[a]	0.25 to 1 oz	1 to 3 oz	...
Velpar (90WSP)	2 to 5 lb	6 to 12 lb	...
Velpar L or RP (2 lb/gal WDL)	1 to 2.5 lb	3 to 6 lb	...

[a]Note that the rate of formulation is in ounces per acre.

Long-Term Residual Control: Granular or Pellet Application

Granules are convenient to use for spot treatments or applications to small areas. Many granules are made with a sodium chlorate-borate base.

Herbicide	Pounds per 1,000 sq ft
Atratol 8P	5 to 10
Casoron-10P	5 to 10
Chlorea-3	10 to 20
Concentrated Borascu	40 to 60
Pramitol 5P	10 to 20
Princep 4G	5 to 25
Sodium chlorate-borate	30 to 40
Sodium chlorate-modified	20 to 40
Spike 20P	0.1 to 0.7
Spike 40P	0.05 to 0.35
Urox-'HX'	7 to 14

BROADLEAF WEEDS

Broadleaf weeds are often best controlled with foliar applications. Deep-rooted perennials can usually be controlled best when they are at the early bud to early bloom stage. Some of the herbicides listed below can move through the air and damage nearby desirable trees, shrubs, and broadleaf plants. Some of the herbicides are mobile in the soil and can damage desirable broadleaves if applied to the soil near their roots.

	Rate of formulation per acre	
	Annual and shallow perennials	Deep-rooted perennials
Banvel (dicamba)	0.5 to 1 qt	1 to 4 qt
Crossbow (triclopyr + 2,4-D)	1 to 2 qt	2 qt
Fenac	2 to 5 gal	10 to 15 gal
Roundup (glyphosate)	1 to 3 qt	4 to 6 qt
Tordon 101 (picloram + 2,4D)	2 to 3 qt	1 to 3 gal
Tordon K (picloram)	1 to 2 qt	2 to 4 qt
2,4-D	1 to 2 qt	2 to 4 qt
Garlon 4 (triclopyr)	1 to 2 qt	2 to 4 qt
Garlon 3A (triclopyr)	2 to 3 qt	3 to 6 qt

UNDESIRABLE WOODY PLANTS

Most of the herbicides used to control woody plants are applied to the foliage, but many of them can also be applied as basal-bark treatments if the woody plants have stems that are smaller than 5 inches in diameter or as cut-surface (frilled) treatments if the plants are larger. Basal-bark treatments are usually applied in fuel oil. Application can be made throughout the year, even during the dormant season. Cut-surface treatments can also be made throughout the year, but the herbicides should be applied to the cut surface within 2 to 3 hours of cutting. Foliar treatments are usually applied in the spring as soon as the leaves of brush or trees have fully expanded.

Herbicide	Method of application	Rate of formulation per acre
Access (picloram + triclopyr)	basal-bark	1 to 2 gal/100 gal spray mixture*
Banvel (4 lb/gal dicamba)	foliar	2 to 4 qt
Crossbow (triclopyr + 2,4-D)	foliar	4 to 6 qt
Escort (metsulfuron)	foliar	1/3 to 2 oz
Garlon 3A (44.4 percent triclopyr)	foliar or cut-surface	2 to 3 gal
Garlon 4 (61.6 percent triclopyr)	foliar or basal-bark	4 to 8 qt
Krenite (4 lb/gal)	foliar	1.5 to 3 gal
Tordon 101 (picloram + 2,4-D)	foliar or basal-bark	1 to 4 gal
2,4-D	foliar or basal-bark	2 to 4 qt

*20 to 30 percent in carrier for low-volume application.

WEEDY GRASS CONTROL

Weedy grasses can be controlled with the herbicides listed below. The use of a spreader-sticker (surfactant) is labeled for some of these herbicides.

Herbicide	Rate of formulation per acre	
	Annuals	Perennials
Asulox	1 to 2 gal	1 to 2 gal
Cytrol, Amitrol-T	1 gal	2 to 3 gal
Daconate	2 to 3 qt	3 to 5 qt
Dowpon	5 to 10 lb	10 to 30 lb
MSMA, DSMA	1 to 2 qt	2 to 4 qt
Roundup	1 to 2 qt	2 to 5 qt
Sodium-TCA	20 to 50 lb	100 to 150 lb

CONTACT WEED CONTROL

Contact herbicides kill only the plant tissue with which they come in contact; therefore, adequate spray volume is needed for thorough coverage of the foliage. A surfactant is often required by the herbicide label to help improve foliar coverage.

Herbicide	Rate per acre
Herbicidal naphtha	20 to 50 gal
Gramoxone Super	1 to 3 qt

COMMENTS

Whenever possible, use desirable plants to compete with and replace undesirable plants. For some areas mechanical control may be the most practical and appropriate method.

Availability, formulations, trade names, and federal clearance for the use of herbicides change from time to time. Always refer to the most recent product label for precautions, directions for use, and rates of application. Use herbicides appropriately to avoid injury to yourself and others, to desirable nontarget vegetation, and to the environment.

Brush Control in Illinois

D. Anderson and M. McGlamery

Brush control is used to improve and maintain pastures, recreational areas, fencerows, drainage ditch banks, rights-of-way, and other noncrop areas. Brush can be controlled by mechanical means such as cutting or digging, by herbicide treatments, or by a combination of mechanical and chemical control measures that remove the plant and prevent resprouting.

Mechanical control is costly and time-consuming. Re-treatment may be required for complete control because resprouting often occurs when herbicides are not used. Herbicides are generally less time-consuming and labor-intensive than are mechanical control methods, because complete control can be achieved with one treatment if the herbicide program is carefully planned. However, chemical control alone does not remove the dead plants.

Some brush herbicides are selective; they leave grasses unharmed while controlling brush and broadleaf weeds. These herbicides can injure desirable broadleaf plants if they are allowed to drift, run off, or leach out of the treatment area. Nonselective herbicides are also potentially hazardous to desirable plants, but they can be used as spot treatments to control brush species if they are applied carefully so that they do not move from the specific treatment area.

Some herbicides used for brush control have grazing and harvest restrictions. Some cannot be applied to aquatic areas, irrigation or drainage ditches, or to areas where they could run off or leach into those water systems. Be sure to follow label restrictions and recommendations closely and to make applications carefully.

METHODS OF APPLICATION

Various methods can be used to get the herbicide into the target plant. Table 1 lists common brush herbicides and indicates the areas for which they are labeled, the appropriate application methods, and the type of brush they control. Tables 2 through 5 describe the susceptibility of common brush species to various herbicides applied by foliar, basal-bark, cut-surface, or soil application methods. The information in these tables was taken from herbicide labels and from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture.

Foliar treatments are most effective when applied to fully developed plant foliage during late spring or early summer. Most herbicides can be applied throughout the growing season although translocation may be restricted by adverse temperature or moisture stress. Good foliar coverage is necessary for control, and some products should be applied so that they also drench the stem.

The effectiveness of some foliar herbicides can be reduced if rainfall occurs on the day of treatment. Foliar treatments should usually be applied only to shrubs or small trees. Large trees should be treated by another method to improve control and reduce drift potential.

When making foliar applications, take precautions against particle drift from the spray to nearby susceptible plants. Do not spray when the wind velocity is greater than 5 miles per hour or when the wind is blowing toward sensitive crops or ornamentals. Reduce the spray pressure and use nozzles with large orifices to apply herbicides that do not require coverage with fine spray droplets to achieve good control. Drift-reducing spray additives and equipment are available, but to achieve good control and to ensure minimum drift, you must adhere closely to all label precautions and directions. Certain formulations volatilize and should not be used when drift prevention is crucial. Some herbicide labels list sensitive species and areas that must be protected from drift and direct application.

Basal-bark treatments are oil-soluble herbicides applied in a carrier of diesel oil or kerosene; they are applied to the lower 12 to 18 inches of brush plants that are less than 4 to 5 inches in diameter. With high-volume, basal-bark applications of 1 to 5 percent herbicide, the spray should thoroughly drench the stem, the groundline, and all exposed roots. With low-volume applications of 20 to 30 percent herbicide, wet the stem to the point of glistening but not runoff. The herbicides commonly used for basal-bark treatments can cause injury if the vapor or particles drift to desirable crops or ornamentals. Although basal-bark treatments can be made throughout the year, applications made during the dormant season are less likely to result in drift injury. Do not apply when snow prevents treating the bark to the groundline. Some species, such as maples, should not be treated during heavy sap flow. Basal-bark treatments are more labor-intensive than foliar treatments, but they are useful as a technique to remove selectively undesirable species from stands of desirable trees. They are also useful where brush density is low to moderate.

Cut-surface treatments are more effective than basal-bark treatments on plants that are greater than 5 inches in diameter and on thick-barked species. The herbicide is applied to the stump of a cut plant or to frills or notches cut around the plant to a depth of at least 1/2 inch into the sapwood. Continuous cuts rather than spaced notches or frills may be more effective for difficult-to-control species. Special injection equipment can be used to cut into the plant and to apply the herbicide in one operation. The herbicide should be applied to the cut surface before the exposed plant tissue dries, which is usually within 2 or 3 hours after cutting. When treating cut stumps, thoroughly drench the cambium area next to the bark. Cut-surface applications can be made during any season of the year, but application during the dormant season minimizes the potential for drift injury.

Soil treatments can be made with certain herbicides that move through the soil to the root zone and then translocate upward to kill the plant. Soil treatments are applied within the dripline of the target species either as sprays or in dry form as granules, beads, or pellets. Apply these herbicides carefully to minimize injury to nearby desirable species. Nontarget injury can result if the herbicide moves laterally in the soil or in treated areas where the root zones of desirable and target species overlap.

Most soil treatments should be made between the last hard frost in the spring and the first hard frost in autumn. Soil treatments should not be applied to frozen ground. Many soil-applied herbicides remain active in the soil for several

months; for this reason, do not use soil-applied herbicides where they might run off into water sources or leach into groundwater.

BRUSH HERBICIDES

Phenoxy herbicides used for brush control are 2,4-D and dichlorprop (2,4-DP). These herbicides are sold under several different trade names. 2,4-D is labeled for brush control in pastures, drainage ditch banks, rights-of-way, and noncrop areas. Dichlorprop is labeled for use on rights-of-way and noncrop areas. Other herbicides are sometimes combined with 2,4-D or dichlorprop to broaden the spectrum of susceptible plants.

The phenoxy herbicides are readily absorbed by plant foliage. Oil-soluble formulations (esters or oil-soluble amines) applied in kerosene or diesel oil carriers will penetrate the bark of most woody plants. The esters are usually more effective than the amines for treating brush and trees with foliar or basal-bark sprays. Amines are preferable for injection and cut-surface treatments.

A minute amount of phenoxy herbicide may cause injury to highly susceptible nontarget plants, such as tomatoes, grapes, cucumber, and ornamentals--whether the method of application is foliar, basal-bark, or cut-surface. Generally a foliar treatment is potentially more hazardous than the other methods because it requires a greater volume of herbicide spray solution. The vapor from a phenoxy treatment may travel up to 1/2 mile. To reduce vapor drift, use amine rather than ester formulation when possible. Do not use an ester when the temperature on the day of treatment might exceed 85°F. Do not treat in the vicinity of sensitive nontarget plants. Do not apply phenoxy herbicides to water intended for domestic use or irrigation.

If possible, do not use phenoxy spray equipment to apply other pesticides to phenoxy-susceptible plants. Some residue may remain even after thorough cleaning. Follow all use restrictions listed on the herbicide label.

Banvel (dicamba) is a selective, translocated herbicide that can be absorbed through either the roots or the aboveground portions of plants. Banvel is used for foliar, cut-surface, or basal-bark treatments. For multiflora rose control, a spot concentrate application of Banvel to the soil can be made. Spray the soil as closely as possible to the crown root (within six to eight inches of the crown). Foliar sprays can be applied with ground or aerial equipment, but aerial application should not be made in the vicinity of sensitive plants. The spectrum of species controlled with Banvel can be broadened by the addition of 2,4-D as recommended on the label.

Like the phenoxys, Banvel volatilizes readily and is effective in small amounts. Prevent drift to sensitive feed and food crops, ornamentals, and conifers. Do not apply Banvel when the temperature is expected to exceed 85°F. Because Banvel is root absorbed, do not treat areas where the herbicide may leach or run off and contact the roots of desirable plants.

The label restricts the use of Banvel near soybeans in certain stages of growth. Grazing and harvest intervals are stated on the label. Study the label carefully before applying Banvel. If possible, do not use equipment used to spray Banvel to apply other pesticides to Banvel-susceptible plants because some residue may remain even after thorough cleaning.

Tordon (picloram) is a selective, translocated herbicide that is absorbed by plant roots and foliage. Formulations are available for foliar, basal-bark, soil, or cut-surface applications. Mixtures with phenoxy herbicides (Tordon 101, 101R, RTU) are available to give broader-spectrum weed control.

Soil treatments are broadcast, and control is enhanced as rainfall moves the herbicide into the root zone. Broadcast soil treatments are recommended for dense brush. Spot treatments can be made to individual plants or scattered stands of brush. Tordon products can be mixed with Garlon herbicides to provide a broad spectrum of broadleaf weed and woody plant control.

A low concentration can cause extensive damage to susceptible species. Do not apply where runoff or groundwater could move the herbicide into the root zone of susceptible nontarget plants, such as conifers or broadleaf ornamentals and crops. Prevent picloram from drifting into water containments and areas where desirable plants are growing. Drift injury to nontarget species is much less likely to result in injury if treatment is made during the dormant season.

Tordon K and Tordon 101 are restricted-use herbicides (RUP) that can be applied only by certified private or commercial applicators. Tordon RTU and 101R, which are premixed and labeled for cut-surface application only, are general-use herbicides.

Garlon (triclopyr) is a selective, translocated herbicide that can be applied as a foliar, basal-bark, or cut-surface treatment. Basal-bark treatments can be applied throughout the year. Compared to many brush herbicides, Garlon gives superior control of ash, oak, and certain root-sprouting species, such as sassafras and black locust. Commercial mixes of triclopyr plus 2,4-D (1:2) (***Crossbow***) or triclopyr plus picloram (***Access***) are available to control a broader spectrum of brush species. Take measures to prevent drift of Garlon formulations to susceptible ornamentals, crops, and conifers. The ester formulation is toxic to fish.

Trimec 352, Brush Killer 875, and other commercial mixtures of 2,4-D, mecoprop (MCPP), and dicamba are designed for foliar applications to give broad-spectrum brush control. A low concentration can damage susceptible species. Take precautions to prevent drift injury.

Escort (metsulfuron methyl) is labeled for the control of herbaceous and woody broadleaf plants. It is available as a 60 percent, dry flowable formulation labeled for foliar application at rates of 1/3 to 2 ounces per acre. For greatest effectiveness the herbicide should be applied to completely cover the foliage and stems. The application can be made anytime between one-half leaf stage in the spring until just before autumn leaf coloration. Plants are most susceptible when the application is made during warm, moist conditions and less susceptible when the weather is cool or dry. Woody species listed on the label include ash, cherry, elm, oak, red maple, and multiflora rose. Escort is most effective against broadleaf species but at medium to high label rates it can suppress or severely injure certain grasses. Read the label carefully before making applications, especially in areas of desirable grasses.

Escort is labeled for use in noncrop areas, such as airports, roadsides, and utility, pipeline, and railroad rights-of-way. However, it should not be used on lawns, walks, driveways, tennis courts, or similar areas.

Escort injury symptoms (leaf discoloration) can take several weeks to appear, depending on environmental conditions. However, treated plants stop growth very soon after the application.

Do not apply the herbicide or drain or rinse application equipment near desirable plants, or on soil where roots of desirable plants may extend, or in locations where the herbicide may be moved into contact with the roots. Do not use spray equipment to apply products to desirable plants after it has been used to apply Escort because low rates of Escort can kill or severely injure desirable plants.

Krenite (fosamine) is a contact herbicide that is applied to the foliage of brush during the two-month period before autumn leaf coloration. No effects are seen until the following spring, when treated plants fail to refoliate and subsequently die. Pine species may respond during the season of treatment. Thorough coverage is required for complete control. By carefully directing the application, you can use Krenite to trim woody species without killing the entire plant. A surfactant can be used to improve control.

Krenite should not be applied to desirable plants, brush standing in water, or food crops. Krenite can be slightly corrosive to brass or copper spray equipment. Clean thoroughly after use to protect the spray equipment.

Amitrole is a nonselective, translocated herbicide that is especially effective against poison ivy, poison oak, brambles, and honeysuckle. Amitrole can be used only where there is no possibility that residues will remain on food or feed crops (see Table 1). Amitrole is available in **Amizol**, which is a 90 percent, water-soluble powder and in **Amitrol-T**, which is a 2-pound-per-gallon soluble liquid. Amitrole is applied in foliar sprays. All leaves, stems, and suckers should be thoroughly wet to the groundline. The addition of a surfactant may improve control.

Because amitrole gives nonselective control, it should be directed away from desirable species if their loss would be detrimental. Keep amitrole out of aquatic areas if the water is intended for irrigation, drinking, fishing, or other domestic purposes. Keep livestock off treated areas. Amizol and Amitrol-T are restricted-use pesticides.

Roundup (glyphosate) is a nonselective, translocated herbicide that can be used for spot treatments in areas where loss of ground cover is detrimental. Because plants absorb the herbicide through their foliage, glyphosate must be applied during the season of active growth. Flowering species should be treated when the plants are at or beyond the full-bloom stage of growth. Roundup has no soil activity. Prevent drift to foliage of nontarget species.

Arsenal (imazapyr) is a 2-pound-per-gallon formulation that is taken up by both foliage and roots. It controls annual and perennial grasses and broadleaves at low concentrations and brush species at the higher rates. Arsenal can be applied preemergence or postemergence, but postemergence is the method of choice, especially to control perennials. Arsenal usually provides residual soil activity after a postemergent application. Prevent drift to desirable plants. Do not apply to irrigation ditches, and prevent runoff to crop land. Arsenal is corrosive to mild steel, brass, and copper. (Imazapyr is a proposed name.)

Hyvar (bromacil) is a nonselective herbicide that is labeled for use on a wide spectrum of woody species. Two formulations are available: **Hyvar X**, which is an 80-percent wettable powder, and **Hyvar X-L**, which is a 2-pound-per-gallon water-

soluble liquid formulation that stays in solution without continuous agitation. Both formulations are labeled for broadcast soil application on noncrop areas and rights-of-way. The recommended application time is just before emergence or during the period of active growth of the plants to be controlled. Hyvar X-L can be applied as a basal-bark or soil application in noncrop areas and rights-of-way and also in drainage ditches.

In addition to controlling brush species, Hyvar also controls herbaceous broadleaf and grass plants. Grass species are especially susceptible to injury. Spot treatments around the base of woody plants may be appropriate in areas where bare ground is undesirable.

Injury symptoms are generally slow to appear. Treated plants may not respond until the herbicide has been carried into the root zone by rainfall. In areas of dense growth, results will be improved if vegetation is removed before Hyvar is applied.

Do not apply to frozen soil or to brush standing in water. Do not use water from treated ditches for irrigation, and do not treat ditches that are adjacent to desirable plants.

Hyvar X is noncorrosive, nonflammable, and nonvolatile. Hyvar X-L is corrosive to aluminum and should not be applied with aluminum spray nozzles. Undiluted Hyvar X-L is combustible, so it must be kept away from heat and open flame. Do not smoke when handling this product.

Velpar (hexazinone) is a nonselective herbicide that is taken up by the roots and foliage of plants. Velpar is most effective when applied to the soil just before or soon after weed emergence. Velpar also has some contact activity if an appropriate surfactant is added to the spray mix. The recommended rate varies with soil type. Higher rates are recommended when treating hard-to-control species.

Avoid application of Velpar to the root zone or foliage of desirable plants. Spot treatment is necessary when bare soil is undesirable. Exceeding the concentration recommended on the label might clog nozzles and result in uneven distribution. Agitate the herbicide mixture for at least ten minutes until Velpar is thoroughly dissolved.

Spike (tebuthiuron) is a soil-applied nonselective herbicide that is absorbed by the roots of plants. Spike can be applied anytime, except when the ground is frozen or the soil is saturated with moisture. To achieve the best results, apply the herbicide before or during active growth of target plants. Spike can be applied to the soil dry or with a water carrier. The dry application requires rainfall to wash the herbicide into the root zone.

Due to differences in susceptibility, different species require different rates of Spike. Consult the label for the correct rate of use for the plant species to be controlled. Spike can be applied broadcast or as an individual plant treatment, depending on the size, density, and location of the brush to be controlled.

The wettable powder formulation requires continuous agitation. Spike does not leach readily in the soil. Avoid application where runoff can wash the dry herbicide into nontarget areas. Prevent drift or direct application of Spike to the root zones of desirable plants.

Table 1. Label Clearances: Common Brush Herbicides

Brush herbicide	Area				Application				Type of brush	
	Pasture	Drainage-ditch bank	Right-of-way	Non-crop	Foliar-stem spray	Cut surface or injection	Basal bark[a]	Soil	Deciduous	Conifer
2,4-D amine	X	X	X	X	X	X	..	..	X	..
2,4-D ester	X	X	X	X	X	X	X	..	X	..
2,4-DP (dichlorprop)	..	..	X	X	X	X	X	..	X	..
Weedone 170 or Weedone CB (2,4-D + dichlorprop)	..	X	X	X	X	X	X	..	X	..
Banvel + 2,4-D	X	X	X	X	X	X	X[b]	..	X	X
Banvel 5G or 10G	X	X	X	X	..	..	..	X	X	X
Garlon 3A (triclopyr amine)	X	X	X	X	X	X	..	..	X	X
Garlon 4 (triclopyr ester)	X	X	X	X	X	..	X	..	X	X
Tordon K (picloram)	c	..	X	X	X	..	..	X	X	X
Tordon RTU or 101R	..	..	X	X	..	X	..	..	X	X
Tordon 101 Mixture (picloram + 2,4-D)	d	..	X	X	X	X	..	X	X	X
Access (esters of picloram + triclopyr)	..	..	X	X	..	..	X	..	X	X
Crossbow (triclopyr + 2,4-D)	X	e	..	X	X	X	X	..	X	X
2,4-D + mecoprop + dicamba	..	X	X	X	X	..	..	..	X	..
Escort (metsulfuron)	..	..	X	X	X	..	..	..	X	..
Krenite	..	X	X	X	X	..	..	..	X	..
Amitrole + T	..	X	X	X	X	..	..	..	X	..
Roundup	..	..	X	X	X	..	..	..	X	..
Hyvar-X	..	X[f]	X	X	X	..	..	X	X	X
Velpar	..	..	X	X	X	..	..	X	X	..
Spike	X[g]	X[g]	X	X	..	..	..	X	X	X

[a]Oil-soluble forms only.
[b]Not for pasture use.
[c]Sold for pasture use as 22k.
[d]Sold for pasture use as Grazon P + D.
[e]Non-irrigation ditch banks only.
[f]Soil application only.
[g]See specific formulation label.

Table 2. Foliar Herbicide Treatment: Susceptibility of Common Brush Species[a]

	2,4-D	Dichlorprop	Banvel	Tordon	Hyvar	Garlon	Escort	Amitrole	Roundup	Krenite
Ash, white (*Fraxinus americana*)	R	R	S-R	S-R	S-R	S	S	S	S-I	I
Birch (*Betula* spp.)	S-I	S	S	S	S	S	...	...	S	S
Boxelder (*Acer negundo*)	S-I	I-R	...	S-I	S	S	...	...	S	...
Brambles--blackberry, raspberry, etc. (*Rubus* spp.)	I-R	I-R	S-I	S-I	S-I	S-I	...	S-I	S-I	S
Cherry, black and choke (*Prunus serotina and P. virginiana*)	I-R	I-R	S	S-I	S-I	S-I	S	S	S	I
Cottonwood, eastern (*Populus deltoides*)	S-R	R	R	...	S-I	S-I	...	...	...	S-I
Crabapple (*Pyrus ioensis*)	S-I	S	S	S	S	...	...	...	S	...
Elderberry (*Sambucus canadensis*)	S-I	I	S	S	S	S-I	...	...	S	...
Elms, American and slippery (*Ulmus* spp.)	I	S-I	I	S-I	S-I	S-I	S	...	S	S-I
Grapes, wild (*Vitis* spp.)	S-I	S-I	I-R	S-I	...	...	...	...	S	S-I
Greenbrier or catsbriar (*Smilax* spp.)	R	R	R	I-R	R	...	...	...	...	...
Hackberry (*Celtis* spp.)	I-R	I-R	I	S-I	S-I	...	...	...	S	...
Hawthorn (*Crataegus* spp.)	I-R	R	R	S-I	...	S	...	...	S	I
Hedge-apple or osage orange (*Maclura pomifera*)	I-R	R	I-R	S-I	...	...	...	...	...	...
Honeylocust (*Gleditsia triacanthos*)	I-R	I	S-I	S	S	S-I	...	...	S	...
Honeysuckle (*Lonicera* spp.)	S-I	S-I	I	S-I	S	S	...	S-I	S	...
Locust, black (*Robinia pseudoacacia*)	S-I	S-I	S	S-I	S	S-I	...	S	S	S
Maple, red (*Acer rubrum*)	R	R	I-R	S-I	S	S-I	S-I	...	S	...
Maple, silver (*Acer saccharinum*)	I-R	...	...	S	S	...	...	...	...	...
Maple, sugar (*Acer saccharum*)	I-R	...	...	...	...	...	...	...	...	...
Mulberry, red (*Morus rubra*)	I-R	I-R	S-I	S-I	...	S-I	...	...	...	...
Persimmon, eastern (*Diospyros virginiana*)	I	I-R	S-I	S-I	...	S-I	...	...	...	I
Plum, wild (*Prunus* spp.)	S-I	I	S-I	S	...	...	...	...	S	S-I
Poison ivy (*Rhus radicans*)	I	I	S	S	S	S	...	S	S	...
Redcedar, eastern (*Juniperus virginiana*)	R	R	I-R	S-I	S	R	...	...	S	S
Rose, multiflora (*Rosa multiflora*)	...	...	...	S	...	S	S	...	S	S-I
Sassafras (*Sassafras albidum*)	S-I	I	I	S-I	S	S	...	...	S	I
Sumac (*Rhus* spp.)	S	S	S	S	S-I	S	...	S	S	S
Tree-of-heaven (*Ailanthus altissima*)	S-I	S-I	S-I	S-I	S	S	...	...	S	S-I
Trumpetcreeper (*Campsis radicans*)	...	...	S-I	...	...	...	...	...	S-I	...
Virginia creeper (*Parthenocissus quinquefolia*)	S	S-I	...	...	...	...	...	...	S	...
Willow (*Salix* spp.)	S	S	S-I	S-I	S	S	...	...	S	I

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook No. 493, U.S. Department of Agriculture, and from herbicide companies.

Table 3. Basal-Bark Herbicide Treatment: Susceptibility of Common Brush Species[a]

	2,4-D	Dichlorprop	Banvel	Access	Hyvar	Garlon
Ash, white (*Fraxinus americana*)	R	R	S-I	S	S	S
Birch (*Betula* spp.)	S	...	...	S	S	S
Boxelder (*Acer negundo*)	S	S	S	S	S	R
Brambles--blackberry, raspberry, etc. (*Rubus* spp.)	I-R	S-R	S	S	S	S
Cherry, black and choke (*Prunus serotina and P. virginiana*)	S-R	S	S	S	S-I	S
Cottonwood, eastern (*Populus deltoides*)	...	...	...	S	S	S
Crabapple (*Pyrus ioensis*)	S-I	S-I	S	S	S-I	...
Elderberry (*Sambucus canadensis*)	S-I	S	S	S	S	S
Elms, American and slippery (*Ulmus* spp.)	S-I	S-I	S	S	S-I	S
Grapes, wild (*Vitis* spp.)	...	...	...	S	...	S
Greenbrier or catsbriar (*Smilax* spp.)	I	...	R	I-R	R	...
Hackberry (*Celtis* spp.)	S	S	...	S	S	S
Hawthorn (*Crataegus* spp.)	I	S-R	S-R	S	S	S
Hedge-apple or osage orange (*Maclura pomifera*)	I	R	...	S	I	...
Honeylocust (*Gleditsia triacanthos*)	I	I	...	S	S	S
Honeysuckle (*Lonicera* spp.)	S	S	S	S	I-R	R
Locust, black (*Robinia pseudoacacia*)	I	I-R	S-I	S	S	S
Maple, red (*Acer rubrum*)	R	R	S	S	S	S-I
Maple, silver (*Acer saccharinum*)	I	...	...	S	S	...
Maple, sugar (*Acer saccharum*)	...	...	...	S	...	...
Mulberry, red (*Morus rubra*)	I-R	I-R	S	S	I	S
Persimmon, eastern (*Diospyros virginiana*)	I-R	R	S	S	I	S
Plum, wild (*Prunus* spp.)	S-I	S-I	S	S	S	...
Poison ivy (*Rhus radicans*)	I	...	...	S	S	S
Redcedar, eastern (*Juniperus virginiana*)	R	R	S-I	S	S	R
Rose, multiflora (*Rosa multiflora*)	...	...	...	S	...	S
Sassafras (*Sassafras albidum*)	S-I	S-R	S	S	I	S
Sumac (*Rhus* spp.)	R	R	S	S	S	S
Tree-of-heaven (*Ailanthus altissima*)	S-R	S-I	S	S	S	S
Trumpetcreeper (*Campsis radicans*)	...	...	...	...	...	...
Virginia creeper (*Parthenocissus quinquefolia*)	...	...	...	...	R	...
Willow (*Salix* spp.)	S	S	...	S	S	S

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture, and from herbicide companies.

Table 4. Injection and Cut-Surface Treatment: Susceptibility of Common Brush Species[a]

	2,4-D	Dichlorprop	Garlon 3A	Banvel	Tordon + 2,4-D
Ash, white (*Fraxinus americana*)	I	...	S	S	S
Birch (*Betula* spp.)	...	S-I	S	S	S
Boxelder (*Acer negundo*)	...	...	R	...	S-I
Brambles--blackberry, raspberry, etc. (*Rubus* spp.)	...	S	S	...	...
Cherry, black and choke (*Prunus serotina and P. virginiana*)	...	S-I	S	...	S
Cottonwood, eastern (*Populus deltoides*)	S-I	...	S	...	S
Crabapple (*Pyrus ioensis*)	...	...	S	...	...
Elderberry (*Sambucus canadensis*)	...	...	S	...	S
Elms, American and slippery (*Ulmus* spp.)	S-I	...	S	...	S-I
Grapes, wild (*Vitis* spp.)	S	...	S	...	S
Greenbrier or catsbriar (*Smilax* spp.)	...	...	...	...	...
Hackberry (*Celtis* spp.)	S	...	S	...	S
Hawthorn (*Crataegus* spp.)	R	...	S	...	S-I
Hedge-apple or osage orange (*Maclura pomifera*)	S-I	...	...	...	S-I
Honeylocust (*Gleditsia triacanthos*)	...	...	S-I	...	S
Honeysuckle (*Lonicera* spp.)	...	S-I	R	...	S
Locust, black (*Robinia pseudoacacia*)	S	S-I	S	...	S
Maple, red (*Acer rubrum*)	I-R	...	S	S-I	S
Maple, silver (*Acer saccharinum*)	...	...	...	...	...
Maple, sugar (*Acer saccharum*)	R	...	...	S	...
Mulberry, red (*Morus rubra*)	...	...	S	...	S
Persimmon, eastern (*Diospyros virginiana*)	I	...	S	S	S-I
Plum, wild (*Prunus* spp.)	...	...	...	...	...
Poison ivy (*Rhus radicans*)	...	S-I	S	...	S
Redcedar, eastern (*Juniperus virginiana*)	R	...	R	S-I	I
Rose, multiflora (*Rosa multiflora*)	...	...	S	...	S
Sassafras (*Sassafras albidum*)	...	...	S	...	S
Sumac (*Rhus* spp.)	...	...	S	...	S
Tree-of-heaven (*Ailanthus altissima*)	...	...	S	...	S-I
Trumpetcreeper (*Campsis radicans*)	...	...	...	...	S
Virginia creeper (*Parthenocissus quinquefolia*)	...	...	...	...	...
Willow (*Salix* spp.)	S	S-I	S	...	S

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture, and from herbicide companies.

Table 5. Soil Herbicide Treatment: Susceptibility of Common Brush Species[a]

	Tordon	Hyvar	Velpar	Spike
Ash, white (*Fraxinus americana*)	I	S	...	I
Birch (*Betula* spp.)	S	S	...	S
Boxelder (*Acer negundo*)	S	S	...	S
Brambles--blackberry, raspberry, etc. (*Rubus* spp.)	S-I	S	...	I
Cherry, black and choke (*Prunus serotina* and *P. virginiana*)	S	S-I	...	I
Cottonwood, eastern (*Populus deltoides*)	S	...	...	S
Crabapple (*Pyrus ioensis*)	S	I	...	...
Elderberry (*Sambucus canadensis*)	S-I	S	...	...
Elms, American and slippery (*Ulmus* spp.)	S	S	...	S
Grapes, wild (*Vitis* spp.)	S-I	...	...	...
Greenbrier or catsbriar (*Smilax* spp.)	R	R	...	I-R
Hackberry (*Celtis* spp.)	S	S	...	S
Hawthorn (*Crataegus* spp.)	S	S-R	S-I	S
Hedge-apple or osage orange (*Maclura pomifera*)	S-I	R	...	...
Honeylocust (*Gleditsia triacanthos*)	S-I	S	...	I
Honeysuckle (*Lonicera* spp.)	S	I-R	...	...
Locust, black (*Robinia pseudoacacia*)	S-I	S	...	S
Maple, red (*Acer rubrum*)	S-I	S	...	S-I
Maple, silver (*Acer saccharinum*)	I	S	...	I
Maple, sugar (*Acer saccharum*)	...	...	...	S
Mulberry, red (*Morus rubra*)	S-I	I	...	I
Persimmon, eastern (*Diospyros virginiana*)	S	I	...	I-R
Plum, wild (*Prunus* spp.)	S	S	...	S
Poison ivy (*Rhus radicans*)	S	S	...	I-R
Redcedar, eastern (*Juniperus virginiana*)	S-I	S	...	S
Rose, multiflora (*Rosa multiflora*)	S-I	...	...	S
Sassafras (*Sassafras albidum*)	S-I	I	...	I-R
Sumac (*Rhus* spp.)	S	S	S-I	S
Tree-of-heaven (*Ailanthus altissima*)	S	S	...	S
Trumpetcreeper (*Campsis radicans*)	S	...	S-I	S
Virginia creeper (*Parthenocissus quinquefolia*)	S	R	...	S
Willow (*Salix* spp.)	S	S	S-I	S

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Data are from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture and from herbicide companies.

Chemical Control of Some Aquatic Plants

R. Hiltibran

Group and species	Herbicide	Rate of application	Remarks
EMERSED PLANTS			
Arrowhead (*Sagittaria* spp.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb/440 sq ft	Spread on water
	ester (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	amine (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	diquat cation (2 lb/gal)	1/4 cup/gal	Wet foliage
Bulrush (*Scirpus actus* Muhl.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb/440 sq ft	Spread on water
	ester (4 lb/gal)	1/2 cup/2 gal	Wet stems
	diquat cation (2 lb/gal)	2 tbsp/3 gal and 1 tsp non-ionic wetting agent	Wet foliage to point of run-off
	dichlobenil (aquatic granules 10%)	40 lb/A	Apply in March to exposed bottom soil
Cattail (*Typha* spp.)	Use one of the following:		
	dalapon	4 oz/gal and 3 caps detergent	Wet foliage
	amitrole	2 oz/gal and 3 caps detergent	Wet foliage
	2,4-D ester (4 lb/gal)	1/2 cup/gal and 3 caps detergent	Wet foliage
	diquat cation (2 lb/gal)	2 tbsp/3 gal and 1 tsp nonionic wetting agent	Wet foliage
	glyphosate Rodeo (4 lb/gal)	2 tbsp/1 gal plus 1/2 to 1 tbsp of non-ionic surfactant	Wet foliage of actively growing plants at bloom stage or later

Group and species	Herbicide	Rate of application	Remarks
Creeping water primrose (*Jussiaea repens L.* var. *glabrescens* Ktze.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb/440 sq ft	Spread on water
	ester (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	amine (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	diquat cation (2 lb/gal)	1/4 cup/2 gal	Wet foliage
Phragmites (*Phragmites australis*)	glyphosate Rodeo (4 lb/gal)	2 tbsp/1 gal plus 1/2 to 1 tbsp of nonionic surfactant	Wet foliage at full bloom stage or during autumn. Repeat treatments required
Spatterdock (*Nuphar advena* (Ait.) Ait. f.)	dichlobenil (aquatic granules 10%)	60 lb/A	Spread on water
	glyphosate Rodeo (4 lb/gal)	2 tbsp/1 gal plus 1/2 to 1 tbsp of nonionic surfactant	Wet foliage at full bloom stage during summer or fall.
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Waterwillow (*Justicia americana* (L.) Vahl)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb/440 sq ft	Spread on water
	ester (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	amine (4 lb/gal)	1/4 cup/2 gal	Wet foliage
	diquat cation (2 lb/gal)	1/4 cup/2 gal	Wet foliage
SUBMERSED PLANTS WITH ALTERNATE LEAF ATTACHMENT			
Curlyleaf pondweed (*Potamogeton crispus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below surface

Group and species	Herbicide	Rate of application	Remarks
Curlyleaf pondweed (*continued*)	diquat cation (2 lb/gal)	0.5 ppm or 1 gal/ surface A	Same as previous
	dichlobenil (aquatic granules 10%)	80 lb/A	Preemergent application
	fenac	See manufacturer's directions	Must be applied to exposed pond bottom
	diquat cation/copper-triethanolamine complex	0.25 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	simazine (80WP)	0.5 ppm	Apply to total water volume
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Leafy pondweed (*P. foliosus* Raf.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb/gal)	0.5 ppm or 1 gal/ surface A	Same as above
	dichlobenil (aquatic granules 10%)	40 lb/A	Preemergent application*
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	simazine (80WP)	0.5 ppm	Apply to total water volume
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Sago pondweed (*P. pectinatus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb/gal)	0.5 ppm	Same as above
	dichlobenil (aquatic granules 10%)	80 lb/A	Preemergent application

*The preemergent aquatic herbicides have not given satisfactory season-long control of leafy pondweeds.

Group and species	Herbicide	Rate of application	Remarks
Sago pondweed (*continued*)	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	simazine (80WP)	0.5 ppm	Apply to total water volume
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Small pondweed (*P. pusillus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb/gal)	0.5ppm	Same as above
	dichlobenil (aquatic granules 10%)	80 lb/A	Preemergent application
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed bottom
	simazine (80WP)	0.5 ppm	Apply to total water volume
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Waterstargrass (*Heteranthera dubia* (Jacq.) MacM.)	Use one of the following:		
	diquat cation (2 lb/gal)	1 ppm or 2 gal/ surface A	Apply on or below water surface
	endothall (potassium salt, 4.23 lb/gal or 10% G)	5 ppm	Same as above
SUBMERSED SQUATIC PLANTS WITH OPPOSITE LEAF ATTACHMENT			
White buttercup (*Ranunculus trichophyllus* Chaix)	diquat cation (2 lb/gal)	0.5 ppm	Apply below water surface
Slender naiad (*Najas flexilis* (*Willd.*) Rostk. & Schmidt)	Use one of the following:		
	copper-ethylene-diamine complex*	0.5-1.0 ppm (copper)	Apply below water surface

*Sold under the trade name of Komeen by the Sandoz Corporation.

Group and species	Herbicide	Rate of application	Remarks
Slender naiad (*continued*)	diquat cation (2 lb/gal)	1 ppm or 1.5 gal/ surface A	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	endothall (potassium salt, 4.23 lb/gal or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above
	dichlobenil (aquatic granules 10%)	80 lb/A	Preemergent application
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Southern naiad (*N. guadalupensis (Spreng.) Magnus*)	Use one of the following:		
	copper-ethylene-diamine complex*	0.5-1.0 ppm(copper)	Apply below water surface
	diquat cation (2 lb/gal)	1 ppm or 1.5 gal/ surface A	Apply below water surface
	diquat cation/copper triethanolamine	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	endothall (potassium salt, 4.23 lb/gal or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above
	dichlobenil (aquatic granules (10%)	80 lb/A	Preemergent application
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
SUBMERSED AQUATIC PLANTS WITH WHORLED LEAF ATTACHMENT			
Common coontail (*Ceratophyllum demersum L.*)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal or 10% G)	2 ppm	Spread on water

*Sold under the trade name of Komeen by Sandoz Corporation.

Group and species	Herbicide	Rate of application	Remarks
Common coontail (*continued*)	2,4-D ester (20% G)	2 ppm	Spread on water
	diquat cation (2 lb/gal)	1 ppm, or 2 gal/ surface A	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Elodea (*Elodea canadensis Michx.*)	Use one of the following:		
	copper-ethylenediamine complex*	0.5-1.0 ppm (copper)	Apply below water surface
	diquat cation (2 lb/gal)	1 ppm,or 2 gal/ surface A	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Watermilfoil (*Myriophyllum* spp.)	Use one of the following:		
	2,4-D ester (20% G)	2 ppm	Spread on water
	endothall (potassium salt, 4.23 lb/gal	3 ppm	Apply below water surface
	or 10% G)	3 ppm of 10% G	Spread on water
	diquat cation (2 lb/gal)	1 ppm	Apply below water surface
	dichlobenil (aquatic granules 10%)	100-150 lb/A	Spread on water
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface

Group and species	Herbicide	Rate of application	Remarks
FLOATING-LEAVED AQUATIC PLANTS			
American pondweed (*Potamogeton nodosus* Poir.)	Use one of the following:		
	endothall (10% G)	1 ppm	Spread on water
	endothall (potassium salt, 4.23 lb/gal)	1/2 cup/gal	Apply to leaves
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
Waterlily (*Nymphaea* spp.)	dichlobenil (aquatic granules 10%)	50 lb/A	Spread on water
	2,4-D (20% G)	200 lb/A	
	fluridone Sonar (4AS,5P, SRP)	Rate is dependent on water depth (see label)	Apply to water surface
FREE-FLOATING AQUATIC PLANTS			
Common duckweed (*Lemna minor L.*)	Use one of the following:		
	endothall (potassium salt, 4.23 lb/gal)	1 cup/4 gal	Apply to leaves
	diquat cation (2 lb/gal)	1 cup/4 gal	Apply to leaves
	simazine (80WP)	0.5 ppm	Apply to total water volume
	fluridone Sonar (4AS, 5P, SRP)	Rate is dependent on water depth (see label)	Apply to leaves and water surface
Watermeal (*Wolffia columbiana Karst.*)	simazine (80WP)	1 ppm	Apply to total water volume
ALGAE			
Chara (has cylindrical, whorled branches and resembles, in form, of the plants mentioned above) (*Chara* spp.)	Use one of the following:		
	dichlobenil (aquatic granules 10%)	40 lb/A	Preemergent application only
	copper sulfate**	1 ppm	Postemergent application
	Aquatic Herbicide System M***	15-25 lb/A	Apply on water surface

Group and species	Herbicide	Rate of application	Remarks
ALGAE			
(continued)			
Filamentous algae	copper sulfate**	1 ppm (copper)	Postemergent
	Aquatic Herbicide System M***	15 lb/A	Spread on water
	simazine (80WP)	0.5 ppm	Apply to total water volume

*Sold under the trade name of Komeen by Sandoz Corporation.
**Crystalline copper sulfate can be used; there are several copper-containing formulations that contain copper-chelating compounds, which prevent the immediate precipitation of copper carbonate. Check the label for instructions concerning their uses and rate of application. A lower rate of application for copper can be used with these latter formulations. Their copper contents may vary.
***A copper-containing formulation developed by the 3M Company and distributed under the trade name of Mariner.

ADDITIONAL INFORMATION

Aquatic Plants and Their Control. Fishery Bulletin No. 4, Illinois Department of Conservation, Springfield, IL 61706

Controlling Johnsongrass, Shattercane, and Sorghum-almum in Illinois

D. Anderson and M. McGlamery

Johnsongrass (*Sorghum halepense*) was used as a forage in the United States beginning about 1820. It spread rapidly and is now a problem weed in Illinois, particularly in the southern half of the state, where the rhizomes can overwinter. In the colder climate of northern Illinois, johnsongrass spreads primarily by seed. Since 1959, johnsongrass has been listed as a primary noxious weed under the Illinois Noxious Weed Law.

Shattercane (*Sorghum bicolor*), or wild cane, developed from the natural crossing of diverse wild and cultivated sorghum types. Shattercane produces seeds that remain viable in the soil for one or more seasons. Planting sorghum seedlots contaminated with wild sorghum helped the spread of shattercane in Illinois.

Sorghum-almum (*Sorghum almum*) was introduced in Illinois in the late 1950s as a perennial sudangrass for use as a forage crop. Sorghum almum is a hybrid between johnsongrass and a cultivated sorghum. It is listed as a perennial member of the sorghum genus under the Illinois Noxious Weed Law.

DESCRIPTIONS

Johnsongrass is a perennial that reproduces by seeds and rhizomes. The root system is a fibrous network of roots plus freely branching, fleshy, scaly rhizomes that are white with purple spots. The rhizomes may grow several feet in length and may reach a diameter of 0.75 inch. The stems are erect and smooth, and from 3- to 10-feet tall depending on the biotype and environment. The leaves are alternate, simple, and smooth--12- to 30-inches long and 0.70- to 1.3-inches wide. Johnsongrass has a large open panicle-type seedhead that is purplish, hairy, and diversely branched. The seeds are oval with a glossy, mahogany cast. They are 0.13- to 0.15-inch long and are enclosed in straw-colored glumes.

Shattercane is an annual that reproduces by seed. The root system is a well-developed, fibrous network. The stems are erect and smooth, from 3- to 12-feet tall depending on parentage and environment. Several stems may grow from a single crown because the plant readily tillers. The plant closely resembles cultivated sorghum or sudan. Shattercane has a panicle-type seedhead that varies from compact to loose to open. The seeds are oval and are usually enclosed in shiny black to dark mahogany glumes. Shattercane seeds closely resemble those of forage sorghum. The seedheads may droop to one side at maturity. The seeds usually shatter before the crop is harvested.

Sorghum-almum is a weak perennial that reproduces primarily by seed. However, it may produce plants from overwintering rhizomes. At maturity, the rhizomes usually extend less than 6 inches into the soil profile and closely resemble those produced during the early stage of johnsongrass development. The plants resemble johnsongrass, but have larger and taller stems with wider and longer leaves. The panicle also is longer, spread more, and branched at the whorl.

PREVENTION

Johnsongrass, sorghum-almum, and shattercane are spread by birds, livestock, wind, water, and by contaminated feed, machinery, and crop seed. The seeds remain viable in the soil for a long period of time. Therefore, many areas are continually plagued with new seedlings, even though established plants are controlled.

New johnsongrass and sorghum-almum plants also develop from overwintering rhizome buds located at each rhizome node. When rhizome pieces are moved and dropped into clean soil, the area may become infested.

Take the following measures to prevent the spread of seeds and rhizomes:

1. Plant only clean crop seed that is free of johnsongrass, shattercane, and sorghum-almum seed.

2. Avoid the introduction of shattercane by planting only pure, cultivated sorghum seed that has been produced under proper isolation to reduce cross-pollination. Cut forage-type sorghums of sorghum-sudan hybrids before the seed matures.

3. Do not bring straw and hay from infested areas into noninfested areas.

4. Do not allow livestock grazing on infested fields to move into noninfested fields.

5. Clean all machinery--particularly combines where seeds might lodge--before moving it from infested to noninfested fields.

6. Avoid dragging rhizome pieces from infested to noninfested areas with farm implements.

7. Do not let plants develop mature seed.

CONTROL PROGRAMS

The control of johnsongrass, sorghum-almum, and shattercane is based on the growth habits of the plants. Effective long-term control involves integrating cultural and chemical methods that prevent seed and rhizome production and reduce the number of viable seeds in the soil.

Winter Grain and Fallow Programs

Winter grain production followed by summer fallow effectively prevents the production of seeds and rhizomes and reduces their number in the soil. Once the small grain is harvested, clean-plow and disk thoroughly. To control johnsongrass, repeat the diskings at two- to three-week intervals to keep emerging plants from initiating rhizome spurs.

Tillage destroys weed seedlings and germinating seeds by exposing them to sunlight and dessication or by covering over them with soil. Cutting rhizomes into small sections and exposing them to drying conditions reduce their viability. Under winter fallow programs, rhizomes near the soil surface will be exposed to below-freezing temperatures. That further reduces rhizome viability.

Where soil erosion is a problem, apply postemergence treatments of dalapon (Dowpon) or glyphosate (Roundup) following small-grain harvest for rhizome and seedling control. Often, a second application is required late in the season to control new rhizome and top growth and to prevent seed production (see Table 1).

Forage, Grazing, and Mowing Programs

A competitive forage crop, such as alfalfa, helps smother out shattercane, sorghum-almum, and johnsongrass seedlings. Frequent harvesting of forage crops, heavy grazing, or repeated mowings also prevent seed production and reduce rhizome vigor. Although pasturing and mowing will not eliminate the weeds, the weakened plants will be more susceptible to other control measures.

Always follow control programs of winter grain, fallow, and forage with an effective seedling-control program after returning to row crops; otherwise, reinfestations of johnsongrass, shattercane, or sorghum-almum may occur. Fallowing programs also take land out of production, usually making them economically impractical.

Corn and Soybean Programs

Proper soil preparation is critical for effective seedling and rhizome control in row crops. Before incorporating the preplant herbicide, prepare the infested ground by bringing the rhizomes to the surface and cutting them into small pieces. The moldboard plow and the tandem disk work best, but chisel plows and cutting disks also work well in some soil types. Once the large soil clods and excess residues are removed, the field is ready for a preplant incorporated herbicide treatment (see Table 1).

Poor control of seedling johnsongrass, sorghum-almum, and shattercane usually results from improper herbicide incorporation or from using low herbicide rates. Uniform herbicide distribution is essential for effective control. The tandem disk is often used to incorporate the herbicide. The disk incorporates herbicides at about half the operational depth. Disk twice--preferably with the second disking at an angle to the first--to get a uniform distribution of the herbicide. Therefore, set the disk to cut 4 to 6 inches for the first disking and, at most, 4 inches for the second disking. Do not incorporate the herbicides deeper than 3 inches.

Rotary-hoeing and cultivating are usually required regardless of the preplant-incorporated herbicide treatment employed. Preplant treatments only suppress rhizomes and often allow some seedlings to escape. Time the cultivations carefully. To control johnsongrass, repeat the cultivations carefully. To control johnsongrass, repeat the cultivations at intervals of two to three weeks in order to prevent new rhizome spur growth. Set the cultivator sweeps for shallow cultivations--2 inches or less--and avoid cultivating below the herbicide incorporation depth. Deep cultivation brings untreated soil containing viable seeds to the surface where they can germinate.

Scattered plants of johnsongrass, sorghum-almum, and shattercane that are not controlled by soil-applied herbicides or cultivation should be controlled before mature seeds are produced. Roguing and spot treating with glyphosate (Roundup) are an integral part of the control program. Plants that escape produce seeds, rhizomes, or both, which reinfest the field. Applying Roundup as a spot treatment or with selective equipment and then roguing are more effective in soybeans

than in corn, because the size of the soybean plants makes treating the problem grasses easier.

Roundup is the only herbicide presently labeled for spot treatment in corn and soybeans. Crop plants sprayed with Roundup will be severely injured, resulting in tissue chlorosis and necrosis.

Noncropland Programs

Johnsongrass, sorghum-almum, and shattercane plants in fencerows and noncropland ares are source of new seeds or rhizomes. Treat such areas to eliminate the seed source and to prevent field infestations (see Table 1).

Dalapon (Dowpon) is considered to be an economical herbicide treatment for controlling large infestations of shattercane and sorghum-almum. Roundup or dalapon may be the most economical control treatment for infestations to adequately control seedling or rhizome regrowth. You may need to re-treat heavy johnsongrass infestations to adequately control seedling or rhizome regrowth. Soil sterilants or MSMA will control small johnsongrass patches in noncrop areas, but they may not be economical to use in areas where there are large infestations.

Even after using a good control program for a few years, you may still have a weed problem. Watch for new weeds that grow from old seed left in the soil or from newly introduced seed.

REMARKS

The numbered paragraphs that follow are keyed to the "Remarks" column of Table 1.

1. With PPI herbicides, follow the label instructions on incorporation. Thoroughly incorporate the herbicide immediately after application. The treatment is labeled only for seedling control. Destroy emerging plants and break up large clods of soil in the field before the herbicide is applied or incorporated. Include a broadleaf herbicide for overall weed control. Some POE herbicides should be applied with a crop oil concentrate, surfactant, or other additive. However, some applications should *not* be made with any additive. Refer to the label on the herbicide and follow its guidelines. Regrowth can and should be treated; see label for rate.

2. Clean plowing and disking will cut up the rhizomes in the upper plow layer, thus reducing their vigor. Increased herbicide rates will only suppress, not control, rhizomes.

3. Apply Roundup to johnsongrass foliage at the early boot stage (plants must be at least 18 inches tall), or before related sorghum species produce mature seeds. Roundup is a nonselective, systemic herbicide that controls both foliage and rhizomes. Roundup is a nonselective systemic herbicide that controls both foliage and rhizomes. Roundup usually kills or injures crop plants and desirable vegetation it contacts. ***Do not mix, apply, or store Roundup spray solutions in galvanized containers or in unlined steel containers except for stainless steel containers.***

4. Follow the treatment instructions on the label. Use surfactants according to the manufacturer's directions. Broadcast treatments in a minimum 40 to 50 gallons of water when the johnsongrass is 12- to 15-inches tall. Plow three days later. Wait five days after plowing before planting soybeans or corn.

If the soil is dry, avoid crop injury by waiting five days after a rain of 1/2 inch or more before planting. If a row crop is to be planted, disk two or more times to cut up rhizomes before applying a herbicide for seedling control. Include a broadleaf herbicide for overall weed control.

5. Broadcast treatments in at least 20 to 40 gallons of water per acre when the johnsongrass is a minimum of 18-inches tall, but before mature seeds are produced. Plow the ground seven days later. Corn, soybeans, oats, wheat, barley, or sorghum may be planted following the treatment. Viable weed seeds remaining in the soil will not be controlled. Use a herbicide for seedling control if a row crop is to be planted. Include a broadleaf herbicide for better overall weed control.

6. Follow a tillage program to cut up the rhizomes and destroy the emerging seedling plants before applying the herbicide. Do not plant soybeans until the adverse weather conditions of the early season have passed. Do not plant soybeans deeper than 2 inches. Apply the herbicide at the rates suggested for seedling control and rhizome suppression for two consecutive years. Use good cultural control practices. Reduce the rate to that suggested for seedling control in the third year. Plant only crops labeled for preplant use with these herbicides before rotating to another crop.

7. Follow the label instructions for treatment. Use surfactants according to the manufacturer's directions. Broadcast treatments in a minimum of 40 to 50 gallons of water when the johnsongrass is 12- to 15-inches tall. Repeat the treatments a second and third time at 10- to 15-day intervals as needed, and plow 7 to 14 days after the last treatment. Disk when needed to destroy regrowth from viable weed seeds in the soil. Alfalfa, permanent pasture mixtures, or small grains may be seeded in the fall--3 to 5 weeks after the last treatment.

8. Follow the directions on the label. Treat the soil while problem grasses are small, or mow the older growth to prevent seed production and then treat the soil below the stubble. Repeat the treatment when necessary to destroy regrowth. These materials are short-term soil sterilants. ***Use on noncropland only. Do not graze or feed sprayed or treated forage to animals.***

9. Follow the label directions. Use for johnsongrass control on noncropland only. Viable weed seeds remaining in the soil will not be controlled. ***Do not contaminate domestic waters used by livestock, wildlife, or aquatic life. Do not contaminate irrigation water. Do not graze or feed treated foliage to livestock.*** Complete coverage of foliage is necessary. Do not allow the spray solution to run off the foliage. It may take several weeks before the plants die. Do not mow for four to six weeks after treatment. At recommended rates, Asulox usually will not harm desirable plants, such as tall fescue and perennial bluegrass. Late-season treatments may be more effective.

NOTE: Availability, formulations, trade names, and federal clearances for herbicide use change occasionally. Always refer to the most recent product labels for precautions and for use and rate directions. Apply herbicides carefully to keep from injuring desirable vegetation, wildlife, yourself, and others. Store herbicides properly so children do not have access to them. Store herbicides only in the original, well-marked containers. Dispose of used herbicide containers and old herbicides properly.

Table 1. Controlling Johnsongrass, Shattercane (Wild Cane), and Sorghum-almum

Weed controlled	Herbicide and formulation	Rate per acre of formulation	Method of application[a]	Remarks[b]
		CORN or SOYBEANS--preplow or spot-treat		
Johnsongrass Shattercane Sorghum-almum	Roundup 4E	1-1/2 ounces per gallon of water (1 percent of solution)	Foliar spot-treatment	3
Johnsongrass Shattercane Sorghum-almum	Dowpon 85% WP plus a surfactant	5 to 8 pounds plus a surfactant	Foliar spring preplow	4
Johnsongrass	Roundup 4E	2 to 3 quarts	Foliar spring preplow or foliar spot-treatment	3, 5
		CORN		
Johnsongrass Sorghum-almum (seedling control)	Genep 6.7E	4-3/4 pints	PPI	1
	Sutan 6.7E	4-3/4 pints	PPI	
	Eradicane 6.7E	4-3/4 pints	PPI	
	Eradicane Extra	5-1/3 pints	PPI	
Johnsongrass (rhizome suppression) Shattercane	Genep 6.7E	7-1/3 pints	PPI	1, 2
	Sutan 6.7E	7-1/3 pints	PPI	
	Eradicane 6.7E	7-1/3 pints	PPI	
	Eradicane Extra 6E	8 pints	PPI	
		SOYBEANS		
Johnsongrass Shattercane Sorghum-almum (seedling control)	Sonalan 3E	2 to 3 pints	PPI	1
	Treflan 4E	2 to 2-1/2 pints	PPI	
	Prowl 4E	2 to 3 pints	PPI	
	Vernam 7E	3-1/2 pints	PPI	
	Vernam 10G	30 pounds	PPI	
	Assure 0.8E*	10 ounces	POE	

[a]PPI--preplant and incorporate. POE--postemergence.
[b]Numbers in the "Remarks" column refer to the numbered paragraphs at the end of the text, see pages 193 and 194.
*See Table 2 for susceptibility ratings.

Table 1. Continued.

Weed controlled	Herbicide and formulation	Rate per acre of formulation	Method of application[a]	Remarks[b]
		SOYBEANS (continued)		
Shattercane	Treflan 4E	3 to 4 pints	PPI	6, 2
Sorghum-almum	Prowl	2 to 4 pints	PPI	
Johnsongrass (seedling control and rhizome suppression)	Fusilade 2000 1E*	1 pint	POE	1
	Poast 1.53S*	1-1/2 pints	POE	
	Option 1E*	1.2 pints	POE	
	Assure 0.8E*	26 ounces	POE	
Johnsongrass Shattercane Sorghum-almum	Roundup 4E	1 gallon per 2 gallons of water or 5 ounces per gallon of water	Ropewick applicator or recirculating sprayer	3
		FALLOW GROUND OR NONCROPLAND		
BROADCAST TREATMENTS				
Johnsongrass Shattercane	Dowpon 85% WP plus a surfactant	5 to 10 pounds plus surfactant	Foliar: plants 12- to 15-inches tall	7
Sorghum-almum Fields not being cropped or after small grain harvest	Roundup 4E	2 to 3 quarts	Foliar: plants 18-inches tall	3,5
Johnsongrass (noncropland only)	Asulox	1 gallon	Foliar: plants at least 15-inches tall	9

*See Table 2 for susceptibility ratings.

Table 1. Continued.

Weed controlled	Herbicide and formulation	Rate per acre of formulation	Method of application[a]	Remarks[b]
		NONCROPLAND		
SPOT TREATMENTS				
Johnsongrass	Sodium chlorate	2 to 4 lb/100 sq ft	Foliar or soil	8
Shattercane	Dowpon 85% WP plus	1/2 to oz/100 sq ft	Foliar: plants 12- to	
Sorghum-almum	surfactant	(single treatment)	15-inches tall	7
Ditchbank, levees,	Roundup 4E	1-1/3 oz/gal	Foliar: spot treatment	3
fencerows, or wasteland		water (1% of solution)		
Johnsongrass	Ansar 529 or	2 quarts	Foliar (point of	9
Shattercane	Daconate (MSMA)	2 quarts	runoff). Repeat at 1-week intervals as necessary.	
Johnsongrass	Pramitol 25E	4 to 5-1/2 pints/1,000 sq ft	Foliar or stubble (thorough coverage)	8
	Pramitol 5PS	2 lb/100 sq ft	Soil (distribute evenly)	
	Hyvar X-L (3 lb/gal)	12 oz/1,00 sq ft	Soil or stubble	8
	Hyvar X-WS (50%)	8 oz/500 sq ft	Soil (distribute evenly)	8

Table 2. Relative Effectiveness of Postemergence Soybean Herbicides on Johnsongrass, Shattercane, and Sorghum-almum

	Assure	Fusilade	Option	Poast + Dash
Johnsongrass				
seedling	E	E	E	VG
rhizome	E	E	VG-G	F-G
Shattercane	E	E	VG	F-G
Sorghum-almum	E	VG	VG-G	F-G

E = +95 percent; excellent.
VG = 90 to 95 percent; very good.
G = 80 to 90 percent; good.
F = 70 to 80 percent; fair.
P = <70 percent; poor.

The Toxicity of Herbicides

D. Anderson and M. McGlamery

Toxicity is the capacity of a substance to produce injury. Toxic effect can be immediate (acute) or accumulative (chronic), depending upon the exposure duration and dose. Toxicity varies with the animal species, age, sex, and nutritional status and with the route of exposure--oral (stomach), inhalation (lungs), or dermal (skin). Eye and skin effects are also of concern.

Pesticide manufacturers are required to conduct acute, subacute, and chronic toxicity tests as well as mutagenic, teratogenic, and carcinogenic tests. The usual expression of toxicity is called the LD_{50}, which is the average lethal dose in milligrams per unit of body weight in kilograms required to kill 50 percent of a test population. Toxicity tests are usually conducted on white rats, mice, or rabbits.

Conversion factors to convert milligrams per kilogram (mg/kg) of body weight are:

mg/kg x 0.0016 = ounces/hundredweight
mg/kg x 0.0030 = ounces/187 pounds

Because toxicity depends upon body weight, the amount of chemical considered lethal for a child is less than the amount for an adult. And similarly, it takes more to kill a large animal than a small one.

The classes of toxicity are given in the table below. The herbicide label will indicate the extent of toxicity by the signal word it carries.

Toxicity class	Label signal words	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Inhalation LC_{50} (mg/liter)
High	Danger-Poison*	<50	<200	<0.2
Moderate	Warning	50-500	200-2,000	0.2 to 2
Low	Caution	500-5,000	2,000-20,000	2 to 20
Very Low	Caution	5,000+	20,000+	20+

*Accompanied with skull and crossbones.

Danger-Poison. Herbicides that carry these signal words plus a skull and cross bones contain the active ingredient endothall or paraquat. Endothall is available in liquid form as Aquathol K (3S) and as Hydrothol 191 (2S). Paraquat is available as ICIs Gramoxone Super and Prelude (paraquat plus metolachlor).

These herbicide labels carry precautions: the user is advised to wear goggles or a face shield as well as rubber gloves and a rubber apron when working with concentrates. Avoid breathing spray mists.

Danger-Corrosive indicates the risk of irreversible eye or skin burns. This warning is usually accompanied by a recommendation for the use of goggles or a face shield, especially when the user is handling concentrates. The label may also call for rubber gloves and an apron when the user is handling or mixing concentrates or adjusting equipment. The first aid statement says: "In case of contact with eyes, immediately flush eyes with plenty of water for at least 15 minutes and **get medical attention promptly.**" If the contact is on the skin, the label calls for washing the skin with plenty of water. If skin irritation occurs, medical attention should be sought. Herbicides in this category are:

Trade name	Common name	Trade name	Common name
Aquathol 7G	endothall	Laddok 3.33L	bentazon + atrazine
Balan 1.5EC	benefin	Lasso 4EC	alachlor
Blazer 2L	acifluorfen	Pramitol 25E, 5PS	prometon
Bronco 4WDL	alachlor + glyphosate	Squadron 2.33L	imazaquin + pendimethalin
Butyrac 200	2,4-DB	Storm 4E	acifluorfen + bentazon
Cobra 2E	lactofen		
Commence 5.25E	clomazone + trifluralin	Sutazine 6ME	butylate + atrazine
Devrinol 2E	napropamide	Tackle 2S	acifluorfen
Galaxy 3.67E	acifluorfen + bentazon	Transline 2.4S	clopyralid + 2,4-D
		Velpar 2L	
Garlon 3A	triclopyr amine	ULW	hexazinone
Hoelon 3EC	diclofop-methyl	Weedar 64, 64A	2,4-D amine
Hydrothal 191	endothall	Weedone 638	2,4-D amine + ester
Krovar I 80DG	bromacil + diuron		

Warning is the signal word for herbicides containing the active ingredient cyanazine or bromoxynil, which are moderately toxic through oral, dermal, or inhalation exposure. These herbicide labels state the following under Human Precautions: "May be fatal or harmful if swallowed, inhaled, or absorbed through the skin."

Cyanazine	Bromoxynil	Diquat
Bladex 4L, 80W, 90DF	Buctril	Diquat
Extrazine II 4L, 90DF		

Warning also appears as a signal word on other herbicides with label statements indicating that they can cause eye or skin irritation or burns, or may be harmful if swallowed, inhaled, or absorbed through the skin. Herbicides in this category are listed below and on the following page.

Most of these herbicide labels state "Do not get into eyes or on skin." If skin or eye contact occurs, they call for washing the contacted areas thoroughly for 15 minutes and for calling a physician if eye contact occurs. Some herbicide labels recommend the use of goggles or face shield and other protective clothing. Fusilade, Goal, and Laddok labels specify the use of goggles or face shield. Dual, Fusilade, and Laddok labels also call for the use of rubber gloves.

Trade name	Common name	Trade name	Common name
Acclaim	fenoxaprop	Poast 1.5E	sethoxydim
Alanap 2L	naptalam	Prowl 4EC	pendimethalin
Banvel 4S	dicamba	Ramrod 4WDL, 20G	propachlor
Cannon 3E	alachlor + trifluralin	Ramrod/atrazine 4WDL	propachlor + atrazine
Command 4EC	clomazone	Reflex 2LC	fomesafen
Dalapon 85	dalapon	Rescue 2.06S	naptalam + 2,4-DB
DMA-4S	2,4-D amine		
Dowpon-M	dalapon	Ronstar 2.5G	oxadiazon
Escort 60DF	metsulfuron	Roundup 4S, Rodeo 5.4S	glyphosate
Goal 2EC	oxyfluorfen	Sodium TCA	TCA
Hyvar X-L, 2WSL	bromacil	Sonalan 3EC	ethalfluralin
Krenite 4S	fosamine	Squadron 2.33L	pendimethalin + imazaquin
Lariat	alachlor + atrazine	Tandem 4EC	tridiphane
Lasso II 15G	alachlor	Tornado	fomesafen + fluazifop
Lorox Plus 60DF	linuron + chlorimuron	Treflan 4EC	trifluralin
Option	fenoxaprop	Tri-Scept 3E	trifluralin + imazaquin
		Velpar 90WSP	hexazinone

The Environmental Hazards section includes statements regarding toxicity to fish and wildlife. Herbicides that state that they are toxic to fish or wildlife contain the active ingredients bromoxynil, propachlor, or oxyfluorfen.

Bromoxynil	Propachlor	Other
Bronate	Ramrod 4F	Diquat (diquat)
Buctril	Ramrod 20G	Evik (ametryn)
Buctrilatrazine	Ramrod/atrazine	Goal (oxyfluorfen)
		Gramoxone Super (paraquat)
		Pramitol (prometon)
		Prelude (paraquat + metolachlor)

Some herbicide labels carry the statement, "Toxic to Fish." These include certain esters of phenoxy and pyridinoxy-phenoxy herbicides, the dinitroaniline herbicides, and miscellaneous others. All herbicide labels warn the user to keep the product out of lakes and streams. With the above herbicides, however, the user has to be especially careful.

Phenoxy esters*	Oxy-phenoxy esters	Dinitroanilines	DNA mixes
Butoxone ester	Hoelon (diclofop)	Balan (benefin)	Commence (trifluralin + clomazone)
Butyrac ester	Fusilade (fluazifop)	Prowl (pendimethalin)	Prozine (pendimethalin + atrazine)
Esteron 44, 99	Verdict (halazifop)	Sonalan (ethalfluralin)	Salute (trifluralin + metribuzin)
Weedone 170	Whip (fenoxaprop)	Treflan (trifluralin)	Squadron (pendimethalin + imazaquin)
Weedone LV			Tri-Scept (trifluralin + imazaquin)

*There are many phenoxy herbicide products.

The potential for the contamination of groundwater with pesticides has prompted the addition of groundwater statements on several pesticide labels especially those products containing atrazine, simazine, alachlor, metolachlor, or metribuzin. The following herbicides carry label statements cautioning the user to handle the herbicides in a manner that will minimize the potential for groundwater contamination.

Trade name	Common name	Trade name	Common name
AAtrex, Atrazine	atrazine	Laddok	atrazine + bentazone
Bicep	atrazine + metolachlor	Lariat	atrazine + alachlor
Bladex	cyanazine	Lasso	alachlor
Bullet	atrazine + alachlor	Lexone	metribuzin
Cannon	alachlor + trifluralin	Preview	metribuzin + chlorimuron
Canopy	metribuzin + chlorimuron	Princep	simazine
Dual	metolachlor	Rhino	atrazine + butylate
Extrazine II	cyanazine + atrazine	Salute	trifluralin + metribuzin
Freedom	alachlor + trifluralin	Sencor	metribuzin
		Turbo	metribuzin + metolachlor

Herbicide labels carry precautions about human and environmental hazards, and are also labeled with signal words--Danger-Poison, Danger-Corrosive, and Warning. *Always read and heed the label!*

Herbicides, Formulations, and Toxicities

D. Anderson and M. McGlamery

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
AAtrex	atrazine					
80W	*Ciba-Geigy*	5,100	9,300	moderate	mild	Caution
4L		1,075	> 5,000	mild	mild	Caution
Nine-O (90 WDG)		1,600	>10,000	mild	mild	Caution
Access*	triclopyr + picloram					
3E	(2 + 1 lb) *Dow*	2,525	> 2,000	moderate	moderate	Caution
Acclaim	fenoxaprop					
1EC	*Hoechst*	> 3,310	> 2,000	mild	moderate	Warning
Alanap-L	naptalam					
2EC	*Uniroyal*	1,770		mild	moderate	Warning
Ala-Scept	alachlor + imazaquin (32:1) *American Cyanamid*					
Amiben	chloramben	5,620	> 3,160			
2S	*Rhone-Poulenc*			mild	mild	Caution
10G				mild	mild	Caution
75DS				mild	mild	Caution
Amitrol-T*	amitrole					
2S	*Rhone-Poulenc*	24,600	>10,000	mild	mild	Caution-(carcinogenic)
Amizol*	amitrole					
90WSP	*Rhone-Poulenc*	24,600	>10,000	mild	mild	Caution-(carcinogenic)

NOTE: A blank indicates that the information is not available at this time.
*Restricted-Use Pesticide (RUP).
[a]EC or E means emulsifiable concentrate; G, granules; L, liquid; S, water soluble; WDG, water-dispersible granule; WDL, water-dispersible liquid; WP or W, wettable powder; WSP, water-soluble powder; DF, dry flowable; P, pellet; F, flowable. ME means micro-encapsulated. Liquid formulations (EC, E, L, S, WDL, F) are in pounds per gallon; dry formulations (G, WDG, WP, WSP, DF, P) are in percentages.
[b]Weed Science Society of America approved name or experimental number.
[c]LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of a population of test animals, usually white rats, when administered in a single, oral dose.
[d]LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of a population of test animals, usually rabbits, when administered in a single, dermal dose.
[e]Dermal irritation is determined by applying an amount of pesticide onto the skin of shaved test animals.
[f]Eye irritation is determined by applying an amount of pesticide into the eye of test animals.

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Dermal[d]	Irritation Dermal[e]	Eye[f]	Label signal word
Aquathol	endothall					
K (3S)	*Pennwalt*	125	171	severe	severe-corrosive	DANGER-Poison
7G		1,340	>10,000	moderate	severe-corrosive	DANGER
Aquazine	simazine					
80W	*Ciba-Geigy*	>15,380	>10,200	mild	mild	Caution
Arsenal	imazapyr					
2L	*American Cyanamid*	> 5,000	> 2,148	mild	mild	Caution
Arsonate	MSMA	3,639	10,000			
6.6S	*Fermenta*			moderate	mild	Caution
Assure	quizalofop					
0.8EC	*DuPont*	1,480	> 2,000	mild	mild	Caution
Asulox	asulam					
3.34S	*Rhone-Poulenc*	> 8,000	> 1,000	mild	mild	Caution
Atrazine	atrazine					
80W	*DuPont*	5,100	9,300	moderate	mild	Caution
4L		1,075	> 5,000	mild	mild	Caution
Balan	benefin	> 5,000				
1.5EC	*Elanco*			moderate	severe	DANGER
2.5G				mild		Caution
60DF				mild		Caution
Banvel	dicamba					
4S	*Sandoz*	2,629	> 2,000	moderate	severe	Warning-Corrosive
Banvel 720	dicamba + 2,4-D (1:2)					
3S	(1 + 2 lb) *Sandoz*	2,500				Caution
Basagran	bentazon					
4S	*BASF*	1,816	> 2,450	moderate		Caution
Betasan	bensulide					
3.6G	*ICI Americas*	> 1,000	> 5,000	none	moderate	Caution
7G		3,549	> 2,000	none	moderate	Warning
12.5G		1,987	> 2,000	none	moderate	Warning
4E		1,115	> 2,000	mild	severe	Caution
2.9E		1,420	> 2,000	mild	moderate	Caution
Bicep	metolachlor + atrazine					
6L	(3.33 + 2.67 lb)	4,060	> 2,010	moderate	moderate	Caution
4.5L	(2.5 + 2 lb) *Ciba-Geigy*	4,680	> 2,000	slight	mild	Caution
Bladex	cyanazine					
80W*	*DuPont*	266	> 2,000	slight	moderate	Warning
90DF*		369	> 2,000	mild	moderate	Warning
4L*		473	> 2,000	slight	mild	Warning

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Blazer 2S	acifluorfen *BASF*	4,790	3,250	moderate	severe	DANGER
Bronco 4 WDL	alachlor + glyphosate (2.6 + 1.4 lb) *Monsanto*	3,152	> 5,000	slight	severe	DANGER
Buctril 2EC	bromoxynil *Rhone-Poulenc*	260-400	> 3,660	moderate		Warning
Buctril + atrazine 3WDL	bromoxynil + atrazine (1:2) (1 + 2 lb) *Rhone-Poulenc*			mild	mild	Caution
Bullet 4MT	alachlor + atrazine (2.5 + 1.5 lb) *Monsanto*					Caution
Butoxone 1.75EC	2,4-DB *Cedar*	1,960	>10,000	mild		
Butyrac 200 2EC	2,4-DB *Rhone-Poulenc*	1,960	>10,000	mild	severe	DANGER-Corrosive
Butyrac Ester 2EC	2,4-DB *Rhone-Poulenc*	1,960	>10,000	mild		Warning
Caliber 90 90WDG	simazine *Ciba-Geigy*	> 5,000	> 2,000	slight	slight	Caution
Cannon 3EC	alachlor + trifluralin (2.5 + 0.5 lb) *Monsanto*	3,150	> 5,000	slight	moderate	Warning
Casoron 50W 4G	dichlobenil *Uniroyal*	3,160	1,350	mild	mild	Caution Caution
Chipco Turf 2EC 4EC	mecoprop (MCPP) *Rhone-Poulenc*	1,060	900			
Cinch 7EC	cinmethylin *DuPont*	1,594	> 2,000	moderate	mild	Warning
Classic 25DF	chlorimuron *DuPont*	> 5,000	> 2,000	mild	mild	Caution
Cobra 2E	lactofen *Valent*	2,530	> 2,000	severe	severe	DANGER
Command 4EC	clomazone *FMC*	2,235	> 2,000	mild	moderate	Warning

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Commence	trifluralin + clomazone					
5.25EC	(3 + 2.25 lb) *Elanco and FMC*	2,235	> 2,000	moderate	severe	DANGER
Contain	imazapyr					
1S	*American Cyanamid*	> 5,000	> 2,000	none	slight	Caution
Crossbow	triclopyr + 2,4-D (1:2)					
3EC	(1 + 2 lb) *Dow*	1,792	1,796	mild	slight	Caution
Curtail	clopyralid + 2,4-D					
2.4S	(.38 + 2 lb) *Dow*	> 2,830	> 4,000	moderate	severe	DANGER-Flammable
Dacthal	DCPA	> 3,000	>10,000	mild	moderate	Warning
75WP	*Fermenta*					
2.5G						
5G						
Dalapon-85	dalapon					
74WSP	*Fermenta*	7,570		moderate		Caution
Deploy	glyphosate					
4S (3 a.e.)	*Monsanto*	> 5,000	> 5,000	mild	none	Warning
Devrinol	napropamide					
50WP	*ICI Americas*	2,710	> 4,640	mild	mild	Caution
10G		> 5,000	> 5,000	none	none	Caution
5G		> 5,000	> 5,000	none	moderate	Caution
2G		> 5,000	> 5,000	none	moderate	Caution
2E		3,690	> 5,000	moderate	severe	DANGER-Corrosive
Diquat	diquat					
2S	*Valent*	230	>400	moderate	moderate	Warning
Dowpon-M	dalapon					
74WSP	*Cedar*	7,570		moderate		Caution
Dozer	fenuron TCA	4,000		moderate		
3L	*Hopkins*					
25P						
Dual	metolachlor					
8E	*Ciba-Geigy*	>820	> 5,009	slight	mild	Caution
25G		> 5,000	> 2,000	mild	slight	Caution
Endothal	endothall					
Turf 1.5S	*Pennwalt*	198	> 2,000	severe-corrosive	severe-corrosive	
Enide	diphenamid					
90WP	*Nor-Am*	970	> 6,320	mild	mild	Caution
Eptam	EPTC					
7E	*ICI Americas*	1,325	2,750	mild	moderate	Caution
10G		> 5,000	> 5,000	none	moderate	Caution

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Eradicane 6.7E	EPTC + safener *ICI Americas*	> 2,000	3,830	mild	severe	Caution
Eradicane Extra 6E	EPTC + safener + extender *ICI Americas*	776	> 2,000	mild	moderate	Caution
Escort 60DF	metsulfuron *DuPont*	> 5,000	> 2,000	none	moderate	Warning
Evik 80WP	ametryn *Ciba-Geigy*	1,950	> 3,100	mild	mild	Caution
Extrazine II	cyanazine + atrazine (3:1)					
90DF	(67.5% + 32.5%)	369	> 2,000	mild	mild	Warning
4L	(3 + 1 lb) *DuPont*	369	> 2,000	slight	mild	Warning
Freedom 3EC	alachlor + trifluralin (2.67 + 0.33 lb) *Monsanto*					Warning
Furloe Chloro IPC	chlorpropham *Valent*					
4L		3,700	10,200	mild	mild	Caution
20G		3,700	10,200	mild	mild	Caution
Fusilade 2000 1EC	fluazifop-butyl *ICI Americas*	4,350	> 2,000	mild	mild	Caution
Galaxy	acifluorfen + bentazon (1:4.5)					
3.67S	(.67 + 3.0 lb) *BASF*				severe	DANGER
Gallery	isoxaben *Elanco*	>10,000				Caution
Garlon	triclopyr					
3A	*Dow*	2,830	> 3,980	moderate	severe	DANGER
4E		800	2,315	moderate	mild	Caution
Genate Plus 6.7EC	butylate *Valent*	3,878	4,640	moderate		Caution
Genep 7EC	EPTC *Valent*	1,652	10,000	mild	mild	Caution
Goal 2EC	oxyfluorfen *Rohm & Haas*	5,800	> 3,000	moderate	moderate	Warning
Gramoxone Super* 1.5S	paraquat *ICI Americas*	120	>480	moderate	moderate	DANGER-Poison
Harmony 75DF	DPX-M6313 *DuPont*	> 5,000	> 2,000	mild	moderate	Warning

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Hoelon*	diclofop-methyl					
3EC	*Hoechst*	2,176	640	moderate	moderate	DANGER-(possible carcinogen)
Hydrothal 191	endothall					
2S	*Pennwalt*	221	50	severe	severe-corrosive	DANGER-poison
5G		1,540	>10,000	moderate	severe-corrosive	DANGER
Hyvar	bromacil					
X (80WP)	*DuPont*	5,000	> 5,000	moderate	slight	Caution
X-L (2WSL)						Warning
Karmex	diuron					
80DF	*DuPont*	2,900	> 2,000	none	moderate	Warning
80WP		3,956	> 2,000	none	mild	Caution
Kerb	pronamide					
50WP	*Rohm & Haas*	5,620	> 3,160	mild		Caution
Kleenup	glyphosate	5,600	> 5,000			
0.55	*Ortho*			slight	slight	
Krenite	fosamine					
4L	*DuPont*	7,380	> 1,680	mild	none	Caution
S (4L)	*DuPont*	> 5,000	> 5,000	mild	moderate	Warning
Krovar I	bromacil + diuron					
80DF	(40% + 40%)	> 2,500	> 2,000	severe	mild	DANGER
80WP	(40% + 40%) *DuPont*	5,980	> 7,500	moderate	mild	Caution
Krovar II	bromacil + diuron					
80DF	(53% + 27%) *DuPont*	3,816	> 2,000	moderate	moderate	Caution
Laddok	bentazon + atrazine (1:1)					
3.33L	(1.67 + 1.67 lb) *BASF*	3,340		moderate	moderate	DANGER-Corrosive
Lariat	alachlor + atrazine (5:3)					
4F	(2.5 + 1.5 lb) *Monsanto*	4,400	> 5,000	severe	moderate	Warning
Lasso	alachlor					
4MT	*Monsanto*	> 5,000	> 5,000	mild	mild	Caution
II (15G)		5,800	16,000	slight	severe	Warning
4EC		2,000	7,800	moderate	severe	DANGER
Lexone	metribuzin					
4L	*DuPont*	2,890	> 7,500	none	moderate	Caution
75DF		2,795	>20,000	none	moderate	Caution
Linex	linuron	1,500			mild	Caution
4WDL	*Griffin*					

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Lorox	linuron					
4L	*DuPont*	2,437				Caution
50DF		4,600	> 2,000	none	mild	Caution
Lorox Plus	chlorimuron + linuron					
60DF	(1:16) *DuPont*	2,400	> 2,000	moderate	severe	Warning
Marksman	dicamba + atrazine					
3.2F	(1.1 + 2.1 lb) *Sandoz*	5,900	> 2,000	mild	mild	Caution
Option	fenoxaprop					
1EC	*FMC*	> 3,310	> 2,000	mild	moderate	Warning
Oust	sulfometuron					
75DG	methyl *DuPont*	> 5,000	> 2,000	none	mild	Caution
Pennant	metolachlor					
5G	*Ciba-Geigy*	> 5,030	> 2,010	mild	slight	Caution
Pinnacle	DPX-M6316					
25DF	*DuPont*	> 5,000	> 2,000	none	moderate	Caution
Poast	sethoxydim					
1.5E	*BASF*	4,900	> 4,000	moderate	moderate	Warning
Pramitol	prometon					
25E (2EC)	*Ciba-Geigy*	2,110	2,000	severe	corrosive	DANGER-corrosive
5PS (5%)		2,745	> 2,000	severe	corrosive	DANGER-corrosive
Prefar	bensulide					
4-E	*ICI Americas*	826	> 4,640	mild	moderate	Caution
Prelude	paraquat + metolachlor					
2.5S	(.5 + 2.0 lb) *ICI Americas*	1,218	> 2,000	moderate	severe	DANGER-Poison and Corrosive
Preview	chlorimuron + metribuzin					
75DF	(7.5% + 67.5%) *DuPont*	1,500	2,000	none	moderate	Caution
Princep	simazine					
4L	*Ciba-Geigy*	> 5,000	> 2,500	slight	slight	Caution
80W		>15,380	>10,200	mild	mild	Caution
4G		> 5,070	> 2,010	slight	mild	Caution
Probe	methazole					
75WDG	*Sandoz*	2,975	> 2,000	none	severe	Warning
Prowl	pendimethalin					
4EC	*American Cyanamid*	3,380	> 5,000	mild	moderate	Warning

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Prozine	pendimethalin + atrazine					
70DF	(1:1) *American Cyanamid*	7,071	> 2,000	mild	mild	Caution
Pursuit	imazethapyr					
2EC	*American Cyanamid*	> 5,000	> 2,000	mild	none	Caution
Pursuit Plus	imazethapyr + pendimethalin (14:1) *American Cyanamid*					
Ramrod	propachlor					
4F	*Monsanto*	3,269	4,194	severe-corrosive	moderate	Warning
20G		4,000	>20,000	slight	severe-corrosive	Warning
Ramrod/ atrazine	propachlor + atrazine (3:1)					
4L	(3 + 1 lb) *Monsanto*	2,374	> 5,000	slight	moderate	Warning
Reflex	fomesafen					
2LC	*ICI Americas*	> 5,000	> 2,000	mild	moderate	Warning-Carcinogenic
Rescue	naptalam + 2,4-DB					
2.06EC	(2 + .06 lb) *Uniroyal*			mild	moderate	Warning
Rhino	butylate + atrazine					
6L	(4.3 + 1.7 lb) *Valent*					Warning
Rodeo	glyphosate					
5.4S (4 a.e.)	*Monsanto*	> 5,000	> 5,000	mild	none	Warning
Ronstar	oxadiazon					
2.5G	*Rhone-Poulenc*	> 8,000	8,000	severe		Warning
Roundup	glyphosate					
4S (3 a.e.)	*Monsanto*	5,400	> 5,000	moderate	slight	Warning
Salute	metribuzin + trifluralin					
4E	(1.33 + 2.67 lb) *Mobay*	1,561	> 2,000	mild	mild	Caution
Scepter	imazaquin					
1.5EC	*American Cyanamid*	> 5,000	> 2,000	mild	mild	Caution
Sencor	metribuzin					
4L	*Mobay*	> 1,500	>20,000	none	none	Caution
75DF		2,379	> 5,000	slight	moderate	Caution
Sinbar	terbacil					
80WP	*DuPont*	> 5,000	> 5,000	none	mild	Caution

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Acute LD_{50} Dermal[d]	Irritation Dermal[e]	Irritation Eye[f]	Label signal word
Snapshot	isoxaben + oryzalin *Elanco*					Caution
Solicam 80DF	norflurazon *Sandoz*	> 9,000	>20,000	none	none	Caution
Sonalan 3EC	ethalfluralin *Elanco*	>10,000	> 2,000	moderate	moderate	Warning
Sonar 4AS	fluridone *Elanco*	>10,000		slight	slight	Caution
5P (5%)						Caution
5SRP (5%)						Caution
Spike 85DF	tebuthiuron *Elanco*	579				Warning
20P						Caution
40P						Caution
Squadron 2.33L	pendimethalin + imazaquin (6:1) (2.0 + .33 lb) *American Cyanamid*	3,695	> 2,000	mild	severe	DANGER
Storm 4S	acifluorfen + bentazon (1.33 + 2.67 lb) *BASF*	> 1,470	> 2,000	none	severe	DANGER
Surflan 4AS	oryzalin *Elanco*	>10,000	> 2,000	mild	mild	Caution
Sutan + 6.7E	butylate *ICI Industries*	3,690	> 4,640	moderate	moderate	Caution
Sutazine + 18:6G	butylate + atrazine (18 + 6 lb)	> 5,000	> 5,000	none	none	Caution
6ME	(4.8 + 1.2 lb) *ICI Industries*	3,200	> 2,000	moderate	severe	DANGER-Corrosive
Tackle 2S	acifluorfen *Rhone-Poulenc*	3,300	> 2,000	moderate	severe	DANGER-Corrosive
Tandem 4EC	tridiphane *Dow*	1,668	1,000	moderate	severe	Warning
Team 2G	trifluralin + benefin *Elanco*					Caution
Telar 75DG	chlorsulfuron *DuPont*	2,341	> 3,400	none	mild	Caution
Thistrol 2S	MCPB *Rhone-Poulenc*	680		mild		Caution

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Dermal[d]	Irritation Dermal[e]	Eye[f]	Label signal word
Tordon 101*	picloram + 2,4-D					
2.5S	(.5 + 2.0 lb) *Dow*	2,598	> 2,000	moderate	moderate	Caution
Tordon 101R	picloram + 2,4-D					
1.3S	(.3 + 1.0 lb) *Dow*	> 5,000	> 3,980	moderate	moderate	Warning
Tordon K*	picloram					
2EC	*Dow*	> 5,000	> 2,000	slight	severe	Caution
Tordon RTU	picloram + 2,4-D					
1.3S	(.3 + 1.0 lb) *Dow*	> 5,000	> 3,980	moderate	moderate	Warning
Tornado	fomesafen + fluazifop					
1.75E	(1.0 + .75 lb) *ICI Americas*	2,000		moderate	severe	Warning
Transline	clopyralid + 2,4-D					
2.4S	(.38 + 2 lb) *Dow*	> 2,830	> 4,000	moderate	severe	DANGER-Flammable
Treflan	trifluralin					
4EC	*Elanco*	> 2,000		slight	moderate	Warning
4MTF						Caution
5G						Caution
5EC						Caution
Tri-Scept	imazaquin + trifluralin (1:6)					
3EC	(.43 + 2.6 lb) *American Cyanamid*	4,330	> 2,000	mild	severe	DANGER
Tupersan	siduron					
50WP	*DuPont*	7,500	> 5,500	none	mild	Caution
Turbo	metribuzin + metolachlor					
8EC	(1.45 + 6.55 lb) *Mobay*	849	> 2,000	slight	slight	Caution
Turflon D	triclopyr + 2,4-D					
3EC	(2 + 1 lb) *Dow*	1,792	1,796	mild	slight	Caution
Velpar	hexazinone					
90WSP	*DuPont*	860	> 5,278	none	moderate	Warning
2L		6,887	> 7,500	none	severe	DANGER
2RP		6,887	> 7,500	none	severe	DANGER
ULW (75G)		1,200	> 2,000	none	moderate	DANGER
Vernam	vernolate					
7E	*ICI Industries*	1,200	> 5,000	severe	moderate	Caution
Weedar 64, Weedar 64A	2,4-D amine *Rhone-Poulenc*	> 300				
3.8S				moderate	severe	DANGER-Corrosive

(See footnotes on first page of table.)

Trade name and formulation[a]	Generic name[b] and producer	Acute LD_{50} Oral[c]	Dermal[d]	Irritation Dermal[e]	Eye[f]	Label signal word
Weedone 2,4-DP 4EC	dichlorprop (2,4-DP) *Rhone-Poulenc*	800	1,400	mild		Caution
Weedone LV4 3.8E	2,4-D ester *Rhone-Poulenc*	> 500				Caution
Weedone 170	dichlorprop + 2,4-D *Rhone-Poulenc*	> 500	> 2,000			Caution

(See footnotes on first page of table.)

GENERIC AND TRADE NAMES OF HERBICIDES

Generic name	Trade name(s)	Generic name	Trade name(s)
acifluorfen	Blazer	benefin	Balan
	*Galaxy		*Team
	*Storm		
	*Tackle	bensulide	Betasan
			Prefar
alachlor	*Ala-Scept		
	Arena	bentazon	Basagran
	*Bronco		*Galaxy
	*Bullet		*Laddok
	*Cannon		*Storm
	Confidence		
	*Freedom	bromacil	Hyvar
	Judge		*Krovar
	*Lariat		
	Lasso	bromoxynil	Buctril
	Saddle		*Buctril + atrazine
	Stall		
		butylate	Genate Plus
ametryn	Evik		*Rhino
			Sutan +
amitrole	Amitrol-T		*Sutazine +
	Amizol		
		chloramben	Amiben
asulam	Asulox		
		chlorimuron	*Canopy
atrazine	AAtrex		Classic
	Atrafine		*Gemini
	Atrazine		*Lorox Plus
	*Bicep		*Preview
	*Buctril + atrazine		
	*Bullet	chlorpropham	Furloe Chloro IPC
	*Extrazine II		
	*Laddok	chlorsulfuron	Telar
	*Lariat		
	*Marksman	cinmethylin	Cinch
	*Prozine		
	*Ramrod/atrazine	clomazone	Command
	*Rhino		*Commence
	*Sutazine +		

*Formulated mixture with additional active ingredient(s).

GENERIC AND TRADE NAMES OF HERBICIDES

Generic name	Trade name(s)	Generic name	Trade name(s)
clopyralid	*Curtail	endothall	Aquathol
	*Transline		Endothal
			Hydrothal
cyanazine	Bladex		
	*Extrazine II	EPTC	Eptam
			Eradicane
2,4-D	*Banvel 720		Eradicane Extra
	*Crossbow		Genep
	*Curtail		
	*Tordon 101	ethalfluralin	Sonalan
	*Tordon 101R		
	*Tordon RTU	fenoxaprop	Acclaim
	*Transline		Option
	Weedar 64		Whip
	Weedar 64A		
	Weedone LV4	fenuron TCA	Dozer
	*Weedone 170		
	(many others)	fluazifop	Fusilade 2000
			*Tornado
dalapon	Dalapon 85		
	Dowpon-M	fluridone	Sonar
2,4-DB	Butoxone	fosamine	Krenite
	Butyrac 200		
	Butyrac Ester	fomesafen	Reflex
	*Rescue		*Tornado
2,4-DP	(see dichlorprop)	glyphosate	Accord
			*Bronco
DCPA	Dacthal		Deploy
			Kleenup
dicamba	Banvel		Ranger
	*Banvel 720		Rodeo
	*Marksman		Roundup
dichlobenil	Casoron	hexazinone	Velpar
dichlorprop	Weedone 2,4-DP	imazapyr	Arsenal
(2,4-DP)	*Weedone 170		Contain
diclofop-methyl	Hoelon	imazaquin	*Ala-Scept
			Scepter
diphenamid	Enide		*Squadron
			*Tri-Scept
diquat	Diquat		
		imazethapyr	Pursuit
diuron	Karmex		*Pursuit Plus
	*Krovar		
DPX-L5300	*Harmony Extra	isoxaben	Gallery
			*Snapshot
DPX-M6316	Harmony		
	*Harmony Extra	lactofen	Cobra
	Pinnacle		

*Formulated mixture with additional active ingredient(s).

GENERIC AND TRADE NAMES OF HERBICIDES

Generic name	Trade name(s)	Generic name	Trade name(s)
linuron	*Gemini	pendimethalin	Prowl
	Linex		*Prozine
	Lorox		*Pursuit Plus
	*Lorox Plus		*Squadron
MCPB	Thistrol	picloram	*Access
			Tordon
MCPP	(see mecoprop)		
		prometon	Pramitol
mecoprop	Chipco Turf		
(MCPP)	(many turf mixtures)	pronamide	Kerb
methazole	Probe	propachlor	Ramrod
			*Ramrod/atrazine
metolachlor	*Bicep		
	Dual	quizalofop	Assure
	Pennant		
	*Prelude	sethoxydim	Poast
	*Turbo		
		siduron	Tupersan
metribuzin	*Canopy		
	Lexone	simazine	Aquazine
	*Preview		Caliber 90
	*Salute		Princep
	Sencor		
	*Turbo	sulfometuron	Oust
metsulfuron	Escort	tebuthiuron	Spike
MSMA	Arsonate	terbacil	Sinbar
napropamide	Devrinol	triclopyr	*Access
			*Crossbow
naptalam	Alanap-L		Garlon
	*Rescue		
		tridiphane	Tandem
norflurazon	Solicam		
		trifluralin	*Cannon
oryzalin	*Snapshot		*Commence
	Surflan		*Freedom
			*Salute
oxadiazon	Ronstar		*Team
			*Treflan
oxyfluorfen	Goal		*Tri-Scept
paraquat	Gramoxone Super	vernolate	Vernam
	*Prelude		

*Formulated mixture with additional active ingredient(s).

Factors Affecting Herbicide Persistence

W. Curran

Herbicides are applied to the soil in hopes of obtaining season-long weed control. It is desirable for the chemicals to control weeds during the season of application, but they should not remain to affect subsequent crop growth. The length of time that a herbicide remains active in the soil is called "soil persistence" or "soil residual life." Anything that affects the disappearance or breakdown of herbicides will affect persistence. Many factors determine the length of time herbicides persist. Most factors fall into three categories: soil factors, climatic conditions, and herbicidal properties. These categories strongly interact with one another.

Herbicides vary in their potential to persist in the soil. Some herbicide families that have persistent members include the triazines, uracils, phenylureas, sulfonated ureas, dinitroanilines, certain hormone herbicides, and some recently developed herbicide chemistry. Table 1 lists several common herbicides in these groups. Table 2 lists the soil persistence of some common herbicides.

SOIL FACTORS

The soil factors affecting herbicide persistence fit into three categories: physical, chemical, and microbial. Soil composition is a physical factor that measures the relative amounts of sand, silt, and clay (the soil texture) and the organic-matter content of the soil. Chemical properties of the soil include pH, cation exchange capacity (CEC), and nutrient status. The microbial aspects of the soil environment include the type and abundance of soil microorganisms present.

Soil composition affects phytotoxicity and persistence through adsorption, leaching, and volatilization. Generally, soils high in clay or organic matter or both have a greater potential for carryover because of increased adsorption to soil colloids with a corresponding decrease in leaching and loss through volatilization. This "tie-up" results in decreased initial plant uptake and herbicidal activity. Therefore, more herbicide is held in reserve to be released later, potentially injuring susceptible future crops.

Some herbicides, principally the triazines (atrazine, propazine, and simazine) are particularly affected by soil pH, an important part of the soil chemical makeup. Lesser amounts of these herbicides are adsorbed or held to soil colloids at higher soil pH, so they remain in the soil solution. Herbicides in the soil solution are available for plant uptake. Chemical breakdown and microbial breakdown, two major herbicide degradation processes, are often slower in higher pH soils. So although decreased adsorption of triazine herbicides occurs in higher pH soils, there is also less breakdown activity. Therefore, these herbicides are more available for plant uptake for a longer period of time on higher pH soils. Certain members of the sulfonylurea group (chlorsulfuron and

chlorimuron) can also persist in higher pH soils because of decreased rates of chemical breakdown. Soil pH has little effect on the persistence of some herbicides.

Research shows that various nutrients and cations in the soil affect both herbicide activity and degradation. The CEC, which is principally a function of clay type and organic matter content, is directly involved in herbicide adsorption. Some herbicides are more available in the presence of certain cations, whereas others may be tied up and therefore unavailable. The literature indicates that there is much variation in the effect that cations and nutrients can have on herbicide activity and breakdown, depending on soil composition, nutrient type and concentration, and the chemistry of the herbicide.

Soil microorganisms are partially responsible for the breakdown of many herbicides. The type of microorganisms and their relative amounts will determine how quickly decomposition occurs. Soil microbes require certain environmental conditions for optimum growth and utilization of any pesticide. Factors that affect microbial activity are temperature, pH, oxygen, and mineral nutrient supply. Usually, a warm, well-aerated, fertile soil with a medium soil pH is most favorable for microorganisms and hence herbicide breakdown.

CLIMATIC FACTORS

The climatic variables involved in herbicide breakdown are moisture, temperature, and sunlight. Herbicide degradation rates generally increase with increased temperature and soil moisture because both chemical and microbial decomposition rates increase under higher temperature and moisture. Cool, dry conditions slow down herbicide degradation, and as a result, carryover potential is greater. If winter and spring conditions are wet and mild, the likelihood of herbicides to persist is less.

Sunlight is also an important factor in herbicide degradation. Photodecomposition, or decomposition by light, has been reported for many herbicides. The dinitroanilines (trifluralin, pendimethalin, and ethalfluralin) are sensitive to light degradation. They may be lost when surface applied if they remain for an extended time period without rainfall. Therefore, degradation would be accelerated on very sunny days. This sensitivity to light and loss by volatility are primary reasons for soil incorporation.

HERBICIDAL PROPERTIES

Finally, the chemical properties of a herbicide affect its persistence. Important factors include water solubility, vapor pressure, and susceptibility to chemical and microbial alteration or degradation.

The water solubility of a herbicide helps to determine its leaching potential. Leaching occurs when a herbicide is dissolved in water and moves down through the soil profile. Herbicides that readily leach may be carried away or carried to susceptible plant rooting zones. Herbicide leaching is determined not only by its water solubility, but also by its ability to adsorb to soil particles. Additionally, soil texture and available soil water affect herbicide leaching. Herbicides that are low in water solubility, that are strongly adsorbed to soil colloids, and that exist in dry soils are less likely to leach and have a greater potential to persist.

The vapor pressure of a herbicide determines its volatility. Volatility is the process whereby herbicides change from a liquid or solid to a gas. Volatility increases with temperature. Volatile herbicides such as the thiocarbamates (EPTC, butylate) must be incorporated immediately to avoid gaseous losses. These herbicides are less likely to persist than herbicides with a low vapor pressure. Herbicides may be rapidly decomposed by microoraganisms in the soil if the right kind and number of microorganisms are present and if soil conditions are favorable for their growth. However, herbicides vary greatly in their susceptibility to microbial decomposition. For example, microbial decomposition of 2,4-D occurs very quickly in the soil, whereas atrazine degradation is slow.

Chemical decomposition is dependent not only on the chemistry of the herbicide (how susceptible it is to chemical breakdown), but also on soil and climatic factors. Chemical breakdown of a herbicide involves reactions such as hydrolysis, oxidation, and reduction. The occurrence of these reactions and the rate at which they take place will vary with soil type and climatic conditions. These reactions along with microbial degradation are important processes in the decomposition of herbicides.

Avoiding Herbicide Persistence in Subsequent Crops

There are several ways to avoid herbicide carryover problems. First, always apply the correct rate of any pesticide for your specific soil type and weed problem. This means applying the lowest rate of the chemical consistent with obtaining the desired effect. In order to accomplish this goal, accurate acreage determination, accurate chemical measurement, proper sprayer calibration, and uniform application are essential. Always read the label before applying any herbicide.

The method and time of application can be important in avoiding herbicide carryover. Some herbicides must be incorporated. However, if herbicides have the potential to persist longer than desired, those applied preplant incorporated will more likely remain longer than those surface applied without incorporation. Incorporating the herbicide makes it less susceptible to loss by volatilization and photodecomposition. In addition, the herbicide is immediately exposed to charged soil particles and possibly tied up through adsorption. Decreased environmental losses (volatilization and photodecomposition) and increased adsorption both favor herbicide carryover. Banded herbicide applications can reduce carryover potential because less total herbicide is applied in a band than if it is broadcast. Also, postemergence and late applications have a greater potential for being present in next year's crop.

The amount of tillage will affect herbicide persistence. Tillage encourages herbicide decomposition indirectly through increased microbial and chemical breakdown. Minimum-till and no-till, which leave crop residue on the soil surface, also tend to leave a greater concentration of herbicide near the surface zone. Persistent herbicides present in this concentrated zone may affect susceptible crops. In addition, higher rates of herbicides are often used in reduced tillage systems to maximize weed control and adjust for greater amounts of crop residues. If a herbicide carryover problem already exists, some tillage to dilute the chemical may help.

Herbicide combinations may reduce the risk of carryover problems. By tank mixing two or more herbicides, we might reduce application rates of those products that potentially cause problems and broaden our weed control spectrum at the same time.

Herbicides may interact with one another or with other pesticides and enhance crop injury when they are applied in the same or in consecutive years. For example, a soybean crop may tolerate a certain level of atrazine carryover. However, if another photosynthetic inhibitor such as metribuzin is applied to soybeans after atrazine-treated corn, injury is more likely. Chlorimuron (the active ingredient in Classic and a component of Gemini and Canopy), a sulfonylurea, should not be used the same year with other products containing chlorimuron or imazaquin (Scepter) if a crop other than soybeans will be planted the following year. Chlorimuron and imazaquin have the same mode of action in plants, and both have the potential to persist and to injure corn.

Plants absorb herbicides from the soil in which they are growing. Persistence may be less if the herbicide is metabolized or broken down by the plant or if the plant containing the absorbed herbicide is harvested and removed from the field. Plant extraction of the herbicide from the soil may not be an important factor under most situations, but it has been used in some situations to help remove persistent herbicides from treated soils.

Finally, the selection of a tolerant rotational crop or variety will help minimize carryover problems. Quite often, economics will dictate crop rotation; however, there are varietal differences that might affect the likelihood of serious crop injury. For example, some soybean varieties are more sensitive to the triazine herbicides than others and should not be used if the potential for triazine injury exists. Also, as a general rule, smaller seeded crops and varieties have a greater potential for injury from persistent herbicides than do larger seeded species.

If herbicide carryover is suspected, a soil chemical test or biological assay can help determine if harmful levels of herbicide residue are present. Chemical analysis can be expensive, so a biological bioassay may be more feasible. Either can help you to determine if herbicide residues exist and if a tolerant crop or variety should be planted into a problem area.

Many variables interact in predicting herbicide persistence. Factors involved in the degradation of herbicides include many soil, climatic, and herbicidal properties. The potential for herbicide carryover problems can be reduced by using the appropriate rates and the accurate timing of proper application methods. The use of selective tillage, herbicide combinations, and tolerant crops and varieties can also help reduce the risk of crop injury.

Table 1. Herbicide Families with Their Persistent Members

S-triazines	Phenylureas	Sulfonylureas
atrazine	diuron (Karmex)	chlorsulfuron (Glean)
hexazinone (Velpar)	fluometuron (Cotoran)	chlorimuron (Classic)
propazine (Milogard)		sulfometuron (Oust)
simazine (Princep)		
Dinitroanalines	**Uracils**	**Hormone herbicides**
benefin (Balan)	bromacil (Hyvar-X)	picloram (Tordon)
ethalfluralin (Sonalan)	terbacil (Sinbar)	fenac (Fenatrol)
oryzalin (Surflan)		
pendimethalin (Prowl)		
trifluralin (Treflan)		
Others		
bensulide (Prefar, Betasan)		
diphenamio (Enide)		
fluridone (Brake, Soner)		
norflurazon (Zoriel, Solicam)		
sodium borates		
tebuthiuron (Spike)		
FMC 57020 (Command)		
imazaquin (Scepter)		

Table 2. Relative Soil Persistence of Some Common Herbicides Applied at Labeled Illinois Use Rates

1 month	1-3 month	3-12 month	>12 month
2,4-D	aciflourfen (Blazer/ Tackle)	atrazine	bromacil/Hyvar-X
glyphosate/ Roundup	Alachlor (Lasso)	benefin (Balan)	chlorsulfuron (Glean)
MCPA	ametryn (Cvik)	bensulide (Prefar, Betasan)	picloram (Tordon)
paraquat (Gramoxone)	bentazon (Basagran)	bromoxynil (Buctril/ Brominal)	prometon (Pramitol)
	butylate (Sutan/ Genate)	chlorimuron (Classic)	sodium borate
	chloramben (Amiben	diphenamio (Enide)	sulfometuron (Dust)
	cyanazine (Bladex)	diuron (Karmex)	Tebuthiuron (Spike)
	OCPR (Dacthal)	ethalflural (Sonolan)	
	EPIC (Eptam/Eradicane)	fluridone (Brake, Sonar)	
	linuron (Lorox)	FMC 57020 (Command)	
	metolachlor (Dual)	hexazionne (Velpar)	
	metribuzin (Sencor/ Lexone)	imazaquin (Scepter)	
	maptalam (Alanap)	norflurazon (Zoriel, Solicam)	
	oxyfluorfen (Goal)	oryzalin (Surflan)	
	propachlor (Ramrod)	pendimethalin (Prowl)	
	siduron (Tupersan)	pronamid (Kerb)	
	terbutryn (Tgran)	propazine (Milogard)	
	vernolate (Vernam/ Reward)	simazine (Princep)	
		terbacil (Sinbar)	
		trifluralin (Treflan)	

Testing for Herbicide Residues

W. Curran, M. McGlamery, E. Knake, D. Pike, and D. Anderson

Herbicides vary in their potential to persist in soil. Those herbicides that can persist to the next season may injure subsequent crops and need to be monitored closely. Two methods used to determine if harmful herbicide residues might exist are a soil chemical test done at a laboratory and a bioassay, done either in the suspect field or in a warm sunny location indoors, such as a greenhouse. These tests help predict potential herbicide residue problems so that the grower can make better decisions about crop rotation, herbicide selection, planting date, and other cultural practices.

With the lab analysis or indoor bioassay, proper sampling of the soil is the first step. The soil sampling procedures for submitting a soil for laboratory analysis and for conducting an indoor bioassay are similar. These guidelines should be followed:

SOIL COLLECTION AND PREPARATION

1. Collect representative soil samples from the suspect field. These samples are usually collected in early to mid spring or prior to planting. Take samples from several locations in the field. For the bioassay or laboratory analysis, take 15 to 20 soil cores for your sample, which represents no more than 15 to 20 acres. Enough areas must be sampled to avoid missing locations with high herbicide residue content. **Take separate samples from areas where excessive residues are suspected such as sprayer turnaround points and end rows. Do not mix these with the others.** Sample the soil to a 6-inch depth and divide the samples into 0- to 3-inch and 3- to 6-inch sections for greater accuracy. Be sure to mark on the bags the depths from which the samples came. Approximately 8 pounds of soil (4 quarts) are needed for each bioassay or 2 pounds of soil (about 1 quart) for each laboratory analysis.

2. Sample an area that is not suspect for use as a "check" soil. This may be taken from a nearby fence row, garden, or other untreated area. Keep this soil sample separate from the others. Many laboratories also require a check soil.

3. Submit the samples to the laboratory as soon as possible after sampling. If bioassays are to be performed, they should be run on the soil samples as soon as possible after they have been obtained from the field. If samples cannot be assayed immediately, then store the soil in a cold environment, such as a refrigerator or freezer that is not used for food. If samples are stored in a warm environment, herbicide residue may decrease with time.

BIOASSAY

The bioassay can help predict potential crop injury. These tests are inexpensive and can be done with a few simple supplies. The bioassay will not provide an exact measure of the amount of herbicide residue present in the soil, but it may indicate whether enough residue is present to harm a sensitive crop.

Field Bioassay

A field bioassay is conducted by planting one or more strips of a sensitive species in a suspect field. This procedure can be done in the fall or spring, but it is more accurate if performed closer to the planting of the intended crop. Plants for bioassay must have enough time to grow and develop symptoms of injury if herbicide residues are present before planting the desired crop. The strips should be planted in several locations if possible and include an area that is most suspect and an area that can serve as a check. Choose an appropriate species for bioassay, such as one of the more sensitive ones listed in this paper. Include several species of differing sensitivity for greater accuracy.

Indoor Bioassay

The procedure for conducting an indoor bioassay will vary depending on what herbicide residue is of concern. For the indoor bioassay, the procedures for soil collection and preparation, however, are the same.

1. For the indoor bioassay, take the samples and allow them to air dry until they can be worked readily. Do not overdry the samples. If the soil is cloddy, crush the clods into small pieces (the size of a pea seed or smaller). If the soil contains a high amount of clay, the addition of coarse sand (50 percent by volume) will improve its physical condition. If sand is added, thoroughly mix it with the soil.

2. Tin cans, milk cartons, or cottage cheese containers are appropriate containers in which a bioassay can be conducted. Punch holes in the bottom of the containers to allow water drainage. Fill two or more containers (a set) with the soil samples from the suspect areas. Additional containers will increase the accuracy of the test. Place the soil samples from the 0- to 3-inch depth in one set of containers and in another set, place the soil obtained from the 3- to 6-inch depth. In addition, fill a third set of containers with the check soil.

Triazine Residues

For suspected injury from triazine herbicides, such as atrazine and simazine, an oat plant bioassay works best. Place about 15 oat seeds in each container of soil and cover the seeds with approximately 1 inch of soil. Wet the soil with water but do not saturate it.

Place the containers in a warm location (70° to 75°F) where they will receive ample light. Sunlight is essential for the development of the plant as well as for inducing symptoms of triazine injury. The container should be watered when necessary.

Injury symptoms should become apparent in 10 to 14 days after planting. Triazine injury is characterized by chlorosis (yellowing) followed by necrosis (browning) of the leaf tissue. Injury symptoms will start at the leaf tip and develop toward the base of the leaf. Smaller amounts of herbicide residue may only stunt the plant. Therefore, it is essential that a comparison with the plants in the check soil be made.

If injury appears on the oats, then enough herbicide residue may be present to injure a susceptible crop, and a more tolerant crop is suggested. In general, the order of susceptibility to triazine herbicides is:

Ryegrass > Alfalfa > Oats = Wheat > Soybean > Sorghum > Corn

DNA Residues

If dinitroaniline (DNA) residues, such as Treflan, Surflan, or Prowl are suspected, a different assay technique is used. A sorghum or corn root bioassay is relatively quick and easy to perform.

Wrap sorghum or corn seed in a moist paper towel and store them at room temperature for 2 to 3 days. This procedure allows the seed to imbibe water and germinate (sprout). Once the seed has germinated, carefully place 3 to 5 pregerminated seeds into containers with the suspect and check soils. Cover the seed with soil to a depth of approximately 1 inch, and leave them for 10 to 14 days, depending on the air temperature. Water the plants as needed but do not saturate the soil.

At the end of the 7- to 14-day period, carefully remove the plants and observe radicle and root formation. DNA herbicides inhibit root development. Symptoms include stunted plants, stubbed roots, inhibited root-hair development, thickened hypocotyls, and leaves that fail to unroll. If the plants in the suspect soil display any of these symptoms in comparison to the check plants, then DNA residues may be present and injure susceptible crops. In general, the order of susceptibility to DNA herbicides is:

Annual Rye > Oats > Sorghum > Wheat = Corn > Alfalfa > Soybean

Imazaquin or Chlorimuron Residues

Imazaquin, the active ingredient in Scepter and a component of Squadron and Tri-Scept, and chlorimuron, the active ingredient in Classic and a component of Preview and Lorox Plus, have the same mode of action in sensitive plants. Both of these herbicides affect root and shoot growth and development. Symptoms of plant injury include inhibited root development, stunted plants, and intervenal chlorosis or leaf striping. Therefore, a sorghum or corn root bioassay performed according to the procedure outlined for suspected DNA residue is appropriate. Corn is more sensitive to Scepter, and sorghum is more sensitive to chlorimuron. In addition to root observations, look for stunted shoot growth and intervenal chlorosis or yellowing. Bioassay plants should be grown for 14 to 21 days.

The order of crop susceptibility to Scepter and chlorimuron are as follows:

Scepter

Rape > Alfalfa > Corn = Sunflower > Sorghum > Oats > Wheat > Soybean

Chlorimuron

Rape > Alfalfa = Sunflower > Sorghum > Corn > Oats > Wheat > Soybean

Command Residues (clomazone)

Command and Commence inhibit the production of photosynthetic pigments in susceptible plants, and, therefore, causes plants to emerge lacking green color, so they are white or albino. Lower levels of Command residue may appear as a chlorosis or mild bleaching of the plants. Oats or wheat can be used to detect

Command residues using the same procedure as outlined above for detecting triazine residues. Bioassay plants should be grown for 10 days to two weeks. Susceptible plants that are exposed to significant levels of Command residues will be white, while untreated or tolerant plants are green. Keep in mind that oats and wheat are usually more susceptible than corn to injury from Command. The order of susceptibility to Command residues are as follows:

Oats = Wheat = Alfalfa > Sunflower = Sorghum > Corn > Soybean

Bioassays can be made for other herbicides using similar techniques. If the mode of action of a specific herbicide is known, then we can develop a procedure for detecting the herbicide. For example, if the herbicide is a root meristematic inhibitor, that is, it stops cell division in the roots, then a root bioassay is the appropriate test. If the herbicide inhibits photosynthesis, then injury symptoms will first appear in the leaves. Choose a species that is moderately susceptible to the suspected herbicide and always include a check soil. Wheat and oats are very good indicator plants for many herbicides but may be more sensitive than the desired crop. Include several different species in the bioassay to give a better range of susceptibility. The desired crop is always a good bioassay plant to be included.

LABORATORY ANALYSIS

Laboratory analysis involves extracting the herbicide from the soil with the use of specialized equipment to detect very small amounts of herbicide. The amount of herbicide is expressed in parts of herbicide per million parts of soil (ppm). Parts of herbicide per million parts of soil can be transposed into pounds of herbicide per acre if we assume that an acre of soil weighs 1,000,000 (million) pounds in the top 3 inches and 2,000,000 pounds in the top 6 inches.

Thus, for a soil sample taken to a 6-inch depth, 1 ppm = 2 lb/A of residue.

For a soil sample taken to a 3-inch depth, 1 ppm = 1 lb/A of residue.

So a lab report of 0.2 ppm atrazine is equivalent to 0.2 pound of atrazine per acre if the samples were taken to a 3-inch soil depth, and 0.4 pound per acre if taken to a 6-inch soil depth.

The location and concentration of the chemical will depend on what herbicide is used, the soil type, whether the ground was tilled, and the amount of rainfall since application. In most medium-textured soils (silt loams, silty clay loams, sandy clay loams) some herbicides remain primarily in the top 3 inches, unless there was excessive rainfall, the ground was plowed, or the herbicide deeply incorporated. If the soil has a high sand content (coarse texture), then herbicide leaching may be greater. The risk of crop injury is increased when the herbicide residue is concentrated in the top 3 inches rather than distributed throughout the 6-inch soil depth. Therefore, it is best to sample the 0- to 3-inch and 3- to 6-inch sections separately.

Whether we use parts per million or pounds of active ingredient of herbicide, translating these units of measure into potential crop injury is difficult. Many variables affect crop susceptibility or tolerance, including soil type, crop sensitivity, and environmental conditions after planting. Crop injury is more likely on more coarsly textured soils or under cool-wet weather conditions. Additionally, high soil pH increases the likelihood of triazine and chlorimuron injury.

The following general guidelines are provided, although the reader is cautioned that crop injury may still occur below these levels:

General Guidelines

Herbicide	Safe level	Crop
	ppm	
Triazine	< 0.25	soybean
	< 0.10	alfalfa, oats
Dinitroanaline	< 0.10	corn
Command[a]	0.025 - 0.20	corn
	0.013 - 0.10	wheat, alfalfa
Scepter[a] (imazaquin)	0.002 - 0.01	corn
chlorimuron[a]	0.001 - 0.002	corn

[a]Due to differences in herbicide availability from the soil, "safe" values for herbicide residues differ according to soil type. Low range values are for coarsely textured soils with low levels of organic matter; higher range values are for finely textured soils with high levels of organic matter.

Laboratories may differ in available tests and in the price of the analysis. The cost can range from $20 to $200 per sample or herbicide analysis. Most laboratories can analyze a sample and have the results in 5 to 7 days. Contact your county Extension adviser for more information on laboratory selection.

CORRECTING FOR HERBICIDE RESIDUES

If the soil-test or bioassay plants indicate that a potential herbicide residue problem exists, several steps can be taken.

1. First select a tolerant crop or variety. This selection will depend on what herbicide is of concern. Check current herbicide labels for more information on crop tolerance.
2. Till to help dilute the herbicide in a problem field.
3. Plant the field of concern last. Delaying the planting allows more time for the herbicide to break down.
4. If the triazine herbicides or a member of the sulfonylurea group (Classic, Preview, or Lorox Plus) are suspect, be sure to check the soil pH and adjust your management practices accordingly.

In summary, a bioassay or laboratory test is not 100 percent accurate in predicting herbicide residue problems. Crop response to herbicide residue depends on a number of factors, including species and variety, soil type, and environmental conditions after planting. Therefore, predicting crop injury is often difficult. However, using a soil chemical test or biological assay can help in deciding whether a potential problem exists and in choosing the appropriate crop or variety.

1989 Condensed Plant Disease Management Guide for FIELD CROPS

You must be certified as a pesticide applicator to use restricted-use pesticides. See your county Extension adviser in agriculture for information.

The best way to ensure the success of a disease management program is to adapt it to the diseases expected and to use integrated disease control measures. Among these measures are the use of resistant varieties, crop rotations, fungicides, nematicides, and suggested agronomic practices. The success of any one or all of these measures may depend on how carefully you scout your crops. Because periodic crop scouting increases the likelihood that disease controls will be applied properly, it can help prevent both loss through disease and unnecessary use of pesticides.

Specific information for the control of the important diseases of corn, soybeans, wheat, and alfalfa can be found in the following issues of *Report on Plant Diseases:*

No. 123: "Winter Wheat Disease Management Program"
No. 212: "Illinois Corn Disease Management Program"
No. 308: "Alfalfa Disease Management Program"
No. 507: "Illinois Soybean Disease Management Program"
No. 1001: "Seed Treatments for Field Crops"

These and other issues of *Report on Plant Diseases* are available from the Department of Plant Pathology, University of Illinois, N533 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801 at a cost of fifty cents each.

FEDERAL AND STATE LAWS RESTRICTING PESTICIDE APPLICATION

The U.S. Environmental Protection Agency (EPA) is classifying pesticides for "general" or "restricted" use. Anyone applying a restricted-use pesticide, whether "commercial" or "private," must be certified.

Commercial applicators include not only persons applying restricted-use pesticides for hire but also government personnel, chemical company representatives, and others involved in demonstrational, regulatory, and public health pest control. Certification as a commercial applicator requires passing a written examination administered either by the Illinois Department of Agriculture or the Illinois Department of Public Health.

Private applicators who use restricted-use pesticides "for the purpose of producing any agricultural commodity on property owned or rented by [the applicator] or as exchange labor (no compensation) on the property of another must also be certified, either by attending an educational training program or by passing an examination."

Educational training programs for farmers (private applicators) and commercial pesticide applicators are conducted by the Illinois Cooperative Extension Service to prepare persons for certification. The actual certification and the issuing of permits or licenses are handled by the Illinois State Department of Agriculture.

ALWAYS READ THE LABEL BEFORE USING A PESTICIDE

The chemical names used in this circular may be unfamiliar to you. They are the common, coined chemical names and are not capitalized (for example, benomyl). Trade names are capitalized (for example, Benlate). Common chemical names are used in Table 1, and Table 2 lists both the common names and trade names of fungicides and nematicides.

FUNGICIDE APPLICATION

At present, aircraft are the best vehicles for applying fungicides to agronomic crops. Some aircraft may not be equipped or calibrated to do this job. It is therefore important to select an aerial applicator who is familiar with disease control and whose aircraft has been properly calibrated for uniform, thorough coverage of all aboveground plant parts. With the equipment now available, a reasonable job of applying fungicides requires a minimum of 5 gallons of water carrier per acre. Superior coverage may be obtained with more water, but the cost may be prohibitive. Conversely, a lower volume (under 3 to 4 gallons per acre) gives correspondingly poorer control. Five gallons of water can be applied uniformly using approximately 30 to 70 properly spaced nozzles, depending on the aircraft. The nozzles should be D-8 to D-12, hollow cone, with No. 45 or No. 46 cores. The final decision on nozzle number, size, swath width, and placement depends on the air speed, pressure, and volume desired. Droplet size is also important. Ideally, droplets should be 200 to 400 microns in size for thorough and uniform coverage.

This circular was prepared by H.W. Kirby and M.C. Shurtleff, Extension Plant Pathologists with the Department of Plant Pathology, University of Illinois at Urbana-Champaign. The suggestions given in this circular are revised annually.

CIRCULAR 1231 (revised annually) October 1988

ADJUVANTS

When it is compatible with the product label, add a spray adjuvant (surfactant) to the spray mix. Some commonly available surfactants are: Bio 88, BioFilm, Regulade, Plyac, Triton AG-98, Triton B-1956, Triton CS-7, Chevron Spray Sticker, Chevron Spreader, X-77, NuFilm P, NuFilm 17, and DuPont Spreader Sticker (liquid) spreader sticker.

Adjuvants are suggested for use when you spray corn or small grains. These materials help disperse fungicides and improve coverage.

NEMATICIDE APPLICATION

Granular nematicides/insecticides registered for use on corn, sorghum, and soybeans may be used as in-furrow or band treatments, depending on the product label. In general, band applications have given more consistent control than have in-furrow applications. Follow the manufacturer's suggestions on incorporation. Nematicides should be used only where soil analysis shows an economic problem. Follow soil sampling instructions in *Report on Plant Diseases* No. 1100, "Collecting and Submitting Soil Samples for Nematode Analysis." This publication is available from Extension Plant Pathology, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

Trade Names. A more complete list of trade names can be found in *Report on Plant Diseases* No. 1002, "Fungicides, Disinfectants, Grain Preservatives, Surfactants, and Soil-Disinfesting Chemicals." This publication is available from Extension Plant Pathology, University of Illinois, N-533 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801.

Table 1. Condensed Disease-Control Recommendations for Field Crops

Crop	Diseases	Fungicide or nematicide	Comments
Alfalfa	Bacterial wilt, Phytophthora root rot		Resistance should be strongly considered when choosing a variety.
	Leafspots, spring blackstem, and anthracnose		Cut forage in a timely manner to maximize yields and minimize leaf loss. Grow adapted resistant varieties.
	Crown and root rots		Maintain proper fertility and soil pH. Avoid cutting or grazing during the last 5 to 6 weeks of the growing season. Control insect pests.
	Verticillium wilt		Seed treatment with thiram is suggested to prevent seed transmission. This disease will only be a problem in stands that are more than 3 years old. Resistant varieties should also be considered.
	Seed rots and seedling blights	captan, captan + zineb, or thiram plus metalaxyl	Seed treatment is not usually necessary with high-quality seed.
	Sclerotinia white mold		Spring planting, deep and clean plowing, using 3- to 4-year rotations with nonlegume crops, and avoiding excessively lush growth may help. Chemical controls are not available. The variety Cimarron is reported to be moderately resistant.
Barley	Seed rot, seedling blight, loose smut, and semiloose smut	carboxin + thiram, carboxin (planter-box) plus maneb + HCB or captan + HCB (planter-box), captan + carboxin	Seed treatment is strongly suggested. Carboxin is required for loose smut control.
	Helminthosporium leaf blight, Septoria leaf blotch	mancozeb	Apply when disease conditions warrant. Apply when plants are in the late tillering to jointing stage; repeat at 7- to 10-day intervals. Do not make more than 3 applications. Do not apply within 26 days of harvest.
	Barley yellow dwarf virus		Plant winter barley after the fly-free date and spring barley as early as possible.
Clover	Anthracnose diseases		Grow adapted resistant varieties.
	Crown and root rots		Same as for alfalfa.
	Seed rots and seedling blights		Same as for alfalfa.
Corn	Seed rots and seedling blights	captan, captan + maneb, captan + zineb, captan + HCB + maneb, carboxin, carboxin + thiram, mancozeb, maneb, PCNB + etridiazol, TCMTB, thiram, thiram + maneb	Sow injury-free, plump seed in soils at 50°F or above. Prepare the seedbed properly and place herbicide, fertilizer, insecticide, and seed correctly. Note: fungicide plus insecticide seed treatments are commonly used.
	Helminthosporium leaf blights northern leaf blight northern leaf spot southern leaf blight Helminthosporium leaf blight	zineb, mancozeb	Plant resistant hybrids. Apply 2 to 4 sprays at 10-day intervals starting when disease appears. Fungicide control is justified only when significant disease occurs less than 2 weeks after tasseling. Use a spreader sticker. Fungicide applications are generally economically feasible only in seed-production fields. Do not apply within 40 days of harvest. Do not feed fodder or forage to livestock.

Table 1. (continued)

Crop	Diseases	Fungicide or nematicide	Comments
Corn (cont.)	Common rust and southern rust	zineb, mancozeb	Same as for Helminthosporium leaf blights.
	Stewart's disease		Plant resistant hybrids or use insecticides to control flea beetles when necessary.
	Goss's bacterial wilt and leaf blight		Plant resistant hybrids. Clean plowdown and 2-year crop rotations also give control. Use clean plowdown only where erosion will not be a problem.
	Anthracnose, Physoderma brown spot, eyespot, gray leaf spot, yellow leaf blight		Plant resistant or tolerant hybrids. Practice crop rotation or clean tillage where soil-erosion considerations allow.
	Crazy top and sorghum downy mildew		Plant resistant or tolerant hybrids. Improve drainage in affected area. Control wild cane to reduce sorghum downy mildew inoculum.
	Virus diseases		Plant resistant hybrids. Control johnsongrass to reduce overwintering source of MDMV and MCDV.
	Stalk rots *Diplodia* charcoal *Gibberella* *Nigrospora* *Fusarium* anthracnose		Plant hybrids with good stalk rot resistance and stalk strength. The use of a nitrogen stabilizer may be helpful where nitrogen loss is expected. Maintain adequate phosphorus and potassium fertility for the rate of nitrogen used. Control corn borers and corn rootworms. Scout fields at 30- to 40-percent moisture for lodging potential. Walk a zig-zag pattern through the field pushing random plants about 5 inches from the vertical. If more than 10 to 15 percent lodge, schedule the field for early harvest.
	Storage molds *Penicillium* spp. *Aspergillus* spp.	propionic acid, isobutyric acid, acetic acid, or mixtures of these	Grain treated with an acid grain preservative can be used only for animal feed. Store undamaged corn at 15 to 15.5 percent moisture from fall until spring, then dry to 13 percent for long-term storage. Grain damaged by field molds, insects, etc., should be dried to 13 to 13.5 percent moisture at harvest. Watch stored grain for heating, a musty odor, crusting, or other signs of storage mold activity. Control stored grain insects. Make sure combine is adjusted to avoid damage to grain. Remove fines and foreign material before storage.
	Nematodes root-lesion needle dagger spiral lance stubby-root sting stunt	carbofuran, ethoprop, terbufos	Use nematicidal rates of these materials only where soil tests indicate economic populations of nematodes. Use crop rotation where appropriate.
Oats	Seed rots and seedling blights, loose smut and covered smut	captan + HCB, captan + HCB + maneb, carboxin, carboxin + thiram, HCB + maneb, PCNB, TCMTB, captan + carboxin, carboxin + maneb	Seed treatment is strongly suggested for control of smut diseases.
	Barley yellow dwarf		Grow resistant varieties. Plant susceptible varieties as early in the spring as possible.
	Crown rust		Plant resistant varieties. Fungicides applied for *Septoria* and *Helminthosporium* will also aid in crown rust control.
	Helminthosporium leaf spot, Septoria leaf blotch	mancozeb	Spray when disease is present and weather conditions favor disease development. Start applications at tillering to jointing stage. Make a second application 10 days later. A third application is permissible but may be uneconomical. Do not apply within 26 days of harvest.
Sorghum	Seed rots, seedling blights, and smuts	captan, captan + thiram, captan + zineb, captan + PCNB, HCB + maneb, PCNB + etridiazol, thiram	Fungicide seed treatment is strongly suggested. Plant in soils at 60°-65°F or above.
	Other diseases		Plant resistant or tolerant hybrids. Diseases other than the smuts have not been important in Illinois.
	Nematodes	aldicarb, carbofuran	Apply only where soil analysis indicates an economic problem.

Table 1. (continued)

Crop	Diseases	Fungicide or nematicide	Comments
Soybeans	Seed rots and seedling blights (primarily Pythium, Phytophthora, Rhizoctonia)	captan, captan + maneb, captan + thiram, captan + HCB + maneb, captan + PCNB, HCB + maneb, mancozeb, maneb, PCNB + etridiazol, TCMTB, thiram, Vitavax + thiram, carboxin + captan, Vitavax + meta-laxyl, captan + metalaxyl, metalaxyl, thiram + thiabendazole	Plant high-quality seed germinating greater than 70 percent in a cold germination test. Seed treatment is recommended where (1) seed of poor quality due to fungal infection must be planted; (2) delays in emergence are anticipated; (3) seed is planted to produce seed; (4) reduced seeding rates are used; and (5) seed is planted into heavy crop residues (reduced or no-till). Plant in soils at 55°F or above.
	Charcoal rot		Plant full-season varieties as early as possible. Avoid excessive seeding rates and maintain optimal fertility. Deep fall plowing may be beneficial where soil-erosion concerns allow.
	Brown stem rot		Rotate, using 2 years of corn in fields where disease has been damaging. The varieties BSR 301, BSR 302, BSR 201, BSR 101, and Chamberlain have moderate resistance.
	Sclerotinia white mold		Rotate with nonlegume crops. Plant moderately resistant varieties in fields where disease has been present before.
	Phytophthora root rot	metalaxyl	Plant varieties with race-specific or field resistance (tolerance). Race-specific resistance will provide immunity to specific races. However, in many areas, races of the Phytophthora fungus are present that can attack this type of resistance. Varieties with field tolerance are resistant after two sets of trifoliate leaves develop. However, they are very susceptible to the seedling blight phase of the disease. Therefore, varieties with field-tolerance should be protected in the seedling stage with metalaxyl (Apron) fungicide applied as a seed treatment. Varieties with field tolerance can be protected for 6 to 8 weeks after planting by using metalaxyl (Ridomil 2E or 5G) as a band or furrow treatment at planting.
	Soybean cyst nematode	aldicarb, carbofuran, fenamiphos	Rotate to nonhost crops for 3 years and monitor SCN populations by taking soil samples the second and/or third year. Every other soybean crop should be a susceptible variety to reduce the buildup of new races. If the same resistant bean is rotated with a nonhost, new races can rapidly develop. Nematicides are suggested only where (1) crop rotations are not possible and (2) resistant varieties cannot be used. Aldicarb has given the most consistent control in Illinois; applied in-furrow, it has given control equal to higher rates applied as bands. Both aldicarb and carbofuran can be applied in-furrow. See *Report on Plant Diseases* No. 501 for more information.
	Sudden death syndrome		No direct control methods have been identified. Controlling the soybean cyst nematode may be beneficial. Early maturing or early planted beans appear more susceptible.
	Pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, and purple seed stain	benomyl, thiabendazole, thiophanate-methyl	Suggested for use where disease conditions warrant (see Table 2). Two applications are suggested for maximum yield and seed quality. Benomyl, thiophanate-methyl, and thiabendazole have 24c labels for a single late application at higher labeled rates for improved seed quality. Use pod tests to determine the need for late applications.
Wheat	Seed rots, seedling blights, loose smut, and bunt (stinking smut)	carboxin + thiram, carboxin (planter-box) plus maneb + HCB, captan + carboxin, or maneb + thiabendazole	Seed treatment is strongly suggested. Higher labeled rates of carboxin are required for bunt control. Only carboxin controls loose smut.
	Leaf rust, Septoria leaf blotch, Septoria glume blotch, Helminthosporium leaf blight, stem rust, and Pyrenophora tan spot	mancozeb, zineb, triadimefon, benomyl + mancozeb, tiabendazole + mancozeb	Apply fungicide when disease conditions warrant. Begin applications at the jointing stage and repeat at 7-day intervals. Do not make more than 3 applications of mancozeb or zineb. Do not apply within 26 days of harvest. Triadimefon is limited to two applications per season. Triadimefon will give excellent control of rust, moderate control of Septoria leaf blotch, and poor control of Septoria glume blotch and tan spot. Do not apply within 21 days of harvest or within 35 days of seeding corn, sorghum, or soybeans. Benomyl plus mancozeb will give good to excellent control of the Septoria diseases, powdery mildew, tan spot, and will provide some control of scab. Apply no more than 3 sprays at 14-day intervals starting at the boot stage. Thiabendazole will provide control of Septoria glume blotch. Apply 2 sprays, one at "boot" and a second application 14 days later. Plant resistant varieties.

Table 1. (continued)

Crop	Diseases	Fungicide or nematicide	Comments
Wheat (cont.)		propacanazole	Limit of one application per season. Applied at growth stage 8 (Feekes scale). Do not double-crop treated acreage where fungicide is applied to the first crop. Do not graze or feed forage, fodder, or straw from rotational crops planted in the fall or spring following treatment.
	Powdery mildew	triadimefon, propacanazole	Plant resistant varieties. Check with your Extension adviser for chemical control recommendations.
	Virus diseases wheat streak mosaic wheat soilborne mosaic barley yellow dwarf mosaic wheat spindle streak mosaic		Plant resistant or tolerant varieties. Plant after the fly-free date. Control volunteer wheat in and around production fields.
	Take-all		Plant after the fly-free date. Use ammonium form of nitrogen fertilizer. Use crop rotations of 2 to 3 years between wheat crops where possible.

FUNGICIDE GUIDELINES

Seed Treatments

Fungicide seed treatments will generally increase stands regardless of quality. However, the greatest benefits will be found (1) where low seeding rates are used; (2) where seed must be used that is of poor quality because of fungal infection; and (3) where seed is planted in a seedbed in which delays in germination or emergence are likely.

Fungicide seed treatments are not a substitute for high-quality seed and will not improve the performance of seed that is of low quality due to mechanical damage or physiological factors. Treated seed of low quality will not produce stands and/or yields equal to untreated high-quality seed. Therefore, only high-quality seed should be considered for planting.

The following checklist for soybean seed treatments (Table 2) is designed to assist in determining the need for seed treatments, especially for control of damping-off fungi. Selection of the proper seed treatment is very important because of the specificity of certain fungicides for controlling only Phytophthora and Pythium.

Foliar Treatments

Foliar fungicide treatments may reduce losses from Septoria brown spot, Cercospora leaf blight (purple seed stain), anthracnose, pod and stem blight, and stem canker. These diseases are most damaging when the weather is warm (70° to 80°F) and wet from early pod fill to maturity. Foliar sprays of fungicides may increase yields 10 to 15 percent, increase seed quality, and reduce disease losses when such fields are planted to soybeans the following year. The use of fungicides should be based on expected disease severity. The six diseases just listed will *not* be as severe in cool, dry seasons and where adequate rotations have been used.

Based on seven years of research data, yields have been increased by an average of 4.7 bu/A (range 1.2-13.4), and seed quality has been increased by an average of 10.7 percent (range 0-42.5 percent) by the use of foliar fungicides.

The checklist in Table 3 can be used at early bloom

Table 2. Soybean Seed Treatment Checklist for Reducing Early Season Stand Losses Due to Damping-Off from Pythium and Phytophthora Fungi

Risk factors	Point value if answer is yes
Rainfall for the 7-day period before planting was:	
Below normal	2
Normal	1
Above normal	4
Seedbed preparation was:	
Conventional tillage	1
Rough surface (conservation tillage)	2
No-till	4
Germination at time of planting is less than 85 percent in a warm test or less than 70 percent in a cold test (such seed should be discarded if at all possible)	3
Previous soybean stand in field was reduced by damping-off or Phytophthora root rot	4
Level of resistance to Phytophthora root rot is:	
Susceptible	2
Tolerant	4
Resistant to one or more races	1
Expected rainfall for 96 hours following planting is:	
Lower than normal	1
Normal	1
Above normal	3
Low areas of field remain flooded for 48 hours following 1 inch of rainfall	4
Seeding rate is less than 55 pounds per acre	3
Field is planted to double-crop soybeans	3
TOTAL POINTS AND SUGGESTIONS	
Less than 7 points: seed treatment will probably not be beneficial.	
Seven to 15 points: seed treatment may be beneficial if weather conditions do not favor rapid germination and growth.	
Greater than 15 points: seed treatment will be beneficial to stand development.	

Table 3. Checklist to Determine Whether Foliar Fungicide Application Should Be Made to Soybeans

Risk factors	Point value if answer is yes
Rainfall, dew, and humidity up to early bloom and pod set are:	
Below normal	0
Normal	2
Above normal	4
Soybeans were grown in the field last year	2 to 3
Chisel-plow, disk, or no-till was used	1
Pycnidia (black specks) are visible on fallen petioles, and Septoria brown spot is obvious on the lower leaves	2
Early maturing variety (not full-season)	1 to 2
Soybeans are to be used or sold for seed	6
Yield potential is better than 35 bushels per acre	2
Seed quality at planting time is less than 85 percent germination in a warm test	1
Other conditions that favor disease development (weather forecast with a 30-day period of greater-than-normal rainfall and a field history of disease)	1 to 3

NOTE: If the total point value is 15 or more, application will probably mean increased yields and higher seed quality.

to determine whether fungicide controls for the six diseases mentioned previously should be used. A key factor in this checklist is the presence of black specks (pycnidia) on fallen petioles. Only brown, fallen petioles should be assayed, and more than two-thirds to three-fourths of these petioles should show pycnidia. If growers use the checklist and apply fungicides correctly, maximum benefits should be achieved. Less than optimal benefits will be achieved if fungicides are applied incorrectly or if disease severity does not warrant spraying.

DISEASE REACTIONS OF FIELD CROP VARIETIES RECOMMENDED FOR ILLINOIS

Disease reactions may vary from one locality to another and from year to year, depending on what physiologic races of the pathogens are present. For the latest information on suggested crop varieties, consult your county Extension adviser or the Department of Agronomy, University of Illinois, W-201 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801.

We wish to thank the following for their assistance in preparing the tabular material given below: D.C. Arny, Department of Plant Pathology, University of Wisconsin, Madison; F.L. Kolb, Department of Agronomy, University of Illinois, Urbana-Champaign; E.D. Nafziger, Department of Agronomy, University of Illinois, Urbana-Champaign; R.L. Bernard, USDA-SEA, University of Illinois, Urbana-Champaign; D.W. Graffis, Department of Agronomy, University of Illinois, Urbana-Champaign; C.R. Grau, Department of Plant Pathology, University of Wisconsin, Madison; C.D. Nickel, Department of Agronomy, University of Illinois, Urbana-Champaign; E.W. Palm, University of Missouri, Columbia; F.L. Patterson, Department of Agronomy, Purdue University, West Lafayette, IN; G.E. Pepper, Department of Agronomy, University of Illinois, Urbana-Champaign; A.P. Roelfs, USDA-SEA, Cereal Rust Laboratory, University of Minnesota, St. Paul; and R.G. Timian, USDA-SEA, North Dakota State University, Fargo.

Soft Winter Wheat

Variety	Recommended area of state[a]	Stem rust	Leaf rust	Loose smut	Septoria	Powdery mildew	Soil-borne mosaic	Barley yellow dwarf	Spot blotch	Pyrenophora	Wheat streak mosaic	False black chaff	Wheat spindle streak
Argee	N	R	S	MR		MS	R	MR					
Arthur 71	N,C,S	R	S	MS	MS	MS	R	MS				R	MS
Auburn	N,C,S	R	R	MR	R	MR	R	MS					MS
Becker	N,C,S		MR		MS	S	MR						R
Caldwell[b]	N,C,S	R	MR	MR	MS	MR	MR	MR		S			MS
Cardinal[b]	C,S	MS	MR										
Dynasty	N,C,S		R			MR							
Hart	N,C,S	S	S	R	MR	VS	R	MR					MR
Pike	N,C,S	S	S	MR	MS	S	MR	MR					MS
Roland	C,S	R	S	MS	S	MS	R	MS			MS		MR
Scotty	C,S	R	MR		MR	R	R	MS					
Tyler	S	S	S			R	R	MR					

Note: Several private varieties have high yield potentials and are widely planted. Growers should contact seed company representatives for information on disease resistance.

Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information or disease is not important.

[a] Area of Illinois where variety is recommended: N = northern; C = central; S = southern.

[b] Moderate resistance to take-all.

Variety	Endophyte level	Helminthosporium and rust diseases	Alkaloid level	Maturity	Winter hardiness
Orchardgrass					
Benchmark		..		Early	H
Boone		..		Early	H
Crown		R (Rust)		Medium Late	EH
Dart		R (Rust Leaf Scorch)		Medium	MH
Dawn		..		..	..
Hawk		R (Rust)		Medium Early	H
Ina		..		Medium	H
Juno		GR		Early	EH
Napier		..		Medium Late	H
Pacific		R (Stem Rust)		Medium Early	..
Pennlate		..		Late	SH
Pennmeade		..		Medium	SH
Potomac		..		Early	MH
Ranco		R (Stem Rust)		Late	H
Sterling		..		Medium Early	H
Reed canarygrass					
Castor		..	..	Early	EH
Flare		..	..	Medium	H
Palaton		GT	Low	Medium Early	EH
Vantage		..	Moderate	Medium	H
Venture		..	Low	Medium Early	EH
Bromegrass, smooth					
Barton		..		Medium	H
Baylor		..		Medium	H
Blair		..		Medium	H
Bravo		..		Medium	H
FS Beacon		..		Medium	H
Fox		..		Medium	H
Lincoln		..		Medium	H
Rebound		..		Medium	H
Sac		..		Medium	H
Jubilee		LR		Medium Early	H
Tall fesuce					
Fawn	Varies	..	..	Late	MH
Forager	Low	..	..	Late	MH
Johnstone	Low[a]	..	Low	Medium	MH
Kenhy	Low	..	Medium	Medium	MH
Kenwell	Varies	..	Medium	Medium	MH
Ky-31	Varies	..	Medium	Medium	MH
Martin	Low	ER	..	..	MH
Mozark	Low	GR	..	..	MH
Timothy					
Itasca		..		Early	H
Mariposa		..		Medium	H
Mohawk		..		Late	H
Pronto		..		..	H
Richmond		..		Early	H
Timfor		..		..	H

Note: In this table, average disease reaction is indicated as follows: LR = low resistance; R = resistance; GR = good resistance; ER = excellent resistance; and GT = good tolerance. For varieties that do not offer resistance to all Helminthosporium and rust diseases, the specific diseases for which these varieties offer resistance appear in parenthesis. The degree of winter hardiness in this table is as follows: SH = some hardiness; MH = moderately hardy; H = hardy; and EH = excellent hardiness. A blank under the columns for the level of endophytes and the level of alkaloids indicates that this category does not apply to the given variety.

[a] Certified as low by seed standards.

Soybeans

Variety	Suggested area of the state[a]	Phytoph-thora rot[b]	Bacterial pustule	Powdery mildew	Pod and stem blight	Soybean cyst nematode (races 3 and 4)		Purple seed stain	Downy mildew	Sclerotinia white mold
Beeson 80	N	R-1-3,7-9	S	MR	S	S	S	S	S	
BSR 101[c]	N	R			MS	S	S	MR		
BSR 201[c]	N,C	R			MS	S	S			
BSR 301[c], 302[c]	C,S	R		S	MS	S				
Cartter	C,S	S				R	R			
Century 84	N,C	R-1-9	S		S	S	S	S	MS	S
Chamberlain[c]	C,S	R				S	S			
CN290	N,C	R	R			R	S			
Corsoy 79	N,C	R-1-3,7-9	S	VS	S	S	S	S	MS	
Cumberland	C,S	MR	R		MR	S	S	S	MS	
DeSoto	C,S	S	S		S	S	S	S	S	S
Egyptian	S	S				R	R			
Elgin 87	N,C	R-1-9	R					S		
Essex	S	S	R	MR	S	S	S	MS	MS	
Fayette	C,S	S	R		S	R	R	S		
Forrest[de]	S	MR	R			R	S			
Franklin[e]	S	R	R		S	R	S	S	S	S
Gnome 85	N,C	R-1-9	R		S	S	S			S
Hack	N,C	R				S	S			
Hardin	N	R	S			S	S			
Harper 87	C,S	R-1-9	R			S	S			
Hobbit 87	C,S	R-1-9	R			S	S			
Lawrence	S	S				S	S			
Pella 86	C,S	R-1-9	R			S	S	S	S	S
Pennyrile	S	S				S	S			
Pershing	S	S				S	S			
Pixie	S	S			S	S	S			
Preston	N,C	S				S	S			
Pyramid	S	S				R	R			
Resnik	C,S	R-1-9				S	S			
Ripley	S	S				S	S			
Sherman	C,S	S				S	S			
Union	S	S			MS	S	S		R	MR
Williams 82	C,S	R-1-9				S	S	S	S	

Note: Growers should contact individual seed companies for information on disease resistance of private varieties.
Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information. R-1,2 indicates resistant (R) to the pathogens indicated by the race numbers.
[a] Area of Illinois where variety is suggested: N = northern; C = central; S = southern.
[b] Races 1 and 2, except where other races are indicated.
[c] Resistant to brown stem rot.
[d] Also resistant to wildfire, target spot, reniform nematode, and root-knot nematode.
[e] Also resistant to race 1.

Barley

Variety	Recom-mended area of state[a]	Stem rust	Leaf rust	Loose smut	Covered smut	Septoria	Powdery mildew	Barley yellow dwarf	Barley stripe mosaic	Spot blotch	Net blotch	Helmin-thospor-ium stripe	Scald
Spring													
Larker	N	MR	S	S	S	S	S	MS	S	S	MS		S
Manker	N	MR	S	S	S	S	S	MS	S	MR	MR		S
Winter													
Barsoy	C,S	MS	S	S			MR	S	S		MS	S	S
Pike	C,S	MS	S	S			MR	S	S		MR	MR	S
Wysor	C,S		R			MS	R	MR			MS		R

Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information.
[a] Area of Illinois where variety is recommended: N = northern; C = central; S = southern.

Oats

Variety	Recommended area of state[a]	Stem rust	Crown rust	Smuts	Barley yellow dwarf	Septoria
Spring						
Don	N,C,S	S	R	R	MR	MS
Hazel	N,C,S	S	R	S	R	MS
Lang	N,C,S	MS	S	MS[b]	MR	MS
Larry	N,C,S	MS	S	MS	MR	MS
Noble	N,C,S	MS	S	R	MR	MS
Ogle	N,C	MS	S	MS	MR	MS
Otee	N,C,S	MS	S	MS	R	MS

Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information.

[a] Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.

[b] Susceptible to new races of smut fungi.

Red Clover

Variety	Powdery mildew	Northern anthracnose	Southern anthracnose	Viruses	Variety	Powdery mildew	Northern anthracnose	Southern anthracnose	Viruses
Arlington	R	R		MR	Mega	R	R	R	
E-688	R	T	R		MorRed	R	R	MR	
Flare	R	MR	R		Redland	R	MR	R	S
Florex	R	R		R	Redland II	R	R	R	
Florie	R	R	R	R	Redman	S	R	MR	S
Kenland	S	S	R	S	Ruby	S	R	R	
Kenstar	S	S	R	MR					

Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; T = tolerant; S = susceptible; Blank = no information.

Alfalfa

Variety	Verticillium wilt	Bacterial wilt	Fusarium wilt	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness[a]
Action	R	R					HR	R	MH
Americana Acclaim	MS	R	R	MR			MR	MR	H
Americana PH2121		HR	R	MR			MR	R	MH
Apollo		R		MR	MS	MS	MS	R	H
Apollo II	MR	R	R				MR	R	MH
Armor		R	R				MR	R	MH
Arrow	R	HR	HR				MR	HR	H
Bell Ringer	R	R	MR				HR	MR	MH
Blazer		R	R				MS	R	MH
Challenger		R	MR				R	R	MH
Cimarron	MS	HR	HR	MR			HR	MR	MH
Classic		HR					..	..	H
Conquer		R		S			MR	MR	MH
DK 125	R	R	R				R	R	MH
DK 135	HR	R	R		HR		MR	MR	MH
Dart	R	HR	HR				R	HR	MH
Decathlon	MT	HT	T				MT	MT	MH
DeKalb Brand 120		HR	MR				MR	R	H
Drummor		R	MR				MR	R	H
Duke		HR	HR				MR	VHR	H
Eagle	MR	HR	R				R	MR	H
Edge	R	R					HR	R	MH
Elevation	MR	R	R				MR	MR	MH
Embro A-54		R		MR			..	..	H
Endure	R	R	R				MR	R	H
Epic		R	R				S	R	MH
Excalibur	R	R	HR				MR	MS	MH
Expo		R	R				MR	MS	MH

Variety	Verticillium wilt	Bacterial wilt	Fusarium wilt	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness[a]
Funk's G-2815		R					MR	MS	MH
Funk's G-2818		HR	R				MS	R	H
Funk's G-2841	R	R					R	R	
Funk's G-2852	R	HR	R				HR	R	MH
Funk's G-7730		HR	R				MS	HR	H
Garst 624	S	MR	MR				MR	MR	H
Garst 629	MR	MR	R				MR	MR	MH
Garst 630	MR	HR	R				MR	MR	
Garst 636	R	HR	R				MR	R	MH
Garst 655	S	R	MR				MR	MS	
Hi-phy		R						R	H
Honeoye		MR							MH
Husky		R	R				R	MR	MH
Jubilee		R	R				R	R	MH
Magnum		HR					MR	T	MH
Magnum III	R	R	R				MR	R	MH
Magnum +	MS	R					MR	R	MH
Mercury		R	HR				MR	HR	H
Milkmaker		R	HR				MR	MR	MH
Mohawk		HR					HR		MH
Oneida		R						R	H
Oneida VR	R	R					S	MR	MH
Peak	MS	R					MS	R	H
Perry		R					T	S	MH
Pioneer Brand 526	S	HR	MR				MS	MS	VH
Pioneer Brand 5432	R	HR	HR				S	MR	H
Pride Polar II		R						R	H
Pride Preserve	S	R	R	R			MR	MR	MH
Raidor		R	MS				R		MH
Riley	S	HR					HR	S	MH
Salute		HR					MR	R	MH
Saranac	S	MR	S					S	H
Saranac AR	S	MR		MR	MS	MS	R	S	H
Shenandoah		R	R	MR		MR	R	R	MH
Surpass	R	R	R				MR	R	H
Target	MR	R	R				MR	R	MH
Thorobred		R						R	H
Thunder		HR	HR				MR	R	MH
Top Gun	R	R	R				R	R	MH
Total	MS	R	R	T			MR	R	MH
Trident	MS	MR	HR				MR	HR	LH
Trumpetor	MR	MR	R	MR			R		H
Vancor		R	MR				R	MR	H
Vernal	S	R		MS	MS	MS	S	S	H
Vernema	MR	MR					MS	MS	MH
Voris		HR	MR				MS	MR	H
Voris VA-77		HR					HR	MS	H
WA-1		HR	HR					MR	MH
WA-2	MR	HR	R				MR	R	MH
WL-221		R	MR	R	R		MR		H
WL-225	R	HR	R				MR	HR	H
WL-315		HR	HR				MR	MR	MH
WL-316	R	MR	R				R	MS	MH
WL-320	MR	R	R				MR	R	MH
Wrangler	MS	R	R				MS	HR	H

NOTE: In the table, average disease reaction is indicated as follows: HR = highly resistant; R = resistant; MR = moderately resistant; HT = highly tolerant; MT = moderately tolerant; T = tolerant; MS = moderately susceptible; S = susceptible; and blank = no information.

[a] Winter hardiness is based primarily on autumn growth ratings: VH = very hardy; H = hardy; MH = moderately hardy; LH = low winter hardiness.

1989 Disease Management Guide for Commercial Vegetable Growers

THE SUCCESSFUL CONTROL OF VEGETABLE DISEASES requires an integrated program that includes the use of resistant varieties, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture as well as the proper selection and timing and method of application of fungicides, bactericides, or nematicides. Economical control depends on establishing an overall disease management system for the entire farm. Keeping careful records of the crops that have been planted, the problems encountered, and the pesticides used is important.

The information in this circular is updated annually. The grower should also consult the current versions of Circular 897, *Insect Pest Management Guide: Commerical Vegetable Crops and Greenhouse Vegetables,* and Circular 907, *Weed Management Guide for Commercial Vegetable Growers,* as well as Circular 1174, *Vegetable Varieties for Commercial Growers,* which contain information on disease resistance. Those circulars are revised each year.

Because many disease problems originate with seeds or transplants, growers should follow the seed treatment recommendations given in this circular and in Report on Plant Diseases No. 915, *Vegetable Seed Treatment,* or be sure to obtain planting material that is certified as disease free.

This publication presents the vegetable fungicide tolerances and application intervals for various crops as approved by the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA) as of September 1, 1988. The tables on the next two pages give the number of days between the last application at the normal rate and the harvest as well as other restrictions that will keep residues within the tolerances set by the FDA. Refer to current labels for information on rates, timing, and methods of application, as well as for information on followup crops and other restrictions.

The listing of a chemical as approved for use on a particular crop does not mean that the Illinois Cooperative Extension Service or Agricultural Experiment Station recommends the use of the chemical for that crop. Our specific recommendations for disease control are given in the table entitled "Condensed Recommendations on Disease Management . . ."

In some instances a tolerance has been set, but a definite interval has not been established. The absence of an interval for a particular crop in the listings does not necessarily mean that the fungicide may not be used on that crop. To ensure that the crop produced does not exceed the tolerance, the use of the fungicide would require a restriction such as "do not apply after first blooms appear" or "do not apply after edible parts form." This information appears on the product label.

In a few cases the interval and dosage have been established, but the allowable residue concentration has not been determined. Again, this does not mean that the fungicide may not be used on the crops for which it is labeled. It does mean, however, that until the tolerance is established, it must be considered as zero. These cases are reviewed each year, and some are cancelled when the chemical manufacturer supplies the EPA with additional data.

Growers must follow a program of disease control that will assure that the vegetables produced do not contain excessive fungicide residues. Vegetables marketed with residues exceeding the FDA tolerances may be injurious to consumers, may be confiscated, and may cause the grower to be brought to court.

Growers have nothing to fear from the law as long as they use fungicides and other pesticides according to the current label and only on the crops specified, in the amounts specified, and at the time specified. The prudent grower keeps a record of the products and trade names used, the percentage of active ingredients, dilutions, rates of application per acre, and dates of application.

This circular is revised each year. Be sure you are using the most recent copy.

Prepared by D.M. Eastburn, M.C. Shurtleff, and R.E. Wagner, Department of Plant Pathology

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE

Urbana, Illinois Circular 1184 (revised annually) October 1988

LIMITATIONS ON DAYS BETWEEN APPLICATION AND HARVEST AND OTHER RESTRICTIONS WHEN USING FUNGICIDES ON VEGETABLES IN ILLINOIS

Crop	Benlate[a]	Captan (D)	Bravo[b]	Dyrene	maneb + zinc salt[c]	mancozeb[d]	Botran[f]
Asparagus	..	root dip	..	..	A	A; root dip	..
Beans (dry, lima, snap)	14, 28 on lima, B	pp, B	7, (snap only) B; 42, (lima, dry)	..	4, B	..	2, B
Beet, garden	..	pp	..	..	..	..	..
Broccoli	..	pp	0	..	7, or trim and wash, 3	..	..
Brussels sprout	..	pp	0	..	0	..	..
Cabbage	..	pp	0	..	7	..	..
Cantaloupe (muskmelon and honeydew melon)	0	0, ph, pp	0	..	5	5	..
Carrot	4	0	0	..	0	7, B (tops)	ph
Cauliflower	..	pp	0	..	0	..	..
Celery	7	0, pb	7	0	14, strip and wash	14	..
Chinese cabbage	..	..	..	..	..	..	..
Corn, sweet and pop	..	..	14, B[e]	..	0, B	7, B	..
Cucumber	0	0, ph, pp	0	..	5	5	0
Eggplant	..	0, pb	..	..	0	..	..
Endive, escarole	..	..	..	..	10, and wash	..	14
Fennel	..	..	..	..	..	7	..
Garlic	..	..	7	0	..	..	pp, ph
Kale, collard	..	pp	..	..	10, and wash	..	..
Kohlrabi	..	pp	14	..	0	..	..
Leek	..	..	..	..	..	..	..
Lettuce	..	..	..	..	10, strip and wash	..	14
Mustard greens	..	pp	..	..	10, and wash	..	..
Onion	..	0, ph	green, 14; dry, 7	0	0	7, D, pb	pp, ph
Parsley	..	..	..	..	..	..	..
Parsnip	..	..	..	..	..	..	..
Peas	..	pp	..	..	..	..	..
Pepper	..	0, pb, pp	..	..	0	..	..
Potato, Irish	..	ph	0	0	0, C	0	14, B
Pumpkin	0	0, pp	0	..	0	..	..
Radish	..	..	..	..	..	..	..
Shallots	..	..	14	..	..	..	..
Spinach	..	0, pp	..	..	10, and wash	..	..
Squash	0	0, pp	0	..	5	5	..
Tomato	0	0	0	0	5, F	5	0
Turnip, rutabaga	..	..	..	..	10, and wash	..	..
Watermelon	0	0, pp	0	..	5	5	..

NOTE: Numbers in the table indicate number of days between last application and harvest; 0 = up to harvest. Dots in a column indicate that the fungicide is not registered for use on that particular vegetable. Other abbreviations used in the table are as follows:

A = Postharvest application to ferns only or to young plantings that will not be harvested.
B = Do not feed treated tops or forage to livestock.
C = Do not use treated seed or seed pieces for feed or food.
D = Do not apply to exposed bulbs.
F = To avoid damage, do not use on tender young plants.
pb = Plant bed treatment.
ph = Postharvest spray or dip.
pp = Preplant soil treatment.

[a] Do not apply Benlate alone; always use in combination with mancozeb or other labelled protective fungicide such as Captan, Bravo, Dyrene, or maneb. Do not mix with Mertect or Topsin-M.
[b] Chlorothanonil is sold as Bravo 75WP, 500, 720, and 90DG. It is also sold in combination with metalaxyl as Ridomil/Bravo 81W and with copper and maneb as Bravo C/M.
[c] Maneb with zinc salt is sold as Dithane M22 Special, Maneb Plus, Maneb 4L Plus, and Manex Maneb F.
[d] Mancozeb is sold as Dithane M-45, Manzate 200, Manzate 200 Flowable, Dithane F-45, and Pencozeb.
[e] Do not apply if the crop will be used for processing.
[f] Dichloran is sold as Botran 75W.

LABEL INFORMATION ON FUNGICIDES AND NEMATICIDES OF LESS GENERAL USE

Fungicide (tolerance)	Crops and use restrictions
Aldicarb (Temik 15G)	Nematodes, **Beans** (dry), **potato, sweet potato.**
carbofuran (Furadan 15G)	**Corn** (sweet and pop) — Nematodes. Apply in band or furrow at planting. **Cucumber, melons, squash, pumpkin** — incorporate into top 3 inches of soil.
Copper fungicides[b] tribasic copper sulfate (many trade names)	**Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, pepper, potato, pumpkin, radish, spinach, squash, tomato, watermelon.**
copper sulfate (many)	**Beans, broccoli, cabbage, cantaloupe, cassaba melon, cauliflower, celery, cucumber, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, watermelon.**
copper ammonium carbonate (Copper-Count N)	**Beans, cabbage, cantaloupe, carrot, cassaba melon, celery, crenshaw melon, cucumber, honeydew melon, lettuce, muskmelon, pepper, Persian melon, potato, squash, tomato, watermelon.**
copper hydroxide (Champion, Kocide 101 and 606)	**Beans, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, lettuce, muskmelon, onion, pea, pepper, potato, pumpkin, squash, tomato, watermelon.**
copper oxychloride sulfate (COCS, Copro 50, CS-56, Coxysul)	**Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cassaba melon, cauliflower, celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.**
Bordeaux mixture (many trade names)	**Asparagus, beans, beets, broccoli, Brussels sprout, cabbage, carrot, cassaba melon, celery, collard, crenshaw melon, cress, cucumber, eggplant, honeydew melon, horseradish, kale, mustard, pepper, rape, rutabaga, spinach, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, turnip, watermelon.**
Dikar	**Cantaloupe, cucumber, melon, summer squash** — 7 days[a].
dinocap (Karathane)	**Cantaloupe (muskmelon), cucumber, honeydew melon, pumpkin, squash, watermelon** — 7 days[a]. For control of powdery mildew only.
etridiazole (Terrazole, Truban)	Seed treatment: **Beans, peas.**
ethoprop (Mocap)	Nematodes. **Beans, cabbage, corn, cucumber, potato, sweet potato.**
fenamiphos (Nemacur 15G)	Nematodes. **Brussels sprout, cabbage, garlic,** and **okra.**
Iprodione[d] (Rovral)	**Beans**[c] — Sclerotinia. **Broccoli** — blackleg. **Carrot** — Alternaria and Cercospora leaf spots, no more than 8 applications. **Garlic** — white rot. **Head lettuce** — lettuce drop and bottom rot, no more than 3 treatments, 14 days[a]. **Onion** (dry) — Botrytis and Alternaria purple blotch, 7 days[a]. Root crops, cereal grains, soybeans, and tomatoes may be planted the next year. Garlic and leafy vegetables may be planted following treated lettuce.
metalaxyl (Apron 25WP)	Seed treatment for control of Pythium and Phytophthora damping-off and root rot on **beans, beets, dill, pea, lentils, okra,** and **edible soybeans.**
(Ridomil 2E)	*Bedding plants* to control Pythium damping-off — **Broccoli, cabbage, cauliflower, cucumber, lettuce, melons, spinach,** and **squash.** Apply 2-4 pints per acre as preplant broadcast in 50 gal. of water (1-2 fl. oz. or 2-4 tablespoons per 150 sq. yd. of bed in 2 gal. of water) before or at the time of seeding to the surface of the beds and lightly incorporate or follow with one-half inch sprinkler irrigation water.
	(Field use). **Asparagus** — Phytophthora crown and spear rot. **Beans** (all), **lentils, pea, soybeans** (edible). Pythium damping-off and root rot when used at 1 pint per 13,000 linear feet of row, either in furrow or in a 7-inch band at planting. **Broccoli, cabbage, cauliflower** — Pythium damping-off and Phytophthora basal stem rot. Applications may be broadcast using 4 pints per acre, applied at planting in 20-50 gal. of water, or at 4-8 pints per acre, incorporated into the upper 2 inches. Seven-inch band applications at 2 pints per 13,000 linear feet of row are also labeled. **Cucumbers, melons, squash** — Pythium damping-off and cottony leak. Applications can be in a 7-inch band over the row at planting or at 4-8 pints per acre broadcast, using 20-50 gal. of water. Broadcast applications may be incorporated to the 2-inch depth. **Onions, leafy vegetables, lettuce** (head), **spinach.** Pythium damping-off. Apply either broadcast or banded at planting. Follow label directions. **Pepper, eggplant** — Pythium damping-off, Phytophthora crown rot, 7 days[a]. **Tomatoes** — Pythium damping-off. Apply either broadcast or banded immediately before or after planting in 20-50 gal. of water. Pythium and Phytophthora fruit and root rots. Apply as soil surface spray under vines 4-12 weeks before harvest. Incorporate with irrigation.
Ridomil/ Bravo 81	**Broccoli, cabbage, cauliflower** — downy mildew and Alternaria leaf spot, 7 days[a]; **Cucumber, melons, squash** — downy mildew, anthracnose, Cercospora leaf spot, gummy stem blight, leaf blight and scab; **Onions**[d] (dry bulb, seed and green) — downy mildew, Botrytis leaf blight (blast) and purple blotch, dry — 7 days and green — 21 days[a]; **potato** — late blight, tuber and storage rots (Pythium or Phytophthora), early blight and Botrytis vine rot, 7 days[a]; **Tomato** — late blight, early blight, anthracnose, and gray leaf spot.
Ridomil MZ58	**Cucumber, melons, squash** — 5 days, no more than 20 lb/A/yr. **Onion** — 7 days, no more than 12.5 lb/A/yr. **Potato** — 7 days, no more than 22.5 lb/A/yr. **Tomato** — 5 days. Use only where downy mildew or late blight problems exist.
Subdue	*Bedding vegetables* (**broccoli, cabbage, cauliflower, cucumber, lettuce, melon, spinach, squash, tomato**) — Pythium damping-off. Do not use for greenhouse-grown plants.
metiram (Polyram)	**Asparagus** — rust; **cantaloupe,** and **cucumber** — Alternaria leaf blight, downy mildew, gummy stem blight, 5 days[a]; **potato** — early blight and late blight, 0 days.
oxamyl (Vydate L)	**Carrots, eggplant, pepper, potato, sweet potato, vine crops** — Nematodes. Apply before or at planting. Apply in transplant water for pepper or as foliar spray for peppers and vine crops — 7 days.
PCNB (Terraclor)	**Beans** — base of plants *before* blossoming, soil and seed treatment at planting, or foliar spray. Do *not* feed treated **Bean** vines to livestock. Do *not* apply after first bloom. **Broccoli, Brussels sprout, cabbage, cauliflower** — transplant solution (¾ pint per plant) or row treatment before transplanting. **Pepper, potato, tomato** — soil treatment at or before planting. **Tomato** (greenhouse) — transplant solution (½ pt. of 0.2% per plant). **Garlic** — soil and seed treatment at planting.
streptomycin (Agri-Strep, Agrimycin 17, Streptomycin 17)	**Pepper, tomato** — plant beds only (200 ppm spray); **potato** — seedpiece treatment only (100 ppm dip or dust). Soak cut seed pieces less than 30 min. Do not use treated seed for food or feed.
sulfur	Exempt when used with good agricultural practices. See label.

[a] Number of days between last application and harvest.
[b] There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.
[c] Do not feed treated tops or forage to livestock.
[d] Phytotoxicity to crop or followup crop. See label.

LABEL INFORMATION ON FUNGICIDES AND NEMATICIDES (continued)

Fungicide (tolerance)	Crops and use restrictions
terbufos (Counter 15G)	**Corn** (sweet and pop) — apply in band or furrow at planting.
thiabendazole (Mertect 340F)	**Beans** — white mold, 28 days[a]. **Carrot** — storage rot control. **Sweet potato** — "seed" root treatment. Do not use treated pieces for food or feed. **Potato** — seedpiece treatment and storage rot control.
thiophanate methyl (Topsin-M, Topsin M4.5F)	**Beans** — white mold and gray mold. Snap or dry beans, 14 days; lima, 28 days. **Celery** — early and late blight, 7 days.
(TOPS 2.5D)	**Potato** — seedpiece treatment.
thiram, TMTD	**Onion** — furrow treatment. **Celery** — 7 days (strip, trim, and wash). **Sweet potato** — preplant root dip. **Tomato** — 0 days, for leaf spots and fruit rots. Seed treatment: **Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, collard, corn, cucumber, eggplant, endive, kale, kohlrabi, lettuce, lentils, mustard, okra, onion** (bulb, seed, and set), **pea, pepper, pumpkin, radish, spinach, squash, Swiss chard, tomato, turnip, watermelon.** WARNING: Do not use treated seed for food, feed, or oil — 7 days.
triadimefon (Bayleton, 50% WP)	All **Cucurbits** — powdery mildew. May apply a maximum of 1 lb./A/yr.
triphenyltin (Du-Ter, Super-Tin 4L)	**Carrot** — Alternaria leaf spot and late blight — 14 days. **Potato** — early and late blight, 7 days[a]. May be applied through irrigation systems (solid set or center pivot only).
vinclozolin (Ronalin)	**Lettuce** (head or leaf). Sclerotinia drop — 28 days[a]. No more than 3 treatments. **Onion** (dry) — white rot, Botrytis blight, neck rot, 18 days[a].
Zineb	**Broccoli, cabbage, cauliflower** — 7 days[a], maximum of 6 lb./A/yr. **Cantaloupe, cucumber, eggplant, squash, tomato, watermelon** — maximum of 4 lb./A/yr. **Pepper** — maximum of 8 lb./A/yr.

[a] Number of days between last application and harvest.
[b] There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.
[c] Do not feed treated tops or forage to livestock.
[d] Phytotoxicity to crop or followup crop. See label.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT FOR DISEASES OF COMMERCIAL VEGETABLE CROPS FOR 1988

Vegetable	Disease management practices
Asparagus	
Crown or root rots, Seedling blights, and wilt	No resistant varieties are available for control of these diseases. Treating the crowns with captan or mancozeb may aid in control. Phytophthora can be controlled using Ridomil 2E applied over the bed. These diseases are best managed by good asparagus culture. Provide optimal soil fertility, and weed, insect, and rust control. Avoid excessive cutting. Avoid acidic (low pH) and poorly drained soils.
Rust, Cercospora and other leaf and branchlet blights	Grow rust-resistant varieties. Apply maneb, mancozeb, or Polyram to nonharvested fields up to August 15 and to harvested fields after harvest only. Applications should be made at 7- to 10-day intervals. Control is needed in 1- and 2-year beds, even with resistant varieties.
Beans (snap, dry, wax, and lima)	
Most diseases	When possible, use rotations of 2-3 years or longer between bean crops. Strict sanitation.
Seed decay, damping-off, seed-borne stem blights, and root rots	Plant only western-grown, certified seed in a seed bed that is warm (60°-65° F), well-prepared and well-drained. Treat seed with Apron 25WP plus thiram or captan and an insecticide. In-furrow sprays of Ridomil 2E or seed treatment with Apron 25WP may be helpful for early season root-rot control. PCNB can be used to help control Rhizoctonia.
Root rots	Pythium root rot can be controlled using Ridomil 2E as a band or furrow treatment at planting. Maintain optimal soil fertility. Utilize rotations of at least 2-3 years with other crops.
Bacterial blights	Plant only western-grown, certified seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet. Field applications of 2-4 pounds of fixed copper (e.g., Kocide 101 or 606) per acre will provide good control of brown spot and halo blight, but only moderate control of common or fuscous blight. Do *not* use copper on fresh market lima beans.
Downy mildew	Make early and weekly applications of maneb or mancozeb plus fixed copper.
Rust, anthracnose, and other fungal leaf, pod, and stem diseases	Utilize crop rotations of 2-3 years. Apply maneb or Bravo at 7- to 10-day intervals starting when disease first appears. Rust-resistant varieties are available for some types of beans. Sulfur can also be used but may be phytotoxic at high temperatures.
White mold, gray mold	Apply Benlate, Botran, or Topsin-M first at initial to 25 percent bloom and again at full bloom. Botran may be used on snap beans only. Thorough coverage of all blossoms is essential.
Mosaic virus diseases	Plant varieties with resistance to bean common mosaic, NY15 strain of common mosaic, and bean yellow mosaic. Avoid planting near clovers, birdsfoot trefoil, gladiolus, etc.
Soybean cyst nematode	Rotate at least 2-3 years with corn, small grains, alfalfa, red clover, or other nonhost crop. Do *not* include soybeans in the rotation. Temik may be used on dry beans.
Root-knot and lesion nematodes	Apply Temik (dry beans only) or Mocap (snap or lima beans) at planting.
Beet (garden), Swiss chard	
Seed rot, damping-off, and seed-borne leaf spot	Sow in a well-prepared seed bed. Treat seed with captan, thiram, or Apron (for Pythium). Make sure boron levels are adequate. Several soluble-boron formulations are available.
Cercospora leaf spot	Apply fixed copper weekly at the first sign of disease. Separate new from old plantings.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Crucifer crops (broccoli, Brussels sprout, cauliflower, cabbage, Chinese cabbage, collard, kale, kohlrabi, mustard, radish, rutabaga)	
Seed rot, damping-off, black rot, blackleg, Alternaria leaf spot	Sow only western-grown, hot-water-treated seed. Seed also should be treated with thiram or captan. Place seed beds where no crucifer has grown for 4 years or more and where water will not drain from fields recently planted to crucifers. Ridomil 2E applied at planting time will control Pythium damping-off and Phytophthora basal stem rot.
Wirestem (*Rhizoctonia*)	Incorporate PCNB-captan in upper 3 inches of soil before planting or drench after planting.
Clubroot	Use only healthy transplants. Avoid soils with a history of clubroot. If clubroot is present, adjust soil pH to 7.2 with hydrated lime. Rotate out of cruciferous crops for 7 years. Apply PCNB (Terraclor 75WP) in transplant water; use ¾ pint per plant.
Black rot and blackleg	Use a crop rotation of 4 years or more. Use only hot-water-treated seed. Use care in the selection of plant bed sites. Be sure no drainage occurs to seed bed from old plantings. Control wild mustard and other cruciferous weeds. Purchase only certified, disease-free transplants. Do not dip transplants before planting. Sprays of fixed copper may help control black rot. Rovral can be used to control blackleg on broccoli. Bravo applied to control downy mildew may also help control blackleg. Some cabbage varieties resistant to black rot are available. Losses are generally lower where direct seeding is used.
Downy mildew, Alternaria leaf spot, and other fungal leaf diseases	Apply maneb, Bravo, Ridomil/Bravo 81W, or Zineb at weekly intervals. Start applications in seed bed or when plants are young. Rotate with noncruciferous crops and use disease-free seed or transplants.
Internal tipburn	Plant resistant varieties. Avoid overfertilizing, especially with nitrogen.
Fusarium yellows	Plant only yellows-resistant varieties.
Radish black root	Plant resistant varieties. Avoid planting radishes in severely infested soil.
Nematodes	Mocap (cabbage only) or Nemacur (Brussels sprout and cabbage only) may be applied at planting.
Carrots, Parsnips	
Seed rot, damping-off	Treat seed with captan or thiram. Plant in well-drained seed bed. Avoid overwatering.
Cercospora leaf spot, Alternaria leaf blight	Apply maneb, mancozeb, Rovral, Du-Ter, or Bravo on 7-10-day interval. Start when disease first threatens and repeat as needed.
White mold	Apply Benlate at 7- to 10-day intervals. Use a crop rotation of 3-4 years.
Aster yellows	Use insecticides to control leafhoppers that transmit the mycoplasma. Excellent early season leafhopper control is essential. Control must occur *before* leafhoppers feed.
Root-knot nematode	Fumigate mineral soils with Telone II, Vapam, or Vorlex, *or* practice a 3-year rotation with corn or other nonhost crops. Control broadleaf weed hosts. Vydate L may be applied at planting (carrot only).
Parsnip canker, leaf spot, mildew	Spray with fixed copper 3 times at 10-day intervals at first sign of disease. Ridge soil over the shoulders to prevent canker infections.
Celery, Parsley	
Seed rot, damping-off, and seed-borne leaf blights	Treat seed with hot water, then captan or thiram. If damping-off starts, spray 2-3 times, 5-7 days apart with Bravo, mancozeb or fixed copper. Seed 2-3 years old is free of late blight.
Leaf blights and spots (celery only)	Spray maneb, Benlate, Topsin-M, Dyrene, Bravo, or mancozeb at 7-10-day intervals.
Aster yellows and Root-knot nematode	(See the section on Carrots and Parsnips)
Corn (sweet and pop)	
Seed rot, seedling blights, and seed-borne diseases	Plant seed treated with captan or thiram plus an insecticide. Plant shallow in warm, well-drained soil.
Goss' bacterial wilt	Use 2- to 3-year crop rotations when using susceptible corn (dent or sweet) varieties.
Stewart's disease	Control corn flea beetles on young plants with an insecticide, or plant tolerant varieties.
Smut	Plant tolerant varieties. Control corn borers as first tassels appear.
Maize dwarf mosaic, chlorotic dwarf, and wheat streak mosaic	Control johnsongrass and volunteer wheat. Plant wheat after the fly-free date. Some varieties tolerate maize dwarf better than others, but none are highly resistant.
"Helminthosporium" leaf blights, and anthracnose leaf blight	Spray mancozeb, maneb, or Bravo when disease first appears. Crop rotation and clean tillage will help reduce disease risk.
Rusts	Spray as for "Helminthosporium" blights or plant resistant varieties.
Nematodes	Apply Furadan, Counter, or Mocap (sweet corn only) at planting time.
Cucurbits (cucumber, muskmelon or cantaloupe, pumpkin, squash, and watermelon)	
General	Use a crop rotation of 3-4 years. Grow resistant varieties whenever possible.
Seed rot, damping-off, seed-borne diseases	Plant only certified, western-grown seed treated with captan or thiram. Damping-off can be treated with a captan or Ridomil 2E seed-bed drench. Plant shallow in warm soil.
Bacterial wilt	Provide season-long control of striped and spotted cucumber beetles. Start as the plants begin to emerge. Planting-time treatment with Furadan will provide moderate control for 3-4 weeks. Supplemental insecticide use will be necessary.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Cucurbits (cont.)	
Anthracnose, scab, blossom blights, and gummy stem blight, or black rot	Grow resistant varieties when possible. Spray weekly with maneb, mancozeb, Bravo, Benlate, or Ridomil/Bravo 81W. Start when vines begin to run. Store only blemish-free fruit.
Downy mildew, Alternaria leaf blight	Grow resistant varieties when possible. Maintain ample but *not* excessive nitrogen fertility. Apply maneb, mancozeb, or Bravo on a weekly schedule. Ridomil/Bravo 81W provides excellent control of downy mildew. Practice a 2-3 year rotation.
Fruit spots and rots	Maintain fungicide schedule as for anthracnose throughout the season. Avoid harvest injuries.
Fusarium wilt	Grow only resistant varieties.
Angular leaf spot	Apply fixed copper sprays in combination with Bravo, maneb, or mancozeb. Start applications early in the season. Practice crop rotations of 3-4 years. Resistant cucumber varieties are available.
Powdery mildew	Apply Bayleton or Karathane WD at the first sign of disease and again 10 days later for Karathane (10-14 days later for Bayleton). Where Benlate or Bravo is applied to control other diseases, mildew will be controlled under moderate disease pressure. Plant resistant varieties where possible. Karathane can cause injury at high temperatures.
Mosaic viruses	Control aphids and beetles in the field. Eliminate broadleaf weeds around field borders before plant establishment. Plant only mosaic-resistant cucumbers.
Root-knot nematode	Fumigate with Vapam, Telone C-17, Telone II, or Vorlex in the fall before planting or use Furadan or Vydate L at planting.
Eggplant	
Seed rot, damping-off, and seed-borne diseases	Plant hot-water-treated seed when possible. Treat the seed with captan or thiram. Damping-off can be controlled with a captan drench (1 gal./20 sq. ft. of bed surface). Ridomil can be used for Pythium damping-off.
Phomopsis blight, Alternaria leaf spot, Cercospora leaf spot, and anthracnose	Spray plants weekly with maneb at first sign of disease or when first fruits are half sized. Follow good sanitary practices. Use a crop rotation of 2-3 years. Avoid bruising fruit; handle carefully at all times.
Verticillium wilt, nematodes	Fumigate the soil with Vapam, Vorlex, or methyl bromide plus chloropicrin. Planting under a black plastic mulch will help reduce disease severity. Vydate L will control nematodes.
Horseradish	
Leaf spots, white rust	Apply fixed-copper fungicides. Start when conditions are wet or dews are heavy. Continue until a killing frost occurs. Practice a 2-year field rotation with any other crop.
Brittleroot	Plant clean sets. Control leafhoppers that spread the disease agent.
Verticillium wilt, nematodes	Fumigate the soil before planting with Telone C-17.
Lettuce, Endive, Escarole	
Seed rot, damping-off, Gray mold	Treat seed with captan or thiram. In the field or seed bed, work Botran into the soil before planting and spray Botran 7 days after transplanting. Repeat when plants are 50% mature. Ridomil 2E as a soil application at seeding controls Pythium damping off.
Aster yellows, mosaic viruses	Control leafhoppers and aphids throughout the season. Early season control is most important.
Rhizoctonia bottom rot, Sclerotinia drop, gray mold	Plant on raised beds and deep plow when possible. Apply Rovral or Ronalin at 3-leaf stage and again 10 and 20 days later. Botran applications as previously described may help. Use 100 gallons of water carrier per acre.
Gray mold, white rust, anthracnose, and downy mildew	Apply maneb at 7- to 10-day intervals under average conditions or 3-5 days if severe. Remove residues by stripping and washing. Botran can also be used.
Nematodes	Apply Telone C-17, Telone II, Vapam, or Vorlex in the field in the fall before planting. In greenhouses, steaming the soil will provide control.
Okra	
Seed rot, damping-off	Treat seed with captan or thiram plus Apron 25WP. Plant in warm, well-drained soil.
Fusarium and Verticillium wilts	Fumigate soil with Vorlex, Vapam, or methyl bromide plus chloropicrin.
Onions, garlic, leek, chives, shallot	
Smut, seed rot, damping-off	Treat the seed with captan or thiram. Use Methocel sticker to pellet the seed with fungicide. Use 1⅓ pounds of active ingredient to 20 pounds of seed for set onions; 6 pounds of active ingredient to 8 pounds of seed for bulb onions. Mancozeb or Ridomil can be used as an in-furrow drench at planting.
Blast, downy mildew, Alternaria purple blotch, Botrytis neck rot	Apply maneb, mancozeb, Dyrene, Rovral, or Bravo on a weekly schedule. Begin spraying with first ozone alert. Continue until harvest. Bravo has given superior control. Use Ridomil MZ58 or Ridomil/Bravo 81W when downy mildew appears.
Bulb and stem nematode, root-knot nematode	Fumigate with Telone II, Telone C-15, D-D, Vapam, or Vorlex. Eradicate volunteer plants from fields with a history of bulb and stem nematode.
White rot of garlic	Apply Rovral on cloves and in furrow covering soil. Plant disease-free cloves in well-drained soil.
Fusarium basal rot	Avoid heavily infested fields. Grow resistant varieties. Cure bulbs rapidly and properly.
Storage decays	Maintain excellent control of leaf diseases in the field. Maintain dry storage conditions.
Yellow dwarf	Control aphids. Keep old and new plantings as far apart as possible. Destroy volunteer onions.
Peas	
Seed rot, seedling and seed-borne diseases	Plant western-grown seed treated with captan or thiram and Apron 25WP plus an insecticide. Graphite at 1 ounce per bushel may be added to reduce friction in the drill.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Peas (cont.)	
Root rots	Index production fields. Avoid planting in fields with an index of 75 or higher. In fields with a lower root rot index, apply dinoseb (Premerge 3) or trifluralin preplant incorporated. Ridomil 2E in the seed furrow gives good Pythium damping-off and root rot control.
Fusarium wilt and near wilt, virus diseases	Grow resistant varieties. Viruses are spread by aphids. Plant as early as possible in well-fertilized and well-drained soil. Rotate 4 years or more.
Powdery mildew	Apply sulfur dust or spray when mildew first appears and temperatures are less than 80°F. Two applications a week apart provide good control. Plant resistant varieties.
Peppers	
Seed rot, damping-off, and seed-borne diseases	Use only western-grown seed and treat with hot water or a household bleach (Clorox) soak. The bleach soak controls seed-borne bacterial spot. Use 1 part bleach to 3 parts water, soak 1 minute. Use 1 gallon of fresh bleach-water solution to 1 pound of seed. Rinse thoroughly before treating with captan or thiram seed protectant. Ridomil can be used to control Pythium damping-off.
Bacterial spot	Use crop rotations of 2-3 years, excluding small grains and tomatoes. Control broadleaf weeds in and around field borders. Apply fixed copper plus streptomycin (200 ppm) to seedlings. After transplanting, apply fixed copper plus maneb on a 5- to 7-day interval. Purchase only certified, disease-free transplants. Planting peppers in narrow strips between early planted corn may help reduce spread during severe rain and wind storms. Maintain a high balanced level of soil fertility.
Phytophthora crown rot	Plant on raised beds in well-drained soil. Treat soil with Ridomil 2E. Rotate to non-solanacious crops for 3-4 years.
Anthracnose, Cercospora leaf spot, other fungal leaf spots, and fruit rots	Apply maneb on a 5- to 7-day interval when disease appears or after first fruits form. Use disease-free seed. Practice 3-year crop rotation. Burn or plow down crop refuse after harvest.
Nematodes	Add Vydate L to transplant water and supplement with foliar applications. Follow label directions.
Verticillium wilt	Fumigate soil with Vapam, Vorlex, or methyl bromide plus chloropicrin.
Virus diseases	Grow resistant varieties. Control aphids that transmit viruses. Eliminate broadleaf weeds within 150 ft. of fields before crop is established. Plant only healthy transplants.
Potatoes (Irish)	
General	Purchase only certified seed. Seed-production fields should be inspected for virus, nematode, or fungal disease problems. Good sanitation and seed-handling practices will reduce losses.
Seedpiece decay, seed-borne diseases, Verticillium wilt, and blackleg	Treat seed with captan, maneb, mancozeb, or TOPS 2.5D. Keep seed storage at approximately 40°F during the winter. In the spring, warm the seed to 65°-70°F for 2-3 weeks before cutting. Streptomycin may be added to fungicide dusts to improve the control of bacterial diseases. Avoid bruising seed during handling.
Scab	Plant resistant varieties. Do *not* apply manure or other organic matter immediately before the potato crop. Maintain acidic soil.
Storage rots	Store healthy, sound, unbruised mature potatoes. Maintain a proper storage environment. Apply Mertect 340-F as a spray to unwashed tubers before storage. It helps control Fusarium dry rot.
Rhizoctonia	Use a Terraclor 2 EC soil treatment. Practice a 3-year rotation. Plant shallow.
Verticillium wilt	Practice crop rotation, use only seed free of Verticillium. Control root-knot and root-lesion nematodes. Soil fumigation with Vapam or Vorlex may be practical.
Nematodes	Where soil samples indicate damaging levels of nematodes, apply Temik or Vydate L, or fumigate with Vapam, Vorlex, D-D, or Telone C-17.
Early blight and late blight, leak, pink rot	Apply maneb, mancozeb, Bravo, Polyram, Du-Ter, Super-Tin, or Dyrene on 7- to 10-day schedule. Maintain an adequate supply of nitrogen throughout the season to provide good control of early blight. Use Ridomil MZ58, or Ridomil/Bravo 81W only where late blight, leak, and pink rot are a threat. Avoid bruising tubers, especially in hot weather.
Virus diseases and purple-top wilt (Aster yellows)	Plant only certified seed. Control aphids and leafhoppers with insecticides. Practice clean cultivation. Rogue first infected plants including tubers.
Rhubarb (greenhouse only)	
Botrytis leaf rot	Apply Botran (3 days to harvest) or fixed copper after budding and at weekly intervals.
Crown and root rots	Plant only in well-drained soil. Maintain optimal soil fertility. Drench the crowns with fixed copper at 3 pounds per acre in the early spring and after harvest if crown rot is a problem.
Spinach	
Seed rot and damping-off	Treat seed with captan or thiram. Apply Ridomil 2E for Pythium damping-off.
Downy mildew or blue mold, white rust, anthracnose, and other fungal leaf diseases	Grow downy mildew-resistant varieties or spray with maneb on a 5- to 7-day schedule starting before the plants begin to rosette. A soil application of Ridomil 2E (2-4 pts./treated acre) at planting in 50 gal. water controls blue mold and white rust for about 60 days.
Cucumber mosaic virus or blight	Grow tolerant varieties. Control aphids that spread the virus.
Sweet potatoes	
Black rot, foot rot, Fusarium wilt and scurf	Grow resistant varieties. Use clean soil in plant beds and maintain temperature of 80° to 85°F. Plant disease-free roots and use crop rotations of 3-4 years. Dip the roots or sprouts in Botran, Mertect 340-F, or thiram.
Storage rots	Fumigate storage crates and houses with formaldehyde. Use Botran as a postharvest dip. Cure and store only healthy, blemish-free roots.
Nematodes	Plant resistant varieties. Practice crop rotation. Temik, Mocap, Vydate L, or Dasanit (suppression only) may be used for chemical control; or fall fumigate with Vapam or Vorlex.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Tomatoes (field)	
Seed decay, damping-off, and seed-borne diseases	Plant hot-water- or household bleach-soaked seed that has been treated with captan or thiram. See treatment for pepper seed. Use Ridomil 2E drench for Pythium damping-off in the seed bed.
Bacterial spot, speck, and canker	Purchase only certified, disease-free plants. Use crop rotations of 3-4 years, excluding small grains. In the seed bed, spray with fixed copper plus streptomycin. After transplanting, spray with fixed copper plus mancozeb or Bravo C/M. Once established, bacterial spot and canker are difficult to control.
Septoria blight, early blight, anthracnose, buckeye rot, gray leaf spot, and leaf mold, gray mold, and white mold (*Sclerotinia*)	Apply maneb, mancozeb, Dyrene, or Bravo on a 7- to 10-day schedule after the first sign of disease or after the first fruits form. A soil surface spray of maneb after the last cultivation will improve anthracnose control. Benlate may be used for Botrytis, Septoria, white mold, and leaf mold control. Ridomil 2E or Ridomil/Bravo 81W helps control buckeye, Pythium fruit rots, and late blight.
Blossom-end rot	Mulch plants or maintain uniform soil moisture. Four weekly applications of calcium nitrate starting when the fruits are grape size may reduce losses. Avoid cultivation close to plants.
Verticillium wilt and Fusarium wilt	Grow only resistant (VF) varieties. Avoid soils with a history of wilt.
Viruses	Take care to avoid infecting the seedlings. Start with virus-free seed. Control insects and broad leaf weeds in and around fields. See greenhouse tomatoes below.
Nematodes	Plant root-knot-resistant varieties. Vydate L or Dasanit may be applied at planting. Fall fumigation with Vapam or Vorlex may also be used.
Tomatoes (greenhouse)	
Virus diseases	Start with hot-water-treated seed. Do not allow the use of tobacco on the premises. Smokers should wash their hands with soap and hot water before working with plants. If possible, plant TMV-resistant hybrids. Control insects. Remove first infected plants if possible.
Botrytis gray mold, leaf mold, gray leaf spot, and early blight	Avoid excessive humidity by heating and venting, especially at night during the fall, early winter, and early spring. Spray weekly with Benlate, mancozeb, or Bravo *or* fumigate with Exotherm Termil. Botran as a directed spray controls stem canker; cover stems up to 18-24 inches from ground.
Nematodes, root rots, and soil-borne TMV	Steam the plant beds. Plant resistant varieties whenever available.

GENERAL SUGGESTIONS ON FUNGICIDE APPLICATION

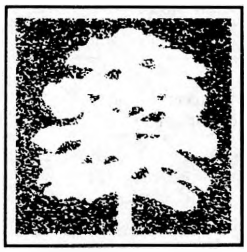
1. Cover the foliage uniformly. *Ground equipment* — Apply 75 to 125 gallons per acre at approximately 400 pounds per square inch of pressure. Lowering volumes and/or pressures may provide adequate coverage, but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom, height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application* — Apply recommended amounts of pesticide per acre in 3 to 5 gallons of water. Make sure nozzles are properly aligned and clean, so uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields that are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.
2. Whenever possible spray when the air is still or when wind velocity is not excessive (less than 10 mph).
3. Avoid situations where pesticide drift may cause needless problems.
4. When it is compatible with the product label, use a spray adjuvant (surfactant). Some commonly available surfactants are: Kalo: Bio 88, Bio-Film, and Regulaid (for systemic fungicides); Hopkins: Plyac; Rohm & Haas: Triton AG-98, B-1956, CS-7; Ortho: Chevron Spray Sticker, Chevron Spreader, X-77 Spreader; Miller: NuFilm P, NuFilm 17; DuPont: Spreader Sticker. Spray adjuvants are most useful on cabbage, cauliflower, Brussels sprout, onions, and peppers.

GENERAL SUGGESTIONS ON SOIL FUMIGATION

Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° to 60°F at the 6-inch depth, with a time lapse of 21-28 days between treating and seeding. Some require gas-tight plastic covers. Many fumigants are restricted-use chemicals.

GENERAL SUGGESTIONS FOR USE OF NEMATICIDES

Use nematicides only where soil analysis shows a nematode problem to be present. Follow soil sampling instructions in *Report on Plant Diseases* No. 1100, "Collecting and Submitting Soil Samples for Nematode Analysis." This publication is available for 50 cents from Extension Plant Pathology, N-533 Turner Hall, 1102 South Goodwin Ave., Urbana, IL 61801. Checks should be made out to the University of Illinois.



1989 Plant Disease Control Guide

WOODY ORNAMENTALS

Disease control programs for woody ornamental trees and shrubs should be based on a thorough knowledge of the diseases that are likely to appear and the plants that are susceptible to attack and on an early and accurate diagnosis of the problem. Control measures *must* start before or at the early onset of disease, but preferably before symptoms appear. Disease control programs should begin with the purchase of the best seed or planting materials available and continue until the plants are sold or discarded.

Traditionally, four fundamental principles apply to plant disease control. The four may be applied individually or concurrently for integrated control of infectious agents or pathogens. These principles are exclusion, eradication, immunization, and protection. All cultural and chemical practices that are used to keep plants from becoming diseased can be placed into one of these four categories.

Exclusion involves preventing the disease-causing organisms and agents from becoming established in or around susceptible plants. Exclusion is achieved through federal or state embargoes, quarantines, inspections, and disinfection of seeds, plants, cuttings, or other propagative plant parts. Other methods include certification of plants and cuttings before shipment and culture indexing of planting stock to ensure freedom from pathogens.

Eradication is the elimination of the disease-causing agent or pathogen after it has become established in or on a plant where it is growing or being stored. Eradication involves the removal and destruction of infected plant parts, diseased plants, infected debris, weeds, alternate hosts, and other overwintering host plants. It also involves seed or plant treatment with wet or dry heat or a systemic chemical such as a multipurpose soil fumigant; crop rotation; and cleaning and disinfesting potting benches, soil bins, greenhouse benches, nursery beds, storage areas, tools, and equipment.

Immunization involves growing resistant or immune species, varieties, or cultivars and treating the disease with a systemic chemical that internally kills, inactivates, or protects against infection. Unfortunately, there are no woody ornamental plants resistant or immune to all diseases. Much less time and effort has been put into developing disease-resistant trees and shrubs than into field crops, vegetables, and fruits.

Protection is the placing of a physical or chemical barrier between the susceptible part of the host plant and the disease agent or pathogen. Protection usually means uniform applications of recommended disease-control chemicals, including fungicides, bactericides, or nematicides, as dusts, sprays, or soil drenches. Chemicals should be applied to the plant or its propagative parts *before* the pathogen arrives.

Protective cultural practices include proper spacing of plants; time and depth of planting; proper soil reaction (pH); careful handling of plants and propagative parts during harvest, grading, and packing; proper lighting, temperature control, watering, fertilization, and pruning; and the alteration of the air and soil environment to make it unfavorable for the pathogen to infect, develop, reproduce, or spread during growth, storage, and shipment.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
COOPERATIVE EXTENSION SERVICE

COLLEGE OF AGRICULTURE
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To be successful, the right chemical must be applied at the right concentration, at the right time, and in the right way. Correctly applying the proper chemicals ensures an active and complete chemical barrier on the susceptible plant surface during the time when infection may occur. Several applications, spaced about 7 to 10 days apart for protective fungicides and 10 to 21 days or longer for systemic fungicides, are usually needed to keep expanding foliage, flowers, and fruits covered with a protective film.

Protection also includes the killing of insects, mites, and other inoculating agents before these pests can feed and infect plants with pathogens carried on or in their bodies. Some seed treatments, such as captan, thiram, and Apron, will protect against seed- and soilborne organisms.

To help in diagnosing the common diseases of woody ornamentals, an identification key is presented in Table 1. The symptoms in the key are divided into those that appear on the leaves; twigs, branches, and trunk; and on the roots.

The pesticides listed in Table 2 are presented by their common and trade names as much as possible. The percentage of active ingredients and formulation information are presented adjacent to these names. Various formulations of common fungicides such as Truban are available: wettable powders (WP), emulsifiable concentrates (EC), and granules (G). The fact that Truban 25% EC is cleared for use on Chamaedora palm, for example, does not mean that the 30% WP or the 5% G formulations are also legal to use on this species. Specific formulations differ in their percentages of active ingredient and therefore in efficacy and crop safety.

Some common fungicides such as zinc ion and maneb complex (mancozeb) are often available under several major trade names. For example, the labels of DuPont's Manzate 200 and Rohm & Haas's Dithane M-45 list the same percentages of active ingredient, yet Manzate 200 is legal to use on a number of ornamentals while Dithane M-45 is not. Rohm & Haas's Fore is the equivalent of Dithane M-45 for use on ornamentals. Always read and follow label directions and precautions. Use the product only on the plants listed on the label. It is illegal to do otherwise.

Watering

During the growing season, woody ornamentals should receive the equivalent of one inch of water each week as rainfall or supplemental irrigation. If irrigating, apply water in the morning on a rising temperature *not* during late afternoon or evening. Where possible use a soaker hose or feeding needle rather than overhead watering. Try to keep water off the foliage.

NOTE: The information in the following tables is for educational purposes only. Reference to commercial products or trade names does not constitute an endorsement by the University of Illinois and does not imply discrimination against other similar products. Trade names are presented for reasons of clarity only. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

Table 1. Disease Symptoms of Woody Ornamentals

General symptoms	Specific symptoms	Disease
LEAVES		
Small to large scattered spots in various sizes, shapes, and colors.	Roundish spots; may contain dark, speck-sized fungus fruiting bodies.	Fungus leaf spot
	Spots may have dark margins or drop out (shot-hole).	Spot anthracnose Scab Shot-hole
	Black, shiny spots.	Tar spot
	Irregular dead areas in leaves.	Leaf blight or blotch
	Variously colored "blisters"; leaves often partly or entirely puffy, thickened, or curled.	Leaf curl or blister
Leaves spotted or blighted; later covered with dusty mold growth.	Tan to gray, coarse mold.	Botrytis blight or gray-mold
	White to light gray mold, powdery to mealy.	Powdery mildew
	Black mold, sooty or crusty.	Sooty mold
	Yellow, orange, reddish-orange, reddish-brown, chocolate brown, or black mold in raised pustules.	Rust
Leaves mottled light and dark green or yellow.	Irregular mosaic pattern	Mosaic
	Yellow-green or reddish-brown rings, "oakleaf," "watermark," or line patterns.	Ringspot
Leaves wilt, wither, and die; may involve one or many branches or entire plant.	Discoloration in outer sapwood.	Wilt disease
	Foliage appears scorched by fire; twig tips curl downward to form "shepherd's crooks."	Fire blight

General symptoms	Specific symptoms	Disease
LEAVES, con't.	Other possible causes include: wood rot; black knot; drought or excess water; transplant shock; construction damage; change in soil grade; girdling roots; injury from insects, rodents, or other animals; pesticide or fertilizer damage; winter and frost injury; salt damage; lightning or fire injury; roots in septic tanks or sewer lines; or other mechanical injuries.	Miscellaneous diseases and injuries
Leaves "scorched" at margins and tips; often later between the veins.		Leaf scorch (See also Miscellaneous diseases and injuries above)
TWIGS, BRANCHES, AND TRUNKS		
Twigs and branches die back, usually starting at the tips; foliage commonly wilts, withers, and dies.	Discoloration in outer sapwood.	Wilt disease
	No discoloration in outer sapwood. (See Root Symptoms below.)	Root rot
	Foliage appears scorched by fire; twig tips curve downward.	Fire blight
	Sap flows down trunk and branches from wounds; becomes gray to white stain on bark.	Wetwood
	Definitely marked, often sunken, swollen, flattened, or targetlike areas (cankers) in bark and outer wood of twigs and branches.	Canker or dieback
	Wood in branches or trunk decays; bracket, shelf, or mushroom fungi may form on bark surface or trunk base.	Wood rot

General symptoms	Specific symptoms	Disease
TWIGS, BRANCHES, AND TRUNKS, con't.	Other possible causes include: injury from fertilizer, pesticide, or salt; drought or excess water; lightning or fire injury; transplant shock; winter injury; excess shade; construction damage; girdling roots; insect, rodent, or other animal injury; various types of mechanical damage; change in the soil grade; or chlorosis.	Miscellaneous diseases and injuries
Greatly swollen areas on twigs, branches, or trunk.	Galls on *Prunus* rough and black or olive green and velvety in spring.	Black knot
	Roundish or spindle-shaped galls on branches or trunk; often covered with yellowish to orange dusty masses in spring or early summer.	Rust gall
	Rough, roundish, tumorlike galls, usually at or near soil line or graft union.	Crown gall
	Large, irregular swellings anywhere on trunk or scaffold limbs of older trees.	Burr
Dense, brushy masses of stubby shoots form on branches.		Witches'-broom
ROOTS		
Trees lose vigor, growth slows, foliage off-color; tops (crowns) may wilt and die back.	Roundish, rough, tumorlike galls on roots, up to a foot or more in diameter.	Crown gall
	Roots decay; feeder roots die back; mold growth under bark or over roots; usually shoestringlike black strands are evident.	Root rot

General symptoms	Specific symptoms	Disease
ROOTS, con't.	Roots somewhat necrotic, lacking feeder roots; appear stunted or have small galls.	Nematodes (must be confirmed by soil or root analysis)
	Other possible causes include: excess water, change in soil grade, construction damage, injury from fertilizer or pesticide, girdling roots, winter injury, salt, insect or animal feeding, or wilt disease.	Miscellaneous diseases and injuries

Fertilization

Unthrifty and undernourished woody ornamentals are susceptible to a variety of diseases and environmental stresses. Their vigor can often be greatly improved by periodic applications of fertilizer and timely watering. Soil tests are always suggested prior to feeding, especially if a soil or lawn fertilization program has been in effect. In general, a 10-10-10 (NPK) fertilizer is recommended at the rate of 2 to 4 pounds per inch of trunk diameter at breast height. The fertilizer can be injected into holes in the ground evenly distributed beneath the tree and extending out to the drip line or beyond. Alternatively, apply fertilizer by surface broadcasting about 1 or 2 pounds of actual nitrogen per 1,000 square feet during the dormant season; ammonium nitrate or nitrate of soda are acceptable compounds.

Sanitation

Proper selection of planting site, planting method, and materials, as well as soil preparation, pruning, winter protection, disease and pest control, and avoidance of unnecessary wounding will aid in control of a wide range of diseases.

Prune during dry weather and sterilize tools frequently between cuts. Use a fresh 10 percent solution of liquid household bleach, 70 percent denatured alcohol, or radiator antifreeze-type alcohol or 4 percent formaldehyde. When pruning or removing diseased wood, paint the newly exposed inner bark and sapwood with a germicidal or fungicidal coating. Shellac is useful for many diseases. Follow the shellac with a tree wound paint containing benomyl (Benlate) fungicide, 50% WP, at the rate of 1 gram in 5,000 grams or 2-2/3 ounces per 100 gallons. This mixture, although harmless to living bark, is toxic to spores of such canker- and wilt-producing fungi as *Botryosphaeria*, *Ceratocystis*, *Cytospora* (*Valsa*), and *Verticillium*.

Surfactants

Wetting, spreading, and sticking agents (surfactants) are often added to spray mixtures for hard-to-wet foliage such as on conifers, broadleaf evergreens, boxwood, and roses. Some commercial spreader-stickers available for tank mixing include Biofilm Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film -P and -17, De-Pester Spreader-Activator, DuPont Spreader-Sticker, and Aqua T Non-ionic Organic Wetting Agent. Commercial spreaders include Chevron Spreader, Chipco and Rhodia Spreader-Activator, Flo-Wet, Multi-Film L and X-77, Ortho X-77 Spreader, Pinolene, Sure Spred, Surfactant II, Triton B-1956, Tween 20, Flexit, Sanomerse 80, and Penex. The fungicide label usually indicates any restrictions that should be observed in selecting compatible surfactants. Use these commercial preparations according to label directions. The addition of any extra wetting, spreading, or sticking agent may cause excess runoff and result in a poor spray deposit.

Leaf Scorch of Broadleaf Evergreens

Winter drying or leaf scorch of broadleaf evergreens, including magnolia, holly, rhododendron, and boxwood, can often be prevented by applying an antidesiccant such as Folicote, Foli Guard, Vapor-Gard, or Wilt Pruf NCF, according to label directions. Apply to the upper surfaces of leaves in late November or early December and repeat again in midwinter.

Fungicide Sprays

In general, spray only when a destructive disease is a known threat. Annual sprays or routine spray schedules are required for relatively few diseases in home, recreational, or industrial plantings. Most fungicide sprays are designed to protect against infection. To be effective, the fungicide must be on the plant before infection occurs. Rainy, foggy, or very humid weather favors infection by practically all fungi and bacteria. When possible, therefore, spray schedules should be altered to provide maximum fungicidal protection during rainy periods.

Table 2. Suggestions for Specific Trees and Shrubs

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
ALDER			
Powdery mildew	benomyl, 50% WP[2] sulfur, 80-95% WP	1/2 2-3	Spray 2 or more times, 7 to 10 days apart starting when disease first appears.
ALMOND—See Cherry.			
AMELANCHIER, SHADBUSH, SERVICEBERRY, JUNEBERRY			
Cedar rusts	thiram, 65-75% WP mancozeb, 80% WP	1-1/2 to 2 1-1/2 to 2	Spray 3 times at 10-day intervals starting when new growth appears in the spring.
Powdery mildew	Karathane, 19.5% WP benomyl, 50% WP sulfur, 80-95% WP Bayleton, 25% WP	1/2 1/2-1 2-3 2-4 oz[b]	Spray when disease first appears or as leaves start to expand. Repeat 2 or 3 times 10 days apart.
APPLE—See Crabapple.			
ARBORVITAE			
Phomopsis needle and twig blight	benomyl, 50% WP	1	Only new growth is susceptible. Spray whenever new growth appears and after shearing or wet weather. Spray at bud-break and repeat at 10- to 14-day intervals until new growth has matured.
Root rot	Banrot	See label	Apply 40% WP product in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Retreat at 4- to 12-week intervals. Work 8% granular product into soil before planting.
Nematodes	Vydate L[7]	See label	See Boxwood.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
ASH			
Anthracnose Fungus leaf spots	copper[3] maneb, 80% WP benomyl, 50% WP[2] mancozeb, 80% WP chlorothalonil Duosan, 75% WP Zyban, 75% WP	See label 1-1/2 to 2 1/2-1 1-1/2 See label. 1-1/2 1-1/2	Apply when buds begin to open. Repeat 10 to 14 days later. Maneb, and mancozeb also control rust.
AZALEA—See Rhododendron.			
BARBERRY			
Bacterial leaf spot and twig blight Fungus leaf spot Blotch Anthracnose	copper[3]	See label	Spray 2 to 3 times, 10 days apart, beginning when new leaves appear in spring.
Nematodes	Dasanit, 15G[7] Vydate L[7]	See label See label	See Boxwood. See Boxwood.
BASSWOOD—See Linden.			
BEECH			
Fungus leaf spot	copper[3]	See label	If severe, spray twice, 10 days apart, starting as the leaves begin to unfold.
Powdery mildew	Karathane, 19.5% WP benomyl, 50% WP sulfur, 80-95% WP	1/2 1/2-1 2-3	If severe, spray twice, 10 days apart, starting when mildew is first seen.
BIRCH			
Leaf blister	copper[3] liquid lime-sulfur	See label 2 gal[b]	Spray once before buds swell in early spring.
Anthracnose	benomyl, 50% WP mancozeb, 80% WP	1 1-1/2	Spray twice, 10 to 14 days apart, starting at budbreak.
Rust	mancozeb, 80% WP Bayleton, 25% WP	1-1/2 2-4 oz[b]	Spray several times 10 days apart. Start about a week before rust normally appears.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
BITTERSWEET			
Powdery mildew	benomyl, 50% WP[2]	1/2-1	If severe, spray 2 or 3 times at 10-day intervals starting when mildew first appears.
	Karathane, 19.5% WP	1/2	
Fungus leaf spots	copper[3]	See label	Spray twice, 10 days apart, starting as leaves unfold.
BOSTON IVY—See Ivy.			
BOXELDER—See Maple.			
BOXWOOD			
Canker or stem blight	copper[3]	See label	Spray 4 times: (1) while dormant after old leaves have been cleaned up and before new growth starts; (2) 10 to 14 days later; (3) when growth is half complete; and (4) in autumn when fall growth has ceased.
Fungus leaf blights or spots	liquid lime-sulfur	2 gal	
Anthracnose			
Phytophthora root rot	etridiazole (Truban or Terrazole)	See labels	Apply as drenches around plants to saturate the soil. Repeat at 4- to 12-week intervals in spring and autumn. Check label registrations.
	metalaxyl (Subdue)[2]	See label	
	Banrot	See label	
	fosetyl-Al, 80% WP (Aliette)	See label	
Nematodes, including root-knot lesion	fenamiphos (Nemacur, 10G)[7]	180 lb/A	*For nursery stock:* Apply postplant and irrigate after application with 1/2 inch of water; only 1 application per year.
	Vydate 2L[7]	3-4 gal to 20 gal	*Preplant:* Incorporate 4 to 8 inches deep immediately after application. Use proportionately less material for band application.
	Vydate 2L drench	1 pt per 100 gal	*Pot drench*: Drench soil with mixture; 4 to 8 oz/6-inch pot or 2 to 4 oz/4-inch pot.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
BOXWOOD, con't.			
Nematodes	Vydate 2L foliar spray	2-4 pints per 100 gal	Apply as dilute spray, up to 8 pints/A. Apply on a 2- to 3-week schedule for 4 applications. Spray when plants are actively growing and not under stress. Use with a spreader-sticker.
	ethoprop (Mocap EC)[7]	1/2 pint per 100 gal	*Field nursery stock*: Apply 1 gal of mixture/sq. yd. Avoid contact with foliage. Apply enough water to soak soil 4 to 6 inches deep.
		1/2-1 pint per 1,000 sq ft	*Bed and bench treatment:* Same as for field nursery stock (above).
		1/2 pint per 100 gal	*Pot drench*: Drench soil with mixture; 1/2 pint/6-inch pot or 1 pint/8-inch pot.
	Temik, 10G (SLN 8000-003)[8]	92-122 oz per 1,000 sq ft of row	Sidedress 3-4 inches deep 10-12 inches on each side of row.
BUCKEYE—See Horsechestnut.			
BUSH HONEYSUCKLE			
Fungus leaf spots	copper[3]	See label	Spray twice, 10 days apart, starting as the leaves unfold.
Powdery mildew	benomyl, 50% WP[2]	1/2-1	Spray 2 or 3 times, 10 days apart. Start when mildew first appears.
	Karathane, 19.5% WP	1/2-1	
BUTTERNUT—See Walnut.			
BUTTONBUSH			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray weekly several times. Start when disease first appears.
	sulfur, 80-95% WP	2-3	
	Karathane, 19.5% WP	1/2	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
BUTTONWOOD—See Sycamore.			
CATALPA			
Powdery mildew	benomyl, 50% WP[2]	1/2-1	Spray when disease first appears. Repeat 10 and 20 days later.
	Karathane, 19.5% WP	1/2	
	sulfur, 80-95% WP	2-3	
Fungus leaf spots	copper[3]	See label	If severe, spray when leaves are unfolding, when leaves reach full size, and 2 weeks later.
CHERRY, PEACH, NECTARINE, PLUM, ALMOND, MAYDAY-TREE, CHERRY-PLUM, CHERRY-LAUREL			
Black knot	dodine, 65% WP	1/2-1	Spray as buds begin to swell. Repeat at pink bud, at full bloom, and 2 to 3 weeks later. Sanitation is important. Check label registrations.
	maneb, 80% WP	1-1/2 to 2	
	benomyl, 50% WP	1	
	mancozeb, 80% WP	1-1/2	
	Topsin M	See label	
Brown rot, blossom and twig blight	benomyl, 50% WP	1/2-1	Spray when first blossoms open, during full bloom, and again at petal-fall. Thorough coverage is required. Check label registrations.
	sulfur, 80-95% WP	5-10	
	captan, 50% WP	2	
	triforine (Funginex)	See label	
	Topsin M	See label	
	mancozeb, 80% WP	1-1/2	
	Ornalin, 50% WP	1/4-1/2	
	chlorothalonil	See label	
Nematodes	Dasanit, 15G	See label	Apply evenly and incorporate into top 2 to 4 inches. For pot mix, thoroughly mix 1.4 qt/cu ft into soil. For outdoor use only.
	Temik, 10G	28-37 oz per 1000 sq ft	Broadcast under drip line and incorporate into soil. For trees under 6 ft see Boxwood. Do not treat trees that are to bear fruit within 2 years.
Nematodes (cherry, peach)	Nemacur, 15G[8]	66.7-133.3 lb per A	Band or broadcast; incorporate into top 2 to 4 inches of soil.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
CHERRY, con't.			
Nematodes (flowering cherry, nursery stock)	Vydate L[7]	See label	See Boxwood.
	Nemacur, 10G[7]	See label	See Boxwood.
Nematodes (plum)	Vydate L	See label	See Boxwood.
Leaf blister or curl	captan, 50% WP	2	Spray once in late fall or just before buds swell in early spring.
	liquid lime-sulfur	2-6 gal[b]	
Plum pockets	chlorothalonil	See label	
Witches'-broom	dodine, 65% WP	1/2-1	
	mancozeb, 80% WP	1-1/2	
	copper[3]	See label	
Coccomyces leaf spot, blight, or shot-hole	benomyl, 50% WP[2]	1/2-1	Spray 4 times, 2 weeks apart. Start as buds are opening.
	dodine, 65% WP	1/2-3/4	
	captan, 50%	2	
	Topsin M	See label	
	chlorothalonil	See label	
Perennial or Valsa canker	benomyl, 50% WP	1/2-1	Delay pruning until buds open in spring. Spray just after pruning.
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when mildew first appears. Repeat once or or twice at 7- to 10-day intervals.
	Karathane, 19.5% WP	1/2-3/4	
	sulfur, 80-95% WP	1-1/2 to 2	
	Topsin M	See label	
Rust	sulfur, 80-95% WP	4-6	Spray several times, about 10 days apart. Start about 2 weeks after petal-fall.
Scab	benomyl, 50% WP	1/2-1	Spray 3 to 5 times, 10 to 14 days apart, starting at petal-fall. Check label registrations.
Shot-hole	sulfur, 80-95% WP	3-6	
Fungus leaf spots	Zyban, 75% WP	1-1/2	
	captan, 50% WP	2	
	Duosan, 75% WP	1-1/2	
	Topsin M	See label	
	chlorothalonil	See label	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
CONIFERS—See Pine.			
COTONEASTER			
Fire blight	bordeaux mixture	2-6-100[3]	Apply during bloom at 5- to 7-day intervals if temperature is above 65°F.
Nematodes	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
Scab	benomyl, 50% WP[2]	1/2-1	Apply in spring as buds start to swell and repeat 2 to 3 weeks later.
	dodine, 65% WP	1/2-1	
Fungus leaf spots Botrytis blight	benomyl, 50% WP	1/2-1	Spray several times 10 to 14 days apart starting at budbreak. Check label registrations.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	Kocide 101, 77% WP	1	
Nematodes	Nemacur, 10G	See label	See Boxwood.
CRABAPPLE, APPLE, PEAR	triforine (Funginex)	See label	Spray as new growth first appears and flower buds start to open. Repeat 3 or 4 more times at 7- to 10-day intervals or follow label directions and check registrations. (Also see Juniper.)
Cedar rusts (apple, hawthorn, and quince)	chlorothalonil	See label	
	Zyban, 75% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	Bayleton, 25% WP	2-4 oz[b]	
	Duosan, 75% WP	1-1/2 to 2	
	Rubigan	See label	
	Dikar, 76.7% WP	1-1/2 to 2	
Scab Fungus leaf spots and fruit rots Sooty blotch and flyspeck	benomyl, 50% WP	1	Spray when growth first appears. Repeat 4 more times, 7 to 10 days apart until two weeks after petal-fall. Thorough coverage of new growth is essential.
	dodine, 65% WP	1/2-3/4	
	captan, 50% WP	2	
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	Dikar, 76.7% WP	1-1/2 to 2	
	Zyban, 75% WP	1-1/2 to 2	
	Duosan, 75% WP	1-1/2 to 2	
	chlorothalonil	See label	
	Rubigan	See label	
	triforine (Funginex)	See label	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
CRABAPPLE, con't.			
Fire blight	streptomycin formulations	See label	Spray when 20 percent of blossoms are open and repeat at 5-to 7-day intervals during bloom. Then apply weekly for 5 or 6 weeks. Best control is obtained by spraying at night.
	copper[3]	See label	
Nematodes (crabapple)	Nemacur, 10G[7]	See label	See Boxwood.
(apple, nonbearing)	Nemacur, 15G	See label	See Cherry.
(apple, pear, non-bearing)	Vydate L[7]	See label	See Boxwood.
	Temik, 10G	See label	See Cherry.
Powdery mildew	triforine (Funginex)	See label	Spray when disease first appears or as leaves start to expand. Repeat 2 or 3 times, 7 to 14 days apart.
	benomyl, 50% WP[2]	1/2-1	
	sulfur, 80-95% WP	6-8	
	Karathane, 19.5%	1/2-3/4	
	Dikar, 76.7% WP	1-1/2 to 2	
	Bayleton, 25% WP	2-4 oz[b]	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	Rubigan	See label	
Phytophthora crown rot	Ridomil	See label	For nonbearing (12 months) trees only.
CURRANT, ALPINE			
Anthracnose	benomyl, 50% WP	1/2-1	Spray 2 or 3 times, 10 to 14 days apart. Start at leaf emergence or when leaves are nearly expanded.
Fungus leaf spots	maneb, 80% WP	1 1/2-2	
	mancozeb, 80% WP	1-1/2	
Powdery mildew	benomyl, 50% WP	1/2-1	Apply when mildew first appears. Repeat 2 or 3 times at 7- to 14-day intervals.
	Karathane, 19.5% WP	1/2-1	
DOGWOOD			
Fungus leaf spots	chlorothalonil	See label	Spray just before flower bracts are fully expanded. In wet years, repeat 2 or 3 more times 10 to 14 days apart.
Leaf blotch	benomyl, 50% WP	1	
Anthracnose	maneb, 80% WP	1-1/2	
Spot anthracnose	mancozeb, 80% WP	1-1/2	
Flower and leaf blights	captan, 50% WP	2	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
DOGWOOD, con't.			
Powdery mildew	benomyl, 50% WP[2]	1/2-1	Spray when mildew first appears. Repeat 7 to 10 days later if needed.
	Bayleton, 25% WP	2-4 oz[b]	
	Karathane, 19.5% WP	1/2-1	
ELM			
Anthracnose	sulfur, 80-95% WP	2-3	Spray 3 times, 10 to 14 days apart. Start when the leaf buds break open. Sanitary measures are very important.
Black leaf spot and other fungus leaf spots	benomyl, 50% WP	1	
	copper[3]	See label	
Twig blight	mancozeb, 80% WP	1-1/2	
Dutch elm disease	metam or SMDC (Vapam Soil Fumigant)	See label	Treat soil when disease first appears to prevent transmission by root grafts. Follow label directions.
	methoxychlor	See label	Apply just before bud-break to prevent inoculation by elm bark beetles.
	Arbotect 20-S[4]	See label	For protective treatment. Should be injected into elms more than 5 inches in diameter by a trained arborist before elms contract the disease or when trees are newly infected and wilt symptoms are less than 5 percent. Apply before the removal of diseased branches and when leaves approach full size.
	MBC-phosphate-carbendazin[4] (formerly Lignasan BLP, now sold as Hopkins Correx Fungicide, Agway Elmosan, Pratt Elm Tree Noculate, Arboral Fungicide, and Lily/Miller Ulmasan)	See label	
EUONYMUS			
Fungus leaf spots	benomyl, 50% WP	1/2-1	Apply at budbreak or at first sign of disease. Spray 2 or 3 times at 7- to 10-day intervals. Sanitary measures are important. Check label directions and registrations.
Anthracnose	maneb, 80% WP	1-1/2 to 2	
Scab	mancozeb, 80% WP	1-1/2	
Botrytis blight	Kocide 101, 77% WP	1	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	Chipco 26019, 50% WP	1-1/2 to 2	
	chlorothalonil	See label	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
EUONYMUS, con't.			
Powdery mildew	Karathane, 19.5% WP	1/2	Apply at first evidence of disease. Repeat at 7- to 10-day intervals. Follow label directions.
	Bayleton, 25% WP	2-4 oz[b]	
	benomyl, 50% WP[2]	1/2-1	
	triforine (Funginex)	See label	
	Rubigan	See label	
Root rots	Banrot	See label	Apply Banrot 40% WP at the rate of 6 to 12 oz in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Mix Banrot 8% granules into soil before planting. Retreat at 4- to 12-week intervals. Apply Chipco 26019 at transplant time.
Crown rot	Chipco 26019, 50% WP	6 1/2 oz[b]	
Nematodes	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Temik, 10G	See label	See Boxwood.
EVERGREENS—See Fir, Juniper, Pine, Yew.			
FIR			
Needle and twig blights Leaf casts	copper[3]	See label	Spray 2 or 3 times, 15 to 30 days apart, starting when new needles are half grown.
Rusts	sulfur, 80-95% WP	3-5	Spray 2 or 3 times, 7 to 10 days apart. Start a week before rust usually appears.
	Bayleton, 25% WP	2-4 oz[b]	
Root rots	Banrot	See label	Apply 6 to 12 oz of 40% WP in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Work 8% granules into soil before planting. Retreat at 4- to 12-week intervals.
Nematodes (Douglas fir)	Vydate L	See label	See Boxwood.
	Temik, 10G	See label	See Cherry.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
FIRETHORN-- See Pyracantha.			
FORSYTHIA			
Fungus leaf spots	mancozeb, 80% WP	1-1/2	Apply at budbreak and repeat at 7- to 10-day intervals as needed to keep foliage protected in damp weather.
	maneb, 80% WP	1-1/2 to 2	
	copper[3]	See label	
	Chipco 26019, 50% WP	1-2	
HAWTHORN, RED HAW			
Leaf blight	captan, 50% WP	2	Apply 3 or 4 sprays at 7- to 10-day intervals, starting in early June. Extend the schedule during rainy seasons. Sanitation is important. Paul's Scarlet and English hawthorns are very susceptible. Maneb, chlorothalonil and mancozeb also control rusts.
Scab	benomyl, 50% WP[2]	1	
Other fungus leaf spots	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	dodine, 65% WP	3/4	
	chlorothalonil	See label	
Cedar rusts	Bayleton, 25% WP	2-4 oz[b]	Spray as new growth appears and flower buds start to open. Repeat 3 or 4 times at 7- to 10-day intervals.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	chlorothalonil	See label	
	Duosan, 75% WP	1	
	Zyban, 75% WP	1	
Fire blight	streptomycin formulations	See label	Spray when 20 percent of blossoms are open and at 5- to 7-day intervals during bloom. Do not use streptomycin on *C. mollis*.
Powdery mildew	Karathane, 19.5% WP	1/2-1	Spray twice, 10 days apart, starting when mildew first appears.
	benomyl, 50% WP	1/2-1	
	chlorothalonil	See label	
	Bayleton, 25% WP	2-4 oz[b]	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
HICKORY			
Anthracnose Fungus leaf spot or blotch Scab Spot anthracnose	benomyl, 50% WP[2] mancozeb, 80% WP maneb, 80% WP	1/2-1 1-1/2 1-1/2 to 2	Spray 3 or 4 times, 7 to 10 days apart, starting as buds break open. Sanitation is important.
HOLLY			
Fungus leaf spots Tar spot Anthracnose Spot anthracnose	chlorothalonil benomyl, 50% WP maneb, 80% WP mancozeb, 80% WP	See label 1/2-1 1-1/2 to 2 1-1/2	Apply 3 or 4 sprays at 10- to 14-day intervals. Start as leaves begin to unfold. Sanitary measures are important.
Leaf and twig blight and algae	copper[3]	See label	Spray 3 or 4 times, 10 days apart. Start with the first autumn rains.
Powdery mildew	sulfur, 80-95% WP benomyl, 50% WP Karathane, 19.5% WP Bayleton, 25% WP	4-5 1/2-1 1/2-1 2-4 oz[b]	Apply when disease first appears. Repeat at 7-day intervals as needed.
Root rots	Banrot	See label	Apply 6 to 12 oz of 40% WP in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Mix 8% granules into soil before planting. Retreat at 4- to 12-week intervals.
Nematodes	Nemacur, 10G[7] Vydate L[7] Temik, 10G Mocap EC[7]	See label See label See label See label	See Boxwood. See Boxwood. See Boxwood. See Boxwood.
HONEYSUCKLE			
Herpobasidium leaf blight	copper[3] mancozeb, 80% WP maneb, 80% WP	See label 1-1/2 1-1/2 to 2	Apply several sprays 7 to 10 days apart. Start when new growth appears. Only young leaves are infected.
Powdery mildew	benomyl, 50% WP sulfur, 80-95% WP Karathane, 19.5% WP Topsin M	1/2-1 4-5 1/2-1 See label	Spray 2 or more times at weekly intervals. Start when disease first appears.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
HORSECHESTNUT, BUCKEYE			
Leaf blotch	benomyl, 50% WP[2]	1/2-1	Spray 3 or 4 times, 10
Fungus leaf spot	mancozeb, 80% WP	1-1/2	to 14 days apart, start-
or blotch	maneb, 80% WP	1-1/2 to 2	ing as the buds begin to
Anthracnose	dodine, 65% WP	1-2	open. Thorough coverage
Spot anthracnose	chlorothalonil	See label	is required for control. Resistant species are available.
Nematodes	Vydate L[7]	See label	See Boxwood.
HYDRANGEA			
Fungus leaf spots	chlorothalonil	See label	Spray 3 times, 7 to 10
Rust	Topsin M	See label	days apart. Start when
	mancozeb, 80% WP	1-1/2	new growth appears.
Botrytis leaf and	benomyl, 50% WP	1/2-1	Spray when symptoms
flower blight	Botran, 75% WP	1-1/3	first appear. Repeat
or gray-mold	chlorothalonil	See label	twice weekly during
	Ornalin, 50% WP	1/2-1	rainy periods. In
	Chipco 26019, 50% WP	1-2	storage, apply Exotherm
	Topsin M	See label	Termil dust or Botran 75W.
	mancozeb, 80% WP	1-1/2	Check label directions.
	maneb, 80% WP	1-1/2	
Root and stem	Banrot, 40% WP	6-12 oz[b]	Drench established
rots of potted	Truban or		plants with mixture.
plants	Terrazole +	See labels	Avoid overwatering.
	benomyl, 50% WP	1	Check label directions and registrations.
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times, 7
	Karathane, 19.5% WP	1/4-1/2	to 10 days apart. Start
	Topsin M	See label	when disease first
	Rubigan	See label	appears.
IVY, ENGLISH—See *1989 Plant Disease Control Guide: Flowers and Other Nonwoody Ornamentals*, Circular 1259.			
IVY, BOSTON AND VIRGINIA CREEPER			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times at
	sulfur, 80-95% WP	3-4	7- to 10-day intervals.
	Topsin M	See label	Start when disease first appears.
Leaf spots	Duosan, 75% WP	1-1/2	Spray 3 times at weekly
	Zyban, 75% WP	1-1/2	intervals. Start as new growth appears.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
JUNEBERRY—See Amelanchier.			
JUNIPER, REDCEDAR			
Rusts	Bayleton, 25% WP	2-4 oz[b]	Spray susceptible junipers 4 times, 10 to 20 days apart, starting in early July. Resistant species and cultivars are available.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
Phomopsis twig blight	benomyl, 50% WP[2]	1	Spray several times at 2-week intervals. Keep new flushes of growth protected. Resistant species are available.
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Cleary 3336	See label	
	mancozeb, 80% WP	1-1/2	
Cercospora needle blight	copper[3]	See label	Spray when disease first appears or after June 1. Repeat at 7- to 10-day intervals.
	benomyl, 50% WP	1	
	mancozeb, 80% WP	1-1/2	
Root rots	Banrot	See label	Apply 6 to 12 oz of 40% WP in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Mix 8% granules into soil before planting. Retreat at 4- to 12-week intervals.
Nematodes (including lesion)	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Dasanit, 15G[7]	See label	See Boxwood.
	Temik, 10G	See label	See Boxwood.
LILAC			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times at 2-week intervals. Start when disease first appears, usually in July. Milban is a restricted-use pesticide.
	Karathane, 19.5% WP	1/2	
	triforine (Funginex)	See label	
	Bayleton, 25% WP	2-4 oz[b]	
	Milban, 39% EC	See label	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	Topsin M	See label	
Bacterial and Phytophthora blights	copper[3]	See label	Spray 2 or 3 times at 7- to 10-day intervals. Start when new growth appears in spring.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
LINDEN, BASSWOOD			
Anthracnose Fungus leaf spots Leaf blight Spot anthracnose	copper[3] benomyl, 50% WP[2]	See label 1	Spray just after bud-break and again 10 and 20 days later. Sanitary measures are important.
Powdery mildew	benomyl, 50% WP sulfur, 80-95% WP	1/2-1 4-6	Spray when mildew first appears. Repeat 10 days later.
MAGNOLIA			
Powdery mildew	benomyl, 50% WP Karathane, 19.5% WP	1/2-1 1/2-1	Spray 2 or 3 times, 7 to 10 days apart. Start when disease first appears.
Fungus leaf spot Leaf blight	copper[3]+ benomyl, 50% WP mancozeb, 80% WP	See label 1/2-1 1-1/2	Spray twice, 10 days apart. Start as buds break open.
Nematodes	Vydate L[7]	See label	See Boxwood.
MAPLE, BOXELDER			
Anthracnose Fungus leaf spots Leaf blight or blotch Leaf scab Tar spot Leaf blister	mancozeb, 80% WP maneb, 80% WP benomyl, 50% WP chlorothalonil captan, 50% WP Duosan, 75% WP Zyban, 75% WP	1-1/2 1-1/2 to 2 1 See label 2 1-1/2 1-1/2	Spray 3 or 4 times, 10 days apart, starting as buds begin to open. For tar spot, spray just before the buds swell in early spring. Sanitation is important.
Nematodes (sugar maple)	Vydate L Temik, 10G	See label See label	See Boxwood. See Cherry.
Root rots	Banrot	See label	Treat in seed bed and nursery bed. Follow label directions.
MAYDAY-TREE—See Cherry.			
MOUNTAIN-ASH			
Leaf blight and scab Fungus leaf spots	benomyl, 50% WP mancozeb, 80% WP maneb, 80% WP chlorothalonil	1/2-1 1-1/2 1-1/2 to 2 See label	Spray 2 to 4 times, 10 days apart, starting as the leaf buds open.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
MOUNTAIN-ASH, con't.			
Rusts	mancozeb, 80% WP	1-1/2	Apply 4 to 5 sprays, 10 days apart. Start as flower buds begin to open.
Fire blight	streptomycin formulations	See label	Spray when 20 to 25 percent of blossoms are open and again at full bloom.
	copper[3]	See label	
MULBERRY			
Bacterial blight or leaf spot Fungus leaf spot False mildew	bordeaux mixture	5-5-100[3]	Apply at budbreak and repeat at 7-day intervals during moist periods. If severe, spray twice, 10 days apart, starting as the leaves unfold.
	copper[3]	See label	
Powdery mildew	benomyl, 50% WP[2]	1/2-1	Spray twice, 10 days apart. Start when mildew first appears.
	Karathane, 19.5% WP	1/2-1	
Nematodes	Vydate L[7]	See label	See Boxwood.
NECTARINE—See Cherry.			
OAK			
Anthracnose[5] Fungus leaf spots and blights Spot anthracnose Leaf blotch Leaf blister	chlorothalonil	See label	Spray 3 times: (1) just before buds open; (2) when leaves are half grown; and (3) 10 to 14 days later. Follow label directions. Sanitary measures are important.
	copper[3]	See label	
	benomyl, 50% WP	1	
	dodine, 65% WP	1	
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	1-1/2 to 2	
Oak wilt	fuel oil or fuel oil + ammonium sulfate (Ammate)	See label	Apply to deep girdle and axe cuts in roots to the point of runoff before tree wilts 50 percent. Treatment kills infected trees and prevents disease spread to healthy oaks.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
OAK, con't.	metam or SMDC (Vapam Soil Fumigant)	See label	Treat soil when disease first appears to prevent transmission to nearby healthy oaks through root grafts. Follow label directions.
PEACH—See Cherry.			
PECAN			
Scab	benomyl, 50% WP[2]	1/2-1	Apply 4 to 6 sprays, 10 to 14 days apart. Start when buds begin to open. Thorough coverage is required. Follow manufacturer's directions.
Fungus leaf spots	maneb, 80% WP	1-1/2 to 2	
Leaf blotch and scorch	mancozeb, 80% WP	1-1/2	
Spot anthracnose	dodine, 65% WP	1/2-1	
Anthracnose	Du-Ter	See label	
Sooty mold	Topsin M	See label	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when mildew is first seen. Repeat at 10- to 14-day intervals.
	Du-Ter	See label	
	Karathane, 19.5% WP	1/2-1	
PHOTINIA			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times at 7- to 14-day intervals. Start when new leaf growth or disease first appears. Check label registrations.
Entomosporium leaf spot	sulfur, 80-95% WP	4-6	
	triforine (Funginex)	See label	
	Bayleton, 25% WP	2-4 oz[b]	
	Topsin M	See label	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	chlorothalonil	See label	
PINE			
Dothistroma needle blight	copper[3]	See label	Spray twice: when new needles are just emerging and when new needles are fully expanded 6 to 8 weeks later.
Scirrhia brown spot and needle blight	copper[3]	See label	Spray once or twice, 30 days apart, starting when new needles are half grown. If rainy, spray at 2-week intervals.
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	1-1/2	
	chlorothalonil	See label	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
PINE, con't.			
Lophodermium needle cast or blight	mancozeb, 80% WP maneb, 80% WP chlorothalonil benomyl, 50% WP[2]	4 4 See label 1-1/2 to 2	Spray 4 times, 2 to 3 weeks apart, starting in early July when the new needles are fully grown.
Sphaeropsis or Diplodia tip blight or dieback	copper[3] benomyl, 50% WP mancozeb, 80% WP	See label 1 2	Spray 3 or 4 times, 10 to 14 days apart. Start just before budbreak.
Scleroderris or Gremmeniella canker	chlorothalonil	See label	Spray as new growth appears in spring. Repeat at 2-week intervals until early July, then monthly until early September.
Soil nematodes	Nemacur, 10G[7] Vydate L[7]	See label See label	See Boxwood. See Boxwood.
Pine Wilt	None	See label	Remove tree and other dead pines in area. Destroy dead wood immediately.
Annosus root and butt rot	borax, 100% (dry, powdered)	1 lb per 50 sq ft of stump surface[b]	Cover fresh-cut stump surface immediately after felling tree. Sprinkle liberally and evenly.
Cylindrocladium blight	benomyl, 50% WP Cleary 3336	1 See label	Apply as a soil drench to seedling beds at 2- to 4-week intervals.
Damping-off Root rot Rhizoctonia needle blight	etridiazole (Truban or Terrazole) Banrot	See labels See label	Drench around plants in nursery beds at 2- to 12-week intervals or mix Banrot or Truban granules into soil before planting.
	PCNB (Terraclor) + metalaxyl[2] (Subdue or Ridomil)	See label See label	Apply at a 1:16 ratio to nursery beds prior to seeding; may also apply metalaxyl as a broadcast spray.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
PLANETREE—See Sycamore.			
PLUM—See Cherry.			
POPLAR			
Leaf rusts	triforine (Funginex)	See label	Spray in early summer about a week before rust is expected and again 10 to 14 days later.
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	2	
	sulfur, 80-95% WP	4-6	
	Bayleton, 25% WP	2-4 oz[b]	
Yellow leaf blister	mancozeb, 80% WP	1-1/2	Apply several weekly sprays starting when spots first appear on the lower leaves.
	maneb, 80% WP	2	
Powdery mildew	sulfur, 80-95% WP	4-1/2 to 5-1/2	Apply at first sign of disease. Repeat 2 or 3 times at 5- to 10-day intervals.
	benomyl, 50% WP[2]	1	
	Bayleton, 25% WP	2-4 oz[b]	
PRIVET			
Anthracnose Fungus leaf spot Twig blight	benomyl, 50% WP	1	Spray several times at 10-day intervals starting in mid-spring.
	Bayleton, 25% WP	2-4 oz[b]	
	chlorothalonil	See label	
	mancozeb, 80% WP	1-1/2	
Powdery mildew	Bayleton, 25% WP	2-4 oz[b]	Spray twice, 10 days apart. Start when mildew appears.
	benomyl, 50% WP	1/2-1	
	Karathane, 19.5% WP	1/2	
	sulfur, 80-95% WP	3-5	
Root rots Stem rots Damping-off	Banrot	See label	Apply 6 to 12 oz of 40% WP in 100 gal water to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Mix 8% granules into soil before planting. Retreat at 4- to 12-week intervals.
Nematodes	Dasanit, 15G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
PYRACANTHA, FIRETHORN			
Fire blight	streptomycin formulations	See label	Spray when 20 to 25 percent of blossoms are open and repeat at 5- to 7-day intervals during bloom.
	copper[3]	See label	
Scab	benomyl, 50% WP[2]	1	Spray 4 times: (1) at budbreak; (2) just before blossoms open; (3) at petal-fall; and (4) 2 weeks later. Add a spreader-sticker to the spray mix.
	chlorothalonil	See label	
	mancozeb, 80% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	Topsin M	See label	
	Cleary 3336	See label	
Nematodes	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Dasanit, 15G[7]	See label	See Boxwood.
QUINCE			
Fire blight	bordeaux mixture	2-6-100[3]	Spray when 20 percent of blossoms are open. Repeat when 75 percent are open. Do not use streptomycin on quince.
Rust Scab Fungus leaf spots	maneb, 80% WP mancozeb, 80% WP chlorothalonil	1-1/2 to 2 1-1/2 See label	Apply several sprays at 10-day intervals starting at budbreak.
REDBUD			
Cercospora and other fungus leaf spots	copper[3]	See label	If serious, apply at budbreak and repeat several times at 10-day intervals during spring rainy periods.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2	
Botryosphaeria canker	benomyl, 50% WP		Treat wounds and pruning scars with 1/2 t benomyl in 1 gal of tree-wound dressing.
REDCEDAR—See Juniper.			
RED HAW—See Hawthorn.			

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
RHODODENDRON, AZALEA			
Ovulinia petal or flower blight of azalea	Zyban, 75% WP	1-1/2	Spray as flowers begin to open. Then apply benomyl at 5-day intervals. Or apply mancozeb 3 times weekly during bloom. See labels for details.
	benomyl, 50% WP[2]	1	
	mancozeb, 80% WP	1-1/2	
	chlorothalonil	See label	
	Bayleton, 25% WP	1/2-1	
	Duosan, 75% WP	1-1/2	
	Topsin M	See label	
	triforine (Funginex)	See label	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times at 7- to 14-day intervals. Start when disease first appears.
	Karathane, 19.5% WP	1/2-1	
	Bayleton, 25% WP	2-4 oz[b]	
	Topsin M	See label	
Fungus leaf spots Rusts Leaf, flower, and stem galls	maneb, 80% WP	1-1/2 to 2	Spray several times at 10-day intervals. Start at budbreak. Benomyl is not effective against rusts.
	mancozeb, 80% WP	1-1/2	
	benomyl, 50% WP	1/2-1	
	chlorothalonil	See label	
Bud and twig blight Dieback	copper[3]	See label	Spray 3 times, 7 to 10 days apart, starting at budbreak.
	chlorothalonil	See label	
	benomyl, 50% WP	1/2-1	
Root and crown rot and dieback Wilt (*Phytophthora cinnamomi* and other fungi)	etridiazole (Truban or Terrazole)	See labels	Apply as a drench around plants to saturate the soil. Repeat at 3- to 12-week intervals in spring and autumn. Follow label directions.
	Banrot, 40% WP	6-12 oz[b]	
	metalaxyl (Subdue)[2]	See label	
	fosetyl-Al, 80% WP (Aliette)	See label	
	propamocarb (Banol)	See label	
Nematodes	Dasanit, 15G[7]	See label	See Boxwood.
	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Mocap EC[7]	See label	See Boxwood.
Cutting rot or dieback Cylindrocladium root rot	benomyl, 50% WP	See remarks	Mix 1 part benomyl with 39 parts of root-inducing hormone powder by weight. Treat cut ends with mixture before sticking in rooting medium. Then drench soil as for root and crown rot or wilt. Apply etridiazole as for root and crown rot or wilt.
	Topsin M	See label	
	etridiazole (Truban or Terrazole)	See labels	
	Cleary 3336	See label	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
ROSE			
Botrytis blight	benomyl, 50% WP[2]	1/2	Mist flowers at 7- to 10-day intervals in moist weather. Do not apply Ornalin immediately after yearly cutback. Ornalin and Botran may be used as a post harvest cut flower, budwood, or bareroot nursery stock dip in cold storage or transit.
	Botran, 75% WP	1/2-3/4	
	Ornalin, 50% WP	1 to 1-1/2	
	Chipco 26019, 50% WP	1-2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	chlorothalonil	See label	
	Cleary 3336	See label	
Black spot Cane blight Cankers Spot anthracnose Anthracnose Fungus leaf spots	triforine (Funginex)	See label	Spray at 7- to 10-day intervals starting when new growth appears. Shorten spray interval to 5 or 7 days in rainy weather. Maneb, mancozeb, triforine, and chlorothalonil also control rusts.
	chlorothalonil	See label	
	maneb, 80% WP	1-1/2	
	mancozeb, 80% WP	1-1/2	
	benomyl, 50% WP	1	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Topsin M	See label	
Powdery mildew	benomyl, 50% WP	1	Spray at 7- to 14-day intervals starting when new growth appears. Thorough coverage is required. Follow label directions. Milban is a restricted-use pesticide. Pipron is for use only in commercial greenhouses.
	Karathane, 19.5% WP	1/2	
	Bayleton, 25% WP	1-4 oz[b]	
	Milban, 39% EC	32 oz[b]	
	triforine (Funginex)	See label	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Rubigan	See label	
	Pipron, 82.4% L	See label	
Fungus leaf spots	copper[3]	See label	Spray twice, 10 days apart, starting as leaves unfold. Thorough coverage is required.
	Bayleton, 25% WP	2-4 oz[b]	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	mancozeb, 80% WP	1-1/2	
Nematodes	Dasanit, 15G[7]	See label	See Boxwood.
	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Temik, 10G	See label	See Boxwood.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
RUSSIAN-OLIVE			
Fungus leaf spots	copper[3]	See label	Spray twice, 10 days apart, starting as leaves unfold.
	Bayleton, 25% WP	2-4 oz[b]	
SERVICEBERRY, SHADBUSH—See Amelanchier.			
SPRUCE—See Pine.			
SUMAC			
Fungus leaf spots	maneb, 80% WP	1-1/2 to 2	Apply when disease is first seen. Repeat as needed at 7- to 10-day intervals during rainy periods.
	sulfur, 80-95% WP	4-6	
	mancozeb, 80% WP	1-1/2	
SYCAMORE, PLANETREE, BUTTONWOOD			
Anthracnose[5]	chlorothalonil	See label	Spray 3 times: (1) just before buds break open; (2) at budbreak; and (3) when leaves are expanded, 10 to 20 days later. Thorough coverage is required. Check label directions.
Fungus leaf spots	benomyl, 50% WP[2]	1	
Leaf blight	copper[3]	See label	
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	1-1/2 to 2	
	dodine, 65% WP	1	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray 2 or 3 times, 7 to 10 days apart, starting when disease first appears.
	sulfur, 80-95% WP	4-6	
	Bayleton, 25% WP	2-4 oz[b]	
Canker stain	benomyl, 50% WP	See remarks	Add 1/2 t per gal to asphalt-base tree wound dressing.
TAXUS—See Yew.			
TULIPTREE			
Fungus leaf spots	copper[3]	See label	If severe, spray 2 or 3 times, 10 days apart. Start at budbreak.
Powdery mildew	benomyl, 50% WP	1/2-1	If severe, spray twice, 10 days apart, starting when mildew first appears.
	Karathane, 19.5% WP	1/2-1	

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
VIBURNUM			
Powdery mildew	benomyl, 50% WP[2]	1/2-1	Spray 2 or more times, 7 to 10 days apart. Start when disease first appears.
	Karathane, 19.5% WP	1/2	
	Bayleton, 25% WP	2-4 oz[b]	
	chlorothalonil	See label	
Nematodes	Nemacur, 10G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
	Dasanit, 15G[7]	See label	See Boxwood.
	Temik, 10G	See label	See Boxwood.
VIRGINIA CREEPER—See Ivy.			
WALNUT, BUTTERNUT			
Anthracnose Yellow leaf blotch Fungus leaf spots or blights	benomyl, 50% WP	1	Spray 3 or 4 times at 2-week intervals starting when the leaves begin to unfold. Thorough coverage is required.
	dodine, 65% WP	1	
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	1-1/2 to 2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
Bacterial blight (of Persian or English walnut)	copper[3]	See label	Spray 4 times: (1) when flowering starts; (2) at full bloom; (3) at petal-fall; and (4) 7 to 10 days later.
	streptomycin formulations	See label	
WILLOW			
Tar spot Leaf blight Scab Black canker Spot anthracnose	copper[3]	See label	Spray 3 times, 10 days apart, starting as the buds open. Maneb, and mancozeb also control rust. Sanitary measures are important.
	mancozeb, 80% WP	1-1/2	
	maneb, 80% WP	1-1/2 to 2	
	dodine, 65% WP	1/2-1	
Powdery mildew Rust	sulfur, 80-95% WP	4-6	Apply 2 or more times, 7 to 10 days apart. Start when disease first appears.
	Bayleton, 25% WP	2-4 oz[b]	
WITCHHAZEL			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray 2 or more times, 7 to 10 days apart. Start when disease first appears.
	Karathane, 19.5% WP	1/2-1	
	sulfur, 80-95% WP	3-4	
Fungus leaf spots	copper[3]+ benomyl, 50% WP	See label 1/2-1	If severe, spray twice, 10 days apart. Start as leaves begin to unfold.

See footnotes at the end of Table 2.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
YEW (*Taxus*)			
Twig blight	bordeaux mixture	4-4-100[3]	Apply when new growth emerges. Repeat twice more at 7- to 10-day intervals.
Phytophthora root rot	Aliette, 80% WP	See label	Apply as a soil drench.
Nematodes	Nemacur, 10G[7]	See label	See Boxwood.
	Mocap EC[7]	See label	See Boxwood.
	Dasanit, 15G[7]	See label	See Boxwood.
	Vydate L[7]	See label	See Boxwood.
ALL WOODY PLANTS			
Seed decay	thiram, 42-75% WP	See remarks	Apply 2 oz per lb of seed. If damping-off starts, drench seedbed at 4T per gal when first seen. Follow label directions.
Damping-off	captan, 50% WP	See remarks	
Seedling blights			
Root rots	methyl bromide	See label	Apply under gas-proof cover several weeks prior to planting in nursery beds. Controls damping-off, root rots, and nematodes.
Nematodes	methyl bromide 2:1 + chloropicrin mixtures	See labels	
	Vorlex	See label	
	Vapam	See label	
	etridiazole (Truban or Terrazole)	See labels	Apply as a soil drench after plants are set. Repeat at 2- to 12-week intervals. Etridiazole, fosetyl-Al, and metalaxyl control only *Phytophthora* and *Pythium*. May be combined with captan or thiram. Follow label directions.
	Banrot, 40% WP	See label	
	metalaxyl (Subdue)[2]	See label	
	fosetyl-Al, 80% WP (Aliette)	See label	
Wood rots or decays	thiram, 75% WP	1	Apply thinly in an asphalt or other nonfortified tree wound preparation. See also remarks on Sanitation preceding Table 2. Dip tools in 70% denatured alcohol or 4% formaldehyde to disinfect them between working on trees.
	benomyl, 50% WP	1/4	

See footnotes at the end of Table 2.

Footnotes

1 The rates given are based on hydraulic application and are expressed in pounds per 100 gallons unless specified otherwise. If using a mistblower, follow label directions.

2 Whenever possible, benomyl and metalaxyl should be alternated with another fungicide or mixed with it to avoid development of resistant strains or races of fungi.

3 Copper fungicides include fixed or neutral copper compounds and bordeaux mixtures, usually 4-4-100 or 8 8-100. The first number in a bordeaux mixture refers to pounds of copper sulfate, the second refers to pounds of hydrated spray lime, and the third refers to gallons of water.

4 Arbotect 20-S and MBC-phosphate or carbendazin materials have not been fully tested by specialists in tree pathology. Therefore, they cannot be recommended without reservations. The products should be used by trained arborists and others acquainted with the identification of Dutch elm disease and with injection techniques. Infection through trunk wounds has led to woodstain and decay.

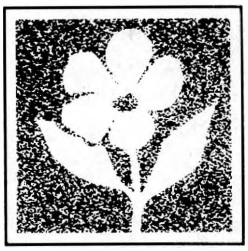
5 Treatments listed are recommended for the leaf-blight stage of anthracnose only.

6 Do not try to remove rotted, soft tissues in order to fill cavities. Internal wounds break decay-resistant barriers, so avoid boring holes through sound wood into rotted wood. Callus may close the outer opening, but the plant cannot close the inner opening. Decay fungi can thus pass the natural barrier.

7 For commercial use only. Restricted use, only for application by certified applicators or operators.

8 SLN 8000-003 is a state local need number (Illinois only).

[a]WP = wettable powder; EC = emulsifiable concentrate; G = granular; L = liquid.
[b]gal = gallon(s); sq ft = square foot(feet); oz = ounce(s); lb = pound(s); ai = active ingredient.



1989 Plant Disease Control Guide

FLOWERS and NONWOODY ORNAMENTALS

Disease control programs for flowers and other nonwoody ornamentals should be based on a thorough knowledge of the diseases that are likely to appear and the plants that are susceptible to attack and on an early and accurate diagnosis of the problem. Control measures *must* start before or at the early onset of disease, but preferably before symptoms appear. Disease control programs should begin with the purchase of the best seed or planting materials available and continue throughout the season until the plants or their parts are sold or discarded.

Traditionally, four fundamental principles apply to plant disease control. The four may be applied individually or concurrently for integrated control of infectious agents or pathogens. These principles are exclusion, eradication, immunization, and protection. All cultural and chemical practices that are used to keep plants from becoming diseased can be placed into one of these four categories.

Exclusion involves preventing the disease-causing organisms and agents from becoming established in or around susceptible plants. Exclusion is achieved through federal or state embargoes, quarantines, inspections, and disinfection of plants, seeds, cuttings, bulbs, corms, and other propagative plant parts. Other methods include certification of plants, cuttings, and seed before shipment and culture indexing of planting stock to ensure freedom from pathogens.

Eradication is the elimination of the disease-causing agent or pathogen after it has become established in or on a plant where it is growing or being stored. Eradication involves the removal and destruction of infected plant parts, diseased plants, infected debris, weeds, alternate hosts, and other overwintering host plants. It also involves seed or plant treatment with wet or dry heat or a systemic chemical; crop rotation; treatment of the soil or other medium with heat or an eradicative chemical such as a multipurpose soil fumigant; and cleaning and disinfesting potting benches, soil bins, greenhouse benches, nursery beds, storage areas, tools, and equipment.

Immunization involves growing resistant or immune species, varieties, or cultivars and treating the disease with a systemic chemical that internally kills, inactivates, or protects against infection. Unfortunately, there are no ornamental plants resistant or immune to all diseases. Much less time and effort has been put into developing disease resistance in flowers and nonwoody ornamentals than into field crops, vegetables, and fruits.

Protection is the placing of a physical or chemical barrier between the susceptible part of the host plant and the disease agent or pathogen. Protection usually means uniform applications of recommended disease-control chemicals, including fungicides, bactericides, or nematicides, as dusts, sprays, or soil drenches. Chemicals should be applied to the plant or its propagative parts *before* the pathogen arrives.

Protective cultural practices include proper spacing of plants; time and depth of planting; proper soil reaction (pH); careful handling of plants and propagative parts during harvest, grading, and packing; proper lighting, temperature control, watering, fertilization, and pruning; and the alteration of the air and soil environment to make it unfavorable for the pathogen to infect, develop, reproduce, or spread during growth, storage, and shipment.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
COOPERATIVE EXTENSION SERVICE

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To be successful, the right chemical must be applied at the right concentration, at the right time, and in the right way. Correctly applying the proper chemicals ensures an active and complete chemical barrier on the susceptible plant surface during the time when infection may occur. Several applications, spaced about 7 to 10 days apart for protective fungicides and 10 to 21 days or longer for systemic fungicides, are usually needed to keep expanding foliage and flowers covered with a protective film.

Protection also includes the killing of insects, mites, and other inoculating agents before these pests can feed and infect plants with pathogens carried on or in their bodies. Some seed treatments, such as captan, thiram, and Apron are protective against seed- and soilborne organisms.

To help in diagnosing the common diseases of flowers and other nonwoody ornamentals, a key to their identification is presented in Table 1. The symptoms in the key are divided into those that appear on the leaves, stems and branches, flowers, and underground parts.

The pesticides listed in Tables 2 and 3 are presented by their common and trade names as much as possible. The percentage of active ingredients and formulation information are presented adjacent to these names. Various formulations of common fungicides, such as Truban, are available: wettable powders (WP), emulsifiable concentrates (EC), and granules (G). The fact that Truban 25% EC is cleared for use on Chamaedora palm, for example, does not mean that the 30% WP, or the 5% G formulations are also legal to use on this species. Specific formulations differ in percentages of active ingredient and, therefore, in efficacy and crop safety.

Some common fungicides such as zinc ion and maneb complex (mancozeb) are often available under several major trade names. For example, DuPont's Manzate 200 and Rohm & Haas's Dithane M-45 labels list the same percentages of active ingredient, yet Manzate 200 is legal to use on a number of ornamentals while Dithane M-45 is not. Rohm & Haas's Fore is the equivalent of Dithane-45 for use on ornamentals. Always read and follow label directions and precautions. Use the product only on the plants listed on the label. It is illegal to do otherwise.

Fertilization

Unthrifty and undernourished flowers and nonwoody ornamentals are susceptible to a variety of diseases and environmental stresses. Their vigor can often be greatly improved by having a soil test made prior to planting and following suggestions in the report.

Sanitation

Proper selection of planting site, planting method (depth and spacing), and plant materials as well as soil preparation, disease, insect, and weed control, and avoidance of unnecessary wounding will all aid in control of a wide range of diseases.

Watering

Ornamental plants should receive the equivalent of an inch of water as rainfall or supplemental irrigation each week during the growing season. If irrigating, apply water in the morning on a rising temperature not during late afternoon or evening. Where possible use a soaker hose rather than overhead watering. Try to keep water off the foliage.

NOTE: The information in the following tables is for educational purposes only. Reference to commercial products or trade names does not constitute an endorsement by the University of Illinois and does *not* imply discrimination against other similar products. Trade names are presented for reasons of clarity only. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

Table 1. Disease Symptoms of Flowers and Nonwoody Ornamentals

General symptoms	Specific symptoms	Disease
LEAVES		
Leaves show small to large, definite spots that vary in size, shape, and color.	Small, dark specks are present, indicating fungal fruiting bodies; spots often roundish with dark margins.	Fungus leaf spot Scab Spot anthracnose
	Dark, water-soaked angular spots in leaves; spots later turn gray, brown, reddish-brown, or black; margins usually water-soaked.	Bacterial leaf spot or blight
	Irregular, often large, dead areas in leaves.	Leaf blight or blotch Anthracnose
Leaves spotted or blighted; later covered with dusty mold growth.	Tan to gray, coarse mold.	Botrytis blight or gray-mold
	White to light gray mold.	
	Powdery to mealy; easily wiped off.	Powdery mildew
	Powdery, white raised pustules on underleaf surface; may later turn yellow, then brown.	White rust
	Light gray to pale purplish downy growth on underleaf surface.	Downy mildew
	Black mold.	
	Sooty or crusty; easily wiped off.	Sooty mold or blotch
	Sooty mold inside "blisters" or galls.	Smut
	Yellow, orange, reddish-orange, reddish-brown, chocolate brown, or black mold in raised pustules.	Rust
Leaves with yellow to brown or black angular spots; plants stunted or bushy.		Foliar nematodes

General symptoms	Specific symptoms	Disease
LEAVES, cont'd.		
Leaves mottled light and dark green or yellow; often stunted, curled, and crinkled.	May form an irregular light and dark green mosaic or mottled pattern.	Mosaic Mottle Crinkle Streak
	Yellow-green or reddish-brown rings, "oakleaf," "watermark," or line patterns in leaves.	Ringspot or spotted wilt
Leaves and shoots stunted or dwarfed and erect; appear "bunchy"; younger parts uniformly yellow, sometimes red or purple.		Yellows Dwarf Stunt
Leaves wilt, wither, and die; may involve part or all of plant.	Discoloration inside lower stem.	Wilt disease
	Leaves wilt, wither, and die from stem or crown rot, root rot, drought or excess water, transplant shock, injury from insects or other animals, fertilizer or pesticide injury, an excess of soluble salts, frost, other mechanical injuries.	Miscellaneous diseases and injuries
STEMS AND BRANCHES		
Plants lack vigor; leaves are small and pale, may later wilt or turn yellow.	Seedlings collapse and die; stand is poor.	Damping-off Seed Rot
	Stems of older plants are water-soaked or discolored and decayed, often just at the base.	Stem or crown rot
	Stems or branches show definitely marked, discolored, often sunken dead areas; parts beyond may wither and die.	Canker or dieback
	Shoots are often dwarfed or aborted; leaves are distorted; cauliflowerlike growth may appear at the soil line.	Leaf gall or fasciation

General symptoms	Specific symptoms	Disease
STEMS AND BRANCHES, con't.	Rough, swollen gall, either flesh-colored, greenish, or dark, usually found at or near the soil line.	Crown gall
FLOWERS		
Flowers are spotted, often wither or rot; may be covered with mold growth.		Flower or blossom blight
Flowers are blotched or streaked with white or yellow.		Mosaic or flower breaking
Flowers are greenish-yellow, dwarfed, aborted, or absent.		Aster yellows
ROOTS, BULBS, CORMS, AND TUBERS		
Plants lose vigor, often are stunted; may turn pale or yellow; tops may wilt and die back.	Roots decay; feeder roots die back; may be covered with mold.	Root rot
	Bulb, corm, or tuber decays; may be covered with mold.	Bulb, corm, or tuber rot
	Rough, roundish galls form on roots, corms, or tubers.	Crown gall
Root damage	Lack of hairy roots; root browning or galling.	Nematodes

Table 2. General Instructions for Most Ornamentals

Disease	Chemicals for control	Remarks
Damping-off Seed rot or decay Seedling blights	captan, metalaxyl (Subdue), etridiazole (Truban or Terrazole), Banrot, or iprodione (Chipco 26019)	Apply captan as a seed treatment any time before planting. Grow plants in sterilized (pasteurized) soil wherever feasible. Iprodione, metalaxyl, Banrot, and etridiazole are mixed into soil or applied as drenches. Check labels for crop rates and registrations.
Storage decay	captan, Botran, benomyl, or vinclozolin (Ornalin)	Spray, dust, or dip plants, bulbs, tubers, corms, and other plant parts before shipping or placing in storage. Check labels for crop registrations.
Cutting rots Damping-off Seedling blights Crown (foot) and stem rots Root rots	PCNB (Terraclor), captan-PCNB mixtures, Banrot, benomyl (Benlate), PCNB-etridiazole (SA Terraclor Super-X), thiophanate-methyl (Topsin M), or iprodione (Chipco 26019)	For Botrytis, Rhizoctonia, Sclerotinia, and Sclerotium stem and root rots **only**. Apply as a soil drench at 1 pint per square foot or work into upper 2 to 4 inches of soil before planting. Check labels for crop registrations.
	etridiazole (Truban or Terrazole), Banrot, metalaxyl (Subdue), PCNB-etridiazole (SA Terraclor Super-X), propamocarb (Banol), or fosetyl-Al (Aliette)	For Aphanomyces, Phytophthora, and Pythium stem and root rots (water molds) **only**. Usually applied as a soil drench at intervals of 2 to 8 weeks. Check label instructions. Sometimes combined with PCNB (Terraclor) or other fungicide.
Leaf, stem, and flower spots or blights caused by fungi Botrytis blight or gray-mold	benomyl + captan, maneb, mancozeb, chlorothalonil (Daconil 2787, Exotherm Termil), vinclozolin (Ornalin), iprodione (Chipco 26019), thiophanate-methyl + maneb and zinc ion (Duosan, Zyban), triadimefon (Bayleton), or triforine (Funginex)	Benomyl plus captan, folpet, chlorothalonil, maneb, or mancozeb also gives *Botrytis* control, as does vinclozolin, iprodione, and thiophanate-methyl plus maneb and zinc ion. Applications are needed at intervals of 5 to 7 days in rainy weather and every 7 to 10 days in drier weather. Check labels for specific information and crop registrations.
Rusts	maneb, mancozeb, oxycarboxin (Plantvax), triadimefon (Bayleton), or triforine (Funginex)	Applications are usually needed at intervals of 7 to 10 days starting when rust first appears. Check labels for current crop registrations.

Disease	Chemicals for control	Remarks
Powdery mildews	benomyl, sulfur, dinocap (Karathane), triforine (Funginex), triadimefon (Bayleton), thiophanate-methyl (Topsin M), Zyban, or Duosan	Frequent applications and thorough coverage are essential. Sulfur, and dinocap may cause plant injury, especially in hot weather at 85°F or above. Check labels for current crop registrations.
Bacterial flower, leaf, and shoot blights	streptomycin formulations or copper fungicide	Strictly follow manufacturer's directions or plant injury may result. Note label restrictions.
Wilt diseases (mostly *Fusarium* and *Verticillium*) Crown and root rots Fasciation Crown gall	Steam at 180°F for 30 minutes or 160°F for 1 hour at the coolest spot or fumigate soil with methyl bromide, Vorlex, Vorlex 201, chloropicrin, or Vapam Soil Fumigant. Methyl bromide-chloropicrin or chloropicrin provide the best control of Verticillium wilt.	Treat soil several days to a month before planting. Carefully follow the manufacturer's directions as chemicals are very toxic and some can be used only by licensed commercial applicators. Also treat containers, benches, work surfaces, potting table, tools, and other equipment. Galltrol-A and Norbac 84-C are crown gall controls.
Soil nematodes (including root-knot and root-lesion nematodes)	Same as for wilt diseases above or apply Dasanit, Mocap, Nemacur, Temik, or Vydate L.	For application by certified commercial applicators only. Carefully follow all label directions and precautions. See labels for specific uses.
Foliar nematodes	Same as for wilt diseases above or use oxamyl (Vydate L).	For application by certified commercial applicators only. Carefully follow all label directions and precautions. See label for Vydate L uses.
Viruses Viroids Mycoplasmas	Apply insecticides at frequent intervals to keep the insects from feeding, as recommended by University of Illinois Extension entomologists.	Control insects that transmit the causal agents, especially leafhoppers, aphids, and thrips. Destroy the first infected plants. Keep down all broadleaf weeds.

Table 3. Instructions for Specific Flowers and Other Nonwoody Ornamentals

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	Rate[b] 1 gallon	Remarks[c]
AFRICAN VIOLET				
Botrytis blight	chlorothalonil	See label	See label	Spray at 1- to 2-week intervals during cool, damp, overcast weather. In greenhouses, may use Exotherm Termil.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Topsin M	See label	See label	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Nematodes: foliar	Temik, 10G	See label	See label	Apply 18-28 oz/1000 sq ft.
Nematodes: soil	Temik, 10G	See label	See label	Apply 28-37 oz/1000 sq ft.
Nematodes: Root-knot, sting, lesion, stunt	Vydate L	15-20 gal	See label	Preplant incorporate 4 to 8 inches.
	Potted soil mix	27-1/2 fl oz	See label	Spray 2.5 to 3.3 gal/1 cu yd of soil while tumbling in mixer.
	Pot drench	1 pint	See label	4 to 8 oz/6-inch pot, 2 to 4 oz/4-inch pot. Apply as a dilute spray not to exceed 8 pints per acre. Apply when plant is actively growing and not under stress. Use a spreader-sticker.
	Foliar	2-4 pints	See label	
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Apply at 10- to 14-day intervals; more frequently when disease is severe. Add a spreader-sticker to the spray. Do not apply Karathane to open flowers. Milban is a restricted-use pesticide.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Milban, 39% EC	See label	See label	
	Bayleton, 25% WP	2-4 oz	See label	
Crown and stem rots	Banol, Truban, Terrazole, or Subdue + PCNB (Terraclor), 75% WP	See labels	See labels	Drench established plants once. You can purchase the fungicides separately or as a combination mix. Repeat at 4- to 12-week intervals as needed. Avoid overwatering.
	Banrot	See label	See label	
AJUGA				
Sclerotium (crown) rot or southern blight	PCNB (Terraclor),	See label	See label	Apply PCNB as dust or granules on soil surface before planting. Thoroughly work into top 2 inches of soil. See label for Banrot applications.
	Banrot	See label	See label	
Powdery Mildew	Rubigan	See label	See label	Make two applications 10 to 14 days apart.
Nematodes (nursery stock)	Nemacur, 10G	See label	See label	Apply 180 lb per acre postplant and irrigate with 1/2 inch of water. One application per year.

[a] WP = wettable powder; L = liquid; EC = emulsifiable concentrate; G = granular.
[b] T = tablespoon(s); t = teaspoon(s); lb = pound(s); oz = ounce(s).
[c] sq ft = square foot (feet); gal = gallon(s); qt = quart(s).

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
AJUGA, con't.	Temik, 10G (SLN 8000-003)	92-122 oz/ 1000/sq ft	See label	Sidedress 3-4 inches deep, 10-12 inches, or each side of row.
AMARYLLIS				
Red blotch or leaf scorch	copper oxychloride	See label		Keep the foliage protected during wet periods. To ensure coverage, add a spreader-sticker to the spray mix.
ASTER, CHINA				
Botrytis blight (bud and stem rot and petal blight)	benomyl, 50% WP	1/2 lb	2 t	For Botrytis petal blight, spray weekly starting when buds form. For mildew, start spraying when disease first appears. Apply benomyl sprays to seedlings at 2-week intervals to control Botrytis stem rot. Only benomyl and Topsin M control powdery mildew.
	chlorothalonil	See label	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
Powdery mildew	Topsin M	See label	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Ornalin, 50% WP	1/2-1 lb	See label	
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 21-day intervals. See label. Begin when disease first appears. Add a spreader-sticker (surfactant) to the spray mix.
Fungal leaf spots	Bayleton, 25% WP	2-4 oz	See label	
	Funginex	See label	1-1/2 T	
	Ziram F-4, 41.5% L	See label	See label	
Rhizoctonia stem (crown) and root rot	PCNB (Terraclor), 75% WP	1/2 lb	1/2 T	Thoroughly drench soil once using 1 pint to 1 qt per sq ft. Spray the base of seedlings with benomyl 50% WP at 1 t per gal of water. Apply Chipco 26019 at transplant time.
	Banrot	See label	See label	
	Chipco 26019, 50% WP	6-1/2 oz	See label	
Sclerotinia or cottony stem rot	benomyl, 50% WP	1/2 lb	2 t	Spray the stems and soil surface at 2- to 4-week intervals during cool, rainy, and overcast periods.
	Ornalin, 50% WP	1/2-1 lb	See label	
Root rots	Banrot	See label	See label	Drench seedlings and older plants at 2- to 4-week intervals using 1 pint to 1 qt per sq ft of bed with 40% WP or mix 8% granules into soil before planting.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
ASTER, CHINA, con't.				
Aster yellows	Apply recommended insecticide at frequent intervals.	See label	See label	Spray weekly, starting about mid-June. Six-spotted leafhoppers are vectors of the aster yellows mycoplasma. Or grow plants under 22-thread cloth to keep out insects.
Foliar nematodes	Temik, 10G	See label	See label	See African Violet.
AZALEA - See *1989 Plant Disease Control Guide: Woody Ornamentals*, Circular 1260.				
BEGONIA				
Botrytis blight,	benomyl, 50% WP	1/2 lb	2 t	Spray at least weekly during
leaf spot, and	Ornalin, 50% WP	1/2-1 lb	See label	cool, damp, overcast
stem rot	chlorothalonil	See label	See label	weather. In greenhouses,
Other fungal leaf	Zyban, 75% WP	1-1/2 lb	See label	may use Exotherm Termil
spots	Duosan, 75% WP	1-1/2 lb	See label	according to label directions.
	Topsin M	See label	See label	Check label registrations.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 14-day intervals, starting when
	Karathane, 19.5% WP	1/4 lb	1 t	mildew first appears. Add
	Bayleton, 25% WP	2-4 oz	See label	a spreader-sticker to the
	Milban, 39% EC	See label	See label	spray mix. Milban is a
	Rubigan	See label	See label	restricted-use pesticide.
Nematodes (Reiger begonia)	Vydate L	See label	See label	See African Violet.
Root and stem or crown rots	PCNB (Terraclor), 75% WP + Truban, Terrazole, or Subdue	See labels	See labels	Apply monthly drenches to plants and soil. Do not apply to very young seedlings. Follow
	Banrot	See label	See label	manufacturer's directions.
Damping-off	captan, 50% WP	4 lb	8 T	Soak clean, disease-free
Tuber rot				begonia tubers for 20 to 30 minutes. Drain and plant in well-drained soil.
Bacterial leaf spot	Kocide 101, 77% WP	1 lb	1 t	Keep foliage protected. Avoid wetting the foliage when watering.
CALENDULA				
Fungal leaf spots	benomyl, 50% WP	1/2 lb	2 t	Spray or dust foliage and
	Topsin M	See label	See label	flowers at 7- to 14-day
	Chipco 26019, 50% WP	1-2 lb	1-2 T	intervals. Start when disease first appears.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
CALENDULA, con't.				
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Several spray or dust applications are usually needed, 7 to 10 days apart. Start when mildew first appears. Check label instructions and precautions.
	Karathane, 19.5% WP	1/4 lb	1 t	
	sulfur, 80-95% WP	3-5 lb	2-1/2 to 4 T	
	Funginex	See label	See label	
	Topsin M	See label	See label	
	Rubigan	See label	See label	
	Bayleton, 25% WP	2-4 oz	See label	
Rhizoctonia stem and root rot	PCNB (Terraclor), 75% WP	1 lb	1 T	Apply Terraclor as a soil drench once or work dust or granules into the top 2 inches of soil about a week before planting. Apply benomyl and Banrot 40% WP as drenches to plants and soil or mix 8% Banrot granules into soil before planting.
Sclerotinia (cottony) stem and root rot	benomyl, 50% WP	See label	See label	
	Banrot	See label	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
CALLA				
Bacterial soft rot	formaldehyde, 38-40% L	See label	See label	Before planting, soak disease-free, dormant rhizomes for 1 hour in solution of 1 part of formaldehyde in 49 parts of water.
CARNATION				
Alternaria branch rot and leaf spot	maneb, 80% WP	1-1/2 lb	1-1/2 T	Use mancozeb, maneb, or Ziram F-4, and captan in alternate sprays at 7- to 10-day intervals. Apply at first sign of disease. Add a spreader-sticker to spray to ensure wetting the foliage. Sanitary measures are important. Spray Zyban, Duosan, Dyrene, and chlorothalonil according to label directions.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	captan, 50% WP	2 lb	2 T	
Greasy blotch	Duosan, 75% WP	1-1/2 lb	See label	
Other fungal leaf spots	Zyban, 75% WP	1-1/2 lb	See label	
	chlorothalonil	See label	See label	
Anthracnose	Dyrene, 50% WP	1 lb	See label	
	Ziram F-4, 41.5% L	See label	See label	
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day intervals and include a spreader-sticker. Start with captan when cuttings are first stuck in the propagating bench. Keep water off the foliage.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	captan, 50% WP	2-1/2 lb	2-3 T	
	Bayleton, 25% WP	2-4 oz	See label	
	Funginex	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
CARNATION, con't.	captan, 50% WP	1/2 lb	1 T	Apply at 7- to 10-day
Botrytis blight	benomyl, 50% WP	1/2 lb	2 t	intervals in damp, cloudy
or gray-mold	chlorothalonil	See label	See label	weather. Start when disease
	Ornalin, 50% WP	1/2-1 lb	See label	first appears. During bloom,
	Duosan, 75% WP	1-1/2 lb	See label	apply twice weekly. In
	Zyban, 75% WP	1-1/2 lb	See label	greenhouses, may use
	Chipco 26019, 50% WP	1-2 lb	1-2 T	Exotherm Termil. Ornalin may also be
	Topsin M	See label	See label	used as a postharvest spray to cut flowers.
Rhizoctonia	PCNB (Terraclor),			Apply Terraclor or Banrot
stem rot	75% WP	1 lb	1 T	once as preplant drenches.
	benomyl, 50% WP	1 lb	4 t	Follow the manufacturer's
	Banrot	See label	See label	directions. Spray base of
	Chipco 26019, 50% WP	6-1/2 oz	See label	cuttings after they are stuck or spray transplants with benomyl or Chipco 26019.
Fusarium stem rot	captan, 50% WP	1-1/2 lb	1/2 T	Apply captan on a weekly basis.
	benomyl, 50% WP	1/2 lb	2 t	Spray cuttings in rooting medium with benomyl.
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Begin when disease first appears.
	Bayleton, 25% WP	2-4 oz	See label	Repeat at 5- to 21-day intervals.
	sulfur, 80-95%	3-5 lb	2-1/2 to 4 T	Check label.
Pythium root rot	Banrot	See label	See label	Apply as soil drenches at
Phytophthora root rot	Truban, Terrazole, Banol, or			3- to 8-week intervals using 1 gal per 8 sq ft of bed.
Damping-off	Subdue	See labels	See labels	Water chemical in well.
CHRYSANTHEMUM (See also Pot Mums and Field Mums.)				
Ascochyta stem and	maneb, 80% WP	1-1/2 lb	1-1/2 T	Spray foliage and flowers at
ray blight	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	5- to 10-day intervals
Septoria and	captan, 50% WP	2 lb	2 T	during damp weather. Start
other fungal	chlorothalonil	See label	See label	when disease first appears.
leaf spots	benomyl, 50% WP	1 lb	1 T	Add a commercial spreader-
Anthracnose	Duosan, 75% WP	1-1/2 lb	See label	sticker (surfactant) to the
	Zyban, 75% WP	1-1/2 lb	See label	spray to ensure wetting the foliage. Mix benomyl with
	Chipco 26019, 50% WP	1-2 lb	1-2 T	another fungicide. Follow label directions and check label registrations.
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day
	maneb, 80% WP	1-1/2 lb	1-1/2 T	intervals, starting a week
	Bayleton, 25% WP	2-4 oz	See label	before rust is expected.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
CHRYSANTHEMUM, con't.				
Botrytis flower blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray foliage or mist-spray blooms weekly during cool, damp, overcast periods. Use fungicides at half strength on blooms. In greenhouses, may use Exotherm Termil. Ornalin may also be used as a postharvest spray.
	Ornalin, 50% WP	1/2-1 lb	See label	
	chlorothalonil	See label	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Topsin M	See label	See label	
	Botran, 75% WP	1/2 - 3/4 lb	1/2 - 3/4 T	
Powdery mildew	sulfur, 80-95% WP	3-1/2 to 5 lb	2-1/2 to 4 T	Spray at 7- to 14-day intervals, starting when mildew first appears. Add a commercial spreader-sticker (surfactant) to the spray mix. Milban is a restricted-use pesticide.
	benomyl, 50% WP	1/2 lb	2 t	
	Karathane, 19.5% WP	1/4-1/2 lb	1 t	
	Bayleton, 25% WP	2-4 oz	See label	
	Milban, 39% EC	See label	See label	
	Rubigan	See label	See label	
Foliar nematodes	Temik, 10G	See label	See label	See African Violet.
	Systox 2	See label	2-4 pints	Spray plants until thoroughly wet.
	soil drench	See label	2-4 pints	Apply 1/4 pint per sq ft of bed or bench. For potted plants use 1/4 pint per 6-inch pot. Follow label directions.
Nematodes	Dasanit, 15G	Granules	See label	Apply evenly and incorporate 4 to 6 inches into soil.
	pot mix	Granules	See label	Mix thoroughly into soil. Outdoor use only.
	Temik, 10G	See label	See label	See African Violet.
	Vydate L	See label	See label	See African Violet.
Pot Mums				Make one soil drench application at 100 gal per 400 sq ft of bed. Or mix Banrot or Terraclor into top 2 inches of soil before planting. Mist-spray base of plants with Subdue, Truban, Terrazole, or Banol plus benomyl at 1t of each per gal of water.
Root and stem or foot rots	Subdue, Truban, Terrazole, or Banol +	See labels	See labels	
	PCNB (Terraclor)	See label	See label	
	Banrot	See label	See label	
Field Mums				Make one soil drench application at 100 gal per 400 sq ft of bed at seeding or transplanting. Or mix Banrot or Terraclor into top 2 inches of soil before
Root and stem or foot rots	Subdue, Truban, Terrazole, or Banol +	See labels	See labels	
	PCNB (Terraclor)	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Field Mums, con't.				
	Banrot	See label	See label	planting. Mist-spray base of plants with Subdue, Terrazole, Truban, or Banol plus benomyl at 1t of each per gal of water.
Rhizoctonia stem rot	benomyl, 50% WP	1 lb	1 T	Spray the base of transplants thoroughly and repeat the application 10 to 14 days later.
	Ornalin, 50% WP	1/2-1 lb	See label	
Sclerotinia (cottony) stem rot	Chipco 26019, 50% WP	6-1/2 oz	See label	
Aster yellows Spotted wilt	Apply recommended insecticides at frequent intervals.			Spray at about weekly intervals. Six-spotted leafhoppers are vectors of the aster yellows mycoplasma. Thrips transmit the spotted wilt virus.
CINERARIA				
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Apply sprays at 7- to 10-day intervals during cool, damp, overcast weather. Sanitation is also very important.
	chlorothalonil	See label	See label	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 10-day intervals. Start when mildew is first seen. Karathane may damage open flowers.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Bayleton, 25% WP	2-4 oz	See label	
Root and crown rots	Truban or Terrazole + PCNB (Terraclor), 75% WP	See labels 1/4 lb	See labels 1 t	Drench the soil once with the fungicide mix. Use 1 pint per sq ft of bed or 1/2 pint per 6-inch pot.
CLEMATIS				
Ascochyta leaf spot and stem rot	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage thoroughly at 7- to 10-day intervals during rainy spring and early summer weather.
	sulfur, 80-95% WP	3-4 lb	2-3 T	
Nematodes	Nemacur, 10G	See label	See label	See Ajuga.
CYCLAMEN				
Botrytis blight or crown rot	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 10-day intervals during damp, overcast weather. Mist-spray blooms at 3- to 7-day intervals with benomyl at 1/2 rate. In greenhouses, may use Exotherm Termil.
	Ornalin, 50% WP	1/2-1 lb		
	chlorothalonil	See label	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
CYCLAMEN, con't.				
Fungal leaf spots	Chipco 26019, 50% WP	1-2 lb	1-2 T	Spray the foliage at weekly intervals during wet weather.
Nematodes	Dasanit, 15G	See label	See label	See Chrysanthemum.
	Temik, 10G	See label	See label	See African Violet.
DAFFODIL—See Narcissus.				
DAHLIA				
Botrytis flower blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Mist-spray blooms weekly in cool, damp, overcast weather. Start when disease first appears. Add a commercial spreader-sticker (surfactant) to the spray to ensure wetting.
	maneb, 80% WP	3/4 lb	3/4 T	
	mancozeb, 80% WP	3/4 lb	3/4 T	
	Zyban, 75% WP	1-1/2 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Powdery mildew	Funginex	See label	See label	Spray or dust the foliage at 7- to 10-day intervals, starting when mildew first appears. Avoid applications in hot weather at temperatures over 85°F. Apply benomyl, Bayleton, or Funginex at 10- to 14-day intervals.
	benomyl, 50% WP	1/2 lb	2 t	
	sulfur, 80-95% WP	3-5 lb	2-1/2 to 4	
	Karathane, 19.5% WP	1/4-1/2 lb	1 t	
	Bayleton, 25% WP	2-4 oz	See label	
	Rubigan	See label	See label	
Crown and root rots	Banrot	See label	See label	Drench seedlings and transplants with Banrot or Chipco 26019 or blend Banrot into soil before planting. Follow the manufacturer's directions.
	Chipco 26019, 50% WP	6-1/2 oz	See label	
Foliar nematodes	Temik, 10G	See label	See label	See African Violet.
DELPHINIUM, LARKSPUR				
Sclerotium root and crown rot	PCNB (Terraclor), 75% WP	1 lb	1 T	Apply as a soil drench at 1 pint per sq ft after planting or to the base of established plants as new growth appears. Banrot or Terraclor granules can be blended into soil before planting.
Sclerotinia wilt	Banrot	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
DELPHINIUM, LARKSPUR, con't.				
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage thoroughly at 7- to 21-day intervals, starting when mildew is first seen. Follow all label directions carefully.
	Karathane, 19.5% WP	1/4 lb	1 t	
	sulfur, 80-95% WP	3-5 lb	2-1/2 to 4 T	
	Bayleton, 25% WP	2-4 oz	See label	
	Rubigan	See label	See label	
Fungal leaf spots	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 10-day intervals. Start when disease first appears. Sanitary measures are important.
	Topsin M	See label	See label	
Botrytis blight or gray-mold	chlorothalonil	See label	See label	Spray the foliage and flowers at 7- to 10-day intervals during cool, damp, overcast periods. Reduce the fungicide rate when the plants are in flower.
	benomyl, 50% WP	1/2 lb	2 t	
	Topsin M	See label	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Ornalin, 50% WP	1/2-1 lb	See label	
Black leaf spot	fixed copper, 50-56% Cu	See label	See label	Drench soil at base of plants in fall. Spray young shoots in spring with fixed copper at 2 T per gal of water.
DIEFFENBACHIA				
Bacterial soft rot or stem rot	streptomycin formulations	Apply at 200 part s per million.	See label	Dip cane cuttings. Carefully follow the manufacturer's directions on the label.
Fungal root and stem rots Damping-off	Banrot	See label	See label	Keep soil mix on the dry side. Apply Banrot as a soil drench or blend granules into soil before planting. Follow label directions.
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage at 10-day intervals in cool, damp weather. Sanitary measures are important.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Bacterial leaf spot	streptomycin formulations	Apply at 200 parts per million.	See label	Spray the foliage and canes during damp weather, starting when disease appears. Follow all label directions carefully.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
DIEFFENBACHIA, con't.				
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
FOLIAGE PLANTS				
Botrytis blight or gray-mold Sclerotinia blight	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage at 10-day intervals in cool, damp weather. Sanitary measures are very important.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	chlorothalonil	See label	See label	
Fungal cutting, stem, or root rots	Banrot	See label	See label	Apply 100 gal to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Retreat at 4- to 12-week intervals. Apply once as a soil drench at 1 pint per sq ft to established plants. Water liberally. Follow label directions.
	Truban, Terrazole, Subdue + PCNB (Terraclor), 75% WP	See labels	See labels	
		1/4 lb	1 t	
Nematodes	Mocap EC	See label	See label	See Gardenia.
Fungal leaf spots	benomyl, 50% WP	1/2 lb	2 t	Keep water off the foliage. Spray at 10-day intervals during rainy periods. Start when disease appears. Add a commercial spreader-sticker (surfactant) to the spray mix.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Kocide 101, 77% WP	1 lb	1t	
	chlorothalonil	See label	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Root rots	Banrot			Apply 100 gal of 40% WP to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Retreat at 4- to 12-week intervals.
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
	Nemacur, 10G	See label	See label	See Ajuga.
FREESIA				
Bacterial scab	thiram, 75% WP	See label		Thoroughly dust corms before planting and again after cleaning and before putting in storage for the winter.
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray foliage and flowers at 7- to 10-day intervals in cool, damp, overcast weather. Follow label directions.
	Ornalin, 50% WP	1/2-1 lb	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
FUCHSIA				
Botrytis blight or gray-mold	chlorothalonil	See label	See label	Spray at 7- to 10-day intervals in cool, damp, overcast weather. In greenhouses, may use Exotherm Termil. Chlorothalonil and mancozeb also control rust.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	See label	
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Nematodes	Vydate L	See label	See label	See African Violet.
GARDENIA				
Fungal leaf spots	maneb, 80% WP	1-1/2 lb	1-1/2 T	Spray cuttings and plants at 7- to 10-day intervals. Start when disease first appears. Add a commercial spreader-sticker (surfactant) to the spray.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	chlorothalonil	See label	See label	
	fixed copper, 50-56% Cu	See label	See label	
Crown and root rots	Banrot	See label	See label	Apply 100 gal of 40% WP Banrot to 400 sq ft of bed or 1/2 pint per 6-inch pot. Irrigate immediately. Or apply 8% Banrot granules and blend into soil before planting.
Nematodes	Dasanit, 15G	See label	See label	See Chrysanthemum.
	Mocap EC			Apply 1 gal per sq yd. Wash from foliage. After treatment, wet soil to 6 to 12 inches.
	Field nursery stock	1/2 pint	See label	
	Bed and bench	1/2-1 pint	See label	Mix with enough water to cover 1000 sq ft. Wet soil to 4 to 6 inches.
	Pot drench	1/2 pint	See label	Drench with 1/2 pint per 6-inch pot and 1 pint per 8-inch pot.
	Root dip	1 pint	See label	Allow only roots to soak for 30 minutes.
	Nemacur, 10G	See label	See label	See Ajuga.
	Temik, 15G	See label	See label	See African Violet.
	Vydate L	See label	See label	See African Violet.
GERANIUM (*Pelargonium*)				
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray weekly during cool, rainy or damp, overcast weather. Start a month before first cuttings are taken. In greenhouses, may use Exotherm Termil. Keep old flowers and leaves picked off and keep water off the foliage. Check label registrations.
	Ornalin, 50% WP	1/2-1 lb	See label	
	chlorothalonil	See label	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Topsin M	See label	See label	
	Botran, 75% WP	1/2-3/4 lb	1/2-3/4 T	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	Rate[b] 1 gallon	Remarks[c]
GERANIUM, con't.				
Fungal leaf spots	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray or dust at 7- to 14-
	chlorothalonil	See label	See label	day intervals. Start when
	maneb, 80% WP	1-1/2 lb	1-1/2 T	disease first appears. Keep
	Duosan, 75% WP	1-1/2 lb	See label	the foliage protected during
	Zyban, 75% WP	1-1/2 lb	See label	damp, overcast weather when
	Topsin M	See label	See label	infections occur.
	benomyl, 50% WP	1/2 lb	2 t	Sanitary measures are important.
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Rust	Plantvax, 75% WP	1 to 1-1/2 lb	1 T	Apply Plantvax or Bayleton
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	at 2- to 4-week intervals
	maneb, 80% WP	1-1/2 lb	1-1/2 T	when rust first appears.
	Bayleton, 25% WP	2-4 oz	See label	Spray maneb, mancozeb,
	chlorothalonil	See label	See label	and chlorothalonil at 7- to 10-day intervals, starting when rust is first evident.
Rhizoctonia root and stem rot	PCNB (Terraclor), 75% WP	1/2 lb	2 t	Drench established plants
Damping-off	benomyl, 50% WP	1/2 lb	2 t	with Terraclor or Banrot
	Banrot	See label	See label	once, using 1 pint to 1 qt
	Chipco 26019, 50% WP	6-1/2 oz	See label	per sq ft or 1/2 pint per 6-inch pot. Spray base of plants with benomyl every 2 to 3 weeks. Apply Chipco 26019 at seeding and transplant time.
Blackleg (*Pythium*)	captan, 50% WP	2 lb	1-1/2 T	Spray cuttings in the
	Subdue, Truban, Banol, or Terrazole	See labels	See labels	cutting bench. Several spray applications may be needed, spaced 1 to 3 weeks apart.
Other root rots	Subdue, Terrazole or Truban +	See labels	See labels	Drench established, well-
	benomyl, 50% WP	1/2 lb	2 t	rooted plants once. Use 1-1/2
	Banrot	See label	See label	pints to 1qt of fungicide mix per sq ft or 1/2 pint per 6-inch pot.
Foliar nematodes	Temik, 15G	See label	See label	See African Violet.
GERBERA, TRANSVAAL DAISY				
Phytophthora root rot	Truban or Terrazole	See labels	See labels	Apply as a soil drench or
	captan, 50% WP	2 lb	2 T	mix granules thoroughly into
	Banrot	See label	See label	the soil just before planting. Follow the manufacturer's directions.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
GERBERA, TRANSVAAL DAISY, con't.				
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Apply several sprays at 7- to 14-day intervals, starting when mildew first appears.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Bayleton, 25% WP	2-4 oz	See label	
Botrytis blight Damping-off Sclerotinia blight	Ornalin, 50% WP	1/2-1 lb	See label	Spray foliage at 7- to 10-day intervals in damp, cloudy weather. Drench soil at seeding time.
	benomyl, 50% WP	1/2 lb	2 t	
Nematodes	Vydate L	See label	See label	See African Violet.
GLADIOLUS				
Fusarium yellows and corm rot Penicillium corm rot	benomyl, 50% WP	1-2/3 lb	2 T	Within 24 hours after digging, soak corms in a basket or loosely woven sack for 15 to 30 minutes at a water temperature of 80° to 85°F. Or dust corms as for bacterial scab. Dry and store properly.
	Mertect 340-F, 42.28% L	30 fl oz	See label	
	Ornalin, 50% WP	1-1/2 to 2 lb	See label	
	Topsin M	See label	See label	
	Cleary 3336	See label	See label	
Stromatinia corm rot	Botran, 75% WP	20 lb	20 T	Before planting, dip corms following label directions. Or apply Botran in-furrow at 1-1/3 lb per 1000 ft of row at planting time.
	Ornalin, 50% WP	1-1/2 to 2 lb	See label	
	PCNB (Terraclor)	See label	See label	
Bacterial scab	thiram, 75% WP	See label	See label	Dust disease-free corms with thiram or thiram-insecticide combination before planting and just before storage.
Nematodes	Dasanit, 15G	See label	See label	See Chrysanthemum.
	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	92-122 oz/1000 ft of row. Apply in-furrow or band incorporate at least 4 inches deep at planting time.
Botrytis leaf and flower spot and corm rot	Topsin M	See label	See label	Spray weekly during damp or rainy periods. Start when disease first appears. Spray the cut flower spikes with benomyl before shipment or storage. Treat the corms as for Fusarium yellows. Check label registrations. Ornalin may also be used as a postharvest cut flower or corm dip.
	benomyl, 50% WP	1/2 lb	2 t	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	captan, 50% WP	2 lb	2 T	
	chlorothalonil	See label	See label	
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Botran, 75% WP	3/4 lb	3/4 T	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
GLADIOLUS, con't.				
Other fungal leaf spots	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray weekly during rainy periods, starting when the leaf spots first appear. Add a commercial spreader-sticker (surfactant) to the spray.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Dyrene, 65% WP	2 lb	2 T	
	chlorothalonil	See label	See label	
	Ziram F-4, 41.5% L	See label	See label	
GLOXINIA				
Botrytis bud and flower rot	benomyl, 50% WP	1/2 lb	2 t	Spray weekly in cool, damp, overcast weather. Start when the buds first begin to appear. Sanitary measures are important.
	chlorothalonil	See label	See label	
	Topsin M	See label	See label	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Crown rot Leaf and tuber rot	Banrot	See label	See label	Drench established plants once, using 1 pint to 1 qt per sq ft of bed or 1/2 pint per 6-inch pot.
	Banol, Subdue, Truban, or Terrazole	See labels	See labels	
HOLLYHOCK				
Rust Leaf spots Anthracnose	chlorothalonil	See label	See label	Thoroughly spray or dust 5 or 6 times, 7 to 10 days apart. Start when new foliar growth commences in the spring. Sanitation is important. Check label registrations.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	sulfur, 80-95% WP	3-5 lb	2-1/2 to 4 T	
	Bayleton, 25% WP	2-4 oz	See label	
HYACINTH				
Botrytis blight or gray-mold	PCNB (Terraclor), 75% WP	1/2 lb	2 t	Drench once after panning. Repeat if gray-mold appears, using Botran at half strength. Or try benomyl 50% WP at 1/2 lb per 100 gal or 2 t per gal. Check label registrations. Apply Ornalin as a spray only.
	Botran, 75% WP	1 lb	1 T	
	Ornalin, 50% WP	1/2-1 lb	See label	
Fungal bulb rots	Truban or Terrazole + benomyl, 50% WP or Mertect 340-F, 42.28% L thiram, 75%WP	See labels	See labels	See remarks for root rot complex of lily for fungicide combinations. Dust disease-free bulbs with thiram just before planting or storage or dip bulbs for 5 to 30 minutes in an Ornalin, PCNB (Terraclor) 75% WP or Mertect 340-F suspension.
		1/2 lb	2 t	
		30 fl oz	See label	
	Ornalin, 50% WP	1-1/2 to 2 lb	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
HYDRANGEA—See *1989 Plant Disease Control Guide: Woody Ornamentals*, Circular 1260.				
IRIS				
Leaf spots	chlorothalonil	See label	See label	Spray 4 to 6 times, 7 to
Rust	maneb, 80% WP	1-1/2 lb	1-1/2 T	10 days apart. Start when
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	new leaves are several
	benomyl, 50% WP	1 lb	1 T	inches tall. Add a
	Bayleton, 25% WP	1 lb	See label	spreader-sticker to the
	Chipco 26019, 50% WP	1-2 lb	1-2 T	spray to ensure better wetting and coverage. If
	Topsin M	See label	See label	rust is a problem, spray with mancozeb, maneb, Bayleton, or chlorothalonil.
Fungal crown, rhizome, and bulb rots	PCNB (Terraclor), 75% WP	1/2 lb	1 T	Apply as a soil drench at 1
	Botran, 50-75% WP	1-1/2 lb	1-1/2 T	pint to 1 qt per sq ft at or before planting and again
	Mertect 340-F, 42.28% L	30 fl oz	See label	when new growth appears in spring. Apply Mertect, Ornalin,
	Topsin M	See label	See label	benomyl, and Topsin M as bulb
	Ornalin, 50% WP	See label	See label	dips only. See under Gladiolus and
	benomyl	See label	See label	Narcissus.
Bacterial soft rot and rhizome rot	Apply recommended insecticides starting when fan leaves are several inches tall.	See label	See label	Spray weekly until bloom. Dig up infected plants after flowering is over and transplant disease-free, borer-free rhizomes. The soft rot bacteria enter through fresh iris borer wounds and other injuries.
Nematodes	Vydate L	See label	See label	See African Violet.
	Dasanit, 15G	See label	See label	See Chrysanthemum.
	Temik, 10G	See label	See label	See Gladiolus.
	Nemacur, 10G	See label	See label	See Ajuga.
IVY, ENGLISH				
Fungus leaf spots and blight	benomyl, 50% WP	1/2 lb	2 t	Spray or dust several times at 7- to 10-day intervals.
Stem spot	fixed copper, 50-56% Cu	See label	See label	Keep the foliage protected
Twig blight	Duosan, 75% WP	1-1/2 lb	See label	during rainy spring and
	Zyban, 75% WP	1-1/2 lb	See label	early summer weather. Start
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	when the disease first appears.
	Chipco 26019, 50% WP	1-2 lb	1-2T	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
IVY, ENGLISH, con't.				
Root rot Crown rot	Banrot	See label	See label	Keep soil mix on the dry side. Apply Banrot as a soil drench or blend granules into soil before planting. Follow label directions. Apply Chipco 26019 at transplant time.
	Chipco 26019, 50% WP	6-1/2 oz	See label	
Nematodes	Nemacur, 10G	See label	See label	See Ajuga.
	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage at 10-day intervals in cool, damp weather. Sanitary measures are important.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
KALANCHOE				
Crown or stem rot Wilt Root rot	Banrot	See label	See label	Drench plants once at 1 pint to 1 qt per sq ft or 1/2 pint per 6-inch pot. Or blend 8% Banrot granules into soil before planting.
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 14-day intervals. Start when mildew first appears. Add a commercial spreader-sticker (surfactant) to the spray. Milban is a restricted-use pesticide.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Zyban, 75% WP	1-1/2 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Milban, 39% EC	See label	See label	
Botrytis blight or gray-mold Sclerotinia blight	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 10-day intervals during cool, damp, overcast weather. Sanitary measures are very important. Keep water off the foliage.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	See label	Same as for Botrytis blight above. Keep water off the foliage.
	Zyban, 75% WP	1-1/2 lb	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
LARKSPUR—See Delphinium.				
LILY				
Root rot complex	Subdue, Terrazole, or Truban + benomyl, 50% WP	See labels 1 lb	See labels 4 t	Drench established plants with Subdue, Terrazole, or Truban plus benomyl at 1/2 pint per 6-inch pot and repeat at monthly intervals. Or mix Subdue, Truban, or Terrazole or Banrot granules into potting mix. Banrot can be applied at 4- to 12-week intervals.
	Banrot	See label	See label	
	Banol, Subdue, Terrazole, or Truban + benomyl, 50% WP or Mertect, 340-F, 42.28% L	See labels 2.7 oz 30 fl oz	See labels See label See label	Dip bulbs 10 to 30 minutes just before planting and within 24 hours after digging. Or mix Truban, Banrot, or Terrazole into porous potting mix. Drench growing plants monthly with Terrazole, Subdue, Truban, Banol, or Banrot. Follow manufacturer's directions.
	Banrot	See label	See label	
	Topsin M	See label	See label	
Botrytis flower blight or gray-mold and leaf spot or blight	benomyl, 50% WP	1/2 lb	2 t	Spray 3 times, 7 days apart, starting when disease first appears on the lower leaves. Mist-spray buds and blooms with benomyl at 1/4 lb per 100 gal or 1t per gal. In greenhouses, may use Exotherm Termil. Sanitation is important.
	chlorothalonil	See label	See label	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Topsin M	See label	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
Bulb rots (*Rhizopus and Penicillium*)	thiram, 75% WP or thiram + benomyl, 50% WP	See labels	See labels	Clean bulbs thoroughly and dust blemish-free ones with thiram or thiram plus benomyl before placing in storage. Discard all diseased bulbs when first discovered.
Fusarium bulb rot Phytophthora shoot or foot rot	Truban or Banol + benomyl, 50% WP or Mertect 340-F, 42.28% L	See labels	See labels	Thoroughly mix fungicides into soil just before planting or drench the plants after potting as outlined for root rot complex. Dip bulbs for 10 to 30 minutes as given under root rot complex.
	Banrot	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
LILY, con't.				
Virus diseases	Apply recommended insecticides to prevent insects from feeding.			Spray at about weekly intervals to control aphids that spread the viruses from plant to plant. Or fumigate greenhouses following label directions.
Nematodes (Easter lily)	Nemacur, 10G	See label	See label	See Ajuga.
	Temik, 15G	See label	See label	
	Dasanit, 15G	See label	See label	See Chrysanthemum.
MARIGOLD				
Botrytis blight or gray-mold	Chipco 26019, 50% WP	1-2 lb	1-2 T	Apply several sprays at 7- to 14-day intervals during cool, damp, overcast weather when infection occurs. Sanitary measures are very important.
	benomyl, 50% WP	1/2 lb	2 t	
	chlorothalonil	See label	See label	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
Phytophthora stem rot and wilt	Banol, Terrazole, Truban, or Subdue	See labels	See labels	Thoroughly mix the fungicide into the soil just before planting and/or transplanting or apply as a soil drench after planting.
	Banrot	See label	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
NARCISSUS, DAFFODIL				
Fungal bulb rots	PCNB (Terraclor), 75% WP	50 lb	1/2 lb	Dip cleaned bulbs for 5 to 30 minutes in a suspension of Terraclor, Mertect, Cleary 3336, Topsin M, or benomyl with water at 80° to 85°F. Apply Ornalin according to label directions. Or dust bulbs with thiram before planting and again before putting in storage. Keep bulbs dry.
	Mertect 340-F, 42.28% L	30 fl oz	See label	
	benomyl, 50% WP	1-2/3 lb	2 T	
	Ornalin, 50% WP	1-1/2 to 2 lb	See label	
	thiram, 75% WP	See label	See label	
	Topsin M	See label	See label	
	Cleary 3336	See label	See label	
Foliar nematodes				See Chrysanthemum.
ORCHIDS				
Black rot Root rot Damping off	Truban or Terrazole	See labels	See labels	Drench plants following label directions.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
ORCHIDS, con't.				
Botrytis flower spot or blight or gray-mold	chlorothalonil	See label	See label	In closed greenhouses, you may use Exotherm Termil. Test trial varieties for possible injury.
	Ornalin, 50% WP	1/2-1 lb	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
Foliar nematodes	Temik, 10G	See label	See label	See African Violet.
PACHYSANDRA				
Volutella leaf and stem blight or canker	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Make 5 spray applications at about 10- to 14-day intervals starting in the spring when new growth begins.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	chlorothalonil	See label	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
	Nemacur, 10G	See label	See label	See Ajuga.
	Temik, 10G	See label	See label	See African Violet.
PANSY, VIOLET, VIOLA				
Anthracnose Scab Fungal leaf spot Botrytis blight or gray-mold	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray weekly during damp or rainy periods. Start when disease first appears. Add a spreader-sticker (surfactant) to all sprays. Also make a fall application just before covering plants with mulch. Check labels carefully.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	benomyl, 50% WP	1/2 lb	2 t	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	chlorothalonil	See label	See label	
Rust Powdery mildew	Bayleton, 25% WP	2-4 oz	See label	Spray when disease first appears. Follow label directions.
Seed rot Seedling blights Damping-off	captan	See label	See label	Dust seeds thoroughly with captan just before planting. Screen off excess fungicide. Avoid overseeding and overwatering. Apply Banrot as a soil drench or blend 8% granules into soil before planting. Follow label directions.
	Banrot	See label	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	Rate[b] 1 gallon	Remarks[c]
PELARGONIUM—See Geranium.				
PEONY				
Botrytis blight, leaf blotch, bud blast, shoot blight, and leaf spot	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray weekly during cool, damp, overcast weather. Start when new shoot growth is 2 to 4 inches tall and continue until flowers begin to open. Add a commercial spreader-sticker to the spray.
	benomyl, 50% WP	1 lb	1 T	
	Topsin M	See label	See label	
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
Phytophthora blight	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray foliage, bases of shoots, and nearby soil at 7- to 10-day intervals during rainy periods. Add spreader-sticker to each spray to ensure wetting the foliage.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
Foliar nematodes	Temik, 10G	See label	See label	See African Violet.
Nematodes	Vydate L	See label	See label	See African Violet.
PERIWINKLE (*Vinca minor*)				
Phoma stem rot or canker	benomyl, 50% WP	1/2 lb	2 t	Thoroughly soak stems and soil once before disease appears in midspring.
Nematodes	Nemacur, 10G	See label	See label	See Ajuga.
	Vydate L	See label	See label	See African Violet.
PETUNIA				
Botrytis blight or gray-mold, leaf blotch, and flower blight	benomyl, 50% WP	1/2 lb	2 t	Apply sprays at 10- to 14-day intervals during cool, damp, overcast weather. In greenhouses, may use Exotherm Termil.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	chlorothalonil	See label	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
Fungal root and crown or foot rots (*Pythium* and *Rhizoctonia*)	Banrot	See label	See label	Drench the soil surface using 1 pint to 1 qt per sq ft of bed after plants are set. Repeat several more times at 3- to 12-week intervals. Or blend granules into soil before planting.
	Truban, Terrazole, Subdue, or Banol + PCNB (Terraclor)	See labels	See labels	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
PHILODENDRON				
Bacterial leaf spot	streptomycin formulations	Apply at 200 parts per million.		Remove spotted and dead leaves. Spray foliage during damp weather at 4- to 5-day intervals starting when disease first appears. Follow label directions.
	Kocide 101, 77% WP	1 lb	1t	
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	See label	Spray several times about 10 days apart. Start when spots are first evident. Keep water off the foliage.
	Zyban, 75% WP	1-1/2 lb	See label	
	chlorothalonil	See label	See label	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Damping-off Root and stem rots	Banrot	See label	See label	Drench plants following the manufacturer's directions or blend granules into soil mix before planting.
Nematodes	Mocap EC	See label	See label	See Gardenia.
	Vydate L	See label	See label	See African Violet.
	Temik, 10G	See label	See label	See African Violet.
PHLOX				
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray several times, about 10 days apart. Start when mildew is first seen on the lower leaves. Proper spacing of plants and plenty of sunlight are important.
	Bayleton, 25% WP	2-4 oz	See label	
	Karathane, 19.5% WP	1/4 lb	1 t	
	Funginex	See label	See label	
	sulfur, 80-95% WP	3-1/2 to 5 lb	2-1/2 to 4 T	
	Rubigan	See label	See label	
Fungal leaf spots Rust	benomyl, 50% WP	1/2 lb	2 t	Spray several times, 7 to 10 days apart. Start when disease first appears on the leaves. For rust use Bayleton.
	Bayleton, 25% WP	2-4 oz	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
Root rots	Banrot	See label	See label	Drench plants following the manufacturer's directions.
POINSETTIA				
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 7- to 14-day intervals during cool, damp, overcast weather. Do not spray Ornalin when plants are in color; some poinsettia cultivars may be sensitive to leaf spotting.
	Ornalin, 50% WP	1/2-1 lb	See label	
Stem canker and leaf spot	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
Scab	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	chlorothalonil	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
POINSETTIA, con't.				
Root and stem rot complex (*Rhizoctonia*, *Thielaviopsis*, *Pythium*, etc.)	Banrot	See label	See label	If disease appears after potting, drench established plants once. Apply 1/2 pint per 6-inch pot. If disease appears later, apply Subdue, Banol, Truban, or Terrazole plus benomyl at 1/4 lb per 100 gal using 1/2 pint per 6-inch pot at 21-day intervals. Or apply Banrot alone according to label directions. Apply Chipco 26019 at transplant time to control *Rhizoctonia*.
	Truban, Terrazole, Subdue, or Banol + PCNB (Terraclor), 75% WP or	See labels	See labels	
	benomyl, 50% WP	1/4 lb	1 t	
		1/2-1 lb	3 t	
	Chipco 26019, 50% WP	6-1/2 oz	See label	
ROSE — See *1989 Plant Disease Control Guide: Woody Ornamentals*, Circular 1260.				
SNAPDRAGON				
Anthracnose Fungal leaf spots	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray or dust at 7- to 10-day intervals during rainy periods. Start when disease first appears. Adding a spreader-sticker ensures better wetting. In closed greenhouses, may use Exotherm Termil. Sanitation is important.
	chlorothalonil	See label	See label	
	benomyl, 50% WP	1/2 lb	2 t	
	captan, 50% WP	2 lb	2 T	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Topsin M	See label	See label	
	Ziram F-4, 41.5% L	See label	See label	
Botrytis blight or gray-mold Phyllosticta leaf and stem blight	benomyl, 50% WP	1/2 lb	2 t	Spray at weekly intervals during cool, damp, overcast weather. In closed greenhouses, may use Exerotherm Termil. When plants are in bloom, use only benomyl and at half strength: 1/4 lb per 100 gal or 1t per gal.
	chlorothalonil	See label	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Rust Downy mildew Other fungal leaf spots and blights	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 5- to 10-day intervals in damp or rainy weather. Start when disease first appears. Use mancozeb, maneb, Funginex, or Bayleton to control rusts. Bayleton will not control any of the other diseases.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Zyban, 75% WP	1-1/2 lb	See label	
	Duosan, 75% WP	1-1/2 lb	See label	
	Bayleton, 25% WP	2-4 oz	See label	
	Funginex	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
SNAPDRAGON, con't.				
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 10-day intervals. Add a commercial spreader-sticker to the spray. Use benomyl at 1 t per gal on seedlings.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Bayleton, 25% WP	2-4 oz	See label	
	Funginex	See label	See label	
Rhizoctonia stem and root rot or wirestem	PCNB (Terraclor), 75% WP	1/2 lb	1 T	Apply as a soil drench once to established plants when disease is expected. Follow all label directions. Apply Chipco 26019 at seeding and transplanting time.
	Banrot	See label	See label	
Damping-off	Chipco 26019, 50% WP	6-1/2 oz	See label	
Nematodes	Vydate L	See label	See label	See African Violet.
Pythium and Phytophthora crown and root rots	Banol, Subdue, Truban, or Terrazole	See labels	See labels	Drench established plants using 1 pint to 1 qt per sq ft. Repeat in 4 to 8 weeks if needed.
	Banrot	See label	See label	
STOCK				
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 7- to 10-day intervals during cool, damp, overcast weather. Sanitation is important.
	Duosan, 75% WP	1-1/2 lb	See label	
Fungal leaf spots	Zyban, 75% WP	1-1/2 lb	See label	
Root and stem rots	PCNB (Terraclor), 75% WP	1/2 lb	2 t	Drench plants using 1 pint to 1 qt per sq ft after transplanting. Repeat if the disease appears.
SWEETPEA				
Powdery mildew	Karathane, 19.5% WP	1/4 lb	1 t	Spray several times at 7- to 21-day intervals. Start when mildew first appears on the leaves. Check label directions.
	benomyl, 50% WP	1/2 lb	2 t	
	sulfur, 80-95% WP	3-5 lb	2-1/2 to 4 T	
	Rubigan	See label	See label	
	Bayleton, 25% WP	2-4 oz	See label	
Anthracnose Fungal leaf spots and blights	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 10- to 14-day intervals during rainy weather. Start when disease is first evident.
Anthracnose Streak	formaldehyde, 38-40% L			Dip seed in formaldehyde solution for 5 minutes just before planting in fertile, well-drained soil.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
SWEETPEA, con't.				
Root and stem rots	PCNB (Terraclor)	See label	See label	Thoroughly mix Terraclor and benomyl as dust granules into the top 2 inches of soil before planting. Or apply Terraclor or benomyl as a soil drench once after planting at 1 pint to 1 qt per sq ft.
	benomyl, 50% WP	See label	See label	
TRANSVAAL DAISY—See Gerbera.				
TULIP				
Fire or Botrytis blight or gray-mold	Botran, 75% WP	1 lb	1 T	Spray several times at 5- to 10-day intervals. Start when the leaves emerge and continue to early bloom. Add a spreader-sticker to the spray to ensure wetting the foliage. Treat the soil at planting time and drench the soil before emergence using Botran or benomyl at 1 T per gal. Ornalin may also be used as a bulb dip (1-1/2 to 2 lb per 100 gal).
	chlorothalonil	See label	See label	
	benomyl, 50% WP	1/2 lb	2 t	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Topsin M	See label	See label	
Bulb rots	PCNB (Terraclor), thiram, 50-75% WP, or Truban, or Terrazole	See label	See label	Before planting, dip bulbs for 5 minutes in a Terraclor, Mertect, Topsin M, or Ornalin suspension or 15 to 30 minutes in benomyl or Mertect 340-F in water at temperature of 80° to 85°F. Or dust bulbs thoroughly with thiram. See remarks on root rot complex of lily.
	+ benomyl, 50% WP, or	See labels	See labels	
	Mertect 340-F, 42.28% L	1/2 lb	2 t	
	Ornalin, 50% WP	30 fl oz	See label	
	Topsin M	1-1/2 to 2 lb	See label	
		See label	See label	
VERBENA				
Rhizoctonia stem and root rot	PCNB (Terraclor)	See label	See label	Thoroughly mix Terraclor or Banrot into top 2 inches of soil before planting. Or apply Terraclor, Banrot, or benomyl as a soil drench once after planting at 1 pint to 1 qt per sq ft.
	benomyl, 50% WP	See label	See label	
	Banrot	See label	See label	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
VERBENA, con't.				
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	See label	Spray foliage several times at 10-day intervals during wet periods. Start when disease first appears.
	Zyban, 75% WP	1-1/2 lb	See label	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Powdery mildew	Rubigan	See label	See label	Make two or more applications 10 to 14 days apart.
Nematodes	Vydate L	See label	See label	See African Violet.
VINCA—See Periwinkle.				
VIOLA, VIOLET—See Pansy.				
ZINNIA				
Alternaria leaf spot or blight	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray foliage weekly during rainy periods in spring and early summer. Start when disease first appears or when plants are 6 to 12 inches tall. Treat seed with captan 50% WP. Sanitation is important.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Powdery mildew	Funginex	See label	See label	Thoroughly spray the foliage at 7- to 10-day intervals. Start when mildew first appears. Adding a commercial spreader-sticker (surfactant) to the spray usually aids in disease control. Milban is a restricted-use pesticide.
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	benomyl, 50% WP	1/2 lb	2 t	
	Karathane, 19.5% WP	1/4 lb	1 t	
	chlorothalonil	See label	See label	
	Bayleton, 25% WP	2-4 oz	See label	
	Milban, 39% EC	See label	See label	
	Rubigan	See label	See label	
Botrytis blight or gray-mold	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage several times at 10- to 14-day intervals during cool, damp, overcast weather. Sanitary measures are very important.
	Ornalin, 50% WP	1/2-1 lb	See label	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Duosan, 75% WP	1-1/2 lb	See label	
	Zyban, 75% WP	1-1/2 lb	See label	
	chlorothalonil	See label	See label	
Root and stem rot complex	Banrot	See label	See label	Thoroughly drench the soil around established plants once. Use 1 pint to 1 qt of spray mix per sq ft of bed. Apply Chipco 26019 at seeding and at transplant time to control *Rhizoctonia*.
	Banol, Subdue, Terrazole, or Truban + PCNB (Terraclor), 75% WP	See labels	See labels	
		1/2 lb	2 t	
	Chipco 26019, 50% WP	6-1/2 oz	See label	

See footnotes at the beginning of Table 3.

Fungicides, Disinfectants, Grain Preservatives, Surfactants, and Soil-Disinfesting Chemicals

M. Shurtleff, R. Wagner, W. Kirby, and D. Eastburn

FUNGICIDES

ANILAZINE [4,6-dichloro-N-(2-chlorophenyl]-1,3,5-triazine-2-amine or 2,4-dichloro-6-(o-chloranilino)-s-triazine]

A broad-spectrum, protective foliar fungicide that is useful in controlling many turfgrass diseases plus some anthracnose, *Botrytis* blights, fungus leaf spots, and blights of many vegetables, woody ornamentals, flowers, bush and bramble fruits, and strawberries.

Trade names. Dyrene 50% Wettable Powder Foliage Fungicide; Agway Granular Turf Fungicide with Dyrene; Patterson's Turf Fungicide W/Dyrene; Dyrene Lawn Disease Control; Scotts ProTurf Fungicide III; Dymec 50 Turf Fungicide; Dyrene Turf Fungicide; Lescorene; Lofts Lawn Fungicide; Dyrene 4; Professional Lawn Disease Control.

BENOMYL [Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate]

A broad-spectrum fungicide that is preventive, curative, long lasting, and systemic. Benomyl is effective against a wide range of fungus diseases on a wide range of plants.

Trade names. DuPont "Benlate" Fungicide, Benlate 50 DF, and Benlate PNW; Security Benomyl Spray; Tersan 1991 Turf Fungicide; Benlate PNW; Bonide Benomyl (DuPont New Systemic Fungicide); Science Benomyl Systemic Fungicide; Rockland Benomyl Fungicide; Benomyl Turf Fungicide; Miller's Benomyl Systemic Fungicide; Patterson's Benomyl Systemic Fungicide; Scotts ProTurf fertilizer plus DSB Fungicide; Lebanon Fungicide Type B; Ferti-lome Systemic Fungicide; Security Benomyl Spray.

BORDEAUX MIXTURE [A mixture of hydrated spray lime and copper sulfate]

A broad-spectrum, long-lasting, protective fungicide now used mostly as a soil drench, dormant spray, and a foliar spray to control needle diseases of conifers. It is also used as an insect repellent, as an emulsifier in dormant oil sprays, and as a general disinfectant for work surfaces, storage cellars, and other areas.

Trade names. Prepared dry bordeaux products include Acme Bordeaux Mixture; Patterson's Bordeaux Mixture; Copper Hydro Bordo; Bor-dox; Pratt Bordeaux Mix; Black Leaf Bordeaux Powder; Ortho Bordo Mixture; Nutra-Spray Copper Bordeaux 22.

BOTRAN (DCNA) [2,6-dichloro-4-nitroaniline]

A foliar, seed, soil, preharvest and postharvest fungicide that controls a range of seed decays and seedling blights; stem (crown), fruit, bulb or corm rots; and

blights of certain vegetables, tree and bush fruits, and ornamentals caused by species of *Botrytis*, *Monilinia*, *Rhizopus*, *Sclerotinia*, and *Sclerotium*. Also effective as a cut-flower spray or dip for *Botrytis* control. Botran may injure some tender crops.

Trade names. Botran 75W; Botran 75WP; Gustafson Botran 30-C; E-Z-Flo Botran 6 Dust. Bo Cap and Botec Peanut Seed Protectant are 30-30 mixtures of Botran and captan.

CAPTAN [N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide]

A broad-spectrum fungicide used on foliage, fruit, and in soil. Does NOT control powdery mildews and rusts. Available primarily as wettable spray powders, flowables, dusts, and special flowable seed protectants. Both a protectant and a mild eradicant. Captan is more effective against *Botrytis* under low temperatures (48°-50°F) than some other fungicides.

Trade names. Captan 75 Seed Protectant, Captan 10 Potato Seed Protectant, Captan-Moly-Planterbox Treater, Captan-Thiram 43-43 WP & Dust; Gallotox Captan FP-700R; Agway Captan 5D and 7.5D; Miller's Captan 50W; Captec 4L; Micro Flo Captan 4L 50 WP and 80WP; Patterson's Captan Garden Spray; F & B Captan 7.5 Dust and Captan 50-WP; Chipman Captan Dust; Hopkins 7-1/2% Captan Dust; Security Captan Garden Spray; Occidental Captan; Security Captan; Miller's Captan Dust and Captan Garden Dust; Bonide Captan 50W; E-Z-Flo Captan 7-1/2 Dust; Hopkins 25% Captan Seed Protectant and Captan-Moly Planter Box Seed Protectant; Farmrite Captan 5% and 10% Dust; Green Cross 7.5% Captan Dust; Security 7-1/2% Captan Peach Dust; Naco Captan 7.5 Dust; Chevron 90 Concentrate; Soybean MO(2X) Seed Protectant, Nu-Gro Captan 65 Sprills Seed Protectant; Gustafson (Captan Technical, Captan 400 Seed Protectant, Captan 400-D Seed Protectant, Captan 75% Seed Protectant, Captan 50, Captan 300; Evershield II) Granox is a 30:30 mixture of captan and maneb. Granox P-F-M is a 30:30 combination of captan and maneb with 1% molybdenum. Agrox 2-Way is a combination of captan and diazinon, whereas Agrox D-L plus is a combination of captan, diazinon, and lindane. Both Agrox products are seed protectants. Triple Seed Protectant is a mixture of captan, diazinon, and lindane for use on corn, sorghum, soybeans, beans, and peas as a seed treatment. Capt'n Moly is a combination of 25% captan and 5.3% molybdenum used as a seed treatment for soybeans.

CARBOXIN [5,6-dihydro-2-methyl-N-phenyl-1,4-oxathiin-3-carboxamide or 2-3-dihydro-5-carboxanilido 6-methyl-1,4-oxathiin]

A protective contact-systemic fungicide effective against various seedborne and soilborne smuts (including loose smut of wheat and barley), some seed-rotting and seedling blight fungi, some rusts, common scab of potato, Rhizoctonia damping-off of seedlings, and Verticillium wilt of annuals. Applied to seeds or soil at planting time. It is registered for use on barley, corn, cotton, oats, peanuts, rapeseed, rice, sorghum, soybeans, and wheat.

Trade names. Vitavax Fungicide; Vitavax-25 DB Fungicide; Vitavax-EVS Concentrate; Vitavax Flowable Fungicide; Vitavax-17 Flowable Fungicide.

Vitavax-200 Fungicide contains 37.5% carboxin and 37.5% thiram. Vitavax 200 Flowable Fungicide contains 17% each of carboxin and thiram. Orthocide Vitavax 20-20, Captan 20 Carboxin 20 Seed Protectant, Enhance Vitavax Captan Seed Protectant, Vitavax/Moly, and Captan Vitavax 20-20 Seed Protectant all contain 20% each of

carboxin and captan. Germate and Enhance Plus contain 20% carboxin, 35% maneb, and 18.75% lindane. They are registered for wheat, oats, barley, and soybeans as a drill-box treatment.

CHLORONEB [1,4-dichloro-2,5-dimethoxybenzene]

A protective, locally systemic soil fungicide that controls preemergence and post-emergence damping-off (seedling blights), and root rots of vegetables, soybeans, and ornamentals, as well as *Pythium* blight and snow molds of turfgrasses.

Trade names. Teremec SP; Terraneb SP; Scotts ProTurf Fungicide II; Chloroneb; Nu-Flow D.

CHLOROTHALONIL [2,4,5,6-tetrachloroisophthalonitrile]

A broad-spectrum, protectant fungicide that controls many diseases of vegetables, fruits, flowers, woody ornamentals, and turfgrasses. Gives poor control of soil-borne fungi because of rapid breakdown. Use cautiously; cases of dermatitis have been reported with all formulations.

Trade names. Daconil 2787, 500, and 2787 Flowable Fungicide; Ole 75% Fungicide; Bravo W-75 6F, 500, 720, 90DG and Flowable Fungicide; Ornathol; Turf Disease Control; Exotherm Termil; Diamond 75% Chlorothalonil; Scotts ProTurf 101-V Broad Spectrum Fungicide and ProTurf Fertilizer plus 101 Broad Spectrum Fungicide; Lebanon Fungicide Type D; Green Gold Turf Fungicide; Thal-O-Nil; Fungi-Gard; Ferti-lome Broad Spectrum Liquid Fungicide; Security Fungi-Gard; The Andersons Daconil; Ortho Multi-Purpose Fungicide-Daconil 2787; Ortho Vegetable Disease Control; Ortho Liquid Lawn Disease Control; Ferti-lome Broad Spectrum Liquid Fungicide; Lawn Fungicide 2787. Exotherm Termil is a special formulation (20% chlorothalonil) for use in closed greenhouses to control *Botrytis* and other foliar and flower blights of many species of ornamentals and tomatoes. One can treat 1,000 square feet of greenhouse area. Bravo C/M contains 27% chlorothalonil, 45.8% copper oxycholoride, and 5.4% maneb.

COPPER (Fixed or Neutral) COMPOUNDS

Low toxicity. Moderately residual, broad-spectrum fungicides and bactericides that have largely replaced bordeaux mixture and are available for use on fruits, vegetables, and as sprays, dusts, and soil drenches. Useful for controlling a wide range of fungal leaf and fruit spots; blotches and blights; downy mildews; powdery mildews; rots; scabs; anthracnoses; rusts; and some bacterial diseases including blights of beans, pepper, tomato, lilac, and walnut.

Federal agencies have decided that no tolerance levels need to be established for most copper compounds.

Trade names. These materials can be conveniently divided into five categories:

1. *Sulfates*--Basic Copper Sulfate, Basicop, Copper Pride, Blueshield Agricultural F, Kilcop 53, CP Basic Sulfate, Microcop, Tri-Basic Copper Sulfate, Naco 53% Basic Copper Sulfate, Copper '7' Dust, Spraycop 530, T-B-C-S 53, Neutro Cop 53, Copper 53 Fungicide, Basic Copper "53," Micro Flo Copper, Microsperse Copper 53. Cop-O-Zinc contains copper sulfate plus zinc salt.

2. *Chlorides*--Coprantol, Aceto Copper Chloride, Copper Oxychloride Sulfate, C-O-C-S, Kauritil, C5-56, Coxysul.

3. *Oxides*--Kuprite; Cuprocide; Kocide 101 Wettable Powder, 606, 404S Flowable, 3% and 5% Dust, and SD Seed Dressing; Champion Copper Oxide; Cuprous Oxide; Micro Flo C.O.C.3FL and 53 WP Champion WP; Brown Copper Oxide; and Yellow Cuprocide. Kocide 404S is a flowable formulation containing 27% cupric hydroxide (copper equivalent 17.5%) and 15.5% sulfur for use on peanuts. Kocide 20/20 contains 30.7% copper hydroxide (copper equivalent 20% and metallic zinc equivalent (20%) and is used on stone fruits, pears, and walnuts.

4. *Liquids*, i.e., emulsifiable--Oxy-Cop 8L, Copoloid, K-Cop, Super-Cu, Copper-Count, Copper-Count-N, Sol-u-Cop, Carmel Formula GH-41 & Greenhouse Fogging, Emulsifiable Liquid Copper Fungicide.

5. *Miscellaneous*--Basic Copper Carbonate, Tri-Cop, Zinc Coposil Fungicide, Copper Zeolite.

Copper-Count-S is a liquid fungicide containing 8% ammoniacal copper and 5% sulfur.

DINOCAP [2-1(1-methylheptyl)-4,6-dinitrophenyl crotonate and isomers]

A short residual but good eradicant fungicide specific against powdery mildews of fruits, vegetables, and ornamentals. Also suppresses mites. Do *not* use in hot weather (above 85°F), because dinocap may be phytotoxic. Use a wetting agent with dinocap to ensure wetting the mildew growth.

Trade names. Karathane WD, Karathane Liquid Concentrate, Miller's Karathane 2D and Garden Karaspray.

Dikar is a broad-spectrum fungicide-miticide containing 4.77% dinocap and 72% mancozeb (Dithane M-45) used primarily by commercial apple growers.

Orthocide Karathane 50-6 Wettable contains 50% captan and 4.87% dinocap. It is used on fruits, ornamentals, and vegetables.

DODINE [N-dodecylguanidine acetate]

Controls certain foliar diseases (fungus leaf spots and blotches, scabs, and anthracnoses) of various fruit and nut crops, roses, and shade trees. Gives long-lasting protection; a good eradicant with local systemic activity. Does NOT control powdery mildews and rusts.

Trade names. Cyprex 65-W Fruit Fungicide; Agway Dodine 1D; Miller's Cyprex 4D; Naco Dodine 2,3,4, and 6 Dusts; Cyprex Dodine Dust; E-Z-Flo Cyprex 4 Dust; Hopkins 2% and 4% Dodine Dust; Melprex.

ETRIDIAZOLE [5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole]

Low toxicity. A moderately residual soil and seed fungicide specific for controlling soilborne water molds (*Aphanomyces, Phytophthora, Pythium*) of turf, vegetables, and ornamentals.

Trade names. Terrazole (35% Wettable Powder, 25% EC, 5% Granular, and 4 lb. Emulsifiable), Koban, Truban (30% wettable powder, 25% emulsifiable concentrate, and 5% granular).

Etridiazole-PCNB is sold as Terra-Coat and Terraclor Super X to control seedling disease complex (*Fusarium, Rhizoctonia, Pythium,* and *Phytophthora*) on field crops, vegetables, ornamentals, and turf. Terraclor Super X is also available with disyston and thimet.

MANCOZEB (or Manganese and Zinc Formulations) [Includes products containing zinc and maneb]

Very low toxicity. Excellent, broad-spectrum, largely protective contact seed and foliar fungicide for cereals, corn, sugar beets, nuts, fruits, turfgrasses, vegetables, trees, flowers, and shrubs. Does NOT control powdery mildews.

Trade names. Manzate 200 Fungicide, Manzate 200DF, and Manzate 200 Flowable Fungicide; Dithane M-45 and F-45; Penncozeb; Fore; Acme Fore; Tersan LSR; Amazin Zinc Enriched Maneb 80 Fungicide; Manex; Science Fore Lawn Fungicide; Pratt Lawn & Garden Fungicide and Liquid Maneb; Naco Potato Seed Piece Fungicide Dust; Farmrite Potato Seed Dust; E-Z-Flo Dithane M-45 Potato Seed Piece Fungicide; Potato Seed-Piece Fungicide Dust; Security 6% Dithane M-45; Agsco Blitex Dust DM-6; Sup'-r-Flo Maneb Flowable, Formec 80 Turf & Ornamental Fungicide; Lesco 4 Flowable with Zinc and 80WP.

Zyban and Duosan contain 60% mancozeb and 15% thiophanate-methyl.

MANEB [Manganese ethylenebisdithiocarbamate] plus Maneb and Zinc Formulations

Very low toxicity. Excellent, general, broad-spectrum, largely protectant fungicide used to control a wide range of diseases on a wide range of plants. Controls rusts but NOT powdery mildews.

Trade names. Maneb Spray; Maneb Liquid Fungicide; Maneb Plus; Maneb 4L Plus Zinc; Dithane M-22 Special with Zinc; Aceto Amazin Maneb 80 WP and Maneb 80 and Maneb Flowable; Patterson's Maneb Fungicide; E-Z-Flo Maneb 7 Dust; Shepard Chemical Maneb 80% WP; Pennwalt Maneb 80; Agsco DB Yellow and DB Green; Black Leaf Maneb Fungicide; Agrisect Brand Maneb (Wettable Powders and Dusts); Agway Maneb 4.5D; Champion 2% Maneb Dust; Miller's Dithane M22-6D and Dithane Dust; Twin Light Maneb Dust; Science Maneb Garden Fungicide; Naco Maneb 80 Fungicide; BASF Maneb 80WP; Security Maneb Liquid Fungicide and Maneb Spray; Agrox N-M Drill Box Non Mercurial; Polyram M; Griffin Manex.

Granox Plus contains 50% maneb and 2% thiabendazole. Griffin Pro-Tex contains 32.6% maneb and 4.72% triphenyltin hydroxide. Kalo Maneb-Lindane contains 50% maneb and 18.75% lindane and is used as a seed protectant for cereals and flax. Pro-Tex contains 32.63% maneb and 4.72% triphenyltin hydroxide for potatoes and sugar beets as a foliar spray.

PCNB or Quintozene [Pentachloronitrobenzene]

A very long-lasting soil, turf, seed, bulb, and corm fungicide that controls various soilborne diseases of many vegetables, ornamentals, turfgrasses, cotton, peanuts, rice, and sorghum.

Trade names. Terraclor 75 WP; Tri-PCNB; Pearson's Green Lawn Fungicide; Fungi-clor; Turfcide 10% Granular Fungicide and Emulsifiable Fungicide; Aceto PCNB 80% and 100%; Scotts Lawn Disease Preventer, Turf Builder Plus Lawn Disease Preventer, and ProTurf New FFII; Ortho Lawn Fungicide; LT-2N and LT-Z Seed Protectants; PCNB Seed-Coat; Terra-Coat LT-2 and 2-LF Seed Treatment Fungicide; Naco Terraclor Dust; Terraclor 2 EC and 10% Granular; Lesco PCNB 10% Granular Fungicide; Turfcide 10% Granular and Emulsifiable; Lawn Fungicide Spray; RTU-PCNB.

Captan-PCNB mixtures are sold as Orthocide Soil Treater "X" and "3X"; Orthocide PCNB 10-20 Dust; Orthocide PCNB-Nutrient Spray; Terraclor 20-Captan 10 Dust; Terraclor 50-Captan 25 Wettable Powder, PCNB-Captan 25-25 Wettable Powder.

POLYRAM or METIRAM [Zinc polyethylenethiuram disulfide complex or polyethylene polymer]

Very low toxicity. A broad-spectrum, largely protectant fungicide for application on foliage, fruit, seed, and soil. Polyram's range of activity is very similar to mancozeb and maneb.

Trade names. Polyram Wettable Powder; Niagara Polyram 80 WP, 7 Dust, and Seed Treater; Security Polyram; Farmrite Potato Seed Piece Treater; Gold Kist 5% Polyram Dust; Agway Polyram 7D and Polyram 80W, Naco Polyram 3.5 Dust and Polyram Dust; Polyram 80 Wettable Powder; Polyram 7 and 10 Dust; Polyram Seed Treater; Hopkins Potato Seed Treater-P Fungicide; Niagara Polyram Potato Seed Treater.

Polyram-PCNB is sold as a 10:10 dust.

STREPTOMYCIN [Streptomycin sulfate or nitrate]

A short residual, antibacterial antibiotic used to control fire blight of some fruits and ornamentals; walnut blight; bacterial spots of pepper, tomato, and foliage plants; bacterial wilts; blights and rots of various trees and ornamentals; and blackleg (soft rot) of potato. May cause injury to some plants. Apply only under slow-drying conditions (such as during the night) and before infections occur. Do *NOT* use at low temperatures, which impair its effectiveness. Streptomycin should be used alone unless it has been purchased in prepared mixes.

Trade names. Agrimycin 17; Streptomycin 17; Streptomycin Antibiotic Spray Powder; Streptomycin Wettable Powder; Agri-Strep 500; Security Fire Blight Spray; Gustafson Agricultural Streptomycin. Agri-mycin 100 and 500 also contain the antibiotic oxytetracycline (Terramycin).

Captan-Streptomycin 7.5-.01 Potato Seed-Piece Protectant contains 7.5% captan and 0.01% streptomycin.

Hopkins Bean Seed Protectant contains 25% each captan and diazinon, and 6.25% streptomycin sulfate.

SULFUR COMPOUNDS (including Liquid Lime-Sulfur)

Old-time combination fungicide-insecticide-miticide that is only protective. It controls powdery mildews, rusts, and many fungus leaf spots, blights, scabs, and fruit rots, on a wide range of fruits, vegetables, and ornamentals. May injure plants in hot (85°F or above), dry weather. In dust form the particles should be fine enough to pass through a 325-mesh screen.

Trade names. Sulfur; Sulfuron; Microfine Sulfur; Corosul S; Sandoz Thiolux Dry Flowable Sulfur; Kolodust; Kolospray; Microsperse Wettable Sulfur; Bonsul Spray-Dust Sulphur; Naco Micronized Wettable Sulfur; Pratt Wettable Sulfur; Sperlox-S; Nutonex Sulphur Wettable; Ortho Flotox Garden Sulfur; Magnetic 95; Micro-Sul; Micro-Sul Wettable Powder; Magnetic 6 Flowable Sulfer; THAT; Micro Flo Dual Spraying and Dusting Sulfur, Endura Sulfur, Micro Flo Sulfur.

Kolofog contains 30% fused bentonite sulfur. Fungi-Sperse, Liquid Sulfur 6, Super Six, and Sperlox are liquid sulfurs. Magnetic 6 and Super Six are trade names for flowable sulfur, a microfine formulation in a liquid suspension with an average particle size not more than 5 microns. Micro-Sperse contains 54% sulfur and 3% copper.

Lime-sulfur (calcium polysulfides) is a combination fungicide-insecticide (scalecide)-miticide more phytotoxic than other sulfurs. It is caustic, disagreeable to apply, and will discolor paint. Now used exclusively as a dormant or delayed dormant spray for bush and tree fruits, roses, and other woody plants.

Lime-sulfur is sold as Acme Lime Sulfur Spray, Miller Lime Sulfur Solution, F & B Lime Sulphur Solution, Security Lime Sulfur, Ortho Dormant Disease Control, Ortho Orthorix Lime-sulfur Spray.

THIABENDAZOLE OR TBZ [2-(4-thiazolyl) benzimidazole]

Very low toxicity. A broad-spectrum, preventative-curative-systemic fungicide closely related to benomyl and used to control a variety of the same diseases. Useful as a foliar, fruit, bulb, corm, tuber, seed, and soil fungicide, and for thermal fumigation. Formulated as a 60% wettable powder, 45% flowable, and smoke generator.

Trade names. Mertect 340-F; Tecto; Potato Seed Dust T; Thiabendazole; TBZ.

Arbotect 20-S, the hypophosphite salt of TBZ, is registered for the control of Dutch elm disease and sycamore anthracnose.

THIOPHANATE MATERIALS, Dimethyl or diethyl [(1,2,-phenylene) bis-(iminocarbonothioyl)] bis carbamate]

Very low toxicity. Broad-spectrum, preventative-curative-systemic fungicides closely related to benomyl and used to control a variety of the same diseases on turfgrasses, fruits, vegetables, cereals, ornamentals, and nursery crops. Formulated as wettable powders, 3% paste, 50% ULV, flowables, and dusts.

Trade names. Topsin-M 70WP, ULV 4.5F, and EC; Fungo 50; Cleary 3366; Tops 2.5 D; Topmec 70W Turf Fungicide; Scotts ProTurf Systemic Fungicide and ProTurf Fertilizer plus Systemic Fungicide.

Banrot is a combination of etridiazole (Truban 15%) and thiophanate-methyl (Topsin M 25%). Zyban and Duosan are combinations of thiophanate-methyl (15%) and mancozeb (60%) used as foliar sprays on woody and nonwoody ornamentals and nursery crops. Bromosan is a combination of thiophanate-ethyl plus thiram; Scotts ProTurf Fluid Fungicide is a combination of thiophanate-methyl plus iprodione.

THIRAM or TMTD [Tetramethylthiuram disulfide]

A broad-spectrum, protective fungicide for field crops, vegetables, flowers, grasses, and certain tree and bush fruits. Controls rusts but NOT powdery mildews. Applied to seed or soil as a dust or drench to control crown rot, damping-off, and seedling blights. Do NOT apply to produce intended for canning or deep freezing as it may "taint" the produce.

Trade names. Thi-Protect-L; Moly-Co-Thi; Agway Thiram 4.8D and Tinasad; E-Z-Flo 5% Thylate Dust; Rhodia Sup'r-Wet Thiram; Farmrite Thiram "95" and 5% Dust; Liquid Thi Concentrate; Doggett Fison Turftox; Metasol Thiram 75%; Robeco Thiram 98/100%; Shephard Chemical Thiram; Occidental Thiram; Fungisan; Southland Pearson Moly-Stand; Chipco Thiram 75; Naco Hi-Test Thiram Wettable Powder; Thiuram 75; Spotrete F and WP75; Thiramad Turf Fungicide; Niagara Thiram 65 Wettable Powder; Aceto Thiram-75; Thiram 65% and Thiram-100; Miller's Thiram 65 and 75W; Chemform 75% Thiram WP; Kerr-McGee Thiram; Science Gladiolus and Bulb Dust; Lebanon Fungicide Type T; Lesco Thiram 75WP; Polyram-Ultra; Fernason; Gustafson Thiram Technical; Lesco Thiram 75WP; Micro Flo Thiram 75WP Fungicide. Moly-T and Planter Box Soybean Seed Treatment contain 26.6% thiram, 5.27% molybdenum, and 15% graphite.

Lesco Snow Mold Turf Fungicide is a granular containing 2.5% thiram and 0.38% cadmium chloride.

ZIRAM [Zinc dimethyldithiocarbamate]

Very low toxicity. General, fungicide, strictly protective. Useful for certain fungus leaf spots and blights of vegetables, fruits, nuts, and ornamentals; especially good for tender seedlings. Applied as spray, dust, or soil drench. Does NOT control rusts or powdery mildews.

Trade names. Karbam White; Ziram Spray Fungicide; Aceto Ziram-75 and -100; Allied Ziram; E-Z-Flo Ziram 76WP; Miller's Ziram and 95W; Wood Ridge Ziram; Cuman; Chempar Ziram 76WP; Corozate; Shepard Chemical Ziram; Samincorp Ziram; Ziram F-4; Ziram 76WP.

FUNGICIDES OF LESS GENERAL USE

University of Illinois Cooperative Extension Service circulars 1184, 1231, 1259, and 1260 are also sources of further information. These chemicals include a large number of products with limited use. In this paper, see also **Disinfectants; Grain Preservatives; Lawn Fungicides; Other Soil Treatments (including Nematicides); Table 1, Soil-Disinfecting Chemicals; Surfactants or Surface-Active Agents.**

Banrot--A very effective broad-spectrum, contact-systemic soil fungicide for control of damping-off and root and stem rots of a broad range of ornamentals caused by *Fusarium, Phytophthora, Pythium, Rhizoctonia,* and *Thielaviopsis.* The 40 WP formulation contains 15% etridiazole and 25% thiophanate-methyl as the active ingredients, while the 8% granules contain 3% etridiazole and 5% thiophanate-methyl.

Fenarimol (Rubigan)--A broad-spectrum, protective, curative, and locally systemic foliar fungicide that is highly effective against many different fungi-infecting ornamentals, turfgrasses, and fruits. Available as a 12.5% EC and a 50% WP. Contains a-(2-chlorophenyl)-a-(4-chorophenyl)-5-pyrimidime methanol as the active ingredient.

Imazalil (Gustafson Flo-Pro-IMZ, Nu-Zone 10EC)--A systemic fungicide for the control of root and foot rots and seedling diseases of barley and wheat. It is also used to control postharvest decay of some fruit crops. Contains 1-[2-(2,4-dichlorophenyl)-2-(2-propenyloxy) ethyl]-1H-imidazole as the active ingredient. Formulations include emulsifiable concentrates (10, 20, 50, and 80%), 75% water soluble powder, 5.8% liquid, 50% oily liquid, and 0.5% granules.

Iprodione (Chipco 26019 50WP and 2 Flo, Rovral 50WP)--A broad-spectrum contact seed, soil, and foliar fungicide for fruits, ornamentals, turf, and vegetables, with excellent activity against *Botrytis, Corticium, Monilinia, Sclerotinia, Penicillium, Rhizopus, Ascochyta, Phoma, Alternaria, Fusarium, Helminthosporium (Drechslera), Rhizoctonia, Sclerotium,* and *Sclerotinia.* Scotts ProTurf Fungicide VI is a granular turfgrass fungicide containing 1.3% iprodione. Iprodione contains -(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidine carboxamide as the active ingredient.

Fosetyl-Al (Aliette)--A systemic, wettable powder foliar and soil fungicide with preventative and curative activity for use on turf, grapevine, strawberries, vegetables, and woody and nonwoody ornamentals to control *Pythium* and *Phytophthora* species. It contains 80% aluminum tris(O-ethyl phosphonate) as the active ingredient.

Metalaxyl (Subdue 2E and 2G and 5G; Apron 25W and FL; Ridomil 2E and 5G; Scott's Pro Turf Pythium Control)--Wettable powder, granular, and emulsifiable concentrate protective seed, soil, and foliar fungicides with systemic properties for fungal diseases of field crops, vegetables, grapes, raspberries, apples and nut trees (nonbearing), woody and herbaceous ornamentals, turf, peanuts, and hops. Fungi controlled include certain downy mildews, *Pythium* and *Phytophthora* spp. Contains N-(2,6-dimethylphenyl)-N-(methoxyacetyl)alanine methyl ester as the active ingredient. Ridomil MZ58 is a combination of 10% metalaxyl and 48% mancozeb. Ridomil/Bravo 81W is a combination of 9% metalaxyl and 72% chlorothalonil widely used on vegetables and certain deciduous tree and bush fruits to control a wide range of diseases.

Milban--a fungicide specific for control of powdery mildews on certain ornamentals. Contains 39% dodemorph acetate or 4-cyclododecyl-2,6-dimethyl-morpholinium acetate as the active ingredient. Milban is a restricted-use pesticide.

Propamocarb (Banol)--A completely miscible soil and foliar fungicide active against species of *Pythium* and *Phytophthora* attacking turfgrasses and woody and herbaceous ornamentals. It contains propyl 3-(dimethylamino)propyl carbamate monohydrochloride as the active ingredient.

Propiconazole (Banner, Tilt)--A turf, grass (grown for seed), and wheat, barley, and rye protective, curative, and systemic fungicide that controls rusts, powdery mildews, anthracnose, Septoria leaf blight and glume blotch, tan spot, barley scald and net blotch, dollar spot, red thread, leaf smuts, brown patch, necrotic ring spot and summer patch, leaf spot, and melting out. Contains 1-[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl)-1H-1,2,4-triazole as the active ingredient.

Triadimefon (Bayleton, Scotts ProTurf Fungicide 7)--A 25% or 50% wettable powder, protective fungicide with systemic and eradicant properties. Has excellent activity against rusts, powdery mildews, and other fungi on fruits, vegetables, turf, ornamentals, and small grains. Contains 1-(4-chlorophenoxy) 3,3-dimethyl-1-(1H-1,2,4-trizol-1yl)-2-butanone as the active ingredient.

Triadimenol (Baytan)--A systemic fungicide used as a seed treatment for small grains. Controls loose smut and bunt of wheat and barley, head smut of corn and grain sorghum, and provides protection for 40 to 60 days after planting for control of powdery mildew, leaf rust, take-all of wheat and barley, and *Septoria nodorum* on wheat. Contains 3-(4-chlorophenoxy)-a-(1,1,dimethylethyl)-1H-1,2,4 triazole-1-ethanol as the active ingredient.

Triforine (Ortho Funginex, Funginex 1-6 EC)--A foliar, locally systemic (also protectant-contact-curative) fungicide that gives excellent control of powdery mildews, scabs, rusts, fungus leaf spots, blights, anthracnoses, and rots of ornamentals, fruits, vegetables, and cereals. Triforine is an emulsifiable concentrate that contains N,N'[1,4,piperazinediyl-bis(2,2,2-trichloroethylidene)-bis-[formamide]] as the active ingredient.

Triphenyltin hydroxide or TPTH (Du-Ter, Duter, Du-Ter 30 F, Griffin Super-Tin 4L).--Long-lasting protective fungicide for use on white potatoes, sugar beets, soybeans, carrots, peanuts, and pecans. Contains triphenyltin hydroxide as the active ingredient.

Vinclozolin (Ornalin, Ronilan, Vorlan)--A long-lasting protective-contact fungicide used as a seed, bulb and corm treatment, foliar spray, and postharvest dip for turf, woody and herbaceous ornamentals, vegetables, and small fruits to control *Botrytis, Monilinia, Sclerotinia, Ovulinia, Drechslera, Stromatinia, Ciborinia, Fusarium, Rhizoctonia,* etc. It is sold as a 50% wettable powder and 41.3% flowable. Contains 3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4- oxazolidinedione as the active ingredient.

DISINFECTANTS

There are a number of different chemicals that are used to kill or inactivate bacteria and fungi on tools, equipment, potting tables, empty greenhouse benches, pots, flats, other containers, storage areas, and hydroponic equipment. These include dipping, brushing, or spraying with 70 to 100% alcohol (grain, rubbing, or wood); 37 to 40% formaldehyde (1 pint in 5 gallons of water); Lysol; Listerol Household Disinfectant; potassium permanganate; and household bleach or sodium hypochlorite (Clorox, Purex, Sunny Sol), 1 pint of bleach in 1 gallon of water. Several commercial disinfectants are available. These include:

Bardac-22 Quaternary Ammonium Compounds--Used for treating storage areas, tools, and equipment. Used in algicides, antiseptics, deodorants, detergent-sanitizers, germicides, and microbicides.

Germ-I-Tol--Used for treating storage areas and equipment. It contains 50% alkyl dimethyl benzyl ammonium chloride.

LF-10 (Amphyl)--Used on greenhouse benches, potting tables, walks, tools, flats, plastic pots, and automatic watering systems. A 65% solution containing a mixture of potassium ricinoleate, o-benzyl-p-chlorphenol, isopropyl alcohol, tetrasodium ethyleneamine, tetraacetate, and alcohol. Not effective against resistant resting bodies of some fungi.

Hyamine compounds (Hyamine 1622, 2389, and 3500)--Compounds that show germicidal effectiveness against a wide range of microorganisms. They contain quaternary ammonium compounds and are used in antiseptics, germicides, algicides, detergent-sanitizers, and deodorants. These compounds are available as an 80% ethanol solution, 5% aqueous solution, 50% and 100% crystals.

Physan--Used for treating storage areas, tools, and equipment. It contains 10% each of n-alkyl dimethyl benzyl ammonium chlorides and n-alkyl dimethyl ethyl benzyl ammonium chlorides.

Roccal--A bactericide-fungicide used mainly for treating potato storage areas and equipment. It contains 10% alkyl dimethyl benzylammonium chloride.

GRAIN PRESERVATIVES

These are liquids containing propionic acid or mixtures of it with closely related acids (e.g., acetic acid) that allow early harvesting and storage of high-moisture grain to be utilized for animal feed *only* without the problems of handling and postharvest spoilage from storage molds (primarily species of *Aspergillus* and *Penicillium*). Sold under such trade names as Aceto Propcorn, Grain Storer P, Tenox, P Grain Preservatives, and Grain Treet. These products are NOT for treating grain that might be used for seed, malting purposes, or human consumption. Treated grain is reduced to sample grade due to persistent odors from the chemical treatment.

LAWN FUNGICIDES

These are usually formulated as multipurpose mixtures to control a number of lawn and fine turfgrass diseases. The more widely available and used products include anilazine (Dyrene, Dymec); chlorothalonil (Daconil 2787); iprodione (Chipco 26019); Fore; Tersan LSR; triadimefon (Bayleton); propiconazole (Banner); fenarimol (Rubigan); Tersan 1991 Turf Fungicide; Bromosan; Duosan; Vorlan; thiophanate materials (Fungo 50, Cleary 3336, Scotts ProTurf Systemic Fungicide); Scotts ProTurf and Lawn Disease Preventer fungicides. Turf fungicides that control one to several diseases contain cadmium (Caddy, Cad-Trete, Lebanon Fungicide Type C), maneb or mancozeb, and others. See also **Fungicides** and **Fungicides of Less General Use**.

SURFACTANTS OR SURFACE-ACTIVE AGENTS

These wetting, spreading, and sticking agents are added to spray mixes to help keep the pesticide in suspension, improve cohesiveness of the spray, and increase the wetting of leaves, fruits, and stems. They are most useful when spraying hard-to-wet foliage such as that of conifers, broadleaf evergreens, boxwood, carnation, euonymus, gladiolus, iris, narcissus, peonies, roses, cabbage, onions, peas, and peppers. These materials can be classed as nonionic, anionic, cationic, and amphoteric. Most emulsifying agents are of the nonionic type; they do not ionize. Wetting agents and detergents are mostly anionic, becoming ionized in solution with the negative molecule being of primary influence. Cationic forms are not widely used; when these materials are ionized, the positive part of the molecule is dominant.

A few commercial spreader-stickers (film extenders) available for tank mixing include Ag-Chem Activator, Ad-Here, Bond, Chem-Stik, Stick-It, Stik, Surfix, Aqua T Non-ionic Organic Wetting Agent, Agway Spreader-Sticker, Bio-Film Spreader-Sticker, DuPont Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film-P and -17, De-Pester Spreader-Activator, Sprint-38 Spreader-Sticker, Triton B-1956, Plyac Non-Ionic Spreader-Sticker, Spray-Stay, At-plus S26, Adsee, R56-Spreader Sticker, Leaf Act 80, Pratt Spreader-Sticker, WSCP, WSCP-2, Mezclafix, Obex M, Obex P.

Commercial spreaders and spreader-activators include Ortho Chevron Spreader, Chemcol, Chipco and Rhodia Spreader-Activator, Flo-Wet, Multi-Film L and X-77, X-77 Spreader, Pinoline, Sure Spred, Tween 20, Surfactant II, Triton AF and CS-7, Fluxit, Santomerse 80, Penex, Sur-Ten Wetting Agents, Activiate 3, Neptune, At-plus, Bio-88, Regulaid, Buffer-X, R-11 Spreader-Activator, Pegafix, Flo-Wet. Some common stickers or adhesives include Goodrite PEPS, De-Pester Sticker, Flo-Mo 200-4, and Exhalt 800.

The fungicide or other pesticide label should indicate restrictions in selection of compatible surfactants. Use these commercial preparations according to label directions. The addition of excess wetting or spreading agent may cause excessive runoff and may result in a poor spray deposit and reduced pest control.

When selecting a surfactant, consider such factors as the homogeneity of the concentrate, its storage stability, corrosion factors on storage or packaging, ease of mixing in water, effect of water hardness on the emulsion stability or dispersion, plus the added cost to the spray mix.

NEMATICIDES--NONFUMIGANTS (all highly toxic and restricted-use pesticides)

Aldicarb (Temik 10G, TSX, and 15G)--A granular systemic insecticide-nematicide-miticide with some fungicidal activity. It may be soil applied at planting for control of nematodes on soybeans, dry beans, potatoes, sorghum, sweet potatoes, sugar beets, peanuts, and many ornamentals. Effective for soybean cyst nematode control. The active ingredient is 2-methyl-2(methylthio) propionaldehyde-o-(methylcarbamoyl)oxime. Oral LD_{50}(rat) = 0.9 mg/kg. Water solubility = 6000 ppm.

Carbofuran (Furadan 10G and 15G)--A broad-spectrum nematicide-insecticide-miticide that may be soil applied at planting for control of nematodes on corn, soybeans, sorghum, grapes, and cucurbits. The active ingredient is 2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate. Oral LD_{50}(rat) = 11 mg/kg. Water solubility = 700 ppm.

Ethoprop (Mocap 10G, 15G, and 20G; Mocap EC; Mocap Plus; Proturf)--A long-lasting, broad-spectrum, contact nematicide-insecticide that is applied at planting on corn, soybeans, garden beans, cabbage, cucumbers, and white potatoes, and 2 to 3 weeks before planting on sweet potatoes. It is applied as a dip and soil drench to ornamentals. For commercial turf (but not bentgrass), distribute evenly over established turf and drench in *immediately* with at least 0.5 inch of water. The active ingredient is 4-benzothienyl- N-methylcarbamate. Oral LD_{50}(rat) = 61.5 mg/kg. Water solubility = 750 ppm. Formulated as 6EC, 69.6EC, 10G, 15G, 20G, and 10% combined with 5% disulfoton.

Fenamiphos (Nemacur 3, 15G)--A broad-spectrum systemic and contact nematicide for use on commercial turf, many ornamentals, some vegetables, apples, cherries, peaches, grapes, and soybeans. Applied as outlined for ethoprop (above). The active ingredient is ethyl 3-methyl-4-(methylthio) phenyl (1-methylethyl) phosphoramidate. Oral LD_{50}(rat) = 8.1-9.6 mg/kg. Water solubility = 400 ppm. Formulated as 10G, 15G, 3EC, and in combination with fensulfothion.

Fensulfothion (Dasanit 15G and Spray Concentrate, Terracur P)--A broad-spectrum contact nematicide-insecticide for use on commercial tomatoes, sweet potatoes, many ornamental flowers, shrubs, and foliage plants. Used as a plant dip and soil drench. The active ingredient is 0,0-diethyl 0-[4-(methylsulfinyl)phenyl]phosphorothioate. Oral LD_{50}(rat) = 2-10 mg/kg. Water solubility = 1600 ppm. Formulated as 15G, 6EC, and in combination with fenamiphos or fensulfothion.

Oxamyl (Vydate 2L)--A nematicide-insecticide-miticide for use on carrots, celery, some cucurbits, eggplant, peppers, sweet and white potatoes, soybeans, tomatoes, many ornamentals, nursery stock, and nonbearing fruit trees. Applied preplant soil incorporated, in a soil mix, as a foliar spray, in a liquid drench, and as a root, corm, or bulb dip. The active ingredient is methyl N',N'-dimethyl-N-[(methylcarbamoyl)oxy]-1-thiooxamimidate. LD_{50}(rat) = 5.4 mg/kg. Water solubility = 280,000 ppm.

Terbufos (Counter 15G)--A systemic soil nematicide-insecticide applied at planting for the control of nematodes on corn. The active ingredient is S-[(1,1-dimethylethyl)thio]methyl 0,0-diethyl phosphorodithioate. LD_{50}(rat) = 9.2 mg/kg. Water solubility = 15 ppm.

NEMATICIDES--FUMIGANTS

(See Table 1 for Applications)

The use of all nematicides, except Diazinon, is restricted, and they are to be purchased and applied only by certified pesticide applicators or operators.

Applications listed here are for nematode control only. See "Insecticide Formulations and Toxicities" in this book for insect control applications.

1,3 Dichloropropene (Telone C-17, Telone II). Often mixed with chloropicrin.

Chloropicrin (Chlor-O-Pic, Larvacide 100, Telone C, Pic-Clor, Tri-clor). Usually mixed with 1,3 dichloropropene or methyl bromide.

Dazomet or DMTT (Basamid-Granular, Crag Nematicide, Crag Fungicide 974, Dazomet-Powder BASF, DMTT, Micofume 25-D, Mylone).

Methyl Bromide (Dowfume MC-2 Brom-O-Gas, Brom-O-Sol, Celfume, Terr-O-Cide II, MeBr, Meth-O-Gas, Terr-O-Gas 98 and 100). Many combination formulations are available; most also contain chloropicrin.

Methylthioisocyanate *or MIT* (Vorlex). Vorlex is 20% MIT, and 40% 1,3 dichloropropene and other C_3 hydrocarbons.

Table 1. Soil-Disinfecting Chemicals: Treatments, Problems Controlled, Application and Remarks

Materials, brands	Controls	Application and remarks
Treatments		
Steam heat		
Heat soil (6 inches deep or the coldest spot) to 180°-200°F (82°-93°C) for 30 minutes, or to 160°F (71°C) for 60 minutes.	All types of pests--fungi, most bacteria, nematodes, mycoplasmas, viruses, soil insects, mites, garden centipedes, and most weed seeds if moist.	Various methods are available: Pressure cooker (for small amounts), tank or vault, buried tile, perforated pipes on top of or in soil, or inverted pan. Soil in benches or beds should be covered with a tarp. When steaming large quantities of soil, use a pressure between 15 to 100 pounds per square inch (psi).
Dry heat		
Heat soil to 180°F (82°C) and keep at this temperature for 30 minutes.	All types of pests--see *Steam heat* (above)	Place small quantities in an oven or use an electric soil-pasteurizing box (e.g., Famco, Thermasoil).
Multipurpose Chemicals		
Chloropicrin Pic-Clor; Tri-clor; Chlor-O-Pic; Telone C; Larvacide 100 (Tear gas or trichloronitromethane.) For combinations with methyl bromide see above.	Nematodes, damping-off, seedling blights, and other soil-inhabiting, disease-causing fungi and bacteria, weed seeds, and soil insects. Controls same range of pests as does methyl bromide (below). The best chemical for control of Verticillium wilt.	Treatment is only for commercial applicators who are properly equipped. Liquid in pressure cans or cylinders. Apply with special injection equipment in holes 6 to 8 inches deep, at 8- to 12-inch intervals. Inject chemical into each hole and close by stepping on the hole (33-50 gal/A for light soils; 41-77 gal/A for heavy soils). After treatment, apply gas-proof cover or sufficient water to soak upper inch of

Table 1. Continued

Materials, brands	Controls	Application and remarks
Multipurpose Chemicals (continued)		
		soil to seal in gas. Maintain water seal or cover for at least 3 days. Do not plant in treated soil until all traces (odor) of chloropicrin have gone (2 to 4 weeks). Use an approved chloropicrin full-face mask, canister, and polyethylene gloves while working. Carefully follow all manufacturer's directions. Do NOT use around living plants.
Dazomet or DMTT Mylone; Crag Fungicide 974; Crag Nematicide; Dazomet-Powder BASF; Basamid-Granular; Mico-Fume 25-D (Mylone) (Tetrahydro 3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione).	Nematodes, soil fungi, certain weed seeds, and soil insects.	Apply as a preplant soil drench (12 to 50 gal/A), dust, wettable powder, or granules using a sprinkling can, sprayer, or fertilizer spreader. Disc, rake, or cultivate (rototill) into soil. Used for seed and plant beds. Cover treated area with gasproof plastic cover or apply water seal as for Metam-sodium (below). Apply 3 to 4 weeks before planting. Fall treatment is best. Fumes are toxic to growing plants; greenhouses must be empty. Follow all manufacturer's directions and precautions.
Formaldehyde (Formalin). DuPont Formaldehyde Solution, Parsons, U.S.P. Formaldehyde. (Usually sold as a 37-40% solution in water and methanol.)	Damping-off, seedling blights, other soil-inhabiting and disease-causing fungi and bacteria, soil insects, and many soft or germinating weed seeds. Good disinfectant for tools, equipment, and storage areas. Also a seed disinfectant. Does NOT control nematodes.	Mix 3 tablespoons of formaldehyde in a cup of water and sprinkle over a bushel of soil (32 qts); 1 tablespoon in 1/2 cup of water treats a florist's flat of soil. Mix in very thoroughly with a shovel or hoe on a flat surface. Put treated soil in flats or pots, or leave in a pile and cover with plastic, wet burlap, or canvas for 2 to 3 days. Drench soil in plant beds or seed flats. Use 1 cup in 3 gal of water. Apply slowly and evenly, 1/2 to 1-1/2 gal/sq ft, using a

Table 1. (Continued)

Materials, brands	Controls	Application and remarks
Formaldehyde (continued)		sprinkling can. Cover soil. After 2 to 4 days remove cover, work soil, and plant when all odor is gone. Never use in a greenhouse or where plants are growing; fumes are toxic to plants.
Metam-sodium or SMDC A7 Vapam, Busan 1020, Soil-Prep, Soil Cleanup, Nemasol, Sometan, Trimaton, Vapam Soil Fumigant, Metam-Fluid BASF, Solasan 500 (32.7% sodium N-methyl dithiocarbamate (anhydrous).	Nematodes, soil-inhabiting and disease-causing fungi and bacteria, germinating weed seeds, and soil insects including garden centipedes; also a herbicide, at higher rates of application.	Sprinkle diluted liquid uniformly over soil with sprinkling can, hose proportioner, sprayer, or meter into irrigation system. Or apply like chloropicrin (above) using 15-45 gal/A. Cover treated area with a tarp for 4 days after treating, or apply a water seal to upper inch of treated soil (15 to 20 gals per 100 sq ft). Do NOT treat more than 100 sq ft at a time before applying water seal. When top-treated soil has dried sufficiently, cultivate 1 to 2 inches deep. Do NOT plant until 3 to 4 weeks or more after treatment. Fall application is best. Do NOT use in greenhouses or close to where desirable plants are present.
Methyl Bromide Terr-O-Gas 98 and 100, Brom-O-Gas,98-2, Brom-O-Sol, Celfume, Meth-O-Gas, Dowfume MC-2, Nemaster, 67-33. (Methyl bromide, usually with chloropicrin added.) There are too many other Terr-O-Gas formulations to list.	Nematodes, grubs, garden centipedes, cutworms, wireworms, and other soil insects; weed seeds, damping-off, seedling blights, wilts, other soil-inhabiting disease-causing fungi, e.g., *Pythium, Fusarium, Phytophthora, Rhizoctonia, Sclerotinia, Verticillium*, actinomycetes.	Treatment is only for commercial applicators who are properly equipped. Compressed gas in aerosol cans, cylinders, or drums. Must apply with a special applicator under a gasproof cover. A fumigation period of 1 to 2 days is needed. A 1- to 2-week wait is normally required between treating and planting. Good in coldframes, greenhouses, turf, nurseries, and outdoor beds. *Very poisonous*. Carefully follow all manufacturer's directions. To kill soil fungi, use 3 to 4 lbs/100 sq

Table 1. (Continued)

Materials, brands	Controls	Application and remarks
Methyl Bromide (continued)		ft; for other pests, 1 to 2 lbs. Do NOT use before planting onions, garlic, celery, carnations, salva, snapdragons, conifers, holly, and multiflora rose. Most formulations contain a small amount of chloropicrin (about 1 or 2%) as a warning agent. Tractor-mounted machines with chisel-type applicators are used for field-scale operations. This equipment simultaneously lays a gasproof cover. To disinfect tools, containers, and machinery, cover with a gasproof cover and weight edges down. Apply 1 to 4 lbs/100 cubic feet. Leave cover in place for 2 to 3 days if the temperature is 50°F to 59°F; 1 day if temperature is 60°F or above. A full-face gas mask fitted with a black canister must be worn during application and when cover is removed. Do NOT use around living plants.
Methyl isothiocyanate or MIT Vorlex Soil Fumigant (20% methyl isothiocyanate and 80% chlorinated C_3 hydrocarbons including dichloropropenes).	Nematodes, soil insects including symphylans, germinating weed seeds, bacteria, damping-off and seedling blight fungi, *Verticillium* and other soil-inhabiting, disease-causing fungi.	Apply like chloropicrin (above), but use chisel spacings of 6 to 8 inches and 7 to 60 gal/A. Pack treated soil, and apply a light water seal or plastic cover. Leave soil undisturbed for at least 7 days, then aerate (cultivate) to prevent soil crusting. Do NOT plant for 3 to 4 weeks or until all odor is gone. Higher rates and cold or heavy soils require longer waiting periods (7 days for each 23 lb of active product). Carefully follow all manufacturer's directions.

Table 1. (Continued)

Materials, brands	Controls	Application and remarks
Chemicals Primarily for Nematode Control (Nematicides)		
1,3-D: Telone II, Telone C-17 is 83.5% 1,3-D and 16.5% chloropicrin.	Nematodes, wireworms, garden centipedes, and other soil insects, weed seeds, and certain other soilborne pests. Gives poor control of soil bacteria and fungi.	Apply preplant 6 to 8 inches under soil surface at 10- to 12-inch intervals using 8 to 120 gallons per acre. Cover with a gasproof plastic cover for 1 week. Do NOT plant until 3 to 6 weeks after treatment. Carefully follow all manufacturer's directions. Never use in a greenhouse or where plants are growing. Recommended for fall treatment only.
Chemicals Primarily for Fungus Control (Fungicides)		
Captan, Terraclor Super X, etridiazole, thiram, Polyram, Banrot, metalaxyl, fosetyl-Al, propamocorb, ziram, benomyl, thiabendazole, chloroneb. (See also under these names.)	Seed rot, damping-off, seedling blights, caused by fungi in greenhouse (cutting) benches, flats, hot beds, pots, cold frames, and flower beds.	Apply as dust or spray uniformly over loose, fairly dry soil. Cultivate thoroughly into top 2-1/2 to 4 inches of soil. Seed can be planted immediately after treatment. May also be applied as a post-plant soil spray or drench. Use about 1 pint to 1 quart of prepared mix per square foot. Repeat at 5- to 40-day intervals if disease persists. Check and follow all label directions and precautions.
PCNB or quintonzene Terraclor; Tri-PCNB; Fungiclor. (Pentachloronitrobenezene)	PCNB controls certain disease-causing fungi, e.g., *Rhizoctonia, Botrytis, Sclerotinia, Sclerotium.* (etridiazole, fosetyl-Al, metalaxyl, and propamocarb control water molds).	Various application methods including suspension in transplant water, soil surface sprays or dusts, and dry mixing into upper 2 to 6 inches of soil. Sometimes mixed with etridiazole, fosetyl-Al (Aliette), metalaxyl (Subdue), propamocarb (Banol), captan, ferbam, captafol, benomyl, or chloroneb. Thorough mixing with soil is essential. Follow manufacturer's directions regarding rates and methods of application.

1989 Turfgrass Pest Control

IMPROVED MANAGEMENT TECHNIQUES and new, more effective materials have made turfgrass culture a highly sophisticated technology. Proper irrigation, mowing, core aerification, thatch removal, and fertilization practices remain the principal defenses against turfgrass pests, but it is sometimes necessary to control weeds, diseases, and insects with the intelligent selection and use of pesticides.

Pesticide formulations. Pesticides are active against one or more turfgrass pests. These chemicals are generally formulated as liquid concentrates — solutions (S) or emulsifiable concentrates (EC); as wettable powders (WP); flowables (F); and as granules (G), wettable dispersable granules (WDG), and dispersable granules (DG). Liquid concentrates and wettable powders are usually added to water and applied to the turf with a sprayer. Granular materials can be applied with a fertilizer spreader.

Active ingredients. Pesticides must be accurately applied at correct rates to yield optimum results. Too little may control pests ineffectively; too much may injure the turf. The specific amount of material that should be applied depends upon the concentration of the pesticide (the "active ingredient") in the commercial preparation.

Concentration is usually expressed as a weight per unit volume or as a percent of the commercial preparation. For example, a 50 percent wettable powder is 50 percent active ingredients (a.i.) and 50 percent inert carrier. If the recommended rate of application is 12 pounds a.i. per acre, then 24 pounds of this commercial preparation are required to treat one acre. This is roughly equivalent to ½ pound per 1,000 sq. ft. (43,560 sq. ft. = 1 acre).

Liquid formulations generally list the number of pounds of the active ingredient per gallon (lb. a.i./ gal.) on the pesticide label. For example, if the concentration is 4 lb./ gal., then 1 quart of the product is required per acre to supply 1 pound of active ingredient per acre.

Precautions. Pesticides should be stored in their original containers with the label securely attached. Keep them in a cool, dry place that is inaccessible to children, pets, and irresponsible persons. **Read the label before using the pesticide and follow all instructions carefully.** A few minutes spent studying the information on the label may prevent misuse and needless accidents.

WEED CONTROL

Herbicides control one or more plant species. They may be classified into one of three types — contact, systemic, or soil sterilant — depending upon the nature of their activity on plants.

Table 1. — Herbicide Control for Selected Broadleaf Weeds in Turf

All herbicides listed below are postemergent chemicals, and should be applied to broadleaf weeds that are actively growing. Be sure to follow label directions for rates and application timing.

	2,4-D[1]	MCPP[2]	dicamba[3]	Combination of first 3 materials	2,4-D + triclopyr	2,4-D + 2,4DP	bromoxynil[4]
black medic	..	xo	x	x	x	x	s
carpetweed	x	xo	x	x	x	..	..
chickweed							
common	..	xx	x	x	x	x	..
mouse-ear	..	xx	x	x	x	x	..
chicory	x	x	x	x	x	x	..
daisy, oxeye	xo	xo	xo	xo	..	..	..
dandelion	x	xx	x	x	x	x	..
dock, curly	xo	..	x	x	x	x	..
ground ivy	..	xo	xx	x	xx	x	..
hawkweed	xx	..	xx	x	..	x	..
henbit	xo	xo	x	x	x	x	s
knotweed	..	xo	x	x	..	x	..
lambsquarters	x	x	x	x	x	x	s
mallow, roundleaf	..	xo	xx	x	x	x	..
pearlwort,							
birdseye	..	..	x	..	..	..	..
plantain							
broadleaf	x	..	..	x	x	x	..
buckhorn	x	..	..	x	x	x	..
purslane	xo	..	x	x	..	x	..
red sorrel	..	..	x	x	..	xo	..
speedwell,							
creeping	..	..	..	xo	..	..	..
purslane	xo	xo	xo	x	xx	x	..
spurge, prostrate	..	xo	xx	x	x	xx	s
thistles	xx	xo	x	xo	x	x	s
violet	..	..	..	..	xx	xo	..
white clover	xo	x	x	x	x	x	..
wild carrot	x	xx	x	x	x	x	..
wild onion	xo	..	xx	x	..	x	..
woodsorrel, yellow	xo	xo	xo	x	x	xx	s
yarrow	xo	..	x	x	x	xx	..

NOTES:
.. Lack of a rating for herbicide weed combinations indicates that information was not available at time of publication.
x Usually provides adequate weed control.
xx Multiple applications may be necessary for control.
xo May only provide partial weed control.
s Used on seedling weeds.

[1] Not recommended for bentgrass putting greens.
[2] Safe for use on bentgrass putting greens during cool weather periods.
[3] Do not apply above the roots of trees and shrubs.
[4] May be used on seedling turf.

Contact herbicides kill plant parts covered by the chemical. *Systemic herbicides,* absorbed by plant organs and translocated throughout the plant, may be either *selective,* killing certain weeds without injuring desirable grasses, or *nonselective,* controlling all vegetation.

Glyphosate, a nonselective herbicide, is useful in renovating turfs infested with extensive populations of

annual weeds. Glyphosate is also used to kill perennial weedy grasses, such as quackgrass, that cannot be controlled by selective herbicides. Because glyphosate has no residual soil activity, treated areas may be reseeded soon after application. Mecoprop is a selective herbicide used to control broadleaf weeds in turf.

Soil sterilants are chemicals that render the soil toxic to all plant life. How long the soil remains sterile depends upon the material used, the rate of application, and the prevailing environmental conditions that affect decomposition of the herbicide in the soil. Soil sterilants have no place in turfgrass management; however, they are useful in preventing plant growth under fences and other areas that are difficult to mow.

Herbicides may be applied to prevent weeds from infesting a turf or to control weeds already present.

Herbicide Trade Names for Broadleaf Weed Control in Turf[a]

2,4-D
Amine 40, Decamine 4D, Dymec Turf Herbicide, Four Power, LESCO A-4D, Turf Weedestroy-D, Weedone LV4, Weedar 64

Mecoprop (MCPP)
Lescopex, MCPP Green, Mecomec, Weedestroy MCPP, Weedone MCPP

dicamba
Banex, Banvel, ProTurf K-O-G Weed Control

bromoxynil
Buctril

chlorflurenol
Break-Thru

triclopyr
Turflon Amine, Turflon Ester

2,4-D + dicamba
Four Power Plus, Triple "D", LESCO Eight-One, Super D Weedone, 101 Weedkiller, 81 Selective WeedKiller

2,4-D + mecoprop
Lescopar, Riverdale Granular Lawn Weed Killer, 4-D Amine, MCPP+2, 2 Plus 2 (MCPP + 2,4-D Amine), 2MCPP + 2D Amine, Turf Kleen

2,4-D + dichlorprop (2,4-DP)
Agway Granular Lawn Weedkiller, LESCO Granular Herbicide, Weedone DPC, Weedone DPC Amine

2,4-D + triclopyr
Turflon D, Turflon II Amine

2,4-D + mecoprop + dicamba
LESCO Three Way, MecAmine-D, Three-Way Lawn Weed Killer, Trex-San, Trimec

2,4-D + dichlorprop + dicamba
Super Trimec

2,4-D + mecoprop + dichlorprop
Triamine Lawn Weedkiller, Weedestroy Triamine, Weedestroy Tri-ester

[a] This is not an exhaustive list of trade names for herbicides used on turf. We will amend this list in future reprints if we are notified of products with similar composition.

Bensulide is a *preemergence* herbicide applied in spring to prevent development of crabgrass. Once the weed has germinated, DSMA may be used as a *postemergence* treatment to selectively control the crabgrass invader.

INSECT CONTROL

Insecticides are pesticides that reduce insect populations below levels injurious to turf. Most commonly used materials are contact poisons. Effective control depends on ensuring contact between insect and insecticide. Control of soil insects (such as grubs) is achieved by drenching the insecticide into the soil, whereas foliar-feeding insects (e.g., sod webworms) are controlled by foliar sprays with no irrigation or rainfall for at least 24 hours afterwards.

Most insecticides are applied after early signs of injury are observed. No insecticide controls all turf pests. Identify the specific insect before attempting control with an insecticide. Learn to recognize early signs of injury to avoid large-scale loss of turf.

DISEASE CONTROL

Fungicides kill or inhibit the growth of fungi. Fungicides are of two general types: protective-contact and systemic.

Protective-contact fungicides are applied to seed, foliage, or soil to keep disease-causing fungi from entering grass plants. They must be applied at 5- to 14-day intervals since mowing, rain, and irrigation soon remove much of the surface chemical. Relatively high spray volumes (3 to 5 gal. water per 1,000 sq. ft.) supplies uniform coverage of the foliage. A surfactant added to the spray increases coverage. Many turf fungicides are the protective-contact type. Examples of protective-contact fungicides include: Calo-Clor and Calo-Gran; captan; Chipco 26019; Daconil and Thal-O-Nil; Dyrene, Lescorene, or Dymec; ethazole (Koban, Terrazole); maneb; mancozeb, Lesco 4, or Fore; PCNB (Terraclor, Turfcide); and thiram (Thiramad, Spotrete).

Systemic fungicides are absorbed and distributed within plants destroying established infections and controlling certain diseases for several weeks or months. These fungicides are absorbed principally by the roots and should be drenched or watered in. Examples of systemic fungicides include: Aliette, Apron, Banner, Bayleton, Cleary 3336, Fungo 50, Rubigan, Subdue, Teremec SP and Terraneb SP, Tersan 1991, and Vorlan.

Combinations of protective-contact and systemic fungicides include Bromosan and Duosan.

Table 2. — Herbicides for Control of Selected Annual Grassy Weeds in Turf

Herbicides listed below are used to control annual grasses in turf. Always follow the label directions for application rates and proper timing. For extended preemergent control of annual grass weeds, apply a second application 6 weeks after initial application at ½ the original rate. The common name of the chemical is listed first; the names in parentheses are trade names.

	Preemergent	Postemergent	Annual bluegrass	Crabgrass, foxtails, barnyardgrass	Goosegrass	Remarks
benefin (Balan)	x	..	ls	es	..	Avoid use on bentgrass.
benefin and trifluralin (Team)	x	..	ls	es	..	Avoid use on bentgrass.
bensulide (Betasan)	x	..	ls	es	..	
DCPA (Dacthal)	x	..	ls	es	es, ej	May injure fine-leaf fescues or bentgrass, especially Cohansey or Toronto. Goosegrass is difficult to control; complete control is rarely achieved. Better control may result if an early application is followed by a second at half the rate in early June.
ethofumesate (Prograss)	x	x	es, ls	..	..	See label for specific uses.
fenoxaprop (Acclaim)	..	x	..	*	*	Avoid use on bentgrass and young Kentucky bluegrass. May injure some mature Kentucky bluegrass cultivars.
oxadiazon (Ronstar)	x	..	..	..	es	Avoid use on red fescue, bentgrass, and wet turf.
organic arsenicals (DSMA — Arrhenal, Weed-E-Rad 360; and MSMA — Arsonate, Daconate 6, Weed Hoe)	..	x	..	*	*	May discolor turfgrass. Apply soon after emergence. May require three applications at 7- to 10-day intervals.
pendimethalin (Scotts Turfgrass Weed Control, LESCO Pre-M)	x	..	ls	es	..	Avoid use on bentgrass and annual bluegrass turf.
siduron (Tupersan)	x	..	..	es	..	May injure some bentgrasses or fine fescues. Do not use on Bermudagrass. Can be used at ½ rate in conjunction with bluegrass seeding.

es — Apply in early spring before weed emergence.
ls — Apply in late summer.
ej — Apply in early June.
* — See label for appropriate rates and timing of application.

Table 3a. — Nonselective Postemergence Herbicides for Control of Perennial Grassy Weeds in Turf[a]

Use nonselective postemergence herbicides for spot control only. Nonselective herbicides will kill or damage desirable turf.

Weeds	Control	Comments
nimblewill, bentgrass Bermudagrass, quackgrass	amitrole (Amitrol-T)	May persist in soil up to 4 weeks. Do not plant new turf in treated areas for 4 weeks following application.
	dalapon (Dalapon 85, Dowpon M)	May persist in soil up to 6 weeks. Do not plant new turf in treated areas for 6 weeks following application.
	glyphosate (Roundup, Weed Wrangler, Kleenup)	Has no residual activity in soil; seeding can follow treatment immediately. However, it is suggested to wait 1 week to allow translocation of the herbicide. Repeat applications of glyphosate may be required for complete control.

[a] Apply these herbicides when weeds are actively growing.

Table 3b. — Selective Postemergence Herbicides for Control of Perennial Grassy or Grasslike Weeds in Turf[a]

Weeds	Control	Comments
tall fescue	chlorsulfuron (LESCO TFC)	For spot treatment with hand-held sprayer in established Kentucky bluegrass, fine fescues, and bentgrass (mowed taller than ½ inch). Avoid using when drift may occur. For nonselective tall fescue control in perennial ryegrass, use amitrole, dalapon, or glyphosate.
yellow nutsedge	bentazon (Basagran)	Apply soon after emergence to actively growing nutsedge. Repeat applications may be necessary up to a total of 3 lb. a.i./A. per season.

[a] Apply these herbicides when weeds are actively growing.

Table 4. — Chemical Control of Turfgrass Diseases

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
"Helminthosporium" diseases			
Leaf spot, Melting-out (*Drechslera poae*)	Kentucky bluegrass	March-June; Sept.-Nov. 7 to 21 days	Bromosan-F (5 to 8 fl. oz.) Chipco 26019 WP 50% or FLO (2 to 4 oz.) Daconil 2787 WP 75% or 500 (2 to 11 oz.) Duosan WP 75% (3 to 5 oz.) Dyrene 4L or 50% WP or Dymec WP 50% (3 to 8 oz.) Fore or Formec 80 WP 80% (4 to 6 oz.) PCNB (Terraclor) WP 75% (see label) Vorlan WP 50% (2 oz.) Turfcide 10G (5 to 7½ lb.) Turfcide 24% EC (1 to 1½ qt.) maneb, 80% WP (3 to 8 oz.)
Leaf spot, crown and root rot (*Bipolaris sorokiniana*)	All turfgrasses	May-Oct. 7 to 21 days	
Zonate eyespot (*Drechslera gigantea*)	Bermudagrass Bluegrasses Bentgrasses	June-Sept. 7 to 21 days	
Net blotch, crown and root rot (*Drechslera dictyoides*)	Fescues Ryegrasses	March-July 7 to 21 days	
Brown blight (*Drechslera siccans*)	Ryegrasses	April-June 7 to 21 days	
Leaf blotch (*Bipolaris cynodontis*)	Bermudagrass	March-June 7 to 21 days	
Red leaf spot (*Drechslera erythrospila*)	Bentgrasses	April-Sept. 7 to 21 days	
Summer patch and necrotic ring spot (*Phialophora graminicola* and *Leptosphaeria korrae*)	Bentgrasses Bluegrasses Fescues Ryegrasses Bermudagrass	April-Sept.	Banner L 14.3% (4 fl. oz.) *or* Rubigan WP 50% (see label) *plus* Bayleton WP 25% (2 to 4 oz.), Chipco 26019 WP 50% or FLO (4 to 8 oz.), Cleary 3336 (see label), Fungo WP 50% (4 to 8 oz.), or Tersan 1991 WP 50% (5 to 8 oz.)
Comments: Apply when disease is expected or first appears. Repeat in 14 to 30 days if necessary. Drench fungicide into root zone using ½ inch (300 gal.) to 1 inch (600 gal.) of water per 1,000 sq. ft. Water the turf thoroughly the day before (300 to 450 gal. water per 1,000 sq. ft.).			
Dollar spot (*Lanzia* and *Moellerodiscus* spp.)	All turfgrasses	May-Nov. 7 to 30 days (see labels)	Banner L 14.3% (2 fl. oz.) Bayleton WP 25% (1 to 2 oz.) Bromosan-F (4 fl. oz.) Chipco 26019 WP 50% or FLO (2 to 4 oz.) Daconil 2787 WP 75% or 500 (2 to 11 oz.) Duosan WP 75% (3 to 5 oz.) Dyrene 4L or 50% WP or Dymec WP 50% (3 to 8 oz) Rubigan (see label) Vorlan WP 50% (2 oz.)
Red thread or pink patch (*Laetisaria fuciformis* and *Limonomyces roseipellis*)	All turfgrasses	April-June; August-Nov. 7 to 30 days (see labels)	
Comments: Resistance to benomyl, thiophanate materials, Dyrene, and other fungicides has been reported in some areas. Using combinations of active ingredients or alternating between products is advisable.			
Rhizoctonia brown patch or blight (*R. solani*)	All turfgrasses	May-Oct. 5 to 21 days (see labels)	Banner L 14.3% (4 fl. oz.) Chipco 26019 WP 50% or FLO (2 to 4 oz.) Daconil 2787 WP 75% or 500 (2 to 11 oz.) Duosan 75% WP (3 to 5 oz.) Dyrene 4L or 50% WP or Dymec WP 50% (4 to 8 oz.) Fungo WP 50% (2 to 3 oz.) Rubigan (see label) + Daconil 2787 (see label) Tersan 1991 WP 50% (1 oz.) + Daconil 2787 (see label) Vorlan WP 50% (2 oz.) + Fungo WP 50% (2 oz.)
Rusts: leaf and stem (*Puccinia* spp.)	All turfgrasses, especially certain cultivars of Kentucky bluegrass, Perennial ryegrass, Zoysiagrass, and Bermudagrass	June-Oct. 7 to 28 days (see labels)	Banner L 14.3% (1 to 2 fl. oz.) Bayleton WP 25% (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (3 to 5 oz.) Dyrene 4L or 50% WP or Dymec WP 50% (4 to 8 oz.) Fore or Formec 80 WP 80% (3 to 4 oz.)

[a] Causal fungus listed in parentheses.

[b] Denotes either fungicide, coined name, or representative trade names. Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products that may be equally suitable. Except where indicated, all materials should be applied in 3 to 5 gal. of water per 1,000 sq. ft. Use lower fungicide rates in *preventative* programs, higher rates for *curative* programs. Only one from each recommended group of preparations need be used. Fungicide use and restrictions are subject to change without notice. Always read and follow the current package label instructions and precautions.

Table 4. — Chemical Control of Turfgrass Diseases (continued)

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Anthracnose (*Colletotrichum graminicola*)	All turfgrasses, especially annual bluegrass	May-Oct. 7 to 30 days (see labels)	Banner L 14.3% (1 to 2 fl. oz.) Bayleton WP 25% (2 oz.) Daconil 2787 WP 75% or 500 (3 to 11 oz.) Duosan WP 75% (3 to 5 oz.) Fungo WP 50% (2 oz.) + Vorlan WP 50% (2 oz.) Rubigan (see label) Tersan 1991 WP 50% (1 to 2 oz.)
Leaf smuts Stripe smut (*Ustilago striiformis*) Flag smut (*Urocystis agropyri*)	All turfgrasses, especially certain bentgrasses, bluegrasses, and ryegrasses	Oct.-Nov. (see labels)	Banner L 14.3% (1 to 2 fl. oz.) Bayleton WP 25% (2 oz.) *or* Fungo WP 50% (6 to 8 oz.) *or* Rubigan (see label) *or* Tersan 1991 WP 50% (6 to 8 oz.) *plus* PCNB (Terraclor) WP 75% (see label)
Comments: Make one or two applications, 14 to 21 days apart. Drench fungicide into soil, using 1 inch (600 gal.) water per 1,000 sq. ft., immediately after application.			
Powdery mildew (*Erysiphe graminis*)	Bluegrasses Bermudagrass Fescues	March-Nov. 7 to 30 days (see labels)	Banner L 14.3% (1 to 2 fl. oz.) Bayleton WP 25% (5 to 8 oz.) Rubigan (see label)
Snow molds Typhula blight (*T.* species) Fusarium patch (*F. nivale*)	All turfgrasses	Nov.-March see labels for interval	Bayleton WP 25% (2 to 4 oz.) Chipco 26019 WP 50% or FLO (2 to 8 oz.) Calo-Clor, Calo-Gran (see label)[c] Daconil 2787 WP 75% or 500 (8 to 11 oz.) Rubigan (see label) *or* Teremec SP or Terraneb SP WP 65% (6 to 9 oz.) *plus* PCNB (Terraclor) WP 75% (8 oz.)
Pythium blight, grease spot, spot blight (many *P.* species)	All turfgrasses	April-Nov. 5 to 21 days (see labels)	Banol L 66.5% (1⅓ to 4 fl. oz.) Koban (see label) Subdue (see label) Terrazole WP 35% (4 to 8 oz.) Teremec SP or Terraneb SP WP 65% (4 to 6 oz.) Chipco Aliette WP 80% (4 to 8 oz.)
Fairy rings (*Marasmius oreades, Agaricus* or *Psalliota campestris, Chorophyllum* [*Lepiota*] species)	All turfgrasses		methyl bromide chloropicrin Vapam Soil Fumigant Vorlex or Vorlex 201 formaldehyde
Comments: Soil temperature should be above 60°F. for fumigation. Cover area with gasproof cover for several days, *or* instead of treating with a soil fumigant, use root feeder attachment on hose to drench rings with water. Repeat when symptoms reappear.			
Seed rot, damping off, seedling blights (*Pythium* sp., *Fusarium* sp., *Rhizoctonia solani, Drechslera* and *Bipolaris* spp.; *Colletotrichum graminicola*)	All turfgrasses	Treat seed before planting.	captan *or* thiram 50% or 75%, *plus* Koban WP 30% *or* Apron (see label)
		Spray just after seeding, at early seedling emergence, and 7 to 14 days later (see labels).	Koban WP 30%, Banol L 14.3%, Subdue 2E, or Terrazole WP 35% *plus one of these:* captan WP 50% Chipco 26019 WP 50% Dyrene 4L or 50% WP *or* Dymec WP 50%
Nematodes (many genera and species)	All turfgrasses	fenamiphos [Nemacur 3L or 10G] (except zoysia) or ethoprop [Mocap 10G, Nematicide-Insecticide, Proturf Nematicide-Insecticide] (except bentgrass).	
Comments: Follow the manufacturer's directions carefully. Follow nematicide *immediately* with at least ½ inch of water to ensure penetration into soil to prevent toxic effects. Treat in fall or spring (or both, if nematodes are a serious problem) when soil temperature is above 55°F. Make no more than two applications per year. Aerifying turf before application improves results. *Do not apply to newly seeded areas.* For use only by certified pesticide applicators.			

[c] Cleared for use *only* on golf course greens, aprons, and tees by certified golf course superintendents.

Table 4. — Chemical Control of Turfgrass Diseases (continued)

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Slime molds (*Physarum cinereum*, *Fuligo* sp., *Mucilago spongiosa*, *Stemonitis* spp.)	All turfgrasses	May-Sept. Mow, rake, pole, or hose down to remove mold when seen. Controlled by any fungicide listed for "Helminthosporium" diseases.	
Algae, green or black scum	All turfgrasses	Apply when first seen; reapply as needed.	copper sulfate (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Fore *or* Formec WP 80% (4 to 6 oz.)
Moss	All turfgrasses	Apply when first seen; reapply as needed.	ferrous ammonium sulfate (1 to 4 lbs.) ferric sulfate (1 to 4 lbs.)

[a] Causal fungus listed in parentheses.
[b] Denotes either fungicide, coined name, or representative trade names. Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products that may be equally suitable. Except where indicated, all materials should be applied in 3 to 5 gal. of water per 1,000 sq. ft. Use lower fungicide rates in *preventative* programs, higher rates for *curative* programs. Only one from each recommended group of preparations need be used. Fungicide use and restrictions are subject to change without notice. Always read and follow the current package label instructions and precautions.

Table 5. — Chemical Control of Insects

Insect	Insecticide[a]	Formulation[b]	Suggestions
Annual white grubs Ataenius grubs	diazinon trichlorfon (Dylox, Proxol) isofenphos (Oftanol) bendiocarb (Turcam) isozofos (Triumph)	EC or G SP or G G or EC WP EC	Apply as spray or granules to small area and then *water in thoroughly* before treating another small area. Grub damage will usually occur in late August and September. Ataenius grubs occur in June, July, and September. Use Triumph *only* on: golf course tees, greens, and aprons; home lawns; and sod farms.
Billbugs	chlorpyrifos (Dursban) isofenphos (Oftanol)	EC EC or G	Control adults in April with foliage treatment. Drench soil in June or July for grub control.
Cicada killer and other soil-nesting wasps Ants	diazinon chlorpyrifos (Dursban)	EC EC	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest and seal in with dirt.
Sod webworms Armyworms Cutworms	carbaryl (Sevin) diazinon chlorpyrifos (Dursban) trichlorfon (Dylox, Proxol)	WP or G EC or G EC or G SP or G	Webworms usually damage lawns in late July and August. As sprays, use at least 2½ gal. water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader.
Millipedes and sowbugs	carbaryl (Sevin) diazinon	WP or G EC or G	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
Chinch bugs	chlorpyrifos (Dursban) diazinon trichlorfon (Dylox, Proxol)	EC EC SP	Spray infested areas where chinch bugs are present.
Aphids	acephate (Orthene) chlorpyrifos (Dursban)	EC EC	Spray grass thoroughly.
Chiggers	diazinon	EC	Spray grass thoroughly.
Slugs	Mesurol	bait	Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.

[a] Use one of the insecticides recommended for a given group of insects, being sure to use the proper dosage for the formulation chosen. Follow labels as to correct rate of application.
[b] EC = emulsion concentrate; WP = wettable powder; G = granules; SP = soluble powder.

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1989 Insect, Disease and Weed Pest Management Guide: COMMERCIAL APPLICATION FOR TREES AND SHRUBS

Commercial arborists, urban foresters and nurserymen find it necessary to control insects, diseases, and weeds at various times throughout the growing season in order to protect their investment and to preserve the aesthetic and social benefits of woody landscape plants.

This pest management guide has been prepared for use by Illinois commercial lawn and tree care personnel, municipal arborists, urban foresters, and nursery operators--it is not for homeowners or home gardeners. Furthermore, the commercial applicator is usually required to use a greater variety of pesticides and at higher rates in order to achieve effective control.

INTEGRATED PEST MANAGEMENT

A pest management program includes the wise and timely selection of cultural, mechanical, biological and chemical control measures to insure maximum effectiveness against the pest, and to minimize cost and environmental effects.

In some cases, chemical control may not be necessary. Planting of resistant varieties and utilization of natural enemies or cultural methods may provide adequate control. In other cases, with high-value specimen plants, chemicals may be an integral part of the pest management program. Familiarization with the habits and life history of the pest will aid in these decisions.

CLASSIFICATION OF PESTICIDES

Pesticides are classified as either general-use or restricted-use by the U.S. Environmental Protection Agency. A person wishing to use a restricted-use pesticide must first be certified as a commercial pesticide applicator by the Illinois Department of Agriculture. Contact your local county Extension adviser for details of the certification program. Some of the products listed in this circular are restricted-use and others may become restricted-use in the near future. Therefore, check with your local county adviser if you are in doubt about the status of a particular pesticide. In some cases, decisions covering the present status of certain chemicals may be pending. Every effort will be made to keep you informed of any label changes or reclassifications via announcements in newsletters, the news media, grower meetings and pesticide training clinics.

PESTICIDE NAMES

The chemical names used in the tables may be unfamiliar to you. Pesticides have chemical, common, and trade names. A pesticide has only one common name but may have several trade names, depending on which company or companies market the product. To assist you in identifying a particular pesticide, common names and corresponding trade names are listed on the last page of this paper.

PROPER USE OF PESTICIDES

In using pesticides, be sure first to read the label and carefully follow label directions. Do not exceed the maximum rates suggested; observe carefully the proper timing for applying the pesticide and apply it only to plant material for which it is approved. Some chemicals may prove to be phytotoxic to certain plants so be sure to check the label. Keep a careful record of the product used, the trade name, the percent content of active ingredient of the pesticide, dilution, the rate of application, and dates of application for future reference.

This circular was prepared by Roscoe Randell and Phil Nixon, Extension entomologists, Malcolm Shurtleff, Extension plant pathologist, and Dave Williams, Extension horticulturist.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
Circular 1264 October 1988

PESTICIDE SAFETY

Remember, these chemicals are toxic and designed to kill the target organism. Also, be aware that hazard and toxicity are not the same! Hazard is a combination of toxicity and exposure. A chemical with low toxicity can still be hazardous if handled improperly. Some low toxic chemicals can cause blindness if splashed in the eyes, so be sure to wear the proper protective equipment as specified on the label. Other chemicals are highly toxic so proper handling and protective equipment is a must.

Pesticides can be an effective tool in controlling pests but they must be handled safely and effectively in order to achieve the desired results and at the same time keep human and environmental hazards to a minimum.

ADDITIONAL SOURCES OF INFORMATION

In the tables, leaflets describing the life history, biology, and habits of tree and shrub insect pests are indicated by the letters "NHE" and the leaflet number. These leaflets are available from your county Extension office or from Entomology Extension, 172 Natural Resources Bldg., 607 E. Peabody Drive, Champaign, IL 61820. The cost of each NHE leaflet is 15 cents. Checks should be made payable to the University of Illinois. Other pest management publications are available from the Office of Agricultural Publications, 54 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801. These include Circular 900, *1989 Insect Pest Management Guide: Home, Yard, and Garden;* Circular 1260, *1989 Plant Disease Control Guide: Woody Ornamentals,* and *1989 Chemical Weed Control.*

The *Report on Plant Diseases* (RPD) series, numbers 600 to 659, are available from Extension Plant Pathology, N-533 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801. The cost of each RPD is 50 cents. Checks should be made out to the University of Illinois.

GENERAL DISEASE CONTROL SUGGESTIONS FOR MOST WOODY ORNAMENTALS*

Diseases	Chemicals for control	Remarks
Damping-off Seed rot or decay Seedling blights	Captan, metalaxyl (Subdue), etridiazole (Truban or Terrazole), iprodione (Chipco 26019), Banrot	Apply captan as a seed treatment any time before planting. Grow plants in sterilized (pasteurized) soil wherever feasible. Mix metalaxyl + Banrot, iprodione, and etridiazole into soil or apply as drenches. Check labels for crop registrations.
Storage decay	Captan, Botran, benomyl, or Ornalin	Spray, dust, or dip plants, and other plant parts before shipping or placing in storage. Check labels for crop registrations.
Cutting rots Damping-off Seedling blights Crown (foot) rots Stem rots Root rots	PCNB (Terraclor), captan-PCNB mixtures, Banrot, benomyl (Benlate), PCNB-etridiazole (SA Terraclor Super-X), or thiophanate-methyl (Topsin M)	For Botrytis, Rhizoctonia, Sclerotinia, and Sclerotium stem and root rots only. Apply as a soil drench at 1 pint to 1 quart per sq ft or work into upper 2 to 4 inches of soil before planting. Check labels for crop registrations.

Diseases	Chemicals for control	Remarks
Cutting rots Damping-off Seedling blights Crown (foot) rots Stem rots Root rots *(continued)*	Propamocarb (Banol), fosetyl-Al (Aliette), etridiazole (Truban or Terrazole), Banrot, metalaxyl (Subdue), or PCNB-etridiazole (SA Terraclor Super-X)	For Aphanomyces, Phytophthora, and Pythium stem and root rots (water molds) only. Usually applied as a soil drench at intervals of 2 to 8 weeks. Check label instructions. Sometimes combined with PCNB (Terraclor).
Leaf, stem, and flower spots, blotches, and blights caused by fungi Anthracnoses Scabs	Benomyl + captan, maneb, mancozeb, chlorothalonil (Daconil 2787, Exotherm Termil), Kocide 101, Zyban, Duosan, vinclozolin (Ornalin), triforine (Funginex), iprodione (Chipco 26019), triadimefon (Bayleton), dodine (Cyprex), or thiophanate-methyl (Topsin M)	Benomyl plus captan, chlorothalonil, or mancozeb also gives *Botrytis* control, as does vinclozolin, Zyban, Duosan, and iprodione. Applications are needed at intervals of 5 to 7 days in rainy weather and 7 to 10 days in drier weather. Check labels for specific information and crop registrations.
Rusts	Maneb, mancozeb, triadimefon (Bayleton), triforine (Funginex), Rubigan, or chlorothalonil (Daconil 2787)	Applications usually needed at intervals of 7 to 10 days, starting when rust first appears. Check labels for current crop registrations.
Powdery mildews	Benomyl, sulfur, dinocap (Karathane), triforine (Funginex), Zyban, Duosan, triadimefon (Bayleton), Rubigan, or thiophanate-methyl (Topsin M)	Frequent applications and thorough coverage are essential. Cycloheximide, sulfur, and dinocap may cause plant injury, especially in hot weather at 85°F or above. Check labels for current crop registrations.
Bacterial flower, leaf, and shoot blights	Streptomycin formulations or copper fungicide	Follow manufacturer's directions strictly to avoid plant injury. Note label restrictions.
Wilt diseases (mostly *Fusarium* and *Verticillium*) Crown and root rots Crown gall	Steam at 180°F for 30 minutes or 160°F for 1 hour at the coolest spot or fumigate soil with methyl bromide, chloropicrin, Vorlex, or Vapam Soil Fumigant.	Treat soil several days to a month before planting. Carefully follow the manufacturer's directions as chemicals are very toxic. Some may be used only by licensed commercial applicators. Also treat containers, benches, work surfaces, potting table, tools and other equipment.

Diseases	Chemicals for control	Remarks
Fire blight	Streptomycin formulations or copper fungicide	Spray when 20 percent of blossoms are open and at 5- to 7-day intervals during bloom. Check labels for current crop registrations.
Soil nematodes (including root-knot and root-lesion nematodes)	Same as wilt diseases or apply oxamyl (Vydate L), Dasanit 15G, Temik 10G, Nemacur 10G or 15G	Galltrol A and Norbac 84-C are crown gall controls. Carefully follow crop registrations and directions.
Viruses Viroids Mycoplasmas	Apply insecticides at frequent intervals to keep the insects from feeding, as recommended by University of Illinois entomologists.	Control insects that transmit the causal agents, especially leafhoppers, aphids, and thrips. Rogue the first infected plants. Keep down broadleaf weeds. Keep greenhouse and nursery beds screened.

* NOTE: For detailed information regarding specific woody ornamentals and the chemicals suggested to control their diseases, obtain a current copy of Illinois Extension Circular 1260, "Plant Disease Control Guide: Woody Ornamentals."

Fertilization

Unthrifty and undernourished woody ornamentals are susceptible to a variety of diseases and environmental stresses. Their vigor can often be greatly improved by periodic applications of fertilizer and timely watering. Soil tests are always suggested prior to feeding, especially if a soil or lawn fertilization program has been in effect. In general, a 10-10-10 (NPK) fertilizer is recommended at the rate of 2 to 4 pounds per inch of trunk diameter at breast height. The fertilizer can be injected into holes in the ground evenly distributed beneath the tree and extending out to the drip line or beyond. Alternatively, apply fertilizer by surface broadcasting about 1 or 2 pounds actual nitrogen per 1,000 square feet during the dormant season; ammonium nitrate or nitrate of soda are acceptable compounds.

Sanitation

Proper selection of planting site, planting method, and materials, as well as soil preparation, pruning, winter protection, disease and pest control, and avoidance of unnecessary wounding will aid in control of a wide range of diseases.

Prune during dry weather and sterilize tools frequently between cuts. Use a fresh 10 percent solution of liquid household bleach, 70 percent denatured alcohol, or radiator antifreeze-type alcohol or 4 percent formaldehyde. When pruning or removing diseased wood, paint the newly exposed inner bark and sapwood with a germicidal or fungicidal coating. Shellac is useful for many diseases. Follow the shellac with a tree wound paint containing benomyl (Benlate) fungicide, 50% WP, at the rate of 1 gram in 5,000 grams or 2-2/3 ounces per 100 gallons. This mixture, although harmless to living bark, is toxic to spores of such canker- and wilt-producing fungi as *Botryosphaeria*, *Ceratocystis*, *Cytospora (Valsa)*, and *Verticillium*.

Surfactants

Wetting, spreading, and sticking agents (surfactants) are often added to spray mixtures for hard-to-wet foliage such as on conifers, broadleaf evergreens, boxwood, and roses. Some commercial spreader-stickers available for tank mixing include Biofilm Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film -P and -17, De-Pester Spreader-Activator, DuPont Spreader-Sticker, and Aqua T Non-ionic Organic Wetting Agent. Commercial spreaders include Chevron Spreader, Chipco and Rhodia Spreader-Activator, Flo-Wet,

Multi-Film L and X-77, Ortho X-77 Spreader, Pinolene, Sure Spred, Surfactant II, Triton B-1956, Tween 20, Flexit, Sanomerse 80, and Penex. The pesticide label usually indicates any restrictions that should be observed in selecting compatible surfactants. Use these commercial preparations according to label directions. The addition of any extra wetting, spreading, or sticking agent may cause excess runoff and result in a poor spray deposit.

CHEMICAL WEED CONTROL RECOMMENDATIONS FOR LANDSCAPE PLANTINGS

Many landscape managers consider weeds to be their most common and bothersome pest problem. Weeds are ubiquitous, infesting beds of woody and herbaceous ornamental plants, turf areas, and cracks in paved areas such as sidewalks and parking lots.

Beside being unsightly and giving an unmanicured appearance to commercial and residential landscape sites, weeds compete with desirable ornamental plants for nutrients, light, and growing space. They also can harbor insect and disease pests; they can be fire hazards, and noxious weeds such as poison ivy and ragweed can be health hazards.

Weed management programs for landscape sites include methods for both the eradication and prevention of weeds. The goal of a successful weed control program should be to integrate cultural decisions, mechanical methods, and chemical methods into an efficient and effective strategy to control weeds with a minimum of labor, cost, and environmental hazard.

The remainder of this article concentrates on the chemical component of weed control in programs of landscape plantings of herbaceous and woody ornamental plants.

HERBICIDE SELECTION

Herbicides provide an efficient means for controlling weeds. They are precise in their activity, but satisfactory results can only be achieved if herbicides are used properly. The first step in selecting a herbicide is to identify your weed problem.

Herbicides are classified as selective or nonselective, depending on the range of plants they kill. Selective herbicides kill certain plants with little or no injury to others. This is of the utmost importance when applying herbicides to areas containing ornamental plants. Selective herbicides include both foliage- and soil-applied herbicides.

Nonselective herbicides are toxic to almost all plants. Some herbicides that are selective at a low rate may be nonselective when applied at a high rate. Nonselective herbicides are useful in areas where total vegetation control is desired, such as in industrial areas, along fences, around buildings, and in other noncrop areas. Nonselective herbicides can be either foliage- or soil-applied.

Herbicides are also classified according to when and how they are applied to the ornamental plants or weeds. *Preplant* herbicides are applied before the ornamentals are planted. They are frequently incorporated into the soil and then referred to as preplant incorporated (PPI). *Preemergence* refers to the use of a herbicide before direct-seeded ornamental plants or weeds emerge, or before the weeds appear in landscape plantings. Most soil-applied herbicides require moisture to facilitate absorption by emerging weed seedlings. Rainfall can move the herbicide into the soil and provide the moisture for absorption. Mechanical incorporation can also move the herbicide into soil, and if sufficient soil moisture is available this can mean less dependence on rainfall. Soil texture and organic matter content affect the activity of soil-applied herbicides. The residual activity of the preemergnce herbicides can vary from several weeks to several months.

Postemergence refers to the use of herbicide after the crop or weeds have emerged. Postemergence herbicides are applied to the foliage of the weeds. Most must remain on the weed foliage for several hours to be effective. If rain falls shortly after application, retreatment may be necessary. Postemergence herbicides may be broadcast *over-the-top* of both ornamental plants and weeds if they are sufficiently selective to kill weeds without significantly affecting the ornamentals. Some less selective herbicides may be applied as *directed postemergence*, when the spray is directed onto the weeds and kept off the ornamental plants as much as possible. For directed sprays, it is helpful to have a height differential with weeds smaller than the ornamental plants. Earlier cultural practices, mechanical cultivation, or herbicides can sometimes help to establish this height differential. Spot treatments are applied to individual weeds or small patches of weeds.

Herbicides are also classified by their type of activity. *Translocated* or *systemic herbicides* move (translocate) in the plant from the site of uptake. The site of uptake can be either the roots or emerging shoots when the herbicide is applied to the soil, or the foliage and/or stem when an aboveground treatment is made. Since the plant must be actively growing for these herbicides to translocate to sites of action, most are applied during the growing season. Injury symptoms may take several days to several weeks to develop, depending on the type of herbicide. Since translocated herbicides can move throughout the plant system, they are effective against annuals, biennials, and perennials. Depending on the particular herbicide, activity may be selective or nonselective. *Nontranslocated* herbicides are active at the site of absorption or contact. They do not translocate within the plant. They are either soil-applied or foliage-applied. They can be applied at various times.

Foliage-applied nontranslocated herbicides are usually called *contact* herbicides. They nonselectively kill green foliage on contact by killing the plant tissue. They can also damage the bark of young trees such as thornless honeylocust and linden. Since only the tissue actually may be killed, surfactants are often added to improve coverage of the foliage. Contact herbicides can be effective for the control of annual plants if all the growing points are aboveground and thoroughly sprayed. They will also burn back the aboveground portions of biennial and perennial plants, but regrowth may occur since these plants have growing points that are underground and therefore protected. The injury symptoms of a plant treated with a contact herbicide are usually visible within a matter of hours. Contact herbicides usually have little or no residual soil activity.

To ensure that the proper herbicide is chosen for the ornamental planting and the particular weed problem, always read the label. The label gives rates and directions for use as well as precautions to prevent possible harm to the applicator, other people, animals, and the environment.

The different herbicide categories are discussed in greater detail in the following sections.

PREEMERGENCE HERBICIDES

Alachlor (*Lasso*)* is available in emulsifiable concentrate, microencapsulated, and granular formulations. It is labeled for use on a limited number of woody plant species. Apply at 4 pounds active ingredient per acre (a.i./A) for the control of annual grasses.

Bensulide (*Betasan*)* is used primarily for the control of annual grasses. Apply at a rate of 10 to 12 pounds a.i./A and irrigate after application. Bensulide can be used in established flower beds and carpet bugle, ivy, pachysandra, and sedum groundcovers. This herbicide is commonly used for preemergence crabgrass control in lawns.

Chloramben (*Ornamental Weeder, Amiben, Garden Weeder, Weedone*)* is used for control of a number of annual broadleaf and grass weeds. Apply at 4 pounds a.i./A to weed-free soil and irrigate following application. Chloramben is registered for use in established flower beds.

Chlorpropham (*Furloe, Chloro-IPC, CIPC*)* is available in emulsifiable and granular formulations. The granular formulation is commonly used in ornamentals. Apply at 4 pounds a.i./A on sandy soil and 6 pounds a.i./A on heavier soils for control of annual broadleaf and grass weeds. Chlorpropham is very effective for chickweed control, both pre- and postemergence. It has an extensive label including many species of trees, shrubs, flowers, and groundcovers.

DCPA (*Dacthal*)* is available in wettable powder and granular formulations. Apply at 10 to 12 pounds a.i./A to a weed-free area primarily for the control of annual grasses. DCPA has a very extensive list of established flower species on its label. It is also labeled for use on many woody species. In areas without vegetative cover, more than one application per growing season will be necessary.

Dichlobenil (*Barrier, Casoron, Dyclomec, Norosac*)* is available in wettable powder and granular formulations. Apply at 4 to 6 pounds a.i./A to control annual and perennial grasses and many broadleaf weeds. Use only on woody plants listed on the label. Dichlobenil is recommended for use in late fall and winter. If it is applied in warm weather, it should be incorporated into the soil or covered with mulch. This compound can also be used to control some aquatic weeds in nonflowing water.

Diphenamid (*Enide*)* is recommended for annual weed control in flower beds and planting of woody ornamentals. Apply at 8 pounds a.i./A to sandy soils and 12 pounds a.i./A to heavy soils. Effectiveness will be increased with shallow incorporation or irrigation following application. More than one application will be necessary for season-long control.

*Trade names appear in parentheses.

EPTC (*Eptam*)* is available in emulsifiable concentrate and granular formulations. Apply at 5 pounds a.i./A for control of annual weeds and suppression of certain perennial weeds such as nutsedge and quackgrass. Incorporation is necessary for good control.

Metolachlor (*Dual, Pennant*)* has recently been labeled for use on a number of woody ornamental species. It will effectively control annual grasses, a number of broadleaf weeds, and nutsedge. Applications of 4 pounds a.i./A will last for one growing season. Pennant is a granular formulation intended for use in ornamentals.

Napropamide (*Devrinol*)* is available in emulsifiable concentrate, wettable powder and granular formulations. It is labeled for use in annual and perennial flower beds, groundcovers, and woody plants. Apply at 4 to 6 pounds a.i./A for control of annual grasses and some broadleaf weeds. Incorporate to a depth of 2 inches or irrigate following application to improve control.

Oryzalin (*Surflan*)* can be used to control annual grasses and some broadleaf weeds in established plantings of groundcovers and woody ornamentals. It does not require incorporation, but it should be irrigated into the soil if there is no rainfall within a week or two of application. Oryzalin is formulated in combination with oxyfluorfen to produce the product *Rout*, which is commonly recommended for use in container plant production.

Oxyfluorfen (*Goal, O.H.2*)* can be used as both a preemergence and postemergence herbicide. Its postemergence activity is limited to young broadleaf weeds. Groundsel and chickweed are controlled by this herbicide. The granular formulation is recommended for deciduous plants. Either the EC or granular formulation can be used on conifers. (See oryzalin for information about *Rout*.)

Oxidiazon (*Ronstar or Scott's Pro Grow Herbicide I*)* is used in new and established plantings of groundcovers and woody ornamental plants. Apply at 4 pounds a.i./A. Two applications may be needed for season-long weed control. It will control a broad spectrum of weed species.

Pronamide (*Kerb*)* should be applied in the fall at 2 pounds a.i./A for the control of winter annuals, chickweed, and quackgrass. It is one of the only selective herbicides that control quackgrass in established landscape plantings.

Simazine (*Princep*)* is available in wettable powder and granular formulations. Spring or fall application at 2 pounds a.i./A to weed-free, woody ornamentals will control a broad spectrum of weeds. Be careful to apply to only labeled species and at recommended rates since simazine will injure a number of ornamental species. This herbicide is also used for weed control on staging area for container-grown plant production.

Trifluralin (*Treflan or Preen*)* is available in emulsifiable concentrate and granular formulations. Apply at 1 pound a.i./A and incorporate into the soil. It is used in flower beds, groundcovers, and woody ornamental plantings. Since it needs to be incorporated it is not easy to use in thickly established plantings.

POSTEMERGENCE HERBICIDES

Dalapon (*Basfapon, Dowpon M* and others)* is used for postemergence control of annual and perennial grasses. Apply at 5 pounds a.i./A. Dalapon will provide excellent control of cattails if applied when the plants are small.

Fluaziflop-butyl (*Fusilade 2000, Ornamec*)* is a grass-selective postemergence herbicide effective at controlling a wide range of grass species. It should be applied to young grasses in the 3- to 5-leaf stage.

Glyphosate (*Roundup, Kleenup*)* is a nonselective systemic postemergence herbicide. After being applied to the foliage of weeds, it is translocated into the root system and the entire plant is killed. Even though enough of this herbicide to kill the plant will enter the tissue within hours, it may take 10 days to 2 weeks for the weed to appear completely dead. Keep this herbicide off the foliage of ornamental plants. There is no soil activity, therefore it can be applied over the root systems of herbaceous and woody ornamentals. It can be used to remove grass from around the base of mature trees since it will not injure the trees' bark. However, applicators should avoid spraying glyphosate on the foliage of suckers at the base of trees. Applicators such as rope wicks, wipers, lighting hoes, etc., have been developed for selectively placed glyphosate on weed foliage but not for the foliage of ornamental and crop plants.

Oxyfluorfen (*Goal*)* has postemergence as well as preemergence herbicide activity. It will control many broadleaf weeds when they are in the seedling stage. It will not control mature plants postemergence. A combination of oxyfluorfen plus oryzalin is sold as the product *Rout*, which is commonly used for weed control in container plant production.

Paraquat (Ortho Paraquat QL, Gramoxone)* is a contact postemergence herbicide. It will give excellent control of annual weeds; however, perennial weeds often grow back from the root system. Apply at 0.5-1.0 pound a.i./A. Since the area to be treated is often less than 1 acre, Table 1 gives a conversion table for using herbicides on small areas where rate per acre is given. Rates per acre are usually given on the label.

Sethoxydim (*Poast*)* is a grass-selective postemergence herbicide labeled for a number of ornamental plants. Grasses are best controlled in the 3- to 5-leaf stage.

HERBACEOUS PLANTINGS

The problematic periods in plantings of annual and perennial bedding plants and groundcovers are during establishment and then during maintenance of the plantings. As many weeds as possible should be controlled prior to planting.

New bed areas are often developed in locations covered with turf that is full of perennial weeds. Spading or rototilling is not adequate to control perennial weeds. There are two approaches to controlling perennial weeds before planting. The first is to treat the perennial weeds with a systemic postemergence herbicide before preparing the soil in the bed area. The best herbicide for this is glyphosate. If the weed infestation is heavy and there is a significant perennial weed population, use two applications of glyphosate one month apart prior to planting.

Another approach to controlling perennial weeds prior to planting is to fumigate the beds. Methyl bromide, chloropicrin, metham-sodium, and Vorlex (Table 2) are fumigants available for this purpose. Methyl bromide and methyl bromide: chloropicrin combinations are most commonly used for this purpose.

After the bed is prepared, preemergence herbicides may be used either before or after planting, depending on the herbicide used. If the preemergence herbicides are used prior to planting, they should be incorporated into the upper 4 inches of soil. If the preemergence herbicides are applied after planting, they should be incorporated into the soil and irrigated. Mulch before planting since it is easier to plant through a mulch than to place mulch on small plants.

Preemergence herbicides recommended for use in herbaceous plantings are bensulide, chloramben, chlorpropham, DCPA, diphenamid, napropamide, oryzalin, and trifluralin. Other herbicides may be labeled for use, but the aforementioned compounds represent those materials with the most extensive list of herbaceous ornamental plants on their labels.

Plantings of Woody Landscape Plants

Beds of new plantings should be cleaned of weeds, treated with a preemergence herbicide, and mulched. This will provide weed control for one season. Future applications of preemergence herbicides can be made in the fall or spring, depending on the herbicide used and the time available. Ideally, a fall treatment for the control of winter annuals followed by a spring application to control summer annuals will give the most satisfactory results.

It should be remembered that no preemergence herbicide will control all species of weeds. A combination of two herbicides controlling different weed species will provide a broader spectrum of weed control. If two preemergence herbicides are used together, use each of them at one-half the rate recommended when they are used alone. Combinations for broad spectrum weed control are simazine + metolachlor, simazine + napropamide, simazine + oryzalin, simazine + DCPA, oxidiazon + chlorpropham, or oryzalin + oxidiazon.

All of the postemergence herbicides mentioned above can be used with care in plantings of woody ornamentals. Glyphosate and paraquat should be kept off the foliage of landscape plants. Paraquat should also be kept off the bark of young trees. When spraying the base of trees with glyphosate, avoid spraying suckers. Combinations of postemergence and preemergence herbicides will control existing weeds as well as weeds that are yet to germinate.

Successful use of herbicides depends upon their proper selection and application. Weed control programs in landscape plantings are only as good as the people who plan, administer, and apply them. Remember, the key to a good weed control program is people and their willingness to keep current with the ever-changing field of herbicide technology.

*Trade name.

Table 1. Conversion Table for Use of Herbicides on Small Areas When Rate per Acre is Given

Rate of commercial formulations per acre	Approximate rate per 1,000 square feet
Liquid materials	
1 pint	3/4 tbls*
1 quart	1 1/2 tbls
2 quarts	3 tbls
1 gallon	6 tbls
Dry materials	
1 pound	2 1/4 tsps**
2 pounds	4 1/2 tsps
3 pounds	2 1/4 tbls
4 pounds	3 tbls
5 pounds	4 tbls
10 pounds	1/2 cup
100 pounds	2 1/4 pounds

* Tablespoons.
** Teaspoons.

Table 2. Common and Trade Names of Fumigants for Preplant Bed Preparation

Common name	Trade name
methyl bromide	Brom-O-Gas, Dowfume, Fumigant-1, Meth-O-Gas, Pestmaster, Terr-O-Gas
metham-sodium	Best Vapam Soil Fumigant, Science Vapam, Vapam, VPM
chloropicrin	Chlor-O-Pic, Pic-clor, Tri-clor, Larvacide
methylisothiocynanate + dichloropentene-dichloropropane	Vorlex, Di-Tapex
methyl bromide + chloropicrin	Dowfume MC-33, Dowfume MC-2, many more formulations

ORNAMENTAL HERBICIDE REGISTRATIONS

	(PPI)				(PRE													) (POST**						)
	EPTAM	LASSO	TREFLAN	BETASAN	CASORON	CHIPCO RONSTAR	DACTHAL	DEVRINOL	DUAL	ENIDE	FURLOE	GOAL	KERB	LASSO	OIL 1	OIL 2	OR. WEEDER	PRINCEP	ROUT	SURFLAN	TREFLAN	FUSILADE	GOAL	KERB	PARAQUAT	POAST	ROUNDUP
Abelia spp.				F			F	X												X						
Abelia grandiflora				F		C	F	X								X				X						
Abies spp.	F						F	X			Y		F									F	F	F	F	F	F
Abies balsamea	F		F				F	X			Y		F					F		F	F	F			F		F
Abies fraseri	F						F	X		S	Y	Z	F					F		F		F	Z		F	F	F
Acer spp.	F				F		F	F	X	F	Y											F					F
Acer ginnala	F				F	F	F	F	X	F	Y											F					F
Acer palmatum	F				F		F	F	X	F	Y											F					F
Acer plantanoides	F		F		F		F	F	X	F	Y										F	F					F
Acer rubrum	F		F		F		F	F	X	F	Y						F				F	F			F	F	
Acer saccharinum	F		F		F		F	F	X	F	Y										F	F			F	F	
Acer saccharum	F		F		F		F	F	X	F	Y										F	F					F
Ajuga spp.	F			F				F														F					
Ajuga reptans	F			F		F		F														F			F		
Berberis spp.	F				F	X	F		X		Y							F				F				F	
Berberis thungergii	F		F		F	X	F		X	F	Y							F	X	X	F	F				F	
Betula spp.					F		F			F	Y											F				F	
Betula nigra					F		F			F	Y											F				F	
Betula papyrifera					F	F	F			F	Y											F					
Betula pendula			F		F		F			F	Y										F	F				F	
Buxus spp.	F			F	F	C	F	X	X		Y					X						F					F
Buxus microphylla	F		F	F	F	C	F	X	X		Y				X	X			X	X	F	F					F
Buxux sempervirens			F	F	F	C	F	X	X		Y				X	X				X	F	F				F	F
Carya spp. (Hickory)					F												F									
Carya illinoiensis					F			F		F															F	
Castanea spp.							F																			
Castanea mollissima			F				F														F					
Cedrus spp.								X			Y															
Cedrus deodora								X																		
Cercis canadensis			F				F			F											F	F				
Chaenomeles japonica					F																	F				
Chamaecyparis spp.	F																			X						
Chamaecyparis obtusa	F															X				X						
Chamaecyparis thyoides	F									F										X						
Cornus spp.	F	F			F		F				Y			F		X	F	F				F			F	
Cornus florida	F	F	F		F	F	F			F	Y			F		X	F	F				F			F	
Cornus sericea (C.stolonifera)	F	F			F	X	F		X		Y			F		X	F	F				F			F	
Cortaderia selloana																										
Cotoneaster spp.		F			F	X	F		X	F	Y						F	F				F			F	
Cotoneaster apiculata		F	F		F	X	F		X	F	Y				X	X	F	F		X	F	F			F	
Cotoneaster dammeri		F			F	X	F		X	F	Y						F	F	X	X		F			F	
Cotoneaster horizontalis		F			F	X	F		X	F	Y						F	F		X		F				
Cotoneaster microphyllus		F			F	X	F		X	F	Y						F	F		X		F				
Cotoneaster zabelii		F	F		F	X	F		X	F	Y						F	F				F				
Crataegus spp.							F	F													F					
Deutzia spp.			F		F		F														F					
Elaeagnus spp.					F		F			F	F							F								
Elaeagnus angustifolia					F	F	F			F								F							F	
Elaeagnus pungens			F		F		F			F								F			F					
Euonymus spp.	F	F			F	X	F	X	X	F	Y			F		X	F					F			F	F
Euonymus alatus	F	F			F	X	F	X	X	F	Y			F			F		X	X	F	F			F	F
Euonymus fortunei	F	F	F		F	X	F	X	X	F	Y			F	X	X	F		X	X	F	F				F
Fagus grandifolia										F												F				
Forsythia spp.			F		F	X	F		X	F	Y		F								F	F		F		
Forsythia intermedia			F		F	X	F		X	F	Y		F			X				X	F	F		F		
Fraxinus spp.					F		F	F														F				

ORNAMENTAL HERBICIDE REGISTRATIONS (continued)

	(PPI		)(PRE															)(POST**						)
	EPTAM	LASSO	TREFLAN	BETASAN	CASORON	CHIPCO RONSTAR	DACTHAL	DEVRINOL	DUAL	ENIDE	FUROLE	GOAL	KERB	LASSO	OH 1	OH 2	OR. WEEDER	PRINCEP	ROUT	SURFLAN	TREFLAN	FUSILADE	GOAL	KERB	PARAQUAT	POAST	ROUNDUP
Fraxinus americana			F		F		F	F		F							F				F	F			F	F	
Fraxinus pennsylvanica					F		F	F														F			F	F	
Ginkgo biloba						C														X							
Gleditsia triacanthos			F		F		F	F			Y							F			F					F	
Hedera helix	F		F	F	F	X	F	X	X	F	Y						F			X		F				F	
Hibiscus syriacus								F		F									X	X							
Hosta spp.																											
Hydrangea spp.							F			F	Y				X												
Hypericum spp.	F		F	F				F		F									X	X							
Iberis sempervirens				F			F												X								
Ilex spp.		X		F			F	X		F	Y		F		X		F	F				F		F			F
Ilex aquifolium		X		F	F	X	F	X		F	Y		F				F	F		F		F		F			F
Ilex cornuta		X		F	F	X	F	X		F	Y		F		X	X	F	F	X	X	F	F		F		F	F
Ilex crenata	F	X	F	F		X	F	X	X	F	Y		F		X	X	F	F		X		F		F		F	F
Ilex glabra		X		F	F		F	X		F	Y		F				F	F				F		F			F
Ilex opaca	F	X		F	F		F	X	X	F	Y		F		X		F	F				F		F			F
Juglans spp.							F	F																	F		
Juglans nigra			F				F	F		Z								F			F				F	F	
Juniperus spp.	F	X		F	F		F	X		F	Y		F	X			F	F		X		F	C	F		F	
Juniperus chinensis	F	X	F	F	F	X	F	X		F	Y	C	F	X	X	X	F	F	X	X	F	F	C	F		F	
Juniperus conferta	F	X	F	F	F	C	F	X	X	F	Y		F	X			F	F	X	X	F	F		F		F	
Juniperus horizontalis	F	X		F	F	X	F	X	X	F	Y	C	F	X	X	X	F	F	X	X		F	C	F		F	
Juniperus procumbens	F	X		F	F	C	F	X	X	F	Y		F	X			F	F		X		F		F			
Juniperus virginiana	F	X	F	F	F		F	X		F	Y		F	X			F	F		X	F	F		F		F	
Kalmia spp.							F		X	F	Y																
Kalmia latifolia			F		F		F		X		Y									X	F						
Koelreuteria paniculata					F	F																					
Kolkwitzia amabilis						F				F																	
Lagerstroemia indica				F		C													X	X		F					
Leucothoe spp.	F				F	C			X		Y																
Leucothoe axillaris	F					C			X		Y									X							
Ligustrum spp.				F	F		F	X	X	F	Y											F				F	F
Ligustrum ovalifolium			F	F	F	X	F	X	X	F	Y										F	F					F
Liquidambar styraciflua			F				F			F										X	F	F				F	
Liriodendron tulipifera			F		F		F			F	Y										F	F				F	
Liriope spp.			F					X												X		F				F	
Lonicera spp.(Xylosema)			F	F	F	X	F		X	F	Y					X				X	F						
Lonicera fragrantissima			F	F	F	X	F		X	F	Y							F		X							
Magnolia spp.	F				F		F				Y						F					F					F
Magnolia grandiflora	F				F	C	F				Y						F			X						F	F
Mahonia spp.										F	Y							F		X							
Malus spp.		F	F		F			F	X	F										F	F	F		F	F	F	
Malus floribunda		F	F		F	F	F	F	X	F	Y			F						F		F		F	F	F	
Malus pumila		F	F		F			F	X	F								F		F		F		F		F	
Nyssa sylvatica			F																		F						
Osmanthus spp.					F	C			X																		
Osmanthus heterophyllus									X											X							
Pachysandra terminalis	F			F			F	F	X		Y															F	
Parthenocissus tricuspidata							F																			F	
Philadelphus spp.			F		F		F			F	Y										F						
Picea spp.	F						F	F			Y											F					F
Picea abies	F		F			F	F	F		S	Y	W						F	X	F	F	F	W		F	F
Picea glauca	F		F				F	F		S	Y				X			F	X	F	F	F				F	F
Picea pungens	F		F				F	F			Y	W			X			F		X	F	F	W			F	F
Pieris spp.	F					C	F		X		Y						F	F									
Pinus spp.	F						F	X			Y		F				F					F		F	F		F
Pinus mugo	F						F	X			Y	C	F		X		F	F	X	X		F	C	F	F	F	F

ORNAMENTAL HERBICIDE REGISTRATIONS (continued)

	(PPI)(				PRE														)(POST**						)
	EPTAM	LASSO	TREFLAN	BETASAN	CASORON	CHIPCO RONSTAR	DACTHAL	DEVRINOL	DUAL	ENIDE	FURLOE	GOAL	KERB	LASSO	OH 1	OH 2	OR. WEEDER	PRINCEP	ROUT	SURFLAN	TREFLAN	FUSILADE	GOAL	KERB	PARAQUAT	POAST	ROUNDUP
Pinus nigra	F		F			X	F	X		S	Y	C	F				F			F	F	F	C	F	F	F	F
Pinus resinosa	F		F			F	F	X			Y		F				F	F				F		F	F		F
Pinus strobus	F		F			F	F	X		S	Y	W	F				F	F	X	X	F	F	W	F	F	F	F
Pinus sylvestris	F		F			X	F	X		S	Y	C	F				F	F		F	F	F	C	F	F	F	F
Pinus thunbergii	F		F			X	F	X			Y		F			X	F		X	X	F	F		F	F	F	F
Pinus virginiana	F						F	X			Y	W	F		X	X	F				F	F	W	F	F	F	F
Platanus spp.							F				Y																
Platanus acerifolia		F	F				F				Y										F						
Platanus occidentalis			F				F			F	Y										F					F	
Platycladus orientalis (Thuja)							F		X			C			X		F	F		X		F	C				
Populus spp.					F		F	F			Y																
Populus deltoides			F		F		F	F		F	Y										F						
Prunus spp.(peach & cherry)			F					F		F	Y				F						F	F			F	F	
Prunus spp.(plum)			F					F		F	Y									F		F			F	F	
Prunus caroliniana			F					F		F	Y									F	F	F			F		
Prunus cerasifera								F		F	Y									F		F			F		
Prunus laurocerasus					F			F		F	Y									F		F			F		
Prunus persica								F		F										F		F			F		
Prunus sargentii								F		F	Y									F		F			F		
Prunus serrulata								F		F	Y									F		F			F		
Prunus subhirtella pendulata								F		F	Y									F		F			F		
Prunus yedoensis								F		F	Y									F		F			F		
Pseudotsuga menziesii/ taxifolia			F				F	X		S	Y	Z	F					F		F	F	F	Z	F		F	F
Pyracantha spp.			F	F	F	C		X	X	F										X	F	F					
Pyracantha coccinea				F	F	C		X	X	F						X				X		F					
Pyrus spp.(pear)					F			F		F										F		F				F	
Pyrus callervana 'Bradford'					F			F												F		F					
Quercus spp.	F				F	C	F			F						X						F			F	F	F
Quercus alba	F				F	C	F			F												F			F		F
Quercus coccinea	F		F		F	C	F			F											F	F			F		F
Quercus palustris	F		F			C	F			F											F	F			F		F
Quercus phellos	F					C	F			F												F			F	F	F
Quercus rubra	F		F			X	F			F							F	F			F	F			F		F
Rhododendron spp. (azalea)				F			F	X		F	Y		F			X	F	X		X		F		F		F	F
Rhododendron spp. (rhodo.)	F				F		F	X	X	F	Y		F		X	X	F			X		F		F		F	F
Rhododendron,Azalea hybrids-Exbury, Satsuki, Glen Dale				F			F	X		F	Y		F			X	F		X	X		F		F			F
Rhododendron indica			F	F		X	F	X		F	Y		F			X	F			X	F	F		F		F	F
Rhododendron molle				F	F		F	X		F	Y		F			X	F			X		F		F		F	F
Rhododendron obtusum			F	F	F	X	F	X		F	Y		F		X	X	F		X	X	F	F		F		F	F
Rosa spp.	F		F		F	X	F	X	X	Z	Y									X	F						
Salix spp.			F		F		F			F											F	F				F	
Sedum spp.	F			F		F	F													X							
Spiraea spp.					F		F		X	F	Y				X	X	F					F				F	
Spiraea vanhouttei			F		F		F		X	F	Y				X	X	F				F	F				F	
Syringa spp.	F				F		F				Y																F
Syringa persica	F				F	F	F				Y																F
Syringa vulgaris	F		F		F		F			F	Y									X	F						F
Taxodium distichum			F							Z											F						

ORNAMENTAL HERBICIDE REGISTRATIONS (continued)

	(PPI		)(		PRE													)(POST**					)
	EPTAM	LASSO	TREFLAN	BETASAN	CASORON	CHIPCO RONSTAR	DACTHAL	DEVRINOL	DUAL	ENIDE	FURLOE	GOAL	KERB	LASSO	OH 1	OH 2	OR. WEEDER	PRINCEP	ROUT	SURFLAN	TREFLAN	FUSILADE	GOAL	KERB	PARAQUAT	POAST	ROUNDUP
Taxus spp.	F	F			F		F	F	X		Y	C	F	F		X	F	F				F	C	F			F
Taxus canadensis	F	F			F		F	F	X	F	Y	C	F				F	F				F	C				F
Taxus cuspidata	F	F	F		F		F	F	X		Y	C	F			X	F	F		X	F	F	C			F	F
Taxus media	F	F	F		F	F	F	F	X		Y	C	F				F	F			F	F	C				F
Thuja spp.					F	C	F	C	X		Y	C				X	F	F		X		F	C		F		F
Thuja occidentalis			F		F	F	F	C	X	Z	Y	C				X	F	F	X			F	C		F	F	F
Tilia spp.	F				F																					F	
Tsuga spp.	F							F			Y						F	F				F					F
Tsuga canadensis	F		F			F		F		Z	Y	S					F	F			F	F	S		F	F	F
Tsuga caroliniana	F							F			Y						F	F				F					F
Ulmus spp.					F		F											F				F		F			
Ulmus americana					F		F											F				F		F			
Vaccinium spp.										F																	
Viburnum spp.	F					X	F		X	F	Y					X	F		X			F					
Viburnum suspensum	F		F			X	F		X	F	Y						F			X	F	F					
Viburnum trilobum																								F			
Viburnum wrightii	F		F			X	F		X	F	Y						F				F	F					
Vinca spp.	F		F	F				F	X	F																	
Vinca minor	F		F	F		X		F	X	F	Y									X		F				F	
Weigela spp.			F		F		F		X	F									X	X	F						
Wisteria spp.																											
Yucca spp.																											
Yucca filamentosa															X												
Zelkova serrata																											

** Many chemicals are labeled for directed applications only; check labels for specific restrictions.

KEY TO WEED CONTROL:
F=field
D=dormant stock only
Y=field-dormant stock
W=field + container + seedbed
C=container
S=seedbed
X=field + container
Z=field + seedbed

INSECT PEST MANAGEMENT RECOMMENDATIONS FOR TREE AND SHRUB INSECTS

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Aphids (NHE-47)	acephate 75% S	1/2	When aphids are numerous. Spray with high pressure and thoroughly cover the foliage.
	malathion 50-57%E, 25W	1	
	diazinon 4E, 4E, 25%E, 50W	1	
Ash borer (NHE-145)	chlorpyrifos 2E, 4E, 50W	1	Apply in early June and repeat 4 weeks later.
	acephate 75%S	1/2	
Bagworm (NHE-16)	malathion 50-57%E, 25W	1	Spray foliage thoroughly about June 15 while worms are still small and before extensive feeding has occurred.
	carbaryl 80%S, 50W	1	
	chlorpyrifos 2E, 4E, 50W,	1/2	
	trichlorfon	1	
	Bacillus thuringiensis	follow label directions	
	acephate 75%S	1/2	
Birch leaf miner	acephate 75%S	1 1/3	Spray foliage thoroughly when miners first appear. Repeat 10 to 12 days later.
	malathion 50-57%E, 25W	1	
	diazinon 4E, 25%E, 50W	1	
	dimethoate 2E, 25W	1/4	
	chlorpyrifos 2E, 4E, 50W	1	
Black vine weevil	acephate 75%S	1	Spray foliage thoroughly in mid-May when adults are on foliage. Allow spray to run off onto soil under shrubs. Repeat twice at two-week intervals.
	bendiocarb 76W	1 1/4	
Bronze birch borer (NHE-143)	dimethoate 2E, 25W	1/2	Spray bark of trunk and limbs in late May and repeat 3 weeks later or apply a 6-inch wide band of concentrate on trunk.

[a] Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Cankerworm (NHE-95)	acephate 75%S	1/2	Spray when worms are still small as leaf buds are opening in spring.
	malathion 50-57%E, 25W	1	
	diazinon 4E, 25%E, 50W	1	
	carbaryl 80%S, 50W	1	
	Bacillus thuringiensis	follow label directions	
Cicada (NHE-113)	carbaryl 80%S, 50W	1	Spray foliage when egglaying begins. Repeat every 5 days while adult cicadas are present.
Cooley spruce gall aphid (NHE-80, 81)	malathion 50-57%E, 25W	1	Apply in late September or in early spring just before buds swell.
	diazinon 4E, 25%E, 50W	1	
Cottony maple scale (NHE-144)	acephate 75%S	2/3	Spray in July after crawlers have hatched and are active and repeat 10 days later.
	malathion 50-57%E		
	diazinon 4E, 25%E, 50W	1	
	superior oil	2 gallons	Apply in spring before leaf emergence. Do not use on Japanese or sugar maple.
Dogwood borer	chlorpyrifos 2E, 4E, 50W	1	Apply in mid-May and repeat 4 weeks later.
Eastern spruce gall aphid	malathion 50-57%E, 25W	1	Apply in late September or in early spring just before the buds swell.
	diazinon 4E, 25%E, 50W	1	
	chlorpyrifos 2E, 4E, 50W	1	
Eastern tent caterpillar	acephate 75%S	1/2	Spray areas of tree where nests first appear in early spring. Remove small nests from trees or prune out webs and destroy them.
	malathion 50-57%E, 25W	1	
	diazinon 4E, 25%E, 50W	1	
	Bacillus thuringiensis	follow label directions	
	chlorpyrifos 2E, 4E, 50W	1	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Elm bark beetles	methoxychlor		Contact Section of Applied Botany and Plant Pathology, Illinois Natural History Survey, Urbana, Illinois 61801, for information on Dutch elm disease control.
Elm cockscomb gall (NHE-80, 81)	diazinon 4E, 25%E, 50W	1	Usually no control is necessary.
	malathion 50-57%E, 50W	1	
Elm leaf beetle (NHE-82)	carbaryl 80%S, 50W	1	Apply when damage first appears, usually late May and again in late July-early August.
	acephate75%S	1/2	
	diazinon 4E, 25%E, 50W	1	
Euonymous scale (NHE-100, 114, 146)	acephate 75%S	2/3	Spray in early June when crawlers are active. Make four applications 10 to 12 days apart.
	dimethoate 2E, 25W	1	
	malathion 25W, 50-57%E	1	
	diazinon 4E, 25%E, 50W	1	
European elm scale (NHE-100, 114, 146)	malathion 25W, 50-57%E	1	Apply in early spring when first leaves appear.
European pine sawfly	carbaryl 80%S, 50W	1	Spray when worms are small and feeding on the needles.
	chlorpyrifos 2E, 4E, 50W	1	
	diazinon 4E, 25%E, 50W	1	
European pine shoot moth (NHE-83)	dimethoate 2E, 25W	1	Spray ends of branches thoroughly in late June before larvae enter the growing shoot. Aerial = 1 qt/A in 4 gal. of water. Ground = 1 qt/A in 100 gal. of water.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Fall webworm	acephate 75%S	1/2	Spray nests or webbed areas in trees in late summer. Do not apply acephate to crabapple. If webs are small, prune out and destroy.
	carbaryl 80%S, 50W	1	
	malathion 50-57%E, 25W	1	
	diazinon 4E, 25%E, 50W	1	
	Bacillus thuringiensis	follow label directions	
	chlorpyrifos 2E, 4E, 50W	1	
Flat-headed apple tree borer	dimethoate 2E, 25W	1/2	Spray in late May and repeat twice at 3-week intervals. Keep trees in vigorous growing condition. Wrap trunks of new set trees with paper or burlap.
Fletcher scale (NHE-100, 114, 146)	malathion 25W, 50-57%EC	1	Apply in early April and repeat in early June.
Forest tent caterpillar	acephate 75%S	1/3	Spray when caterpillars are small.
	carbaryl 80%S, 50W	1	
	malathion 25W, 50-57%E	1	
	diazinon 4E, 25%E, 50W	1	
Gouty oak gall	...	...	Prune out infested branches and destroy.
Hackberry psyllids (NHE-80,81)	malathion 25W, 50-57%E	1	Apply in late May. This insect rarely damages trees. Control is usually not necessary.
	diazinon 4E, 25%E, 50W	1	
Hawthorn leaf miner	acephate 75%S	2/3	Treat in early May or when first sign of leaf-browning appears.
	malathion 50-57%E, 25W	1	
	diazinon 4E, 25%E, 50W	1	
Hawthorn mealy bug	malathion 50-57%E, 25W	1	Apply when insects are numerous.
	diazinon 4E, 25%E, 50W	1	
	dimethoate 2E, 25W	1/2	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Holly leaf miner	dimethoate 2E, 25W	1/2	Spray foliage in late May or early June when leaf miners first appear.
	acephate 75%S	1/2	
Honeysuckle aphid	acephate 75%S	1/2	Spray at first sign of damage. Repeat 4 weeks later.
	dimethoate 2E, 25W	1/2	
	oxydemeton-methyl 25%E	3/4	
Lacebug	acephate 75%S	1/2	Spray when bugs are numerous.
	carbaryl 80%S, 50W	1	
	malathion 25W, 50-57%E,	1	
Leaf crumpler	malathion 25W, 50-57%E	1	Spray in late May and again in late August.
	diazinon 4E, 25%E, 50W	1	
Leafhoppers	carbaryl 50W, 80%S	1	Spray when hoppers are numerous on foliage. Permethrin is for use on nursery stock only.
	permethrin 3.2 E	0.1-0.2	
Lecanium scale (NHE-146)	acephate 75%S	2/3	Apply to infested trees in mid-June when crawlers are active and repeat 2 weeks later.
	diazinon 4E, 25%E, 50W	1	
	malathion 25W, 50-57%E	1	
Lilac borer (NHE-145)	chlorpyrifos 2E, 4E, 50W	1	Apply in mid-May and repeat 4 weeks later.
Locust borer	carbaryl 80%S, 50W	1	Apply in late August and again in mid-September.
	chlorpyrifos 2E, 4E, 50W	1	
Locust mite	fenbutatin-oxide, 50W	1/2	Apply in early spring just before leaves appear. Repeat spray 2 weeks later.
Magnolia scale (NHE-100, 114, 146)	malathion 25W, 50-57%E	1	Treat in late September or early spring when buds are opening.
	diazinon 4E, 25%E, 50W	1	
Maple bladder gall mite (NHE-80, 81)	...	...	No effective control available.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Mimosa webworm (NHE-109)	acephate 75%S	1/2	Spray in early July or when webs first appear. Repeat in early August for second generation.
	malathion 25W, 50-57%E	1	
	diazinon 4E, 25%E, 50W	1	
	Bacillus thuringiensis	follow label directions	
	chlorpyrifos 2E, 4E, 50W	1	
Mountain ash borer	chlorpyrifos 2E, 4E, 50W	1	Treat in early June and repeat 4 weeks later.
Nantucket pine tip moth (NHE-83)	acephate75%S	1/2	Spray ends of branches in mid-April and late June before the larvae enter the growing shoot.
	dimethoate 25W, 2E	1	
Oak kermes	malathion 25W, 50-57%E	1	Apply in early July when crawlers appear on foliage.
	diazinon 4E, 25%E, 50W	1	
Obscure scale (NHE-100, 114, 146)	superior oil	2 gallons	Apply in late October or in early spring just prior to leaf emergence. Apply in early to mid-July when crawlers are active.
	malathion 25W, 50-57%E	1	
	chlorpyrifos 2E, 4E, 50W	1	
Oystershell scale (NHE-100, 114, 146)	malathion 25W, 50-57%E	1	Apply in early June when crawlers are active and repeat 10 to 12 days later. Repeat sprays again in early August in central and southern Illinois.
	dimethoate 2E, 25W	1/2	
	chlorpyrifos 2E, 4E, 50W	1	
Peach tree borer (NHE-112)	chlorpyrifos 2E, 4E, 50W	1	Thoroughly spray the bark of trunk and limbs in mid-June and repeat 4 weeks later. Keep trees vigorous and avoid wounds or mechanical injury of the trunk and upper branches.
Periodical cicada (NHE-113)	carbaryl 80%S, 50W	1	Spray in June when adults are laying eggs.
Pine bark aphid	malathion 25W, 50-57%E	1	Spray when aphids are present, usually in May and later. Add spreader.
	diazinon 4E, 25%E, 50W	1	
	acephate 75%S	1/3	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Pine needle scale (NHE-100, 114, 146)	acephate 75%S	1/2	Apply spray in late May when crawlers are active if trees are infested.
	malathion 25W, 50-57%E	1	
	diazinon 4E, 25%E, 50W	1	
	chlorpyrifos 2E, 4E, 50W	1	
San Jose scale (NHE-100, 114, 146)	superior oil	2 gallons	Apply to bark of trunk and limbs in spring prior to leaf emergence.
Spider mites (NHE-58)	fenbutatin-oxide 50W	1/2	Spray when mites are numerous. Especially on serious juniper. Concentrate spray on the undersides of the foliage.
	dienochlor	1/3	
Spruce spider mite	dimethoate 2E	1/2	Spray when mites are numerous. Thorough coverage of foliage is important.
	dienochlor	1/3	
Spittle bug (NHE-7)			No chemical control is necessary.
Taxus mealy bug (NHE-7)	acephate 75%S	1/2	Spray foliage with force when insects are present. Repeat 2 weeks later.
	malathion 25W, 50-57%E	1	
	diazinon 4E, 25%E, 50W	1	
Thrips	malathion 25W, 50-57%E	1	Spray privet when thrips are numerous.
	acephate 75%S	1/2	
Tuliptree scale	superior oil	2 gallons	Apply oil in late spring before leaves emerge. Apply malathion in mid-August.
	malathion 25W, 50-57%E	1	
Virburnum borer	chlorpyrifos 2E, 4E, 50W	1	Apply to trunks in June, be sure to treat bark at and just below soil surface; repeat in 4 weeks.
White-marked tussock moth	malathion 25W, 50-57%E	1	Treat in June when worms are small.
	carbaryl 80%S, 50W	1	
	diazinon 4E, 25%E, 50W	1	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Yellow-necked caterpillar	malathion 50-57%E, 25W	1	Spray foliage when caterpillars are small, usually in late July.
	diazinon 4E, 25%E, 50W	1	
	acephate 75%S	1/2	
	chlorpyrifos 2E, 4E, 50W	1	
Zimmerman pine moth	dimethoate 2E, 25W	1	Spray bark and foliage either in April for control of larvae or mid-August for control of adults and eggs.
	chlorpyrifos 2E, 4E, 50W	1	

INSECTICIDE NAMES

Common name	Trade names	Common name	Trade names
acephate[a]	Orthene	fenbutatin-oxide	Vendex
Bacillus thuringiensis	Dipel, Thuricide	isofenphos	Oftanol
bendiocarb	Turcam, Dicarb	malathion[e]	Cythion
carbaryl[b]	Sevin	oxydemeton-methyl	Metasystox-R
chlorpyrifos	Dursban	permethrin	Pounce, Ambush
diazinon[c]	Spectracide, diazinon	superior oil[f]	many brands
dienochlor	Pentor	trichlorfon	Dylox, Proxol
dimethoate[d]	Cygon, De-Fend		

[a]Do not use on sugar or Japanese maple, American elm, flowering crab, redbud, cottonwood, or Lombardy poplar.
[b]Do not use on Boston ivy.
[c]Do not use on ferns or hibiscus.
[d]Do not use on chrysanthemums.
[e]Do not use on canaert red cedar.
[f]Do not use on conifers, ferns, sugar maple, or Japanese maple.

Home Fruit Pest Control

PEST CONTROL IS NECESSARY TO GROW TOP-QUALITY fruit. Diseases, insects, mites, birds, and rodents attack all types of fruits grown in home plantings.

Cultural practices such as pruning, fertilizing, planting, and fruit thinning are important pest control practices discussed in Circular 1013, *Growing Tree Fruits in the Home Orchard,* Circular 935, *Growing Small Fruits in the Home Garden,* and Circular 1144, *Controlling Weeds in Home Fruit Plantings.* These circulars are available from your county Extension office or from the Office of Publications, College of Agriculture, University of Illinois at Urbana-Champaign, 54 Mumford Hall, 1301 West Gregory Drive, Urbana, IL 61801.

Cultural Tips for Tree Fruits

Prune fruit trees each year to keep them short and well shaped. Well-pruned trees are easier to spray. Destroy (burn) all prunings including dead and diseased branches.

Keep the grass under and around trees mowed. Grass harbors mites, aphids, and other injurious insects.

During the spray season, pick up and destroy or bury any fallen fruit damaged by insects or diseases. In the fall, rake up all fallen leaves and fruit. Then burn, compost, or bury them.

Cultural Tips for Small Fruits

Good cultural practices help prevent and control insect and disease problems. See the notes under the spray schedule for each small fruit species for specific cultural tips.

Spraying Tips

Good spray coverage is essential for adequate pest control. Thoroughly wet the undersides of the leaves, the fruit, the limbs, and the trunk, as well as the upper sides of the leaves. Because insect and disease control are most difficult in the upper portions of the tree, direct two-thirds of the spray into the top half of the tree. Spray until the tree begins to drip.

If the leaves or fruit are waxy, the spray may stay in drops instead of spreading over the surface. Add one teaspoonful of liquid household detergent per gallon of spray after filling the sprayer to help spread the spray evenly.

Don't skip sprays — insects and diseases do not take vacations. Depending on the crop, sprays must be applied on a 7- to 14-day schedule.

To have a good spray program, always observe the following suggestions:

1. Do not use herbicides (weed-killers) in sprayers to be used for insect and disease control.
2. Spray before rains for disease control and allow sufficient time for the spray to dry. Disease-causing organisms infect plants in as few as 6 to 8 hours when plants are wet.
3. Make up a fresh spray mix for each application. Discard leftover spray; never save it for a future application. Always use clean water.
4. Stir the spray mixture or shake the sprayer frequently while spraying so that the chemicals will not settle out.
5. Wash out the sprayer as soon as you stop spraying. Do not wait until the next day; such a delay may result in a clogged sprayer.
6. During bloom, apply fungicide sprays when they are suggested, but leave out the insecticides. Honeybees and certain other pollinating insects are essential for many kinds of fruit to develop. If insecticides are applied during bloom, helpful insects will be killed, and you will end up with little or no fruit.

Tank Mix and Multipurpose Mix

Wettable powders (WP) are preferred over liquid concentrates (EC) because liquid concentrates are more likely to cause injury to leaves and fruit.

Wettable powders must be thoroughly dispersed in water, or they will clog the spray nozzle. One method of mixing sprays in compressed-air and other types of sprayers without agitators is as follows: measure the pesticides, place them in the tank, and then use a hose to fill the sprayer. Use the hose nozzle to thoroughly mix the spray as the tank is filled. While spraying, shake the tank frequently to keep the materials dispersed.

Another mixing method is to measure the pesticides into a small can or jar, add a small amount of water, and stir into a smooth, thin slurry. Then wash the slurry into the spray tank and fill to the desired level.

For sprayers equipped with an agitator, fill the tank one-third full of water, start the engine and the agitator, then sift in the wettable powders, and finish filling the sprayer.

Using a ready-to-use multipurpose mix (Table 1) is sometimes more convenient than mixing separate materials in the tank. Many multipurpose fruit spray mixes are available. These mixes usually contain one or two insecticides, one or two fungicides, and sometimes a miticide. A widely sold multipurpose fruit spray contains methoxychlor, malathion, and captan. The individual components may be purchased in 1- to 5-pound packages and mixed at home just before spraying.

Imidan or Diazinon may be substituted for the combination of malathion and methoxychlor. Imidan

Table 1. Multipurpose Spray Mix

Materials	Amount of spray mix to add to water to make		
	1 gallon	5 gallons	10 gallons
Methoxychlor	2 tbsp.	1 cup	2 cups
plus Malathion, 25% WP	2 tbsp.	¾ cup	1½ cups
plus captan	1½ tbsp.	¾ cup	1½ cups
or ferbam	2 tbsp.	¾ cup	1½ cups

is labeled only for tree fruits and grapes. Other pesticides not mentioned in this circular are registered for use on certain fruits and may be substituted at certain times in the schedules.

The initial investment for a multipurpose spray is considerably less than buying each material separately, but over a period of years the cost usually is greater for three reasons. First, the cost per pound of material usually is greater. Second, not all of the ingredients in the multipurpose spray are needed for some applications. And third, for some fruits less costly materials are often just as effective. Mixing the separate chemicals also allows variations in the mixture to suit the conditions and the plant being sprayed.

Most spray chemicals will retain their effectiveness for three or more years if stored in a dry place. Malathion, which has a disagreeable odor, should be stored in a closed metal container.

Insecticides, miticides, and fungicides are sold under a number of trade (or product) names. To avoid confusion, both common (or generic) and trade names are used in this circular (Table 2). The common name of the pesticide is always shown on the label as the active ingredient.

Table 2. Common and Trade Names of Pesticides

Common name	Trade name
Insecticides and miticides	
carbaryl	Sevin, 50% WP
diazinon	Diazinon, 50% WP
malathion	Malathion, 25% WP and 57% EC
methoxychlor	Methoxychlor, 50% WP
phosmet	Imidan, 50% WP
Fungicides	
benomyl	Benlate, 50% WP
captan	Captan, 50% WP
dinocap	Karathane, Dinocap, 19.5% WP
Dodine	Cyprex, 65% WP
ferbam	Carbamate, Karbam Black, Ferbam, 76% WP
mancozeb	Manzate 200, Dithane M-45, 80% WP
sulfur, wettable	Many names are used.
zineb	Zineb, 75% WP

A common problem in spraying is knowing how much spray to apply per tree. Table 3 should serve as a guide depending on tree height, width (spread), and growth stage.

Spray Schedules

The amounts given in the following spray schedules (Tables 4-11) are in level teaspoons (tsp.), level tablespoons (tbsp.), and level or partial cups. One level cup equals 16 level tablespoons. The suggested amounts are adequate for control. Do not use more pesticide than label rates. Excessive concentration of spray materials may cause injury to the foliage and fruit, and an insufficient concentration will not control the target pest or pests.

Table 3. Approximate Amount of Spray Required for Fruit Trees of Different Sizes

Height in feet	Spread in feet	Gallons per tree per application[a]
4	3	up to ½
5 to 8	3 to 6	¼ to 1
8 to 10	4 to 8	½ to 2
10 to 15	8 to 15	1 to 3
15 to 20	15 to 25	2 to 6

[a] Use the greater amounts for trees in full foliage.

Preventing Mouse Damage

Mice are serious pests of apple trees and sometimes other fruit trees. They eat bark from the main roots and trunk near and below the ground line. Both young and old trees may be damaged. Mouse injury may occur at any time during the year but is usually more serious in late fall, winter, and early spring when other food is scarce.

Natural predators such as cats, hawks, owls, and foxes will greatly reduce the mouse population if protective cover is eliminated. Mow the grass closely under the trees and throughout the orchard. Hoe out all grass and weeds within one foot of the trunk, leaving the ground bare.

Mulches are advantageous for fruit trees, but they may harbor mice. In autumn pull the mulch away from the trunk, leaving one foot of bare ground between the mulch and the trunk.

Mouse traps and anticoagulant baits (for example, Warfarin) may be used. A repellent on the trunk near the ground line will help protect trees from mouse damage. Use a commercially prepared repellent containing thiram, or use the mixture mentioned below for repelling rabbits. Spray or paint the lower trunk in late November and again in February.

A gravel collar around the tree trunk discourages mice and helps control grass and weeds. The collar should be 6 to 8 inches deep and about 2 feet in diameter. The gravel must remain loose to prevent damage to the trunk (see picture).

Preventing Rabbit Damage

In fall, winter, and early spring when food is scarce, rabbits may eat the bark from the trunk and lower limbs of young fruit trees. They also eat the bark from blackberry and raspberry bushes and eat buds on young blueberry plants. Rabbits seldom cause much damage to older fruit trees and older blueberry plants.

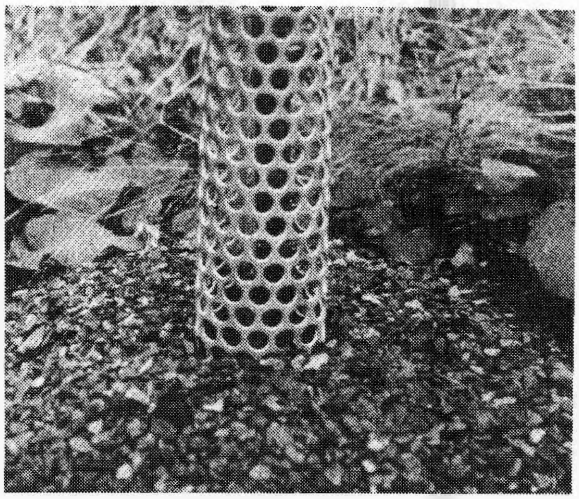
Mechanical barriers prevent rabbit damage effectively unless deep snows occur. For young trees, use a circular metal guard 18 inches tall and 6 inches in

diameter made from an 18-inch-square piece of hardware cloth (see picture). Or wrap the trunk and lower branches with several layers of newspaper in early November and remove the papers in April.

The most practical mechanical barrier for protecting blackberry, raspberry, and young blueberry plants against rabbits is an 18- to 24-inch-high chicken wire fence.

Commercially prepared repellents containing thiram are effective against rabbits, or you can prepare a thiram mixture using a liquid suspension (Gustafson 42-S) 1 part, combined with white latex paint (1 or 2 parts), and water (8 parts).

In October or November paint or spray the parts of plants that need protection from rabbits.



Young apple tree with a metal guard and a gravel collar.

Preventing Bird Damage

Birds are especially destructive pests of blueberries and cherries, and they frequently damage other fruits. Covering the fruit plant with netting just before the fruit ripens is the only practical method of protecting the fruit. Picking fruit promptly as it ripens will reduce losses.

Aluminum pie pans and other reflecting objects hung in fruit plants provide some protection until the birds become adjusted to their presence.

Table 4. Spray Schedule for Apples, Crabapples, Pears, and Quinces

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp.	*cups*	
1	Dormant; *before* buds swell, *not later*	Plant spray oil	5	3	Spray only when the temperature will not go below 33° F for 24 hours
2	When green tissue is ½ inch out of bud *and again* when fruit buds show color (or turn pink)	Captan *plus* zineb or mancozeb *plus* Imidan *or* Diazinon OR multipurpose fruit spray *plus* sulfur (if needed)	1½ 1½ 1 1	1 1 ¾ ¾	Add 5 tablespoons of wettable sulfur per gallon or 1 teaspoon of Benlate where powdery mildew is a problem on apples
3	When three-fourths of the petals have fallen	Same as No. 2 mix			See remarks for No. 2 mix
4	7 to 10 days after No. 3 mix	Same as No. 2 mix			See remarks for No. 2 mix
5	Continue sprays at 7- to 10-day intervals until July 1	Same as No. 2 mix			
6	Continue sprays at 10- to 14-day intervals until 2 weeks before harvest	Same as No. 2 mix			

NOTES: Apply dormant sprays only when the temperature is above freezing and before buds show green tips.

Borers that attack apple and pear trees will be controlled by the spray schedule above if the trunk is thoroughly sprayed. If borers have attacked young, nonbearing trees, spray the trunks every two weeks during June and July with a multipurpose fruit spray.

For apple maggot control in the northern half of Illinois, continue to apply an insecticide or multipurpose fruit spray every 10 to 14 days through July and August.

Only the 25% WP formulation of malathion should be used on apples.

Table 5. Spray Schedule for Grapes

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp.	*cups*	
1	New growth 2 to 4 inches long and again at 10 to 15 inches long	ferbam *plus* Sevin *or* Malathion, 25% WP	2 2 2	1½ 1 1	Primarily for black rot control; also for flea beetles
2	Just before bloom	Same as Mix No. 1			If powdery mildew is a problem, add 1 teaspoon of benomyl (Benlate) per gallon to spray mix
3	Just after bloom (when berries have set)	Captan *plus* Sevin (if needed)	1½ 2	1½ 1	Add Sevin if insects are a problem
4	Three weeks after the last spray	Captan	1½	1½	Primarily for black rot control

NOTES: Grapes should be severely pruned and retied annually. Clean cultivation helps control flea beetles, cutworms, and disease-causing organisms. Select only strong, healthy canes of the previous year's growth to produce the following season's crop. After the fruiting canes have been selected, remove excess growth, dried berries, and leaves. Destroy (burn) all prunings.

The most important problem is black rot, which appears on the leaves as small, reddish-brown to tan-brown spots with dark margins. "Bird's-eye" tan spots on the fruit rapidly enlarge. Berries quickly rot and turn into black, wrinkled mummies that drop early.

Table 6. Spray Schedule for Currants and Gooseberries

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
1	Dormant (before growth starts)	Plant spray oil	5 tbsp.	3 cups	For control of scale and aphid insects
2	When leaf tips show green	Malathion, 57% EC *plus* wettable sulfur *or* Benlate *or* Karathane (if needed)	2 tsp. 3 tbsp. ½ tbsp. 2 tsp.	7 tbsp. 2 cups ½ cup ½ cup	Add 2 tablespoons of sulfur, 1 teaspoon of Benlate, or 2 teaspoons of Karathane to each gallon of the mix if powdery mildew is a problem
3	Full foliage	Malathion, 57% EC	2 tsp.	7 tbsp.	Same as for No. 2 mix
4	Two weeks after bloom	ferbam	2 tbsp.	1½ cups	Mostly for leaf spot and anthracnose control

NOTE: Prune out and destroy severely infested or diseased plant parts.

Table 7. Spray Schedule for Blueberries

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp	*cups*	
1	As buds break open and until three-fourths of blossoms have dropped	Malathion, 25% WP *or* Sevin *plus* ferbam *or* Benlate	2 2 2 ½	1 1½ 1½ ½	If pest problems appear, apply at 10-day to 2-week intervals

NOTES: Pruning out old canes and cleaning out small, weak wood with hand shears will reduce insect, mite, and disease problems. All prunings should be removed and disposed of, preferably by burning.

Heavy nitrogen fertilization increases the chances for more severe disease problems.

Table 8. Spray Schedule for Peaches, Nectarines, Apricots, and Plums

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp.	*cups*	
1	Dormant; *before* buds swell, *not later*	Captan, OR multipurpose fruit spray	1½	1½	This is the *only* spray that controls leaf curl and plum pockets
2	When fruit buds show color (or turn pink)	Captan OR Benlate[a]	1½ ½	1½ ½	Do *not* use insecticides during bloom: pollinating insects will be killed
3	During bloom	Captan OR Benlate[a]	1½ ½	1½ ½	Very important for blossom blight control
4	When husks begin to split and pull away from the base of the fruit	Wettable sulfur *plus* Captan *plus* Imidan *or* Diazinon OR multipurpose fruit spray *plus* sulfur	3 1½ 1 1	2 1½ ¾ ¾	Sulfur is needed for scab control on peaches and may be added to a multipurpose fruit spray
5	7 to 10 days after No. 4 mix	Same as No. 4 mix			
6	Continue sprays at 10- to 14-day intervals until 4 weeks before harvest	Same as No. 4 mix			
7	10 to 14 days after No. 6 mix	Malathion, 25% WP *plus* Captan	1½ 2	1 2	Within 1 week of harvest, spray Captan alone for brown rot

[a] Benlate should be either alternated or combined with Captan in the spray schedule to prevent the occurrence of Benlate-tolerant strains of fungi. *Never* use Benlate alone in repeated spray applications.

NOTE: For special borer sprays for peaches, nectarines, cherries, plums, and apricots, spray or paint *only* the trunk and lower limbs with 3 tablespoons of Sevin per gallon of water about June 15, July 15, and August 15. Keep the spray off leaves and fruit.

Table 9. Spray Schedule for Cherries

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp.	*cups*	
1	When husks begin to split and pull away from the base of the fruit	Captan *plus* Malathion, 25% WP *or* Imidan *or* Diazinon, OR multipurpose fruit spray	1½ 1½ 1 1	1 1 ¾ ¾	
2	7 to 10 days after No. 1 mix	Same as No. 1 mix			
3	Just after fruit is harvested and again 2 to 3 weeks later	Captan	2	1½	Important to control leaf spot and to keep leaves from dropping prematurely

NOTE: For special borer sprays for cherries, see the schedule for peaches. Cyprex and Benlate give outstanding control of cherry leaf spot and, if available, are recommended as a replacement for Captan in the spray program above.

Table 10. Spray Schedule for Strawberries

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
			tbsp.	*cups*	
1	Early bloom	Multipurpose fruit spray			Apply at the appearance of the first blossoms
		plus Captan	1½	1½	
		or Benlate[a]	1	½	
2	Cover sprays (7 to 10 days after No. 1 mix; repeat every 7 to 10 days until harvest	Multipurpose fruit spray			Apply Captan or Benlate *alone*[a] during bloom at weekly intervals; Benlate, if powdery mildew develops
		or Captan	1½	1½	
		or Benlate[a]	½	½	
3	Postharvest sprays	Multipurpose fruit spray			Apply 1 or more times after renovation to protect the new foliage for next year's crop

[a] Benlate should be either alternated or combined with Captan in the spray schedule to prevent the occurrence of Benlate-tolerant strains of fungi.

NOTE: To reduce insect and disease problems of strawberries —

1. Renovate beds immediately after each harvest.
2. Use certified, virus-free plants for new plantings. Plan a good aphid control program during spring and summer to reduce the chance of contaminating your virus-free plantings. Malathion is good against aphids.
3. Practice crop rotation. Because of Verticillium wilt, avoid planting within three years of tomatoes, peppers, potatoes, eggplant, melons, or roses. Strawberry varieties most resistant to Verticillium wilt include Allstar, Catskill, Delite, Earliglow, Guardian, Redchief, Sunrise, Surecrop, Tennessee Beauty, Tribute, and Tristar.
4. Plant red-stele-resistant varieties; this is the *only* control for this disease. Planting in light, well-drained soil may provide a measure of relief. The following strawberry varieties are resistant to red stele root rot (the number in parentheses is the number of races of the fungus to which the variety is resistant): Allstar (2), Darrow (5), Delite (5), Earliglow (5), Guardian (5), Midway (2), Redchief (5), Sunrise (5), Surecrop (5), Tribute (2), and Tristar (2)
5. Avoid white grubs. Do not plant strawberries on sod land until it has been under cultivation for at least two years. If grub damage is present, apply diazinon as a postharvest treatment.
6. If slugs are a problem, apply metaldehyde bait according to label directions.

Table 11. Spray Schedule for Brambles (Blackberries and Raspberries)

Mix no.	Time to apply	Spray material	For 1 gal.	For 10 gal.	Remarks
1	Delayed dormant (before leaflets are ⅜-inch long)	Liquid lime-sulfur	1½ cups	1 gal.	For control of mites, scale insects, anthracnose, and spur blight
2	Cover sprays (when new canes are 6 to 8 inches high, just before bloom, and immediately after bloom)	Sevin	2 tbsp.	1 cup	For control of anthracnose, spur blight, cane blight, fruit rots, leaf spot, and insects
		or Malathion, 25% WP	2 tbsp.	1 cup	
		plus ferbam	2 tbsp.	1½ cups	
3	Special sprays	Malathion, 57% EC	2 tsp.	7 tbsp.	Apply as fruit begins to color to control picnic beetles
		ferbam	2½ tbsp.	1½ cups	Apply right after harvest to control anthracnose and spur blight

NOTE: to reduce insect and disease problems of brambles —

1. Remove and dispose of insect-infested, diseased, and old fruiting canes immediately after harvest. Thin out all weak, short, spindly, and injured canes. Clean cultivation helps control fruit worms.
2. Remove all nearby wild brambles and neglected plantings.
3. Keep fruit plantings and surrounding areas free of weeds.
4. Use certified, virus-free plants when starting a new planting. Select adapted, disease-resistant varieties.
5. All plants infected with orange rust, crown gall, and viruses must be dug out and removed from the planting when first noticed.
6. See strawberries spray schedule for note on Verticillium wilt control.

HANDLE PESTICIDES CAREFULLY

All pesticides should be handled with care. The materials suggested in this circular are relatively low in toxicity, but careless use can cause illness.

- Read the label and follow all precautions and directions.
- Keep pesticides in their original containers and lock them away from children, pets, food, and feeds.
- Avoid getting spray materials and spray on the skin. If an accident happens, wash the area liberally with soap and water IMMEDIATELY.
- Mix sprays in a well-ventilated area to avoid breathing spray dust and fumes.
- Wear a cap, a long-sleeved shirt, and full-length pants when spraying to protect the skin from spray drift. Avoid breathing the dust or spray.
- Don't smoke or eat while spraying or handling spray chemicals.
- Don't spray from inside a fruit tree.
- Wash hands and face with soap and water when spraying is finished.
- Avoid spray drift on vegetables, small fruits, birdbaths, fishponds, and water supplies of animals.
- Bury surplus pesticides and dispose of containers in a manner that will prevent their reuse.

AVAILABLE PUBLICATIONS

Control of pests is dependent on a rapid and accurate diagnosis. A number of entomology Fact Sheets (NHE's) and Reports on Plant Diseases (RPD's) covering most fruit pests are available. Contact your county Extension office concerning the availability of these publications.

This circular was prepared by M. C. Shurtleff and S. M. Ries, Extension Specialists in Plant Pathology, Roscoe Randell, Extension Specialist in Entomology, and D. B. Meador, Extension Specialist in Horticulture.

Application Equipment and Calibration References

L. Bode and R. Wolf

SPRAYER CALIBRATION GUIDELINES

Variables Affecting Application Rate

Three variables affect the amount of spray mixture applied per acre: (1) the nozzle flow rate; (2) the ground speed of the sprayer; and (3) the effective sprayed width per nozzle.

The gallons of spray applied per acre can be determined from the three variables in the following equation:

$$GPA = \frac{GPM \times 5940}{MPH \times W}$$

When:

GPA = spray applied, in gallons per acre.

GPM = output per nozzle, in gallons per minute.

MPH = ground speed, in miles per hour.

W = effective sprayed width per nozzle, in inches.
For broadcast spraying, W = the nozzle spacing.
For band spraying, W = the band width.
For row crop applications, such as spraying from drop pipes or directed spraying, $W = \frac{\text{row spacing (or band width)}}{\text{number of nozzles per row (or band)}}$.

5940 = a constant to convert gallons per minute, miles per hour, and inches to gallons per acre.

Selecting the Proper Nozzle Tip

The proper size nozzle can be selected by determining the required flow rate from each nozzle at a selected application rate (GPA), ground speed (MPH), and

effective sprayed width in inches (W) per nozzle. The required flow rate per nozzle can be determined from one of the following equations:

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

or

$$OPM = \frac{GPA \times MPH \times W}{46.4}$$

When:

OPM = output per nozzle, in ounces per minute

Select a nozzle that will give the required flow rate when the nozzle is operated within the recommended pressure range. The tables on the following pages list the flow rates from commonly used nozzles that are available from several manufacturers.

Calibrating the Sprayer

Install the selected nozzle tips in the sprayer. Determine the required flow rate for each nozzle in ounces per minute (OPM) from the following equation:

$$OPM = GPM \times 128$$
(1 gallon = 128 ounces)

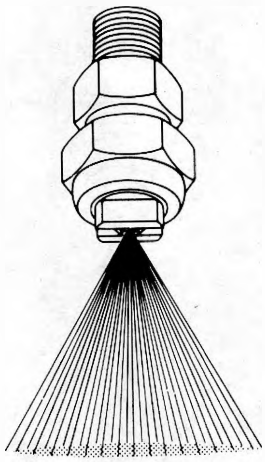
Collect the output from a nozzle using a container marked in ounces. Adjust the pressure until the required OPM is collected. Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear. Replace the nozzle tips and recalibrate when the output has changed 10 percent or more from that of a new nozzle, or when the pattern has become uneven.

Types of spray nozzles are shown on the next two pages.

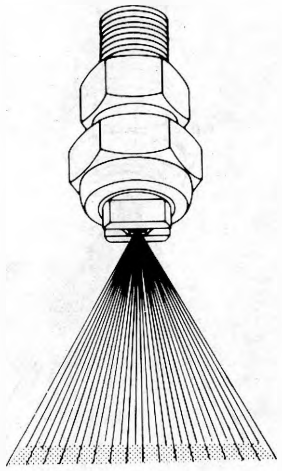
NOZZLE NOMENCLATURE

There are many types of nozzles available, each providing different flow rates, spray angles, and droplet sizes and patterns. The tip number is often used to indicate some of these spray characteristics. Other indications for spray characteristics are identified with letters representing different operating conditions. The following table is presented to help classify various nozzles and their spray characteristics.

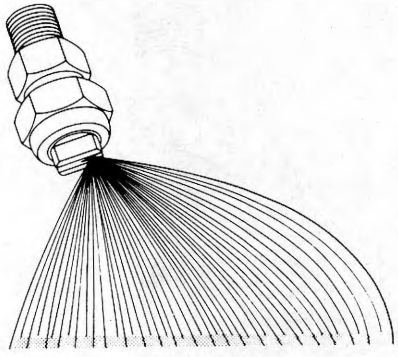
TYPES OF SPRAY NOZZLES



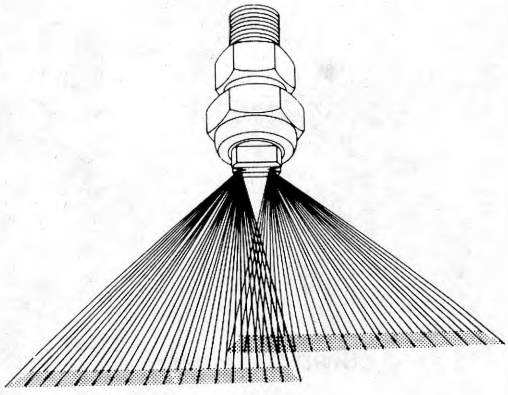
Flat Fan



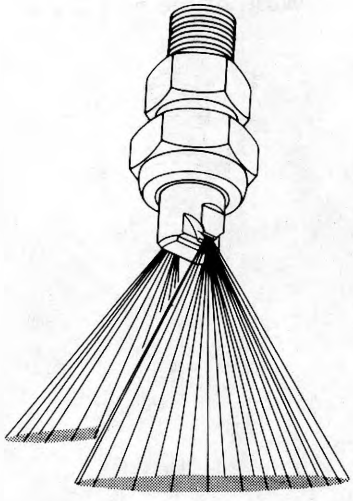
Even Fan



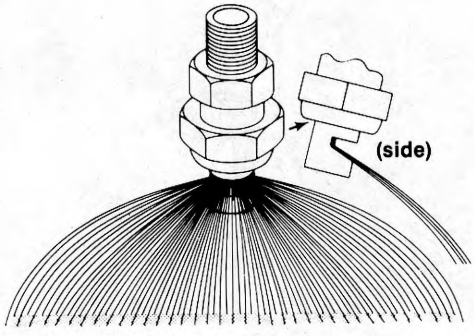
Off Center Fan



Twin Orifice (Off – Center)

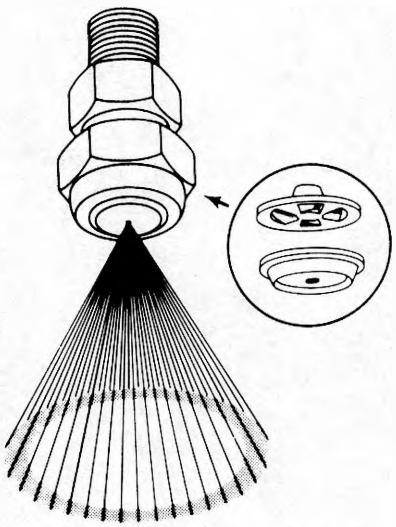


Twin Orifice (Flat Fan)

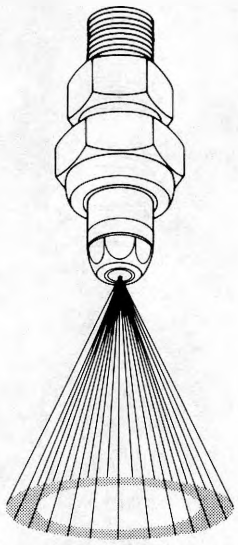


Flooding (front)

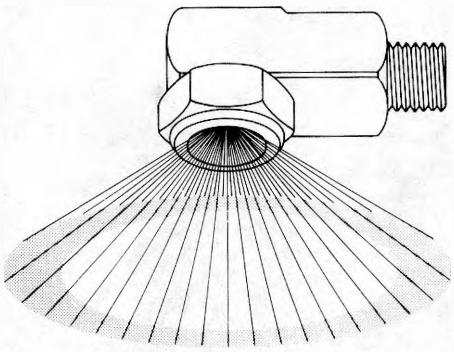
TYPES OF SPRAY NOZZLES



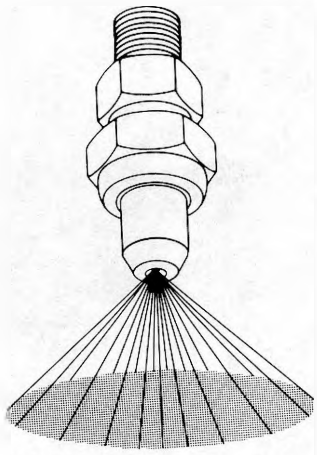
Hollow Cone (Disc – Core)



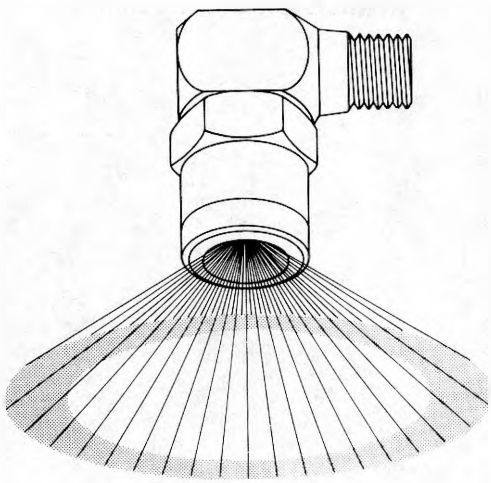
Hollow Cone (1 piece)



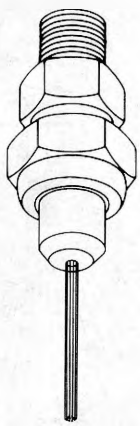
Swirl Chamber



Wide Angle Full Cone



RA – Raindrop



Straight Stream

Nozzle type	Nozzle Nomenclature			
	Delevan	Spraying systems	Lurmark	Chem Farm
flat fan	LF	XR	F	
even fan	LE	E	E	
low pressure flat fan	R or LFR	LP		
twin orifice	2LF	TJ		
off center	LX	OC	OC	
flooding	D or F	TK or K	AN	
whirlchamber, raindrop, wide angle-full cone	WRW, RA	FL, B, W	HW	MC
hollow-cone	HB, HC	TX	HAF	
hollow-cone (disc and core type)	DC	D	DC	
flooding, raindrop, and whirlchamber (high capacity)	F, 3/4 WRW	K, QCK	AN	

FLAT-FAN NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity	
		gal/min (GPM)	oz/min (OPM)
Spraying Systems 800067 Delavan LF.67 (100 mesh)	15	.04	5.1
	20	.05	6.4
	30	.06	7.7
	40	.067	8.6
	50	.07	9.0
Spraying Systems XR8001 Delavan LF1 Lurmark 01-F80 Hardi 2080-10 (100 mesh)	15	.06	7.7
	20	.07	9.0
	30	.09	11.5
	40	.10	12.8
	50	.11	14.1
Spraying Systems XR80015 Delavan LF1.5 Lurmark 015-F80 Hardi 2080-12 (100 mesh)	15	.09	11.5
	20	.11	14.1
	30	.13	16.6
	40	.15	19.2
	50	.17	21.8
Spraying Systems XR8002 Delavan LF2 Lurmark 02-F80 Hardi 2080-14 (50 mesh)	15	.12	15.4
	20	.14	17.9
	30	.17	21.8
	40	.20	25.6
	50	.23	29.4

FLAT-FAN NOZZLES *(continued)*

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Spraying Systems XR8003	15	.18	23.0
Delavan LF3	20	.21	26.9
Lurmark 03-F80	30	.26	33.3
Hardi 2080-16	40	.30	38.4
(50 mesh)	50	.34	43.5
Spraying Systems XR8004	15	.24	30.7
Delavan LF4	20	.28	35.8
Lurmark 04-F80	30	.35	44.8
Hardi 2080-20	40	.40	51.2
(50 mesh)	50	.45	57.6
Spraying Systems XR8005	15	.31	39.7
Delavan LF5	20	.35	44.8
Lurmark 05-F80	30	.43	55.0
	40	.50	64.0
(50 mesh)	50	.56	71.7
Spraying Systems XR8006	15	.37	47.4
Delavan LF6	20	.42	53.7
Lurmark 06-F80	30	.52	66.6
Hardi 2080-24	40	.60	76.8
(50 mesh)	50	.67	85.8
Spraying Systems XR8008	15	.49	62.7
Delavan LF8	20	.57	73.0
Lurmark 08-F80	30	.69	88.3
Hardi 2080-30	40	.80	102.0
(50 mesh)	50	.89	114.0
Spraying Systems XR8010	15	.61	78.1
Delavan LF10	20	.71	90.9
Lurmark 10-F80	30	.87	111.4
Hardi 2080-36	40	1.00	128
	50	1.12	143.4
Spraying Systems XR8015	15	.92	117.8
Delavan LF15	20	1.06	136
Lurmark 15-F80	30	1.30	166
	40	1.50	192
	50	1.68	215
Spraying Systems XR8020	15	1.20	153.6
Delavan FL20	20	1.41	180
Lurmark 20-F80	30	1.73	221.4
Hardi 2080-50	40	2.00	256
	50	2.23	285.4

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

EVEN FAN NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan LE-1	20	.07	9.0
Spraying Systems 8001E	25	.08	10.2
Lurmark E9501	30	.09	11.5
(100 mesh)	40	.10	12.8
Delavan LE-1.5	20	.11	14.1
Spraying Systems 80015E	25	.12	15.4
Lurmark E95015	30	.13	16.6
(100 mesh)	40	.15	19.2
Delavan LE-2	20	.14	17.9
Spraying Systems 8002E	25	.16	20.5
Lurmark E9502	30	.17	21.8
(50 mesh)	40	.20	25.6
Delavan LE-3	20	.21	26.9
Spraying Systems 8003E	25	.24	30.7
Lurmark E9503	30	.26	33.3
Hardi 4598-10	40	.30	38.4
(50 mesh)			
Delavan LE-4	20	.28	35.8
Spraying Systems 8004E	25	.32	41.0
Lurmark E9504	30	.35	44.8
Hardi 4598-12	40	.40	51.2
(50 mesh)			
Delavan LE-5	20	.35	44.8
Spraying Systems 8005E	25	.40	51.2
Lurmark E9505	30	.43	55.0
Hardi 4598-14	40	.50	64.0
(50 mesh)			
Delavan LE-6	20	.42	53.7
Spraying Systems 8006E	25	.47	60.2
Lurmark E9506	30	.52	66.6
Hardi 4598-16	40	.60	76.8
(50 mesh)			
Delavan LE-8	20	.57	73.0
Spraying Systems 8008E	25	.63	80.6
Lurmark E9508	30	.69	88.3
Hardi 4598-18	40	.80	102.0
(50 mesh)			
Delavan LE-10	20	.71	91.0
Spraying Systems 8010E	25	.79	101.0
Lurmark E9510	30	.87	111.0
	40	1.00	128.0
Delavan LE-15	20	1.06	136.0
Spraying Systems 8015E	25	1.19	152.0
Lurmark E9515	30	1.30	166.0
Hardi 4598-20	40	1.50	192.0

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

LOW PRESSURE FLAT-FAN NOZZLES, PART I

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Spraying Systems 8001LP (100 mesh)	15	.10	12.8
	20	.12	15.4
	30	.14	17.9
	40	.16	20.5
Spraying Systems 80015LP (50 mesh)	15	.15	19.2
	20	.17	21.8
	30	.21	26.9
	40	.24	30.7
Spraying Systems 8002LP (50 mesh)	15	.20	25.6
	20	.23	29.4
	30	.28	35.8
	40	.33	42.2
Spraying Systems 8003LP (50 mesh)	15	.30	38.4
	20	.35	44.8
	30	.42	53.7
	40	.49	62.7
Spraying Systems 8004LP (50 mesh)	15	.40	51.2
	20	.46	58.9
	30	.57	73.0
	40	.65	83.2
Spraying Systems 8005LP (50 mesh)	15	.50	64.0
	20	.58	74.2
	30	.71	91.0
	40	.82	105.0
Spraying Systems 8006LP	15	.60	76.8
	20	.69	88.3
	30	.85	109.0
	40	.98	125.0
Spraying Systems 8008LP	15	.80	102.0
	20	.92	115.0
	30	1.11	41.0
	40	1.3	166.0
Spraying Systems 8010LP	15	1.0	128.0
	20	1.2	154.0
	30	1.4	179.0
	40	1.6	205.0

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

LOW PRESSURE FLAT-FAN NOZZLES, PART II

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delevan 80-1.5R (100 mesh)	15	.092	11.8
	20	.11	14.10
	30	.13	16.60
	40	.15	19.2
Delevan 80-2R	15	.12	15.4
	20	.14	17.9
	30	.17	21.8
	40	.20	25.6
Delevan 80-3R	15	.18	23.0
	20	.21	26.9
	30	.26	33.3
	40	.30	38.4
Delevan 80-4R	15	.24	30.7
	20	.28	35.8
	30	.35	44.8
	40	.40	51.2
Delevan 80-5R	15	.31	39.7
	20	.35	44.8
	30	.43	55.0
	40	.50	64.0
Delevan 80-6R	15	.37	47.4
	20	.42	53.8
	30	.52	66.6
	40	.60	76.8
Delevan 80-8R	15	.49	65.7
	20	.57	73.0
	30	.69	88.3
	40	.80	102.4

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TWIN ORIFICE FAN NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Spraying Systems 15001	20	.07	9.0
	30	.09	11.5
	40	.10	12.8
(200 mesh)	50	.11	14.1
	60	.12	15.4
Spraying Systems 150015	20	.11	14.1
Delavan 2LF 1.5	30	.13	16.6
	40	.15	19.2
(100 mesh)	50	.17	21.8
	60	.18	23.0
Spraying Systems 15002	20	.14	17.9
Delavan 2LF-2	30	.17	21.8
Spraying Systems TJ60-8002	40	.20	25.6
	50	.22	28.2
(100 mesh)	60	.25	32.0
Spraying Systems 15003	20	.21	26.9
Delavan 2LF-3	30	.26	33.3
Spraying Systems TJ60-8003	40	.30	38.4
	50	.34	43.5
(100 mesh)	60	.37	47.4
Spraying Systems 15004	20	.28	35.8
Delavan 2LF-4	30	.35	44.8
Spraying Systems TJ60-8004	40	.40	51.2
	50	.45	57.6
(50 mesh)	60	.49	62.7
Spraying Systems 15005	20	.35	44.8
Delavan 2LF-5	30	.43	55.0
	40	.50	64.0
(50 mesh)	50	.56	71.7
	60	.61	78.1
Spraying Systems 15006	20	.42	53.7
Delavan 2LF-6	30	.52	66.6
Spraying Systems TJ60-8006	40	.60	76.8
	50	.67	85.8
(50 mesh)	60	.74	94.7
Spraying Systems 15008	20	.57	73.0
Delavan 2LF-8	30	.69	88.3
Spraying Systems TJ60-8008	40	.80	102.0
	50	.89	114.0
(50 mesh)	60	.98	125.0
Spraying Systems 15009	20	.64	81.9
Delavan 2LF-9	30	.78	99.8
	40	.90	115.0
(50 mesh)	50	1.00	128.0
	60	1.10	141.0

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OFF-CENTER FAN NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan LX-2	20	.14	17.9
Spraying Systems OC-02	30	.17	21.8
Lurmark OC2	40	.20	25.6
(50 mesh)	60	.24	30.7
Delavan LX-3	20	.21	26.9
Spraying Systems OC-03	30	.26	33.3
Lurmark OC3	40	.30	38.4
Hardi G150	60	.37	47.4
(50 mesh)			
Delavan LX-4	20	.28	35.8
Spraying Systems OC-04	30	.35	44.8
Lurmark OC4	40	.40	51.2
Hardi G200	60	.49	62.7
(50 mesh)			
Delavan LX-6	20	.42	53.8
Spraying Systems OC-06	30	.52	66.6
Lurmark OC6	40	.60	76.8
(50 mesh)	60	.73	93.4
Delavan LX-8	20	.57	73.0
Spraying Systems OC-08	30	.69	88.3
Lurmark OC8	40	.80	102.4
Hardi G250	60	.98	125.4
(50 mesh)			
Delavan LX-12	20	.85	108.8
Spraying Systems OC-12	30	1.0	128.0
Lurmark OC12	40	1.2	153.6
	60	1.5	192.0
Delavan LX-16	20	1.11	40.8
Spraying Systems OC-16	30	1.41	79.2
Lurmark OC16	40	1.6	204.8
	60	2.0	256.0

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FLOODING NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Spraying Systems TK-.5 Lurmark AN0.5 (100 mesh)	10	.05	6.4
	20	.07	9.0
	30	.08	10.2
	40	.10	12.8
Delavan D.75 Spraying Systems TK-.75 Lurmark AN0.75 (100 mesh)	10	.075	9.6
	20	.11	14.1
	30	.13	16.7
	40	.15	19.2
Delavan D1 Spraying Systems TK-1 Lurmark AN1 (100 mesh)	10	.10	12.8
	20	.14	17.9
	30	.17	21.8
	40	.20	25.6
Delavan D1.5 Spraying Systems TK-1.5 Lurmark AN1.5 (50 mesh)	10	.15	19.2
	20	.21	26.9
	30	.26	33.3
	40	.30	38.4
Delavan D2 Spraying Systems TK-2 Lurmark AN2 (50 mesh)	10	.20	25.6
	20	.28	35.8
	30	.35	44.8
	40	.40	51.2
Delavan D2.5 Spraying Systems TK-2.5 Lurmark AN2.5 (50 mesh)	10	.25	32.0
	20	.35	44.8
	30	.43	55.0
	40	.50	64.0
Delavan D3 Spraying Systems TK-3 Lurmark AN3 (50 mesh)	10	.30	38.4
	20	.42	53.8
	30	.52	66.6
	40	.60	76.8
Delavan D4 Spraying Systems TK-4 Lurmark AN4	10	.40	51.2
	20	.57	73.0
	30	.69	88.3
	40	.80	102.4
Delavan D5 Spraying Systems TK-5 Lurmark AN5	10	.50	64.0
	20	.71	90.9
	30	.87	111.4
	40	1.0	128.0

FLOODING NOZZLES, ***continued***

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan D6	10	.60	76.8
	20	.85	108.8
	30	1.0	128.0
	40	1.2	153.6
Delavan D7.5 Spraying Systems TK-7.5 Lurmark AN7.5	10	.75	96.0
	20	1.11	40.8
	30	1.31	66.4
	40	1.5	192.0
Delavan D10 Spraying Systems TK-10 Lurmark AN10	10	1.0	128.0
	20	1.4	179.2
	30	1.7	217.6
	40	2.0	256.0
Delavan D15 Spraying Systems TK-15	10	1.5	192.0
	20	2.1	268.8
	30	2.6	332.8
	40	3.0	384.0
Delavan D20 Spraying Systems TK-20 Lurmark AN20	10	2.0	256.0
	20	2.8	358.4
	30	3.5	448.0
	40	4.0	512.0
Spraying Systems TK-30	10	3.0	384.0
	20	4.2	537.6
	30	5.2	565.6
	40	6.0	768.0

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WHIRLCHAMBER, RAINDROP, AND WIDE ANGLE FULL CONE NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan 1/4WRW2 Delavan RA-2 Lurmark HW2 (50 mesh)	10	.10	12.8
	20	.14	17.9
	30	.17	21.8
	40	.20	25.6
	50	.22	28.2
	60	.24	30.7
Chem Farm MC1.25	10	.13	
	20	.18	
	30	.22	
	40	.25	
	50	.28	
	60	.31	
Delavan 1/4WRW4 Delavan RA-4 Lurmark HW4 (50 mesh)	10	.20	25.6
	20	.28	35.8
	30	.35	44.8
	40	.40	51.2
	50	.45	57.6
	60	.49	62.7
Delavan 1/4WRW5 Delavan RA-5 Spraying Systems FL-5 Chem Farm MC2.5 (50 mesh)	10	.25	32.0
	20	.35	44.8
	30	.43	55.0
	40	.50	64.0
	50	.56	71.7
	60	.61	78.1
Delavan 1/4WRW6 Delavan RA-6 Lurmark HW6 (50 mesh)	10	.30	38.4
	20	.42	53.8
	30	.52	66.6
	40	.60	76.8
	50	.67	85.8
	60	.73	93.4
Delavan RA8 Spraying Systems FL-8	10	.40	51.2
	20	.57	73.0
	30	.70	89.6
	40	.80	102.4
	50	.90	115.2
	60	.99	126.7
Delavan 1/4WRW10 Spraying Systems 1/4B-SS5-5W Delavan RA-10 Spraying Systems FL-10 Lurmark HW10	10	.50	64.0
	20	.71	90.8
	30	.87	111.4
	40	1.0	128.0
	50	1.1	140.8
	60	1.2	153.6

WHIRLCHAMBER, RAINDROP, AND WIDE ANGLE FULL CONE NOZZLES, *continued*

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan 1/4WRW15 Delavan RA-15 Spraying Systems FL-15 Lurmark HW15	10	.75	96.0
	20	1.1	140.8
	30	1.3	166.4
	40	1.5	192.0
	50	1.7	217.6
	60	1.8	230.4
Delavan 1/4WRW20 Spraying Systems 1/4B-SS10-10W Lurmark HW20	10	1.0	128.0
	20	1.4	179.2
	30	1.7	217.6
	40	2.0	256.0
	50	2.2	281.6
	60	2.4	307.2

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

HOLLOW-CONE NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity	
		gal/min (GPM)	oz/min (OPM)
Delavan HB-1 (HC-1) Spraying Systems TX1 Lurmark HAF0180 (100 mesh)	30	.0145	1.8
	40	.0167	2.1
	60	.0200	2.6
	75	.0233	3.0
	90	.0250	3.2
Delavan HB-2 (HC-2) Spraying Systems TX2 Lurmark HAF0280 (100 mesh)	30	.0283	3.6
	40	.0333	4.3
	60	.0400	5.1
	75	.0450	5.8
	90	.0500	6.4
Delavan HB-3 (HC-3) Spraying Systems TX3 Lurmark HAF0380 (100 mesh)	30	.0433	5.5
	40	.0500	6.4
	60	.0617	7.9
	75	.0683	8.7
	90	.0750	9.6
Delavan HB-4 (HC-4) Spraying Systems TX4 Lurmark HAF0480 (50 mesh)	30	.0583	7.5
	40	.0667	8.5
	60	.0817	10.5
	75	.0917	11.7
	90	.1000	12.8
Delavan HB-6 (HC-6) Spraying Systems TX6 Lurmark HAF0680 (50 mesh)	30	.0867	11.1
	40	.1000	12.8
	60	.1217	15.6
	75	.1367	17.5
	90	.1500	19.2
Delavan HB-8 (HC-8) Spraying Systems TX8 Lurmark HAF0880 (50 mesh)	30	.1150	14.7
	40	.1333	17.1
	60	.1633	20.9
	75	.1833	23.5
	90	.2000	25.6
Delavan HB-10 (HC-10) Spraying Systems TX10 Lurmark HAF1080 (50 mesh)	30	.1450	18.6
	40	.1667	21.3
	60	.2033	26.0
	75	.2283	29.2
	90	.2500	32.0
Delavan HB-12 (HC-12) Spraying Systems TX12 Lurmark HAF1280 (50 mesh)	30	.1733	22.2
	40	.2000	25.6
	60	.2450	31.4
	75	.2733	35.0
	90	.3000	38.4

HOLLOW-CONE NOZZLES, *continued*

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan HB-18 (HC-18) Spraying Systems TX18 Lurmark HAF1880 (50 mesh)	30	.2600	33.3
	40	.3000	38.4
	60	.3667	46.9
	75	.4100	52.5
	90	.4500	57.6
Delavan HB-26 (HC-26) Spraying Systems TX26 Lurmark HAF2680 (50 mesh)	30	.3750	48.0
	40	.4333	55.5
	60	.5300	67.8
	75	.5933	75.9
	90	.6500	83.2

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HOLLOW-CONE NOZZLES (DISC AND CORE TYPE)

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan DC2-13	40	.08	10.2
Spraying Systems D2-13	60	.10	12.8
Lurmark 2-13	80	.11	14.1
Hardi 1553-10 Blue Swirl	100	.12	15.4
(50 mesh)	150	.14	17.9
Delavan DC2-23	40	.10	12.8
Spraying Systems D2-23	60	.13	16.6
Lurmark 2-23	80	.14	17.9
(50 mesh)	100	.16	20.5
	150	.19	24.3
Delavan DC3-23	40	.12	15.4
Spraying Systems D3-23	60	.14	17.9
Lurmark 3-23	80	.16	20.5
(25 mesh)	100	.18	23.0
	150	.21	26.9
Delavan DC2-25	40	.16	20.5
Spraying Systems D2-25	60	.19	24.3
Lurmark 2-25	80	.22	28.2
Hardi 1553-10 Black Swirl	100	.25	32.0
(25 mesh)	150	.29	37.1
Delavan DC3-25	40	.19	24.3
Spraying Systems D3-25	60	.23	29.4
Lurmark 3-25	80	.26	33.3
Hardi 1553-22 Blue Swirl	100	.29	37.1
(25 mesh)	150	.35	44.8
Delavan DC3-45	40	.23	29.4
Spraying Systems D3-45	60	.28	35.8
Lurmark	80	.33	42.2
Hardi 1553-30 Blue Swirl	100	.36	46.1
(25 mesh)	150	.44	56.3
Delavan DC4-25	40	.29	37.1
Spraying Systems D4-25	60	.35	44.8
Lurmark 4-25	80	.40	51.2
Hardi 1553-40 Blue Swirl	100	.45	57.6
(25 mesh)	150	.54	69.1
Delavan DC5-25	40	.35	44.8
Spraying Systems D5-25	60	.42	53.8
Lurmark 5-25	80	.48	61.4
Hardi 1553-16 Gray Swirl	100	.54	69.1
(25 mesh)	150	.65	83.2
Delavan DC4-45	40	.36	46.1
Spraying System D4-45	60	.43	55.0
Lurmark 4-45	80	.50	64.0
Hardi 1553-18 Gray Swirl	100	.56	71.7
(25 mesh)	150	.68	89.0

HOLLOW-CONE NOZZLES (DISC AND CORE TYPE), *continued*

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan DC5-45	40	.45	57.6
Spraying System D5-45	60	.55	70.4
Lurmark 5-45	80	.64	81.9
Hardi 1553-20 Gray Swirl	100	.71	90.9
(25 mesh)	150	.86	110.1
Delavan DC7-25	40	.52	66.6
Spraying System D7-25	60	.63	80.6
Lurmark 7-25	80	.73	93.4
Hardi 1553-24 Gray Swirl	100	.81	103.7
(16 mesh)	150	.98	125.4
Delavan DC6-45	40	.58	74.24
Spraying System D6-45	60	.72	92.2
Lurmark 6-45	80	.83	106.2
Hardi 1553-22 Black Swirl	100	.93	119.0
(16 mesh)	150	1.15	147.2
Delavan DC7-45	40	.68	87.0
Spraying System D7-45	60	.84	107.5
Lurmark 7-45	80	.97	124.2
Hardi 1553-24 Black Swirl	100	1.11	142.1
(16 mesh)	150	1.35	172.8
Delavan DC8-45	40	.84	107.5
Lurmark 8-45	60	1.04	133.1
Hardi 1553-30 Black Swirl	80	1.21	154.9
(16 mesh)	100	1.35	172.8
	150	1.68	215.00
Delavan DC12-25	40	.93	119.00
Spraying System D12-25	60	1.15	147.2
Lurmark 12-25	80	1.32	169.0
(16 mesh)	100	1.47	188.2
	150	1.81	231.7
Delavan DC12-45	40	1.36	174.1
Spraying Systems D12-45	60	1.68	215.0
Lurmark 12-45	80	1.95	249.6
(16 mesh)	100	2.20	281.6
	150	2.69	344.3
Delavan DC8-46	40	1.84	235.5
Spraying Systems D8-46	60	2.25	288.0
	80	2.62	335.4
(16 mesh)	100	2.93	375.0
	150	3.60	460.8
Delavan DC10-46	40	2.48	317.4
Spraying System D10-46	60	3.05	390.4
	80	3.53	451.8
(16 mesh)	100	3.96	506.9
	150	4.83	618.2

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FLOODING, RAINDROP, AND WHIRL CHAMBER NOZZLES (HIGH-CAPACITY)

Manufacturer tip no.* (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)
Delavan F20 Spraying Systems 1/8K-20 Delavan RA-40 Spraying Systems QCK-SS20 Delevan 3/4 WRW40 Lurmark AN20	10	2.0
	20	2.8
	30	3.5
	40	4.0
	50	4.5
Delavan F30 Spraying Systems 3/8K-30 Delavan RA-60 Spraying Systems QCK-SS30 Delevan 3/4 WRW60 Lurmark AN30	10	3.0
	20	4.2
	30	5.2
	40	6.0
	50	6.7
Delavan F40 Spraying Systems 3/8K-40 Delavan RA-80 Spraying Systems QCK-SS40 Delevan 3/4 WRW80 Lurmark AN40	10	4.0
	20	5.7
	30	6.9
	40	8.0
	50	9.0
Delavan F50 Spraying Systems 1/2K-50 Delavan RA-100 Spraying Systems QCK-SS60 Delevan 3/4 WRW100 Lurmark AN50	10	5.0
	20	7.1
	30	8.7
	40	10.0
	50	10.5
Delavan F60 Spraying Systems 1/2K-60 Delavan RA-120 Spraying Systems QCK-SS60 Delevan 3/4 WRW120 Lurmark AN60	10	6.0
	20	8.5
	30	10.4
	40	12.0
	50	13.4
Delavan F80 Spraying Systems 1/2K-80 Spraying Systems QCK-SS80 Delevan RA-160 Delevan 3/4 WRW160 Lurmark AN80	10	8.0
	20	11.3
	30	13.9
	40	16.0
	50	17.9
Delavan F100 Spraying Systems 3/4K-100 Delavan RA200 Spraying Systems QCK-SS100 Delevan 3/4 WRW200 Lurmark AN100	10	10.0
	20	14.1
	30	17.3
	40	20.0
	50	22.3

FLOODING, RAINDROP, AND WHIRL CHAMBER NOZZLES (HIGH-CAPACITY) *continued*

Manufacturer tip no.* (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)
Delavan F120 Spraying Systems 3/4K-20 Delavan RA-240 Spraying Systems QCK-SS120 Delevan 3/4 WRW240 Lurmark AN120	10	12.0
	20	17.0
	30	20.8
	40	24.0
	50	26.8
Delavan F150 Delavan RA-300 Spraying Systems QCK-SS150	10	15.0
	20	21.2
	30	26.0
	40	30.0
	50	33.5
Delevan F180 Spraying Systems QCK-SS180	10	18.0
	20	25.5
	30	31.2
	40	36.0
Delavan F210 Spraying Systems 3/4K-210 Spraying Systems QCK-SS210 Lurmark AN210	10	21.0
	20	29.7
	30	36.4
	40	42.0
Spraying Systems 1K-300	10	30.0
	20	42.4
	30	52.0
	40	60.0
Spraying Systems 1K-450	10	45.0
	20	63.6
	30	77.9
	40	90.0

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FLOW RATE

Nozzle flow rate varies with spraying pressure. The relationship between GPM and pressure is as follows:

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

With the above relationship, doubling the flow through the nozzle requires increasing the pressure four times. The above equation can be used to determine nozzle flow rates achieved at various pressures.

EXAMPLE:

If a certain nozzle achieved a flow rate of .10 GPM at a pressure of 40 PSI, what would that same nozzle flow rate be at 15 PSI?

SOLUTION

Rearrange the above formula to achieve GPM_2.

$$GPM_2 = \frac{\sqrt{PSI_2} \text{ X } GPM_1}{\sqrt{PSI_1}}$$

Solve for the new pressure.

$$GPM_2 = \frac{\sqrt{15 \text{ PSI}} \text{ x } .10 \text{ GPM}}{\sqrt{40 \text{ PSI}}}$$

$$GPM_2 = \frac{3.873 \text{ x } .10}{6.325}$$

$$GPM_2 = .06$$

MEASURING GROUND SPEED

To measure ground speed, mark off a distance in the field to be sprayed or in a field with similar surface conditions. Suggested distances are 100 feet for speeds up to 5 miles per hour, 200 feet for speeds from 5 to 10 miles per hour, and at least 300 feet for speeds above 10 miles per hour. At the engine throttle setting and gear used for actual spraying, determine the travel time between the measured stakes. Calculate ground speed using the following formula or look up the speed in the table below:

$$\textbf{Travel speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Travel Speeds

Speed (miles per hour)	Time required to travel a distance in seconds		
	100 feet	200 feet	300 feet
3.0	23	45	68
3.5	20	39	58
4.0	17	34	51
4.5	15	30	45
5.0	14	27	41
6.0		23	34
7.0		19	29
7.5		18	27
8.0		17	26
9.0		15	23
10.0		14	20
12.0			17
15.0			14

EFFECT OF SOLUTION DENSITY ON NOZZLE FLOW RATE

Density is the weight of a solution per unit volume (lb/gal). Specific gravity (SG) is the weight of a solution relative to water, which weighs 8.34 lb/gal. Nozzle flow rate varies inversely with the square root of specific gravity. Conversion factors to compare flow rates of solutions of any known density can be calculated by:

$$\textbf{Conversion Factor} = \sqrt{SG}$$

The following table can be used to predict the flow rate from various solutions and to select the proper nozzle size from a nozzle catalog table. Because nozzle tables are based on spraying water, the conversion factors from the table can be multiplied by the desired GPM or GPA to determine the water flow rate for the solution being sprayed. Use the converted GPM or GPA to select the proper nozzle size from the catalog.

Specific Gravity and Conversion Factor for Selected Solution Weights

Weight of solution (lb/gal)	Specific gravity	Conversion factor
7.0	.84	.92
8.0	.96	.98
8.34*	1.00	1.00
9.0	1.08	1.04
10.0	1.20	1.10
10.65**	1.28	1.13
11.0	1.32	1.15
12.0	1.44	1.20
14.0	1.68	1.30

*Water
**28% Nitrogen
NOTE: This table is based on theoretical solution densities only and may vary in actual practice because of differing solution characteristics. Applies to flood nozzles but not Raindrop nozzles.

Example: 3 GPM (28% N) x 1.13 = 3.39 GPM (water)

If the flow rate (GPM) or application rate (GPA) of water is known, the GPM or GPA of a solution can be predicted by dividing the flow or application rate by the conversion factor.

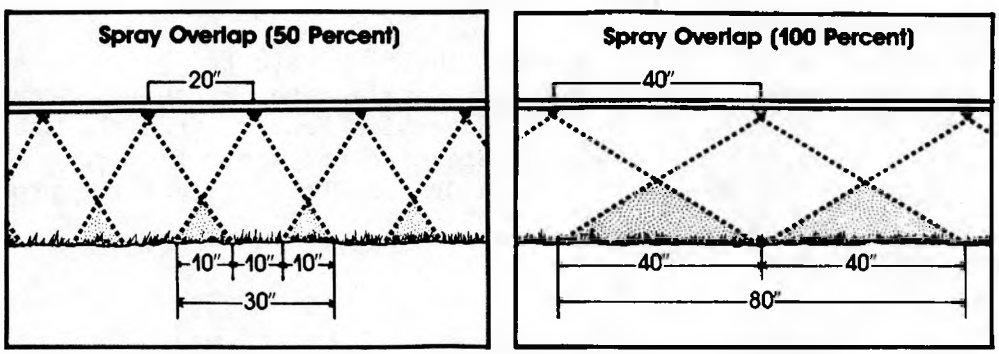
Example: 20 GPA (water) ÷ 1.13 = 17.7 GPA (28% N)

SPRAY OVERLAP

For uniform application each nozzle type must be operated at a spacing and height that provides a specific spray overlap. The overlap may vary from 30 percent to over 100 percent. The percent overlap or spray coverage can be calculated from the following formulas:

$$\text{Percent overlap} = \frac{\text{Spray Coverage - Nozzle Spacing}}{\text{Nozzle Spacing}}$$

Spray Coverage = (Nozzle Spacing x percent overlap) + Nozzle Spacing

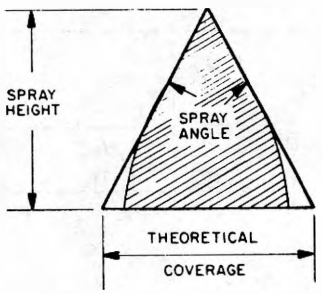


Spray Coverage Required to Obtain Proper Overlap

Overlap (%)	Spray Coverage at Various Nozzle Spacings						
	20"	25"	30"	35"	40"	50"	60"
20	24	30	36	42	48	60	72
30	26	33	39	46	52	65	78
40	28	35	42	49	56	70	84
50	30	38	45	53	60	75	90
60	32	40	48	56	64	80	96
70	34	43	51	60	68	85	102
80	36	45	54	63	72	90	108
90	38	48	57	67	76	95	114
100	40	50	60	70	80	100	120
110	42	53	63	74	84	105	126
150	50	63	75	88	100	125	150

SPRAY ANGLE COVERAGE AT VARIOUS HEIGHTS

The following table lists the theoretical coverage of spray patterns as calculated from the included spray angle of the spray and the distance from the nozzle orifice. These values are based on the assumption that the spray angle remains the same throughout entire spray distance. In actual practice, the tabulated spray angle does not hold for long spray distances.



Computed Spray Coverage

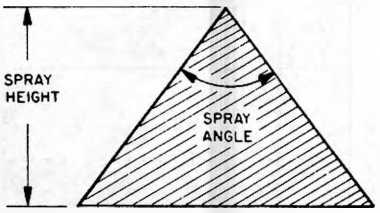
Spray angle (degrees)	Width of spray pattern at various distances from nozzle orifice													
	2"	4"	6"	8"	10"	12"	15"	18"	24"	30"	36"	42"	48"	60"
15	.5	1.1	1.6	2.1	2.6	3.2	3.9	4.7	6.3	7.9	9.5	11.1	12.6	15.8
25	.9	1.7	2.7	3.5	4.4	5.3	6.6	8.0	10.6	13.3	15.9	18.6	21.2	26.6
30	1.1	2.1	3.2	4.3	5.4	6.4	8.0	9.7	12.8	16.0	19.3	22.4	25.9	32.0
40	1.4	2.9	4.3	5.8	7.2	8.7	10.9	13.0	17.4	21.6	26.2	30.6	34.9	42.8
45	1.7	3.3	4.9	6.6	8.2	9.9	12.4	14.9	19.8	24.8	29.8	34.8	39.7	49.6
50	1.9	3.6	5.6	7.4	9.3	11.2	14.0	16.8	22.4	28.0	33.6	39.1	44.8	56.0
60	2.3	4.6	6.9	9.2	11.4	13.9	17.3	20.8	27.6	34.6	41.6	48.4	55.4	69.2
65	2.5	5.1	7.6	10.2	12.7	15.2	19.1	22.9	30.5	38.1	45.8	53.2	61.0	76.4
70	2.8	5.6	8.2	11.2	14.0	16.8	21.0	25.2	33.6	42.0	50.4	59.8	67.2	84.0
73	2.9	5.9	8.8	11.8	14.8	17.8	22.2	26.6	36.4	44.4	53.2	62.0	71.0	88.5
75	3.1	6.1	9.2	12.3	15.3	18.4	23.0	27.6	26.8	46.0	55.2	64.2	73.5	92.0
80	3.4	6.7	10.1	13.4	16.8	20.1	25.2	30.2	40.2	50.2	60.4	72.5	80.8	100.0
90	4.0	8.0	12.0	16.0	20.0	24.0	30.0	36.0	48.0	60.0	72.0	84.0	96.0	120.0
100	4.8	9.5	14.3	19.1	23.8	28.6	35.8	42.4	57.2	71.4	86.0	100.0	114.6	143.0
120	6.9	13.9	20.8	27.8	34.7	41.6	52.0	62.4	83.0	104.0	125.0	145.8	166.2	208.0
140	11.0	22.0	33.0	44.0	54.9	65.9	82.4	98.9	131.9	164.8	197.8	230.8	263.8	329.7

Suggested Minimum Spray Heights

Adjust the spray height to give proper spray overlap. The following table gives suggested minimum spray heights for several spray angles.

Suggested Minimum Spray Heights

Spray angle	20-inch spacing	30-inch spacing
65 degrees	22" to 24"	33" to 36"
73 degrees	20" to 22"	29" to 36"
80 degrees	17" to 19"	26" to 28"
110 degrees	10" to 12"	14" to 18"



PRESSURE DROP THROUGH SPRAYING SYSTEMS

Hoses and fittings must be selected in order to keep the pressure drops within acceptable limits. The following tables give the pressure drop through various size hoses, pipe, and couplings.

Pressure Drop for Water Flow through Various Hose Sizes

	Pressure drop in pounds per square inch (10-foot length--without couplings)								
Flow in GPM	1/4" I.D.	3/8" I.D.	7/16" I.D.	1/2" I.D	5/8" I.D	3/4" I.D.	1" I.D.	1 1/4" I.D.	1 1/2" I.D.
0.2	.3								
0.3	.6								
0.4	1.0								
0.5	1.4	.2							
0.5	2.0	.3							
0.8	3.3	.5							
1.0		.7	.3						
1.5		1.4	.6	.4					
2.0		2.4	1.1	.6					
2.5		3.4	1.7	.9					
3.0			2.4	1.2	.4				
4.0				2.0	.7				
5.0				2.9	1.0	.4			
6.0				4.0	1.4	.6			
8.0					2.6	.9	.3		
10					3.6	1.4	.4		
15						3.0	.8	.3	
20							1.4	.5	.2
25							2.0	.7	.3
30							2.8	.9	.4
40								1.6	.5
50								2.5	.8
60								3.4	1.2
70									1.6
80									2.0
90									2.6
100									3.0

NOTE: These figures are for standard hose in good, smooth condition (10-foot length with no couplings).

Flow of Water through Schedule 40 Steel Pipe

Flow in GPM	Pressure Drop in psi for Various Pipe Sizes (in 10-foot length)								
	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
0.3	.42								
0.4	.70	.16							
0.5	1.1	.24							
0.6	1.5	.33							
0.8	2.5	.54	.13						
1.0	3.7	.83	.19	.06					
1.5	8.0	1.8	.40	.12					
2.0	13.4	3.0	.66	.21	.05				
2.5		4.5	1.0	.32	.08				
3.0		6.4	1.4	.43	.11				
4.0		11.1	2.4	.74	.18	.06			
5.0			3.7	1.1	.28	.08			
6.0			5.2	1.6	.38	.12			
8.0			9.1	2.8	.66	.20	.05		
10				4.2	1.0	.30	.08		
15					2.2	.64	.16	.08	
20					3.8	1.1	.28	.13	
25						1.7	.42	.19	.06
30						2.4	.59	.27	.08
35								.36	.11
40								.47	.14
45									.17
50									.20
60									.29
70									.38
80									.50
90									.62
100									.76

NOTE: These figures are for standard pipe of either seamless or welded construction, in good clean condition. Recommended maximum capacity to keep velocity at approximately 5 feet per second is shown above underlined value.

Approximate Friction Loss in Pipe Fittings in Terms of Equivalent Feet of Straight Pipe

Pipe size standard weight	Actual inside diameter inches	Gate value FULL OPEN	Globe value FULL OPEN	45 Elbow	Run or standard tee	Standard elbow or run of tee reduced 1/2	Standard tee through side outlet
1/8	.269	.15	8	.35	.40	.75	1.4
1/4	.364	.20	11	.50	.65	1.1	2.2
1/2	.622	.35	18.6	.78	1.1	1.7	3.3
3/4	.824	.44	23.1	.97	1.4	2.14	.2
1	1.049	.56	29.4	1.2	1.8	2.6	5.3
1-1/4	1.380	.74	38.6	1.6	2.3	3.5	7.0
1-1/2	1.610	.86	45.2	1.9	2.7	4.1	8.1
2	2.067	1.1	58	2.4	3.5	5.2	10.4
2-1/2	2.469	1.3	69	2.9	4.2	6.2	12.4
3	3.068	1.6	86	3.6	5.2	7.7	15.5
4	4.026	2.1	113	4.7	6.8	10.2	20.3
5	5.047	2.7	142	5.9	8.5	12.7	25.4
6	6.065	3.2	170	7.1	10.2	15.3	31

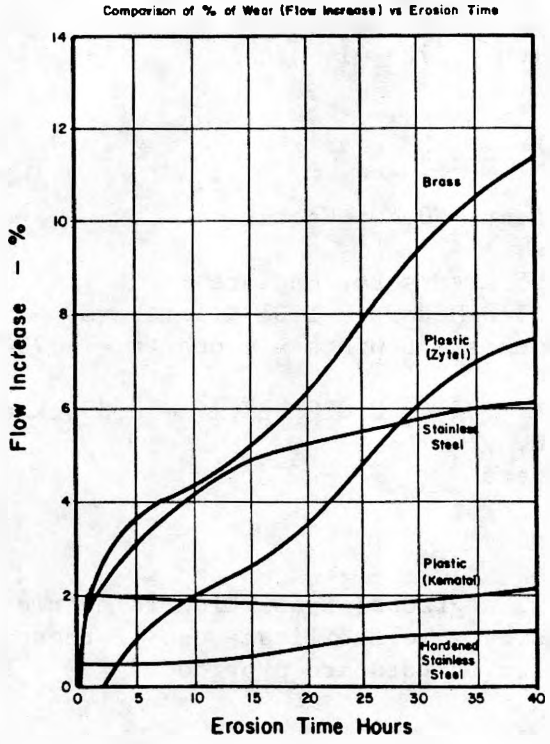
NOZZLE WEAR LIFE

Nozzle tips are available in a variety of materials, including hardened stainless steel, stainless steel, thermoplastics, and brass. Hardened stainless steel is the most wear-resistant material, but it is also the most expensive. Stainless steel tips have excellent wear resistance with either corrosive or abrasive materials. Nylon and other synthetic plastics (thermoplastics) are resistant to corrosion and abrasion but they vary considerably in their wear life, depending on the material used to mold the tips. Brass tips wear rapidly when used to apply abrasive materials such as wettable powders and they are corroded by some liquid fertilizers.

The following figure shows the wear rates of a flat-fan nozzle constructed of various materials. The data was based on testing with 25 pounds kaolin clay in 50 gallons of water at 40 psi.

NOZZLE WEAR TEST
for Flat Fan Nozzle Tip #4

This data was based on 40 hours of testing with 25 lbs (10.75 k) kaolin clay in 50 gallons (189 liters) of water at 40 psig (275 kPa)



MISCELLANEOUS REFERENCE INFORMATION

Standard Abbreviations

GPA---Gallons per Acre
GPM---Gallons per Minute
GPH---Gallons per Hour
MPH---Miles per Hour
OPM---Ounces per Minute
PSI---Pounds per Square Inch (gauge pressure)

Useful Formulas

$$\text{GPM (Per Nozzle)} = \frac{\text{GPA X MPH X W*}}{5940}$$

$$\text{GPA} = \frac{5940 \text{ X GPM (Per Nozzle)}}{\text{MPH x W*}}$$

*W = Nozzle spacing (in boom spraying) or spray swath (in boomless spraying)...in inches.

Volume and Liquid Measures

8 fluid ounces = 16 tablespoons = 1 cup = 236.6
2 cups = 32 tablespoons = 1 pint = 473.1 ml
2 pints = 64 tablespoons = 1 quart = 946.2 ml
4 quarts = 256 tablespoons = 1 gallon = 3785 ml
128 fluid ounces = 1 gallon = 3785 ml

Miscellaneous Conversion Factors

One Acre = 43,560 squre feet = 0.405 Hectares.
One Hectare = 2.471 Acres.
One Gallon Per Acre = 9.35 Liters Per Hectare.
One Mile = 5,280 feet = 1610 Meters = 1.61 Kilometers.
One Gallon = 128 fluid ounces = 8 pints = 4 quarts = 3.79 Liters = 0.83 Imperial Gallons.
One Pound Per Square Inch (PSI) = 0.070 kg/cm^2 = 6.895 kPa (Kilopascal)
One Pound = .454 Kilogram.
One Inch = 2.54 Centimeters.

Metric Conversion Factors

During the next few years, a gradual transition to metric (SI) units is expected in the agricultural industry. To facilitate use of these units, the following metric terms and conversion factors are provided.

To measure	Multiply	By	To obtain
	inches	25.40	millimeters (mm)
LENGTH	inches	2.540	centimeters (cm)
	feet	0.3048	meters (m)
	miles	1.609	kilometers (km)
AREA	acres	046.7	square meters (m^2)
	acres	0.4047	hectares (ha)
VOLUME	gallons	3.785	cubic decimeters (dm^3)
	gallons	3.785	liters (L)
	Imperial gallons	4.546	liters (L)
FLOW RATE	gallons/hours (gph)	3.785	liters/hour (L/h)
	gallons/minute (gpm)	3.785	liters/minute (L/min)
APPL. RATE	gallons/acre (gpa)	9.353	liters/hectare (L/ha)
PRESSURE	pounds per square inch (psi)		
SPEED	miles/hour (mph)	6.895	kilopascals (kPa)
		1.609	kilometers/hour (km/h)

Restricted-Use Pesticides

P. Nixon

In 1972, amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provided the legal mechanism for restricting the use of certain pesticides. The U.S. Environmental Protection Agency (EPA), confronted with the enormous task of reviewing all registered pesticides, proposed to classify pesticides by their active ingredient, subdividing each active ingredient into its various formulations or uses. This classification system provided the EPA with more flexibility to restrict some, but not all, products containing the same active ingredient. The process was called classification by regulation. When pesticides are restricted in this manner, the manufacturer is given 270 days to amend the label on all the affected products. This timetable has been of particular interest to pesticide dealers because once the restricted-use label is applied to the container, it can be sold only to a certified applicator.

In addition to reviewing existing products, the EPA is required to register new products not previously marketed. Some of these new products have been classified for restricted use. This process is called classification by registration.

Pesticides classified for restricted use by registration and regulations are listed in Table 1.

Table 1. Restricted-Use Pesticides (January, 1989)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
alachlor	Lasso, others	herbicide	all formulations	onocogenicity
aldicarb	Temik	insecticide-nematicide	all formulations	accident history
aluminum phosphide	Phoxtoxin, Detia, many others	fumigant	all formulations	human inhalation hazard
amitraz	Taktic, BAAM	insecticide-acaricide	all formulations	possible oncogenicity
amitrol	Weedazol, Amizol	herbicide	all except homeowners	possible oncogenicity
arsenic acid	Desiccant, Zotox	herbicide	all formulations	oral toxicity, oncogencity
arsenic pentoxide	many	wood preservative	all formulations	oncogenic, mutagenic, reproductive, fetotoxic effects
avitrol	Avitrol	avicide	all formulations	hazard to fish and nontarget birds
azinphosmethyl	Guthion, many others	insecticide	all liquids with concentrations above 13.5%	human inhalation toxicity; acute toxicity hazard to avian, aquatic, and mammalian species
brodifacoum	Talon G, Rodenticide Pellets, Rodenticide Bait Pack	rodenticide	pellets	hazard to nontarget organisms
calcium arsenate	Pencal, Spray-Cal Turf-Cal	herbicide, insecticide	granular, wettable powder, dust	oncogenicity, mutagenicity, toxicity
calcium cyanide	A-Dust	fumigant	all formulations	human inhalation hazard
captafol	Difolatan, many	fungicide	all formulations	exposure risk for farm workers, oncogenicity
carbofuran	Furadan	insecticide-nematicide	concentrate suspension and wettable powders; all granular formulations	acute inhalation toxicity
carbon tetrachloride	carbon tetrachloride	fumigant	gas	oncogenicity, poisoning risks

Table 1. (continued)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
chlordimeform	Galecron, others	insecticide	all formulations	causes cancer in laboratory
chlorfenvinphos	Birlane, others	insecticide	formulations greater than 21%	acute dermal toxicity
chlorobenzilate	Acaraben, others	insecticide	all formulations	oncogenicity
chlorophacinone	Rozol Blue Tracking Powder	rodenticide	all formulations	human hazard, potential for food contamination
chloropicrin	many	fumigant	all formulations	acute inhalation toxicity
chlorpyrifos	Killmaster II	insecticide	Killmaster II	----------
creosote, creosote oil, coal tar creosote	many	wood preservative	all formulations	possible oncogenic and mutagenic effects
cyanazine	Bladex, Extrazine II	herbicide	all formulations	groundwater contamination, teratogenicity, fetotoxicity
cycloheximide	Acti-Aid	fungicide	all formulations greater than 2%	acute dermal toxicity
cyfluthrin	Baythroid	insecticide	all formulations	toxic to fish and aquatic organisms
cypermethrin	Cymbush, Ammo, others	insecticide	all formulations	oncogenicity, hazard to non-target organisms
demeton	Systox	insecticide	all formulations	acute oral and dermal toxicity
diallate	Avadex	herbicide	only product	oncogenicity, mutagenicity
diclofop methyl	Hoelon	herbicide	all formulations	oncogenicity
dichloropropene	Telone	fumigant	94% liquid concentrate	possible oncogenicity, acute toxicity
dicrotophos	Bidrin, others	insecticide	all liquid formulations	acute dermal toxicity, residue effects on birds
diflubenzuron	Dimilin	insecticide	all formulations except cattle bolus	lack of environmental hazard data

Table 1. (continued)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
dinocap	Crotothane, Karathane	fungicide, acaricide	liquid, wettable powder, dust, aerosol	special review
dioxathion	Delnav, Deltic	insecticide	formulations greater than 30%	acute dermal toxicity
disulfoton	Di-Syston	insecticide	some emulsifiable concentrates	acute dermal and inhalation toxicity
dodemorph	Milban	fungicide	all formulations	corrosive to eye tissue
endrin	Endrin, many others	insecticide	all formulations	acute dermal toxicity, hazard to nontarget organisms
EPN	EPN, many others	insecticide	all liquid and dry formulations greater than 4%	acute dermal and inhalation toxicity, residue effects on birds
esfenvalerate	Asana	insecticide	all formulations	birds high fish toxicity
ethion	Ethion	insecticide, miticide	8EC	registration action
ethoprop	Mocap	insecticide	all formulations	acute dermal toxicity
ethyl parathion	many	insecticide	all formulations	acute dermal and inhalation toxicity, effects on birds, fish, and mammals
fenamiphos	Nemacur	nematicide	emulsifiable concentrates	acute dermal toxicity
fenitrothion	Sumithion, others	insecticide, acaricide	----------	potential hazard to birds and aquatic organisms
fensulfothion	Dasanit	insecticide	emulsifiable concentrates and solutions, all granular formulations	acute dermal and inhalation toxicity
fenvalerate	Pydrin	insecticide	emulsifiable concentrates, except ear tags, Ectrin WDL	high fish toxicity
flucythrinate	Pay-Off	insecticide	all formulations	possible adverse effects on aquatic organisms

Table 1. (continued)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
miral	Triumph	insecticides, nematicides	all formulations	toxic to fish and wildlife
monocrotophos	Azodrin, others	insecticide	liquid formulations	residue effects on birds and mammals; acute dermal toxicity
nicotine (alkaloid)	Black Leaf 40	insecticide	all formulations	acute inhalation toxicity, effects on aquatics
oxamyl	Vydate	insecticide, nematicide	all formulations	acute oral and inhalation toxicity
oxydemeton-methyl	Metasystox-R	insecticide	all formulations	reproductive effects
paraquat dichloride paraquat bis (methyl-sulfate)	Gramoxone	herbicide	all formulations	use and accident history
pentachlorophenol	Penta wood preservative; many others	wood preservative	all formulations	possible oncogenic, teratogenic and fetotoxic effects
permethrin	Ambush, Pounce	insecticide	all formulations, excluding livestock and premise use	high fish toxicity
phorate	Thimet, Phorate	insecticide	all liquid and granular formulations	acute dermal toxicity, residue effects on birds and mammals
phosphamidon	Dimecron, others	insecticide	all formulations	acute dermal toxicity, residue effects on birds and mammals
picloram	Tordon, others	herbicide	all formulations except Tordon 101R	hazard to nontarget plants
potassium pentachlorophenate	Permatox 182	herbicide	all formulations	oncogenicity, mutagenicity, fetotoxicity
potassium tetrachlorophenate	Permatox 182	herbicide	all formulations	oncogenicity, mutagenicity, fetotoxicity
profenofos	Curacron, Selecron, Polycron	insecticide, acaricide	emulsifiable concentrates	corrosive to eyes

Table 1. (continued)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
fluoroacetamide	1081, others	rodenticide	all formulations	acute oral toxicity
fluvalinate	Mavrik	insecticide	emulsifiable concentrate and flowable concentrate at 2 lbs/gal	toxicity to aquatic organisms
fonofos	Dyfonate	insecticide	all liquid formulations, granular formulations greater than or equal to 20%	acute dermal toxicity
hydrocyanic acid	Cyclon	fumigant	all formulations	human inhalation hazard
isofenphos	Pryfon	insecticide	Pryfon 6	----------
lambda-cyhalothrin	Karate	insecticide	all formulations	toxicity to fish and aquatic invertebrates
lindane	many	insecticide	all liquid formulations	possible oncogenicity
magnesium phosphide	Fumi-Cel, Detia	fumigant	all formulations	acute inhalation toxicity
methamidophos	Monitor	insecticide	liquid formulations 40% or greater; dust formulations 2.5% or greater	acute dermal toxicity, residue effects on birds
methidathion	Supracide	insecticide	all formulations	residue effects on birds
methiocarb	Mesurol	bird repellent	dusts, hopper box treater	possible hazard to avian, fish, and wildlife species
methomyl	Lannate, Nudrin	insecticide	all concentrated solution formulations	residue effects on mammals, accident history
methyl bromide	many	fumigant	all formulations in containers heaviers than 1.5 pounds	accident history, acute inhalation toxicity
methyl parathion	many; Penncap-M	insecticide	all formulations	acute dermal toxicity, residue effects on birds, bees, and mammals
mevinphos	Phosdrin, others	insecticide	all formulations	acute dermal toxicity, residue effects on birds and mammals mammals; acute dermal toxicity

Table 1. (continued)

Active ingredient	Trade name	Type	Formulations restricted	Criteria for restricted use
pronamide	Kerb	herbicide	Kerb 50W	oncogenicity
propetamphos	Safrotin	insecticide	only product	voluntary restriction
simazine	many	herbicide	all formulations	terrestrial uses; possible groundwater contamination
sodium cyanide	Cymag	fumigant	all formulations	human inhalation toxicity
sodium fluoroacetate	1080	rodenticide	all formulations	acute oral toxicity, use and accident history
starlicide	Gull-Toxicant 98% Concentrate	bird repellent	only product	hazard to nontarget organisms
strychnine	many	rodenticide	all formulations greater than 0.5%	acute oral toxicity, effects on nontarget organisms, accident history
sulfotep	Bladafum	fumigant	all formulations	acute inhalation toxicity
sulfuryl fluoride	Vikane	fumigant	all formulations	acute inhalation hazard
sulprofos	Bolstar	insecticide	all formulations	wildlife hazard
tefluthrin	Force	insecticide	all formulations	fish toxicity
terbufos	Counter	insecticide	all formulations	effects on nontarget organisms
terbutryn	Igran, Terbutrex	herbicide	all end-use formulations	oncogenicity, dermal toxicity
tralomethrin	Scout	insecticide	emulsifiable concentrate formulations	toxicity to aquatic organisms
triphenyltin hydroxide	TPTH, others	fungicide	all formulations	possible mutagenic effects
zinc phosphide	many	rodenticide	all formulations	acute oral and inhalation toxicity, hazard to nontarget organisms

Suggestions for Minimizing Bee, Fish, and Wildlife Losses from Pesticides

G. Sanderson, P. Tazik, E. Killion, and K. Steffey

It may be impossible to use pesticides without endangering some nontarget species. However, through prudent use, pesticide hazards to fish and wildlife can be substantially reduced. Here are some precautions to follow:

1. Apply pesticides according to the instructions given by the manufacturer and the Cooperative Extension Service.

2. If more than one pesticide is available to control a specific pest, use the pesticide least toxic to nontarget organisms.

3. Avoid drift if at all possible.

4. Follow instructions in disposing of pesticide containers.

5. In wildlife and aquatic areas, use ground equipment so that pesticides can be confined to specific target areas.

6. Make sure that pesticide-treated seed is not readily available to birds or mammals.

7. For application to water, use only those pesticides registered by the federal EPA for aquatic use (Rule 203h, Water Pollution Regulations, as amended).

8. If a pesticide is extremely toxic to fishes, avoid applying it in the immediate watershed, including ditches and channels that drain into bodies of water.

9. Wash application equipment properly, and do not permit wash water to contaminate any body of water.

SOME CHARACTERISTICS OF ANIMAL POPULATIONS IN ILLINOIS THAT ARE HELPFUL IN UNDERSTANDING THE WILDLIFE-PESTICIDE PROBLEM

First, it should be emphasized that there is still a great deal to learn about the overall effects of any pesticide on any population of vertebrate animals in the wild. Certain general facts have been established, however. Considerable data are available on the acute toxicity of various compounds to a variety of species in captivity. Also, there are a limited number of studies of population recovery rates after one or more applications of a pesticide to an area. Some pesticides may cause high mortality in populations of wild vertebrates both directly and indirectly through the food chain. It has been shown that persistent chemicals, such as the chlorinated hydrocarbons, are concentrated from the bottom to the top of the food chain. Animals at the top of the food chain often accumulate heavy dosages of the toxin, and as a result, whole populations may lose their reproductive capacity. Accumulations of organo-chloro insecticides through the food chain, for example, may have reduced the reproductive capacity

of the bald eagle, duck hawk, and other raptor populations both in Europe and North America. The reproductive capacity of certain species of fishes and fish-eating birds, such as loons, cormorants, and pelicans, may have been reduced as well.

Although this discussion refers to all wild vertebrates, most of the remarks and examples refer to birds. Because of their migratory and highly mobile nature, birds are more susceptible to poisoning in large numbers from a single application of pesticide.

The simpler the habitat, the fewer organisms it supports, in terms of the variety or diversity of organisms. Conversely, the more complex the habitat, the greater the number and variety of organisms. For example, in summer, bare plowed ground usually supports only about three to five native species of birds with only about one bird for every two acres. At the other extreme is a forest, which supports about eighty to eighty-five nesting species of birds with about five to eight birds per acre. Of the agricultural habitats in Illinois, corn and soybean fields have the lowest bird populations, essentially the same as plowed bare ground; wheat fields support only slightly higher numbers; and oat fields have conspicuously higher bird populations. Grasslands and hayfields are very rich bird habitats, with forty to seventy native species in the summer and three to five birds per acre. The shrub borders and hedges at the edges of cultivated fields have some of the densest populations of birds of any Illinois habitat. Marshlands also have high populations and many species. In Illinois, the prairie-grassland and marsh-dwelling species are in greatest danger, declining to dangerously low population levels.

Regrettably, the effects of pesticides applied to a field may not stop at the borders of that field. Animals, especially birds, from adjacent fields may pass through a pesticide-treated field or forage at its boundaries. A 1964 study in Illinois indicated that in a single breeding season two successive populations of birds in a hayfield were killed from the effects of one application of 1/4 pound of dieldrin on a nearby wheatfield. The hayfield had not been sprayed, but the birds there were dead. A third population of birds that moved into the hayfield within a month of the spray date was unable to produce fertile eggs.

Populations of birds shift greatly from season to season. Between April 15 and June 10, and again between September 1 and November 15, the bird populations in all parts of Illinois reach their greatest numbers. More than 200 species are present in the state, and their numbers are many times greater than the normal breeding populations. Many of these species are insectivorous. After October 1, increasing numbers of waterfowl appear in the wetlands of the state. The songbird populations penetrate every habitat, but they are most abundant where there is some woody vegetation. Populations of songbird migrants in open habitats probably reach their peaks in late March to mid-May and again in October and early November. Fortunately, most of the migrants do not spend time in plowed fields or in corn and bean fields, that is, in bare fields. An exception is the golden plover, thousands of which pass through the state in April and May; these birds regularly feed in bare fields and grasslands and concentrate particularly around rain pools.

In Illinois, bird populations reach their lowest levels in the northern third of the state in the winter (January 1 to March 1), but in the southern third of the state, winter populations are even higher than the summer populations in practically all habitats.

FACTS ABOUT PESTICIDES AND FISH MORTALITY

Fish kills in ponds and streams can be caused by a number of factors, including runoff from fields treated with insecticides, herbicides, and fertilizers; improper application of aquatic pesticides; and other reasons not related to pesticide use. Insecticides and herbicides that enter water systems can be very toxic to fish. Thus, pesticides should be applied carefully in areas near ponds, lakes, or streams. Precautions should be taken to prevent pesticide drift from the target area and runoff from pesticide-treated fields.

Even chemicals registered for use in aquatic systems can cause fish kills when applied improperly or carelessly. When applying chemicals registered for use in aquatic systems, follow label directions and take precautions to avoid drift of the chemical into nontarget areas. It is especially important to be cautious when applying chemicals in drainage ditches, streams, or canals, where the water in the application area is moving to another area even during application. Fish and other organisms may be killed as the toxic agent flows downstream.

Table 1 shows comparative fish toxicities of some agricultural insecticides used in Illinois. The toxicity of a compound is expressed as an LC_{50}, the concentration of a pesticide, expressed in milligrams of pesticide per liter of water (mg/L, or parts per million), needed to kill 50 percent of the test fish in an aquarium during a 96-hour period. The LC_{50} value indicates only those fish killed immediately after exposure, not delayed mortality caused by compounds in fish fat reserves. Most of the toxicity values we have used are printed in the 8th edition of *The Pesticide Manual: A World Compendium* published in 1987 by the British Crop Protection Council (Lavenham Press Ltd.). A few of the values were taken from the *Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates* published in 1980 by the United States Department of the Interior, Fish and Wildlife Service. When the data were available, we used toxicity values for rainbow trout and bluegill, the two most common species used in toxicity trials.

Stability, storage in fat tissue, affinity, and solubility are chemical characteristics that should be considered when choosing chemicals for use. Stability is the length of time the chemical remains in a particular form in the environment. Stable compounds remain in the environment for longer periods of time than compounds more readily broken down. Compounds readily stored in fat could theoretically cause fish mortality after initial exposure if, under stress, the fat is suddenly used and the pesticides are redistributed throughout the fish's system. High affinity for soil particles means that the pesticide adheres to the soil rather than being readily removed and relocated to a nontarget area. Highly soluble chemicals dissolve readily in water. The more soluble a chemical is, the more quickly it may enter nearby water resources.

SOME FACTS ABOUT PESTICIDES AND BEES

Bees are highly important as pollinators of apples, pumpkins, clovers, cantaloupes, watermelons, blueberries, cucumbers, squash, and other crops in Illinois. Honey bees visit blooming soybeans in all areas of the state and improve yields of some varieties. The bees also visit sweet corn and field corn tassels when they are shedding pollen. Applicators should consider the bees' presence before applying insecticides during soybean bloom and when corn is pollinating. Highly poisonous to bees of all kinds, some common insecticides may cause serious losses

to social bees, such as honey bees and bumble bees, as well as to the less-known solitary bees, such as alkali bees and leaf cutter bees.

Efficient management of pest control programs and of bees can do much to reduce the loss of bees through necessary agricultural pest-control operations. Relating spraying operations to daily bee activity, insecticide toxicity, plant maturity, and the potential for spray drift will reduce bee losses and may mean the difference between a satisfied producer and one faced with a lawsuit.

The toxicity of insecticides to bees can be drastically modified by abnormal weather conditions. Unusually low temperatures that occur after an application can cause insecticide residues on crops to remain toxic to bees up to 20 times longer than these residues would be toxic during reasonably warm weather. Also, if abnormally high temperatures occur during late evening or early morning, bees may actively forage on treated crops during these times when bees are *usually* less active.

RELATIVE TOXICITY OF PESTICIDES TO HONEY BEES

Pesticides differ greatly in their effects on honey bees. The formulation of the pesticide also plays an important role in its toxicity to bees. In general, sprays are safer than dusts, and emulsifiable concentrates are less toxic than wettable powders. Granular materials usually are not hazardous to bees. Microencapsulated formulations of highly toxic materials are extremely hazardous to bees. Penncap-M should not be used on crops visited by bees or in locations where it may contaminate other blooming crops or weeds. Fungicides, acaricides (miticides), herbicides, defoliants, desiccants, nematicides, and blossom thinners are relatively nontoxic.

Pesticides can be placed in three groups in relation to their effects on bees: highly toxic, moderately toxic, and relatively nontoxic.

HIGHLY TOXIC MATERIALS

This group includes materials that kill bees on contact during application and for one or more days after treatment. Bees should be moved from the area if highly toxic materials are used on plants the bees are visiting.

Pesticides (trade names and common names)

Aldrin
Ambush, permethrin (honey bee repellent)
Ammo, cypermethrin
arsenicals
Asana, esfenvalerate
Azodrin, monocrotophos
Baygon, propoxur
Baytex, fenthion
Baythroid, cyfluthrin
Cygon, dimethoate
Cymbush, cypermethrin
Cythion, malathion
Dasanit, fensulfothion
DDVP, dichlorvos
De-Fend, dimethoate
Dibrom, naled*
Dimecron, phosphamidon
Dursban, chlorpyrifos
D-Z-N, diazion
EPN
Furadan, carbofuran

Pesticides (trade names and common names)

Gardona, tetrachlorvinphos
Guthion azinphos-methyl
heptachlor
Imidan, phosmet
Lannate, methomyl
Lorsban 4E, chlorpyriofos
malathion
Mesurol, methiocarb
methyl parathion
miral, Triumph
Monitor, methamidophos
Nemacur, fenamiphos
Nudrin, methomyl
Orthene, acephate
parathion
Pay-Off, flucythrinate
Penncap-M (micro-encapsulated methyl parathion)
Phosdrin, mevinphos*
Pounce, permethrin (honey bee repellent)
Pydrin, fenvalerate
Resmethrin
Sevin, carbaryl
Spectracide, diazinon
Supracide, methidathion
Synthrin, resmethrin
Tamaron, methamidophos
Temik, aldicarb
Vapona, dichlorvos
Zectran, mexacarbate

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*Short residual activity. Can usually be applied safely when bees are not in flight. Do not apply over hives.

MODERATELY TOXIC MATERIALS

These materials can be used with limited damage to bees if not applied over bees in the field or at the hives. Correct dosage, timing, and method of application are essential

Insecticides (trade names and common names)

Abate, temephos
Carzol, formetanate hydrochloride
Ciodrin, crotoxyphos
Counter, terbufos
Di-Syston, disulfoton (honey bee repellent)
Dyfonate, fonofos
Larvin, thiodicarb
Lorsban 15G, chlorpyrifos
Metasystox-R, oxydemeton-methyl
Mocap, ethoprop
Pyramat
Systox, demeton (honey bee repellent)
Thimet, phorate
Thiodan, endosulfan
Trithion, carbophenothion
Vydate, oxamyl
Zolone, phosalone

RELATIVELY NONTOXIC MATERIALS

Materials in this group can be used around bees with few precautions and a minimum of injury to bees.

Insecticides and Acaricides (trade names and common names)

Acaraben, chlorobenzilate
Bacillus thuringiensis (several trade names)
Birlane, chlorfenvinphos
Delnav, dioxathion
Dessin, dinobuton
Dimilin, diflubenzuron (insect growth regulator)
Dylox, trichlorfon
Fundal, chlordimeform
Galecron, chlordimeform
Heliothis polyhedrosis virus
Kelthane, dicofol
Marlate, methoxychlor
Morestan, oxythioquinox
Morocide, binapacryl
Murvesco, fenson
Omite, propargite
Pentac, dienochlor
Plictran, cyhexatin
pyrethrum
rotenone
Sevin XLR Plus, carbaryl
Tedion, tetradifon

Fungicides (trade names and common names)

Afugan, pyrazophos
Arasan, thiram
Benlate, benomyl
Bordeaux mixture
Bravo, chlorothalonil
captan
copper oxychloride sulfate
copper sulfate
Cyprex, dodine
Difolatan, captafol
Dithane M-45, mancozeb
Dithane Z-78, zineb
Du-Ter, triphenyltin hydroxide
Dyrene, anilazine
ferbam
glyodin
Karathane, dinocap
Kocide, copper hydroxide
Morestan, oxythioquinox
Morocide, binapacryl
Mylone, dazomet
Phaltan, folpet
Polyram, metiram
Ridomil, metalaxyl
sulfur
Vitavax, carboxin
Zerlate, ziram

Herbicides, Defoliants, and Desiccants (trade names and common names)

Aatrex, atrazine
Alachlor
Alanap, naptalam
Amiben, chloramben
amitrole
Ammate, AMS
Avenge, difenzoquat
Balan, benefin
Banvel, dicamba
Basagran, bentazon
Betanal, phenmedipham
Betanex, desmedipham
Bladex, cyanazine
Blazer, acifluorfen
cacodylic acid
Casoron, dichlobenil
2,4-D
DNBP, dinitrobutylphenyl
dichlorprop, 2,4-DP
diquat
Dual, metolachlor
Eptam, EPTC
Eradicane, EPTC + safener
Evital, norflurazon
Garlon, triclopyr
Goal, oxyfluorfen

Hoelon, diclofop-methyl
Hyvar, bromacil
Karmex, diuron
Kerb, pronamide
Lasso, alachlor
Lorox, linuron
Maloran, chlorbromuron
MCPA
Methar, DSMA TOK, nitrofen
Milogard, propazine
Modown, bifenox
Paarlan, isopropalin
Planavin, nitralin
Pramitol, prometon
Preforan, fluorodifen
Princep, simazine
Probe, methazole
Prowl, pendimethalin
Ramrod, propachlor
Randox, CDAA
Roundup, glyphosate
Sancap, dipropetryn
Sencor, metribuzin
Sinbar, terbacil
Surflan, oryzalin
Sutan +, butylate
Telvar, monuron
Tenoran, chloroxuron
TOK, nitrogen·
Tolban, profluralin
Tordon, picloram
Treflan, triflurali
Zorial, norflurazon

Nematicides and Miscellaneous (trade names and common names)

Exhalt 800 (sticker/extender)
gibberellic acid (plant growth regulator)
Mylone, dazomet
N-Serve, nitrapyrin (nitrification inhibitor)

SOME ADDITIONAL POINTS TO REMEMBER

1. Prevention of bee losses is the joint responsibility of the spray operator, the farmer, and the beekeeper. Beekeepers should be notified in ample time before a pesticide application to allow them to protect or move their colonies. Most beekeepers cannot move their colonies before a spray application.

2. Sprays are generally less hazardous to bees than are dusts.

3. Late evening and early morning spray treatments (after 9 p.m. and before dawn) will generally reduce bee deaths. However, bees are safer when applications to corn are made between noon and midnight, *not* early in the morning.

4. Aircraft applications of technical or low-volume malathion are *highly* poisonous to bees and should be used chiefly on rangelands for grasshopper control.

5. Ground sprayer treatments usually are less hazardous to bees than are aircraft applications.

6. Spraying or dusting while bees are active in the fields will increase bee kills.

7. During hot weather when bees are clustered outside the hives, treatment over hives increases bee deaths.

8. Drift to neighboring fields in blossom, or to adjacent blossoming weeds and wild flowers, may result in substantial bee poisoning.

9. Bees located in or very near fields at the time pesticide treatments are made may sustain serious death losses. Bees moved into fields and orchards after spraying is completed may suffer little loss.

10. To eliminate pests without endangering the bees, use the recommended amount of a pesticide that is least toxic to the bees but potent enough to kill targeted pests.

11. Bees fly most actively at temperatures above 55°F. Spraying when temperatures stay below 55°F will do little harm to bees.

12. Insecticides cause heavy bee losses if applied to orchards when the clover beneath the trees is in bloom. Significant bee losses also occur when insecticides are applied to alfalfa when weeds, such as yellow rocket and mustard, are in bloom.

Table 1. Fish Toxicities (LC_{50}s) of Agricultural Insecticides Used in Illinois.

Trade name	Common name	LC_{50}[a] Rainbow trout	Bluegill	Other	
Pay-off (ingredient of Aastar)	flucythrinate	0.0003	...	0.001 (minnow)	*Extremely toxic.* Do not use in the vicinity of streams or ponds or where drift or runoff will probably occur..
Lorsban	chlorpyrifos	0.003	...		
Pydrin	fenvalerate	0.0036	...		
Ambush, Pounce	permethrin	0.009	...		
Supracide	methidathion	0.01	0.0022		
Counter	terbufos	0.01	0.004		
Dyfonate	fonofos	0.02[b]	0.007[b]		
Thimet	phorate	0.013	...		
Cythion	malathion	...	0.103		*Highly toxic.* Use great caution if applied in the immediate vicinity of streams and ponds.
Furadan	carbofuran	0.28	...		
Imidan	phosmet	0.50[b]	0.16[b]		
Dylox	trichlorfon	1.75[b]	3.17[b]	6.2 (carp)	*Moderately toxic.* Use cautiously around streams and ponds. Avoid direct application of the pesticide to fish-bearing ponds or streams.
Larvin	thiodicarb	2.55	1.21		
Diazinon	diazinon	2.6-3.2	16		
Penncap-M	methyl parathion	2.7	...		
Lannate, Nudrin	methomyl	3.4	0.87		
Sevin	carbaryl	...	...	5-13 (fish)	
Mocap	ethoprop	13.8	2.07		
Cygon	dimethoate	...	...	40-60 (mosquito fish)	*Least toxic.* Reasonably safe for use around fish-bearing ponds or streams.
Orthene	acephate	>1,000	2,050		
Dipel	*Bacillus thuringiensis*	NT[c]	NT[c]		

[a]Concentration (parts per million, or mg/L of pesticide needed to kill 50 percent of the test fish in an aquarium during a 96-hour period. Values obtained from *The Pesticide Manual: A World Compendium*, 8th edition (1987, Lavenham Press, Ltd.), unless otherwise noted.

[b]Value obtained from W.W. Johnson and M.T. Finley (1980) *Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates* (U.S. Dept. Interior, Fish and Wildlife Service, Resource Publ. 137).

[c]NT - No evidence of acute or chronic toxicity to fish.

Rodent Damage Control in Conservation Tillage Systems

R. Corrigan

There is considerable concern among farmers who practice conservation tillage that rodents will become a more serious problem because of the increased amount of vegetation, or "rodent cover," left on the surface of the soil. However, one should not assume that rodents, in general, will become significant economic pests in *all* fields under conservation tillage. Whether rodent populations will increase and cause economic damage in a particular cornfield depends on many conditions. The species of rodent, phase of the rodents' population cycle, reproductive condition of the rodents, past history of the field, type of edge surrounding the field, weather conditions, and several other factors all affect the potential for rodent damage.

Of the various types of conservation tillage operations, *no-till* and *cover crop operations* are probably the best candidates for damage caused by rodents. The large amounts of vegetation change the habitat structure, and the lack of tillage allows undisturbed establishment of rodent burrows. Damage occurs in these fields after herbicide applications destroy much of the food resource of the rodents, which often turn to the corn seeds and young plants as an alternate food source.

DAMAGE

The rodents that can cause damage to corn in Illinois include:

1. deer mouse (*Peromyscusmaniculatus*)
2. house mouse (*Mus musculus*)
3. thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)
4. prairie and meadow voles (*Microtus* spp.)

The rodents reduce plant stands by digging and consuming newly planted seeds and kernels attached to seedlings. Damage usually occurs within the first three weeks after planting. Reported stand losses have been as great as 80 percent, but average stand losses are usually lower and quite variable. Damage is occasionally severe enough to necessitate replanting.

MONITORING FIELDS

The best way to determine whether rodents may become a problem is to scout fields that have the greatest potential for harboring significant populations of rodents, especially field mice and ground squirrels.

Scout no-till fields for field mice several weeks before planting. Look for signs of mouse activity in grassy borders adjacent to the crop, weedy ditch banks, roadside and railroad rights-of-way, and throughout the field itself. Look for mouse runways, fresh soil around burrow openings, and fecal deposits in

runways. If populations are heavy, mice can usually be seen darting down their runways. These runways are about 1 1/2 inches wide. Mouse burrows are approximately 2 inches in diameter.

Ground squirrels can also be a nuisance in cornfields, where they may dig up and consume both freshly planted seed and seedlings. As few as 5 or 6 squirrels per acre can cause significant damage, sometimes necessitating a second planting. When scouting for ground squirrels, inspect the same areas as those mentioned for field mice, but pay particular attention to weedy and grassy edges. The burrows of ground squirrels measure approximately 2 inches in diameter. Probably the easiest way to determine if ground squirrels are present is to watch for them on any spring or summer morning between 9:00 a.m. and 11:00 a.m. These rodents are usually active during this time, and they are easily spotted.

RODENT DAMAGE CONTROL

If a farmer is concerned about the potential for damage caused by rodents or if surveys indicate the presence of a large population of rodents, control may be warranted. Repellents and toxic baits are two management tools that may prevent significant damage.

Repellents. The product Mesurol can be applied to seed corn and will effectively control both seed consumption by rodents and sprout pulling by blackbirds. For best results, the planter box should be filled halfway with seed, and then half of the required amount of Mesurol should be added. Thoroughly mix the material with the seed using a stick or paddle. Fill the remainder of the planter box with seed, pour on the remainder of Mesurol, and repeat the mixing. Check the label for recommended rates of application and for use precautions.

Mesurol can be ordered through a distributor or a local pesticide dealer. However, most local dealers do not stock Mesurol.

Mesurol can be fairly expensive to use, but if rodents or birds are causing significant damage, the cost may be justifiable. In addition, rodents tend to be more of a problem around the perimeter rows of a field, so it is usually not necessary to plant the entire field using the Mesurol repellent. Birds usually cause damage on the side of a field adjacent to woods or tree stands. Treating several rows next to these areas is often the best use of Mesurol. By utilizing the Mesurol repellent for rodents and birds in this manner, the overall cost can be reduced considerably.

Poison Baits. Poison baits are very effective in reducing field mouse populations. The recommended bait to use is a 2 percent zinc phosphide oat bait. **However, the labels state that poison bait cannot be applied to bare ground or broadcast over growing crops where the oat grain may lodge in the plants.**

When used in no-till and cover-crop situations, zinc phosphide should be applied by broadcasting the bait (using a dry insecticide or fertilizer spreader) about a week before planting. The bait can also be placed by hand (using long-handled spoons or ladles) under cover in active runways. Zinc phosphide baits are restricted-use products and should be sold to and used by only certified applicators. Consult the label for specific rates of application, use precautions, and directions for use.

For ground squirrels, an excellent bait is strycnine-treated oats. One teaspoonful placed according to label directions will very effectively control these rodents.

To obtain zinc phosphide and strychnine bait, contact a United States Department of Agriculture Animal Damage Control Officer. The telephone number in Springfield, Illinois is (217)492-4308. Allow time both for the Officer to contact the appropriate distributor and for delivery of the bait.

SUMMARY

With increased use of no-till and cover-crop systems, the potential for rodent damage also increases. However, the potential for damage in a given field depends on numerous conditions, so field monitoring before planting is the only way to detect significant populations of rodents. Management tools, like repellents and toxic baits, can effectively prevent rodent damage, but they should be used only when necessary.

For more information about rodent control, in both agricultural and urban situations, contact USDA-APHIS, Animal Damage Control, Room 105, 600 East Monroe, Springfield, Ilinois 62701,(217)492-4308. More information about the control of rats and mice and reducing bird damage in Illinois can be found in the *1987 Illinois Pest Control Handbook*, pages 379 through 393.

Notes

Notes

CONVERSIONS

Fluid

1/6 fluid ounce (oz) = 1 teaspoon (tsp)
1/2 fluid ounce = 1 tablespoon (tbs) = 3 teaspoons
1 fluid ounce = 2 tablespoons = 1/8 cup
8 fluid ounces = 1 cup = 1/2 pint (pt)
16 fluid ounces = 2 cups = 1 pint
32 fluid ounces = 4 cups = 1 quart (qt)
128 fluid ounces = 16 cups = 1 gallon (gal)

Linear

1 inch = 2 1/2 centimeters (cm) = 25 1/2 millimeters (mm)
1 foot (ft) = 12 inches (in)
1 yard (yd) = 3 feet
1 rod = 5 1/2 yards = 16 1/2 feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

Area

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod
= 272 1/4 square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

Weight

1 ounce = 28 1/3 grams (g)
1 pound (lb) = 16 ounces = 453 1/2 grams
2 1/5 pounds = 1 kilogram (kg) = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

DILUTION TABLES

Amount of Liquid Pesticide Product Required to Obtain Recommended Rate

Concentration of liquid formulation	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	¼ lb	½ lb	1 lb	2 lb	3 lb
	Amount of pesticide product required				
1 lb/gal	1 qt	2 qt	1 gal	2 gal	3 gal
1½ lb/gal	1⅓ pt	1⅓ qt or 2⅔ pt	5⅓ pt	5⅓ qt	2 gal
2 lb/gal	1 pt	1 qt	2 qt	1 gal	6 qt
4 lb/gal	8 oz	1 pt	1 qt	2 qt	3 qt
6 lb/gal	6 oz	10 oz	1⅓ pt	1⅓ qt	2 qt
8 lb/gal	4 oz	8 oz	1 pt	1 qt	3 pt

Amount of Dry Pesticide Product Required to Obtain Recommended Rate

Concentration of dry formulation	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	¼ lb	½ lb	1 lb	2 lb	3 lb
	Amount of pesticide product required				
15%	1⅔ lb	3⅓ lb	6½ lb	13 lb	20 lb
25%	1 lb	2 lb	4 lb	8 lb	12 lb
40%	10 oz	1¼ lb	2½ lb	5 lb	7½ lb
50%	8 oz	1 lb	2 lb	4 lb	6 lb
65%	6 oz	12 oz	1½ lb	3 lb	4½ lb
75%	5⅓ oz	11 oz	1⅓ lb	2⅔ lb	4 lb
80%	5 oz	10 oz	1¼ lb	2½ lb	3¾ lb

Poison Resource Centers

The Poison Resource Centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency can call the toll-free telephone number for help. Personnel at the Resource Center will give you first-aid information and direct you to local treatment centers if necessary.

Chicago and Northeast Illinois

1753 West Congress Parkway
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