1987 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



The information in this handbook was prepared by specialists employed by the Unversity 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. The recommendations for using pesticides that are included in this handbook 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. Pesticides that are effective and 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 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 you plan to use. Announcement of new registrations, label changes, and changes in recommendations will be made through newsletters and appropriate media sources.

The Illinois Cooperative Extension Service provides equal opportunities in programs and employment.

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1987 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 control 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 control that are included in this circular is based on EPA registrations 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. Insecticides that are effective and 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. If you have questions about the use of insecticides for management of insect pests in field and forage crops, consult your county Extension adviser.

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, nor is discrimination intended against any product. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

PEST-MANAGEMENT SCOUTING PROGRAMS

Integrated Pest Management (IPM) is a systematic method of looking for pests in the field, of determining whether control measures are needed, and, if there is a problem, of deciding on the proper measures to use. Pest scouting enables farmers to detect and control pest outbreaks before significant yield losses occur. Because decisions on chemical control are based on economic thresholds, IPM programs eliminate unnecessary pesticide use.

Pest scouting has been accepted as an important management tool by many Illinois farmers. As farming costs increase, growers are realizing the advantages of treating a field only when an economically harmful pest population occurs, rather than treating it automatically regardless of the situation. By using pesticides on this basis, farmers have a better chance of reducing management costs.

Pest scouting programs have been initiated by several

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pest-management consulting firms throughout the state. In addition to pest scouting, most offer other services such as soil testing and nematode monitoring.

Many growers and their family members have received training for pest identification and scouting techniques. Programs are offered at various locations around the state and on the University of Illinois campus. If you are interested in attending a scout training course, contact your county Extension adviser.

FEDERAL AND STATE LAWS

The U.S. Environmental Protection Agency classifies pesticides for "general" or "restricted" use; several insecticides have been classified for 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.

Table 1. Insecticide Classifications

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

[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.

Private applicators (farmers) who use restricted-use pesticides "for the purpose of producing any agricultural commodity on property owned or rented by him 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 Cooperative Extension Service to prepare persons for certification. For additional information, consult your county Extension adviser in agriculture. The actual certification and the issuing of permits or licenses are handled by the Illinois Department of Agriculture or the Illinois Department of Public Health.

Special Local Need Registrations

Section 24(c) of the amendments to the Federal Insecticide, Fungicide, and Rodenticide Act 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.

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 name in parentheses following the trade name.

PESTICIDE LABELS AND SAFETY

Certain precautionary steps should be taken when handling insecticides. The insecticides suggested in this publication can be poisonous to the applicator. The farmer or applicator is expected to protect himself, his workers, and his family 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. The person most likely to suffer ill effects from insecticides is the applicator. Accidents and careless, needless overexposure can be avoided. Following these rules will prevent most insecticide accidents:

- Wear rubber gloves when handling insecticide concentrates.
- Do not smoke, eat, or drink while handling or using insecticides.
- Keep your face turned to one side when opening, pouring from, or emptying insecticide containers.
- Leave unused insecticides in their original containers with the labels on them.
- Store insecticides out of the reach of children, irresponsible persons, and animals; store preferably in a locked building. Do not store near livestock feeds. Better yet, buy no more pesticide than you will use, thus eliminating a pesticide storage and disposal problem.
- Triple rinse, bury, or burn all empty insecticide containers or take them to an appropriate sanitary landfill.
- Do not put the water-supply hose directly into the spray tank or blow out clogged nozzles or spray lines with your mouth.
- Wash with soap and water exposed parts of the body and clothes contaminated with insecticides.
- Do not apply to fish-bearing or other waters.
- Do not leave puddles of spray on impervious surfaces or apply insecticides near dug wells or cisterns.
- Do not apply insecticides, except in an emergency, to areas with abundant wildlife.
- Do not spray or dust when weather favors drift.
- To avoid bee kill, apply insecticides after bee activity has ceased for the day; use the least toxic materials. *Warn beekeepers that you are applying insecticides.*

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 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 soil insect damage in a particular field during previous years is also helpful because infestations tend to occur in the same fields and in the same area.

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 risk of damage caused by soil insects and the need for applying a soil insecticide at planting.

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 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 most fields of corn after corn. Wireworms are occasionally a problem in the southern part of Illinois. 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 corn

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 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 should 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

Problem Area

Populations of northern and western corn rootworm beetles were extremely high in 1986. 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 erratic 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, carbamates and organophosphates, 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 insecticide applications (rates that were too low).

In some fields, lack of rain prevented the movement of the insecticide from the soil surface or 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 clearcut nor predictable. In all probability, environmental conditions combined with accelerated degradation of the insecticides are major causes for rootworm control problems.

Table 2. Probability Estimates of Economic Soil Insect Damage in Corn and Suggestions for Control 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	1:200	1:25	1:1,000	1:1,000	1:150	1:100	1:1,000	very low	Use planter-box seed treatment; scout for cutworms.
Corn	1:200	1:100	2:3	1:1,000	1:50	1:100	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.
Legume	1:25	1:25	1:50	1:150	1:10	1:50	1:4	low-mod	Bait for wireworms prior to planting.
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.

Are the rootworms more tolerant 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. Unfortunately most tests to detect resistance are conducted with the adult stage rather than the damaging larval stage. So at this point, tolerance to insecticides cannot be ruled out.

Extended Diapause

During 1986 in the northern half of Illinois, a small number of fields of corn following soybeans were damaged by corn rootworm larvae. This was the first time that Illinois entomologists had confirmed economic rootworm damage in this cropping sequence in Illinois. 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.

Evidently a proportion of the northern corn rootworm population has biologically evolved to remain in extended diapause, thereby enabling rootworm eggs to survive two winters before hatching. Ordinarily rootworm eggs hatch the year after they are deposited. Extended diapause is not known to occur in the western corn rootworm population, the predominant species of rootworms in Illinois.

Should a farmer use a corn rootworm soil insecticide on corn following soybeans to control corn rootworms in 1987? Although the answer is not a clear-cut "no," the percentage of cornfields following soybeans that were economically damaged by corn rootworms was extremely small in 1986. Based on a random survey of 300 fields of corn following soybeans in the northern half of Illinois, less than 1 percent of the fields sampled had economic rootworm damage. At this point there seems to be little justification for using a soil insecticide in corn following soybeans on the vast majority of fields. A few isolated fields may sustain damage in 1987, 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 1987 as a consequence of extended diapause in the northern corn rootworm population? Northern corn rootworm beetle numbers would likely have to have exceeded 2 beetles per plant in a field of corn during August, 1985, to result in a sufficient number of diapausing eggs to cause larval damage to corn after soybeans in 1987. Minnesota and South Dakota researchers have shown that as many as 50 percent of the northern corn rootworms in some areas in these states were of the extended (2 year) life cycle type. Illinois research entomologists are conducting investigations into the phenomenon of extended diapause within the northern corn rootworm populations in Illinois.

Determining Potential for Damage in 1987

Corn growers should base the need for using a rootworm soil insecticide in 1987 on the abundance of rootworm beetles in cornfields during late summer of 1986. Generally, if beetle numbers reached or exceeded 0.75 per plant at any time during late July, August, or September, 1986, plan to apply a rootworm soil insecticide if the field is to be replanted to corn in 1987.

However, if the field scouted in 1986 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 1987 may be as low as 0.5 beetle per plant.

Fields of corn planted in late May or June, 1986, may have extensive rootworm damage if replanted to corn in 1987. 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 1987 is suggested to reduce the rootworm population.

SUGGESTIONS FOR ROOTWORM CONTROL, 1987

In recent years, the performance of rootworm soil insecticides has been quite variable. They have performed effectively at some locations and have been marginal or ineffective at others. This trend could continue in 1987. An immediate solution to the phenomenon 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 1987, 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 is 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 by 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. Adult northern and western corn rootworms were attracted to these weedy soybean fields to deposit eggs. As a result, root damage by larvae occurred the following season. Good weed control in soybeans will prevent rootworm damage in corn following soybeans. Soybean fields with 5,000 or more volunteer corn plants per acre will usually warrant treatment for rootworm control the following year if planted to corn.

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 before becoming egg-laying beetles.

Soil Insecticides

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

At Planting. Apply Aastar G, Broot 15GX, Counter 15G, Dyfonate 20G 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. 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 furrow for rootworm control. Mocap 15G is labeled for application over a closed seed 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. This degree of control is 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 in treatments using a liquid insecticide with a liquid fertilizer 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 20G, 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 in-

secticide may enable soil microorganisms to break it down rapidly or may hasten the onset of insect 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 1987.
2. Avoid using carbamates in consecutive years.
3. Avoid using the same organophosphate for several consecutive years.

Laboratory and field research indicates that using the same rootworm soil insecticide for several consecutive years can eventually lead to erratic, if not poor, rootworm control.

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.

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 Control 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 1986.

2. If you intend to grow corn after corn and 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, 1987, to determine the potential for rootworm larval damage in 1988.

Scouting to Determine Rootworm Potential in 1988

The abundance of rootworm beetles in a cornfield in July and August is an excellent indicator of future rootworm problems. Corn growers can determine the potential for rootworm damage in 1988 by counting western and northern corn rootworm beetles from mid-July through August, 1987, in this way:

1. Make 3 or more counts for western and northern corn rootworm beetles 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 1988. If populations do not exceed an average of ½ 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.

CORN CUTWORMS

The occurrence and extent of cutworm infestations are difficult to predict each year. ***Sandhill, dingy,*** and ***claybacked cutworms*** all overwinter in Illinois as partially grown larvae, but their populations are seldom widespread. As a result, they cause damage early in the growing season in scattered areas. Sandhill cutworms are a problem in sandy areas almost every year. Dingy and claybacked cutworms occur more frequently in corn planted after sod or forage legumes than in other crop rotations.

Black cutworms do not overwinter in Illinois, so outbreaks are difficult to forecast. Infestations of black cutworm larvae arise from eggs laid by moths that fly into Illinois in the early spring. A statewide program of monitoring black cutworm pheromone traps provides information about the time and intensity of spring moth flights.

Certain factors favor black cutworm outbreaks. The most important factors may be late planting and preplant weed infestations. Fields that are tilled and planted late are more likely to develop a preplant weed infestation than fields that are planted early. These late-planted fields with weeds are more attractive to cutworm moths as a site on which to deposit their eggs.

Currently, two options are available for cutworm control: applications of soil insecticides to prevent damage and rescue treatments after the infestation appears.

Because of the uncertainty in predicting which fields will have light, moderate, or heavy infestations of cutworms, it may be more feasible to use rescue treatments for cutworm outbreaks rather than to use a preplant or planting-time treatment unnecessarily.

Based on the relatively low incidence of cutworm problems over the past 25 years, a grower may find an economic advantage to the wait-and-see system, which involves field scouting rather than a costly always-apply program in which the soil insecticide is routinely applied at or before planting for a problem that may not exist.

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

The keys to effective cutworm control with the 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, Lorsban, Pay-Off, 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 is needed on corn in the 2-leaf stage if 3 percent or more of the plants are cut and if there are 2 or more cutworms per 100 plants. At the 4-leaf stage, control is justified if 3 percent or more of the plants are cut and if there are 4 or more worms per 100 plants. A single cutworm will cut fewer of the 4-leaf plants than those in the 2-leaf 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. Lorsban 15G is registered for the control of cutworms in corn and has provided the best cutworm control in research trials. In fields with a history of cutworm problems or in high-risk fields, Lorsban 15G should give the most consistent control of cutworms.

Pre-emergent sprays of Ambush, Pounce, and Pydrin may be applied in fields where the probability of cutworm damage is great.

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 extremely 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 pre-emergent spray of Ambush, 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. 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. As a minimum, place 2 stations at the highest elevation in a field, 2 on a slope, and 2 in the lowest area.

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 black plastic. The plastic collects solar heat and speeds germination of the corn and wheat, which entices 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.

Need for Treatment

If you find an average of one or more wireworm 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 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.

PLANTER-BOX SEED TREATMENTS

Corn. Use 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 certain 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. Use a diazinon or diazinon + lindane seed protectant to prevent damage to germinating soybeans from seedcorn maggots. Follow the label directions for application. The potential for damage is greatest during cool, wet springs when germination is slow.

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 quantity (ounces) per bag against those given in Table 3. To obtain one pound of active ingredient per acre the following amounts of material should be collected:

Formulation, percent	Oz. collected per 1,000 ft.
10	12
15	8
20	6

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

EUROPEAN CORN BORERS

Corn borer moths begin to emerge in late May in southern Illinois and mid- to late June in the central and northern regions. The females lay most of their eggs in the evening. They spend the daylight hours in fencerows and other protected areas.

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

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. Control is warranted if 50 percent or more of the plants have fresh whorl-feeding and live borers are present. Seed production fields should be treated when 15 to 25 percent of the plants have whorl-feeding and larvae are present.

Corn hybrids have varying degrees of tolerance or resistance to leaf-feeding by first-generation borers. Consider this trait when selecting varieties for 1987.

Corn planted late is most attractive to moths laying eggs for the *second generation.* Yield losses caused by second-generation borers are a result of stalk breakage and ear drop, as well as physiological damage. Corn-borer entrance holes also provide avenues for stalk rot organisms. Monitor fields from mid-July to mid-August for egg masses or newly hatched larvae of the second brood.

To assess the potential for second-generation corn borers, start checking for egg masses when moth flight is under way. Examine a minimum of 25 plants, selected at random throughout the entire field, and count the number of egg masses that are found on each plant. Although the moths usually lay their eggs on the two or three leaves above or below the developing ear, you should check all the leaves. 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. Calm nights favor

Table 3. Soil Insecticides Suggested for Rootworm Control, Illinois, 1987

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 20G	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
*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.

egg deposition by the moths. The absence of hard, beating rains during moth emergence also increases the potential for infestations.

Egg masses are flat and about half the size of your little fingernail. 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 hides in grass and weeds during the day. Noncrop areas that border cornfields may harbor large numbers of corn borer moths during the day. Check these areas for moths as you enter the field to determine the potential for corn borer infestation.

Treatment is warranted when you find 1 egg mass for every two plants. Because peak egg laying generally occurs over a period of 2 to 4 weeks, it will be necessary to resample fields if egg masses are not present on half of the plants during the initial survey. If cumulative counts (taken 1 week apart) exceed 1 egg mass for every two plants, apply a 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. Because egg laying for the second generation extends over a 3- to 4-week period, timing of insecticide application should be precise. Occasionally, two treatments may be necessary for satisfactory control.

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 controlled 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 rotations 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 where no-tillage is used in corn than where conventional or reduced-tillage systems are used.

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 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 planter-box seed protectant will give protection against seedcorn maggots and seedcorn beetles.

Surface 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. Granules remaining on the soil surface are degraded by sunlight, resulting in erratic or poor control.

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 will 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, but 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 with other tillage systems. Moths of this insect deposit their eggs on weeds in late August and September. 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 of 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.

FORAGE 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 a lot of 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 organism that attack alfalfa weevil larvae sometimes regulate weevil numbers in the spring. Although the wasp and the fungus will be present in alfalfa fields in 1987, we cannot yet predict their effect on weevil numbers.

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 and is more evident during dry weather. 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.

CHEMICAL INJURY TO SOYBEANS

There have been instances of phytotoxicity to soybeans when organic phosphate soil insecticides were used. The problems have occurred where growers started planting soybeans without first emptying the insecticide boxes. Organic phosphate 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 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

Table 5. Field Corn

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworms	*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	At first migration, or when worms are eating leaves above ear level. Ambush, Lorsban 4E, Pounce, and Pydrin can also be applied as a preemergent treatment in no-till corn.
	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	2 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.

Table 5. Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Chinch bug	Lorsban 4E	2 pt.	Spray at base of plant.	At start of migration from small grains. Use only ground equipment and apply 20 to 40 gallons of finished spray per acre.
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR	2-4 pt.		
Common stalk borer	*Ambush 2E	6.4-12.8 oz.	Broadcast	Apply postemergence sprays when damage first appears. See labels for specific instructions about effective control. Furadan 15G applied at 2-3 lb. a.i./acre at planting time may provide early season suppression of common stalk borers.
	Lorsban 4E	2-3 pt.		
	*Pounce 3.2EC	4-8 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
Corn earworm	*Ambush 2E	6.4 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. Ambush and Pounce have 24(c) labels for control of corn earworms in seed production fields.
	Lannate, Nudrin 90WSP	¼-½ lb.		
	*Pounce 3.2EC	4 oz.		
	*Pydrin 2.4EC	5⅓ oz.		
Corn leaf aphid	Cygon 400	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 oz.	Overall spray or directed toward ear zone	To protect pollination, treat before 75% of plants have silked, if there are 5 or more beetles per plant, and if silk clipping is observed. Apply Ambush or Pounce prior to the brown silk stage.
	Imidan 50WP	1 lb.		
	Lorsban 4E	1-2 pt.		
	malathion 57%EC	1½ pt.		
	*Penncap-M	2 pt.		
	*Pounce 3.2EC	4 oz.		
	*Pydrin 2.4EC	5⅓ oz.		
	Sevin XLR	2 pt.		
Corn rootworm larvae	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	Broot 15GX	8 oz. per 1,000 ft. row	Band	Broot 15GX, Counter 15G, Dyfonate 20G, Furadan 15G and 4F, Lorsban 15G and 4E, Mocap 15G, and Thimet 20G can also be applied at cultivation time.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Dyfonate 20G	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	
Cutworms	*Aastar G	8 oz. per 1,000 ft. row	Band at planting	Counter 15G, Dyfonate 20G, Furadan 15G, and Mocap 15G will control light to moderate infestations of cutworms.
	*Ambush 2E	6.4-12.8 oz.	PRE[d]	
	Lorsban 15G	8 oz. per 1,000 ft. row	Band or furrow at planting	
	Lorsban 4E	2-4 pt.	Broadcast-PPI[c]	
	Pounce 15G	6.7-13.3lb.	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.	Broadcast-PE[e]	Apply as a postemergence rescue treatment when 3 percent or more of the plants are cut in the 2-leaf stage and there are 2 or more cutworms per 100 plants. At the 4-leaf stage, control is justified if 3 percent or more of the plants are cut and there are 4 or more worms per 100 plants.
	Lorsban 4E	2-3 pt.	Broadcast-PE[e]	
	*Pay-Off 2.5EC	2-4 oz.	Broadcast-PE[e]	
	*Pounce 3.2EC	4-8 oz.	Broadcast-PE[e]	
	*Pydrin 2.4EC	5⅓-10⅔ oz.	Broadcast-PE[e]	

Table 5. Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
European corn borer, first generation	*Ambush 2E	6.4-12.8 oz.	On upper ⅓ of plant and into whorl	When 50% or more of the plants have fresh whorl-feeding and live borers are present. 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 20G	5 lb.		
	*Furadan 15G	6.7 lb.		
	*Furadan 4F	2 pt.		
	Lorsban 15G	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	Dipel ES	2 pt.	On foliage	Apply at first hatch when half of the plants have egg masses, or when cumulative counts, made one week apart, exceed 1 egg mass for every 2 plants. Apply Dipel ES only by ground equipment or center pivot irrigation.
	*Dyfonate 20G	5 lb.		
	*Furadan 15G	6.7 lb.		
	*Furadan 4F	2 pt.		
	Lorsban 15G	6.5 lb.		
	Lorsban 4E	2 pt.		
	*Penncap-M	4 pt.		
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	¼-½ 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 some plants are being killed.
	Lorsban 4E	2 pt.		
	*Penncap-M	2-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR	2 pt.		
Grasshoppers	Cygon 400	1 pt.	On foliage	As needed. The higher rates are suggested for control of adult grasshoppers.
	*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 pt.		
	Sevin XLR	1-3 pt.		
Hop vine borer	None labeled	..	....	Postemergence sprays of Ambush, Pounce, Pydrin, or Lorsban may give some control if applied when damage first appears.
Japanese beetle	Sevin XLR	2 pt.	On foliage	During the silking period to protect pollination if there are 3 or more beetles per ear and pollination is not complete.
Picnic, sap beetles	Lannate 90WSP	¼-½ lb.	On foliage	Justified only in seed corn fields when beetles are feeding on ear tips.
	malathion 57%EC	1½ pt.		
	Sevin XLR	2 pt.		
Seedcorn beetles	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Dyfonate 20G	6 oz. per 1,000 ft. row	Band	
	Lorsban 15G	8 oz. per 1,000 ft. row	Furrow	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	
	diazinon	See label	On seed	Use formulations that are prepared as seed treaters.
	diazinon + lindane	See label	On seed	
	Lorsban 50-SL	See label	On seed	

Table 5. Field Corn (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Seedcorn maggots	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Dyfonate 20G	6 oz. per 1,000 ft. row	Band	
	*Furadan 15G	8 oz. per 1,000 ft. row	Furrow	
	Lorsban 15G	8 oz. per 1,000 ft. row	Furrow	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	
	diazinon	See label	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.
	diazinon + lindane	See label	On seed	
	Germate	See label	On seed	
	Lorsban 50-SL	See label	On seed	
Sod webworm	Lorsban 4E	1-2 pt.	Broadcast	At time of initial attack.
Southwestern corn borer	*Dyfonate 20G	5 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.
	*Furadan 15G	6.7 lb.		
	*Furadan 4F	2 pt.		
	Lorsban 15G	6.5 lb.		
	Lorsban 4E	2 pt.		
	*Penncap-M	4 pt.		
Spider mites	Cygon 400	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.
	diazinon AG 500	1 pt.		
	ethion 4EC	2 pt.		
	*Thimet 20G	5 lb.		
Symphylans	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	At planting.
	*Dyfonate 4E	4 pt.	Broadcast-PPI[c]	
	Lorsban 15G	8 oz. per 1,000 ft. row	Band	
	Lorsban 4E	2-4 pt.	Broadcast-PPI[c]	
	*Mocap 15G	8 oz. per 1,000 ft. row	Band	
Thrips	malathion 57%EC	1½ pt.	On foliage	When severe wilting and yellowing of leaves are noticed.
White grubs	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	Lorsban 15G	8-16 oz. per 1,000 ft. row	Furrow	
	Lorsban 4E	4 pt.	Broadcast-PPI[c]	
	*Thimet 20G	6 oz. per 1,000 ft. row	Band	
Wireworms	*Aastar G	8 oz. per 1,000 ft. row	Band	At planting.
	*Counter 15G	8 oz. per 1,000 ft. row	Band, furrow	
	*Dyfonte 20G	6 oz. per 1,000 ft. row	Band	
	*Dyfonate 4E	8pt.	Broadcast-PPI[c]	
	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	
	Agrox D-L Plus	See label	On seed	Use formulations that are prepared as seed treaters.
	Germate	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. 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	**Before bloom:** when defoliation reaches 30%, at least 1 cotyledon per foot of row is destroyed, 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.
	Cygon 400	1 pt.		
	Larvin 3.2F	18-30 oz.		
	Lorsban 4E	1-2 pt.		
	Orthene 75S	⅔ lb.		
	*Penncap-M	2 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓ oz.		
	Sevin XLR	1-2 pt.		
Blister beetles	Sevin XLR	2 pt.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Corn earworm	*Ambush 2E	6.4 oz.	On foliage	Damage occurs when larvae feed on pods. Apply control if populations exceed 1 per foot of row.
	Lannate, Nudrin 90WSP	¼-½ lb.		
	Larvin 3.2F	10-16 oz.		
	Orthene 75S	1⅓ lb.		
	*Pounce 3.2EC	4 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
Cutworms	Larvin 3.2F	20-30 oz.	Broadcast	Scout as plants are emerging. Treat if 20% of plants are cut and stand has gaps of one foot or more and cutworms are present.
	Lorsban 4E	2 pt.	Broadcast	
	*Pydrin 2.4EC	5⅓-10⅔ oz.	Broadcast	
Grasshoppers	Cygon 400	1 pt.	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. The higher rates are suggested for control of adult grasshoppers.
	*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	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.
	Dipel, Thuricide, Bactur, SOK (*Bacillus thuringiensis*)	See label		
	Larvin 3.2F	10-16 oz.		
	Lorsban 4E	½-1 pt.		
	Orthene 75S	⅔ lb.		
	*Penncap-M	2 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR	1-2 pt.		
Japanese beetle adults	*Penncap-M	3-4 pt.	On foliage	When defoliation reaches 20% during bloom and pod fill.
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR	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.
	Larvin 3.2F	18-30 oz.		
	Orthene 75S	⅔-1⅓ lb.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Thuricide, Dipel, Bactur, SOK (*Bacillus thuringiensis*)	See label		

Table 6. Soybeans (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
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.
	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 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR	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.
	Cygon 400	1 pt.		
	*Penncap-M	2 pt.		
	*Pounce 3.2EC	2-4 oz.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR	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	As needed on field margins or entire field.
	Lorsban 4E	1 pt.		
	*Penncap-M	2 pt.		
Stink bugs	Lorsban 4E	2 pt.	On foliage	When adult bugs or large nymphs reach 1 per foot of row during pod fill.
	Orthene 75S	1-1⅓ lb.		
	*Penncap-M	2-3 pt.		
	*Pydrin 2.4EC	5⅓-10⅔ oz.		
	Sevin XLR	2-3 pt.		
Thistle caterpillar	Sevin XLR	4 pt.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Thrips	*Penncap-M	2-3 pt.	On foliage	If seedlings are being seriously damaged and some plants are being killed.
	Sevin XLR	2 pt.		
Webworms	Sevin XLR	2 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	3.2-6.4 oz.	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	Larvin 3.2F	10-16 oz.		
	Lorsban 4E	1-2 pt.		
	*Pounce 3.2EC	4 oz.		
	*Pydrin 2.4EC	2⅓-5⅔ oz.		

* 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. Alfalfa and Clover
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	Dylox 80SP	8-10 oz.	On foliage	When damage is obvious
	Sevin XLR	1-2 pt.		

Table 7. Alfalfa and Clover (continued)

Insect	Insecticide[a,b,c]	Amount of product per acre[c]	Placement	Timing of application, comments
Alfalfa weevil (spring treatment for larvae)	*Furadan 4F Imidan 50WP Lorsban 4E[d] *Penncap-M *Supracide 2E	½-1 pt. 2 lb. 2 pt. 2-3 pt. 2 pt.	On foliage	Refer to Circular 1136. Or when 25% 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. 2 pt. 2-3 pt.	On foliage	As a stubble spray.
Aphids	Cygon 400 *Furadan 4F Lorsban 4E[d] malathion 57%EC *Penncap-M *Supracide 2E	½ pt. ½ pt. 1 pt. 1½ pt. 2 pt. 2 pt.	On foliage	When aphids average 100 or more per sweep and lady beetle larvae and adults, parasites, and diseases are not abundant. Avoid treatments when plants are blooming.
Blister beetles	Sevin XLR	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.
Clover leaf weevil	malathion 57%EC	1½ pt.	On foliage	When larvae are numerous (5 or more per crown) and leaf feeding is noticeable, usually in early to mid-April.
Cutworms	Dylox 80SP Lorsban 4E[d] Sevin XLR	10-20 oz. 2 pt. 2-3 pt.	On foliage	As needed on regrowth.
Fall armyworm	Dylox 80SP Lorsban 4E[d]	20 oz. 2 pt.	On foliage	Usually in late summer or early fall on new seedlings or established stands.
Grasshoppers	Cygon 400 *Furadan 4F Lorsban 4E[d] *Penncap-M Sevin XLR	½-1 pt. ¼-½ pt. ½-1 pt. 1-3 pt. 2-3 pt.	On foliage	When grasshoppers are small and before damage is severe. The higher rates are suggested for control of adult grasshoppers. Avoid treatments when plants are blooming.
Leafhoppers	Cygon 400 Dylox 80SP *Furadan 4F Imidan 50WP Lorsban 4E[d] *Penncap-M Sevin XLR *Supracide 2E	½-1 pt. 10-20 oz. 1 pt. 2 lb. 1-2 pt. 2-3 pt. 2 pt. 2 pt.	On foliage	Treatment is justified at these combinations of alfalfa height and leafhopper numbers: Alfalfa height (inches) / Leafhoppers per sweep 0-3 / 0.2 3-6 / 0.5 6-12 / 1.0 12 or taller / 1.5 Avoid treatments when plants are blooming.
Plant bugs	Cygon 400 Dylox 80SP *Furadan 4F Lorsban 4E[d] *Penncap-M Sevin XLR	½-1 pt. 20 oz. 2 pt. 1-2 pt. 2-3 pt. 2 pt.	On foliage	When tip damage is obvious and nymphs and adults are numerous. Avoid treatments when plants are blooming.
Spittlebug	Imidan 50WP Lorsban 4E[d] malathion 57%EC *Penncap-M	2 lb. 1-2 pt. 1½ pt. 2-3 pt.	On foliage	When spittle masses are found and nymphs average more than 1 per stem. Avoid treatments when plants are blooming.

Table 7. Alfalfa and Clover (continued)

Insect	Insecticide[a,b,c]	Amount of product per acre[c]	Placement	Timing of application, comments
Webworms	Dylox 80SP	20 oz.	On foliage	If damage appears.
	Sevin XLR	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 pollination, 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. 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	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	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.
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	As needed. The higher rates are suggested for control of adult grasshoppers.
	Lorsban 4E[c]	½-1 pt.		
	Sevin XLR	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	Cygon 400	¼-½ 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.
	diazinon AG500	½ pt.		
	Lorsban 4E[c]	½ pt.		
	Sevin XLR	3 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	

Table 8. Grain Sorghum (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Webworms	Lorsban 4E[c] Sevin XLR	2 pt. 2-4 pt.	Over row	When 5 or more larvae per head are found.
Yellow sugarcane aphid	Cygon 400 *Furadan 15G Lorsban 4E[c]	1 pt. 8 oz. per 1,000 ft. row ½-1 pt.	Over row Band, Furrow at planting	Sprays should be applied at first sign of damage to seedling sorghum; 5 to 10 aphids per leaf.

* 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. Small Grains (Barley, Oats, Rye, Wheat)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworm	Dylox 80SP Lannate, Nudrin 90WSP *Penncap-M Sevin XLR	10-20 oz. ¼-½ lb. 2-3 pt. 2 pt.	On foliage	When there are 6 or more armyworms per linear foot of row and before extensive head cutting occurs. Do not use Dylox or Penncap-M on rye.
Cereal leaf beetle	*Furadan 4F *Lannate 90WSP malathion 57%EC Sevin XLR	1 pt. ¼-½ lb. 1½ pt. 2 pt.	On foliage	When there are one or more small larvae per stem or flag leaf. Apply Furadan before heads emerge from the boot.
Fall armyworm	Dylox 80SP	10-20 oz.	On foliage	During fall when damage to new growth is apparent. Do not use Dylox on rye.
Grasshoppers	Cygon 400 *Furadan 4F malathion 57%EC *Penncap-M Sevin XLR	¾ pt. ¼-½ pt. 1½ pt. 1-3 pt. 1-3 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.
Greenbug, English grain aphid, oat bird-cherry aphid	Cygon 400 Lannate 90WSP malathion 57%EC *Penncap-M	½-¾ pt. ¼-½ lb. 1½ pt. 1-2 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.
Variegated cutworm	Dylox 80SP	10-20 oz.	On foliage	As needed. Do not use Dylox on rye.
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. Grass Pasture

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworms	Dylox 80SP	20 oz.	On foliage	As needed. Sevin and Dylox may be applied without removal of grazing livestock.
	malathion 57%EC	2 pt.		
	*Penncap-M	2-3 pt.		
	Sevin XLR	2 pt.		Do not apply when weeds are blooming.
Grasshoppers	diazinon AG500	1 pt.	On foliage	As needed. The higher rates are suggested for control of adult grasshoppers.
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-3 pt.		
	Sevin XLR	1-3 pt.		Do not apply when weeds are blooming.

* 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. Noncrop Areas

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Grasshoppers	diazinon AG500	1 pt.	On foliage	When grasshopper nymphs average 15 to 20 per square yard along roadsides and fence rows. The higher rates are suggested for control of adult grasshoppers. Do not spray areas adjacent to water or where runoff is likely to occur. Apply treatments while hoppers are small and before they migrate into row crops.
	malathion 57%EC	1½ pt.		
	*Penncap-M	1-3 pt.		
	*Pydrin 2.4EC	2⅔-5⅓ oz.		
	Sevin XLR	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. Sunflowers

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
Armyworm	Sevin XLR	3-4 pt.	Over row	When defoliation reaches 25%.
Cutworms	Sevin XLR	3 pt.	Over row	When 10% of the seedlings are damaged.
	Lorsban 4E	2-3 pt.		
Fall armyworm	Sevin XLR	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	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.		
Stem weevil	*Furadan 4F	1 pt.	Over row	When there are 2 or more beetles per plant.
	Lorsban 4E	1-1½ pt.		
	Sevin XLR	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	2-4 pt.		

Table 12. Sunflowers (continued)

Insect	Insecticide[a,b]	Amount of product per acre[b]	Placement	Timing of application, comments
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.		
	*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. 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)

	Field corn		Grain	Forage crops		
	Grain	Ensilage	Sorghum	Alfalfa	Clover	Pasture
*Aastar G (phorate + flucythrinate)	A	60	...	...	...	...
*Ambush 2E (permethrin)[a,b]	B	B	...	...	...	...
Broot 15GX (trimethacarb)	90	90	...	...	...	...
*Counter 15G (terbufos)	A	30,C	D	...	...	...
Cygon 400 (dimethoate)[b]	14,E	14,E	28,E	10,F	...	...
Diazinon AG500	A	A	7	10	10	0
Dipel (*Bacillus thuringiensis*)	A	A	...	...	...	...
*Dyfonate 20G, 4E (fonofos)[a,b]	30	30	...	...	...	...
Dylox 80SP (trichlorfon)	G	G	...	0,G	0,G	0,G
Ethion[a,b]	50,H	50,H	...	...	...	...
*Furadan 15G, 4F (carbofuran)[a,b]	30,I,J	30,I,J	75	K	...	...
Imidan 50WP (phosmet)	14	14	...	7,F	...	...
Lannate 90WSP (methomyl)[a,b]	A	3	14	...	...	...
Lorsban 15G, 4E (chlorpyrifos)	35,L	14,L	60,M	21,N	...	...
Malathion57% EC	5	5	7	0	0	0
*Mocap 15G (ethoprop)	A	A	...	...	...	...
Nudrin 90WSP (methomyl)[a,b]	A	0	14	0	...	...
*Pay-Off 2.5EC (flucythrinate)[a,b]	28,P	28,P	...	...	...	...
*Penncap-M (microencapsulated methyl parathion)[a,b]	12	12	...	15	...	15
*Pounce 3.2EC (permethrin)[a,b]	B	B	...	...	...	...
*Pydrin 2.4EC (fenvalerate)[a,b]	21,Q	21,Q	...	...	...	...
Sevin XLR (carbaryl)	0	0	21	3	0	0
*Supracide 2E (methidathion)[a,b]	...	...	...	10,R	...	...
*Thimet 20G (phorate)	30,S	30,S	...	...	...	...

	Barley	Oats	Rye	Wheat	Soybeans	Sunflowers
*Ambush 2E (permethrin)[a,b]	...	...	...	...	60,T	...
Cygon 400 (dimethoate)[b]	...	...	...	60	21	...
Dipel, Thuricide, Bactur, SOK (*Bacillus thuringiensis*)	...	...	...	...	0	...
Dylox 80SP (trichlorfon)	21	21	...	21	...	...
*Furadan 15G, 4F (carbofuran)[a,b]	U	U	...	U	21,V	28,W
Lannate 90WSP (methomyl)[a,b]	7	7	7	7	14	...
Larvin 3.2F (thiodicarb)	...	...	...	...	28,X	...
Lorsban 15G, 4E (chlorpyrifos)	...	...	...	...	28,Y	42,Z
Malathion 57% EC	7	7	7	7	0	...
Nudrin 90WSP (methomyl)[a,b]	7	7	7	7	14	...
Orthene 75S (acephate)	...	...	...	...	14,X	...

Table 13. Limitations (continued)

	Barley	Oats	Rye	Wheat	Soybeans	Sunflowers
*Penncap-M (microencapsulated methyl parathion)[a,b]	15	15	...	15	20,AA	...
*Pounce 3.2EC (permethrin)[a,b]	...	...	...	...	60,T	...
*Pydrin 2.4EC (fenvalerate)[a,b]	...	...	...	...	21,BB	28,BB
Sevin XLR (carbaryl)	...	...	...	21	0	60
*Supracide 2E (methidathion)[a,b]	...	...	...	..	...	50,X

Read the label for more detailed information.

A. No specific restriction when used as recommended.

B. Apply prior to the brown silk stage.

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

D. Only one application per year may be used.

E. Make no more than 3 applications per year. Do not apply to sorghum after heading.

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

G. 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.

H. Do not make more than 1 application after ear formation. Do not feed treated foliage to livestock.

I. 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.

J. Do not make more than 2 applications of Furadan 4F per season at the 1½-2 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.

K. 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.

L. 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.

M. 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.

N. Do not apply more than once per cutting. Do not cut or graze treated alfalfa within 14 days after application of 1 pint of Lorsban 4E per acre, nor within 21 days after application of rates above 1 pint per acre. Do not make more than 4 applications per year.

P. Do not apply by air. Do not make more than 2 applications per season.

Q. Do not exceed 1.0 pound of active ingredient per acre per season.

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

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

T. Do not graze or feed soybean forage or hay. Ambush: Do not apply more than 0.4 lbs. a.i. per acre per season. Pounce: Do not make more than 2 applications per season.

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

V. Do not use Furadan 4F as a foliar application if Furadan 10G, Furadan 15G, 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.

W. No more than 4 applications per season.

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

Y. 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.

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

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

BB. 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
Broot	C	trimethacarb	moderate	low	. . .	. . .	. . .
*Counter	OP	terbufos	high	high	high	very high	. . .
Cygon	OP	dimethoate	moderate	moderate	moderate	very low	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	moderate	. . .	. . .
Dylox	OP	trichlorfon	low	low	low	very low	low
Ethion	OP	ethion	high	high	low	. . .	very low
*Furadan	C	carbofuran	high	moderate	moderate	moderate	high
Imidan	OP	phosmet	moderate	low	low	. . .	high
**Lannate, **Nudrin	C	methomyl	high	moderate	low	. . .	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
*Methyl parathion	OP	methyl parathion	high	high	moderate	very low	high
*Mocap	OP	ethoprop	moderate	high	moderate	. . .	moderate
Orthene	OP	acephate	moderate	moderate	moderate	low	high
*Pay-Off	P	flucythrinate	moderate	low	low	very high	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.
** Liquid formulations are restricted.
[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*
Ambush 2E	Wait until spray is dry.
Broot 15G	After dust has settled in treated field.
Counter 15G	Do not enter treated area without protective clothing until treatments have been completed.
Cygon 400	Wait four days, unless protective clothing is worn.
Diazinon AG500	After spray is dry.
Dyfonate 4EC	After spray is dry.

Insecticide	*Reentry statement on lable*
Dyfonate 20G	After dust has settled in treated field.
Ethion EC	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.
Imidian	After spray has dried.
Lannate 90SP, 1.8L	After spray has dried.
Larvin 3.2	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 90SP, 1.8L	After spray has dried.
Orthene 75SP	After spray has dried.
Penncap-M	After spray has dried.
Pounce 3.2EC	After spray has dried.
Pydrin 2.4EC	After spray has dried.
Sevin XLR Plus	After spray has dried.
Supracide	Wait 48 hours.
Thimet 20G	Do not enter treated areas until soil treatment is completed; 7 days for foliar application.

INFORMATION

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 $.15 each.

Insect Pest Management Guides

Other insect pest management guides available are Circular 897, *1987 Insect Pest Management Guide: Commercial Vegetable Crops and Greenhouse Vegetables;* Circular 898, *1987 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 for $4 from the Office of Agricultural Publications, 54 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois, 61801; telephone (217)333-2007. Checks should be made payable to the University of Illinois.

Spray School Proceedings

The proceedings of the Illinois Agricultural Pesticides Conference '87 (Spray School) are available from Extension Entomology (see address and telephone above). 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. The cost for a copy of the proceedings is $4. Make checks payable to the University of Illinois.

Insect, Weed, and Plant Disease Survey Bulletin

The *Insect, Weed, and Plant Disease Survey Bulletin* is issued weekly from April through August. This series of bulletins 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. The subscription rate is $11 per year.



1987 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. 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. The Illinois Department of Agriculture administers the certification procedure for private applicators. *Commercial* applicators also 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.

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

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 1242 November 1986
Prepared by Richard A. Weinzierl, Extension Entomologist

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. 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 only 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 do 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. 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. New labeling requires the use 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 illigal. 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; 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 a grain spreader to evenly distribute remaining fine material and to help level the grain surface. Once the bin is full, if fine material is concentrated in a central core beneath the auger spout, remove 1 or 2 loads from the bin in order to 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 8 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 between May 1 and September 30 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 most 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

Summer-harvested grains that are to be stored 1 month or more and fall-harvested grains that are to remain in storage beyond May and June of the year following harvest should be treated with a protectant insecticide. 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. Table 1 summarizes uses for registered grain protectants. Dichlorvos resin strips, although not applied directly to grain, also are listed in Table 1.

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

Corn. 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

Table 1. Insecticides Registered For Use to Protect Stored Grain

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.
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 1-5 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.
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 4-6 inches of grain as it is augered into the bin or incorporate by raking once the bin is filled.
pirimiphos-methyl (Actellic 5E)	corn, sorghum	8.6 to 11.5 fl oz/1,000 bu.	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.
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.
dichlorvos 20% resin strip (Farm Strips, Vapona Strips, etc.)	corn, soybeans, wheat, oats, rye, barley, sorghum, sunflower	1 strip/1,000 cu ft of space above the grain mass.	Install once bin is filled or by May 15. Replace every 6-8 weeks from May to October. Effective only in closed bins; controls adult moths only.

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. Use *Bacillus thuringiensis* (*B.t.*) or dichlorvos resin strips to prevent Indianmeal moth infestations. Apply *B.t.* or hang dichlorvos strips at harvest or by May of the following year.

Soybeans. Only Indianmeal moth will infest soybeans stored at moisture levels that prevent mold growth. To protect against Indianmeal moth infestation, use dichlorvos resin strips or *B.t.* at harvest 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 mid-summer 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 4-6 inches of grain or hang dichlorvos resin strips to prevent Indianmeal moth infestations. Reldan controls Indianmeal moth and the weevils and "secondary" beetles that infest grain.

Sorghum. 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 use *B.t.* or dichlorvos strips at harvest or by May to control Indianmeal moth.

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. 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	• More than 1 live weevil, or • One live weevil plus any other stored grain insect pest, or • No live weevils, but 5 or more other live pest insects.
Corn, Barley, Oats, Sorghum, and Mixed Grains	• More than 1 live weevil, or • One live weevil plus 5 or more other live pest insects, or • No live weevils, but 15 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 dockage 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 both *B.t.* and dichlorvos resin strips or Actellic or Reldan as outlined in Table 1. Unincorporated surface treatments of 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 re-infestation 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

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 eaves, hatches, side door, unloading auger shaft, and fan openings. Leave only the necessary access openings to seal after fumigant application.

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.

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. Gas released from pellets or tablets usually does not reach a dangerous concentration above the grain for 1 to 2 hours after application, but this period can be much shorter if grain is very warm or very moist.

6. 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.

An additional fumigant that is effective and registered for application to stored grain is methyl bromide. Because methyl bromide is a restricted-use fumigant that is applied as a gas, it is available only to professional fumigators.

Once it is aired out, fumigated grain is subject to reinfestation. Surface application of a protectant insecticide and/or placement of dichlorvos resin strips should follow fumigation if storage is to continue.

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



1987 Insect Pest Management Guide

LIVESTOCK and LIVESTOCK BUILDINGS

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 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 publications available from the Office of Agricultural Publications (47 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801) include Circular 899, *1987 Insect Pest Management Guide: Field and Forage Crops;* Circular 900, *1987 Insect Pest Management Guide: Home, Yard, and Garden;* Circular 925, *Insect Pests of Cattle;* Circular 897, *1987 Insect Pest Management Guide: Commercial Vegtetable Crops and Greenhouse Vegetables;* 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.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 898 (revised annually) October 1986
Prepared by Richard A. Weinzierl, Extension Entomologist

- 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.

Beef Cattle and Nonlactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
LICE, cont.	Spray	Apply sufficient spray to thoroughly wet each animal. Use up to 1 gallon finished spray per animal. Do not contaminate feed or water.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	2 gal/100 gal water.	0 days. Make a second application 10-14 days after first. Repeat as necessary but not more often then every 7 days. Do not treat Brahman cattle.
		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.
		Ravap 28.7% EC (stirofos plus dichlorvos)	1 gal/75 gal water.	0 days. Beef cattle only. Do not treat more often than once every 10 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.
		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.

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
CATTLE GRUBS Larvae ("grubs") bore through the skin and migrate within the host to the skin of the back. Grubs ruin hides and reduce weight gain. 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. Treat only pastured cattle in herds 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.
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.			

Beef Cattle and Nonlactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
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 thorougly wet each animal; use up to 1 gallon finished spray per animal. Do not contaminate feed or water.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	2 gal/100 gal water.	0 days. Repeat application 10-14 days after first spray. Do not use more than once every 7 days.
		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.
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.			
	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.)		
		Vapona 23.4% EC (dichlorvos)	1 qt/6 gal water. Mist 1-2 fl oz/ animal/day.	1 day. Do not contaminate feed or water. Do not wet skin. Do not apply in conjunction with trichlorfon.
		pyrethrin (0.1%) plus synergist	Mist 1-2 fl oz/ animal.	0 days. Do not contaminate feed or water. Do not wet skin. Repeat as necessary.
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. Annoyance to cattle reduces feeding. Face flies also transmit pinkeye. Face flies do not attack cattle in barns or sheds. **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.	Moving cattle into barns or sheds will reduce attacks by horn flies and face flies.			
	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, but only partial control of face flies is provided by these devices. Oilers do not control stable flies.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 qt/4 gal fuel or mineral oil.	0 days.
		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 of 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.
		Ravap 28.7% EC (stirofos plus dichlorvos)	1 qt/7 gal fuel or mineral oil.	0 days. Beef cattle only.
	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 manure. Stable flies do not develop in fresh manure and are not controlled by feed additives. Face flies migrate considerable distances, so larval control in manure of a single herd will not significantly reduce fly populations if other herds in the area do not also receive 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.
		phenothiazine 17.8%	Mix 1:3 with salt. Use 1 lb mixture/10 head/day.	0 days. Feed no other salt. Use 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.
	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. Mid-season 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.		

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES, cont.	Ear tag or ear tape, cont.	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 (crotoxyphos, dichlorvos, coumaphos, dioxathion, or stirofos) or a chlorinated hydrocarbon (methoxychlor) on a regular basis, even in herds treated with pyrethroid tags. Use these treatments as least once before tagging and again after tags have been removed in September and October. Organophosphate ear tags (Rabon tags) provide another alternative to pyrethroids, but combination tags containing a pyrethroid plus chlorpyrifos (Dursban) have not been shown to delay resistance development or control pyrethroid-resistant 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% tag (Ectrin, Insecta-Shield, Ear Tag Plus, Starbar, Vet Shack)	1-2 tags per head.	0 days. Apply when fly activity begins in spring; remove in fall or before slaughter.
		flucythrinate 7.5% tag (Guardian)	1-2 tags per head.	0 days. Apply when fly activity begins in spring; remove in fall or before slaughter.
		permethrin 10% tag (Atroban, Apollo, Insecta-Gard, Gard Star, Fearing Du-flex, Gen-Sal, Permectrin)	1-2 tags per head.	0 days. Apply when fly activity begins in spring; remove in fall or before slaughter.
		permethrin 0.9 g tape (Ectiban)	1 tape per animal.	0 days. Apply when fly activity begins in spring; remove in fall or before slaughter.
		stirofos 13.7% tag (Rabon)	1-2 tags per head.	0 days. Apply when fly activity begins in spring; 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.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 pint/1.5 gal water. Use 1-2 fl oz mist/animal/day. *OR:* 2 gal/50 gal water. Use 1-2 qt/animal.	0 days. 0 days. Repeat as needed, but not more often than once every 7 days.
		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.		
		Ectrin 10% WDL (fenvalerate)	8 oz/2½ gal water. Mist 2-3 fl oz/animal every 4-7 days. Or mix 8 oz/12 gal water. Use 1 qt/animal every 7 days.	0 days. State-labeled use; applicator must have label in possession.
		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.
		Ravap 28.7% EC (stirofos plus dichlorvos)	1 gal/75 gal water. Use ½ to 1 gal/animal.	0 days. Beef cattle only. Repeat as needed, but not more often than once every 10 days.

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.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 qt/12 gal water.	0 days. Make a second application 10-14 days after first. Repeat as needed, but not more than once every 7 days.
		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.)		
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 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 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	Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 qt/12 gal water. Use up to 1 gal/animal.	0 days. Make a second application 10-14 days after first. Do not apply more often than once every 7 days.
		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.		
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.			
	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.)		
		Vapona 23.4% EC (dichlorvos)	1 qt/6 gal water. Mist 1-2 fl oz/animal/day.	1 day. Do not wet skin. Do not contaminate feed, water, milk, or milking equipment.
		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. Annoyance to cattle reduces feeding. Face flies also transmit pinkeye. Face flies do not attack cattle in barns or sheds. **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.	Reduce attacks by horn flies, face flies, deer flies, and horse flies by moving cattle into barns or sheds.			
	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. The will not control stable flies.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 gal/16 gal fuel or mineral oil.	0 days.
		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.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 qt/3 gal water. Mist 1-2 fl oz/ animal/day.	0 days.
		Ectiban 5.7% EC (permethrin)	1 qt/25 gal water. Use 1-2 qt/animal.	0 days. Retreat 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.)		
		Ectrin 10% WDL (fenvalerate)	8 oz/2½ gal water; mist 2-3 oz/animal every 4-7 days. *OR:* 8 oz/12 gal water; use 1 qt/animal every 7 days.	0 days. State-labeled use; applicator must have label in possession.

Lactating Dairy Cattle, continued

Pest	Treatment method	Insecticide and formulation	Dilution and rate	Preslaughter interval, restrictions, comments
PASTURE FLIES, cont.	Spray, cont.	Vapona 23.4% EC or 1% EC oil base (dichlorvos)	1 qt 23.4%/6 gal water; use 1-2 fl oz/animal/day. *OR:* 1% EC (oil base), ready to use; mist 1-2 fl oz/animal/day.	0 days. Do not wet skin.
		pyrethrin (0.1%) plus synergist	Ready to use. Apply 1-2 fl oz/animal.	0 days. Repeat as needed.
	Feed additive	Animals must consume the recommended dosage for the feed additive to be effective. A feed additive reduces fly development only in treated manure; it does not control existing adult flies. Increase control by practicing good sanitation; remove nearby manure, silage, feed, and other fly-breeding materials.		
		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.
	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. Mid-season 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. 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 (crotoxyphos, dichlorvos, coumaphos, dioxathion, or stirofos) or a chlorinated hydrocarbon (methoxychlor) on a regular basis, even in herds treated with pyrethroid tags. Use these treatments at least once before tragging and again after tags have been removed in September or October. Organophosphate ear tags (Rabon tags) provide another alternative to pyrethroids, but combination tags containing a pyrethroid plus chlorpyrifos (Dursban) have not been shown to delay resistance development or control pyrethroid-resistant 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. Apply tags when flies first appear in the spring. Remove in fall or before slaughter.
		flucythrinate 7.5% tag (Guardian)	1-2 tags per head.	0 days. Apply when fly activity begins in spring; remove in fall or before slaughter.
		permethrin 10% ear tag (Atroban, Apollo, Insecta-Gard, Gard Star, Fearing, Permectrin, Wellcome Tag)	1-2 tags per head.	0 days. Apply tags when flies first appear in spring. Remove in fall or before slaughter.
		permethrin 0.9 g ear tape (Ectiban)	1 tape per animal.	0 days. Apply tape when flies first emerge in spring. Remove in fall or before slaughter.
		stirofos 13.7% tag (Rabon)	1-2 tags per head.	0 days. Apply when fly activity begins in spring. 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. **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.	Sarcoptic mange can be controlled effectively with the insecticides listed below. Although these insecticides will aid in controlling demodectic mange, there is no satisfactory chemical control for the hog follicle mites that cause demodectic mange. Prevent sarcoptic mange outbreaks by treating pigs as soon as possible after weaning; treat sows 30-45 days before farrowing; treat boars before the breeding season. Follow label precautions against the use of organophosphate sprays, dusts, or pour-ons simultaneously with medications used for internal parasite control. Do not contaminate feed or water. Isolate hogs with demodectic mange. Kill and destroy severely infested animals; market for slaughter the animals that are less severely attacked. Clean and disinfect pens, sheds, etc., before moving in uninfested animals.			
	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.
	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 suck blood and cause irritation and itching of skin. Animals may rub infested areas and cause bleeding. Infested animals appear generally unthrifty.	Insecticides listed for controlling mange mites on hogs will also control lice. Do not contaminate feed or water. Follow label precautions against the use of organophosphate sprays, dusts, or pour-ons simultaneously 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 retreat 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 retreat 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.		
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	2 gal/100 gal water. Use up to 1 gal/animal.	0 days. Make second application 10-14 days later. Do not retreat within 7 days.
		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.
	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)	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.
FACE FLIES (NHE 106)	Spray	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	Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	2 gal/100 gal water. Use 2-4 qt/animal.	0 days. Make second application 14 days after first. Do not apply more often than every 7 days. Do not contaminate feed, water, milk, or milking equipment.
		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)	Spray	Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	1 qt/3 gal. water. Use 1 pt/animal/ week.	0 days. Do not apply more often than every 7 days. Do not contaminate feed, water, milk, or milking equipment.
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.		Ravap 28.7% EC Poultry Spray and Larvicide (stirofos + dichlorvos)	1 pt/6 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.
		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 very 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.

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.
		Ravap 28.7% EC Poultry Spray and Larvicide (stirofos + dichlorvos)	1 pt/6 gal water. Use 1-2 gal/1,000 sq ft.	0 days. Apply thoroughly to litter, walls, roosts, cracks, and crevices.
		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. They are ingested and survive long enough to bite and damage the alimentary canal.	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.
		Horse Wormer (dichlorvos)	19.5 g/300 lb body weight mixed with feed. Give to individual horse in half its normal grain ration.	Nonfood use. Treat 30 days after killing frost. Withhold water 4-6 hours before and 3 hours after consumption of the medicine. Do not treat sick animals or animals that have received tranquilizing drugs or other worm medicines within 1 week of application.
	Oral paste	Eqvalan 1.87% (ivermectin)	Ready to use. Follow directions on prefilled syringe.	Nonfood use.
	Injection	Consult with a veterinarian for treatment with carbon disulfide, dichlorvos (Equigard), 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. Retreat 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 practices are almost always necessary for 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 fly development. 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.

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 repeat applications of the same insecticide for an entire season. Alternate applications of pyrethroids (permethrin products) and organophosphates (naled, dichlorvos). 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.
		Vapona 23.4% EC (dichlorvos)	*Misting:* 1 pt/6 gal water; use 1 qt/8,000 cu ft. *Fogging:* 1 pt/3.5 gal diesel oil; use 1 pt/8,000 cu ft.	0 days.
		Vapona Feedlot 43.2% EC (dichlorvos)	1 gal/100 gal water. Use 5 gal/acre.	0 days. For cattle feedlots only.
	Surface residual spray	To minimize control failures caused by insecticide resistance, do not repeat applications of the same insecticide for an entire season. Alternate applications of pyrethroids (permethrin, fenvalerate) and organophosphates (fenthion, crotoxyphos, dichlorvos, 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 run-off. 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.
		Ciovap 12.5% EC (crotoxyphos plus dichlorvos)	2 gal/25 gal water. Use 1 gal/500 sq ft.	0 days. Do not use in poultry houses. Residue persists 1 week.
		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.

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.
		Vapona 0.5% Dry Bait (dichlorvos)	4 oz/1,000 sq ft.	0 days.
	Resin strip	Farm Strip 20% resin strip (dichlorvos)	Suspend 1 strip/ 1,000 cu ft.	0 days. Close doors and windows so that vapor concentrations reach recommended levels. Do not hang near light bulbs or within reach of animals.
	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.
		Ravap 28.7% EC (stirofos plus dichlorvos)	1 gal/25 gal water. Use 1 gal/100 sq ft manure.	0 days.
		Vapona 23.4% EC (dichlorvos)	1 gal/25 gal water. Use 1-2 qt/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.

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. For biological control programs to effectively manage flies around livestock facilities, frequent and thorough sanitation practices (including manure removal, water management, and weed control) must be practiced. 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. Dichlorvos resin strips will give excellent control if windows and doors are kept closed when one strip per 1,000 cubic feet of space is used. Replace strips when they become ineffective. 5. Use a mist or aerosol spray of 0.06-0.1% pyrethrin plus piperonyl butoxide oil-based fly sprays in the milkroom when resin strips 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 bee-like 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 appy 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.



1987 Insect Pest Management Guide

COMMERCIAL VEGETABLE CROPS AND GREENHOUSE VEGETABLES

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 control insects at maximum efficiency and minimum cost. The housewife of today will not accept unsightly wormy vegetables; not only are wormy fruits and vegetables unappetizing but the waste from trimming increases food costs. Thus the commercial vegetable gardener must produce a quality product that is acceptable and safe to the consumer. Careful use of the right insecticides will enable him to do this.

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 gardener 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, read the label and carefully follow the instructions. Do not exceed maximum rates suggested; observe carefully the interval between application and harvest, and apply 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, his workers, and his family 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 the label for instuctions as to the interval required between application and feeding.

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

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

Requested label clearances for a few uses of insecticides, carriers, and solvents are uncertain for 1987, since many requests have not been officially cleared. Anticipating needed changes in labeling, we began modifying these suggested uses a few years ago.

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.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. A person wishing 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 1986

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	..
*azinphosmethyl (Guthion)	..	...	15	7	21	15	..	..	....	....	..	..	..
Bacillus thuringiensis[2]	..	...	0	0	0	0	..	..	....	....	..	..	0
carbaryl (Sevin)	0	...	3	3	3	3	3	3	3, 14A	....	0	0	0
*carbofuran (Furadan)	..	...	..	..	..	..	..	..	....	....	..	21B	..
chlorpyrifos (Lorsban)	..	...	C	C	C	C	..	C	....	C, D	..	..	..
diazinon	..	...	5	..	7	5	..	10	10	10	..	..	1
dimethoate (Cygon)	0E	0E	7	..	3	7	..	..	14	....	..	0	7
*fonofos (Dyfonate)	..	...	C	..	C	C	..	..	....	C, D	..	..	..
*ethion	..	...	..	..	..	..	..	..	....	C	..	..	..
*fenvalerate (Pydrin)[3]	..	3E,N	3	..	3	3	..	..	....	....	..	..	1K
malathion	1	...	3	7	7	7	7	7	3	3	3	3	1
*methomyl (Lannate, Nudrin)	1	1, 5A	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)	..	...	1H	1H	1H	1H	22	..	....	....	..	..	..
*phorate (Thimet)	C	...	..	..	..	..	..	..	....	....	..	..	..
rotenone	..	...	..	..	..	..	..	..	....	....	1	1	1
trichlorfon (Dylox)	..	...	..	21	21	21	..	..	28E	....	..	21	21

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

* 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.

A. If tops or stover are to be used for feed.
B. Not more than twice per season.
C. Soil applications at planting time only.
D. Do not use on green onion crop.
E. Do not use tops for feed or food.
F. Not more than 3 times per season.
G. Not after edible portions or heads begin to form.
H. Not more than 8 times per season.
I. Crops other than corn and soybeans may be planted 10 months after application.
J. Not more than once per season.
K. Do not exceed 2 lb. a.i. per acre.
L. Not more than 4 applications per season.
M. Not more than 6 applications per season.
N. Do not exceed 0.4 lb. a.i. per acre.

REENTRY INTERVALS FOR WORKER PROTECTION

Insecticide	Hours
azinphosmethyl (Guthion)	24
demeton (Systox)	48
ethion	24
parathion	48

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.

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.
		*Guthion	3 oz. W.P. or 2 oz. E.C. per 50 gal. transplant water	Furrow	6 fluid oz. transplant water per plant.
		diazinon	4 oz. per 50 gal. transplant water		
		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	*Guthion	¾	Foliage	When aphids appear, but before leaves begin to curl.
		Cygon	0.3		
		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		
		*Lannate, Nudrin	0.45-0.9		
		*Monitor	1		
		*Ambush, Pounce	0.1-0.2		
Cutworms	At planting	*Pydrin	0.1-0.2	Base of plants	As needed.
		Dylox	1		
Flea beetles and leafhoppers	All season	Sevin	1½	Foliage	As needed.
		*Pydrin	0.1-0.2		

E.C. = Emulsion concentrate; W.P. = 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.
		rotenone	¼		

* Use restricted to certified applicators only.

[1] Do not use on spinach or Swiss chard.
[2] Use limited to lettuce and spinach 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	Sevin[1]	2-3	Base of plants	When first damage appears.
		Lorsban 4E	1½	Broadcast	
Flea beetles (NHE-36)	April-July	Sevin[1]	1½	Foliage	As necessary.
		*Furadan G	1	Furrow	
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		
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.

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]	1½	Spears and ferns	As needed, not more often than every 3 days.
		malathion[1]	1		
		rotenone[1]	0.2-0.4	Spears	As needed.

[1] One-day restriction between last application and harvest.

PEAS

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

* Use restricted to certified applicators 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 *Pydrin Dylox	2 0.1-0.2 1	Base of plants or foliage	As needed.
Flea beetles	May-June	Sevin rotenone	2 0.2-0.4	Foliage	Apply every week as long as needed.
Aphids (NHE-47)	May-July	diazinon Cygon[1] malathion	½ 0.3 1	Foliage	As needed, but before leaves curl.
Cabbage loopers	July-September	*Bacillus thuringiensis* *Pydrin *Lannate, Nudrin	See rates on label 0.1-0.2 0.45-0.9	Foliage	When loopers are present.
Corn earworms Corn borers Hornworms	July-September	Sevin *Pydrin *Lannate, Nudrin	2 0.1-0.2 0.45-0.9	Foliage	Add to weekly applications of fungicide sprays beginning at first fruit set when first small worms appear.
Mites	July-September	Cygon[1]	0.3	Foliage	As needed.
Russet mites	July-September	sulfur dust[2] sulfur spray[2]	10 10	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. [2] No limitations on use.

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	*Pydrin malathion Cygon[2] *Ambush, Pounce[4]	0.1-0.2 1 0.3 0.1-0.2	Foliage	As needed.
Squash vine borers	June-September	Sevin *Pydrin	1 0.1-0.2	Base of stem for 3 ft.	Weekly applications when vines begin to run—usually 5 applications.
Pickle worms	August-September	Sevin *Pydrin	1 0.1-0.2	Foliage	Weekly applications, beginning in late August.
Mites	July-September	Cygon	0.3	Foliage	As needed.
Cutworms (NHE-77)	April-June	Sevin *Pydrin *Ambush, Pounce[4]	2 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.

BEANS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Seed maggots (NHE-27)	All season	diazinon 50% W.P.[1]	3/5 oz./bu.	Seed	Treat seed no longer than 3 months before planting.
		Lorsban 25% W.P.[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	Foilage	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 drouthy 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.

ONIONS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Onion maggots (NHE-50)	All season	diazinon W.P.	½-1 for 40-50 lb. of seed	Seed	Seed treatment for set onions only. Use lighter dosage of diazinon on sandy, highly mineral soils.
		*ethion W.P.	1 for 40-50 lb. of seed		
		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 *Guthion	½ 1 ½	Foliage	When injury first appears and every 10 days as necessary.

* 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.
		*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.
		*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 fence rows, roadsides, ditch banks, etc., before migration.
		Cygon	0.3		

* 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.

* Use restricted to certified applicators only.

FOR ADDITIONAL INFORMATION

Obtain the following circulars on insect control from the Office of Agricultural Publications, University of Illinois, 47 Mumford Hall, 1301 W. Gregory Drive, Urbana, Illinois 61801.

Circular 899, 1987 Insect Pest Management Guide — Field and Forage Crops

Circular 900, 1987 Insect Pest Management Guide — Home, Yard, and Garden

Circular 1076, 1987 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.

FOR YOUR PROTECTION

Always handle insecticides with respect. The persons most likely to suffer ill effects from insecticides are the applicator and his 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; store preferably in a locked cabinet.
6. Triple-rinse and bury or burn all empty insecticide containers or take 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 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.*

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. WILLIAM R. OSCHWALD, *Director,* Cooperative Extension Service, University of Illinois at Urbana-Champaign. The Illinois Coopeative Extension Service provides equal opportunities in programs and employment. 10-86—65648—esl

1987 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 nurseryman; 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 is 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.

This circular was prepared by Roscoe Randell and Fredric Miller, Extension entomologists, Malcolm Shurtleff, Extension plant pathologist, John Fech, Dave Williams, and Thomas Fermanian, Extension horticulturists.

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.

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 Circular 900, *1987 Insect Pest Management Guide: Home, Yard, and Garden; Circular 1260, 1987 Plant Disease Control Guide: Woody Ornamentals,* and *1987 Chemical Weed Control.*

The *Report on Plant Disease* (RPD) series, numbers 600 to 654, are available from Extension Plant Pathology, N-533 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801. The cost of each RPD is 25 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	Zineb, 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 per sq ft or work into upper 2 to 4 inches of soil before planting. Check labels for crop registrations.
	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) or other fungicide.
Leaf, stem, and flower spots and blights caused by fungi	Benomyl + captan, zineb, maneb, mancozeb, ferbam, folpet (Phaltan), chlorothalonil (Daconil 2787, Exotherm Termil), Zyban, Duosan, vinclozolin Ornalin), triforine (Funginex), iprodione (Chipco 26019), or triadimefon (Bayleton)	Benomyl plus captan, zineb, folpet, 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.

Diseases	Chemicals for control	Remarks
Rusts	Zineb, maneb, mancozeb, ferbam, oxycarboxin (Plantvax), triadimefon (Bayleton), bitertanol (Baycor), or triforine (Funginex)	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), cycloheximide (Acti-dione PM), 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 (most *Fusarium* and *Verticillium* Crown and root rots Crown gall	Steam at 180°F for 30 minutes or 160°F for 1 hour 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. Galltrol-A and Norbac 84-C are crown gall controls. See label for Vydate uses.
Soil nematodes (including root-knot and root-lesion nematodes)	Same as wilt diseases (above) or apply 1,3-D (D-D) or oxamyl (Vydate).	
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.

1987 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 appplied 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* if 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. 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 below.

PREEMERGENCE HERBICIDES

Alachlor (*Lasso*)* is available in emulsifiable concentrate and granular formulations. It is labeled for use on a limited number of woody plant species. Apply at 4 pounds active ingredient per acre (aia) 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 aia and irrigate after application. Bensulide can be used in established flower beds and carpet bugle, ivy, pachysandra, and sedum groundcovers.

Chloramben (*Ornamental Weeder, Amiben, Garden Weeder, Weedone*)* is used for control of a number of annual broadleaf and grass weeds. Apply at 4 pounds aia to weed-free soil and irrigate following application. Chloramben is registered for use in established flower beds. Vegiben* is another formulation registered for several vegetable crops.

Chlorpropham (*Furloe, Chloro-IPC, CIPC*)* is available in emulsifiable and granular formulations. The granular formulation is commonly used in ornamenals. Apply at 4 pounds aia on sandy soil and 6 pounds aia 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 aia to a weed-free area primarily for the control of annual grasses. DCPA has a very extensive list of establishd 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 may be necessary.

Dichlobenil (*Barrier, Casoron, Dyclomec, Norosac*)* is available in wettable powder and granular formulations. Apply at 4 to 6 pounds aia 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.

Diphenamid (*Enide*)* is recommended for annual weed control in flower beds and planting of woody ornamentals. Apply at 8 pounds aia to sandy soils and 12 pounds aia 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.

EPTC (*Eptam*)* is available in emulsifiable concentrate and granular formulations. Apply at 5 pounds aia for control of annual weeds and suppression of certain perennial weeds such as nutsedge and quackgrass. Incorporation is necessary for good control.

Metolachlor (*Dual*)* 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 aia will last for one growing season.

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*Trade name.

Napropamide (*Devrinol*)* is available in 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 aia 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.

Oxyfluorfen (*Goal*)* 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.

Oxidiazon (*Ronstar or Scott's Pro Grow Herbicide I*)* is used in new and establishd plantings of groundcovers and woody ornamental plants. Apply at 4 pounds aia. 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 aia 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 aia 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.

Trifluralin (*Treflan or Preen*)* is available in emulsifiable concentrate and granular formulations. Apply at 1 pound aia 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 aia. Dalapon will provide excellent control of cattails if applied when the plants are small.

Fluaziflop-butyl (*Fusilade 2000*)* 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

*Trade name.

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.

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 aia.

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 preemergnce 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.

*Trade name.

Preemergence herbicides recommended for use in herbaceous plantings are bensulide, chloramben, chlorpropham, DCPA, diphenamid, napropamide, and trifluralin. Other herbicides may be labeled for use, but the above-mentioned 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 + surflan, simazine + DCPA, or oxidiazon + chlorpropham.

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. 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.

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	OH 1	OH 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	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		F	
Forsythia intermedia			F		F	X	F		X	F	Y		F			X				X	F	F		F			
Fraxinus spp.					F		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 calleryana '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
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

1987 INSECT PEST MANAGEMENT GUIDE FOR COMMERCIAL APPLICATORS FOR TREES AND SHRUBS

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	
	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	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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.
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 (NHE-80, 81)	malathion 50-57%E, 25W	1	Apply in late September or in early spring just before the the buds well.
	diazinon 4E, 25%E, 50W	1	
	chlorphyrifos 2E, 4E, 50W	1	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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	
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	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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/ac. in 4 gal. of water. Ground = 1 qt/ac. in 100 gal. of water.
Fall webworm	acephate 75%S	1/2	Spray nests or webbed areas in trees in late summer. Do 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	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	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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	
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 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.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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.
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	
	carbaryl 80%S, 50W	1	
	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	

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
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	
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 serious juniper. Concentrate spray on the undersides of the foliage.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Spruce spider mite	dimethoate 2E	1/2	Spray when mites are numerous Thorough coverage of foliage is important.
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 75%S, 25W, 50-57%E	1	
Twig pruner			No known chemical control.
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	
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	

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

INSECTICIDE NAMES

Common name	Trade names
acephate[a]	Orthene
Bacillus thuringiensis	Dipel, Thuricide
bendiocarb	Turcam, Dicarb
carbaryl[b]	Sevin
chlorpyrifos	Dursban
diazinon[c]	Spectracide, diazinon
dimethoate[d]	Cygon, De-Fend
fenbutatin-oxide	Vendex
isofenphos	Oftanol
malathion[e]	Cythion
oxydemeton-methyl	Metasystox-R
permethrin	Pounce, Ambush
superior oil[f]	many brands
trichlorfon	Dylox, Proxol

[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.



1987 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 may 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.

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 listed in this circular 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 1987, 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 1987, 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 these tables, *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.

This circular was prepared by Roscoe Randell and Fredric Miller, Jr., Extension Entomologists, University of Illinois College of Agriculture.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 900 (revised annually) October, 1986

VEGETABLE INSECTS

Insects	Crop	Insecticide	Suggestions
Aphids (NHE-47) Mites (NHE-58) Thrips	Most garden crops	malathion or diazinon	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.
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
diazinon	..	7	..	7	2	..	7	3	..	..	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 (Sevin) 50% W.P.	2 tbl.	¾ cup	2 lb.	5%
diazinon 25% E.C.	2 tsp.	4 tbl.	1 qt.	4%
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-17, 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 2% granules	6 oz. per 2-3 gal. water 5 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	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.
Leaf-feeding caterpillars	Same as for leaf-feeding beetles		
Plant bugs and leafhoppers	Same as for leaf-feeding beetles		
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 spary	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.

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.

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.
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 diazinon 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 carbaryl 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 are 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.*

[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]
Scales (cont.) 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.

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. Oftanol 1.5% G.	1 cup 2½ lb. 3 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.

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 Pharoah ants (NHE-10)	diazinon 25% E.C. chlorpyrifos R.T.U. diazinon R.T.U. propoxur R.T.U. hydrazone baits propoxur baits	**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. *Do not use diazinon E.C. inside.* **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.
Bed bugs	malathion 50-57% E.C. malathion 1% dust	**Chemical.** Use 4½ tablespoons of malathion 50-57% E.C. per gallon of water to thoroughly spray slats, springs, and bed frame. Apply a light dust to seams, tufts, and folds of mattresses. **Non-chemical.** Proper personal hygiene and good housekeeping will help keep populations low. Frequent washing of bed clothing and linens is also helpful.
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.** Keep screens, and other openings in good repair. Caulk all seams around windows and doors. Spray or soak boxelder bugs with soapy solutions where they congregate on tree trunks or buildings. Indoors remove the bugs by simple vacuuming.
Carpet beetles, clothes moths (NHE-87)	chlorpyrifos R.T.U. diazinon R.T.U.	**Chemical.** Spray storage areas, edges of carpeting, baseboards, etc. **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. Carefully examine cut flowers or dried flowers before bringing into the home. 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 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)	diazinon 25% E.C. 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)	dicofol 18.5% E.C. pyrethrin R.T.U.	**Chemical.** *Indoors:* Spray with pyrethrin. **Non-chemical.** Eliminate grass and other vegetation in a 6-24 inch 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.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Cluster flies (NHE-1)	dichlorvos 20% resin strip[2] pyrethrin R.T.U.	**Chemical.** Place resin strips in attic or closets. Fog lightly in rooms with pyrethrin. 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. hydrazone bait hydroprene R.T.U.	**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	diazinon 25% E.C. 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 an R.T.U. spray to baseboards, cracks, and door thresholds. *Do not use diazinon E.C. inside.* **Non-chemical.** To prevent entry, remove all shrubs and other plant material from around building foundations and entry ways. 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)	dichlorvos 20% resin strip[2] pyrethrin 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)	diazinon 25% E.C. 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.** 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. pyrethrin R.T.U.	**Chemical.** *Outdoors:* Spray with carbaryl on nearby Chinese elm trees to control elm leaf beetle larvae and adults. *Indoors:* Spray with pyrethrin. **Non-chemical.** Keep outside populations to a minimum by spraying infested elm trees. Seal cracks and crevices around windows and other openings to prevent entry. *Indoors:* Remove by vacuuming.
Fleas (NHE-107)	dichlorvos or naled carbaryl 5% dust pyrethrin R.T.U. methoprene 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.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Fleas (cont.)	diazinon 25%E.C. diazinon 5% G.	**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:* pyrethrin 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 pyrethrin. **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. pyrethrin 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 Pubic Body	malathion 1% dust 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 doctor'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:* pyrethrin 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 pyrethrin. **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 insests.
Pantry and Cereal Pests (NHE-11) Grain beetles Indian meal moth Flour beetles	diazinon R.T.U. propoxur R.T.U. pyrethrin 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.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Suggestions for control
Silverfish (NHE-86)	diazinon R.T.U. propoxur R.T.U.	**Chemical.** Spray runways, baseboards, closets, and places where pipes go through the walls. Repeat treatments in 2 weeks if needed. **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)	diazinon 25% E.C. 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 is 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)	chlordane 45% or 72% E.C. chlorpyrifos 42% E.C. (Dursban T.C.)	**Chemical.** For soil injection along the building foundation and under footings, use 1 gal. per 2 cu. ft. of soil. Use only chlorpyrifos on slab-on-ground structures with ducts in floor. Dilute to 1% with water or oil. **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, however; 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, fence rows, 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 (NEH-141) Hornets Yellowjackets	carbaryl 5% dust diazinon R.T.U. dichlorvos R.T.U. dichlorvos 20% resin strip[2] pyrethrin R.T.U.	**Chemical.** Hang dichlorvos resin strips in attic to prevent infestations. For nests below ground, apply diazinon according to label and seal opening with soil. Spray above-ground wasp and hornet nests in partitions with carbaryl. Drill holes through siding to inject insecticide, if necessary. Remove nests and honey 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 picnicing, 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 on page 8. You need to know only the formulation of the insecticide when using the dilution table. [2] Do not use in pet shops or if tropical fish are present. Do not use in kitchens, restaurants, or areas where food is present. Do not use in nurseries or rooms where infants, individuals who are ill, or aged persons are confined. Do not use in hospitals or medical clinics.

Pesticide Dilution Table for Household Insects

HOW TO USE: 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.

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 (Sevin) 50% W.P.	..	2 tbsp.	4 tbsp.	8 tbsp.	..
chlordane 45% E.C.	..	..	8 tsp.	5 tbsp.	..
chlordane 72% E.C.	..	..	4 tsp.	8 tsp.	..
chlorpyrifos	..	..	..	5 tbsp.	..
diazinon (Spectracide) 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*)

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

NAMES OF INSECTICIDES

Below is a list of the common names of insecticides used in the preceding 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, Bactur, SOK-BT	
carbaryl	Sevin	1-naphthyl methylcarbamate
chlorpyrifos	Dursban	O, O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate
DEET	Off, Kik	N, N-diethyl-m-toluamide
diazinon	Spectracide	O, O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
dichlorvos	Vapona, DDVP	2,2-dichlorovinyl dimethyl phosphate
dimethoate	Cygon	O, O-dimethyl S-(N-methyl carbamoyl methyl) phosphorodithioate
ethyl hexanediol	6-12, Rutgers 612	2-ethyl-1, 3-hexanediol
hydrazone	Combat	Tetrahydro-5,5-dimethyl-2(IH)-pyrimidinone
hydroprene	Gencor	Ethyl-3,7,11-trimethyl dodeca-2,4 dienoate
isofenphos	Oftanol	1-methylethyl 2-[[ethoxy [(1-methylethyl) amino] phosphinothioyl] oxy] benzoate
malathion	Cythion	diethyl mercaptosuccinate, S-ester with O, O-dimethyl phosphorothioate
methoprene	Precor	Isopropyl-11-methoxy-3,7,11 trimethyl-2,4 dodecadienoate
propoxur	Baygon	O-isopropoxyphenyl methyl carbamate
pyrethrin		principally from plant species *Chrysanthemum cinariaefolium*
resmethrin	Chryson, SBP-1382	(5-benzyl-3-furyl) methyl 2,2 dimethyl-3-(2-methylprophenyl) cyclopropanecarboxylate
tetrachlorvinphos	Rabon	2-chloro-1-(2,4,5,-trichlorophenyl) vinyl dimethyl phosphate

Insecticide Formulations and Toxicities

K. Steffey and F. Miller

The following list of insecticides is intended for use as a quick reference of insecticide 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 quickly find 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.

Acute oral toxicity ratings are usually obtained by feeding white rats; acute dermal ratings are determined by skin absorption tests on rats or rabbits. These figures are expressed as LD_{50}. This term 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. 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 times 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 succumb. 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 man, fatal doses of those chemicals would be in the range of 0.003 to 0.03 ounce.

By comparison, the oral LD_{50} value of aspirin is 1,200 mg/kg, or 3.6 ounces per 187-pound man, the equivalent of malathion. The oral LD_{50} value of ethyl alcohol is 4,500 mg/kg. If a group of 187-pound men each consumed somewhat more than 1 quart of 80 proof whiskey in 45 minutes, they would not only be intoxicated; 50 percent of them might die.

These toxicity ratings are approximate and pertain to white rats and sometimes rabbits. Such ratings, however, do 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 ratings expressed as LD_{50} are classified as 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, toxicity ratings of insecticides 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.

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 quick insecticide reference to compare common chemical names with trade names and to determine their toxicity ratings and general use.

INDEX: INSECTICIDE TRADE NAMES

Trade Name	Common Name
Aastar	combination of phorate and flucythrinate
Abate	temephos
Actellic	pirimiphos-methyl
Alfa-tox	combination of diazinon and methoxychlor
Alleviate	allethrin
Altosid	methoprene
Ambush	permethrin
Ammo	cypermethrin
Arrivo	cypermethrin
Atroban	permethrin
Attac	toxaphene
Avid	avermectin
Azodrin	monocrotophos
Baygon	propoxur
Baytex	fenthion
Baythroid	cyfluthrin
Bidrin	dicrotophos
Black Leaf 40	nicotine
Brigade	biphenate
Broot	trimethacarb
Capture	biphenate
Chloro-Pic	chloropicrin
Ciodrin	crotoxyphos
Ciovap	combination of crotoxyphos and dichlorvos
Co-Ral	coumaphos
Comite	propargite
Counter	terbufos
Cygon	dimethoate
Cymbush	cypermethrin
Cythion	malathion
Dasanit	fenulfothion
DBP	dibutyl phthalate
DDVP	dichlorvos
De-Fend	dimethoate
Delnav	dioxathion
Demon	cypermethrin
Derris	rotenone
Detia	aluminimum phosphide
Dibrom	naled
Dimecron	phosphamidon
Dimilin	diflubenzuron
Dipel	*Bacillus thuringiensis*
Di-Syston	disulfoton
DNOC	dinitro compounds
Doom	*Bacillus thuringiensis*
Dowfume	methyl bromide
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
Equalon	ivermectin
Famphos	famphur
Ficam	bendiocarb
Fumitoxin	aluminum phosphide
Furadan	carbofuran
Gardona	tetrachlorvinphos
Gastoxin	aluminum phosphide
Gencor	hydroprene
Germate	lindane
Grasshopper spore	*Nosema locustae*
Guardian	flucythrinate
Guthion	azinphosmethyl
HCN	hydrocyanic acid
Imidan	phosmet
Insectrin	permethrin
Ivomec	ivermectin
Javelin	*Bacillus thuringiensis*
Karate	*Bacillus thuringiensis*
Karathane	dinocap
Kelthane	dicofol
Knox Out	diazinon
Korlan	ronnel
Lance	cloethocarb
Lannate	methomyl
Larvin	thiodicarb

Trade Name	Common Name
Larvacide	chloropicrin
Larvadex	cyromazine
Lorsban	chlorpyrifos
Marlate	methoxychlor
Mavrik	fluvalinate
Mesurol	methiocarb
Metasystox-R	oxydemeton-methyl
Mocap	ethoprop
Monitor	methamidophos
Moorman's IGR	methoprene
Morestan	oxythioquinox
Morocide	binapacryl
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
Phostoxin	aluminum phosphide
Phthalthrin	tetramethrin
Plictran	cyhexatin
Pounce	permethrin
Pramex	permethrin
Precor	methoprene
Premgard	resmethrin
Prolate	phosmet
Proxol	trichlorfon
Pydrin	fenvalerate
Pynamin	allethrin
Pyretherm	resmethrin
Quasar	chloropicrin
Rabon	tetrachlorvinphos
Ravap	combination of dichlorvos and tetrachlorvinphos
Reldan	chlorpyrifos-methyl
Ripcord	cypermethrin
Safrotin	propetamphos
Savit	carbaryl
SBP-1382	resmethrin
Scout	tralomethrin
Sevin	carbaryl

Trade Name	Common Name
SOK-BT	*Bacillus thuringiensis*
Spectracide	diazinon
Spur	fluvalinate
Supracide	methidathion
Synerid	erythrosine-B
Synthrin	resmethrin
Systox	demeton
Talstar	bifenthrin
Tedion	tetradifon
Temik	aldicarb
Tetralate	combination of tetramethr and resmethrin
Thimet	phorate
Thiodan	endosulfan
Thuricide	*Bacillus thuringiensis*
Tiguvon	fenthion
Tiovel	endosulfan
Torpedo	permethrin
Trigard	cyromazine
Trithion	carbophenothion
Turcam	bendiocarb
Vapona	dichlorvos
Vendex	fenbutatin-oxide
Vigilante	dimilin
Vydate	oxamyl
Warbex	famphur
Zectran	mexacarbate
Zolone	phosalone

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b] Fish	Bee	Bird	Acute LD_{50}[c] Oral	Dermal	Signal word
acephate (Chevron)	Orthene	75 SP	L	H	M	866-945	2,000	caution
aldicarb (Union Carbide)	Temik	10G, 15G	-	H	M	1	2.5-3	danger
allethrin (Stauffer, Fairfield Am.)	Alleviate, Pynamin MGK	many	H	L	L	680-1,000	11,200	caution
aluminum phosphide (Degesch Am.)	Detia, Fumitoxin, Gastoxin, Phostek Phostoxin	55% tablets, pellets	-	-	-	AV[d] 2,000 ppm		danger
aspon (Stauffer)	Aspon	2E, 6E, 5G	-	-	VL	2,710-5,010	...	caution
avermectin (Merck)	Avid	EC	M	H	M	650	2,000	caution
azinphosmethyl (Mobay)	Guthion	2S, 2L, 50WP	VH	H	M	11-16	220	danger
Bacillus popilliae (Reuter, Fairfax Biological)	Doom	WP	EL	EL	EL	...	...	caution
Bacillus thuringiensis (Abbot Labs, Biochem, Tuco, Zoecon, NOR-AM, Reuter)	Dipel, SOK-BT Thuricide, Javelin, Karate	suspension, WP, bait	EL	EL	EL	> 20,000	> 20,000	caution
bendiocarb (NOR-AM)	Dycarb, Ficam, Turcam	29 and 76WP, 1D, 25% oil suspension	-	-	-	179	1,000	warning
benzyl benzoate	...	30L	-	-	-	500-5,000	...	caution
bifenthrin (Hoechstag)	Talstar	10WP	L	H	L	375	> 2,000	warning
biphenate (Exacto Chemical)	Capture, Brigade	adjuvant, drift retardant	-	-	-	-	-	-
carbaryl (Union Carbide, BASF)	Savit, Sevin	XLR, 4-oil, 80S, 50W, 4F, Bait	VL	H	VL	307-986	500-4,000	caution
carbofuran (FMC, Mobay)	Furadan	3G, 5G, 10G, 15G, 4F	M	H	M	8-44	1,000	warning danger
carbon disulfide (Stauffer)	...	liquid fumigant	-	-	-	AV 200 ppm CV[d] 20 ppm		warning
carbon tetrachloride (Stauffer, Vulcan)	...	liquid fumigant	-	-	-	5,730-9,770 AV 300 ppm CV 10 ppm	5,070-8,780	warning
carbophenothion (Stauffer)	Trithion	8E	VH	H	-	6-100	22-66	warning
chlordane (Velsicol)	...	G, D, WP, EC, oil	VH	M	M	283-590	580-1,600+	warning
chloropicrin (Great Lakes, Niklor, IMC)	Chlor-o-pics, Lavacide 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	82-245	2,000	caution warning
chlorpyrifos-methyl (Dow)	Reldan	4E	-	-	-	2,000-3,000	3,700	warning

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
cloethocarb (BASF)	Lance	15G	-	-	-	35	> 2,500	warning
coumaphos (Bayer AG)	Co-Ral	25WP, pour-on, EC, D, F	M	M	H	13-963	860-1,000+	warning danger
crotoxyphos (DuPont, SDS Biotech)	Ciodrin	EC, D, oils	H	H	-	74-125	302-375	danger
cyfluthrin (Mobay)	Baythroid	0.05G, 2E	VH	H	L	590	> 5,000	caution
cyhexatin (Dow)	Plictran	50W	VH	L	-	540	2,000	warning
cypermethrin (FMC, ICI)	Ammo, Cymbush Arrive, Ripcord	EC, WP	VH	H	L	4,123	> 1,000	warning
cyromazine (CIBA-Geigy)	Larvadex, Trigard	0.3% feed premix, 75WP (insect growth regulator)	-	-	-	3,387	> 3,100	caution
deet (McLaughlin-King)	Off	in alcohol	-	-	-	1,950-2,000	10,000	caution
demeton (Mobay)	Systox	2E, 6E	M	M	M	2-12	8-14	danger
diazinon (CIBA-Geigy, Pennwalt)	D·Z·N, Knox Out, Spectracide	4E, 14G, 50W, AG500, 2F	H	H	H	66-600	379-1,200	caution warning
dibutyl phthalate (Rhone-Poulenc)	DBP	liquid repellent	-	-	VL	8,000	...	caution
dichlorvos (CIBA-Geigy, SDS Biotech, DuPont)	DDVP, Vapona, others	many	M	H	M	25-170	59-900	danger
dicofol (Rohm and Haas)	Kelthane	1.6EC, 35WP	M	L	L	575-1,331	1,000-1,230	caution
dicrotophos (DuPont, CIBA-Geigy)	Bidrin	8M	-	H	H	16-75	42-43	danger
dienochlor (Zoecon)	Pentac	4F, 50WP	-	-	L	3,160	3,160	warning
diflubenzuron (Uniroyal)	Dimilin, Vigilante	25W, 4G	VL	-	VL	> 4,640	> 2,000	caution
dimethoate (BASF, Am. Cyanamid)	Cygon, De-Fend	400(4E), 2.67E	VL	H	M	28-500	150-1,150	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	EC	H	M	VL	19-176	53-350	danger
disulfoton (Mobay, Sandoz)	Di-Syston	8E, 15G	M	M	M	2-12	6-15	danger
endosulfan (FMC, Velsicol)	Thiodan, Tiovel	2EC, 3EC, 50WP	VH	M	M	18-43	74-130	warning danger
endrin (DuPont, Velsicol)	Endrin	1.6E, WP, D	VH	M	VH	3-45	12-19	danger

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
erythrosine-B	Synerid	bait	-	-	-	6,700-7,000	-	caution
EPN (DuPont)	EPN	2G, 4G, 4E, 5E	H	H	M	7-65	22-262	warning danger
ethion (FMC, Rhone-Poulenc)	Ethion	8E, 5G, 4M, superior 70 oil, 25WP	H	M	VL	27-119	62-245	warning
ethoprop (Rhone-Poulenc)	Mocap	10G, 15G, 6E	-	M	M	61	26	warning danger
ethylene dichloride (PPG Industries)	EDC	liquid fumigant	-	-	-	670-890 AV 1,000 ppm CV 50 ppm	...	danger
eugenol (several)	...	attractant	-	-	-	500-5,000	...	...
famphur (Am. Cyanamid)	Famphos, Warbex	pour-on	-	H	H	35-62	1,460-5,093	danger
fenbutatin-oxide (DuPont)	Vendex	50WP, 4L	-	-	-	2,631	> 2,000	danger
fensulfothion (Mobay)	Dasanit	15G, spray concentrate	-	H	H	2-10	3-30	danger
fenthion (Mobay)	Baytex, Entex, Tiguvon, Spotton	pour-on, spray concentrate	L	H	VH	255-740	300-400	warning
fenvalerate (DuPont)	Ectrin, Pydrin	2.4EC, 10L	H	H	L	451	> 5,000	caution warning
flucythrinate (Am. Cyanamid)	Guardian, Pay-Off	2.5EC	VH	H	L	67	> 1,000	danger
fluvalinate (Zoecon)	Mavrik, Spur	2E, 23.3F	-	-	-	260-280	20,000	danger
fonofos (Stauffer)	Dyfonate	4E, 10G, 20G	-	M	M	8-16	147	danger warning
geraniol (several)	...	attractant	-	-	-	...	...	...
gyplure (National Chemical)	Disparlure	attractant	-	-	-	...	...	...
hydrocyanic acid (several)	HCN	liquid fumigant	-	-	-	4 AV 40 ppm CV 10 ppm	...	danger
hydroprene	Gencor	aerosol, IGR	-	-	-	10,000	4,550	caution
isofenphos (Mobay)	Oftanol	G, EC	-	-	-	28-38	162-315	danger
lead arsenate (Drevel, Mechema Chemical)	...	...	-	H	L	1,050	> 2,400	danger
lindane (Rhone-Poulenc)	several	many	H	H	M	76-200	500-1,200	warning
malathion (Am. Cyanamid, Rhone-Poulenc)	Cythion, Malathion, others	57EC, ULV, others	M	H	L	885-2,800	4,000-4,444+	caution
metaldehyde (several)	several	bait	-	-	-	630	...	caution warning

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b] Fish	Bee	Bird	Acute LD_{50}[c] Oral	Dermal	Signal word
methamidophos (Chevron, Mobay)	Monitor, others	4L	-	H	-	13-30	110	danger
methidathion (CIBA-Geigy)	Supracide	2E	H	H	M	25-48	375	danger
methiocarb (Mobay)	Mesurol	75WP, bait, powder	-	H	L	130-135	> 2,000	warning
methomyl (DuPont)	Lannate, Nudrin	90SP, 1.8L, 2.4LV	M	H	L	17-24	1,500	danger
methoprene (Zoecon)	Altosid, Precor Moorman's IGR, Pharorid	EC, bait	VL	L	VL	34,600	3,038-3,500+	caution
methoxychlor (Hopkins, Prentiss)	Marlate	many	VL	M	VL	5,000-7,000	2,820	caution
methyl bromide (Dow, Great Lakes Chemical)	Metho-gas, others	liquid fumigant	-	-	-	AV 200 ppm CV 20 ppm		danger
methyl parathion (Monsanto)	many	EC, WP, D	VL	H	H	9-42	63-72	danger
methyl parathion, encapsulated (Pennwalt)	Penncap-M	2F	VL	H	H	270-480	5,400	warning
mevinphos (DuPont)	Phosdrin	4EC, 10.3WS	VH	H	-	3-7	3-90	danger
mexacarbate (Union Carbide)	Zectran	2E, 25W	-	-	-	24	...	warning danger
MGK-R11 (McLaughlin-Gormley-King)	...	repellent	-	-	-	2,500	...	caution
MGK-R326 (McLaughlin-Gormley-King)	...	repellent	-	-	-	5,230-7,230	...	caution
monocrotophos (CIBA-Geigy, DuPont)	Azodrin	5M	-	-	-	8-23	354	danger
naled (Chevron)	Dibrom	8E, oil	H	H	L	250-430	800	danger
nicotine (Black Leaf)	Black Leaf 40, others	40S	-	-	L	50-91	140-285	danger
Nosema locustae (Reuter)	Grasshopper spore	WP, bait	EL	EL	EL	> 5,000	...	caution
oxamyl (DuPont)	Vydate	2L	-	-	-	5-6	740-2,960	danger
oxydemeton-methyl (Mobay)	Metasystox-R	2E	VH	M	M	47-75	100-250	warning
oxythioquinox (Mobay)	Morestan	25WP	-	L	-	1,100-3,000	> 2,000	caution
paradichlorobenzene (PPG-Industries)	PDB	fumigant (crystals, liquid)	-	-	-	500-5,000	2,000	warning
parathion (Monsanto, Am. Cyanamid)	several	EC, WP, D, oils	H	H	H	3-30	4-200	danger

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
permethrin (FMC, ICI, Penwick)	Ambush, Atroban, Ectiban, Pounce, Pramex	2E, 3.2EC, 5.7EC, 25WP	VH	H	L	2,000-4,000+	4,000	warning danger
phorate (Am. Cyanamid)	Thimet	20G	VH	H	M	1-5	2-300	danger
phosalone (Rhone-Poulenc)	Zolone	3EC, 25WP	H	M	-	125-180	1,500	warning
phosmet (Stauffer)	Imidan, Prolate	50WP	H	H	L	113-299	1,550	warning
phosphamidon (Chevron, CIBA-Geigy)	Dimecron	8L, soluble concentrates	L	H	VH	15-33	107-150	danger
piperonyl butoxide (Fairfield Am., Prentiss)	...	synergist	VH	-	-	> 6,150	> 7,950	caution
pirimiphos-methyl (ICI)	Actellic	EC, ULV, D, aerosols, RTU	-	-	-	2,000	> 4,592	caution
propargite (Uniroyal)	Comite, Omite	6.55EC, 6E, 30W	-	L	-	1,480-2,200	250-680	danger
propetamphos	Safrotin	EC, WP	-	-	-	119	2,300	caution
propoxur (Mobay)	Baygon, others	1.5E, 2% bait, 70WP	-	H	L	83-104	> 1,000	warning
pyrethrum (Fairfield Am., Prentiss)	...	flower extract	H	L	VL	200-2,600	> 1,800	caution
resmethrin (Fairfield Am.)	Premgard, Pyretherm, Synthrin, SBP-1382	many	VH	H	VL	1,500	2,500-3,040+	caution
ronnel (Dow)	Korlan	2E, 5G	M	M	-	906-3,025	> 5,000	caution
rotenone (Fairfield Am. Corp., Prentiss)	Derris, others	many	VL	L	L	60-1,500	1,000-3,000+	caution
temephos (Am. Cyanamid)	Abate, Ecopro	4E, G	L	M	M	1,000-1,300	> 4,000	caution
terbufos (Am. Cyanamid)	Counter	15G	H	M	H	4-9	25	danger
tetrachlorvinphos (DuPont, SDS Biotech)	Gardona, Rabon	50WP, 75WP, 3D, EC	-	H	VL	4,000-5,000	> 5,000	caution
tetradifon (Duphar)	Tedion	EC, WP, smokes	M	L	VL	> 5,000	> 10,000	caution
tetramethrin (Fairfield Am.)	Neo Pynamin, Phthalthrin	25EC	-	-	-	4,640	...	caution
thiodicarb (Monsanto, Union Carbide)	Larvin	3.2F	-	M	-	66	> 2,000	warning
toxaphene (NOR-AM, Drexel, Hopkins, Vertac)	Attac	4E, 6E, 8E	VH	M	M	40-283	600-1,613	warning danger

INSECTICIDE FORMULATIONS AND TOXICITIES

Generic name	Trade name	Formulations[a]	Toxicity to[b]			Acute LD_{50}[c]		Signal word
			Fish	Bee	Bird	Oral	Dermal	
tralomethrin (Am. Hoechst)	Scout	EC	VH	-	-	1,070	> 2,000	caution
trichlorfon (Mobay, Tuco)	Dylox, Proxol, others	many	L	M	M	450-630	> 2,000	warning
trimethacarb (Union Carbide)	Broot	15GX	-	-	-	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.
[d]AV - acute vapor (1 hr); CV - chronic vapor (40 hr)

1987 Row Crop Weed Control Guide

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 out traces of 2,4-D or dicamba from the tank before spraying soybeans. Note that some herbicide labels provide cleaning suggestions.
- Correctly calibrate the sprayer and check the nozzle output and adjustment before adding herbicide to a tank.
- Use recommended rates. Applying too much herbicide is costly and, in addition, may 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 harvesting of crops, as well as recommended intervals between application and subsequent planting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label.
- 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.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed from the area. Avoid unnecessary exposure.
- Check the 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.
- 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 optimal stands.

Planting in relatively warm soil helps crops 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 at all 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 within a few hours 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 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. 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 can 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 is 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
Amiben	chloramben
Banvel	dicamba
Basagran	bentazon
Bicep	metolachlor plus atrazine
Bladex	cyanazine
Blazer, Tackle	acifluorfen
Bronco	alachlor plus glyphosate
Buctril, Brominal	bromoxynil
Butoxone, Butyrac	2,4-DB
Classic	chlorimuron ethyl
Command	FMC 57020
Conquest	cyanazine plus atrazine
Dowpon M	dalapon
Dual	metolachlor
Eradicane	EPTC plus safener
Eradicane Extra	EPTC plus safener and extender
Evik	ametryn
Extrazine	cyanazine plus atrazine
Furloe Chloro IPC	chlorpropham
Fusilade 2000	fluazifop
Gramoxone	paraquat
Hoelon	diclofop
Lasso	alachlor
Lorox, Linex	linuron
Lorox Plus	chlorimuron ethyl plus linuron
Marksman	dicamba plus atrazine
Modown	bifenox
Poast	sethoxydim
Preview	chlorimuron ethyl plus metribuzin
Princep, Simazine, Caliber 90	simazine
Prowl	pendimethalin
Ramrod	propachlor
Rescue	naptalam plus 2,4-DB
Reward	vernolate plus extender
Roundup	glyphosate
Sarflan	oryzalin
Scepter	imazaguin
Sencor, Lexone	metribuzin
(several)	2,4-D
Sonalan	ethalfluralin
Sutan+, Genate Plus	butylate plus safener
Sutazine, Rhino	butylate plus atrazine

Tandem ..... tridiphane
Treflan ..... trifluralin
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. Some combinations are sold as a "package mix," while others are tank-mixed. Tank-mixing allows you to adjust the ratio to fit local weed and soil conditions. If you use a tank-mix, you must follow restrictions on all products used in the combination.

Problems sometimes 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-third 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 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 can 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, while the other is 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 can 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 with little organic matter require relatively lower rates of most herbicides than do dark-colored, fine-textured soils with 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 percentage of the area actually treated. Many herbicides have several formulations with different concentrations of active ingredient. Be sure to read the label and make the 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 when the temperature and relative humidity are high. Rainfall occurring too soon after application (1 to 8 hours, depending on the herbicide) can cause poor weed control.

Translocated herbicides can be effective with partial foliar coverage, 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 for aerial application. Spray pressures of 30 to 50 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 can 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 can 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. The early application of preplant, preemergence, and postemergence herbicides is an alternative 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. Do not, however, use a higher rate than that stated on the label. Use great care when selecting herbicides and choosing application rates.

The use of effective postemergence herbicides, which depend upon foliar rather than soil action, may be a logical choice with some conservation tillage systems.

No-till and double-crop

Corn, sorghum, and soybeans can be planted without seedbed preparation, either in last year's crop residue (no-till) or as a second crop after a 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 may 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 herbicide rates be used to obtain acceptable weed control.

Control of existing vegetation in reduced tillage programs

Existing vegetation may be a perennial grass sod, a legume or legume-grass sod, an annual cover crop, or weeds. Perennial legume sods can often be controlled prior to planting corn or sorghum by preplant applications of 2,4-D or Banvel. Applications in the fall or relatively early in the spring may help to reduce risk of injury to the crop. Perennial grass sods can sometimes be controlled with preplant applications of Roundup. If a cutting of forages such as alfalfa or clover is removed before no-till planting, control of sod may be poor if herbicides are applied before there is sufficient regrowth.

Existing vegetation that consists of small annual weeds less than 2 inches tall may not require the use of Gramoxone or Roundup as a knockdown herbicide. Residual herbicides that also have postemergence activity may often control existing vegetation. Bladex, atrazine, Sencor or Lexone, and Lorox or Linex have both preemergence and postemergence activity. Also, postemergence herbicides can often be used to control existing vegetation. Poast is labeled to control existing grass weeds before planting soybeans.

Early preplant application of labeled residual herbicides can often prevent vegetation from being a problem before planting. The earlier that applications are made before planting, the shorter the length of control after planting. To strengthen or lengthen control, an additional application of the same or another herbicide at planting can be considered.

Gramoxone (1½ to 2½ pints per acre) plus a *nonionic* surfactant can be used to "knock down" existing foliage before crop emergence. Smartweed, giant ragweed, and fall panicum may not be controlled if they are more than 4 to 6 inches high. A minimum of 40 gallons or more of spray per acre is suggested to ensure adequate coverage of the foliage. Gramoxone can be applied with certain liquid fertilizers. *Do not apply* with suspension or high-phosphate liquid fertilizers. *Gramoxone is a restricted-use pesticide.*

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 trans-

locate to the roots to give better control of perennials. Use 10 to 40 gallons of spray volume per acre. Roundup plus 2,4-D can be used in some situations to improve broadleaf control.

For control of small annual weeds, Roundup can 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, 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.

For control of broadleaf weeds in no-till programs for soybeans, 2,4-D may be used up to 30 days before planting, with Sarflan or Poast for grass control.

Herbicides for corn

Herbicides mentioned in this section are registered for use on field corn and also on silage corn unless otherwise specified. See Table 2 for registered combinations. Herbicide suggestions for sweet corn and popcorn may be found in Circular 907, *1987 Weed Management Guide for Commercial Vegetable Growers.* Growers producing hybrid seed corn should check with the contracting company or inbred-seed producer about tolerance of the parent lines.

Preplant not incorporated

Interest in early preplant application is increasing, especially with the trend toward reduced tillage. Bladex 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 long as 45 days before planting, followed by a one-third rate at planting. A single application can be made within 30 days before planting.

Bladex may be applied early preplant at labeled rates, but if applied earlier than 15 days before planting, a split application or use of another herbicide at or after planting is suggested. Banvel or 2,4-D is labeled in mixture with Bladex, Bladex plus atrazine, and Bicep for corn with minimum or no tillage.

Banvel (dicamba) can be used as a preplant herbicide before planting corn or sorghum. The rate is 1 to 2 pints per acre. It is suggested that you delay planting corn 1 week and sorghum 1 to 2 weeks after application.

Roundup can be used preplant to corn or sorghum at ¾ to 1 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, such as AAtrex, Bicep, and Dual, may be applied early preplant, as

Table 1. Registered No-Till Herbicide Combinations

	Alone	Combination			
		Dual	Lasso	Sarflan	Prowl
Soybeans					
Amiben	GR	GR	GR	GR	GR
Lorox	GBR	GR	GBR	GR	G
Lexone	GBR	GR	GBR	GR	G
Scepter	GBR	GBR	GBR	—	GBR
Sencor	GBR	GR	GBR	GR	G
Turbo	GR	—	—	—	—
Corn					
Atrazine	GBR	GR	GBR	—	—
Bladex	GBR	G	GBR	—	—
Princep	BR	GR	GBR	—	—
Atrazine + Bladex	B	G	GB	—	—
Atrazine + Princep	GBR	GR	GBR	—	—
Bicep	GR	—	—	—	—

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

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

	Atrazine	Bladex	Princep	Atrazine + Bladex	Atrazine + Princep
PPI only					
Eradicane, Eradicane Extra	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	1,2,3	1,2
Dual	1,2,3	1,2	1,2	1,2	1,2
Lasso	1,2,3	1,2	2	1,2	—

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

long as 45 days before planting. 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 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 shattercane and johnsongrass. 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.

Although these herbicides should be incorporated into the soil soon after application, some labels allow up to 4 hours for incorporation if applied to dry soil. Even though some labels allow application up to 4 weeks before planting, application close to planting time is generally preferable.

Research results indicate that satisfactory weed control may be achieved by applying some of these products directly on soybean stubble in the spring and using one- or two-pass incorporation.

Sutan+, Genate Plus, Eradicane, or Eradicane Extra can be tank-mixed with atrazine or Bladex to improve broadleaf control. Sutan+, Eradicane, or Eradicane Extra can be tank-mixed with Princep. 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 can be applied with liquid fertilizer or impregnated on dry bulk fertilizer.

Sutazine+ 6-ME is a 4:1 mixture of Sutan+ and atrazine. The application rate is 5½ to 10½ pints per acre. Sutazine+ 18:6G and Sutan+ 10G are as granular formulations. Rhino is a butylate-plus-atrazine combination with 4.3 plus 1.7 pounds per gallon, respectively, while Sutazine has 4.8 plus 1.2 pounds per gallon.

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) can 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 can 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 can 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 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 (lbs 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) does not persist in the soil as long as atrazine, but atrazine does have the advantage of better corn tolerance. Bladex provides better control than atrazine of fall panicum, giant foxtail, and some other grass weeds but may not be quite as good as atrazine on some broadleaf weeds, especially pigweed. Bladex can be combined with atrazine in a 3:1, 2:1, or 1:1 ratio of Bladex to atrazine (see label for rates). The higher ratios will provide better grass control, while the 1:1 ratio will provide better broadleaf weed control. Prepackaged combinations include Extrazine (2:1 ratio) and Conquest (3:1 ratio).

Rates of Bladex must be selected accurately on the basis of soil texture and organic matter to reduce the possibility of corn injury. The rate for Bladex is 1½ to 6 pounds of 80W, 1.35 to 5.3 pounds of Bladex 90DF, or 1¼ to 4¾ quarts of 4L. You can lessen the risk of injury to corn by using reduced rates of Bladex in combinations.

Bladex can be tank-mixed with Lasso, Dual, Ramrod, or Prowl to improve grass control. The Lasso or Dual combination can be applied immediately before planting or after planting. Do not incorporate the Prowl or Ramrod combinations.

Three-way combinations of Bladex plus atrazine plus Lasso, Dual, Sutan+, Eradicane, or Eradicane Extra are registered. The addition of a limited amount

of atrazine should improve broadleaf control without increasing concern about carryover. *Bladex is classified for restricted use by certified applicators.*

Lasso (alachlor) or Dual (metolachlor) can 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 can be applied any time during the week before planting corn and shallowly incorporated, or it can 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. Use the higher rate suggested for the type of soil if you plan to incorporate Lasso.

Dual can be applied any time during the 2 weeks before planting corn and shallowly incorporated, or it can 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 can be preplant incorporated or applied after planting until corn is 5 inches tall and grass weeds have not passed the 2-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. Dual is also cleared in a combination with atrazine plus Princep.

Dual and Lasso are both formulated as packaged mixes with atrazine. Bicep contains a 5:4 ratio of metolachlor (Dual): atrazine per gallon. The rate is 1½ to 3 quarts of Bicep 6L per acre. **Lasso/atrazine** (flowable) contains 2½ pounds of alachlor (Lasso) and 1½ pounds of atrazine per gallon. The rate is 3½ to 4½ quarts per acre.

Dual or Lasso plus Bladex can be applied before planting and incorporated, or they can 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. Adjust the rate carefully according to soil texture and organic matter.

Preemergence herbicides

Ramrod (propachlor) can be applied alone before crop or weeds emerge or with atrazine after the corn is planted but before grasses reach the 2-leaf stage and corn emerges. Granular formulations should be applied before crop or weeds emerge. Ramrod performs well on soils with more than 3-percent organic matter.

Ramrod is irritating to the skin and eyes, so observe 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) can be applied alone after planting as long as corn is no more than 5 inches tall. Banvel is approved for use in combinations with Lasso, Dual, atrazine, or Bladex. Banvel may injure corn, especially if recommended rates are exceeded, if applications are not accurate and uniform, or if corn is planted too shallow (less than 1½ inches). Do not use this treatment on coarse-textured soils or soils that are low in organic matter. The rate on fine-textured soils with more than 1½-percent organic matter is one pint of Banvel.

Prowl (pendimethalin) is registered only for use on corn after planting. Incorporation of Prowl may result in serious injury to corn. Use only where it is possible to cover seed adequately with soil. Prowl can control annual grasses, pigweed, and lambsquarters; and it may provide some control of smartweed and velvetleaf. You can improve broadleaf weed control by combining Prowl with atrazine, Bladex, or Banvel. Prowl plus atrazine or Bladex may be applied in the early postemergence period before grasses are in the 2-leaf stage. These combinations may also help reduce the competition from wild proso millet. But avoid postemergence application when corn is under stress from cool, wet weather; otherwise, injury to corn may result. The rate for such combinations is 1 to 1½ quarts of Prowl 4E. Do not use Prowl plus Banvel on sandy soils or soils with less than 1½-percent organic matter.

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 2-leaf stage. For more information about postemergence principles, see the section entitled "Postemergence herbicide principles."

Atrazine can 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 insufficient. In most cases, this rate will need to 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 (80-percent oil and 20-percent surfactant) are used at the rate of one quart per acre. Surfactants are usually added at 0.5 percent of the total spray volume or at a rate of about one pint per acre. Results with the oil-surfactant mixes have generally been better than those with surfactants.

An atrazine-and-oil mix sometimes damages 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 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) can be applied until the fifth leaf of corn is visible and before grass weeds exceed 1½ inches in height. The Bladex rate is 1½ to 2½ pounds of 80W or 1.1 to 2.2 pounds of 90DF per acre. *Do not use Bladex 4L* because it contains oil and can increase the potential for injury. Injury to corn may occur under cold, adverse growing conditions. The injury may be only temporary yellowing but can be more severe. Under droughty conditions, certain agricultural surfactants or vegetable oils may be added to Bladex 80W to improve weed control. Do not use petroleum crop oils or apply with liquid fertilizers for postemergence application. Do not apply Bladex postemergence on corn that is under severe stress.

One may combine Bladex 80W with atrazine 80W, substituting atrazine for 30 percent of the Bladex. Also registered is a Bladex plus Banvel combination that allows for the addition of one-half to two-thirds pint of Banvel per acre; no surfactant or any type of oil should be added to this combination. *Bladex is classified as a restricted-use pesticide.*

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 1- to 3-leaf stage and actively growing. Tandem rates are 1 to 1½ pints per acre. Atrazine 80W, 90DF, or 4L may be used; but only Bladex 80W should be used with Tandem. Atrazine 4L rates are 1½ to 4 pints, and Bladex 80W rates are 1 to 2½ pounds per acre. Rates are adjusted for soil, type of weeds, and tank-mixture being used. Crop oil or crop-oil concentrate should be added to the Tandem-atrazine combination. Do not apply combinations containing Bladex to corn with more than four true leaves or to corn under stress from cold or wet weather. Do not spray if rain is expected within 3 hours. Precautions for avoiding injury to subsequent crops are similar to those for atrazine.

Banvel (dicamba) can be applied from emergence until corn is 36 inches tall or until 15 days before tassel emergence, whichever comes first. Best results can be expected by using one-half to one pint of Banvel per acre when the corn is in the spike to 5-inch stage. Application at this time can offer several weeks of soil (residual) activity when the 1-pint rate is used. With this timing, crop tolerance is better than with preemergence treatments of Banvel. In addition, application rates can be higher than with the later postemergence treatment, and the likelihood of injury to nearby soybeans is diminished. For applications on corn from 5 to 36 inches tall, the rate is one-half pint per acre. Banvel is labeled as an overlay (sequential) treatment following Sutan+, Eradicane, Lasso, Dual, Bicep, Ramrod, atrazine, Bladex, Princep, Roundup, Bronco, or paraquat.

Banvel is also labeled for postemergence use as a tank-mix with atrazine, Bladex 80W, or 2,4-D. The postemergence rate for Banvel is one-half pint (one-fourth pound active ingredient) per acre after corn is 5 inches tall. The label allows for the addition of one-eighth to one-fourth pound of 2,4-D acid equivalent per treated acre. If Banvel or Banvel plus 2,4-D is used on corn that is taller than 8 inches, drop pipes should be used to help keep the spray off the corn leaves and out of the whorl.

For best results, use Banvel before June 20 with a spray volume of 20 gallons per acre and a spray pressure of no more than 20 psi to help reduce the risk to plants outside the target area.

Do not apply Banvel when soybeans are growing nearby if corn is more than 24 inches tall, soybeans are more than 10 inches tall, or soybeans have begun to bloom.

To aid in the control of hemp dogbane, Banvel is approved for use at one-half pint with one pound acid equivalent per acre of 2,4-D LV ester or amine after corn is in the brown silk stage but at least 7 days before harvest.

Marksman (dicamba plus atrazine) is a formulated mixture of 1.1 pound dicamba (active ingredient of Banvel) and 2.1 pounds of atrazine per gallon. The rate is 2 to 3.5 pints per acre, depending on the soil texture and organic-matter content. On most Illinois soils, the rate is 3.5 pints per acre or 0.48 pound of dicamba and 0.92 pound of atrazine per acre. Marksman is cleared as a tank-mix and in sequential combinations with many other herbicides.

Marksman may be applied to actively growing weeds before, during, or after planting but before corn exceeds the 5-leaf stage. In most conventional tillage applications, the recommended timing is from emergence to the 5-leaf stage of corn. Most annual broadleaf weeds should be controlled, and some perennial broadleaf weeds should be suppressed. This formulated mixture will be targeted at the velvetleaf market in Illinois, where Banvel has needed some help.

2,4-D is effective in controlling many broadleaf weeds in corn. If corn is more than 8 inches high, use drop nozzles to decrease the possibility of injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

Do not apply 2,4-D to corn from the tasseling stage to the dough stage. After the hard dough to dent stage, you can apply 1 to 2 pints of certain 2,4-Ds 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 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.

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 or Brominal (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 20 gallons of water per acre, a spray pressure of 30 psi, and flat-fan nozzles.

Bromoxynil will not volatilize and cause the drift injury associated with 2,4-D or Banvel. Bromoxynil, under some conditions, may cause some burning of corn leaves, but the effects are usually temporary. Do not add a surfactant or crop oil to Buctril or Brominal used alone or in combination.

Buctril 2E rates are 1 to 1½ pints per acre when corn and weeds are in the 3- to 8-leaf stage. Brominal 4E rates are one-half to one pint per acre when corn is in the 2-leaf to 14-inch stage and before weeds are 4 to 6 inches tall. Use the higher rate on larger corn and weeds. Most annual broadleaf weeds are controlled. Larger pigweed and velvetleaf may require the higher rate or a combination with atrazine. Atrazine 4L at 0.5 to 1.0 quart (or equivalent rates of 80W or 90DF) can be combined with Buctril or Brominal. Do not add Bladex to bromoxynil.

Buctril plus atrazine is a formulated combination of 1 pound bromoxynil plus 2 pounds atrazine active ingredient per gallon for application at 1½ to 2 pints per acre at the 3- to 8-leaf stage of corn or at 3 pints at the 4- to 8-leaf stage. The lower rates are for smaller weeds.

Brominal and atrazine have been packaged in separate containers in a Torch twin-pack.

Basagran (bentazon) is registered for postemergence use in corn, with recommendations similar to those given for use with soybeans. (See the section entitled "Herbicides for soybeans.") The rate is 1½ to 2 pints of Basagran 4S per acre. Crop-oil concentrate may be added at one quart per acre. Basagran is also cleared at the rate of 1 to 1½ pints per acre in combination with atrazine at 0.6 to 1.0 pound of 80W, 0.6 to 0.9 pound of 90DF, or 1 to 1½ pints of 4L per acre. Laddok is a 1:1 ratio mix of bentazon and atrazine for use in corn. Crop-oil concentrate is added at one quart per acre. This combination controls only annual broadleaf weeds and not annual grasses. The combination provides better control of pigweed and lambsquarters than does Basagran alone and will create less risk of carryover than does atrazine alone.

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. For motorized spot treatments in which less than complete coverage of weeds may result, use a 5-percent solution. Avoid contact of spray with the corn. Add a dye for increased visibility.

Postemergence soil-applied herbicides

Prowl, Treflan, or Lasso can 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 to 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 need to be incorporated if irrigation is used or rainfall occurs soon after application. Prowl or Treflan can 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 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 "layby" treatments in corn. For Dual, as much as 3 pounds active ingredient per acre may be used in a single application, up to a total of 6 pounds active ingredient in one year. With Bicep, as much as 4 quarts of 4.5L or 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 may affect yields.

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 Lorox 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. *Consider this an emergency treatment.*

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. *Consider this an emergency treatment.*

Herbicides for sorghum

Many herbicides used to control weeds in corn can also be used in sorghum.

Atrazine may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids. Application may be 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 seed at least one inch deep. Do not use preplant or preemergence on soils with less than 1-percent organic matter. Incorporated treatments may cause injury if rainfall occurs before or shortly after sorghum emergence.

Injury may 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, Milogard, Bladex, or Modown for sorghum. Ramrod can improve grass control; but rates must not be skimpy, especially on soils that are relatively low in organic matter. For specific rates, consult the label. 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 Lasso/atrazine and to Bronco.

Dual (metolachlor) or Bicep (metolachlor plus atrazine) can be used for sorghum if seed has been treated with Concep. 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.

Modown 4F (bifenox) may be used preemergence at 3 to 4 pints per acre for all soil types. Broadleaf weeds controlled include nightshade, jimsonweed, lambsquarters, smartweed, pigweed, and velvetleaf.

Basagran (bentazon) is registered for postemergence use in sorghum in a manner similar to that for corn. (See the section entitled "Herbicides for corn.") Because sorghum is quite tolerant of Basagran up to and including early boot stage, the addition of a crop-oil concentrate is considered relatively safe. Do not apply to grain sorghum that is heading or blooming. Apply Basagran at the rate of 1 to 1½ pints in combination with atrazine at 0.6 to 1.0 pound of 80W, 0.6 to 0.9 pound of 90WDG, or 1 to 1½ pints of 4L per acre.

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 use in 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.

Brominal or Buctril (bromoxynil) can control broadleaf weeds in grain sorghum that is past the 3-leaf stage and as much as 14 inches tall and before weeds are 4 to 6 inches tall. It is generally safer than 2,4-D on grain sorghum. Combinations with atrazine are also registered to improve pigweed control and provide some residual control of germinating seedlings.

Buctril plus atrazine may be used postemergence for grain sorghum at 1½, 2, or 3 pints per acre from the 2-, 3-, or 4-leaf stage, respectively, up to the 10-leaf stage — but not on sorghum that is more than 10 inches tall. The Torch twin-pack, with separate containers of Brominal and atrazine, is also approved for sorghum as well as corn.

Prowl (pendimethalin) may be applied to grain sorghum from the 4-inch growth stage to as late as

the last cultivation, primarily for control of late-season annual grass weeds. For more information, see the section entitled "Herbicides for corn," subsection on postemergence soil-applied herbicides.

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. Add a dye for increased visibility.

Bronco (glyphosate plus alachlor) 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 suppress many emerged perennial weeds, as well as give preemergence control. Grain sorghum seed must be treated with Screen, as it is when Lasso is used.

Gramoxone may be used for control of annual weeds where grain sorghum is to be planted into the residue of the previous crop.

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 may increase the risk of injury from some herbicides. Accurate rate selection for soil type is especially essential for Lorox, Linex, Lexone, Sencor, or Turbo. Do not apply Lorox, Linex, Lexone, Sencor, Turbo, or Modown after soybeans begin to emerge. Follow label instructions for rates, timing, incorporation, and restrictions. For registered combinations, see Table 3.

Preplant not incorporated

Early preplant application can 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 or Roundup may be necessary. (See the section entitled "Conservation tillage and weed control," subsection on no-till and double-crop.)

Several preemergence herbicides are registered for application before planting soybeans.

Sarflan (oryzalin) can be applied any time before planting no-till soybeans. Sarflan can be applied in fully tillered wheat before heading, and soybeans can then be planted no-till into wheat before harvest or in wheat stubble immediately after harvest.

Sarflan is also labeled for tank-mixing with 2,4-D prior to 30 days before planting to control established winter weeds where soybeans are to be planted no-till. To control existing vegetation, Gramoxone or Roundup combinations with Sarflan plus Sencor or Lexone can be applied before planting no-till soybeans.

Sarflan plus Lexone can be applied as much as 30 days before planting. Dual can be applied as long as 30 days before planting soybeans or as a split application using a two-thirds rate as long as 45 days before planting, followed by a one-third rate at planting.

Either Turbo alone or Sencor applied with Lasso or Dual can be applied 15 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 can also be used before planting soybeans.

Roundup (glyphosate) can 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 (LVE) as a tank-mix may be applied prior to 30 days before soybean planting. Recommended use rates per acre are ½ pint Poast and 1 pint 2,4-D (½ pound acid equivalent) with 2 pints crop-oil concentrate in 5 to 10 gallons of spray solution.

Preplant incorporated herbicides

Incorporation is required for Treflan, Sonalan, Vernam, and Reward. Incorporation of Command will be required to reduce movement outside the target area. Incorporation is optional for Amiben, Preview, Dual, Lasso, Modown, Prowl, and Scepter when used alone or in some combinations. Lorox Plus, Lorox, and Sarflan should not be incorporated.

Incorporation can improve performance if rainfall is limited and may increase 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 cause significant reductions in weed control. For more information, see the section entitled "Herbicide incorporation."

Dinitroaniline herbicides registered for weed control in soybeans are Treflan, Prowl, Sonalan, and

Table 3. Registered Herbicide Combinations for Preplant Incorporated (PPI) or Preemergence (Pre) Use in Soybeans

	Amiben	Sencor or Lexone	Amiben + Sencor or Lexone	Lorox	Scepter	Command	Command + Sencor or Lexone
PPI							
Sonalan	1	1	—	—	—	1	1
Treflan	1	1	1	—	1	1	1
Command	—	1	—	—	—	—	—
PPI or Pre							
Dual	1,2	1,2	1,2	2	1,2	—	—
Lasso	1,2	1,2	1,2	2	1,2	—	—
Prowl	1,2	1,2	1,2	2	1,2	—	—
Sarflan[a]	2	2	—	2	1,2	—	—

1 = Preplant incorporated
2 = Preemergence
— = Not registered
[a] Not for preplant incorporation

Sarflan. Treflan and Sonalan should be incorporated because they have low solubility and are subject to loss by vaporization and photodecomposition. Incorporation is optional with Prowl, but variable weed control and soybean injury may result if Prowl is not incorporated. Incorporation should distribute the herbicide uniformly throughout the top 2 to 3 inches of soil (see label for implement settings). Do not incorporate Sarflan. (See the subsection about preemergence herbicides.)

The dinitroaniline herbicides control annual grasses, pigweed, and lambsquarters and may provide some control of smartweed and annual morningglory. Prowl and Sarflan may also partially control velvetleaf. Acceptable control of most other broadleaf weeds requires combinations 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 may 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 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 any time in the spring. Combinations with Sencor or Lexone should be applied no more than 2 weeks before planting. Incorporate as soon as possible, but do not delay incorporation more than 24 hours (or more than 8 hours if soil is warm and moist). The rate is 1 to 2 pints of Treflan 4E or MTF, 0.8 to 1.6 pints of Treflan Pro-5, or 5 to 10 pounds of Treflan 10G per acre. Treflan MTF is a multitemperature formulation that helps to avoid problems associated with freezing in storage. Treflan Pro-5 contains 5 pounds trifluralin per gallon.

Treflan may be tank-mixed with Scepter as a preplant incorporated (PPI) treatment or applied alone PPI followed by Scepter after planting but before soybean emergence.

Treflan may be tank-mixed with Command or Command plus Lexone or Sencor.

Sonalan (ethalfluralin) may be applied within 3 weeks before planting and should be incorporated within 2 days after application. The rate for general weed control ranges from 1½ to 3 pints per acre, depending on soil texture. Sonalan may provide some control of nightshade at rates of 3 to 3½ pints per acre, but for this purpose it should be used in conjunction with Amiben, Dual, or Lasso or followed with Blazer. Sonalan provides more risk of injury to soybeans than does Treflan; however, Sonalan is less likely to injure corn following soybeans than is Treflan. Sonalan may be tank-mixed with Amiben, Lasso, Dual, metribuzin, Reward, Command, or Scepter. Scepter may be tank-mixed with Sonalan or used preemergence or early postemergence following Sonalan. Sonalan may be tank-mixed with Command or Command plus Lexone or Sencor.

Prowl (pendimethalin) can be applied within 60 days before planting soybeans or applied after planting when used alone; Prowl with Sencor or Lexone can be applied within 7 days before planting soybeans or applied after planting. (See the subsection about preemergence herbicides.) Preplant treatments should be incorporated within 7 days of application. Mechanical incorporation may not be necessary if adequate rainfall occurs. Rates are 1 to 3 pints of Prowl 4E per acre, although rates for combinations with Sencor or Lexone are lower than when the herbicide is used alone.

Sencor or Lexone (metribuzin) plus Treflan, Son-

alan, or Prowl can be tank-mixed and applied within 7 to 14 days of 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 normal rate, or slightly less, of the dinitroaniline herbicide (see labels).

The application of Sencor or Lexone can also be split, one part being incorporated and the other part applied to the surface preemergence. This method requires two applications but can give better broadleaf control and less injury than incorporating the same total amount of Sencor or Lexone in a single application.

Command (FMC-57020) was initially marketed as a 6EC but will be a 4EC in 1987. It will be registered for use in combination with Sencor/Lexone by FMC and for use with Treflan or Sonalan by Elanco. Rates will be three-fourths to one pound of active ingredient (1½ to 2 pints) per acre for Command alone or in the combinations on the Command label and three-eighths to three-fourths pound of active ingredient on Treflan and Sonalan labels. The Elanco labels also include three-way combinations with metribuzin. Command should be incorporated to reduce movement outside the target area. Incorporation should preferably be done immediately, and it should provide uniform distribution. If a delay for incorporation is necessary, it should not exceed 3 hours. Command may be followed by some surface-applied preemergence herbicides or a postemergence treatment.

Soybeans have good tolerance to Command, and at adequate rates it can give good control of annual grass weeds. Command is exceptionally good on velvetleaf and can give good control of lambsquarters, smartweed, jimsonweed, common ragweed, and venice mallow. It needs help on pigweed, cocklebur, and black nightshade. Control of ivyleaf and tall morninglories should not be expected.

Command should not be followed by small grain or alfalfa in the fall or next spring, and some other small-seeded legumes may be questionable. Other rotational crops, including corn and sorghum, should not be planted for 9 months following application of Command. In the next season, do not follow with corn for seed production. Cover crops may follow, but stand reductions may sometimes occur. Applications should be accurate and uniform to avoid overlaps and excessive rates, especially on field ends and odd-shaped fields. Under some weather and soil conditions, and with certain corn hybrids, some effects may be noted the following season, especially if excessive amounts are applied or applications are not uniform.

Some desirable plants — including ornamentals, trees, vegetables, and agronomic crops such as small grains and alfalfa — are sensitive to Command. Spray drift or vapors moving outside the target area may cause visible symptoms of chlorosis or bleaching of sensitive plants growing near treated fields. Do not spray where there is risk of the herbicide's moving to desirable plants that are sensitive to Command. Avoid windy conditions and conditions in which moisture evaporating from moist soil may carry the herbicide. Use care in rinsing equipment to avoid movement to desirable plants and to avoid tank contamination that can affect crops sprayed later.

Amiben (chloramben) can 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 can also be applied and incorporated with Treflan or Prowl plus Sencor or Lexone as a three-way combination.

Reward (vernolate plus extender) and Vernam (vernolate) control annual grasses and pigweed. They sometimes provide fair control of annual morningglory, velvetleaf, and yellow nutsedge. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Vernam 7E or Reward 6E can be applied within 10 days before planting and should be incorporated immediately. The broadcast rate is 2⅓ to 3½ pints of Vernam 7E, 20 to 30 pounds of Vernam 10G, or 2⅔ to 4 pints Reward 6E per acre. Vernam or Reward plus Treflan is labeled at the rate of 1 pint of Treflan plus 2⅓ to 3 pints of Vernam 7E or 2⅔ to 4 pints Reward 6E per acre. The combination may reduce the risk of injury to soybeans. For yellow nutsedge and velvetleaf control, use at least 3 pints of Vernam 7E or 3⅓ pints of Reward 6E per acre. Other labeled combinations include Vernam or Reward plus Amiben, Sonalan, Prowl, Lasso, Furloe, Treflan/Sencor, or Lexone. Reward and Vernam can be applied with liquid fertilizer or impregnated on dry bulk fertilizer.

Preplant or preemergence herbicides

Lasso (alachlor) or Dual (metolachlor) may be applied to soybeans as a preplant incorporated or preemergence treatment. Lasso may be applied within one week of planting. In a single treatment, Dual may be applied to the soil surface early preplant within 30 days before planting. Or a two-thirds rate can be used within 45 days of planting, along with a one-third rate at planting. Soybeans are quite tolerant of Lasso or Dual. The first- to second-trifoliolate leaves often appear crinkled and have a drawstring effect on the middle leaflet, but these symptoms should not cause concern.

Lasso or Dual controls annual grasses and pigweed and can help control nutsedge and black nightshade. These herbicides can be combined with Lexone, Sencor, or Amiben (incorporated or preemergence) and with Lorox (preemergence only) to improve broadleaf weed control.

The rate for Lasso is 2 to 4 quarts Lasso 4E or Microtech 4L or 16 to 26 pounds of Lasso II 15G per acre. The rate for Dual 8E is 1½ to 4 pints per acre, and the rate for Dual 25G is 6 to 12 pounds per acre. Use the higher amount for the soil when incorporating or when black nightshade or yellow nutsedge is to be

controlled. The rate for combinations is slightly less than that for the herbicide used alone (see labels). Lasso may be applied after soybean emergence but before soybeans pass the unifoliolate stage.

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. 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.

Amiben can be applied alone or with Dual, Lasso, or Prowl as a preplant incorporated or preemergence treatment. Amiben plus Sencor can also be mixed with Lasso, Dual, or Prowl as a preplant or preemergence treatment. Amiben can be applied as a preemergence treatment with Lorox, Lexone, or Sencor.

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) can be applied anytime during the 1 to 2 weeks before planting and can be incorporated with Command, Dual, Lasso, Prowl, Sonalan, or Treflan. Incorporation should distribute the herbicide evenly throughout the top 2 inches of soil. Sencor or Lexone can be applied preemergence by itself or with Amiben, Dual, Lasso, Prowl, or Sarflan.

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 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 applied to soybeans that were then being treated with metribuzin.

Turbo 8EC (metolachlor plus metribuzin) is a formulated mixture (9:2 ratio) with 6.55 pounds of metolachlor and 1.45 pounds of metribuzin per gallon. The rate is 1½ to 3½ pints per acre, depending on soil texture and organic matter.

Scepter (imazaquin) is formulated with 1.5 pounds active ingredient per gallon. The use rate is two-thirds pint or one-eighth pound of active ingredient for all methods of application — including preplant incorporated, preemergence, postemergence, and in the various combinations. Approved tank-mix combinations include Prowl, Treflan, Lasso, or Dual. For systems with little or no tillage, it may be used with Prowl, Lasso, or Dual; and Gramoxone, Roundup, or Bronco may be added.

It is preferable to use another herbicide with Scepter to improve grass control. Broadleaf weeds controlled by Scepter include pigweed, lambsquarters, smartweed, jimsonweed, and common ragweed. Scepter can give relatively good control of cocklebur and may help on bur cucumber. Incorporation is recommended to improve control of velvetleaf and giant ragweed. Scepter may provide partial control of ivyleaf and tall morningglories. Although labeled for postemergence use, primarily for control of pigweed and cocklebur, primary emphasis in Illinois will likely be soil-applied use.

Scepter may be soil-applied as long as 30 days before planting or at planting but before crop emergence. Rainfall is relatively important for good performance. Initial labeling has indicated a waiting period of 4 months before planting small grain and 11 months before planting corn or grain sorghum. Research on persistence in the soil suggests that uniform and accurate applications are important. Under certain weather or climatic conditions, excessive rates on field ends and lack of uniformity may result in some effect on sensitive crops (such as corn) the following season. Do not apply Classic, Preview, or Lorox Plus the same year as Scepter because of possible additive residual effects.

Modown (bifenox) can control pigweed, lambsquarters, and smartweed and can provide some control of velvetleaf. Modown 4F rates are 2½ to 4 pints per acre. Combinations with Dual, Lasso, or Sarflan — or an overlay after Treflan — can improve grass control. For preplant incorporation, the application should be made within 2 to 3 days of planting, and incorporation should distribute the herbicides uniformly throughout the top one inch of soil. Do not apply Modown after soybeans begin to emerge.

Soybeans may show stunting from Modown, es-

pecially from preemergence use followed by cold, wet soil conditions during early growth stages. Injury symptoms are cupping and crinkling of the first few leaves. Usually, soybean injury is not reflected in yield.

Furloe Chloro IPC (chlorpropham) can be preplant incorporated with Treflan or Vernam; or it can be applied preemergence by itself or with Lasso to improve smartweed control. Preplant application should be done within a few days of planting soybeans, and incorporation should distribute the herbicide uniformly throughout the top 1 to 2 inches of soil. The rate in sequential or tank-mix combinations is 2 to 3 quarts of Furloe 4E per acre. Furloe 20G is used preemergence at 10 to 15 pounds per acre.

Preview (metribuzin plus chlorimuron ethyl) is a premix herbicide formulated as a 75-percent dry flowable in a ratio of 1 part chlorimuron ethyl to 10 parts metribuzin. It can be used preemergence in combination with Lasso, Dual, or Prowl or preplant incorporated into the top 1 or 2 inches of soil with a dinitroaniline herbicide such as Treflan or acetanilides such as Lasso or Dual. In systems with little or no tillage, Preview can be used preemergence to soybeans and postemergence to small weeds with the addition of 0.25-percent nonionic surfactant or one quart of crop oil as a burndown treatment. Preview can be applied with Roundup, Gramoxone, or Bronco for added postemergence weed control.

Preview controls a wide range of broadleaf weeds, including velvetleaf, cocklebur, jimsonweed, sunflower, pigweed, common ragweed, lambsquarters, and smartweed. Morningglory, giant ragweed, and black nightshade are controlled only partially.

Preview can be used on soils with pH of 7.0 or less with organic matter between 0.5 and 5.0 percent. Rates range from 6 to 10 ounces per acre, depending on soil texture.

When Preview is used, attention should be given to crop rotational plans. Wheat may be grown 4 months after Preview applications; but corn recropping is restricted to 10 months and sorghum to 12 months if normal rainfall occurs. Consult the Preview label for complete recropping information.

Preemergence herbicides

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 and jimsonweed is variable. Accurate and 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 Sarflan to improve grass control. The rate of linuron in these combinations is 1 to 1⅔ pounds of linuron 50DF or 1 to 1⅔ pints of linuron 4L on silt loam soils that have less than 3-percent organic matter.

Sarflan (oryzalin) can control annual grasses, pigweed, and lambsquarters if rainfall is adequate. You should rotary hoe to control emerging weeds if adequate rain does not fall within 7 days after application. Sarflan can 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 1 to 2 pounds per acre of Sarflan 75W (¾ to 1½ quarts AS, aqueous suspension) used alone or ⅔ to 1⅔ pounds of Sarflan 75W in combinations. Sarflan is also available as an 85DF. Sarflan can 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. Sarflan may cause stem callusing, which can lead to soybean lodging. Do not allow Sarflan to contact the soybean seed. For no-till soybeans, Sarflan can be applied in fall or early spring over undisturbed stubble from the previous crop. When combined with 2,4-D, it may be applied prior to 30 days before planting.

Prowl (pendimethalin) may be applied preemergence in combination with Amiben, Lorox, Lexone, or Sencor. When applied to the soil surface, Prowl may cause stem callusing, which can lead to soybean lodging. (For more information, see the subsection about preplant herbicides.)

Lorox Plus (linuron plus chlorimuron ethyl) is a 60-percent, premixed, dispersible granule formulation with linuron and chlorimuron ethyl in a 16:1 ratio. Lorox Plus can be used preemergence in combination with Lasso or Dual or following preplant incorporated applications of grass control herbicides such as Treflan or Prowl. Use in the Midwest should be restricted to soils with pH of 6.8 or lower and with ½- to 3-percent organic matter. Consult the label for further information on soil restrictions.

Lorox Plus controls a variety of broadleaf weeds including cocklebur, velvetleaf, jimsonweed, pigweed, common ragweed, and smartweed. Control of annual morningglory, giant ragweed, and sunflower is partial.

Before using Lorox Plus, consider crop rotational plans. In the Midwest, wheat may be grown 4 months after applications of Lorox Plus, corn or sorghum after 10 months, if Lorox Plus is applied before June 15. Consult the Lorox Plus label for complete information on rotational cropping restrictions.

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 to use timely treatments when using

postemergence herbicides in narrow-row soybeans. Postemergence herbicides have been helpful for controlling some problem weeds such as cocklebur, annual morningglory, and volunteer corn. 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 many broadleaf weeds, such as cocklebur, jimsonweed, and velvetleaf; but it is weak on pigweed, lambsquarters, and annual morningglory. It can be used at higher rates for control of yellow nutsedge and Canada thistle. It does not control annual grasses.

The suggested rate for Basagran is three-fourths to one quart 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 (no more than 2 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 a minimum of 20 gallons of water per acre and 40 psi spray pressure to get complete weed coverage. Adding a crop-oil concentrate to Basagran may increase performance on most weeds but may cause some soybean injury. Morningglory that is up to 10 inches long can be controlled with the addition of 2 fluid ounces of 2,4-DB (Butyrac 200) with Basagran. 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 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. Apply the first pint of Basagran before weeds reach the maximum size or leaf stage as indicated on the label. Make the second application of one pint 10 to 14 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. Cocklebur and morningglory control can be improved with the addition of 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 2 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. Use of surfactant is also recommended with Tackle. 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. With Blazer, do not spray if rain is expected within 6 hours; with Tackle, 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 morningglory, 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 plus Basagran, one quart of 10-34-0 liquid fertilizer or 28-percent nitrogen solution at labeled rate can be used to replace the surfactant or crop-oil concentrate (COC). Do not add COC when using 10-34-0 or 28-percent nitrogen solution. A mixture of Blazer plus Basagran plus 2 fluid ounces of the amine formulation of 2,4-DB can be used to improve control of cocklebur and morningglory under dry weather conditions. Do not add COC or any other additives when using 2,4-DB with Basagran plus Blazer. Refer to individual product labels for specifics.

Classic (chlorimuron ethyl) is formulated as a 25-percent dispersible granule for spraying in a minimum of 10 gallons of water per acre postemergence. It can be applied from after crop emergence to 60 days before soybean maturity. Aerial application is not included on initial labeling. The rate is one-half to three-fourths ounce of product per acre, equivalent to one-eighth to three-sixteenths ounce active ingredient. Do not exceed one ounce per season if more than one application is made.

Classic can control pigweed, cocklebur, smartweed, jimsonweed, common ragweed, and common (wild)

Table 4. Registered Postemergence Herbicide Combinations for Broadleaf Weed Control in Soybeans

	Amiben	Basagran	Blazer	2,4-DB
Alanap	X	—	—	X
Amiben		—	X	X
Basagran	—	—	X	X
Blazer	X	X		X
Classic	—	—	X	—
Tackle	—	X	—	X

X = Registered
— = Not registered

sunflower. It can also help to control ivyleaf, morningglory, tall morningglory, and yellow nutsedge. It should be applied when most weeds are 2 to 4 inches tall, but when morningglories and giant ragweed are 1 to 2 inches tall. It can be applied to common sunflower up to 8 inches tall and to cocklebur up to 12 inches tall. Control of velvetleaf is weak; and it does not control lambsquarters, prickly sida, or venice mallow. Control of black nightshade is questionable, and Classic does not appear to control bur cucumber. Another herbicide should be programmed for control of grass weeds, and provision for control of lambsquarters should be considered.

A surfactant at 0.25 percent by volume should be used with Classic. Apply within 24 hours of mixing; and, if the mixture is allowed to settle during this time, re-agitate well. Classic may cause some temporary yellowing and retardation of soybean growth, with these effects generally most evident 5 to 7 days after application to soybeans under stress. Conditions that put weeds under stress, such as cultivation, may decrease effectiveness. Do not apply Classic if rain is expected within 4 hours.

Determine soil pH before applying Classic, and do not apply to soils with a pH over 6.8. Do not plant wheat within 3 months after application of Classic; do not plant corn or sorghum within 9 months. If Classic is applied after August 1, do not plant corn the next season and do not plant sorghum within 11 months. If Classic is used following Preview or Lorox Plus, the interval before planting corn or sorghum will be extended. Be certain that the correct rate of Classic is applied very uniformly because the residual from excessive rates may affect subsequent crops, such as corn.

Classic may be tank-mixed with Blazer according to label instructions. Do not mix with any other crop production chemicals except as directed by the label. If Scepter is used the same season as Classic, do not recrop (except to soybeans) within 18 months of the last herbicide application. When corn injury occurs, it may be evident when corn is 8 to 10 inches tall, with some stunting and color change.

Amiben (chloramben) can 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. The rate of Amiben 2S alone is 6 quarts; it is 5 to 6 quarts per acre in combination with either 2 to 3 fluid ounces of Butyrac 200, 2 to 3 quarts of Alanap, or 1½ to 2 pints of Blazer per acre. Crop-oil concentrate should be used at one quart per acre with the Amiben alone or tank-mixed with Alanap. Do not add crop oil when tank-mixing with Butyrac. The Amiben plus Alanap or 2,4-DB should be applied when soybeans are in the third- to sixth- trifoliolate stage. Apply the Amiben tankmixed with Blazer at the appropriate rate for the weed size indicated on the Blazer label, but within 33 days after planting. If Amiben is also soil-applied, do not use more than a total of 12 quarts per season.

Rescue (naptalam plus 2,4-DB) can be used for midseason to late-season postemergence control of cocklebur, giant ragweed, and wild sunflower; it may also suppress annual morningglory. Apply 3 quarts per acre after soybeans are about 14 inches tall or after first bloom. The addition of a crop-oil concentrate or surfactant can improve control. Application before the weeds flower is suggested for best control. The water volume per acre is 10 to 25 gallons for ground application and a minimum of 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.*

Poast (sethoxydim) can be used for postemergence control of annual and perennial grasses in soybeans. The rate is one pint per acre to control foxtails or most other annual grasses that are 3 to 8 inches tall. Apply one-half pint per acre when wild proso millet is 4 to 10 inches tall. For control of volunteer cereals as tall as 6 inches, apply 1½ pints per acre before tillering. Poast is not recommended for spring control of volunteer cereals that emerged the previous fall. Wirestem muhly up to 6 inches tall can usually be controlled by a single application of 1¼ pints per acre. Poast can also be used as a rescue treatment for controlling selected annual grasses. Apply Poast at a rate of 1½ pints per acre for control of actively growing foxtails or seedling johnsongrass (up to 16 inches tall), fall panicum or barnyardgrass (up to 12 inches tall), and crabgrass or goosegrass (up to 8 inches tall). For control of actively growing wild proso millet up to 24 inches tall, apply Poast at one pint per acre.

The addition of ammonium sulfate in the spray solution at 2½ pounds per acre may improve grass control. Use high-quality, readily soluble ammonium sulfate to avoid plugging spray nozzles. Components of the tank-mixture should be added slowly, with agitation, in the following sequence: (1) ammonium sulfate, (2) crop-oil concentrate, and (3) Poast. After use, rinse the entire spray system with water to reduce corrosion.

Use 5 to 20 gallons of spray solution per acre for ground application and a minimum of 5 gallons per acre for aerial application. Note that the lower application volumes often result in more consistent control

of grass weeds. Use only standard high-pressure hollow-cone or flat-fan nozzles, with pressure at the nozzle adjusted to a minimum of 40 psi and a maximum of 60 psi. Always add crop-oil concentrate at 2 pints per acre. Do not cultivate within 5 days before Poast application or within 7 days after application.

Poast can be tank-mixed with Basagran, provided the Poast rate is increased by 50 percent to compensate for the reduced grass control that often occurs with this treatment. Sequential applications at least 24 hours apart may be more economical and practical, depending upon the weeds to be controlled and their size. Do not apply Poast if rainfall is expected within 1 hour. Do not apply Poast to grasses under stress from hot, dry weather or herbicide injury.

Blazer may be tank-mixed with Poast (Blazer label) for postemergence control of broadleaf and annual grass weeds in soybeans. For fall panicum and giant foxtail that are 3 to 8 inches tall, the rate per acre is 1½ to 2 pints of Blazer plus 1 pint of Poast plus 2 pints of crop-oil concentrate. For other annual grasses listed on the Poast label, increase the rate of Poast by 50 percent. Sequential applications should always be used instead of the tank-mixtures for perennials and may be more economical for many annuals.

Fusilade 2000 (fluazifop) can be used for postemergence control of annual and perennial grass weeds in soybeans. And it is very effective on volunteer corn. 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 ¾ 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 1 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 a minimum of 10 gallons per acre for ground application and 5 gallons per acre for aerial application. Add either crop-oil concentrate at one 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. *Do not tank-mix Fusilade with other postemergence herbicides intended for control of broadleaf weeds except as specified.* A tank-mix of Fusilade 4E and Blazer 2L is labeled for use without an increase in the Fusilade rate.

Roundup (glyphosate) can 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.

Gramoxone harvest aid

Gramoxone is registered for drying weeds in soybeans just before harvest. For indeterminate varieties of soybeans (most 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.

For the new formulation of Gramoxone Super with 1.5 pounds active ingredient per gallon the rate is 11 to 21 fluid ounces 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 Reward will also help.

Lasso (alachlor) preplant incorporated at 1½ to 4 quarts per acre can often give good control for nutsedge.

Dual (metolachlor) can be applied at 2 to 3 pints per acre to control nutsedge. Preplant incorporated treatment is preferred to treatment at the preemergence stage.

Reward 6E (vernolate) applied preplant at 4 pints per acre is effective against yellow nutsedge. Immediate incorporation is necessary with Reward.

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 can be applied. If needed, a second application can be made 7 to 10 days later. The addition of a crop-oil concentrate to Basagran improves performance.

For corn that is planted relatively early, preplant tillage before nutsedge sprouts is of little help in control. 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. These products must be incorporated immediately. **Lasso** or **Dual** applied in corn 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.

Atrazine or Bladex (cyanazine) may be used as a postemergence spray to control emerged yellow nutsedge when it is small. Split applications of atrazine plus oil 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 needed 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 can 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 can be used at 1½ to 2 times the normal rate each year for 2 years; in the third year, either they are 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) can control johnsongrass in soybeans. Apply 1½ pints per acre when the weed is 8 to 18 inches tall. Apply before the boot stage of growth. If new shoots or regrowth occurs, 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.

Poast (sethoxydim) can control johnsongrass in soybeans. Apply 1½ pints of Poast plus 1 quart crop-oil concentrate per acre when the johnsongrass is 15 to 25 inches tall. Use of ammonium sulfate at 2½ pounds per acre, in addition to the crop-oil concentrate with Poast, and use of low spray volume of 5 to 10 gallons per acre are suggested for best control. If regrowth or new growth occurs, apply one pint per acre when the johnsongrass is 6 to 12 inches tall.

Eradicane Extra can help control rhizome johnsongrass in corn when used at a rate of 8 pints per acre with a tillage program; or Eradicane 6.7E can be used at 7⅓ pints per acre.

Roundup (glyphosate) can 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. (See the section entitled "Herbicides for soybeans," the subsection about postemergence herbicides.)

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.

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. Another 2 quarts per acre should be applied as a preplant or preemergence treatment. Postemergence application is usually less effective. A single treatment with 3 to 4 quarts per acre can 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 can 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 can 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.

Fusilade 2000 (fluazifop) 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.

Poast (sethoxydim) may be applied in soybeans at the rate of 2½ pints plus 1 quart of crop-oil concentrate per acre when quackgrass is 6 to 8 inches tall. If regrowth occurs or new plants emerge, apply 1½ pints per acre when the quackgrass is 6 to 8 inches high.

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

Primarily, wirestem muhly is a problem in northern and western Illinois. A perennial, it reproduces by seeds and scaly rhizomes. These 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) can 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.

Atrazine at high rates may provide a little help on wirestem muhly in corn. Rates must be at the highest labeled rates for soil. (See the subsection about quackgrass.)

Fusilade (fluazifop) may be used postemergence to control wirestem muhly in soybeans. The rate is 1½ pints per acre when wirestem muhly plants are 4 to 12 inches tall.

Poast (sethoxydim) may also be used postemergence in soybeans to control wirestem muhly that is 6 inches tall. The rate is 1½ pints per acre. Addition of ammonium sulfate at 2½ pounds per acre and a low spray volume of 5 to 10 gallons per acre are suggested to improve control. (See the section entitled "Herbicides for soybeans," the subsection about postemergence herbicides, for more information about Poast and Fusilade.)

Canada thistle

Canada thistle is a perennial weed that has large 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 can be used in grass pastures or in noncrop areas than can 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 can be used as an after-harvest treatment in wheat, corn, or soybean fields or 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.

Atrazine and oil applied postemergence has been fairly effective in controlling Canada thistle in corn. Make the application before thistles are 6 inches tall.

Basagran (bentazon) can 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.

Roundup (glyphosate) can 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. Allow at least 3 days after application before tillage.

Black nightshade

Increasingly, black nightshade has become a problem for Illinois soybean growers. The berries, which are about the same size as soybeans at harvest, contain a sticky juice that can gum up a combine.

Black nightshade can be controlled more easily in corn than in soybeans. Herbicides such as atrazine, Bladex, Banvel, Lasso, and Dual are helpful for controlling this weed in corn.

If possible, plant suspect fields to corn rather than to soybeans. If soybeans are planted, plant suspect fields last so that the herbicide is more nearly at full strength when nightshade seed germinates.

For control in soybeans, Lasso, Dual, Amiben, or

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 or Shattercane	Volunteer corn	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Sunflower, wild	Velvetleaf
SOYBEANS																			
Prelant																			
Command	G	G	F-G	G	G	F	F	F	P	F	G	G	P	P	F-G	P	G	P	G
Treflan, Sonalan	F-G	G	G	G	G	G	F	P	P-F	P	P	G	P-F	G	P	P	P-F	P	P
Sencor, Lexone + dinitroaniline	F	G	G	G	G	G	F	P	F	F	F-G	G	P	G	G	F	G	F	F-G
Vernam, Reward	F	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	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-G	P	P	P	F	F-G	G	P-F	P	P-F	P	P
Lasso or Dual + Sencor or Lexone	F	G	G	G	G	P	P	F	P	F	F-G	G	F-G	G	F	F	G	F	F-G
Lasso or Dual + Lorox,[1] Linex[1]	F	G	G	G	G	P	P	P-F	P	F	F	G	F-G	G	G	F	G	F	F
Lorox,[1] Linex[1]	F	F	F	F	F	P	P	P	P	F	F	G	F	G	G	F	G	F	F-G
Sarflan,[1] Prowl	F-G	G	G	G	G	G	F	P	P-F	P	P	G	P	G	P	P	P-F	P	P-F
Scepter	G	F-G	F	F	P-F	F	F	F	F	G	G	G	F-G	G	G	F-G	G	G	F-G
Scepter + Prowl or Treflan	G	G	G	G	G	G	F	F	F	G	G	G	F-G	G	G	F-G	G	G	G
Scepter + Lasso or Dual	G	G	G	G	G	F	F	F-G	F	G	G	G	G	G	G	F-G	G	G	F-G
Sencor, Lexone	F	F	F	F	F	P	P	P	P	F	F-G	G	P	G	F-G	F	G	F	F-G
Postemergence																			
Basagran	F-G	P	P	P	P	P	P	F	P-F	G	G	F-P	P	P	F	F	G	G	F-G
Blazer, Tackle	F	P-F	P	P-F	P	P	P	P	F-G	F	G	F-P	F-G	G	F-G	F-G	G	F	P-F
Classic	F-G	P	P	P	P	P	P	F	F	G	G	P	P	G	F	F-G	G	G	F
2,4-DB	P-F	P	P	P	P	P	P	P	F-G	G	P-F	F	P	F	F	F	P	F	P
Poast, Fusilade	G	G	G	G	G	G	G	P	P	P	P	P	P	P	P	P	P	P	P
Rescue	F-G	P	P	P	P	P	P	P	F	G	F	P-F	P	F-G	P	G	P	G	P

[1] Do not use for preplant incorporation.

linuron at full rates or a combination of Amiben or linuron with Lasso or Dual is helpful. Scepter can also be effective. Suspect fields should be monitored and a postemergence application of Blazer considered. Blazer 2L at 2 pints per acre can control nightshade when applied at the 2- to 4-leaf stage. Tackle is also effective.

Harvest-aid sprays generally do not solve the problem because they do not make the berries fall before the soybeans are harvested.

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 (continued)

	Grasses								Broadleaf weeds										
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings or Shattercane	Volunteer corn	Yellow nutsedge	Annual morninggiory	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	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	G	G	G	G	G	F	G	F-G	F-G
Princep + atrazine	G	F-G	F-G	F	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		F	G	F-G	G	G	G	G	G	G	G	G	F-G
Bladex	F-G	F-G	F-G	F-G	G	P		P	F	F-G	G	G	G	F	G	F-G	G	F-G	F-G
Bladex + atrazine	F-G	F-G	F	F	F-G	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		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		F-G	F-G	F	G	G	G	G	G	F	G	F-G	F
Prowl + atrazine or Bladex[1]	F	G	G	G	G	F		P	F-G	F	G	G	G	G	G	F	G	F-G	F-G
Ramrod[1]	G	G	F	F-G	F	P		P-F	P	P	P	F	P	G	P	P	P	P	P
Postemergence																			
Atrazine + oil	F-G	F-G	G	P	P	P		F	G	G	G	G	G	G	G	F	G	G	G
Banvel	F-G	P	P	P	P	P		P	G	G	G	G	G	G	G	G	G	G	F
Basagran	G	P	P	P	P	P		F	P-F	G	G	F-P	P	P	F	F	G	G	F-G
Bladex	F-G	G	G	F	F-G	P		F	F	F-G	G	F	G	F-G	G	F	G	F	F-G
Buctril, Brominal	F-G	P	P	P	P	P		P	G	G	G	G	G	F	G	F	G	F-G	F
Tandem + atrazine	G	G	G	F	P	P		F	G	G	G	G	G	G	G	G	G	G	G
2,4-D	F	P	P	P	P	P		P	G	G	F	G	F	G	G	G	P-G	G	F-G

[1] Do not use for preplant incorporation.

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; herbicides therefore may not be necessary. Weeds, however, can 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, brush species and thistles can often 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.

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, dicamba (Banvel), or glyphosate (Roundup).

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 ensure establishment of an excellent stand and a crop that is better able to compete with weeds.

If annual broadleaf weeds later become a problem, the judicious use of recommended herbicides may be needed. Postemergence herbicides such as 2,4-D, MCPA, dicamba, and bromoxynil can provide relatively 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 performance. Refer to Figure 1 for a description of growth stages for 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, consider using translocated herbicides such as 2,4-D, dicamba, or glyphosate in combination with tillage after corn or soybean harvest but before establishing small grains.

Wild garlic continues to be a major weed problem in winter wheat. In University of Illinois research trials, Harmony (DPX-M6316) has given good control of wild garlic in winter wheat. Registration is possible by the spring of 1987. Harmony is extremely effective on wild garlic. When applied in the spring at rates of 0.33 to 0.66 ounce per acre, Harmony 75 DF has been effective for controlling aerial bulblets and some underground garlic bulbs. In addition to controlling wild garlic, Harmony also effectively controls common lambsquarters, smartweed, and many species of mustard.

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. (Boot stage refers to the period when head formation causes the sheath to swell.) See Figure 1.
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 most difficult species. Tank-mixes may broaden the weed spectrum and thereby improve control; check the herbicide label for registered combinations.
5. *Economic justification.* Consider 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 most commonly grown small grains 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 poisonous to livestock.

Perennial weeds are generally of greatest concern. They can exist for many years, reproducing from both seed and underground parent rootstocks. Although occasional mowing or grazing helps control certain annuals, perennials can grow back from underground root reserves.

Biennials such as bull thistle can also flourish in grass pastures. The first year, they exist as a prostrate rosette, so 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.

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 weeds become troublesome, however, 2,4-D or Banvel can be used; Tordon and Roundup can also be used as spot treatments. Certain formulations of Spike can now be used in grass pastures, strictly for brush and woody plant control.

Proper identification of target weed species is important. As shown in Table 3, weeds vary in their

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 (many)	MCPA (many)	Dicamba (Banvel), 2-oz rate	Bromoxynil (Buctril, Brominal)
Dandelion	perennial	G	F	F	P
Horseweed (marestail)	annual	F	F	E	F
Lambsquarters, common	annual	E	E	E	G
Mustard, wild	annual	E	E	P	F
Nightshade, eastern black	annual	F	F	G	G
Pennycress, field	annual	E	E	P	F
Pigweed spp.	annual	E	E	E	F
Ragweed, common	annual	E	G	E	F
Ragweed, giant	annual	E	G	E	F
Shepherdspurse	annual	E	E	F	F
Smartweed	annual	P	F	G	G
Velvetleaf	annual	G	G	F	E
Wild buckwheat	annual	P	F	E	G
Wild garlic	perennial	F	F	P	P
Wild lettuce	annual	E	G	F	F

Table 2. Weed Control in Small Grains

Herbicide	Broadcast rate/acre	Remarks	Restrictions
Oats and wheat			
2,4-D, 4 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 pre-harvest 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. Banvel II, 2 lb a.i.	4 fl oz 8 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.
Bromoxynil (Buctril 2E or Brominal ME4)	1½ to 2 pt ½ to 1 pt	Do not apply to small grains with legume underseeding. Apply bromoxynil alone to fall-seeded small grains in the fall or spring but before the boot stage. In spring-seeded oats apply from the one-leaf stage up to the boot stage. Weeds are best controlled before they are past the 3- to 4-leaf stage or when less than 1½ inches across if rosettes.	Do not graze treated fields for 30 days after application.
Wheat only			
2,4-D, 4 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 pre-harvest 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. Do not feed treated straw to livestock.

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 (many)	Dicamba (Banvel)	Picloram (Tordon)	Glyphosate (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	E	E
Horseweed (marestail)	annual	G	E	E	E
Ironweed	perennial	F	G	E	E
Milkweed, common	perennial	P	F	G	F
Multiflora rose	perennial	F	G	G	G
Nettle, stinging	perennial	G	G	G	G
Pennycress, field	annual	E	F	E	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	G	G
Thistle, bull	biennial	E	E	E	E
Thistle, Canada	perennial	F	E	E	G
Thistle, musk	biennial	E	G	E	E
Water hemlock spotted	perennial	G	E	E	G

susceptibility to different 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 may be appropriate if biennials or winter annuals are the main weed problem. Consider a spring or early-summer treatment for summer annuals. To control established perennials, apply herbicides when weeds are in the bud to bloom stage. Perennials are most susceptible at this time because food reserves, along with any translocated herbicide, are moving downward to the roots, potentially killing the entire plant.

When fully leafed out and actively growing, woody brush species should be treated with 2,4-D, Banvel, or Roundup. Where regrowth occurs, a second treatment may be needed in the fall. During the dormant season, oil-soluble formulations of 2,4-D or Banvel can be used in fuel oil. Tordon and Spike control many woody perennials and should be applied to the soil in the spring. They both require rainfall to move them 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 the management of forage legumes. Weeds can severely reduce the vigor of legume stands and thus cause losses in yield and forage quality. Good management begins with weed control practices that prevent weeds from becoming serious problems.

Table 4. Broadleaf Weed Control in Grass Pastures

Herbicide	Rate/acre	Remarks	Restrictions
2,4-D, 4 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. Banvel II, 2 lb a.i. (double the rate shown at right)	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.
Tordon 10K (picloram)	40 lb/acre or 1 lb/1,000 sq ft or 1½ oz/100 sq ft	Apply to soil for control of undesirable woody plants such as multiflora rose, hawthorn, juniper, sumac. Applications are best made in spring or early summer or during times of rapid growth. Apply to individual plants and clumps or to larger, dense infestations. Spread uniformly over plant root areas. Treatment will not be effective until it rains. More than one treatment may be needed. Injury or suppression of certain grasses such as smooth bromegrass may occur. May kill or injure desirable forbs, trees, or shrubs from root uptake.	A restricted-use pesticide. Limit coverage to 25% of an applicator's acreage. Do not use in sandy soils where groundwater levels are less than 10 feet deep. Do not use where surface runoff may flow to adjacent broadleaf crop areas. Apply to forage grasses only. Do not rotate treated pastures to other crops for at least 2 years after application. See label for specific grazing restrictions.
Roundup (glyphosate)	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 (tebuthiuron) Brush Bullets	4-16 bullets/ 1,000 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.
20P	10-20 lb/A		

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.
Butyrac 200 or Butoxone	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 only 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	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.
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 high 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 only 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.
Princep 80W	Alfalfa only	Growing or dormant	1 to 1½ lb	Apply once per year, in the fall after the last cutting but before the ground freezes permanently.	Do not use on sandy soils. Allow 30 days between application and grazing livestock; 60 days between application and cutting for hay.

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 and Eptam or Genep 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. Butyrac 200 or Butoxone (2,4-DB) controls many broadleaf weeds and may be applied postemergence in many seedling forage legumes.

Treflan is approved for use in forage legumes that

Table 5. Weed Control in Forages (continued)

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks	Restrictions
Sencor or Lexone 4L 75 DF 50 WP	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.
Gramoxone	Alfalfa only	Dormant	2½ to 4 pt	Apply after last fall cutting or before spring 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 spreader 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 4L 75 DF 50 WP	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. Futher applications may be made in the same area at 30-day intervals. Do not graze or harvest for 14 days.

are used as cover crops in the Acreage Conservation Reserve Program. Some stand reduction may occur with the use of Treflan, but good weed control can compensate to allow for excellent establishment of the legume. Follow haying and grazing restrictions imposed by the pesticide label and by the Conservation Use Program of the United States Department of Agriculture (USDA).

Eptam or Genep (EPTC) can help suppress johnsongrass seedlings, yellow nutsedge, and shattercane, in addition to many annual grasses and some broadleaf weeds. They will not effectively control mustards, smartweed, or established perennials. Balan, Eptam or Genep, and Treflan need to 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.

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/Lexone, Sinbar, and Velpar are applied after the last cutting in the fall or in the early spring. Princep is approved only for fall application. These herbicides control many broadleaf weeds and some grasses, too. Kerb is used for grass control and is also applied in the fall after the last cutting. Butyrac 200 or Butoxone (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 Table 5 for additional remarks and weed control suggestions.

Once grass weeds have emerged, they are particularly difficult to control in established alfalfa. Poast and Fusilade may be used for control of grass weeds in forage legume crops in the Acreage Conservation Reserve Program; however, in 1986 the treated cover crop could not be grazed or fed. Poast has an anticipated 1987 clearance for use in production alfalfa. This approval should help in the management of both annual and perennial grass problems.

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.

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

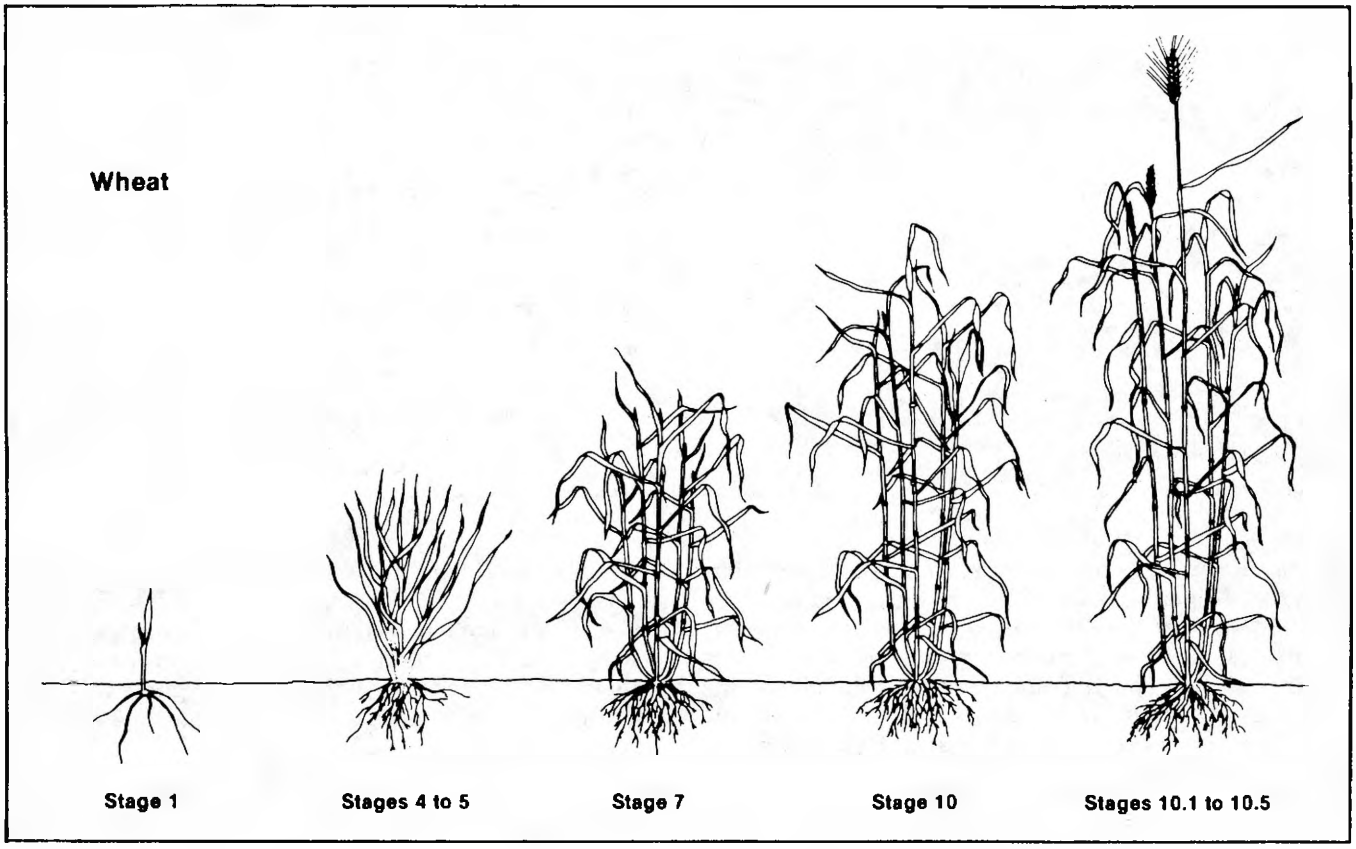


Figure 1. Growth stages of small grains.

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, and P = poor.

	Balan	Genep, Eptam	Butyrac, Butox-one	Dinoseb	Furloe	Kerb	Paraquat, Gramox-one	Princep	Sencor, Lexone[a]	Sinbar	Velpar	Roundup[a]
Barnyardgrass	G	G	P	P	P	F	F	F	F	F	G	E
Chickweed, common	P	P	P	G	G	F	G	G	G	G	G	E
Crabgrass	G	G	P	P	P	F	F	F	F	G	G	E
Dandelion	P	P	F	P	P	P	F	F	G	P	G	G
Dock, curly	P	P	P	P	P	P	F	P	P	P	P	G
Downy brome	G	G	P	P	G	G	G	G	G	G	F	G
Fall panicum	G	G	P	P	P	P	F	F	F	P	P	E
Field pennycress	P	P	G	G	P	P	G	F	G	G	G	E
Foxtails	G	G	P	P	P	F	F	F	F	G	G	E
Henbit	P	G	P	F	P	F	G	G	G	G	F	G
Lambsquarters	G	G	F	G	P	P	F	G	G	G	G	E
Mustard, wild	P	P	E	G	P	P	G	F	G	G	G	E
Nightshade[b]	P	F	F	F	F	P	F	P	G	P	P	E
Orchardgrass	P	P	P	P	P	F	F	F	F	F	G	F
Pigweed	G	G	F	G	P	P	F	G	G	F	G	E
Quackgrass	P	F	P	P	P	G	P	F	F	F	F	G
Ragweed, common	P	P	G	G	P	P	F	G	G	F	F	E
Shepherdspurse	P	P	G	G	P	P	G	G	G	G	G	E
Smartweed	P	P	P	G	F	P	F	F	F	F	F	E
Yellow nutsedge	P	F	P	P	P	P	P	P	F	P	P	F

[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.

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.

1987 Weed Management Guide
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 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 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

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
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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 herbicide labeled for vegetable crops is Gramoxone. A person wishing to use 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)	Broninal (bromoxynil)	Chem Hoe (propham)	2,4-D amine	Dacthal (DCPA)	Dalapon 85, others (dalapon)	Devrinol (napropamide)	Dual (metolachlor)	Enide (diphenamid)	Eptam, Genep (EPTC)	Eradicane Extra (EPTC + safener + extender)	Evik (ametryn)	Furloe (chlorpropham)	Fusilade 2000 (fluazifop-butyl)	Genate Plus, Sutan + (butylate plus safener)	Goal (oxyfluorfen)	Gramoxone (paraquat)	Karmex, others (diuron)	Kerb (pronamide)	Lasso (alachlor)	Lexone, Sencor (metribuzin)	Linex, Lorox (linuron)	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
Cabbage									X		X									X											X			X						X
Carrot																	X			X					X									X						X
Cauliflower									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																				
Greens									X											X														X						X
Horseradish									X																									X						
Lettuce				X			X													X		X					X							X						
Lima Bean			X		X				X			X					X						X											X		X				X
Muskmelon		X	X						X											X							X													
Okra													X																					X						X
Onion						X			X								X			X	X													X						
Peas					X		X			X		X								X											X		X	X				X		X
Pepper			X						X		X		X							X																				X
Popcorn	X				X			X				X			X	X			X					X		X		X							X		X				
Potato									X	X		X	X	X						X				X	X			X							X			X			X
Pumpkin			X																	X							X				X				X						
Snap Beans			X		X				X	X		X		X						X															X						X
Squash			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
Turnip									X		X									X															X						X
Watermelon		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
Basagran (bentazon)		Canada thistle, purslane, lambsquarters, ragweed, galinsoga, jimsonweed, smartweed, velvetleaf, wild mustard, cocklebur

Table 2. Weed Susceptibility to Herbicides Labeled for Use in Vegetable Crops (continued)

Herbicide	Weeds controlled	
	Grasses	Broadleaves
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
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
Evik (ametryn)	panicum, goosegrass, crabgrass, barnyardgrass, foxtail, shattercane, wild proso millet	lambsquarters, cocklebur, annual morningglory, ragweed, smartweed, velvetleaf, pigweed
Furloe (chlorpropham)	annual bluegrass, witchgrass	black nightshade, carpetweed, knotweed, curled dock (seedling), purslane, smartweed, shepherdspurse, mustard
Fusilade 2000 (fluazifop-butyl)	bermudagrass, goosegrass, seedling 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
Linex or Lorox (linuron)	barnyardgrass, crabgrass, fall panicum, goosegrass	annual morningglory, carpetweed, groundsel, lambsquarters, mustard, cocklebur, pigweed, prickly sida, purslane, smartweed, velvetleaf
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

Table 2. Weed Susceptibility to Herbicides Labeled for Use in Vegetable Crops (continued)

Herbicide	Weeds controlled	
	Grasses	Broadleaves
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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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 (fluazifopbutyl)	16-48 fl oz of 1EC	NONBEARING ASPARAGUS ONLY. Use crop oil concentrate or a nonionic surfactant. See label for amount.
Stale Seedbed		
Gramoxone or (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		
Linex or Lorox (linuron)	2 lb of 50WP	Carrots must be at least 3 inches tall. Apply before grasses are 2 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.
	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.
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.
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.
Dual (metolachlor)	1-3 pt of 8EC	Can be applied to the surface before planting or incorporated.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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)	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.
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.
Evik (ametryn)	0.75-2.5 lb of 80WP	Directed postemergence application only. Should use as a rescue treatment only. See label for precautions.
Linex or Lorox (linuron)	1.25-3 pt of 4L, or 1.5-3 lb of 50WP	Directed postemergence application only. Should use as a rescue treatment only. See label for precautions.
Stale Seedbed		
Roundup (glyphosate)	1.5-3 qt	See discussion of stale seedbed treatment.
	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.
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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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.
Sonalon (ethalfloralin)	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	
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.
Stale Seedbed		
Gramoxone (paraquat)	1 qt	See discussion of stale seedbed treatment.
	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.
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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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.
	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.
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	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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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.
Treflan (trifluralin)	1-2 pt of 4EC or MTF	Incorporate. Apply to transplants only.
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 which 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 skin 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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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.
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.

Table 3. Herbicide Rates and Guidelines for Use in Vegetable Crops (continued)

Herbicide	Rate of product per broadcast acre	Remarks
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.
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.
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
ametryn	Evik
atrazine	AAtrex, others
benefin	Balan
bensulide	Prefar
bentazon	Basagran
bromoxynil	Brominal
butylate + safener	Genate Plus, Sutan +
CDAA	Randox
chloramben	Amiben
chlorpropham	Furloe
cycloate	Ro-Neet
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
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.

H-659

1987 Herbicides for Commercial Fruit Crops in Illinois

D.B. Meador, C.C. Doll, and J.W. Courter

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.*

When mixtures of chemicals are applied, the user will assume the responsibility for freedom of residues if such applications are not labeled by the EPA as a mixture.

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 in the amounts of *product* rather than in amounts of *active ingredients.*

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 AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES	Sinbar 80W or Princep 80W or Karmex 80W or Surflan 75W or Devrinol 50W or Solicam 80WP	2 to 4 lb 2½ to 5 lb 2 to 4 lb 2½ to 5 lb 8 lb 2½ to 5 lb	These are preemergence herbicides. They may be used in conjunction with a postemergence herbicide. Apply in the spring before weeds emerge. Do not use on sandy soil. Surflan and Devrinol may be applied to newly planted trees after the soil settles and to bearing and nonbearing trees. Do not use Sinbar on trees established less than 3 years, or Princep, Karmex, or Solicam on trees established less than 1 year. Do not use Karmex on full-dwarf trees. Half rate of two of these materials is sometimes more effective than a full rate of one material. Devrinol must be incorporated within 24 hours by ½ inch of rain or irrigation or by shallow cultivation.
	Gramoxone (paraquat)	1⅓ to 2⅔ qt	A postemergence herbicide. Use lower rate on young, tender weeds and higher rate on older weeds. Use 8 oz of nonionic surfactant per 100 gal of spray to increase effectiveness. Wet foliage! Keep off tree foliage and tender bark. May be used in conjunction with a residual herbicide. Paraquat kills the tops but frequently does not kill the roots.
	2,4-D amine, oil-soluble amine, and acid forms Dacamine 4D and others	see remarks	Use 2 quarts of 4D amine or oil-soluble amine or 3EC acid form plus 2 oz of surfactant per 100 gal of water. Spot treat in May, June, July, and August to control bindweed, climbing milkweed, and other broad-leaved weeds. Spray before vines climb into trees. Keep spray drift off apple foliage. May be used as a broadcast treatment in late fall to kill dandelions.
	Ammate X-NI 95W	see remarks	For poison ivy use 60 lb of Ammate X-NI plus 1 qt of Surfactant WK per 100 gal of water. Spot treat in May, June, and July, wetting the ivy foliage. Keep off apple foliage.
	Casoron 4G or Norosac 4G	100 to 150 lb	This material is both a postemergence herbicide and a residual herbicide. Its action is good in cool weather but dissipates after about 2 months of warm weather. Effective against quackgrass when applied in late fall. Use granular form. Apply any time from fall to early spring.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES (Continued)	Roundup 4EC	1½ to 5 qt	Roundup is a systemic-type postemergence herbicide to be used in a manner similar to Gramoxone. Use sufficient water to wet grass and weed foliage. The rate depends on the weed species. Keep off apple foliage and green-colored bark tissue. It is more effective than Gramoxone against perennials. Do not apply within 14 days of harvest.
PEARS	Same as apples, EXCEPT that Sinbar is not registered for pears.		
PEACHES	Princep 80W, or Sinbar 80W, or Karmex 80W, or Devrinol 50W, or Surflan 75W, or Solicam 80WP	2½ to 5 lb 2 to 4 lb 2 to 4 lb 8 lb 2½ to 5 lb 2½ to 5 lb	See remarks under apples. Do not apply Princep or Solicam on trees established less than 1 year, or Sinbar or Karmex on trees established less than 3 years. Surflan and Devrinol may be used on newly planted trees after the ground settles and on bearing and nonbearing trees.
	Gramoxone (paraquat)	1⅓ to 2⅔ qt	See remarks under apples.
	Casoron 4G or Norosac 4G	100 to 150 lb	See remarks under apples.
CHERRIES AND PLUMS	Princep 80W, or Devrinol 50W, or Surflan 75W, or Solicam 80WP	2½ to 5 lb 8 lb 2½ to 5 lb 2½ to 5 lb	See remarks under apples. Restrictions are the same as for peaches for Princep, Devrinol, Surflan, and Solicam.
	Gramoxone (paraquat)	1⅓ to 2⅔ qt	See remarks under apples.
	Roundup 4EC	1½ to 5 qt	Use only on cherries, not on plums. Do not allow spray drift to contact foliage, fruit, green bark or suckers, or the bark of trees established less than 2 years. See remarks under apples.
	Casoron 4G or Norosac 4G	100 to 150 lb	See remarks under apples.
NON-BEARING: APPLES, BLACK-BERRIES, BLUE-BERRIES, CHERRIES, GRAPES, PEACHES, PEARS, PLUMS, AND RASPBERRIES	Fusilade 2000 IE Poast 1.5E	1½ pt 1½ to 2½ pt	Annual and perennial grass herbicides. Use as a directed spray to actively growing grass 2 to 8 inches tall, avoiding spray contact with crop foliage. Apply Poast in 5 to 25 gallons of water per acre with 2 pt of crop oil concentrate (COC). Apply Fusilade in 5 to 40 gpa water with 1% COC (2 pt/25 gpa) or 0.25% nonionic surfactant (½ pt/25 gpa). Do not apply within 12 months of harvest.
BLACKBERRIES AND RASPBERRIES	Princep 80W or Princep 4G or Sinbar 80W	2½ 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	2½ to 5 lb 8 lb	May be applied to new plantings after the ground settles and to established plantings in the spring before weeds emerge in a band over or along the row. Devrinol must be incorporated with ½ 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.
	Gramoxone (paraquat)	1⅓ to 2⅔ qt	Apply in spring before emergence of new canes or shoots.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
BLUEBERRIES	Princept 80W or Princep 4G or Sinbar 80W or Devrinol 50W	2½ to 5 lb 50 to 100 lb 2 to 4 lb 8 lb	See remarks under blackberries and raspberries. Apply in early spring. Devrinol may be applied to newly planted and established crops. Princep and Sinbar may be applied on crops established at least 1 year.
	Casoron 4G or Norosac 4G	100 lb	See remarks under blackberries and raspberries.
	Gramoxone (paraquat)	1⅓ to 2⅔ qt	See remarks under blackberries and raspberries.
GRAPES	Karmex 80W or Princep 80W	2 to 6 lb 2½ 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.
	Devrinol 50W or Surflan 75W	8 lb 2½ 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 ½ inch of rain or irrigation or by shallow cultivation.
	Gramoxone (paraquat)	1⅓ to 2⅔ 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 weeks. May be repeated. Weak against velvetleaf, ragweed, smartweed, and nutsedge. Incorporate with ½ inch of rain or irrigation or shallow cultivation.
	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. Must be incorporated with ½ 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 per year. Do not apply within 60 days of harvest.
	Gramoxone (paraquat)	1⅓ qt	A directed spray to weeds between rows. Must use shields to protect strawberry plants. No more than 3 sprays per season. Do not apply within 21 days of harvest.
	Sinbar	¼ to ½ lb	Apply no more than 1 pound per year. May be applied at renovation if all leaves are removed before spraying. Or apply to fully dormant plants from late fall to late winter. May apply ½ 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.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
STRAWBERRIES (Continued)	Tenoran 50W	8 lb	Postemergence action against young weeds less than 2 inches tall (many broadleafed and some grasses). Also has residual properties for preemergence action against germinating seeds. Delay application on new plantings until plants are established. No more than 2 applications per year. Do not apply within 60 days of harvest. See label for mixing and application instructions.
	2,4-D amine Formula 40	1 to 1½ qt	Postemergence action. To control many broadleaved weeds in established plantings apply in 25 to 50 gallons of water per acre in late fall or early spring when strawberries are dormant. 2,4-D may also be applied at renovation time.

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 plantings, see Circular 1144, "Controlling Weeds in Home Fruit Plantings."

Urbana, Illinois December 1986

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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 is 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 below-ground 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

1986 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 neeeded.

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*, or Horticulture Fact Sheet H-659, *Herbicides for Commercial Fruit Crops in Illinois*, both of which are revised annually.

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-dipropylthiolcarbamate
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° 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 runoff 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

M.McGlamery and D. Anderson

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 theaters, driveways, patios, 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 temporary control for four months or less. 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 in such areas as: (1) beneath asphalt pavement, (2) along railroads, (3) around buildings, as a means of preventing the growth of weeds that are unsightly or present a fire hazard; and (4) along fences to control weeds. 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 such as 2,4-D and dalapon 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 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 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 fenac, 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 heavy, it may be necessary to mow or cut existing vegetation, add a contact or foliar herbicide, or mix the herbicides with diesel fuel to speed top-kill. 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 types or for the desired length of control. When you want to control growth for two or three years, several maintenance applications are better than treating with an initial application rate that is high.

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.

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, 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 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 (SP), a 25-percent water-dispersible liquid (WDL), and as 20- or 10-percent pellets. Apply 2 to 5 pounds SP or 1 to 2 1/2 gallons WDL per acre for contact kill and short-term control, and 6 to 12 pounds SP or 3 to 6 gallons WDL for season-long control. The gridball formulations are recommended at 1 to 4 pounds active ingredient per acre. Hexazinone is highly water soluble and may move in runoff to damage vegetation in adjacent areas.

8. **Tebuthiuron** (Spike) is available as an 80-percent WP and as a 1 or 5 percent G. Apply before or during periods of active growth at a rate of 5 to 20 pounds per acre.

9. **Diuron** (Karmex) is an 80-percent WP. The rate is 10 to 60 pounds per acre. It is sometimes mixed with bromacil (described above 3).

10. **Dichlobenil** (Casoron) is available as a 50-percent WP and a 4-percent pellet. 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 WDG 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 WDG 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, 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 as a liquid or 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) 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 2- or 4-pound-per-gallon formulation, or as 5-percent granules. 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 persistent, broadleaf herbicide. It is formulated as liquid Tordon K or pelleted Tordon 2K or 10K. Mixtures with 2,4-D are Tordon 101, to be applied to stems and foliage, and Tordon 101R or RTU, which are formulated for cut-surface treatments. Special care must be taken because of the soil mobility and long soil life of picloram. Tordon K, 10K, and 101 Mixture are restricted to use by certified applicators.

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) 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-XL) 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 a 4-pound-per-gallon formulation. 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 4- or 3-pound-per-gallon formulations and in a formulated mix with 2,4-D (Crossbow). 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.

Spray Applications

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-XL (2 lb/gal)	1.5 to 3 gal	3 to 6 gal	6 to 12 gal
Karmex (80W)	5 to 20 lb	20 to 40 lb	20 to 60 lb
Krovar I (80W)	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 (80W)	5 to 10 lb	10 to 20 lb	...
Telar (75 WDG)[a]	1/4 to 1 oz	1 to 3 oz	...
Velpar (90W)	2 to 5 lb	6 to 12 lb	...
Velpar L (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.

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	Lbs per 1,000 sq ft
Atratol 8P	5 to 10
Banvel G	2.3 to 4.6
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 1G	5 to 14
Tordon 10K	1
Urox-'HX'	7 to 14
Velpar Gridball	0.2 to 0.9
Velpar Gridball 1 cc	0.1 to 0.5

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.

Broadleaf Weeds

Herbicide	Rate of formulation per acre: Annual and shallow perennials	Rate of formulation per acre: 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
2,4-D	1 to 2 qt	2 to 4 qt
Garlon 4 (triclopyr)	1 to 2 qt	2 to 4 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 application	Rate of formulation per acre
Ammate X-NI (ammonium sulfamate)	foliar	60 lb
Banvel (4 lb/gal dicamba)	foliar	2 to 4 qt
Crossbow (triclopyr + 2,4-D)	foliar	4 to 6 qt
Garlon 3A (44.4 percent triclopyr)	foliar	2 to 3 gal
Garlon 4 (61.6 percent triclopyr)	foliar or basal	4 to 8 qt
Krenite (4 lb/gal)	foliar	1.5 to 3 gal
Tordon 101 (picloram + 2,4-D)	foliar or basal	1 to 4 gal
2,4-D	foliar or basal	2 to 4 qt

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	Rate of formulation per acre: 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
Fuel oil + dinoseb	50 gal + 2 qt
Herbicidal naphtha	20 to 50 gal
Gramoxone	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 ditchbanks, 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. Retreatment 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 to 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 mph 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 need to 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 the spray should thoroughly drench the stem, the groundline, and all exposed roots. With low-volume applications, 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 are useful in selectively removing undesirable species from stands of desirable trees.

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 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 if areas where the root zones of desirable and target species overlap is treated.

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 ditchbanks, 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 the roots or the above-ground portions of plants. Banvel is used for foliar, cut-surface, basal-bark, or soil treatments. Foliar sprays can be applied with ground or aerial equipment, but aerial application should not be made in the vicinity of sensitive plants. The granular or pellet formulations that are available for soil treatments should be applied in spring or early summer. 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 Banevel 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 of plants. Formulations are available for foliar, basal-bark, soil, or cut-surface applications. Mixtures with phenoxy herbicides (Tordon 101 Mixture) are available to give broader-spectrum weed control.

Soil treatments may be applied in liquid or in dry (pellet) form. Rainfall is required to move the dry formulation 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.

Picloram can move readily in the soil water, and it remains active for a long time. 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. Vapor drift to nontarget species is much less likely to result in injury if treatment is made during the dormant season.

Tordon K, 10K, and 101 Mixture are restricted-use herbicides 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 (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.

Ammate X-NI (AMS or ammonium sulfamate) is a nonselective herbicide that can be used as a foliar spray or as a cut-surface treatment for brush control. Thorough coverage is required for effective control. A surfactant will aid foliar activity.

Because AMS is not volatile, drift should not be a major concern, but avoid spraying desirable plants directly. In pasture or rangeland, spray away from forage plants to avoid suppressing or killing them. Ammate X-NI can be used on land adjacent to streams, lakes, ponds, and public water supply areas as well as many other noncrop areas.

Ammate X-NI is corrosive to spray equipment. Equipment should be coated with an asphaltic base paint. As an alternative, clean equipment thoroughly immediately after applying Ammate X-NI and coat the equipment with oil.

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 as a 90% water-soluble powder as Amizol, and as a 2-pound per gallon soluble liquid as Amitrol-T. Amitrole is applied in foliar sprays. All leaves, stems, and suckers should be thoroughly wet to the ground line. 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 cropland. Arsenal is corrosive to mild steel, brass, and copper. (Imazapyr is a proposed name.)

Hyvar-X (bromacil) is a nonselective foliage or soil-applied herbicide that is used for the control of a wide spectrum of woody species. Depending on the formulation, bromacil can be applied dry or in a water spray. Rainfall or irrigation leaches the herbicide into the root zone. Hyvar-X may be broadcast above the roots of plants just before or during active growth. Spot treatments around the base of woody plants may be appropriate in areas where bare ground is undesirable. Treated plants may not respond until some time after application.

Do not apply Hyvar-X to frozen ground or to brush that is standing in water. Because the undiluted product is combustible, keep it away from heat and open flame. Thoroughly clean all traces of Hyvar-X from spray equipment immediately after use. Do not use aluminum spray nozzles.

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. Velpar gridballs are labeled for some uses.

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.

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
Garlon 4 (triclopyr ester)	..	X	X	X	X	..	X	..	X	X
Tordon K (picloram)	..	..	X	X	X	X	X	X	X	X
Tordon 10K	X	..	X	X	..	..	..	X	X	X
Tordon RTU or 101R	..	..	X	X	..	X	..	..	X	X
Tordon 101 Mixture (picloram + 2,4-D)	..	..	X	X	X	X	..	..	X	X
Access (esters of picloram + triclopyr)	..	..	X	X	X	X	X	..	X	X
Crossbow (triclopyr + 2,4-D)	..	..	..	X	X	X	X	..	X	X
2,4-D + mecoprop + dicamba	..	X	X	X	X	..	..	..	X	..
Ammate X	X	X	X	X	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[c]	X	X	X	..	..	X	X	X
Velpar	..	..	X	X	X	..	..	X	X	..
Spike	X[d]	X[d]	X	X	..	..	..	X	X	X

[a] oil-soluble forms only
[b] not for pasture use
[c] soil application only
[d] See specific formulation label

Table 2. Foliar Herbicide Treatment: Susceptibility of Common Brush Species[a]

	2,4-D	Dichlorprop	Banvel	Tordon	Hyvar	Garlon	Ammate	Amitrole	Roundup	Krenite
Ash, white (*Fraxinus americana*)	R	R	S-R	S-R	S-R	S	S-I	S	S-I	I
Birch (*Betula* spp.)	S-I	S	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	I-R	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	...	...	S-I
Crabapple (*Pyrus ioensis*)	S-I	S	S	S	S	...	S	...	S	...
Elderberry (*Sambucus canadensis*)	S-I	I	S	S	S	S-I	R	...	S	...
Elms, American and slippery (*Ulmus* spp.)	I	S-I	I	S-I	S-I	S-I	S-I	...	S	S-I
Grapes, wild (*Vitis* spp.)	S-I	S-I	I-R	S-I	...	...	S-I	...	S	S-I
Greenbrier or catsbriar (*Smilax* spp.)	R	R	R	I-R	R	...	I-R	...	...	...
Hackberry (*Celtis* spp.)	I-R	I-R	I	S-I	S-I	...	I	...	S	...
Hawthorn (*Crataegus* spp.)	I-R	R	R	S-I	...	S	I	...	S	I
Hedge-apple or osage orange (*Maclura pomifera*)	I-R	R	I-R	S-I	...	...	R	...	...	...
Honeylocust (*Gleditsia triacanthos*)	I-R	I	S-I	S	S	S-I	S-I	...	S	...
Honeysuckle (*Lonicera* spp.)	S-I	S-I	I	S-I	S	S	I	S-I	S	...
Locust, black (*Robinia pseudoacacia*)	S-I	S-I	S	S-I	S	S-I	I	S	S	S
Maple, red (*Acer rubrum*)	R	R	I-R	S-I	S	S-I	I	...	S	...
Maple, silver (*Acer saccharinum*)	I-R	...	...	S	S	...	S	...	...	...
Maple, sugar (*Acer saccharum*)	I-R	...	...	...	...	...	S	...	...	...
Mulberry, red (*Morus rubra*)	I-R	I-R	S-I	S-I	...	S-I	I-R	...	...	...
Persimmon, eastern (*Diospyros virginiana*)	I	I-R	S-I	S-I	...	S-I	I	...	...	I
Plum, wild (*Prunus* spp.)	S-I	I	S-I	S	...	...	I	...	S	S-I
Poison ivy (*Rhus radicans*)	I	I	S	S	S	S	S	S	S	...
Redcedar, eastern (*Juniperus virginiana*)	R	R	I-R	S-I	S	R	I	...	S	S
Rose, multiflora (*Rosa multiflora*)	...	...	...	S	...	S	...	...	S	S-I
Sassafras (*Sassafras albidum*)	S-I	I	I	S-I	S	S	S-I	...	S	I
Sumac (*Rhus* spp.)	S	S	S	S	S-I	S	S-I	S	S	S
Tree-of-heaven (*Ailanthus altissima*)	S-I	S-I	S-I	S-I	S	S	I	...	S	S-I
Trumpet-creeper (*Campsis radicans*)	...	...	S-I	...	...	...	...	...	S-I	...
Virginia creeper (*Parthenocissus quinquefolia*)	S	S-I	...	...	...	...	R	...	S	...
Willow (*Salix* spp.)	S	S	S-I	S-I	S	S	S-I	...	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	Tordon	Hyvar	Ammate	Garlon
Ash, white (*Fraxinus americana*)	R	R	S-I	S-I	S	S	S
Birch (*Betula* spp.)	S	...	...	S-I	S	S	S
Boxelder (*Acer negundo*)	S	S	S	S	S	S-I	R
Brambles--blackberry, raspberry, etc. (*Rubus* spp.)	I-R	S-R	S	S	S	I-R	S
Cherry, black and choke (*Prunus serotina* and *P. virginiana*)	S-R	S	S	S	S-I	S	S
Cottonwood, eastern (*Populus deltoides*)	...	...	...	S	S	...	S
Crabapple (*Pyrus ioensis*)	S-I	S-I	S	S	S-I	S	...
Elderberry (*Sambucus canadensis*)	S-I	S	S	S	S	I	S
Elms, American and slippery (*Ulmus* spp.)	S-I	S-I	S	S	S-I	S-I	S
Grapes, wild (*Vitis* spp.)	...	...	...	S	...	I	S
Greenbrier or catsbriar (*Smilax* spp.)	I	...	R	I-R	R	R	...
Hackberry (*Celtis* spp.)	S	S	...	S	S	S	S
Hawthorn (*Crataegus* spp.)	I	S-R	S-R	S	S	I	S
Hedge-apple or osage orange (*Maclura pomifera*)	I	R	...	S	I	I	...
Honeylocust (*Gleditsia triacanthos*)	I	I	...	S-I	S	S-I	S
Honeysuckle (*Lonicera* spp.)	S	S	S	S	I-R	R	R
Locust, black (*Robinia pseudoacacia*)	I	I-R	S-I	S-I	S	I-R	S
Maple, red (*Acer rubrum*)	R	R	S	S	S	I	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	I	S
Persimmon, eastern (*Diospyros virginiana*)	I-R	R	S	S	I	S-I	S
Plum, wild (*Prunus* spp.)	S-I	S-I	S	S	S	S	...
Poison ivy (*Rhus radicans*)	I	...	...	...	S	S	S
Redcedar, eastern (*Juniperus virginiana*)	R	R	S-I	S	S	S	R
Rose, multiflora (*Rosa multiflora*)	...	...	...	...	...	...	S
Sassafras (*Sassafras albidum*)	S-I	S-R	S	S	I	S-I	S
Sumac (*Rhus* spp.)	R	R	S	S	S	R	S
Tree-of-heaven (*Ailanthus altissima*)	S-R	S-I	S	S	S	I	S
Trumpet-creeper (*Campsis radicans*)	...	...	...	...	...	...	...
Virginia creeper (*Parthenocissus quinquefolia*)	...	...	...	...	R	R	...
Willow (*Salix* spp.)	S	S	...	S-I	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	Banvel	Tordon + 2,4-D	Ammate
Ash, white (Fraxinus americana)	I	...	S	S	S	S-I
Birch (*Betula* spp.)	...	S-I	S	S	S	S-I
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-I	...
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-I	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	...
Trumpet-creeper (*Campsis radicans*)	...	...	...	...	S	...
Virginia creeper (*Parthenocissus quinquefolia*)	...	...	...	...	...	...
Willow (*Salix* spp.)	S	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*, Agriculture Handbook No. 493, U.S. Department of Agriculture, and from herbicide companies.

Table 5. Soil Herbicide Treatment: Susceptibility of Common Brush Species[a]

	Banvel	Tordon	Hyvar	Velpar	Spike
Ash, white (*Fraxinus americana*)	...	I	S	...	I
Birch (*Betula* spp.)	...	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-I	S	S	...	S
Grapes, wild (*Vitis* spp.)	...	S-I	...	...	...
Greenbrier or catsbriar (*Smilax* spp.)	R	R	R	...	I-R
Hackberry (*Celtis* spp.)	...	S	S	...	S
Hawthorn (*Crataegus* spp.)	R	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*)	...	...	...	...	...
Mulberry, red (*Morus rubra*)	...	S-I	I	...	I
Persimmon, eastern (*Diospyros virginiana*)	S	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-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
Trumpet-creeper (*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 (*Scripus 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 runoff
	dichlobenil (aquatic granules (10%)	40 lb/A	Apply in March to exposed bottom soil
Cattails (*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	
	glyphosate Rodeo (4 lb/gal)	2 tbsp/1 gal plus 1/2 to 1 tbsp of nonionic surfactant	Wet foliage of actively growing plants at bloom stage or later
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

Group and Species	Herbicide	Rate of application	Remarks
Phragmites (*Phragmites australis*)	glyphosate Rodeo (4 lb/gal)	2 tbsp/1 gal plus 1/2 to 1 tbsp of nonionic surfactant	Wet foliage 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 Full bloom stage during summer or fall
	fluridone Sonar (4AS, 5P,SPR)	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 of large-scale application) 1.0 ppm (marginal application)	Apply on or below surface
	diquat cation (2 lb/gal)	0.5 ppm or 1 gal/ surface A	Same as above
	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, SPR)	Rate is dependent on water depth (see label)	Apply to water Apply to water surface
Leafy pondweed (*P. foliosos* 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

*The preemergent herbicides have not given satisfactory season-long control of leafy pondweed.

Group and Species	Herbicide	Rate of application	Remarks
Leafy pondweed (continued)	diquat cation (2 lb/gal)	0.5 ppm or 1 gal/ surface A	Same as above
	dichlobenil (aquatic granules 10%)	120 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, SPR)	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 or 1 gal/ surface A	Same as endothall
	dichlobenil (aqquatic 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, SPR)	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	0.5 ppm	Same as above
	dichlobenil (aquatic granules 10%)	80 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, SPR)	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

Group and Species	Herbicide	Rate of application	Remarks
SUBMERSED AQUATIC 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-ethylenediamine complex*	0.5-5.0 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 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, SPR)	Rate is dependent on water depth (see label)	Apply to water surface
Southern naiad (*N. guadallupensis* (Spreng.) Magnus)	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 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, SPR)	Rate is dependent on water depth (see label)	Apply to water surface

*Sold under the trade name of Komeen by the Sandoz Corporation

Group and Species	Herbicide	Rate of application	Remarks
SUBMERSED AQUATIC PLANTS WITH WHORLED LEAF ATTACHMENT			
Common coontail (*Ceratophyllum demerswm 1.*)	Use one of the following:		
	endothal (potassium salt, 4.23 lb/gal or 10% G)	2 ppm	Spread on water
	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
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
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
	flluridone Sonar (4AS, 5P, SPR)	Rate is dependent on water depth (see label)	Apply to water surface
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, SPR)	Rate is dependent on water depth (see label)	Apply to water surface

*Sold under the trade name of Komeen by the Sandoz Corporation

Group and Species	Herbicide	Rate of application	Remarks
Waterlilies (*Nymphaea* spp.)	dichlobenil (aquatic granules 10%)	50 lb/A	Spread on water
	2,4-D (20% G)	200 lb/A	Spread on water
	fluridone Sonar (4AS, 5P, SPR)	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 4AS	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, some 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
Filamentous algae	copper sulfate*	1 ppm	Postemergent
	Aquatic Herbicide System M**	15 lb/A	Spread on water
	simazine (80WP)	0.5 ppm	Apply to total water volume

*Crystalline copper sulfate can be used; however, there are several copper-containing formulations that contain copper-chelating compounds, which prevent the immediate precipation of copper as copper carbonate. Check the label for instructions concerning their uses and rates 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.

The Toxicity of Herbicides

M. McGlamery and D. Anderson

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 cross bones.

DANGER-POISON. Herbicides that carry these signal words with skull and cross bones contain the active ingredient endothall or paraquat. Endothall is available in liquid form as Aquathol K, Hydrothol 47, and Hydrothol 97. Paraquat is available as ICI Gramoxone.

These herbicide labels carry precautions: the user is advised to wear goggles or a face shield and rubber gloves and apron when working with concentrates. Breathing spray mists should be avoided.

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 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
Balan 1.5EC	benefin	Bicep 4.5WDL	metolachlor + atrazine
Blazer 2EC	acifluorfen	Bronco 4EC	alachlor + glyphosate
Devrinol 2EC	napropamide	Laddok 3.3WDL	bentazon + atrazine
Garlon 3A	trichlopyr amine	Milocep 3WDL	metolachlor + propazine
Hoelon 3EC	dichlofop-methyl		
Lasso 4EC	alachlor		
Modown 4WDL	bifenox		
Pramitol 25E, 5PS	prometon		
Velpar L 2WDL	hexazinone		

WARNING is the signal word for herbicides containing the active ingredient cyanazine or bromoxynil, which are moderately toxic through oral, dermal, or inhalation exposure. Some endothall and picloram formulations are moderately toxic. These herbicide labels state the following under Human Precautions: "May be fatal or harmful if swallowed, inhaled, or absorbed through the skin."

Cyanazine	Bromoxynil	Picloram	Endothall
Bladex 4L	Brominal	Tordon 101	Aquathol Granular
Bladex 80W	Buctril	Tordon RTU	Hydrothol Granular

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 on the following page.

Most of these herbicide labels do not carry a recommendation for use of goggles or face shield. They 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. However, the Fusilade, Goal, and Lasso/atrazine labels do specify the use of goggles or face shield. Dual, Fusilade, and Lasso/atrazine labels also call for the use of rubber gloves.

Trade name	Common name	Trade name	Common name
Alanap 2L	naptalam	Pramitol 80W	prometon
Basalin 4EC	fluchloralin	Princep 80W, 4WDL	simazine
DMA-4S	2,4-D amine	Prowl 4EC	pendimethalin
Dual 8EC	metolachlor	Ramrod 4WDL	propachlor

Trade name	Common name	Trade name	Common name
Evik 80W	ametryn	Ramrod/atrazine	propachlor/atrazine
Fusilade 4EC	fluazifop	Revenge 85SP	dalapon + TCA
Goal 2EC	oxyfluorfen	Rhomene 4S	MCPA amine
Hyvar-X 2S	bromacil	Ronstar 2G	oxadiazon
Igran 80W	terbutryn	Roundup 4S	glyphosate
Krenite 4S	fosamine	Sodium TCA	TCA
Lasso II 15G	alachlor	Sencor 75DF	metribuzin
Lasso/atrazine	alachlor/atrazine	Sonalan 3EC	ethalfluralin
Lexone 75DF	metribuzin	Treflan 4EC	trifluralin
MCP Amine 4S	MCPA amine	Velpar 90SP	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, oxyfluorfen, or CDAA.

Bromoxynil	Propachlor	Other
Brominal	Ramrod 4F	Goal
Brominal Plus	Ramrod 20G	Randox
Bronate	Ramrod/atrazine	
Buctril		

Some herbicide labels carry the statement, "Toxic to Fish." These include certain esters of phenoxy and pyridinoxy-phenoxy herbicides and the dinitroaniline herbicides.

Phenoxy esters*	Oxy-phenoxy esters	Dinitroanilines
Butoxone ester	Hoelon (diclofop)	Balan (benefin)
Butyrac ester	Fusilade (fluazifop)	Basalin (fluchloralin)
Esteron 44, 99	Verdict (halazifop)	Prowl (pendimethalin)
Weedone 170	Whip (fenoxaprop)	Sonalan (ethalfluralin)
Weedone LV	Assure (DPX-Y6202)	Treflan (trifluralin)

*There are many phenoxy herbicide products.

Other herbicides that are toxic to fish are Furloe Chloro-IPC, Prefar, Tupersan, and Lasso/atrazine. 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.

Paraquat also carries the statement, "Birds and wildlife in treated areas may be killed." Paraquat is available as ICI Gramoxone.

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

M. McGlamery and D. Anderson

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
acifluorfen			Moderate	3,330	>2,000	DANGER
(Rohm & Haas)	Blazer	2 S				
(Rhone-Poulenc)	Tackle	2 S				
alachlor			Moderate	1,800	8,000	DANGER
(Monsanto)	Lasso	4 ME, 15 G				
alachlor + glyphosate			Moderate			DANGER
(Monsanto)	Bronco	4 WDL				
alachlor + atrazine	Lasso/ atrazine	4 WDL	Moderate			Warning
ametryn			Moderate	1,750	>10,200	Warning
(CIBA-Geigy)	Evik	80 WP				
amitrole			Mild	24,600	10,000	Caution
(Union Carbide)	Amizol	90 WSP				
(Union Carbide)	Amitrol-T	2 S				
AMS			Mild	3,900		Caution
(DuPont)	Ammate-X	95 WSP				
asulam			Mild	>8,000	>1,000	Caution
(Rhone-Poulenc)	Asulox	3.34 S				
atrazine			Mild	5,100	9,300	Caution
(CIBA-Geigy)	AAtrex	80 WP, 4 WDL, 90 WDG				
(Shell)	Atrazine	80 WP, 4 WDL				
atrazine + propachlor			Moderate			Warning
(Monsanto)	Ramrod/ atrazine	3 + 1 WDL				
benefin			Moderate	5,000		DANGER
(Elanco)	Balan	1.5 EC, 2.5 G				
bensulide			Mild	770	>10,000	Caution
(Stauffer)	Betasan	3.6, 7, & 12.5 G,				
	Prefar	4 EC				

[a] Weed Science Society of America approved name or experimental number.

[b] "Several" indicates many trade names.

[c] EC means emulsifiable concentrate; G, granules; L, liquid; S, water solution; WDG, water-dispersible granule; WDL, water-dispersible liquid; WP, wettable powder; WSP, water-soluble powder; DF, dry flowable; P, pellet; F, flowable. ME means micro-encapsulated. Liquid formulations (EC, L, S, WDL, F) are in pounds per gallon; dry formulations (G, WDG, WP, WSP, DF, P) are in percentages.

[d] Dermal irritation is determined by applying an amount of pesticide onto the skin of shaved test animals. A blank indicates that the information is not available at this time.

[e] LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of the test animals, usually white rats, when administered in a single, oral dose.

[f] LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of the test animals, usually rabbits, when administered in a single, dermal dose. A blank indicates that the information is not available at this time.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
bentazon (BASF)	Basagran	4 S	Moderate	1,100	>2,450	Caution
bifenox (Rhone-Poulenc)	Modown	4 WDL	Mild	20,800	9,200	DANGER
boron compounds	several	various	Moderate	2,000		Caution
bromacil (DuPont)	Hyvar-X	2 EC, 80 WP, 10 G	Moderate	5,200	>5,000	*DANGER or Warning
bromoxynil (Rhone-Poulenc)	Buctril	2 EC	Moderate	260 to 440	>3,660	Warning
(Union Carbide)	Brominal	2 & 4 EC				
bromoxynil + atrazine (Rhone-Poulenc)	Buctril/Atrazine	1 + 2 WDL				Caution
butylate (Stauffer)	Sutan+	6.7 EC, 10 G	Moderate	3,878	>4,640	Caution
(PPG Industries)	Genate Plus	6.7 EC				
butylate + atrazine (Stauffer)	Sutazine +	4.8 + 1.2 ME, 18 + 6 G	Moderate Mild	>5,000	>5,000	DANGER-CORROSIVE or Caution
(Griffin)	Atrabute II	4.3 + 1.7 ME	Moderate			
cacodylic acid (several)	several	3.25 & 5.7 L, 65 WSP	Mild	830		Caution
chloramben (Union Carbide)	Amiben	2 S, 10 G, 75 WSP	Mild	5,620	>3,160	Caution
chlorimuron (DuPont)	Classic	25 DF	Mild	>5,000	>2,000	Caution
chlorimuron + linuron (DuPont)	Gemini	60 DF (4.6% + 55.4%)	Moderate	2,300	>2,000	Warning
chlorimuron + metribuzin (DuPont)	Canopy	75 DF (10.7% + 64.3%)	Mild	1,500	>2,000	Caution
(DuPont)	Preview	75 DF (7.5% + 67.5%)				
chlorpropham (PPG Industries)	Chloro IPC, Furloe	4 EC, 20 G	Mild	3,700	10,200	Caution
cinmethylin (Shell)	Cinch	7 EC	Moderate	1,600	2,000	Warning

(See footnotes on first page of table.)
*Varies with the formulation.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
cloproxydim (Chevron)	Select	2 EC		1,360	>500	
copper sulfate	several	various	Mild	470	>8,000	DANGER
cyanazine (Shell)	Bladex	80 WP, 15 G, 4 WDL	Mild	334	>2,000	Warning
cyanazine + atrazine (Shell)	Conquest	90 WDG (67.5% + 22.5%), 4L (3+1)				Warning
(Shell)	Extrazine	90 WDG (60% + 30%), 4L (2 2/3+ 1 1/2)				Warning
cycloate (Stauffer)	Ro Neet	6 EC	Moderate	3,160	>4,640	Caution
cycloxydim (BASF)	BAS 517	1.67 EC		3,940	>2,000	
dalapon (Cedar) (SDS Biotech)	Dowpon-M Dalapon-85	74 WSP	Moderate	7,570		Caution
DCPA (SDS Biotech)	Dacthal	75 WP, 5 G, 2.5 G	Mild	> 3,000	>10,000	Caution
dicamba (Sandoz Crop Protection)	Banvel	2 & 4 S, 5 G	Moderate	1,028	>2,000	Caution
dicamba + atrazine (Sandoz Crop Protection)	Marksman	1.1 + 2.1 F				Caution
dichlobenil (Uniroyal)	Casoron	50 WP, 4 & 10 G	Mild	3,160	1,350	Caution
dichlorprop (Union Carbide)	Weedone 2,4-DP	4 EC	Mild	800	1,400	Caution
diclofop-methyl (Hoechst)	Hoelon	3 EC	Moderate	2,176	640	DANGER
diphenamid (Upjohn)	Enide	90 WP, 50 WP	Mild	970	> 6,320	Caution
diquat (Chevron)	Ortho Diquat	2 S	Severe	230	> 400	Warning
diuron (DuPont)	Karmex	4 WDL, 80 WP	Mild	3,400		Caution

(See footnotes on first page of table.)
*Varies with the formulation.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
DPX-M6313 (DuPont)	Harmony	75 DF	Mild	>5,000	>2,000	
DSMA (Diamond Shamrock)	several	3 S, various WSP	Moderate	3,630	10,000	Caution
endothall (Pennwalt)	Endothal, Aquathol, Hydrothal	various EC & G	Moderate	182 to 206		DANGER-POISON
EPTC (Stauffer)	Eptam	2.3, 5, & 10 G, 7 EC	Mild	1,652	10,000	Caution
	Eradicane Extra	6 EC				
(PPG Industries)	Genep	7 EC				
ethalfluralin (Elanco)	Sonalan	3 EC	Moderate	>10,000	>2,000	Warning
fenoxaprop (Hoechst)	Whip, Acclaim	1 EC	Mild	3,310	>2,000	Warning
fenuron TCA (Hopkins)	Dozer	3 L, 25 P	Moderate	4,000		Caution
fluazifop-butyl (ICI Americas)	Fusilade	1 EC	Mild	4,350	2,000	Warning
fluridone (Elanco)	Sonar	4 EC, 5 G		10,000		Caution
FMC 57020 (FMC)	Command	4 EC	Mild	2,235	>2,000	Warning
fomesafen (ICI Americas)	Reflex	2 L	Mild	>5,000	>2,000	Warning
fosamine (DuPont)	Krenite	4 L	Mild	24,400	>1,683	Warning
glyphosate (Monsanto)	Roundup, Rodeo	3 S	Moderate	5,400	>5,000	Warning
(Ortho)	Kleenup	0.5 S				
haloxyfop (Dow)	Verdict	2 EC	Moderate	2,179	3,536	Warning
hexazinone (DuPont)	Velpar	90 WSP, 2 WDL	Mild	1,690	>5,278	*DANGER or Warning
imazaquin (American Cyanamid)	Scepter	1.5 EC	Mild	>5,000	2,000	Caution

(See footnotes on first page of table.)
*Varies with the formulation.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
imazaquin + pendimethalin (American Cyanamid)	Squadron	.33 + 2 EC	Mild	4,330	>2,000	DANGER
imazethapyr (American Cyanamid)	Pursuit	2 EC	Mild	>5,000	>2,000	
lactofen (PPG)	Cobra	2 EC	Severe	2,533	>2,000	DANGER
linuron (DuPont) (Griffen)	Lorox Linex	4 WDL, 50 DF 4 WDL	Moderate	1,500		Caution
MCPA (Rhone-Poulenc) (Union Carbide)	several several	2 & 4 EC 2 & 4 EC	Mild	800	>1,000	Caution
MCPB (Rhone-Poulenc (Union Carbide)	Can-Trol Thistrol	2 S 2 S	Mild	680		Caution
mecoprop (Rhone-Poulenc)	MCPP, Chipco Turf	2 & 4 EC	Mild	1,060	900	Caution
mefluidide (3M)	Vistar	2 S	Mild	>4,000	>4,000	Caution
metolachlor (CIBA-Geigy)	Dual, Ontrack	8 EC, 25 G	Mild	2,534	>3,000	Warning
metolachlor + atrazine (CIBA-Geigy)	Bicep	6 WDL	Moderate	4,680	>3,000	Caution
metribuzin (Mobay) (DuPont)	Sencor Lexone	50 WP, 4 WDL, 75 DF	Mild	1,090	>20,000	Caution
metribuzin + metolachlor (Mobay)	Turbo 8 EC	1.45 + 6.55 EC				Caution
metribuzin + trifluralin (Mobay)	Salute 4 EC	1.33 + 2.67 EC				Caution
monuron TCA (Hopkins)	Urox	3 EC, 5.5 G	Severe	2,300	1,000	Caution
napropamide (Stauffer)	Devrinol	2 EC, 50 WP, 10 G	Mild	5,000	>4,640	*DANGER or Caution

(See footnotes on first page of table.)
*Varies with the formulation.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
naptalam (NPA) (Uniroyal)	Alanap	2 EC, 10 G	Mild	1,770		Warning
oryzalin (Elanco)	Surflan	75 WP, 4 WDL	Mild	10,000	>2,000	Caution
oxadiazon (Rhone-Poulenc)	Ronstar	2.5 G	Severe	>8,000	8,000	Warning
oxyfluorfen (Rohm & Haas)	Goal	2 EC	Mild	5,800	>3,000	Warning
paraquat (ICI Americas)	Gramoxone	1.5 S	Moderate	120	>480	DANGER-POISON
pebulate (Stauffer)	Tillam	6 EC, 10 G	Severe	1,390	>4,640	Caution
pendimethalin (American Cyanamid)	Prowl	4 EC	Mild	3,380	>5,000	Warning
phenmedipham (Nor-Am)	Betanal	1.3 EC	Mild	>8,000	>4,000	Caution
picloram (Dow)	Tordon	2 EC, 10 G	Mild	8,200	>4,000	*Warning or Caution
prometon (CIBA-Geigy)	Pramitol	80 WP 2 EC	Moderate Severe	2,276	> 2,000	*Warning or DANGER
pronamide (Rohm & Haas)	Kerb	50 WP	Mild	5,620	>3,160	Caution
propachlor (Monsanto)	Ramrod	4 F, 20 G	Severe	4,700	>3,160	Warning
propazine (CIBA-Geigy)	Milogard	4 WDL, 80 WP	Mild	5,000	>10,200	Caution
pyrazon (BASF)	Pyramin	80 WP	Mild	3,600		Caution
quizalofop (DuPont)	Assure	0.8 EC	Mild	1,480	>2,000	DANGER-CORROSIVE
sethoxydim (BASF)	Poast	1.53 EC	Moderate	2,676		DANGER
siduron (DuPont)	Tupersan	50 WP	Moderate	7,500	>5,500	Caution

(See footnotes on first page of table.)
*Varies with the formulation.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute LD_{50} Oral[e]	Acute LD_{50} Dermal[f]	Signal word
simazine (CIBA-Geigy)	Caliber 90	90 WDG	Mild	5,000	10,200	Warning
	Princep	4 WDL, 80 WP, 4 & 10 G				
	Aquazine	80 WP				
sodium chlorate	several	4 L, 99 WSP	Moderate	4,330		DANGER
tebuthiuron (Elanco)	Spike	80 W, 1 & 5 G	Mild	644	200	Caution
terbacil (DuPont)	Sinbar	80 WP	Mild	> 5,000	> 5,000	Caution
terbutryn (CIBA-Geigy)	Igran	80 WP	Mild	2,500	> 10,200	Warning
triclopyr (Dow)	Garlon	3 & 4 EC	Mild	2,140	> 2,000	*Warning or DANGER
tridiphane (Dow)	Tandem	4 EC	Moderate	2,882	5,000	DANGER-CORROSIVE
trifluralin (Elanco)	Treflan	4 EC, 5 G	Mild	3,700	> 5,000	Warning
vernolate (Stauffer)	Vernam	7 EC, 10 G	Severe	1,800	10,000	Caution
	Reward	6.7 EC				
2,4-D (many)	several	various L, G	Moderate	300 to 1,000		*Caution or Warning
2,4-DB (Union Carbide)	Butyrac	2 EC	Mild	1,960	> 10,000	Caution
(Cedar)	Butoxone	1.75 EC				

(See footnotes on first page of table.)
*Varies with the formulation.

Potential for Herbicide Carryover

M. McGlamery and D. Anderson

Although herbicide persistence is essential for extended weed control, under certain conditions the herbicide may persist too long. Herbicide carryover is a problem when the herbicide remains in the soil in sufficient concentration to injure a sensitive crop the following season. Environmental conditions during the season of application and between cropping seasons affect the rate of herbicide breakdown. When environmental stress on the newly seeded crop is extreme enough to interfere with normal crop growth, the problem of carryover is intensified. Thus the potential for carryover is a function of the crop grown, the herbicide used, and environmental conditions.

The herbicides that have sufficient persistence to carry over to a crop the following year are some of the triazines, uracils, phenylureas, sulfonated ureas, dinitroanilines, certain growth hormones, and some recently developed herbicides. Persistent herbicides in the different families are listed below in Table 1.

Table 1. Herbicide Families With Their Persistent Members.

S-triazines	Phenylureas	Sulfonyl-Ureas
atrazine	diuron (Karmex)	chlorsulfuron (Glean, Telar)
propazine (Milogard)	fluometuron (Cotoran)	sulfometuron (Oust)
prometon (Pramitol)		chlorimuron (Classic)
simazine (Princep)		
hexazinone (Velpar)		
Dinitroanilines	**Hormone herbicides**	**Other**
benefin (Balan)	picloram (Tordon)	bensulide (Prefar, Betasan)
oryzalin (Surflan)	fenac (Fenatrol)	diphenamid (Enide)
pendimethalin (Prowl)		fluridone (Brake, Sonar)
trifluralin (Treflan)		norflurazon (Zorial, Solicam)
		sodium borates (many)
		tebuthiuron (Spike, Graslan)
		imazaquin (Scepter)
		FMC 57020 (Command)

Herbicide carryover is influenced by herbicide rate and herbicide distribution. Higher herbicide rates are used on soils that are higher in clay or organic matter, as these soils adsorb more of the herbicide. High adsorptive capacity extends the length of control, which under some conditions can result in carryover. A persistent herbicide is often combined with one that is less persistent so that the rate of the persistent herbicide can be reduced, thus minimizing the risk of herbicide carryover without jepardizing good weed control.

Irregular herbicide distribution in the soil can cause herbicide carryover. Poor distribution can result from improper calibration or agitation, overlapping or double application, or poor incorporation. Overlapping or double application is often evident on turn rows and "boom laps." Slow speeds used in wet soils or on hills can result in the overapplication of herbicides. "Streaked" incorporation can lead to "hot spots," which in turn may cause herbicide injury the first season or herbicide carryover the next.

Time is another factor that affects herbicide carryover. Late application of the persistent herbicide followed by early planting of the subsequent crop increases the probability of herbicide carryover. Delaying planting the subsequent year allows more time for herbicide breakdown, which reduces the probability of carryover injury.

Even less persistent herbicides can cause carryover injury if the normal cropping pattern is not used. For instance, a short residual herbicide can cause carryover injury when double cropping or intercropping are used in the same growing season or year that the herbicide is applied.

The sensitivity of the crop and its genetic makeup (variety or hybrid) affect the probability of herbicide injury. Smaller seeded crops and varieties have a greater potential for injury from photosynthetic inhibitors than those crops with larger seeds. The vigor of the crop and the growing conditions affect the potential for herbicide carryover. The crop is thus more likely to show injury symptoms if it is weakened by climatic stress, disease stress, or nutritional stress.

Because temperature and moisture affect herbicide degradation, they also affect the potential for herbicide carryover. Chemical and microbial reactions are slower at low temperatures and more rapid as temperatures increase to an optimum. Microbial activity can, however, decrease as temperatures get too high for the microorganisms. Chemical degradation is more important than microbial degradation for some herbicides such as the triazine and dinitroaniline herbicides.

Chemical and microbial reactions depend upon soil moisture, and these reactions usually occur in the soil solution. Therefore, soil moisture affects herbicide degradation. Herbicides such as the triazines, phenylureas, and uracils have greater persistence in years of low rainfall, especially if soil temperatures are low. However, dinitroaniline herbicides degrade or are inactivated faster when soils are very wet and low in oxygen. Soil moisture level and soil temperature also affect the subsequent crop's growth and thus its "tolerance" to herbicide injury.

The herbicide or pesticide used subsequently can affect the possibility of injury from herbicide carryover. A soybean crop that may tolerate a certain level of atrazine carryover may be injured if another photosynthetic inhibitor such as metribuzin (Sencor or Lexone) is applied to the crop. Dinitroaniline carryover may be accentuated by use of another dinitroaniline herbicide on corn.

In addition, tillage can affect the potential for herbicide carryover. Minimum tillage that leaves crop residue on the soil surface also tends to leave the "carryover" herbicide concentrated near the soil surface, and sensitive crop seedlings are more likely to be injured when growing through this concentrated layer. Minimum tillage fields often require higher herbicide rates to maximize weed

control since tillage and cultivation are minimized. Ridge tillage may increase the herbicide concentration over the row if the herbicide is applied before the ridges are formed and if the ridge is not "cleared" of this additional soil during planting.

The probability of herbicide carryover can be determined by taking soil samples and using a bioassay or chemical test to determine the concentration of herbicide in the soil. The method of sampling is critical. A group of samples mixed together may lead to a false conclusion because an average will not tell you if "hot spots" exist and where they are. A soil sample taken several inches deep when the herbicide is concentrated in the top two inches will indicate average concentration even though the seed area--the critical area--actually contains a higher concentration.

In a bioassay, one or more sensitive species are grown in the "suspect" soil and compared to the growth from a "check" soil. This comparison makes it possible to separate carryover injury from injury caused by plant disease, environmental stress, and failing to water the plants at the right time.

Chemical test results are usually expressed as parts per million (ppm). Many farmers ask how to translate these test results into practical information. An acre-furrow slice (6.7 inches deep) weighs an average of 2 million pounds. If the soil sample comes from a depth of 3.3 inches, then the parts per million equals the pounds per acre of chemical. If the soil sample is from 6.7 to 10 inches deep, then the parts per million must be multiplied by 2 or 3, respectively, to obtain pounds per acre. Then the question arises, "How many pounds per acre will the crop tolerate?" This is difficult to answer definitively because it depends on the soil adsorptive capacity (clay and organic matter), the sensitivity of the crop, and the environmental conditions under which the crop is grown. Soybeans may tolerate 0.3 ppm of atrazine under some conditions (soil and climatic) yet be injured by 0.15 ppm under other conditions. Corn may be injured by 0.1 ppm of trifluralin under some conditons, yet tolerate 0.2 ppm under other conditions.

Although the potential for herbicide carryover cannot be easily predicted, some factors involved in carryover can be adjusted to reduce carryover potential. Herbicide rotation, crop rotation, and the tillage situation must be taken into account. Accurate calibration and application minimize the risk of herbicide carryover. Herbicide incorporation should distribute the herbicide as evenly as possible, both vertically and horizontally. Herbicide combinations can be used so that reduced rates of persistent herbicides can be applied. Delayed planting can minimize the risk of carryover in some situations by allowing a greater time for herbicide breakdown and more ideal conditions for crop growth.

Remember, early herbicide injury, such as that from carryover, does not always result in yield loss. However, to protect against yield loss from inadequate weed control, many farmers use a persistent herbicide. This is important under conditions in which weed control is needed longer than the normal 4 to 6 weeks, such as in dry years when the canopy does not close.

1987 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 twenty-five cents each.

DISEASES

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 my 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.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
CIRCULAR 1231 (revised annually) October 1986

ADJUVANTS

When it is compatible with the product label, add a spray adjuvant (surfactant) to the spray mix. Some commonly available surfacants are: Kalo: Bio 88, BioFilm and Regulade; Hopkins: Plyac; Rohm & Haas: Triton AG-98, Triton B-1956, Triton CS-7; Ortho: Chevron Spray Sticker, Chevron Spreader, X-77; Miller: NuFilm P and 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 than that in Table 2 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 Disese Control Recommendations for Field Crops

Crop	Diseases	Fungicide or nematicide	Comments
Alfalfa	Baterial 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 fetility 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. Varieties with reported resistance include Apollo II, Trumpeter, WL316, Decathelon, and Funk's G 2640. This disease will only be a problem in stands that are more than 3 years old.
	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		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 nitripyrin (N-Serve) 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 indidates 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 + zineb, captan + HCB + maneb, captan + PCNB, HCB + maneb, mancozeb, maneb, PCNB + etridiazol, TCMTB, thiram, Vitavax + thiram, carboxin + captan, Vitavax + metalaxyl, 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 seedling 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, and BSR 101 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. 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 resistance should be protected in the seedling stage with metalaxyl (Apron) fungicide applied as a seed treatment. Susceptible varieties or 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. One year can be a resistant bean such as Fayette (III), Franklin (IV), CN 210 (II), or CN 290 (II). 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 Illinios; 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.
	Pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, and purple seed stain	benomyl, thiabendazole, thiophanate-methyl, chlorothalonil	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, thiabendazole + 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.)	Powdery mildew	triadimefon	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.

Table 2. Classification, Common Names, and Trade Names of Pesticides Mentioned in This Report

Common name	Trade name	Use classification
aldicarb	Temik	Restricted-use
benomyl	Benlate	Unclassified
captan	Captan, Orthocide, and many others	Unclassified
captan + HCB	Orthocide-HCB, Miller's HCB 4 Flowable, and many others	Unclassified
captan + HCB + maneb	Res Q	Unclassified
captan + PCNB	Stauffer Captan-Terraclor 10-10 and 30-30 Seed Protectant, Orthocide PCNB 10-20 Dust, and many other	Unclassified
captan + thiabendizole	Agrosol, Agrosol Flowable	Unclassified
captan + zineb	Staples Dithane Seed Treatment Dust	Unclassified
captan + carboxin	Orthocide-Vitavax 20-20, Vitavax-Captan 20-20, Captan 20-Carboxin 20, Vitavax-Captan HBM25	Unclassified
carbofuran	Furadan	Restricted-use
carboxin	Vitavax 34	Unclassified
carboxin + captan	Enhance	Unclassified
carboxin + maneb	Enhance Plus	Unclassified
carboxin + thiram	Vitavax 200, Vitavax-T	Unclassified
chlorothalonil	Bravo 500, 720, 90DF, and 90DG	Unclassified
ethoprop	Mocap	Restricted-use
etridiazol	Terrazole	Unclassified
fenamiphos	Nemacur	Restricted EC formulations: restricted-use.
maneb	Manzate D, Manzate Flowable, Dithane FZ, M22 Special, Manex, and many others	Unclassified
maneb + HCB	Granox NM, Granox Flowable	Unclassified
maneb + thiabendazole	Granox Plus	Unclassified
mancozeb	Manzate 200 and 200 Flowable, Dithane M45, F45, Pencozeb	Unclassified
metalaxyl	Apron 2E, FL, and 25WP, Ridomil 2E and 5G	Unclassified
PCNB	Terraclor	Unclassified
PCNB + etridiazol	Terraclor Super X, Terra-Coat L21, L205, and SD205 Seed Treatment, Protreat L	Unclassified
TCMTB	Busan, Cover-Up, and Thiogem	Unclassified
terbufos	Counter	Restricted-use
thiabendazole	Mertect 340F, Mertect LSP	Unclassified
thiophanate-methyl	Topsin M	Unclassified
thiram	Arasan 50-Red, Thiram, Moly-Co-Thi, Stand-up, Thiram 42S, and many others	Unclassified
triadimefon	Bayleton	Unclassified
zineb	Dithane Z-78, Zineb	Unclassified

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 3) 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.

Table 3. 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 then 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.

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 4 can be used at early bloom 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-

Table 4. 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.

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; K.L. Athow, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN; R.L. Bernard, USDA-SEA, University of Illinois, Urbana-Champaign; C.M. Brown, Department of Agronomy, University of Illinois, Urbana-Champaign; D.I. Edwards, 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; Henryk Jedlinski, USDA-SEA, University of Illinois, Urbana-Champaign; L.J. Michel, USDA-SEA, Iowa State University, Ames; 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; W.O. Scott, Department of Agronomy, University of Illinois, Urbana-Champaign; G.E. Shaner, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN; and R.G. Timian, USDA-SEA, North Dakota State University, Fargo.

Wheat

		Recommended area of state[a]	Stem rust	Leaf rust	Loose smut	Septoria	Powdery mildew	Soil-borne mosaic	Barley yellow dwarf	Spot blotch	Pyreno-phora	Wheat streak mosaic	False black chaff	Wheat spindle streak
Spring														
Era		N	R	S[b]	MR	MS	MS			MR	MS			
Olaf		N	MR	MR	S									
Winter	*Type*													
Abe	(Soft)	N,C,S	R	S[b]	MS	S	MS	R	MS				R	MS
Argee	(Soft)	N	R	S	MR		MS	R	MR					
Arthur 71	(Soft)	N,C,S	R	S[b]	MS	MS	MS	R	MS				R	MS
Auburn	(Soft)	N,C,S	R	R	MR	R	MR	R	MS					MS
Beau	(Soft)	N,C,S	R	MS	MS	MR	MS	R	MS				R	MS
Becker	(Soft)	N,C,S		MR		MS	S	MR						R
Caldwell[c]	(Soft)	N,C,S	R	MR	MR	MS	MR	MR	MR		S			MS
Cardinal[c]	(Soft)	C,S	MS	MR										
Centurk 78	(Hard)	N,C	MR	MS	MR	S	S	MS	MR		MR	S		
Fillmore	(Soft)	N,C,S	R	R	MR	MR	MR	MS	MS					MS
Hart	(Soft)	N,C,S	S	S[b]	R	MR	VS	R	MR					MR
Newton	(Hard)	N,C,S	MR	MR				MR	MS					
Pike	(Soft)	N,C,S	S	S	MR	MS	S	MR	MR					MS
Roland	(Soft)	C,S	R	S[b]	MS	S	MS	R	MS			MS		MR
Rosen	(Soft)	S	R	S		S	S		MS					
Scotty	(Soft)	C,S	R	MR		MR	R	R	MS					
Siouxland	(Hard)	C,N	MR	MR		MS	MR	S						
Tyler	(Soft)	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; Blank = no information or disease is not important.

[a] Area of Illinois where variety is recommended: N = northern; C = central; S = southern.

[b] Susceptible to new races that are virulent on *Lr* 9 and very common throughout the central United States in 1981 and 1982. Era is susceptible to nearly all leaf rust races as a seedling but has adult plant resistance that normally prevents leaf rust development on the flag leaf.

[c] Moderate resistance to take-all.

Variety	Recommended area of state[a]	Brown leaf spot (blight)	Bacterial blights	Leaf scald	Rust	Seedling disease complex	Northern leaf blight	Anthracnose
Bromegrass, smooth								
Barton	N,C,S					MS		
Baylor	N,C,S	R	MS	MS				
FS Beacon	N,C,S					MS		
Blair	N,C,S	R	MS	MS		MS		
Lincoln	N,C,S	MS	MS	MS		MS		
Southland	S	S	MS	MS				
Orchardgrass								
Able	N,C,S							
Boone	S	MS			MS			
Comet	N,C							
Dart	N,C,S				MS			
Dayton	N	MS			MS			
Hallmark	N,C	MS			MS			
Ina	S							
Jackson	N,S							
Napier	N,C,S	MS			S			
Potomac	N,C	MS			S			
Sudangrass								
Piper	N,C,S						MR	MS
Tall fescue								
Alta	N,C,S				MR			
Fawn	N,C,S				MR			
Kenhy	N,C,S				MR			
Kentucky 31	N,C,S				MR			
Kenwell	N,C,S				MR			
Timothy								
Clair	N,C,S							
Climax	N,C,S							
Itasca	C							
FS 954	N,C							
FS 955	N,C,S							
Pronto	C							
Timfor	N,C,S							
Toro	N,C							
Verdant	C							
Reed canarygrass								
Flare	N,C							
Rise	N,C,S							
Vantage	N,C,S							

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.

[a] Area of Illinois where variety is recommended: N = northern; C = central; S = southern.

Variety	Suggested area of the state[a]	Phytoph-thora rot[b]	Bacterial pustule	Powdery mildew	Pod and stem blight	Soybean cyst nema-tode	Purple seed stain	Frogeye leaf spot	Downy mildew	Sclerotinia white mold
Amsoy 71	N,C	R	S	VS	S	S	VS	S-2	S	S
Beeson 80	N	R-1-3,7-9	S	MS	S	S	S	R-1,2	S	
Bonus	S	R	S	S	S	S	S	S-2	VS	S
BSR 101[c]	N,C	R			MR		MR			
BSR 201[c]	N,C	R								
Calland	C,S	R	S	R	S	S	S	S-2	S	S
Century 84	N,C	R-1-9								
Century	N,C	R-1,2	S		S	S	S	S-2	MS	S
CN 210						R-3				
CN 290						R-3				
Corsoy 79	N,C	R-1-3,7-9	S	VS	S	S	S	S-2	MS	
Crawford	S	S	S		S	S	MR	S-2	S	
Cumberland	C,S	MS	R		MR	S	S	R-1,2	MS	
Cutler 71	S	R	S	R	S	S	S	R-1,2	S	
Dare	S	S	R		MS	S	S	R-1,2	MR	
DeSoto	C,S	S	S		S	S	S	S-2	S	S
Dyer	S		R		S	R-3				
Egyptian	S					R-3,4				
Elf	C,S	S	R	S		S	S	MR-2	S	VS
Elgin	N,C	S	R				S	S		
Essex	S	S	R	MR	S	S	MS	S-2	MS	
Fayette	C,S	S	R		S	R-3,4	S	S		
Forrest[d]	S	MR	R			R-3				
Franklin	S	R	R		S	R-3	S		S	S
Gnome 85	N,C	R-1-10,13-15,17,18,21,22	R		S	S				S
Hack	N,C	R-1,2,10-19,24								
Harcor	N	R-1,2	S		S	S		S-2		S
Hark	N	S	S	VS	S	S	S	S-2	S	
Harper	C,S	T	R				MR	MS-2		
Hobbit	C	S	R							
Hodgson 78	N	R-1,2			S	S	S	S-2		MR
Lawrence	S	S	R			S				
Nathan[e]	S					R-3,4				
Nebsoy	N,C	R-1,2	S		MR	S		S-2		S
Oakland	C,S	R-1,2	S	R	MR	S	S	S-2	MS	
Pella	C,S	R-1,2	S		S	S	S	S-2	S	S
Pixie	S	S			S	S	S			S
Preston	N,C	S								
Pyramid	S					R-3,4				
Ripley	C,S	T								
Sherman	C,S	S								
Sprite	S	S			S	S	S			S
Union	S	R	R	R	MS	S	S	S-2	R	MR
Wayne	C,S	MS	R	MR	S	S	S	R-1,MR-2	VS	MR
Wells II	N,C	R-1-3,6-9	S	VS	S	S	S	R-2	MS	
Will	C,S	S	R		MS	S	S	S	S	
Williams 82	C,S	R-1-9,13-15	R			S	S	S-2	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: T = field tolerance; VS = very susceptible; Blank = no information. Designations such as S-1,2 or R-1,2 indicate susceptible (S) or 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] BSR 101 and 201 are resistant to brown stem rot.

[d] Forrest is also highly resistant to wildfire, target spot, reniform nematode, and root-knot nematode.

[e] Nathan is also resistant to root-knot nematode.

Barley

Variety	Recommended 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	Helminthosporium 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
Paoli	C,S	MS	MS	MS			MR	S	S		MR	MR	MR
Pike	C,S	MS	S	S			MR	S	S		MR	MR	S

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.

[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						
Clintford	N,C	S	VS	R	MS	MS
Dal	N	MS	MR	MR	MS	MS
Froker	N	MR	MS	S[b]	S	MR
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
Wright	N	MS	S	MS[b]	MS	MS
Winter						
Compact	S	S	S	MR	S	MS
Norline	S	S	S	MR	MS	MS
Walken	S	S	S	MR	S	MS

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.

[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	Recommended area of state[a]	Powdery mildew	Northern anthracnose	Southern anthracnose	Viruses	Variety	Recommended area of state[a]	Powdery mildew	Northern anthracnose	Southern anthracnose	Viruses
Arlington	N,C	R	R		MR	Kenland	C,S	S	S	R	S
E-688	C,S	R	T	R		Kenstar	C,S	S	S	R	MR
Flare	N,C,S	R	MR	R		Lakeland	N	R	R	S	MR
Florex	N	R	R		R	Mega	N,C,S	R	R	R	
Florie	N,C,S	R	R	R	R	Redland	C,S	R	MR	R	S
						Redland II	C,S	R	R	R	
						Redman	N,C,S	S	R	MR	S
						Ruby	C,S	S	R	R	

Note: In this table, average disease reaction is indicated as follows: R = resistant; MR = moderately resistant; T = tolerant; S = susceptible; Blank = no information.

[a] Area of Illinois where variety is recommended: N = northern; C = central; S = southern.

Variety	Verticillium wilt	Bacterial wilt	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness[a]
Acclaim[b]	MR	R	MR			MR	MR	H
Action[b]	R	R				MR	R	MH
Anstar[b]		R				R	S	MH
Answer		R				MR	VR	MH
Apollo II[b]	MR	R				MR	R	H
Armor[b]		R				MR	R	MH
Arrow[b]	R	R				R	R	H
Baker		R	MR			MS	S	H
Blazer[b]		R				S	R	
Centurion[b]	R	R				R	R	H
Cimarron		MR	MR			R	R	MH
Conquest		R						
Dart[b]	R	R				R	R	MH
Defender		R				MR	MR	MH
DeKalb Brand 120		R					R	
DeKalb Brand 135[b]	R	R		R		MR	R	MH
Discovery		R	MS				S	H
Drummor			R			MR	R	H
Duke[b]		R				MR	R	MH
Dynasty[b]	R	R					R	
Edge	R	R				R		
Epic		R				S	R	
Expo		R				MR	R	MH
Funks G-2815[b]		R				MR	MS	MH
Funks G-7730		R				MS	R	
Futura		R				MR	MR	H
Glory		R	R					H
Hi-phy		R					R	
Honeoye		MR	MS	MS	MS	S	S	H
Jubilee[b]		R				R-MR	R	H
Magnum		R					MR	
Marathon		MR	MS	MS		S	S	MH
Mercury[b]		R				MR	R	H
Olympic		R	MR			R	S	H
Oneida		R					R	H
Oneida VR	R	R					MR	H
Pacer		R	MR	MR	MS	S	MS	H
Peak		R				MS	R	
Perry		R				MR	S	H
Pioneer Brand 555		R				MS	MS	MH
Pioneer Brand 5432[b]	R	R					MR	H
Pioneer Brand 526[b]		R				MS	MS	H
Pioneer Brand 532[b]		R				MS	S	
Pride Polar II		R					R	H
Pride Preserve[b]		MR	R			MS	MR	H
Primal		R						H
Raidor		R				MR	S	MH
Riley		VR				R	S	MH
Salute		VR				MR	R	MH
Saranac AR		MR	MR	MS	MS	R	S	H
Shenandoah[b]		R				R	R	MH
Sparta	R	R				S	MR	H
Spredor 2		R				S	S	H
Stetson[b]	R	R				R	R	MH
Summit[b]	R	R				R	R	MH
Sunrise		R						MH
Surpass[b]	R	R				R	R	H
Tempo		MR	MR	MS	MS	S	S	H
Thunder		R				MR	R	H
Trident		R					VR	H
Trumpeter	MR	MR				R	S	H

Alfalfa (continued)

Variety	Verticillium wilt	Bacterial wilt	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness[a]
Valiant[b]	R	R				R	SR	H
Vancor		R				R	MR	H
Vernal		R	MS	MS	MS	S	S	H
Vertat[b]	R	VR				R	R	MH
Voris A-66[b]		R				R	R	H
Voris VA-60		R				S	R	H
Voris A-77[b]		VR				R	MS	H
WL-215		R	MS	MS	MS	S	MS	H
WL-219		R	MR	MS	MS	MS	MS	H
WL-225	R	R				MR	R	H
WL-221		R				MR	S	H
WL-315[b]		R				MR	MR	H
WL-316[b]	R	MR				R	S	H
WL-318		MR	MS	MS	MS	MR	MR	MH
WL-320[b]	MR	R				MR	R	MH
Wrangler[b]	R	R					R	H

NOTE: In the table, average disease reaction is indicated as follows: VR = very resistant; R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information.

[a] Winter hardiness is based primarily on autumn growth ratings: VH = very hardy; H = hardy; MH = moderately hardy; MS = winter hardiness is questionable.

[b] Fusarium wilt resistant.

This circular was prepared by B.J. Jacobsen, M.C. Shurtleff, H.W. Kirby, and T.A. Melton, Extension Plant Pathologists with the Department of Plant Pathology, University of Illinois at Urbana-Champaign. The suggestions given in this circular are revised annually.

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1987 Disease Management Guide for Commercial Vegetable Growers

THE SUCCESSFUL CONTROL OF VEGETABLE DISEASES requires an integrated program that includes the use of resistant varieties, disease certification programs, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture as well as the selective 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 contains 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 or be sure to obtain planting material that is certified free of disease.

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 October 1, 1986. 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.

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. The record sheet at the end of this circular provides a convenient place to record such information.

This circular is revised each year. Be sure you are using the most recent copy.

Prepared by Barry Jacobsen and Tom Melton, Department of Plant Pathology

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE

Urbana, Illinois Circular 1184 (revised annually) November 1986

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LIMITATIONS ON DAYS BETWEEN APPLICATION AND HARVEST AND OTHER RESTRICTIONS WHEN USING FUNGICIDES ON VEGETABLES IN ILLINOIS

Crop	Benlate[a]	Captan (D)	Chlorotholonil[b]	Di-folatan	Dyrene	maneb[c]	mancozeb[d]	Folpet Phaltan	zineb
Asparagus	..	root dip	..	..	..	A	A	..	A
Beans (dry, lima, snap)	14, 28 on lima, B	pp, 0	7, B (snap only)	..	..	0, 4 on limas or snap	..	..	7
Beet, garden	..	0, pp	..	..	..	..	..	..	7
Broccoli	..	pp	0	..	..	7, or trim and wash, 3	..	..	7
Brussels sprouts	..	pp	0	..	..	7	..	..	7
Cabbage	..	pp	0	..	..	7	..	..	7
Cantaloupe (muskmelon and honeydew melon)	0	0, ph, pp	0	0	0	5	5	0	5
Carrot	4	0	0	..	..	0	7, B (tops)	..	7 (tops)
Cauliflower	..	pp	0	..	..	7	..	..	7
Celery	7	0, pb	7	..	0	14, strip and wash	14	7	14
Chinese cabbage	..	..	..	..	..	..	..	..	7
Corn, sweet and pop	..	10, B, pp	14, B[e]	..	..	0, B, C	7, B	..	0, B, C
Cucumber	0	0, ph, pp	0	0	0	5	5	0	5
Eggplant	..	0, ph, pb	..	..	..	0	..	..	0
Endive, escarole	..	..	..	..	..	10, and wash	..	..	10
Fennel	..	..	..	..	..	..	7	..	..
Kale, collard	..	pp	..	..	..	10, and wash	..	..	7, collard 10,kale
Kohlrabi	..	pp	..	..	..	7	..	..	halfgrown
Leek	..	..	..	..	0	..	..	0	..
Lettuce	..	0	..	..	..	10, strip and wash	..	0	10
Mustard greens	..	pp	..	..	..	10, and wash	..	..	10
Onion	..	0, ph	green, 14; dry, 7	0	0	0	7, D	0	7
Parsley	..	..	..	..	..	..	..	..	..
Parsnip	..	..	..	..	..	..	..	..	..
Peas	..	pp	..	..	..	..	..	..	10
Pepper	..	0, pb, pp	..	..	..	0	..	..	0
Potato, Irish	..	0, ph	0	0	0	0, C	0	..	0 and seed, C, pp
Pumpkin	0	0, pp	0	..	0	5	..	0	0
Radish	..	..	..	..	..	..	..	..	0
Rhubarb (greenhouse)	..	0	..	..	..	0	..	..	..
Shallots	..	..	..	..	0	..	..	0	..
Spinach	..	0, pp	..	..	..	10, and wash	..	..	10
Squash	0	0, pp	0	..	0	5	5	0	5
Sugar beet	21	0	..	..	..	14, B, C	14, B	..	..
Swiss chard	..	0	..	..	..	..	..	..	10
Tomato	0	0, pp	0	0[f]	0	5, F	5	0	5
Turnip, rutabaga	..	pp	..	..	..	7, and wash	..	..	7 (tops)
Watermelon	0	0, pp	0	0	0	5	5	0	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.
E = Do not apply after fruit buds form.
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 500, 720, 90DG, and 90DF. It is also sold in combination with metaloxyl as Ridomil/Bravo 81W. This combination product is registered for use on broccoli, cabbage, cauliflower, melons, onions, potatoes, squash, and tomatoes.
[c] Maneb is sold as Maneb 80, Dithane M22, Dithane FZ, Manzate Flowable, and Manzate. Maneb with zinc salt is sold as Dithane M22 Special, Manzate D, Manex, and Manzate Flowable Fungicide.
[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] Machine harvest only.

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.** Do not apply to any field more than once in any two years.
Botran	**Beans** (snap) — white mold, 2 days to harvest. Do not feed forage to livestock. **Greenhouse tomato** — to harvest. Do not drench seedlings or newly set transplants. **Carrot** — postharvest dip or spray, see label. **Garlic, onion** — soil application before seeding or spray to soil around sets or bulbs. *Do not plant spinach* as a followup crop in treated soil. **Leaf lettuce** (greenhouse) — 14 days[a] (do not apply to wilted plants or seedlings). **Head lettuce** — 14 days. **Celery** — 7 days. **Cucumber** (greenhouse) — see label. **Rhubarb** (greenhouse) — 3 days. **Potato** — 14 days (do *not* feed to livestock). **Sweet potato** — root dip and plant bed treatment. **Note:** Do not plant tomatoes as followup in treated soil. Don't use spent roots for food or feed. Postharvest spray or dip as directed. **Tomato** (greenhouse) — 3 days.
carbofuran (Furadan 10G)	**Corn** (sweet and pop) — Nematodes. Apply in band or furrow at planting. **Cucumber, melon, squash, pumpkin** — apply in band at planting.
chloroneb (Demosan)	**Beans** — seedling diseases. Seed treatment or in-furrow spray at planting.
Copper fungicides[b]	
tribasic copper sulfate (many trade names)	**Bean, beet, broccoli, Brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, potato, pumpkin, radish, spinach, squash, tomato, watermelon.**
copper sulfate (many)	**Bean, broccoli, cabbage, cantaloupe, cassaba melon, cauliflower, celery, cucumber, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, watermelon.**
copper resinate (Citcop 4E, Cop-O-Cide, Emulsifiable Liquid Copper Fungicide)	**Bean, broccoli, cantaloupe, cauliflower, chinese cabbage, carrot, celery, cucumber, honeydew melon, lettuce, muskmelon, onion, pepper, pumpkin, squash, tomato, turnip, watermelon.**
copper ammonium carbonate (Copper-Count N)	**Bean, cabbage, carrot, crenshaw melon, celery, cantaloupe, cassaba melon, cucumber, honeydew melon, lettuce, muskmelon, pepper, Persian melon, potato, squash, tomato, watermelon.**
copper hydroxide (Kocide 101 and 404)	**Bean, broccoli, Brussels sprouts, cabbage, cantaloupe, carrot, celery, cucumber, honeydew melon, muskmelon, pepper, potato, pumpkin, squash, tomato, watermelon.**
copper oxychloride sulfate (COCS, Copro 50 and 53)	**Bean, beet, broccoli, Brussels sprouts, 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 sprouts, cabbage, carrot, cassaba melon, celery, collards, crenshaw melon, honeydew melon, horseradish, kale, mustard, pepper, rape, rutabaga, spinach, cress, cucumber, eggplant, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, turnip, watermelon.**
dinocap (Karathane)	**Cantaloupe (muskmelon), cucumber, honeydew melon, pumpkin, squash, watermelon** — 7 days. For control of powdery mildew only.
etridiazol (Terrazole, Truban)	Seed treatment: **Beans, peas, sugar beets.**
ethoprop (Mocap)	Nematodes. **Beans, cucumber, potato, sweet potato.**
fenamiphos (Nemacur 15G)	Nematodes. **Brussels sprouts, cabbage,** and **okra.**
Iprodione (Rovral)	**Head lettuce** — lettuce drop and bottom rot, no more than 3 treatments. **Garlic** — white rot. **Onion** — Botrytis and Alternaria purple blotch. 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 2E)	Seed treatment for control of Pythium and Phytophthora root rot on **sweet corn, popcorn, peas, snap and dry beans.**
(Ridomil 2E)	*(Greenhouse).* **Tomatoes, cucumbers, melons, squash** — Pythium damping-off. Apply 2-4 tablespoons in 2 gal water per 150 sq ft before or at the time of seeding. Follow with ½ inch water to incorporate. *(Field use).* **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. **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 irrigtion. **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. **Beans** (field, French, kidney, lima, mung, navy, pinto, snap, wax, broad), **peas** (chick, field, garden, southern, sugar), **lentils, 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. **Onions, leafy vegetables, lettuce** (head), **spinach.** Pythium damping-off. Apply either broadcast or banded at planting. Follow label directions.
(Ridomil MZ58)	**Cucumber, melon** — 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 disease problems exist. Corn, root crops, or the aforementioned crops may be planted the year following use; other crops may not be planted until 18 months after treatment.
metiram (Polyram)	**Potato, sugar beet** — no time limitations. **Celery** — 14 days. **Cantaloupe, cucumber, tomato** — 5 days. Do *not* feed **sugar beet** tops to meat or dairy animals. **Celery** — strip, trim, and wash — 14 days. Postharvest application to **asparagus ferns. Corn** — fresh market only.
oxymal (Vydate L)	**Carrots, eggplant, peppers, potatoes, 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, Brassicol, Fungiclor)	**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 sprouts, 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	**Celery, pepper, tomato** — plant beds only (200 ppm spray); **Potato** — seed piece treatment only (100 ppm dip or dust). Soak cut seed pieces less than 30 min. **Beans** — seed treatment for halo blight control. Do not use treated seed for food or feed.
sulfur, lime, and lime-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.

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)	**Sweet potato** — "seed" root treatment. Do not use treated pieces for food or feed. **Potato** — "seed" tubers only (1,500 ppm-20 sec. dip). 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, limit of 4 applications per year. **Cucumbers, melons, pumpkin, squash.** For control of anthracnose, gummy stem blight, powdery mildew, and target spot — 0 days.
(TOPS 2.5D)	**Potato** — seed piece 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, beets, broccoli, Brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, collard, corn, cucumber, eggplant, endive, kale, kohlrabi, lettuce, okra, onion** (bulb, seed, and set), **peas, 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)	**Cantaloupe (muskmelon), cucumber, honeydew melon, pumpkin, squash, watermelon** — powdery mildew. May apply a maximum of 1 lb./A/yr. of 50% wp.
triphenyltin (Du-Ter, Super-Tin 4L)	**Carrot** — Alternaria leaf spot and late blight — 14 days. **Potato** — early and late blight. May be applied through irrigation systems (solid set or center pivot only).
vinclozolin	**Head lettuce** only. Sclerotinia drop (Ronalin). No more than 3 treatments. Limit of 28 days to harvest.
ziram	**Cucumber, melon** — 0 days. **Beans** (snap and lima) — 4 days. **Tomato** — 7 days.

[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.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT FOR DISEASES OF COMMERCIAL VEGETABLE CROPS FOR 1987

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. These diseases are best managed by good asparagus culture. Provide optimal soil fertility, and weed, insect and rust control. Avoid excessive cutting.
Rust, other leaf and branchlet blights	Grow rust-resistant varieties. Apply zineb, maneb, mancozeb, or Polyram to nonharvested fields up to August 15 and to harvested fields after harvest only. Applications should be made on 7- to 10-day intervals.
Beans (snap, dry, wax, and lima)	
Most diseases	When possible, use rotations of 2-3 years between bean crops.
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.) and well-prepared. Seed treatment with metalaxyl, thiram, captan, captan plus Terrazole, or chloroneb plus insecticide is suggested. In-furrow sprays of chloroneb or seed treatment with metalaxyl may be helpful for early season root-rot control.
Root rots	Pythium root rot can be controlled using Ridomil 2E as band or furrow treatment at planting. Maintain optimal soil fertility. Utilize crop rotations of 2-3 years.
Bacterial blights	Plant only western-grown, certified seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet. Streptomycin may be added to seed treatment fungicide/insecticide. Field applications of 2-3 pounds of fixed copper per acre will provide good control of brown spot and halo blight, only moderate control of common or fuscous blight.
Downy mildew and syringe blight (brown spot) on lima beans	Make early and weekly applications of maneb plus fixed copper. Eliminate lilac and wild cherry from field borders.
Rust, anthracnose, and other fungal leaf, pod, and stem diseases	Utilize crop rotations of 2-3 years. Apply maneb, zineb, or Bravo at 7- to 10-day intervals. 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.
Virus diseases	Plant varieties with resistance to bean common mosaic, NY15 strain of common mosaic, and bean yellow mosaic.
Soybean cyst nematode	Rotate 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.
Beets (garden and sugar), Swiss chard	
Seed rot, damping-off, and seed-borne leaf spot	Sow in a well-prepared seed bed. Treat seed with captan or thiram. Make sure boron levels are adequate.
Cercospora leaf spot	Apply zineb or fixed copper weekly at the first sign of disease.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Crucifer crops (broccoli, Brussels sprouts, cauliflower, cabbage, chinese cabbage, collards, kale, kohlrabi, mustard, radish, rutabaga)	
Seed rot, damping-off, black rot, blackleg	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.
Wirestem (*Rhizoctonia*)	Incorporate PCNB-captan in upper 3 inches of soil before planting or drench after planting.
Clubroot	Apply PCNB (Terraclor 75) in transplant water.
Black rot and blackleg	Use a crop rotation of 3-4 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. 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, zineb, chlorotholonil, or Ridomil/Bravo 81W on weekly intervals. Start applications in seed bed or when plants are young. Ridomil 2E soil treatment at planting will control downy mildew.
Tipburn	Plant resistant varieties.
Fusarium yellows	Plant yellows-resistant varieties.
Radish black root	Plant resistant varieties.
Nematodes	Mocap (cabbage only) or Nemacur (Brussels sprouts and cabbage only) may be applied at planting.
Carrots, Parsnips	
Seed rot, damping-off	Treat seed with captan or thiram.
Cercospora leaf spot, Alternaria leaf blight	Apply maneb, mancozeb, zineb, or Bravo on 7-10 day interval.
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 D-D, Telone, Vapam, or Vorlex, *or* practice a 3-year rotation with corn or some other nonhost crop with which broadleaf weed hosts will be controlled. Vydate L may be applied at planting (carrot only).
Parsnip canker	Spray with fixed copper at a 10-day interval in late season (August) until the tops die. Ridge soil over the shoulders.
Celery, Parsley	
Seed rot, damping-off, seed-borne leaf blights	Treat plant seed with hot water, then captan or thiram. If damping-off starts, spray 2-3 times, 5-7 days apart with zineb. Seed 2-3 years old is free of late blight.
Leaf blights and spots (celery only)	Spray maneb, zineb, 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, seed-borne diseases	Plant seed treated with captan, thiram, metalaxyl plus captan, or Vitavax-thiram and insecticide.
Goss' bacterial wilt	Use 2- to 3-year crop rotations when using susceptible corn (dent or sweet) varieties.
Stewart's disease	Control flea beetles with insecticide, or plant tolerant hybrids.
Smut	Plant tolerant hybrids.
Maize dwarf mosaic, Wheat streak mosaic	Control Johnsongrass and volunteer wheat. Plant wheat after the fly-free date. Some hybrids tolerate maize dwarf better than others, but no hybrids are highly resistant.
Helminthosporium leaf blights, anthracnose leaf blight	Spray mancozeb, zineb, maneb, Polyram, or Bravo when disease first appears. Crop rotation and clean tillage will help reduce disease risk.
Rust	Spray the same as for Helminthosporium blights or plant resistant varieties.
Nematodes	Apply Furadan, Counter, or Mocap (sweet only) at planting.
Vine Crops (cucumbers, muskmelons (cantaloupe), pumpkins, squash, and watermelons)	
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 bed drench.
Bacterial wilt	Provide season-long control of striped and spotted cucumber beetles. Start as the plants emerge. Planting-time treatment with Furadan will provide moderate control for 3-4 weeks. Supplemental insecticide use will be necessary.
Anthracnose, scab, blossom blights, gummy stem blight, or black rot	Grow resistant varieties whenever possible. Spray weekly with maneb, zineb, Bravo, Dyrene, Difolatan, Benlate, or Topsin M.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Vine Crops (cont.)	
Downy mildew, Alternaria leaf blight	Grow resistant varieties whenever possible. Maintain ample but *not* excessive nitrogen fertility. Apply maneb, zineb, mancozeb, Dyrene, Bravo, or Difolatan on a weekly schedule. Ridomil/Bravo 81W provides excellent control of downy mildew.
Fruit spots and rots	Maintain fungicide schedule as for anthracnose through the season. Avoid harvest injuries.
Fusarium wilt	Grow resistant varieties.
Angular leaf spot	Apply fixed copper sprays in combination with zineb, 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, Topsin M, or Bravo is applied to control other diseases, mildew will be controlled under moderate disease pressure. Plant resistant varieties where possible.
Mosaics	Control aphids and beetles in the field. Control broadleaf weeds around field borders. 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, 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.
Phomopsis blight, Alternaria leaf spot, Cercospora leaf spot, and anthracnose	Spray plants weekly with maneb, zineb, or captan at first sign of disease or when first fruits are half sized.
Verticillium wilt, nematodes	Fumigate the soil with Vapam, Vorlex, or methyl bromide plus chloropicrin. Planting in black plastic mulch will help reduce disease severity. Vydate L will control nematodes.
Horseradish	
Leaf spots	Apply fixed-copper fungicides. Start when conditions are wet or dews are heavy. Continue until a killing frost occurs.
Brittleroot	Plant clean sets. Control leafhoppers.
Verticillium wilt, nematodes	Fumigate the soil before planting with Telone C-17.
Lettuce, Endive	
Seed rot, damping-off, Gray mold	Treat seed with captan. In the field or seed bed, work Botran into the soil before planting and spray Botran after thinning or transplanting and again as necessary. Ferbam or zineb can be used as drenches to control damping-off.
Aster yellows	Control leafhoppers throughout the season. Early season control is most important.
Rhizoctonia bottom rot, Sclerotinia drop	Plant on beds and deep plow when possible. Apply Rovral at 3-leaf stage and again 10 days later. A third application may be made 10 days later if disease conditions warrant. Botran applications as previously described may help. Ronalin should be applied 2 days after thinning, 14 days later, and 14 days after the second spray. Use 100 gallons of water carrier per acre.
Gray mold, white rust, downy mildew	Apply ferbam, maneb, or zineb at 5- to 7-day intervals.
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.
Fusarium wilt or Verticillium wilt	Fumigate soil with Vorlex, Vapam, or methyl bromide plus chloropicrin.
Onions, garlic, leek, chives	
Smut, seed rot, damping-off	Treat the seed with captan or thiram. Use Methocel sticker to pellet the fungicide with seed. Use 1 pound of active ingredient to 20 pounds of seed for set onions; 6 pounds of active ingredient to 8 pounds of seed for bulb onions.
Blast, downy mildew, Alternaria purple blotch, Botrytis neck rot	Apply maneb, zineb, mancozeb, Difolatan, Dyrene, Phaltan, Rovral, or Bravo on a weekly schedule. Begin spraying with first ozone alert. Continue until harvest. Bravo has given superior control in research trials. Use Ridomil MZ58 or Ridomil/Bravo 81W when downy mildew appears.
Bulb and stem nematode, Root-knot nematode	Fumigate with Telone, D-D, Vapam, or Vorlex.
White rot of garlic	Apply Rovral on cloves and furrow covering soil.
Fusarium basal rot	Avoid heavily infested fields. Grow resistant varieties.
Storage decays	Maintain excellent control of leaf diseases in the field. Maintain dry storage conditions.
Yellow dwarf mosaic	Control aphids. Keep old and new plantings as far apart as possible.
Peas	
Seed rot, seedling and seed-borne diseases	Plant western-grown seed treated with captan, thiram, or zineb plus insecticide. Graphite at 1 ounce per bushel may be added to reduce friction in the drill.
Root rot	Index production fields. Avoid planting in fields with an index of 75 or higher. In fields with a lower root rot index, dinoseb (Premerge 3) or trifluralin applied preplant incorporated will provide good to excellent control.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Peas (cont.)	
Fusarium wilt, near wilt, and virus diseases	Grow resistant varieties.
Powdery mildew	Apply lime-sulfur dust (4:6 ratio) at 30 pounds per acre when mildew first appears and temperatures are less than 80° F. Two applications a week apart will provide good control.
Fungal leaf spots and blights	Apply zineb weekly when necessary.
Peppers	
Seed rot, damping-off, and seed-borne diseases	Treat seed with hot water or a sodium hypochlorite (household bleach) soak, then use captan or thiram. The sodium hypochlorite soak will control seedborne bacterial spot. Use 1 part bleach to 3 parts water, soak 1 to 2 minutes. Use 1 gallon of bleach-water solution to 1 pound of seed. Rinse thoroughly before treating with fungicide.
Bacterial spot	Use crop rotations of 2-3 years, excluding small grains and tomatoes. Control broadleaf weeds in field borders. Apply copper plus streptomycin to seedlings. After transplanting, apply fixed copper plus maneb or mancozeb, 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.
Anthracnose, Cercospora leaf spot, other fungal leaf spots, and fruit rots	Apply maneb or zineb after first fruits form on a 5- to 7-day interval.
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 and broadleaf weeds in and around fields. Plant only healthy transplants.
Potatoes (Irish)	
General	Purchase only certified seed. Seed-production fields should be inspected for virus, nematode, or fungal disease problems.
Seedpiece decay, seed-borne diseases, Verticillium wilt, and Blackleg	Treat seed with captan, maneb, mancozeb, or with TOPS 2.5D (Topsin plus Douglas fir bark). Keep seed storage at approximately 40° F. during the winter. In the spring, warm the seed to 60°-70° F. for 1.5-2 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. Working PCNB into the top 4-6 inches of the soil at or before planting may help.
Storage rots	Store healthy, sound, unbruised potatoes. Maintain a proper storage environment. Apply Mertect 340F as a spray to unwashed tubers before storage. This will help control Fusarium dry rot.
Rhizoctonia	Use a Terraclor EC soil treatment.
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	Apply maneb, mancozeb, Difolatan, 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 infection is present.
Virus diseases and Purple-top wilt (Aster yellows)	Plant certified seed only. Control aphids and leafhoppers with insecticides.
Rhubarb (greenhouse only)	
Botrytis leaf rot	Apply maneb or copper after budding and at weekly intervals until harvest.
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 resistant varieties or spray with captan, maneb, or zineb on a 5- to 7-day schedule starting before the plants begin to rosette.
Cucumber mosaic virus or blight	Grow resistant varieties.
Sweet potatoes	
Black rot, foot rot, Fusarium wilt and scurf	Grow resistant varieties. Plant disease-free roots and use crop rotations of 3-4 years. Dip the roots or sprouts in Botran or Mertect 340F.
Storage rots	Fumigate storage crates and houses with formaldehyde. Use Botran as a postharvest dip. Store only healthy, blemish-free roots.
Nematodes	Plant resistant varieties. Use crop rotation. Temik, Mocap, Vydate L, or Dasanit (suppression only) may be used for chemical control. Fall fumigation with Vapam or Vorlex may also be used.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Tomatoes (field)	
Seed decay, damping-off, and seed-borne diseases	Plant hot-water- or sodium-hypochlorite-soaked seed that has been treated with captan or thiram. See treatment for pepper seed. Use Ridomil bed drench for Pythium damping off.
Bacterial spot and bacterial speck	Purchase certified, disease-free plants. Use crop rotations of 2-3 years, excluding small grains. In the seed bed, spray with fixed copper plus streptomycin. After transplanting, spray with fixed copper plus mancozeb. Once established, bacterial spot is difficult to control.
Septoria blight, early blight, buckeye rot, gray leaf spot, and leaf mold	Apply maneb, mancozeb, Polyram, zineb, Dyrene, Bravo, or Difolatan on a 7- to 10-day schedule after the first sign of disease or after the first fruits form. Difolatan may be used only on machine-harvested fruit. A soil surface spray of Difolatan or maneb after the last cultivation will improve anthracnose control. Benlate may be used for Botrytis and Septoria control. Ridomil 2E or Ridomil/Bravo 81W will help control buckeye rot.
Blossom-end rot	Mulch plants or maintain uniform soil moisture. Applications of calcium nitrate starting when the fruits are grape size may reduce losses.
Verticillium wilt and Fusarium wilt	Grow resistant varieties.
Viruses	Take care to avoid infesting 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 infected plants if possible.
Botrytis gray mold, leaf mold, and gray leaf spot	Avoid excessive humidity by heating and venting, especially at night during the late fall, early winter, and early spring. Spray weekly with Benlate, mancozeb, or Bravo *or* fumigate with Exotherm Termil.
Nematodes, root rots, and soil-borne TMV	Steam the plant beds.

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 which 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 to 12 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, Triton B-1956, Triton CS-7; Ortho: Chevron Spray Sticker, Chevron Spreader, X-77 Spreader; Miller: NuFilm P, NuFilm 17.

GENERAL SUGGESTIONS ON SOIL FUMIGATION

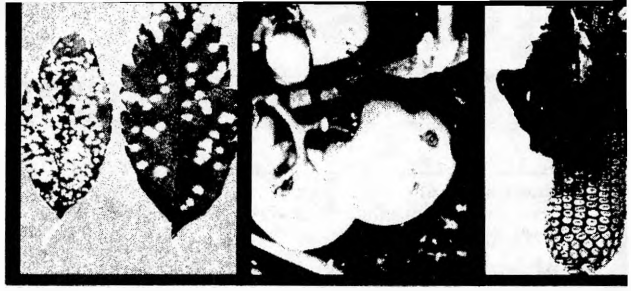
Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° F at the 6-inch depth, with a time lapse of 21-28 days between treating and seeding. Some require gas-tight plastic covers.

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 from Extension Plant Pathology, N-533 Turner Hall, 1102 South Goodwin Ave., Urbana, IL 61801.

Cooperative Extension Service

report on
PLANT
DISEASES



DEPARTMENT OF PLANT PATHOLOG
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAI

No. 900
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Controlling Diseases in the Home Vegetable Garden

B.J. Jacobsen, M.C. Shurtleff, J.W. Courter, and J.C. Schmidt

Diseases of vegetables grown in the home garden may reduce both the yield and quality of vegetables. Controlling such diseases often determines success or failure and adds immeasurably to the pleasure derived from the garden.

Diseases of vegetables are caused by microorganisms, including fungi, bacteria, viruses, mycoplasmas, spiroplasmas, and nematodes. These organisms are spread by wind-blown or water-splashed spores, insects, infected seeds or transplants, and by the movement of infested soil.

Vegetable diseases can be successfully controlled using an integrated disease control program. Such a program means using crop rotation, sanitation, disease-resistant or tolerant varieties, disease-free seeds or transplants, sound horticultural practices, balanced soil fertility (based on soil tests), and proper and timely applications of pesticides. All diseases of any one vegetable cannot be controlled by any single practice. Therefore, several measures must be used to achieve satisfactory control.

DISEASE CONTROL BEFORE THE GARDEN IS PLANTED

Choose and prepare the site. The site for the vegetable garden should be well-drained, have adequate sunlight (8 or 10 hours of direct sunshine per day), and good air circulation. The soil should have adequate soil fertility and the proper pH (5.5 to 7.0). Information on garden location, soil fertility, and soil pH can be found in Illinois Extension Circular 1150, *Vegetable Gardening for Illinois*. Another excellent reference for advanced gardeners is the *Vegetable Production Handbook*, Circular 1241. (Copies of Circular 1150 for $6 each and copies of Circular 1241 for $4 each are available from the Office of Agricultural Publications, 54 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801.)

If the area has produced garden vegetables for several years, sanitation and rotation practices will reduce the risk of disease-causing organisms that have survived from preceding crops. Removing or turning under dead and diseased

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plant material in the fall is important in disease control. Crop residues from healthy plants can be composted and returned to the garden.

Disease-causing fungi and bacteria can survive composting unless the decomposition of the crop residue is COMPLETE, a situation that seldom occurs. Therefore, we suggest that no diseased plant parts be placed in the compost pile. Some disease organisms will even survive complete composting, including corn smut; clubroot of cabbage, broccoli, cauliflower and other crucifiers; Verticillium wilt of potato, tomato, pepper, and eggplant; and root-knot nematodes.

Turning (plowing or tilling) under crop residues in the fall helps prevent the overwintering of many disease-causing organisms. Besides destroying the "winter home" of various organisms, this practice also helps control the insects that transmit certain diseases. Also, crop debris that is turned under improves soil tilth and makes spring garden work easier.

Crop rotation. Crop rotation is an important control measure since many disease-causing organisms only attack related plants in the same family. Unrelated plants do not serve as hosts on which these organisms can multiply. Therefore, if possible, avoid planting any vegetables WITHIN each of the following groups in the same location more than once every three years.

Cole crops--(cabbage family) broccoli, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, mustard greens, kohlrabi, radish, rutabaga, and turnip.

Cucurbits--(cucumber family) cucumber, gourds, muskmelon, pumpkin, squash (all types), and watermelon.

Solanaceous crops--(tomato family) eggplant, husk tomato (ground cherry), potato, pepper, tomato.

Chenopodiaceous crops--beet (red and sugar) and spinach.

Amaryllidaceae--(onion family) chives, leeks, onions, shallots, and garlic.

Legumes--pea, beans (all types).

Umbelliferous crops--carrot, parsnip, celery.

For example, cabbage, broccoli, radish, or turnips should not be planted in the same location for two successive years. Cabbage could be followed with beans, a vine crop such as cucumber, or with sweet corn.

Diseases affecting beans, peas, sweet corn, carrot, lettuce, spinach, rhubarb, okra, the edible soybean, and similar plants are usually specific to only one of these crops, and generally will not infect others or members of the major vegetable crop groups.

Choose disease-resistant varieties. The use of well-adapted, disease-resistant varieties is the simplest and most-efficient method of controlling many diseases. Lists of disease-resistant vegetables recommended for use by Illinois gardeners are given in Circular 1150, *Vegetable Gardening for Illinois*. Additional information on disease resistance is also given in the following paragraphs. Only those varieties that have been recommended by the Department

of Horticulture, UIUC, for Illinois home gardeners and that have disease resistance are listed in this publication. A more complete listing of varieties and their resistance can be found in Circular 1174 *Vegetable Varieties for Commercial Market Growers*.

Start with disease-free seeds, plants, and planting materials. It is important to start with disease-free seeds or planting materials (bulbs, tubers, sets, and so on) to keep from introducing serious diseases into the garden. In general, gardeners are encouraged NOT to save their own seed but to purchase seed from reputable seed dealers. Hot-water soaks and fungicide seed treatments may be used to control the seed-borne disease organisms that cause seed rots and damping-off. Since temperature controls and timing must be precise, home gardeners usually buy seed that has already been treated with hot water by the seed processor. Hot-water treatment of cabbage, broccoli, Brussels sprouts, and cauliflower seed is particularly important. More information on hot-water and fungicide seed treatments can be found in *Report on Plant Diseases* No. 915, "Vegetable Seed Treatment."

Many vegetable seeds are coated with a fungicide at the time of purchase, as evidenced by the colored coating on the seed. Untreated seed can be treated by the home gardener by placing a small quantity (the size of one or two match heads) of captan or thiram in the seed packet and shaking the packet for a minute or two in order to thoroughly cover the seed. Excess protectant may be sifted out before planting.

Do not plant diseased material (for example, transplants, sets, bulbs, or tubers). All planting material should be healthy and free of yellowing and brown or black spots, and should not be stunted or show poor development. Only certified, disease-free potato tubers or sweet potato slips should be used. Examine transplants thoroughly for signs of leaf or stem disease. It never pays to buy and plant diseased transplants, no matter what the price!

Damping-off diseases affecting home-grown vegetable transplants can be controlled by the thorough use of disease-free soil and fungicides. Specific recommendations are given in *Report on Plant Diseases* No. 916, "Damping-Off Diseases of Vegetables."

CULTURAL PRACTICES

Cultural practices such as controlling weeds, planting at the right time, using the proper depth and spacing, employing cages or stakes, and watering when the temperature is rising to promote a rapid drying of the foliage can help control many foliar diseases. Mulches help to control fruit rots and aid in control of blossom-end rot of tomato and pepper by maintaining a uniform supply of moisture in the soil. Weed control in and around the garden reduces the risk of attacks by viruses that overwinter in these plants. Do not work or harvest wet plants, since doing this can spread many diseases, particularly those caused by bacterial and fungal pathogens.

Soil disinfestation. Where diseases such as Verticillium and Fusarium wilts, root and crown rots, root-knot nematodes, or other soilborne diseases build up in garden soils, fumigation can rid the garden of these diseases; also, it may be an alternative to moving the garden. With proper caution, homeowners can apply Stauffer Vapam Soil Fumigant as a drench to fumigate their gardens. CAREFULLY follow the manufacturer's directions when using this material or any

other pesticide. Planting must be delayed for 3 to 4 weeks after treatment, therefore, fall fumigation is best. The soil must be above 55° F at the 4-inch level for successful treatment. Most fumigation is done in the fall.

DISEASE CONTROL DURING THE GROWING SEASON

Many diseases, such as the early blight disease of potato and tomato, occur each year despite all preplanting precautions. For such diseases, applications of fungicides and bactericides to the growing plants may be needed. The best way to apply these materials is as sprays BEFORE the disease occurs. Often a wetting agent such as liquid detergent or soap (1/2 teaspoon in 1 gallon) is added to obtain more thorough wetting and coverage of the foliage. Apply sprays to the point of run-off on a 7- to 10-day schedule. This maintains a fresh or effective covering of fungicide and protects the new growth.

PRINCIPAL DISEASES OF VEGETABLES AND CONTROL MEASURES

Asparagus

Rust. Grow resistant varieties (Mary Washington, Martha Washington, Viking, Waltham Washington, or hybrids including Jersey Centennial, Jersey Giant, and Greenwich). Spray from harvest until mid-August on a 10-day schedule with zineb.

Crown rots. Maintain proper fertility and good soil drainage. Avoid overcutting. The hybrid varieties listed above have resistance to Fusarium crown rot.

Beans

Seed decay and damping-off. Use captan- or thiram-treated seed. Plant in a warm, moist, well-prepared seedbed.

Bacterial blights. Do not save seed from infected plants. Purchase seed from a reputable seed dealer. Spray copper bactericides such as Kocide 101, COCS, Copper Count N, or tribasic copper sulfate, at the first sign of disease, on a 7-day schedule until harvest. DO NOT work among wet plants.

Rust. Grow rust-resistant varieties. Spray at first sign of disease on a 7-day schedule with maneb, zineb, mancozeb, or Bravo. Do NOT apply within 7 days of harvest.

Mosaics. Grow resistant varieties. Table 1 contains a list of disease-resistant bean varieties.

Beets

Seed decay and damping-off. Plant seed treated with thiram or captan.

Leaf spots. Spray with zineb on a 7-day schedule. Do NOT spray within 7 days of harvest.

Table 1. Disease-Resistant Bean Varieties

Variety	Seed source[a]	Disease: Common bean mosaic	Disease: New York 15 strain of bean mosaic	Disease: Rust
Green Snap Beans				
Bush Blue Lake 274	BP, HA, SDY, HB, HO	x	x	
Contender	HB, HO, PA, ST, TW	x		
Provider	HA, HB, HO, ST, TW	x	x	x
Tendercrop	BP, HA, HB, HF, HO, SDY, ST	x	x	
Topcrop	BP, HB, HF, PA, TW	x		
Pole Snap Beans				
Blue Lake	BP, HB, NK, PA, ST	x		
Kentucky Wonder Rust resistant	BP, HB, HF, SDY, TW			x
Dade	FM, HF, NK	x		x
Yellow Wax Beans				
Cherokee	HF, HB			
Goldcrop	BP, HO, PA, SDY, ST	x	x	
Kinghorn Wax	NK, SDY, ST	x		

[a]For a key to seed sources, see page .

Carrots

Seed rot and damping-off. Plant seed treated with captan or thiram.

Leaf spots. Spray weekly with maneb, zineb, mancozeb, or Bravo, starting about mid-June. Do NOT apply maneb, zineb, or mancozeb within 9 days of harvest. Here are some varieties that are resistant to Cercospora leaf spot: Gold Pak, Spartan Fancy, and Danvers 126.

Aster yellows. Destroy infected plants as soon as they appear. Apply insecticide sprays for leafhopper control. Spray before removing infected plants.

Crucifers (Cabbage, broccoli, cauliflower, Brussels sprouts, kohlrabi, mustard greens, radish, and the like.)

Seed decay, damping-off, black rot, and blackleg. Plant hot-water-treated seed which has also been treated with captan or thiram. Several black-rot-resistant cabbage varieties are now available.

Leaf spots and blights. Apply maneb, zineb, mancozeb, or Bravo on a 7-day schedule. Do NOT apply maneb, zineb, or mancozeb within 7 days of harvest. Bravo can be applied only to cabbage, broccoli, and brussels sprouts. Bravo may be applied up until harvest.

Clubroot. Purchase disease-free transplants. PCNB (Terraclor) may be added to the transplant water. Soil fumigation with Vapam will also give control.

Fusarium yellows. Grow only varieties that are resistant to yellows. Table 2 contains a list of cabbage varieties that are disease-resistant.

Table 2. Disease-Resistant Cabbage Varieties

Variety	Seed source	Disease	
		Yellows	Blackrot
Harvest Queen Hybrid	PA	x	x
Harris Resistant Danish	HA	x	
Market Prize	HA	x	
Resistant Golden Acre	BP, HA, SDY, TW, PA, HB, HO, HF	x	
Savoy Ace	HA, ST, PA, HB, BP, TW	x	
Stonehead	BP, NK, ST, PA, HB, HF	x	

Cucurbits (Cucumber, muskmelon, squash, pumpkin, and watermelon)

Seed rot and damping-off. Plant seed treated with captan. Plant in a warm, well-prepared seed bed.

Angular leafspot. Spray with a fixed copper fungicide, such as Kocide 101 or COCS. Remove diseased plant material. Plant resistant varieties whenever possible.

Anthracnose, Alternaria leafspot, downy mildew, blossom blights, fruit rots and spots, and gummy stem blight or blackrot. At weekly intervals, starting when the plants are in the two-leaf stage, spray maneb, zineb, mancozeb, Bravo, Dyrene, folpet, or one of these with benomyl.

Adequate nitrogen fertility is essential for the successful control of Alternaria leaf blight. Do NOT apply maneb, zineb, or mancozeb within 5 days of harvest. Plant resistant varieties when available.

Bacterial wilt. Spray with Sevin to control cucumber beetles as soon as the plants emerge. Continue weekly spraying until the plants are in bloom. Spray in the evening to avoid killing bees.

Fusarium wilt. Grow only those cantaloupe or watermelon varieties that are resistant to Fusarium wilt. Table 3 lists disease-resistant cantaloupe (muskmelon) varieties, and Table 4 lists watermelon varieties that are disease resistant.

Powdery mildew. Spray with dinocap or benomyl at the first sign of disease, and then weekly thereafter. Grow resistant varieties.

Mosaic and other virus diseases. Grow resistant varieties where possible. Only cucumber-mosaic-resistant cucumbers should be grown. Table 5 lists disease-resistant cucumber varieties.

Table 3. Disease-Resistant Cantaloupe (Muskmelon) Varieties

Variety	Seed source	Disease			
		Fusarium wilt	Downy mildew	Powdery mildew	Alternaria leaf spot
Burpee Hybrid	BP, HB, ST, TW	x			
Harper Hybrid	HA, HB, HO, SDY, ST, TW	x			
Harvest Queen	HO, TW	x			
Saticoy Hybrid	HA, HB, HO, PA, SDY, ST, TW	x	x	x	x

Table 4. Disease-Resistant Watermelon Varieties

Variety	Seed source	Disease	
		Fusarium wilt	Anthracnose
Allsweet	ST, TW	x	x
Crimson Sweet	BP, HB, HF, FM, ST, TW	x	x
Iopride	HA		x

Table 5. Disease-Resistant Cucumber Varieties

Variety	Seed source	Disease					
		Cucumber mosaic	Scab	Downy mildew	Powdery mildew	Anthrac-nose	Angular leaf spot
Burpless F-1 Improved	HB	x	x	x	x	x	x
Gemini	HA, PA, ST	x	x	x	x		
Marketmore 80	ST	x	x	x	x		
Pacer	HA	x	x				
Poinsett	BP, HA, HB, HF, PA, ST, TW	x	x	x	x	x	x
Spartan Dawn	ST	x	x				
Sweet Slice	BP, HB, HF, HO, PA, HA, SDY, TW	x	x	x	x	x	x
Sweet Success	BP, HB, PA, TW	x	x	x	x		

Eggplant

Seed rot, damping-off, and Phomopsis blight. Plant seed treated with captan or thiram.

Phomopsis blight and other fruit rots. Spray weekly with maneb, zineb, or captan when fruits are half size, or when disease appears.

Verticillium wilt. Fumigate the soil with Vapam. Follow the manufacturer's directions carefully. Mulching with black plastic may help reduce losses.

Okra

Verticillium or Fusarium wilt. Plant in noninfested soil or fumigate with Vapam. Follow the manufacturer's directions carefully.

Onion

Smut, seed rot, and damping-off. Plant seed treated with thiram or captan.

Leaf diseases. Spray weekly with maneb, mancozeb, Dyrene, folpet, or Bravo. Do NOT apply Bravo or mancozeb within 7 days of harvest on dry onions. Do NOT apply Bravo more than 3 times per season on green onions or within 14 days of harvest.

Bulb rots. Control leaf diseases. Also follow these recommendations: Avoid storing improperly cured or injured bulbs. Let all onion tops fall over (ripen) naturally. Store under cool DRY conditions. Do NOT allow cured bulbs to be exposed to sunscald, water, or high humidity.

Fusarium basal rot. Grow resistant varieties. Elba Globe, Nugget, and Spartan Banner are resistant.

Pea

Seed rot and damping-off. Plant seed treated with captan or thiram.

Root rot. Plant early in well-drained soils. Use a fungicide seed treatment.

Fusarium wilt. Plant only varieties that are resistant to wilt. See Table 6 for a list of disease-resistant varieties.

Table 6. Disease-Resistant Pea Varieties

Variety	Seed source	Disease		
		Fusarium wilt	Downy mildew	Root rot (tolerance)
Freezonian	BP, HA, HB, SDY	x		
Green Arrow	BP, HA, HF, HO, PA, ST	x	x	x
Thomas Laxton	HF, ST	x		
Sugar Snap	BP, HA, HF, HB, SDY, ST, TW	x		

Peppers

Seed rot and damping-off. Plant seed treated with captan or thiram.

Bacterial spot. Use the hot-water seed treatment, or dip seed in a solution of 1 part household bleach to 3 parts water and rinse with water. Follow with a fungicide seed treatment. Apply weekly sprays of a fixed copper fungicide, such as Kocide 101 or COCS, through the bloom stage. Use crop rotation outside the tomato family.

Tobacco mosaic. Plant resistant varieties. See Table 7 for a list of these varieties.

Table 7. Bell Pepper Varieties That Are Resistant to Tobacco Mosaic

Variety	Seed source
California Wonder	BP, HF, HB, ST, TW
Bell Boy	BP, HF, HB, TW
Keystone Resistant Giant	HA, HB, HF, NK, ST, TW
Ladybell	HA
Yolo Wonder	BP, HA, HB, HF, GE, NK, ST, TW

Potato

Viruses, late blight, Verticillium wilt, and ring rot. Plant only "certified" disease-free seed.

Seedpiece rots. Treat cut seedpieces with captan, zineb, or maneb as a dust or dip. Plant in warm soil (over 50°F).

Early blight and late blight. Spray at weekly intervals, starting when the plants are 4 to 6 inches high with maneb, mancozeb, Bravo, or Dyrene. Plant late blight-resistant varieties.

Verticillium wilt and root-knot nematodes. Plant resistant varieties, or fumigate with Vapam following the manufacturer's directions.

Scab. Plant resistant varieties, or adjust the soil pH to 5.2 to 5.5. Use fungicide seedpiece treatments. These varieties have good scab resistance: red potato (Norland, Norchief), white potato (Superior, Norgold Russet).

Storage rots. Store only disease-free, UNBRUISED tubers. Allow tubers to cure at 60° F for 5 to 7 days before reducing temperature to 36° to 40° F (if possible).

Sweet Corn

Seed rot and damping-off. Plant seed treated with captan or thiram.

Smut. Plant tolerant varieties. Remove smut galls from the garden before they break. Do not compost smutted corn or infected corn residues.

Stewart's bacterial wilt. Plant resistant varieties (see Table 8 for a list of varieties resistant to this and other diseases). Control flea beetles with Sevin or another recommended insecticide. Early season control is particularly important.

Foliage blight and rust. Plant varieties resistant to northern and southern corn leaf blights and rusts. Maneb, zineb or Bravo can be used for control; however, the use of fungicides is rarely justified. Diseased plant material should be removed from the garden. Blighted leaf tissue is safe to compost.

Maize dwarf mosaic. Plant as far from Johnsongrass as possible. Control wild Johnsongrass plants. Plant tolerant varieties. Aztec and Apache have some tolerance to the Maize dwarf mosaic virus.

Table 8. Disease-Resistant Sweet Corn Varieties

		Disease				
Variety	Seed source	Stewart's bacterial wilt	Smut tolerance	Rust	Northern corn leaf blight	Southern corn leaf blight
Aztec	SDY, ST	x	x		x	x
Bi-Queen	BP, HF, SDY, TW	x			x	x
Commanche	SDY, ST	x	x		x	x
Gold Cup	HA	x				
Gold Queen	HA	x				
Iochief	BP, CH, HF, GA, PA	x	x	x		
Seneca Chief	HA, ST	x		x		
Silver Queen	BP, HA, HB, HF, PA, ST, TW	x				
Stylepak	SDY, ST	x	x	x	x	

Spinach

Seed rot and damping-off. Plant seed treated with captan or thiram.

Cucumber mosaic virus (blight). Plant resistant varieties.

Downy mildew or blue mold. Plant resistant varieties.

The variety Melody has resistance to both cucumber mosaic virus and downy mildew.

Sweet Potato

Black rot, scurf, foot rot, wilt, soil rot. Buy certified, disease-free slips. Plant resistant varieties. Use a 3- to 4-year rotation. The varieties Allgold and Contennial have good resistance to wilt and soil rot; Allgold also has resistance to black rot.

Storage diseases. Do not expose roots to temperatures below 55° F. Cure the roots immediately after digging at 85° F and high humidity for 10 to 14 days. Store at 55° F. Never store in airtight bags or containers. Botran may be used as a post-harvest dip. Follow the manufacturer's directions carefully.

Tomato

Seed rot, damping-off, bacterial spot, bacterial canker, tobacco mosaic virus. Plant seed which has been treated with hot water or acid and then treated with captan or thiram. Purchase seed or transplants only from reputable dealers. Soaking seed in copper sulfate solution (2 ounces per gallon) or dipping in bleach solution as described under peppers will help prevent bacterial spot and canker if seed are saved.

Bacterial spot. Spray plants weekly with a fixed copper fungicide, such as Kocide 101 or COCS, beginning with the first sign of disease, through the bloom stage.

Early blight, Septoria leaf blight, anthracnose, buckeye rot, and soil rots. Spray weekly with maneb, zineb, mancozeb, Bravo, or Dyrene. Do NOT spray maneb, zineb, or mancozeb within 5 days of harvest. Staking or caging plants and providing good air circulation will help reduce foliar diseases. Staking, caging, or mulching will also help prevent fruit rots, such as anthracnose, buckeye rot, and soil rot. Varieties such as Jetstar, Supersonic, Manlucie, Roma VF, and Floramerica have some tolerance to the early blight disease. If Septoria leaf spot is present, mix benomyl with one of the forementioned fungicides for best control.

Blossom-end rot. Maintain uniform soil moisture by mulching the plants and irrigating when needed. Avoid heavy pruning, excessive nitrogen applications, or damage to the roots by cultivation or hoeing.

Verticillium and Fusarium wilt. Grow only VF- or VFN-resistant varieties. There are many varieties available.

Root-knot nematodes. Grow VFN-resistant varieties. Fumigate with Vapam, if severe. Follow the manufacturer's directions carefully.

Viruses. Avoid contact between potatoes and tomatoes to prevent "double infections" of potato and tomato viruses. Wash hands thoroughly with soap and water before handling your plants. Do NOT use tobacco when working with tomatoes.

Fungicides Recommended for Home Vegetables

Fungicide	Sold as
Benomyl (Benlate)	DuPont "Benlate" fungicide, Bonide Benomyl, Science Benomyl Fungicide, Ferti-lome Systemic Fungicide, Security Benomyl Spray, and many others.
DCNA (Botran)	Botran
Chlorothalonil (Bravo)	Bravo 500, Bravo 720, Bravo 90 DG, or Bravo 90 DF, Ortho Vegetable Disease Control, Ferti-lome Broad Spectrum Liquid Fungicide, and many others.

Fungicide	Sold as
Captan	Stauffer Captan 50 and 80 WP; Captan 25, 75, and 80 Seed Protectant; Captan Garden Spray; Orthocide 50 and 80 Wettable; Ortho 65 and 75 Seed Protectant; Miller's Captan 50 W; Patterson's Captan Garden Spray; Bonide Captan 50 W; Orthocide Potato Seed Treater, and many others.
Fixed copper	Basic Copper Sulfate, Kobasic, Ortho Copper 53 Fungicide, Kocide 101, Copper-Count N, Microcop, Citrocop, Tri-Basic Copper Sulfate, COCS, and many others.
Anilazine (Dyrene)	Dyrene 50% Wettable Powder Foliage Fungicide.
Folpet (Phaltan)	Ortho Phaltan 50 Wettable, Niagara Phaltan 50 Wettable, Stauffer Folpet 50 WP, and many others.
Dinocap (Karathane)	Karathane WD, Karathane Liquid Concentrate, Miller's Karathane 2D, and Garden Karaspray.
Maneb	Manzate Maneb Fungicide, Manzate D Maneb Fungicide, Dithane M22 or M22 Special with Zinc, Patterson's Maneb Fungicide, Pennwalt Maneb 80, Blackleaf Maneb Fungicide, Ortho Maneb 80 Fungicide, Science Maneb Garden Fungicide.
Mancozeb	Dithane M-45, Dithane F-45, Manzate Flowable, Manzate 200 Fungicide, Pencozeb, Manex, Pratt Lawn and Garden Fungicide and many others.
Quintozene (PCNB)	Terraclor 75% Wettable Powder.
Thiram	Arasan 50 Red Thiram Seed Protectant, 70-S Seed Protectant and 75 Thiram Seed Protectant, Miller's Thiram 65 and 75W, Agway Thiram 4.8 D, and Robert's Thiram.
Zineb	Dithane Z-78, Science Zineb Fungicide, Ortho Zineb Wettable, Acme Zineb 75W Fungicide, Niagara Zineb 75 Wettable, Sherwin-Williams Zineb, Stauffer Zineb 65 and 75W, Patterson's Zineb Wettable Powder, Zineb Garden Fungicide, New Diagon Tomato Dust and many others.

Always follow the manufacturer's directions carefully when using pesticides.

KEY TO SEED SOURCES

The following is a key to the seed sources listed in Tables 1 through 8. For a more complete listing of seed sources, obtain a copy of *Horticulture Facts* VC-10-80, "Sources of Vegetable Seeds." This fact sheet is available from the Department of Horticulture, University of Illinois, 125 Mumford Hall, 1301 W. Gregory Drive, Urbana, Illinois 61801.

BP Burpee Seed Co., 300 Park Ave. Warminster, PA 18974

CH C.C. Hart Seed Co., 304 Main St., Box 169, Wethersfield, CT 06109

FM Ferry-Morse Seed Co., P.O. Box 100, Mountain View, CA 94042

GA Germania Seed Co., 5952 N. Milwaukee Ave., Chicago, IL 60646

GE H.G. German Seeds, Inc., Smethport, PA 16749

HA Joseph Harris Co., Inc., Moreton Farm, Rochester, NY 14624

HB Herbst Brothers Seedsmen, Inc., 1000 N. Main St., Brewster, NY 10509

HF Henry Field Seed and Nursery Co. 407 Sycamore St., Shenandoah, IA 51602

HO R.L. Holmes Seed Co., 2125 46th St. N.W., Canton, OH 44709

NK Northrup King and Co., 1500 Jackson St. N.E., Minneapolis, MN 55413

PA Geo. W. Park Seed Co., SC Hwy. 254N, Greenwood, SC 29647

SDY Seedway, Inc., Hall, NY 14463

ST Stokes Seeds Ltd., Inc., Box 548, Buffalo, NY 14240

TW Twilley Seed Co., Inc., P.O. Box 65 Trevose, PA 19047

1987
ILLINOIS COMMERCIAL SPRAY SCHEDULE

Apples, Peaches, Nectarines, Apricots, Plums, Pears, and Cherries

D. B. Meador, Extension Specialist in Horticulture
Roscoe Randell, Extension Specialist in Entomology
Stephen M. Ries, Associate Professor of Plant Pathology
Malcolm C. Shurtleff, Extension Specialist in Plant Pathology

Converting Chemical Rates from Amount per 100 Gallons to Amount per Acre

Chemical rates in this circular are given in amounts per 100 gallons for either handgun application or dilute air-blast application. For dilute air-blast application, adjust sprayers to wet the foliage WITHOUT runoff or drip. Runoff or drip wastes chemicals. Dilute air-blast spray is usually in the range of 200 to 400 gallons per acre, depending on the height and width of the trees (canopy volume).

Chemical rates *per acre* would be 2 to 4 times the dilute rate per 100 gallons.

Low Volume Sprays

Many growers successfully reduce the volume of spray applied per acre by using less water to apply the same amount of chemical per acre. Chemical rates per acre are useful in determining the proper concentration for low volume sprayers.

The following table gives suggestions for low volume sprays.

	Small trees	Medium trees	Large trees
Chemical dilute rate/100 gal. (units)	1	1	1
Gallons/acre dilute	200	300	400
Chemical rate/acre (units)	2	3	4
Chemical rate (units)/100 gal.			
when sprayer applies 150 gal./A	1½	2	3
when sprayer applies 100 gal./A	2	3	4
when sprayer applies 75 gal./A	3	4 ½	6
when sprayer applies 50 gal./A	4	6	8
when sprayer applies 25 gal./A	8	12	16

Example 1: Chemical rate is 1 lb./100 gal. dilute. Sprayer applies 50 gal./A. The amount of chemical per 100 gal. is 4 lb. for small trees; 6 lb. for medium trees; and 8 lb. for large trees: 100 gal. sprays 2 acres.

Example 2: Chemical rate is 2 lb./100 gal. dilute. Sprayer applies 25 gal./A. The amount of chemical for *300 gal.* is 48 lb. for small trees; 96 lb. for large trees: 300 gal. sprays 12 acres.

C-1151 S
SUPPLEMENT TO CIRCULAR 1151

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
IN COOPERATION WITH THE ILLINOIS NATURAL HISTORY SURVEY

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. WILLIAM R. OSCHWALD, *Director,* Cooperative Extension Service, University of Illinois at Urbana-Champaign. The Illinois Cooperative Extension Service provides equal opportunities in programs and employment.

January, 1987 1-87—65651—esl

APPLES

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
DORMANT TO GREEN TIP		
Scale insects, aphids, and red mites	SUPERIOR OIL, 2 gal.	Thorough coverage is the most important factor. Varieties susceptible to powdery mildew should be sprayed in dormancy so that a mildewicide can be used in ½-inch stage. When applied during the delayed dormant to ½-inch green stage, 1 pt. of Lorsban 4E added to superior oil aids in control of San Jose scale.
Scab	DIFOLATAN SPRILLS, 15 or 25 lb.	Application at the 25 lb. rate during silver tip but before ¼-inch green should control scab until calyx (or about 6 weeks, depending on rainfall). Difolatan will not control mildew or the rust diseases; therefore, these diseases on susceptible varieties will need additional control measures beginning at pink bud. On these cultivars the 15 lb. rate or an alternate fungicide (see green tip) is suggested. Application later than ¼-inch green tip will produce severe leaf injury.
Fire blight, black rot, and blotch	COPPER SULFATE, 4 lb., or 8-8-100 BORDEAUX	Mostly for varieties susceptible to fire blight. Use the copper sulfate during dormancy; the bordeaux-oil is best at silver tip. Difolatan and bordeaux are compatible with superior oil at this time of year. do not apply oil after a Difolatan spray.
Collar rot	METALAXYL 2E (Ridomil), 1 qt.	Apply one, two, or more quarts per tree trunk, depending on tree age (see label).
GREEN TIP THROUGH TIGHT CLUSTER		
Aphids	Systemic phosphate insecticide — plus —	Pests tolerant to currently used pesticides are appearing. Therefore we recommend alternating pesticides during the spray program and using labelled pesticide mixes.
Scab, powdery mildew	DODINE 65W (Cyprex), ⅜ to ½ lb. — or — DODINE 65W (Cyprex), ¼ lb., and Microfine wettable SULFUR, 5 lb. — or —	On varieties susceptible to powdery mildew use Dikar, benomyl-captan, or include sulfur with dodine. It is important to provide trees with protective fungicides at 7- to 10-day intervals throughout this period. Scab and mildew control must begin at green tip.
	DIKAR, 2 lb., and TRITON B1956, 3 oz. — or —	Wetting agents increase the effectiveness of Dikar against powdery mildew.
	BENOMYL 50W (Benlate), 2 to 3 oz., or THIOPHANATE-METHYL 70W (Topsin M), 2 to 3 oz., and CAPTAN 50W, 1 lb. — or —	Use 2 oz. of benomyl for normal conditions and 3 oz. during severe scab pressure to deactivate scab. Never use benomyl alone. When benomyl is applied to deactivate scab lesions, combine it with protectant fungicides. Topsin M (thiophanate-methyl) can be substituted for benomyl. Topsin M is formulated as a wettable powder and will control the same diseases as benomyl.
	TRIFORINE 18EC (Funginex), 1 pt. — or — TRIADIMEFON 50W (Bayleton), 1 oz. — plus — CAPTAN 50W, 1 lb. — or — MANCOZEB 80W, 1 lb.	The "kick-back" action of triforine and triadimefon lasts up to 96 hours, with triforine recommended for scab, triadimefon for rust and mildew. Depending on the disease(s) you are trying to control, we recommend that you combine these materials with protectant chemicals such as captan, mancozeb, or mildewicide materials.
PINK BUD		
Scab, powdery mildew, cedar-apple rust	DIKAR, 2 lb., and TRITON B1956, 3 oz. — or —	If the reduced rate of Difolatan was used, now is the time to apply additional scab sprays.
	BENOMYL 50W (Benlate), 2 to 3 oz., or THIOPHANATE-METHYL 70W (Topsin M), 2 to 3 oz., and MANCOZEB 80W, 12 oz., — or —	Rust control must start in this spray. Mancozeb (Manzate 200, Dithane M-45), Polyram, zineb, and ferbam are all good rust fungicides. Ferbam may affect fruit finish of Golden Delicious if used after calyx.

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
PINK BUD (continued)		
	POLYRAM 80W, 12 oz. — or — DODINE 65W (Cyprex), ¼ lb., and Microfine wettable SULFUR, 5 lb., and a rust fungicide — or — TRIADIMEFON 50W (Bayleton)	Do not use dodine after bloom as there is a possibility of fruit russet and continued use encourages the development of resistant strains of the scab fungus. Triadimefon, a new product, is a very effective eradicant against both rust and mildew diseases. If infection has occurred and trees have been poorly protected, we recommend triadimefon combined with a protectant rust or mildew fungicide.
Curculio, leaf roller	AZINPHOSMETHYL 50W (Guthion), ⅝ lb.	Only necessary if curculio or leaf roller is severe or if other chewing insects are present. If fruit dimpling caused by tarnished plant bug is a problem, use a carbamate insecticide such as methomyl or Sevin. Pydrin or permethrin is effective in the pink bud stage. The control of white apple leaf hoppers and leaf miners is most effective at petal-fall.
For fertilizing	SOLUBOR, 1 lb.	This prevents a deficiency of boron, which affects pollen germination. If ground applications of boron are made, eliminate foliar application. See Circular 1151.
EARLY BLOOM		
Fire blight	STREPTOMYCIN, 50 or 100 ppm	On susceptible varieties start steptomycin at pink bud. Continue at 3-day intervals through bloom. Above 65° F. use 50 ppm; below 65° F., or when mixed with fungicides, use 100 ppm. Streptomycin uptake is enhanced by applying it as a dilute spray and by using spreader activators, such as glyodin, Regulaid, or glycerin, at 1 to 2 pints per 100 gal. Resistance to steptomycin is suspected in southwestern Illinois. Spray at recommended rates until petal-fall.
Scab, powdery mildew, and cedar-apple rust	Same as for PINK BUD	Fungicide applications are not recommended at full bloom as many injure pollen and may interfere with fruit set. During prolonged bloom, however, scab, mildew, and cedar-apple rust must be controlled. When simultaneous application of a fungicide and streptomycin is necessary, benomyl, captan, or glyodin should be used. Rust diseases have been extremely severe for the past few years. Maintain a strict schedule from pink bud to third cover.
CALYX AND FIRST COVER		
Codling moth, leaf roller, curculio, aphids Scab, cedar-apple rust, blotch, powdery mildew, frog-eye, quince rust	PHOSMET 50W (Imidan), 1½ lb., or AZINPHOSMETHYL 50W (Guthion), ⅝ lb. — plus either — POLYRAM 80W, 2 lb. — or — DIKAR, 2 lb., and TRITON B1956, 3 oz. — or — BENOMYL 50W (Benlate), 2 or 3 oz., and MANCOZEB 80W, 12 oz., or POLYRAM 80W, 12 oz.	Apply calyx spray when ¾ of the petals have fallen, and first cover, 7 to 10 days later. Imidan may be weak for leaf roller control. For leaf hopper and leaf miner control, apply a phosphate insecticide such as Lorsban that has had little or no past usage in the orchard or use a carbamate insecticide such as methomyl or Pydrin at a low dosage. Sevin and Vydate may thin fruit. Methomyl is safest on predatory mites. Vydate will also kill mites and leaf miners. If the 25 lb. rate of Difolatan was used earlier, scab control fungicides must now be applied. Since Polyram will not control powdery mildew, choose another fungicide on mildew-susceptible varieties or combine a mildewicide (benomyl, sulfur, or dinocap (Karathane)) with Polyram. Thiophanate-methyl can be substituted for benomyl. If quince rust has been a problem and the weather is wet, increase the rust fungicide to the full label rate. Control blight in secondary bloom on susceptible varieties. The use of streptomycin after bloom for twig blight control is of limited value and is not recommended.

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
CALYX AND FIRST COVER (continued)		
For thinning	See Circular 1151.	Summer varieties are best thinned at petal-fall. Fall and winter varieties are best thinned according to fruit size, preferably when king fruit is 10 to 11 millimeters in diameter.
For fertilizing	SOLUBOR, 1 lb.	Add to the calyx spray if there is no ground application of boron. See Circular 1151.
	UREA (45 percent N), 2 to 5 lb.	Use as needed in the first and third cover sprays. Do not use on Golden Delicious.
COVER SPRAYS (remainder of the season)		
All insects, diseases, and mites	AZINPHOSMETHYL 50W (Guthion), ⅝ lb. — plus either — POLYRAM 80W, 1½ lb. — or — DIKAR, 2 lb., and TRITON B1956, 3 oz. — or — BENOMYL 50W (Benlate), 2 oz., and CAPTAN 50W, 1 lb. — or — CAPTAN 50W, 1 lb., and ZINEB 75W, 1 lb.	As needed at 10- to 14-day intervals after the first cover. Alternate phosphate insecticides are phosmet (Imidan), phosalone (Zolone), Lorsban 50W, malathion, parathion, or diazinon. Parathion and diazinon are outstanding for San Jose scale and spotted tentiform leaf miner. Red mites may need suppression through this period. Northern Illinois growers should be aware of apple maggot in late August. If cicadas are laying eggs, spray with carbaryl 50W, 2 lb. per 100 gal. water, every 7 days. Also use carbaryl for young grasshoppers in or near young orchards. Rust and powdery mildew control should continue through third cover. Folpet (Phaltan), 1½ to 2 lb. per 100 gal., should start at fifth cover if Botryosphaeria is serious. Add 2 lb. calcium chloride per 100 gal. in the third, fourth, and fifth cover sprays, 3 lb. in later sprays. For low-volume sprays apply 4 lb. per acre in the third, fourth, and fifth cover sprays and 6 lb. per acre in later srays.
Bitter pit and Jonathan spot	CALCIUM CHLORIDE, 2 lb. or 3 lb.	Add the calcium chloride last when preparing sprays. See Circular 1151.
GROWTH REGULATOR SPRAYS		
To increase "typeness" of Red Delicious	PROMOLIN, 1-1½ pt.	Apply 100 gal. of solution per acre when the kings are in full bloom or split the application, making one application at half rate when the kings are in full bloom plus another at half rate at petal-fall. The split application is preferred.
To increase red color of Jonathan, McIntosh	ALAR, ½ to 1 lb. and PROMOLIN, 1 pt.	Apply 100 gal. of solution per acre 60 to 85 days before normal harvest date.
To delay harvest, increase firmness and color	ALAR, ½ to 1 lb.	Apply Alar 60 to 85 days before normal ripening date to McIntosh, Jonathan, and later varieties. On summer varieties, apply Alar 15 to 25 days after bloom.
To advance harvest	ETHREL, 1 pint, and NAA, 10 ppm, and 2,4,5-TP, 10 ppm	Apply one to two weeks before desired harvest date to Jonathan and spur-type Red Delicious. Apply as a dilute spray with thorough coverage. Stop-drop materials must be applied with Ethrel. Works well on apples previously treated with Alar.
To prevent preharvest drop	See Circular 1151.	Alar applied to delay harvest acts as a stop-drop preventative. NAA and 2,4,5-TP may be applied when apples start to drop.

PEACHES, NECTARINES, APRICOTS

DORMANT		
Scale insects, red mites, leaf curl	SUPERIOR OIL, 2 gal., and 6-6-100 BORDEAUX — or — FERBAM 76W, 2 lb. — or — BRAVO 500, 1½-2 pt.	The oil controls scale and mites; the fungicide prevents the development of leaf curl. Thorough coverage in the fall or BEFORE buds start to swell in the spring is critically important for control of leaf curl. Dichlone 50W, 1 lb., is also effective against leaf curl, but it is not compatible with oil. Bravo is not compatible with spray oils. Do not apply oil after a Bravo spray.

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
PINK BUD		
Tarnished plant bug, curculio, oriental fruit moth	AZINPHOSMETHYL 50W (Guthion), 5/8 lb., or CARBARYL 50W (Sevin), 2 lb., or METHOMYL L (Lannate, Nudrin), 1½ pt.	Apply when buds show pink. *Must not be applied when any blossoms are open, as this will kill honey bees.* Azinphosmethyl is best for curculio. Pydrin or permethrin is good for control of tarnished plant bug and stink bug.
EARLY TO FULL BLOOM		
Brown rot blossom blight	BENOMYL 50W (Benlate), 4 oz., or THIOPHANATE-METHYL 70W (Topsin M), 4 oz., plus CAPTAN 50W, 1 lb. — or — BRAVO 500, 1½ to 2 pt. — or — Microfine wettable SULFUR, 3 lb., and DICHLONE 50W (Phygon), ¼ lb. — or — ROVRAL 50W, ¼ to ½ lb. — or — FUNGINEX 18EC, ¾-1 pt.	Try to make two applications, one in early bloom and one in full bloom. *Do not use insecticides after first blossoms open.* Thiophanate-methyl 70W (Topsin M) is a relatively new fungicide in Illinois. Its spectrum of activity is identical to that of benomyl and it therefore should be used with the same precautions as benomyl (see below). Fungi tolerant to currently used fungicides (benomyl and thiophanate-methyl) are appearing. We therefore recommend alternating fungicides in the spray program and using suggested fungicide mixes. Never use benomyl or thiophanate-methyl alone or in combination with each other. Always combine them with protectant fungicides.
PETAL-FALL THROUGH COVER SPRAYS		
Curculio, oriental fruit moth, stink bugs, red-banded leaf roller, and catfacing insects Brown rot and peach scab	AZINPHOSMETHYL 50W (Guthion), 5/8 lb., or PHOSMET 50W (Imidan), 1½ lb. — plus — Microfine wettable SULFUR, 6 lb.	Parathion and diazinon are alternative insecticides and are especially effective against San Jose scale. For terrapin scale control, either add Systox to the regular spray when needed or use diazinon. Where peach scab has been a problem, use sulfur, benomyl, thiophanate-methyl, or Bravo (chlorothalonil). Discontinue using Bravo at shuck-split, and substitute another scab control fungicide until 40 days before harvest. A complete application is needed about every 14 days through this period. Normally, insecticides are not used after the first 2nd-brood curculio spray. Watch harvest restrictions. See borer control section.
Bacterial spot	MYCOSHIELD 17W, 150 ppm — or — CAPTAN 50W, 1 lb., and DODINE 65W (Cyprex), ½ lb.	Mycoshield (oxytetracycline) should be applied on a strict 7-day schedule beginning at shuck-split and continuing until 3 weeks before harvest. When warm, rainy weather prevails during early to mid-summer, bacterial spot may become serious. The combination of captan and dodine added to the cover sprays may help alleviate the problem.
To advance harvest	ALAR, 1½-2 lb.	Apply as a dilute spray with full coverage just before pit hardening, when the peaches loosen and can be mechanically thinned. Alar advances harvest 3 to 5 days and promotes uniform ripening.

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
PREHARVEST AND POSTHARVEST FUNGICIDES		
Brown rot	BENOMYL 50W (Benlate), 4 oz., or THIOPHANATE-METHYL 70W (Topsin M), 8 oz., plus CAPTAN 50W, 1 lb.	Brown rot becomes increasingly important as fruit begins to ripen; therefore, begin a 7-day spray schedule starting 4 weeks prior to harvest. Benomyl, captan, Funginex, dichlone, and sulfur all control this disease. During hot weather sulfur applied just before harvest may reduce fruit finish. Alternate fungicides and observe harvest restrictions.
	— or —	
	TRIFORINE 18EC (Funginex), ¾-1 pt.	Do not use more than three applications of Funginex to control fruit rot.
	— or —	
	ROVRAL 50W, ¼ to ½ lb.	Rovral is excellent for brown rot control.
	— or —	
Rhizopos rot	CAPTAN 50W, 2 lb., plus BOTRAN 50W, 2 lb.	Botran is specific for *Rhizopus* rot and is best added to the hydrocooler water as a postharvest dip.
BORER CONTROL		
Peach borer, lesser peach borer, American plum borer	ENDOSULFAN 50W (Thiodan) 1½ lb., or AZINPHOSMETHYL 50W (Guthion), ⅝ lb., or CHLORPYRIFOS 4E (Lorsban), 1½-2 pt.	Make two to four applications but adhere to harvest restrictions on the different varieties. July and August are the critical months. Thorough coverage of all wounds and gummy areas of all major branches is essential. This spray *must* be applied with a hand gun instead of the mist-blower type sprayer. Chlorpyrifos (Lorsban) should be applied to peach tree trunks up to scaffold limbs.
	PLUMS	
DELAYED DORMANT		
Scale insects, red mites, black knot	SUPERIOR OIL, 2 gal.	Apply before buds begin to open. The oil controls scale and mites. Prune out and burn all black knots during the dormant period.
PETAL-FALL THROUGH SECOND COVER		
Curculio, brown rot	AZINPHOSMETHYL 50W (Guthion), ⅝ lb.	Apply a spray every 10 to 14 days for three times, starting at petal-fall. Add a miticide if needed. For borer control follow the suggestions given under peaches. Alternate fungicides during the spray program.
	— plus —	
	BENOMYL 50W (Benlate), 4 oz., plus CAPTAN 50W, 1 lb.	Dichlone (Phygon, Quintar) will provide excellent control of brown rot blossom blight. Thiophanate-methyl 70W (Topsin M) can be substituted for the benomyl but should be used in combination with captan or dichlone.
	— or —	
	CAPTAN 50W, 2 lb.	
ADDITIONAL COVERS		
Brown rot	BENOMYL 50W (Benlate), 4 oz., plus CAPTAN 50W, 1 lb.	Start these sprays about 3 weeks before harvest and apply about every 7 days. Alternate fungicides during the spray program.
	— or —	
	CAPTAN 50W, 2 lb.	

APPLICATION AND PURPOSE	MATERIALS, RATE PER 100 GALLONS OF WATER FOR DILUTE SPRAYS	SPECIAL SUGGESTIONS
	PEARS	
DELAYED DORMANT		
Pear psylla, scale insects, leaf spot	SUPERIOR OIL, 2 gal. and FERBAM 76 W, 2 lb.	Apply just before buds begin to open.
BLOOM		
Fire blight	STREPTOMYCIN, 100 ppm	Three sprays 3 days apart, starting with the first blossoms. May be applied during the day for effective control. Be sure to continue on late blossoms. See early bloom section under apples.
CALYX THROUGH COVER SPRAYS		
Codling moth, curculio, leaf spot, scab	AZINPHOSMETHYL 50W (Guthion), ⅝ lb. — plus either — CAPTAN 50W, 1½ lb., or FERBAM 76W, 1½ lb.	Start calyx spray as soon as the petals have fallen and continue at 12- to 14-day intervals for at least 3 covers. Later, apply azinphosmethyl alone if psylla nymphs are visible on water sprouts.
	CHERRIES	
DORMANT		
Scale insects	SUPERIOR OIL, 2 gal.	Apply before the buds open.
FIRST AND SECOND COVER SPRAYS		
Brown rot, cherry leaf spot, curculio, slugs	AZINPHOSMETHYL 50W (Guthion), ⅝ lb. — plus either — CAPTAN 50W, 2 lb. — or — WETTABLE SULFUR, 6 lb. — or — DICHLONE 50W, ½ lb. — or — ROVRAL 50W, ¼ to ½ lb.	Start right after the shucks have fallen with the first cover. Apply a second cover spray 10 days later.
ADDITIONAL SPRAYS		
Cherry leaf spot	DODINE 65W (Cyprex), ½ lb., or CAPTAN 50W, 2 lb.	Apply immediately after harvest. One or two sprays should be adequate. Spray more if there is evidence of leaf spot. A phosphate insecticide may be needed if insects attack leaves. Borers should be controlled as suggested for peaches.

See the section on peaches, nectarines, and apricots for suggested borer sprays.

RESTRICTIONS ON PESTICIDES USED ON TREE FRUITS: The following restrictions are those in effect as of December 1, 1985. Growers are urged to follow directions on the manufacturer's current label at all times. When mixing several pesticides in the same tank, use the time restriction with the longest interval.

Pesticide	Number of days between last application and harvest				
	Apples	Pears	Cherries	Peaches	Plums
Ambush, Pounce (permethrin)	J	14D	...	7	...
Bayleton	0	...	...	...	...
Benlate (benomyl)	0	0	0	0	0
Bordeaux	0	0	0	0	0
Botran	...	...	1H	1H	8
Bravo	...	...	...	K	...
Captan	0	0	0	0	0
Copper sulfate	0	0	...	...	...
Cyprex	7	7	0	15	...
Diazinon	14	14	10	20	10
Difolatan	A	A	...	...	...
Dikar	30	21	...	...	...
Dithane M-45 (mancozeb)	30	21	...	...	...
Ferbam	7	7	0	21	7
Funginex (triforine)	J	...	...	0	...
Glyodin	0	0	7	...	...
Guthion (azinphosmethyl)	15	15	15	21	15
Imidan	7	7	7	14	7
Karathane	21	21	...	45	...
Kelthane	7	7	7	14	7
Lannate, Nudrin (methomyl)	8	...	...	4	...
Lime sulfur	0	0	0	0	0
Lorsban	28	A	...	14	A
Malathion	3	3	3	7	3
Manzate 200 (mancozeb)	30	15	...	...	...
Mesurol	...	...	7D	21E	...
Mycoshield (oxytetracycline)	...	...	...	21	...
Omite	7D	7D	...	14C	28C
Ovex	...	...	...	7	...
Parathion	14	14	14	14	14
Phaltan (folpet)	0	...	...	...	...
Phosphamidon	30	...	...	...	...
Phygon (dichlone)	1	...	3	7	3
Plictran	14E	14E	...	E	E
Polyram	30	...	...	...	...
Pydrin	21F	A	...	14G	...
Quintar (dichlone)	1	...	B	7	...
Ridomil	L	...	...	...	...
Rovral	...	...	0	0	...
Sevin	1	1	1	1	1
Streptomycin	50	30	...	...	...
Sulfur	0	0	0	0	0
Systox	21	21	...	30	30
Tedion	0,E	0,E	0,C	0,C	0,C
Thiodan	...	...	21C	30C	7C
Thiram (Thylate)	0	...	...	7	...
Topsin M (thiophanate-methyl)	0	...	1	1	1
Trithion	30	30	...	...	...
Vendex	14D	14D	...	...	...
Vydate	14	...	...	...	...
Zineb	30	7	...	...	30

. . . Not recommended.
A. Dormant application up until ¼-inch green.
B. Do not apply when fruit is present — apply prebloom or postharvest.
C. Not more than 2 applications to fruit.
C. Not more than 3 applications to fruit.
E. Not more than 4 applications to fruit.
F. Not more than 2.1 lb. active ingredient per acre per season.
G. Not more than 1.5 lb. active ingredient per acre per season.
H. Can be used as a fruit dip.
J. Do not apply after petal-fall.
k. Do not apply after shuck-split.
L. Apply only to nonbearing apple trees. Fruit should not be harvested.

MITE CONTROL: It is important to avoid using insecticides that are toxic to predatory mites. If phosphate insecticides will kill plant-feeding mites, they will also kill predaceous mites. Miticides, however, may be more selective, and the following miticides can be used without killing predatory mites: DICOFOL (Kelthane), OMITE, OVEX, PLICTRAN, TETRADIFON (Tedion), and VENDEX. The miticide OXYMAL (Vydate) will kill all mites. Some fungicides, such as DIKAR and DINOCAP (Karathane), give mite suppression and allow good predatory mite survival. BENOMYL (Benlate) suppresses both types of mites. Where red mites have been a problem, use oil in the dormant spray.

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 is 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 disagreeble 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 disese 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 prentheses 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, bird baths, fish ponds, 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.

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1987 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 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
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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, a key to their identification 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.

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

General symptoms	Specific symptoms	Disease
	Foliage appears scorched by fire; twig tips curl downward to form "shepherd's crooks."	Fire blight
	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)
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 target-like areas (cankers) in bark and outer wood of twigs and branches.	Canker or dieback

General symptoms	Specific symptoms	Disease
	Wood in branches or trunk decays; bracket, shelf, or mushroom fungi may form on bark surface.	Wood rot
	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, tumor-like 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, tumor-like galls on roots, up to a foot or more in diameter.	Crown gall

General symptoms	Specific symptoms	Disease
	Roots decay; feeder roots die back; mold growth under bark or over roots; usually shoestring-like black strands.	Root rot
	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 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% WP2 sulfur, 90-95% WP	1/2 2-3	Spray 2 or more times, 7 to 10 days apart starting when disease first appears.
ALMOND--See Cherry.			

[a]WP = wettable powder; EC = emulsifiable concentrate; G = granular
[b]gal = gallon(s); sq ft = square foot(feet); oz = ounce(s); lb = pound(s);
ai = active ingredient.

Plant and disease	Suggested fungicides or nematicides[a]	Rate, pounds per 100 gallons[1]	Application and remarks[b]
AMELANCHIER, SHADBUSH, SERVICEBERRY, JUNEBERRY			
Cedar rusts	ferbam, 76% WP	2	Spray 3 times at 10-day intervals starting when new growth appears in the spring.
	thiram, 65-75% WP	1-1/2 to 2	
	zineb, 75% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 2	
Powdery mildew	Karathane, 19.5% WP	1/2	Spray when disease first appears or as leaves start to expand. Repeat 2 or 3 times 10 days apart.
	benomyl, 50% WP	1/2-1	
	sulfur, 90-95% WP	2-3	
	Bayleton, 25% WP	2-4 oz[b]	
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	See label.	See Boxwood.
ASH			
Anthracnose	copper[3]	See label.	Apply when buds begin to open. Repeat 10 to 14 days later. Zineb, maneb, and mancozeb also control rust.
Fungus leaf spots	zineb, 75% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	benomyl, 50% WP	1/2-1	
	mancozeb, 80% WP	1-1/2 to 2	
	chlorothalonil	See label.	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
AZALEA--See Rhododendron.			

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]
BARBERRY			
Bacterial leaf spot and twig blight Fungus leaf spot Blotch Anthracnose	copper	See label.	Spray 2 to 3 times, 10 days apart, beginning when new leaves appear in spring.
Nematodes	Dasanit, 15 G	See label.	See Boxwood.
	Vydate L	See label.	See Boxwood.
BASSWOOD--See Linden.			
BEECH			
Fungus leaf spot	copper	See label.	If severe, spray twice, 10 days apart, starting as the leaves begin to unfold.
Powdery mildew	Karathane, 19.5% WP	1/2	If severe, spray twice, 10 days apart, starting when mildew is first seen.
	benomyl, 50% WP	1/2-1	
	sulfur, 90-95% WP	2-3	
BIRCH			
Leaf blister	copper	See label.	Spray once before buds swell in early spring.
	liquid lime-sulfur	2 gal[b]	
Anthracnose	benomyl, 50% WP	1	Spray twice, 10 to 14 days apart, starting at budbreak.
	zineb, 75% WP	1-1/2 to 2	
Rust	zineb, 75% WP	2	Spray several times 10 days apart. Start about a week before rust normally appears.
	mancozeb, 80% WP	1-1/2 to 2	
	Bayleton, 25% WP	2-4 oz[b]	
BITTERSWEET			
Powdery mildew	benomyl, 50% WP	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	See label.	Spray twice, 10 days apart, starting as leaves unfold.
BOSTON IVY--See Ivy.			
BOXELDER--See Maple.			

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			
Canker or stem blight Fungus leaf blights or spots Anthracnose	copper liquid lime-sulfur	See label. 2	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.
Phytophthora root rot	etridiazole (Truban or Terrazole) metalaxyl (Subdue) Banrot fosetyl-Al (Aliette)	See labels. See label. See label. See label.	Apply as drenches around plants to saturate the soil. Repeat at 4- to 12-week intervals in spring and autumn. Check label registrations.
Nematodes, including root-knot, lesion	fenamiphos (Nemacur, 10G)[8]	180 lb/A	For nursery stock: Irrigate after application with 1/2 inch of water; only 1 application per year.
	Vydate 2L[8]	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/100 gal	Pot drench: Drench soil with mixture; 4 to 8 oz/6-inch pot or 2 to 4 oz/4-inch pot.
	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)	1/2 pint/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/ 1,000 sq ft	Bed and bench treatment: Same as for field nursery stock (above).
		1/2 pint/100 gal	Pot drench: Drench soil with mixture; 1/2 pint/6-inch pot or 1 pint/8-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]
BUCKEYE--See Horsechestnut.			
BUSH HONEYSUCKLE			
Fungus leaf spots	copper	See label.	Spray twice, 10 days apart, starting as the leaves unfold.
Powdery mildew	benomyl, 50% WP	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, 90-95% WP	2-3	
	Karathane, 19.5% WP	1/2	
BUTTONWOOD--See Sycamore.			
CATALPA			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when disease first appears. Repeat 10 and 20 days later.
	Karathane, 19.5% WP	1/2	
	sulfur, 90-95% WP	2-3	
Fungus leaf spots	copper	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.
	zineb, 75% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	benomyl, 50% WP	1	
	mancozeb, 80% WP	1-1/2 to 2	
	Topsin M, 70% WP	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.
	sulfur, 90-95% WP	5-10	
	captan, 50% WP	2	
	captafol (Difolatan 4F)	2	
	triforine (Funginex)	See label.	
	Topsin M, 70% WP	See label.	
	mancozeb, 80% WP	1-1/2	
	Ornalin, 50% 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]
Nematodes	Dasanit, 15G	See label.	Apply evenly and incorporate into top 4 to 6 inches. For pot mix, thoroughly mix 1.4 qt/cu. ft. into soil. For outdoor use only.
Nematodes (cherry, peach)	Nemacur, 15G[8]	66.7-133.3 lb/A	Band or broadcast; incorporate into top 2-4 inches of soil.
	Vydate L	--	See Boxwood.
Nematodes (flowering cherry, nursery stock)	Nemacur, 10G	--	See Boxwood.
Nematodes (plum)	Vydate L	--	See Boxwood.
Leaf blister or curl	captan, 50% WP	2	Spray once in late fall or just before buds swell in early spring.
Plum pockets	liquid lime-sulfur	2 gal[b]	
Witches'-broom	ferbam, 76% WP	2	
	chlorothalonil	See label.	
	dodine, 65% WP	1/2-1	
	mancozeb, 80% WP	1-1/2	
	copper	See label.	
Coccomyces leaf spot, blight, or shot-hole	folpet (Phaltan), 50% WP	2	Spray 4 times, 2 weeks apart. Start as buds are opening. Use Acti-dione only on nonbearing trees.
	benomyl, 50% WP	1/2-1	
	dodine, 65% WP	1/2-1	
	captan, 50% WP	2	
	Acti-dione PM	See label.	
	Topsin M, 70% WP	See label.	
Perennial or Valsa canker	ferbam, 76% WP	2	Delay pruning until buds open in spring. Spray just after pruning.
	benomyl, 50% WP	1/2-1	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when mildew first appears. Repeat once or or twice at 7- to 10-day intervals. Use Acti-dione only on nonbearing trees.
	Karathane, 19.5% WP	1/2	
	sulfur, 90-95% WP	1-1/2 to 2	
	Acti-dione PM	See label.	
	Topsin M, 70% WP	See label.	
Rust	ferbam, 76% WP	2	Spray several times, about 10 days apart. Start about 2 weeks after petal-fall.
	zineb, 75% WP	1-1/2 to 2	
	sulfur, 90-95% WP	4-6	

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]
Scab	benomyl, 50% WP	1/2-1	Spray 3 to 5 times, 10
Shot-hole	sulfur, 90-95% WP	3-6	to 14 days apart, start-
Fungus leaf spots	Zyban, 75% WP	1-1/2	ing at petal-fall. Check
	captan, 50% WP	2	label registration.
	Duosan, 75% WP	1-1/2	
	Topsin M, 70% WP	See label.	
	zineb, 75% WP	1-1/2 to 2	
	chlorothalonil	See label.	
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	--	See Boxwood.
	Vydate L	--	See Boxwood.
Scab	benomyl, 50% WP	1/2-1	Apply in spring as buds
	dodine, 65% WP	1/2-1	start to swell and re- peat 2 to 3 weeks later.
Fungus leaf spots	benomyl, 50% WP	1/2-1	Spray several times 10
Botrytis blight	maneb, 80% WP	1-1/2 to 2	to 14 days apart
	mancozeb, 80% WP	1-1/2 to 2	starting at budbreak.
	zineb, 75% WP	1-1/2 to 2	Check label
	Kocide 101, 77% WP	See label.	registrations.
CRABAPPLE, APPLE, PEAR			
Cedar rusts	chlorothalonil	See label.	Spray as new growth
(apple,	Zyban, 75% WP	1-1/2 to 2	appears and flower buds
hawthorn, and	ferbam, 76% WP	2	start to open. Repeat
quince)	maneb, 80% WP	1-1/2 to 2	3 or 4 more times at
	mancozeb, 80% WP	1-1/2 to 2	10-day intervals or
	Bayleton, 25% WP	2-4 oz[b]	follow label directions
	zineb, 75% WP	1-1/2 to 2	and check registrations.
	Polyram, 80% WP	1-1/2 to 2	(Also see Juniper.)
	Duosan, 75% WP	1-1/2 to 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]
Scab	zineb, 75% WP	1-1/2 to 2	Spray when growth first
Fungus leaf spots	benomyl, 50% WP	1	appears. Repeat 4 more
and fruit rots	dodine, 65% WP	1/2-1	times, 7 to 10 days
Sooty blotch and	captan, 50% WP	2	apart until two weeks
flyspeck	maneb, 80% WP	1-1/2 to 2	after petal-fall. Thor-
	mancozeb, 80% WP	1-1/2 to 2	ough coverage of new
	Polyram, 80% WP	1-1/2 to 2	growth is essential.
	folpet (Phaltan), 50% WP	1-1/2 to 2	Captafol (Difolatan 4F) can be applied as a
	Dikar, 76.7% WP	2	single application before
	captafol (Difolatan 4F)	1-1/2 to 2 pints	bloom for control of primary apple scab. See
	Zyban, 75% WP	1-1/2 to 2	label.
	Duosan, 75% WP	1-1/2 to 2	
	chlorothalonil	See label.	
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	See label.	
Nematodes	Nemacur 10G	--	See Boxwood.
(crabapple)			
(apple, nonbearing)	Nemacur 16G	--	See Cherry.
(apple, pear, non-bearing)	Vydate L	--	See Boxwood.
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when disease first
	sulfur, 90-95% WP	6-8	appears or as leaves
	Karathane, 19.5%	1/2	start to expand. Repeat
	Dikar, 76.7% WP	2	2 or 3 times, 10 days
	Bayleton, 25% WP	2-4 oz[b]	apart.
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
CURRANT, ALPINE			
Anthracnose	benomyl, 50% WP	1/2-1	Spray 2 or 3 times, 10
Fungus leaf spots	ferbam, 76% WP	2	to 14 days apart. Start
	maneb, 80% WP	1-1/2 to 2	at leaf emergence or when
	mancozeb, 80% WP	1-1/2 to 2	leaves are nearly
	zineb, 75% WP	1-1/2 to 2	expanded.

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]
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 to 2	
Spot anthracnose	mancozeb, 80% WP	1-1/2 to 2	
Flower and leaf blights	zineb, 75% WP	1-1/2 to 2	
	captan, 50% WP	2	
	folpet (Phaltan), 50% WP	2	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
Powdery mildew	benomyl, 50% WP	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, 90-95% WP	2-3	Spray 3 times, 10 to 14 days apart. Start when the leaf buds break open. Sanitary measures are important.
Black leaf spot and other fungus leaf spots	benomyl, 50% WP	1	
	copper	See label.	
	zineb, 75% WP	1-1/2 to 2	
Twig blight	mancozeb, 80% WP	1-1/2 to 2	
	folpet (Phaltan), 50% WP	2	
	ferbam, 76% WP	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.

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]
	Arbotect 20-S4	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 Anthracnose Scab Botrytis blight	benomyl, 50% WP maneb, 80% WP mancozeb, 80% WP zineb, 75% WP Kocide 101, 77% WP Duosan, 75% WP Zyban, 75% WP Chipco 26019, 50% WP	1/2-1 1-1/2 to 2 1-1/2 to 2 1-1/2 to 2 See label. 1-1/2 1-1/2 1-1/2 to 2	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.
Powdery mildew	Karathane, 19.5% WP Bayleton, 25% WP benomyl, 50% WP triforine (Funginex) Rubigan, 12.5% EC	1/2-1 2-4 oz[b] 1/2-1 See label. 6-7 fl/oz[b]	Apply at first evidence of disease. Repeat at 7- to 10-day intervals. Follow label directions.
Root rots Crown rot	Banrot Chipco 26019, 50% WP	See label. 6 1/2 oz[b]	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.
Nematodes	Nemacur, 10G Vydate L	-- --	See Boxwood. See Boxwood.
EVERGREENS--See Fir, Juniper, Pine, Yew.			

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]
FIR			
Needle and twig blights Leaf casts	copper	See label.	Spray 2 or 3 times, 15 to 30 days apart, starting when new needles are half grown.
Rusts	sulfur, 90-95% WP Bayleton, 25% WP	3-5 2-4 oz[b]	Spray 2 or 3 times, 7 to 10 days apart. Start a week before rust usually appears.
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 Boxwood.
FIRETHORN--See Pyracantha.			
FORSYTHIA			
Fungus leaf spots	mancozeb, 80% WP maneb, 80% WP zineb, 75% WP copper	1-1/2 to 2 1-1/2 to 2 1-1/2 to 2 See label.	Apply at budbreak and repeat at 7- to 10-day intervals as needed to keep foliage protected in damp weather.
HAWTHORN, RED HAW			
Leaf blight Scab Other fungus leaf spots	Polyram, 80% WP captan, 50% WP benomyl, 50% WP maneb, 80% WP mancozeb, 80% WP zineb, 75% WP dodine, 65% WP chlorothalonil	1-1/2 to 2 2 1 1-1/2 to 2 1-1/2 to 2 1-1/2 to 2 3/4 See label.	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, mancozeb, zineb, and Polyram will also control rusts.

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]
Cedar rusts	ferbam, 76% WP	2	Spray as new growth appears and flower buds start to open. Repeat 3 or 4 times at 7- to 10-day intervals.
	Bayleton, 25% WP	2-4 oz[b]	
	zineb, 75% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 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	
HICKORY			
Anthracnose Fungus leaf spot or blotch Scab Spot anthracnose	benomyl, 50% WP	1/2-1	Spray 3 or 4 times, 7 to 10 days apart, starting as buds break open. Sanitation is important.
	zineb, 75% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
HOLLY			
Fungus leaf spots Tar spot Anthracnose Spot anthracnose	chlorothalonil	See label.	Apply 3 or 4 sprays at 10- to 14-day intervals. Start as leaves begin to unfold. Sanitary measures are important.
	benomyl, 50% WP	1/2-1	
	zineb, 75% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 2	
	ferbam, 76% WP	2	
Leaf and twig blight and algae	copper	See label.	Spray 3 or 4 times, 10 days apart. Start with the first autumn rains.
	zineb, 75% WP	1-1/2 to 2	
Powdery mildew	sulfur, 90-95% WP	4-5	Apply when disease first appears. Repeat at 7-day intervals as needed.
	benomyl, 50% WP	1/2-1	
	Karathane, 19.5% WP	1/2-1	
	Bayleton, 25% WP	2-4 oz[b]	

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]
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	--	See Boxwood.
	Vydate L	--	See Boxwood.
HONEYSUCKLE			
Herpobasidium leaf blight	copper	See label.	Apply several sprays 7 to 10 days apart. Start when new growth appears. Only young leaves are infected.
	mancozeb, 80% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray 2 or more times at weekly intervals. Start when disease first appears.
	sulfur, 90-95% WP	4-5	
	Acti-dione PM	See label.	
	Karathane, 19.5% WP	1/2-1	
	Topsin M, 70% WP	See label.	
HORSECHESTNUT, BUCKEYE			
Leaf blotch	benomyl, 50% WP	1/2-1	Spray 3 or 4 times, 10 to 14 days apart, starting as the buds begin to open. Thorough coverage is required for control. Resistant species are available.
Fungus leaf spot or blotch	zineb, 75% WP	1-1/2 to 2	
Anthracnose	mancozeb, 80% WP	1-1/2 to 2	
Spot anthracnose	maneb, 80% WP	1-1/2 to 2	
	dodine, 65% WP	1-2	
	chlorothalonil	See label.	
HYDRANGEA			
Fungus leaf spots	zineb, 75% WP	1-1/2	Spray 3 times, 7 to 10 days apart. Start when new growth appears. Benomyl will not control rust.
Rust	chlorothalonil	See label.	
	Topsin M, 70% WP	See label.	
Botrytis leaf and flower blight or gray-mold	benomyl, 50% WP	1/2-1	Spray when symptoms first appear. Repeat twice weekly during rainy periods. In storage, apply Exotherm Termil dust or Ornalin Fumigator. Check label directions.
	Botran, 50% WP	1 to 1-1/2	
	chlorothalonil	See label.	
	Ornalin, 50% WP	1/2-1	
	Chipco 26019, 50% WP	1-2	
	Topsin M, 70% WP	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]
Root and stem rots of potted plants	Banrot, 40% WP	6-12 oz[b]	Drench established plants with mixture.
	Truban or Terrazole + benomyl, 50% WP	See labels. 1	Avoid overwatering. Check label directions and registrations.
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times, 7 to 10 days apart. Start when disease first appears.
	Karathane, 19.5% WP	1/2	
	Topsin M, 70% WP	See label.	
	Rubigan, 12.5% EC	3-5 fl oz[b]	
IVY, ENGLISH--See *Disease Control Programs for Flowers and Other Nonwoody Ornamentals*, Circular 1259.			
IVY, BOSTON AND VIRGINIA CREEPER			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray several times at 7- to 10-day intervals. Start when disease first appears.
	sulfur, 90-95% WP	3-4	
	Topsin M, 70% WP	See label.	
Leaf spots	ferbam, 76% WP	1-1/2 to 2	Spray 3 times at weekly intervals. Start as new growth appears.
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
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.
	zineb, 75% WP	1-1/2 to 2	
	ferbam, 76% WP	2	
	Polyram, 80% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
Phomopsis twig blight	benomyl, 50% WP	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	
Cercospora needle blight	copper	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 to 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]
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	--	See Boxwood.
	Vydate L	--	See Boxwood.
	Dasanit, 15 G	--	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	1/2-1	
	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, 70% WP	See label.	
Bacterial and Phytophthora blights	copper	See label.	Spray 2 or 3 times at 7- to 10-day intervals. Start when new growth appears in spring.
LINDEN, BASSWOOD			
Anthracnose Fungus leaf spots Leaf blight Spot anthracnose	copper	See label.	Spray just after bud-break and again 10 and 20 days later. Sanitary measures are important.
	benomyl, 50% WP	1	
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when mildew first appears. Repeat 10 days later.
	sulfur, 90-95% WP	4-6	
MAGNOLIA			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray 2 or 3 times, 7 to 10 days apart. Start when disease first appears.
	Acti-dione PM	See label.	
	Karathane, 19.5% WP	1/2-1	
Fungus leaf spot Leaf blight	copper + benomyl, 50% WP	See label. 1/2-1	Spray twice, 10 days apart. Start as buds break open.
Nematodes	Vydate L	--	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]
MAPLE, BOXELDER			
Anthracnose	zineb, 75% WP	1-1/2 to 2	Spray 3 or 4 times, 10
Fungus leaf spots	mancozeb, 80% WP	1-1/2 to 2	days apart, starting as
Leaf blight or	maneb, 80% WP	1-1/2 to 2	buds begin to open.
blotch	benomyl, 50% WP	1	For tar spot, spray just
Leaf scab	chlorothalonil	See label.	before the buds swell in
Tar spot	captan, 50% WP	2	early spring.
Leaf blister	folpet (Phaltan), 50% WP	2	Sanitation is important.
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
Nematodes (sugar maple)	Vydate L	--	See Boxwood.
Root rots	Banrot	See label.	Treat in seed bed and nursery bed. Follow label directions.
MAYDAY-TREE--See Cherry.			
MOUNTAIN-ASH			
Leaf blight	benomyl, 50% WP	1/2-1	Spray 2 to 4 times, 10
and scab	mancozeb, 80% WP	1-1/2 to 2	days apart, starting as
Fungus leaf	zineb, 75% WP	1-1/2 to 2	the leaf buds open.
spots	maneb, 80% WP	1-1/2 to 2	
	chlorothalonil	See label.	
Rusts	zineb, 75% WP	1-1/2 to 2	Apply 4 to 5 sprays, 10
	mancozeb, 80% WP	1-1/2 to 2	days apart. Start as flower buds begin to open.
Fire blight	streptomycin formulations	See label.	Spray when 20 to 25 percent of blossoms are
	copper	See label.	open and again at full bloom.
MULBERRY			
Bacterial blight	bordeaux mixture	5-5-100[3]	Apply at budbreak and
or leaf spot	fixed copper	See label.	repeat at 7-day intervals during moist periods. If severe, spray twice, 10 days apart, starting as the leaves unfold.
Fungus leaf spot			
False mildew			

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]
Powdery mildew	benomyl, 50% WP	1/2-1	Spray twice, 10 days apart. Start when mildew first appears.
	Karathane, 19.5% WP	1/2-1	
Nematodes	Vydate L	--	See Boxwood.
NECTARINE--See Cherry.			
OAK			
Anthracnose	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.
Fungus leaf spots and blights	copper	See label.	
	zineb, 75% WP	1-1/2 to 2	
Spot anthracnose	benomyl, 50% WP	1	
Leaf blotch	dodine, 65% WP	1	
Leaf blister	mancozeb, 80% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
Oak wilt	2,4,5-T[5]	4 lb ai per gal oil[b]	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.
	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	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 to 2	
	dodine, 65% WP	1/2-1	
Spot anthracnose	Polyram, 80% WP	2	
Anthracnose	Du-Ter, 47.5% WP	1/2	
Sooty mold			
Powdery mildew	benomyl, 50% WP	1/2-1	Spray when mildew is first seen. Repeat at 10- to 14-day intervals.
	Du-Ter, 47.5% WP	1/4-1/2	
	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]
PHOTINIA			
Powdery mildew Entomosporium leaf spot	benomyl, 50% WP sulfur, 90-95% WP triforine (Funginex) Bayleton, 25% WP Topsin M, 70% WP Duosan, 75% WP Zyban, 75% WP	1/2-1 4-6 See label. 2-4 oz[b] See label. 1-1/2 1-1/2	Spray several times at 7- to 14-day intervals. Start when new leaf growth or disease first appears.
PINE			
Dothistroma needle blight	copper	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 mancozeb, 80% WP maneb, 80% WP chlorothalonil	See label. 1-1/2 to 2 1-1/2 to 2 See label.	Spray once or twice, 30 days apart, starting when new needles are half grown. If rainy, spray at 2-week intervals.
Lophodermium needle cast or blight	mancozeb, 80% WP maneb, 80% WP chlorothalonil benomyl, 50% WP	1-1/2 to 2 1-1/2 to 2 See label. 1-1/2 to 2	Spray 4 times, 2 weeks apart, starting in early July when the new needles are fully grown.
Diplodia tip blight or dieback	copper 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, 500	1-1/2 qt[b]	Spray as new growth appears in spring. Repeat at 2-week intervals until early July, then monthly until early September.
Soil nematodes	Nemacur, 10G Vydate L	-- --	See Boxwood. See Boxwood.
Pine Wilt	None	--	Remove tree and other dead pines in area. Destroy dead wood immediately.

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]
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 ferbam, 76% WP	1/2 2	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 (Subdue)	See label. See label.	Apply at a 1:16 ratio to nursery beds prior to seeding.
PLANETREE--See Sycamore.			
PLUM--See Cherry.			
POPLAR			
Leaf rusts	triforine (Funginex) zineb, 75% WP mancozeb, 80% WP maneb, 80% WP sulfur, 90-95% WP	See label. 2 2 2 4-6	Spray in early summer about a week before rust is expected and again 10 to 14 days later.
Yellow leaf blister	zineb, 75% WP mancozeb, 80% WP maneb, 80% WP	2 2 2	Apply several sprays weekly when spots first appear on the lower leaves.
Powdery mildew	sulfur, 90-95% WP benomyl, 50% WP	4-1/2 to 5-1/2 1	Apply at first sign of disease. Repeat 2 or 3 times at 5- to 10-day intervals.
PRIVET			
Anthracnose Fungus leaf spot Twig blight	ferbam, 76% WP benomyl, 50% WP Bayleton, 25% WP chlorothalonil mancozeb, 80% WP	2 1 2-4 oz[b] See label. 1-1/2	Spray several times at 10-day intervals starting in mid-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]
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	1/2-1	
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	--	See Boxwood.
	Vydate L	--	See Boxwood.
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	See label.	
Scab	benomyl, 50% WP	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 to 2	
	Duosan, 75% WP	1-1/2	
	Zyban, 75% WP	1-1/2	
	Topsin M, 70% WP	See label.	
Nematodes	Nemacur, 10G	--	See Boxwood.
	Vydate L	--	See Boxwood.
	Dasanit, 15G	--	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	maneb, 80% WP	1-1/2 to 2	Apply several sprays at 10-day intervals starting at budbreak.
Scab	mancozeb, 80% WP	1-1/2 to 2	
Fungus leaf spots	zineb, 75% WP	1-1/2 to 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]
REDBUD			
Cercospora and other fungus leaf spots	copper	See label.	If serious, apply at budbreak and repeat several times at 10-day intervals during spring rainy period.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 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.			
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 zineb or mancozeb 3 times weekly during bloom. See labels for details.
	benomyl, 50% WP	1	
	zineb, 75% WP	1	
	mancozeb, 80% WP	1-1/2	
	chlorothalonil	See label.	
	Bayleton, 25% WP	1/4-1/2	
	Duosan, 75% WP	1-1/2	
	Topsin M, 70% WP	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, 70% WP	See label.	
Fungus leaf spots Rusts Leaf, flower, and stem galls	zineb, 75% WP	1-1/2 to 2	Spray several times at 10-day intervals. Start at budbreak. Benomyl is not effective against rusts.
	maneb, 80% WP	1-1/2 to 2	
	mancozeb, 80% WP	1-1/2 to 2	
	benomyl, 50% WP	1/2-1	
	ferbam, 76% WP	2	
	chlorothalonil	See label.	
Bud and twig blight Dieback	copper	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 4- to 12-week intervals in spring and autumn. Follow label directions.
	Banrot, 40% WP	6-12 oz[b]	
	metalaxyl (Subdue)	See label.	
	fosetyl-Al (Aliette)	See label.	
	propamocarb (Banol)	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]
Nematodes	Dasanit, 15G	--	See Boxwood.
	Nemacur, 10G	--	See Boxwood.
	Vydate L	--	See Boxwood.
	Mocap EC	--	See Boxwood.
Cutting rot or dieback	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, 70% WP	See label.	
Cylindrocladium root rot	etridiazole (Truban or Terrazole)	See labels.	
ROSE			
Botrytis blight	benomyl, 50% WP	1/2	Mist flowers at 7- to 10-day intervals in moist weather. Do not apply Ornalin immediately after yearly cutback. Ornalin may be used as a postharvest cut flower, budwood, or bareroot nursery stock dip in cold storage or transit.
	Botran, 50% WP	See label.	
	zineb, 75% WP	1	
	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.	
Black spot	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, Polyram, triforine, and chlorothalonil also control rusts.
Cane blight	chlorothalonil	See label.	
Cankers	folpet (Phaltan),		
Spot anthracnose	50-75% WP	1-1/2 to 2	
Anthracnose	maneb, 80% WP	1-1/2 to 2	
Fungus leaf spots	mancozeb, 80% WP	1-1/2 to 2	
	Polyram, 80% WP	1-1/2 to 2	
	benomyl, 50% WP	1	
	zineb, 75% WP	1-1/2 to 2	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Topsin M	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]
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.
	Karathane, 19.5% WP	1/2-1	
	Bayleton, 25% WP	1-4 oz[b]	
	Milban, 39% EC	32 oz[b]	
	Acti-dione PM	See label.	
	triforine (Funginex)	See label.	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
	Rubigan, 12.5% EC	See label.	
Fungus leaf spots	copper	See label.	Spray twice, 10 days apart, starting as leaves unfold.
	Bayleton, 25% WP	2-4 oz[b]	
	Zyban, 75% WP	1-1/2	
	Duosan, 75% WP	1-1/2	
Nematodes	Dasanit, 15G	--	See Boxwood.
	Nemacur, 10G	--	See Boxwood.
	Vydate L	--	See Boxwood.
RUSSIAN-OLIVE			
Fungus leaf spots	copper	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, 90-95% WP	4-6	
SYCAMORE, PLANETREE, BUTTONWOOD			
Anthracnose[6]	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	1	
Leaf blight	copper	See label.	
	mancozeb, 80% WP	1-1/2 to 2	
	maneb, 80% WP	1-1/2 to 2	
	dodine, 65% WP	1	
	captafol (Difolatan 4F)	2 pints	
	zineb, 75% WP	1-1/2-2	
	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]
Powdery mildew	benomyl, 50% WP sulfur, 90-95% WP Bayleton, 25% WP	1/2-1 4-6 2-4 oz[b]	Spray 2 or 3 times, 7 to 10 days apart, starting when disease first appears.
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	See label.	If severe, spray 2 or 3 times, 10 days apart. Start at budbreak.
Powdery mildew	benomyl, 50% WP Karathane, 19.5% WP	1/2-1 1/2-1	If severe, spray twice, 10 days apart, starting when mildew first appears.
VIBURNUM			
Powdery mildew	benomyl, 50% WP Karathane, 19.5% WP Bayleton, 25% WP	1/2-1 1/2 2-4 oz[b]	Spray 2 or more times, 7 to 10 days apart. Start when disease first appears.
Nematodes	Nemacur, 10G Vydate L Dasanit, 15G	-- -- --	See Boxwood. See Boxwood. See Boxwood.
VIRGINIA CREEPER--See Ivy.			
WALNUT, BUTTERNUT			
Anthracnose Yellow leaf blotch Fungus leaf spots or blights	benomyl, 50% WP dodine, 65% WP zineb, 75% WP mancozeb, 80% WP maneb, 80% WP Duosan, 75% WP Zyban, 75% WP	1 1 1-1/2 to 2 1-1/2 to 2 1-1/2 to 2 1-1/2 1-1/2	Spray 3 or 4 times at 2-week intervals starting when the leaves begin to unfold. Thorough coverage is required.
Bacterial blight (of Persian or English walnut)	copper streptomycin formulations	See label. See label.	Spray 3 times: (1) when flowering starts; (2) at full bloom; and (3) at petal-fall.

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]
WILLOW			
Tar spot Leaf blight Scab Black canker Spot anthracnose	copper zineb, 75% WP mancozeb, 80% WP maneb, 80% WP dodine, 65% WP	See label. 1-1/2 to 2 1-1/2 to 2 1-1/2 to 2 1/2-1	Spray 3 times, 10 days apart, starting as the buds open. Zineb, maneb, and mancozeb also control rust. Sanitary measures are important.
Powdery mildew Rust	sulfur, 90-95% WP Bayleton, 25% WP	4-6 2-4 oz[b]	Apply 2 or more times, 7 to 10 days apart. Start when disease first appears.
WITCHHAZEL			
Powdery mildew	benomyl, 50% WP Karathane, 19.5% WP sulfur, 90-95% WP	1/2-1 1/2-1 3-4	Spray 2 or more times, 7 to 10 days apart. Start when disease first appears.
Fungus leaf spots	copper + benomyl, 50% WP	See label. 1/2-1	If severe, spray twice, 10 days apart. Start as leaves begin to unfold.
YEW *(Taxus)*			
Twig blight	bordeaux mixture	4-4-100[3]	Apply when new growth emerges. Repeat twice more at 7- to 10-day intervals.
Nematodes	Nemacur, 10G Mocap EC Dasanit, 15G	-- -- --	See Boxwood. See Boxwood. See Boxwood.
ALL WOODY PLANTS			
Seed decay Damping-off Seedling blights Root rots Nematodes	thiram, 42-75% WP captan, 50-75% WP	See remarks. See remarks.	Apply 2 oz per lb[b] of seed. If damping-off starts, drench seedbed at 4T per gal when first seen. Follow label directions. Captan and thiram do not control root rots or nematodes.
	methyl bromide methyl bromide 2:1 + chloropicrin mixtures Vorlex Vapam	See label. See labels. See label. See label.	Apply under gas-proof cover several weeks prior to planting in nursery beds. Controls damping-off, root rots, and nematodes.

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]
	etridiazole (Truban or Terrazole)	See labels.	Apply as a soil drench after plants are set.
	Banrot, 40% WP	See label.	Repeat at 2- to 4-week intervals. Etridiazole, fosetyl-Al, and metalaxyl control only *Phytophthora* and *Pythium*. May be combined with captan or thiram. Follow label directions.
	metalaxyl (Subdue)	See label.	
	fosetyl-Al (Aliette)	See label.	
Wood rots or decays[7]	thiram, 75% WP	1	Apply thinly in an asphalt or other nonfortified tree wound preparation. See also remarks on Sanitation preceeding Table 2. Dip tools in 70% denatured alcohol or 4% formaldehyde to disinfect them between working on trees.
	benomyl, 50% WP	1/4	

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 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 Do not use 2,4,5-T around the home, recreational areas, pond or ditch banks, or similar sites. This treatment helps prevent disease spread into nearby healthy trees. The chemical is illegal to use in most situations.

6 Treatments listed are recommended for the leaf-blight stage of anthracnose only.

7 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.

8 For commercial use only. Restricted use, only for application by certified applicators or operators.

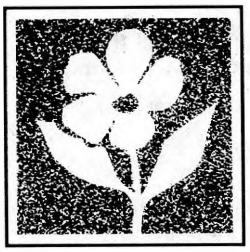
NOTES

Date	Chemical	Plant(s) treated	Dosage	Remarks

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1987 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, 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 in 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
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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, 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 and thiram, 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), flowables (F), 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, the 5% G, or the flowable 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.

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

General symptoms	Specific symptoms	Disease
Leaves with yellow to brown or black spots; plants stunted or bushy.		Foliar nematodes
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

General symptoms	Specific symptoms	Disease
	Shoots are often dwarfed or aborted; leaves are distorted; cauliflower-like growth may appear at the soil line.	Leaf gall or fasciation
	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, corm, or tuber.	Crown gall
Root damage	Lack of hair 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 registrations.

Disease	Chemicals for control	Remarks
Storage decay	zineb, 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, zineb, maneb, mancozeb, ferbam, folpet (Phaltan), 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, zineb, 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	zineb, maneb, mancozeb, ferbam, 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.
Powdery mildews	benomyl, sulfur, dinocap (Karathane), triforine (Funginex), triadimefon (Bayleton), cycloheximide (Acti-dione PM), thiophanate-methyl (Topsin M), Zyban, or Duosan	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.

Disease	Chemicals for control	Remarks
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 or fumigate soil with methyl bromide, Vorlex, 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 1,3-D (D-D), Dasanit, Mocap, Nemacur, Temik, Vydate L	For application by certified commercial applicators only. Carefully follow all label directions and precautions. See label for Vydate uses.
Foliar nematodes	Same as for wilt diseases above or use oxamyl (Vydate).	For application by certified commercial applicators only. Carefully follow all label directions and precautions. See label for Vydate 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. Rogue the first infected plants. Keep down 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.		Spray at 1- to 2-week intervals during cool, damp, overcast weather. In greenhouses, may use Exotherm Termil or Ornalin Fumigator.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	--	
	Topsin M, 70% WP	See label.		

[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]
Nematodes: soil and foliar	Temik 10G (SLN 8003)			Apply 18-28 oz/1000 sq ft.
Nematodes: Root-knot, sting, lesion, stunt	Vydate L Potted soil mix	15-20 gal 27-1/2 fl oz		Preplant incorporate 4 to 8 inches. Spray 2.5 to 3.3 gal/1 cu yd of soil while tumbling in mixer.
	Pot drench Foliar	1 pint 2-4 pints		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.
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.		
	Bayleton, 25% WP	2-4 oz	--	
Crown and stem rots	Banol, Truban, Terrazole, or Subdue + PCNB (Terraclor), 75% WP	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.		
AJUGA				
Sclerotium (crown) rot or southern blight	PCNB (Terraclor), 75% WP	See label.		Apply 2 lb PCNB per 1000 sq ft as dust on soil surface before planting. Thoroughly work into top 2 inches of soil. See label for Banrot applications.
	Banrot	See label.		
Nematodes (nursery stock)	Nemacur, 10G	See label.		Apply 18 lb per acre postplant and irrigate with 1/2 inch of water. One application per year.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
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.		
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
Powdery mildew	Topsin M, 70% WP	See label.		
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Ornalin, 50% WP	1/2-1 lb	--	
	zineb, 75% WP	1-1/2 to 2 lb	1-1/2 to 2 T	
Rust	zineb, 75% 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	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	Bayleton, 25% WP	2-4 oz	--	
	Funginex, 6.5% L or 18% EC	See label.	1-1/2 T	
	ferbam, 76% WP	1-1/2 lb	1-1/2 T	
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 1t per gal of water. Apply Chipco 26019 at transplant time.
	Banrot	See label.		
	Chipco 26019, 50% WP	6-1/2 oz	--	
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	--	
Root rots	Banrot	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 yellows	Apply recommended insecticide at frequent intervals.			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 African Violet.
AZALEA - See *Disease Control Programs for Woody Ornamentals*, Circular 1260.				
BEGONIA				
Botrytis blight, leaf spot, and stem rot	benomyl, 50% WP	1/2 lb.	2 t	Spray at least weekly during cool, damp, overcast weather. In greenhouses, may use Exotherm Termil or Ornalin Fumigator according to label directions. Check label registrations.
	Ornalin, 50% WP	1/2-1 lb	--	
	chlorothalonil	See label.		
Other fungal leaf spots	Zyban, 75% WP	1-1/2 lb	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Topsin M, 70% WP	See label.		
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 14-day intervals, starting when mildew first appears. Add a spreader-sticker to the spray mix. Milban is a restricted-use pesticide.
	Karathane, 19.5% WP	1/4 lb	1 t	
	Acti-dione PM, 0.027% WP	See label.		
	Bayleton, 25% WP	2-4 oz	--	
	Milban, 39% EC	See label.		
	Rubigan, 12.5% EC	3-5 fl oz	--	
Nematodes (Reiger begonia)	Vydate L	--	--	See African Violet.
Root and stem or crown rots	PCNB (Terraclor), 75% WP, + Truban, Terrazole, or Subdue	See labels.		Apply monthly drenches to plants and soil. Do not apply to very young seedlings. Follow manufacturer's directions.
	Banrot	See label.		
Damping-off Tuber rot	captan, 50% WP	4 lb	8 T	Soak clean, disease-free tubers of tuberous begonias for 30 minutes. Drain and plant in well-drained soil.
Bacterial leaf spot	Kocide 101, 77% WP	See label.		Keep foliage protected. Avoid wetting the foliage when watering.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
CALENDULA				
Fungal leaf spots	benomyl, 50% WP	1/2 lb	2 t	Spray or dust foliage and flowers at 7- to 14-day intervals. Start when disease first appears.
	Topsin M, 70% WP	See label.		
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, 90-95% WP	See label.		
	Funginex, 6.5% L or 18.2% EC	See label.		
	Topsin M, 70% WP	See label.		
	Rubigan,12.5% EC	3-5 fl oz	--	
Rhizoctonia stem and root rot	PCNB (Terraclor), 75% WP	1 lb	1 T	Apply Terraclor as a soil drench once or work dust 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.		
	Banrot	See label.		
Nematodes	Vydate L	--	--	See African Violet.
CALLA				
Bacterial soft rot	formaldehyde, 38-40% L			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 zineb, mancozeb, or maneb and captan or folpet 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	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
Greasy blotch	captan, 50% WP	2 lb	2 T	
Other fungal leaf spots	folpet (Phaltan), 50-75% WP	1-2 lb	1-2 T	
Anthracnose	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	chlorothalonil	See label.		
	Dyrene, 50% WP	1 lb	--	
	ferbam, 76% WP	1-1/2 lb	1-1/2 T	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Rust	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	intervals and include a
	maneb, 80% WP	1-1/2 lb	1-1/2 T	spreader-sticker. Start
	captan, 50% WP	2-1/2 lb	2-3 T	with captan when cuttings
	Bayleton, 25% WP	2-4 oz	--	are first stuck in the
	Funginex, 6.5% L or 18.2% EC	See label.		propagating bench. Keep water off the foliage.
Botrytis blight or gray-mold	zineb, 75% WP	1-1/2 lb	1 T	Apply at 7- to 10-day
	captan, 50% WP	1/2 lb	1 T	intervals in damp, cloudy
	benomyl, 50% WP	1/2 lb	2 t	weather. Start when disease
	chlorothalonil	See label.		first appears. During bloom,
	Ornalin, 50% WP	1/2-1 lb	--	apply twice weekly. In
	Duosan, 75% WP	1-1/2 lb	--	greenhouses, may use
	Zyban, 75% WP	1-1/2 lb	--	Exotherm Termil or Ornalin
	Chipco 26019, 50% WP	1-2 lb	1-2T	Fumigator. Ornalin may also be used as a postharvest
	Topsin M, 70% WP	See label.		spray to cut flowers.
Rhizoctonia stem rot	PCNB (Terraclor), 75% WP	1 lb	1 T	Apply Terraclor or Banrot once as preplant drenches.
	benomyl, 50% WP	1 lb	4 t	Follow the manufacturer's
	Banrot	See label.		directions. Spray base of
	Chipco 26019, 50% WP	6-1/2 oz	--	cuttings after they are stuck or spray transplants with benomyl or Chipco 26019.
Fusarium stem rot	zineb, 75% WP	1-1/2 lb	1/2 T	Alternate zineb and captan
	captan, 50% WP	1-1/2 lb	1/2 T	on a weekly basis. Drench
	benomyl, 50% WP	1/2 lb	2 t	soil with zineb at 1/2 lb per 50 gal water per 400 sq ft of bench. Spray cuttings in rooting medium with benomyl.
Nematodes	Vydate L	--	--	See African violet
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Begin when disease first appears.
	Bayleton, 25% WP	2-4 oz	--	Repeat at 10 to 21 day intervals. Check label.
Pythium root rot	Banrot	See label.		Apply as soil drenches at
Phytophthora root rot	Truban, Terrazole, Banol, or			4- to 8-week intervals using 1 gal per 8 sq ft of bed.
Damping-off	Subdue	See labels.		Water chemical in well.

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]
CHRYSANTHEMUM (See also Pot Mums and Field Mums below.)				
Ascochyta stem and ray blight	maneb, 80% WP	1 lb	1 T	Spray foliage and flowers at 5- to 10-day intervals during damp weather. Start when disease first appears. Add a commercial spreader-sticker (surfactant) to the spray to ensure wetting the foliage. Mix benomyl with another fungicide. Follow label directions and check label registrations.
	mancozeb, 80% WP	1 lb	1 T	
Septoria and other fungal leaf spots	zineb, 75% WP	1 lb	1 T	
	captan, 50% WP	2 lb	2 T	
	chlorothalonil	See label.		
Anthracnose	benomyl, 50% WP	1 lb	1 T	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	folpet (Phaltan), 50-75% WP	1-2 lb	1-1/2 to 2 T	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day intervals, starting a week before rust is expected.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	ferbam, 76% WP	1-1/2 lb	2 T	
	Bayleton, 25% WP	2-4 oz	--	
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 or Ornalin Fumigator. Ornalin may also be used as a postharvest spray.
	Ornalin, 50% WP	1/2-1 lb	--	
	chlorothalonil	See label.		
	Zyban, 75% WP	1-1/2 lb	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Topsin M, 70% WP	See label.		
Powdery mildew	Acti-dione PM, 0.027% WP	See label.		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.
	sulfur, 90-95% WP	3-1/2 lb	2-1/2 T	
	benomyl, 50% WP	1/2 lb	2 t	
	Karathane, 19.5% WP	1/4 lb	1 t	
	Bayleton, 25% WP	2-4 oz	--	
	Milban, 39% EC	See label.		
	Rubigan, 12.5% EC	3-5 fl oz	--	
Foliar nematodes	Temik 10G			See African Violet.
	Systox 2	--	2-4 pints.	Spray plants until thoroughly wet.
	soil drench	--	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. 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]
Nematodes	Dasanit, 15G		1 lb/1000 sq ft	Apply evenly and incorporate 4 to 6 inches.
	pot mix		1.4 g/cu ft	Mix thoroughly into soil. Outdoor use only.
	Temik 10G			See African Violet.
	Vydate L			See African Violet.
Pot Mums				
Root and stem or foot rots	Subdue, Truban, Terrazole, or Banol + PCNB (Terraclor), 75% WP	See labels. 1/4 lb	1 t	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.
	Banrot	See label.		
Field Mums				
Root and stem or foot rots	Subdue, Truban, Terrazole, or Banol + PCNB (Terraclor), 75% WP	See labels. 3/4 lb	1 T	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, Terrazole, Truban, or Banol plus benomyl at 1t of each per gal of water.
	Banrot	See label.		
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	--	
Sclerotinia (cottony) stem rot	Chipco 26019, 50% WP	6-1/2 oz	--	
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 important.
	chlorothalonil	See label.		
	Ornalin, 50% WP	1/2-1 lb	--	
	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]
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	
Root and crown rots	Truban or Terrazole + PCNB (Terraclor), 75% WP	See labels. 1/4 lb	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, 90-95% WP	3-4 lb	2-3 T	
CYCLAMEN				
Botrytis blight or crown rot	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day intervals during damp, overcast weather. Mist-spray blooms at 3- to 7-day intervals, but reduce the rate: benomyl 1/2 rate; zineb 1/3 rate. In greenhouses, may use Exotherm Termil or Ornalin Fumigator.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	--	
	chlorothalonil	See label.		
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Fungal leaf spots	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray the foliage at weekly intervals during wet weather.
Stunt disease	ferbam, 76% WP	1-1/2 lb	2 T	Spray at weekly intervals during damp, overcast weather.
Nematodes	Dasanit, 15G	--	--	See Chrysanthemum.
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.
	zineb, 75% WP	3/4 lb	3/4 T	
	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	--	
	Duosan, 75% WP	1-1/2 lb	--	
	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]
Powdery mildew	Funginex, 6.5% L or 18.2% EC	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 80° to 85°F. Apply benomyl, Bayleton, or Funginex at 10- to 14-day intervals.
	benomyl, 50% WP	1/2 lb	2 t	
	sulfur, 90-95% WP	3-4 lb	2-3 T	
	Karathane, 19.5% WP	1/4 lb	1 t	
	Bayleton, 25% WP	2-4 oz	--	
	Rubigan, 12.5% EC	3-5 fl oz		
Crown and root rots	Banrot	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	--	
Foliar nematodes	Temik 10G	--	--	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 granules can be blended into soil before planting.
Sclerotinia wilt	Banrot	See label.		
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray the foliage thoroughly at 7- to 10-day intervals, starting when mildew is first seen. Follow label directions.
	Karathane, 19.5% WP	1/4 lb	1 t	
	sulfur, 90-95% WP	3-4 lb	2-3 T	
	Bayleton, 25% WP	2-4 oz	--	
	Rubigan, 12.5% EC	3-5 fl oz	--	
Fungal leaf spots	ferbam, 76% WP	1-1/2 lb	1-1/2 T	Spray at 7- to 10-day intervals. Start when disease first appears. Sanitary measures are important.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	benomyl, 50% WP	1/2 lb	2 t	
	Topsin M, 70% WP	See label.		
Botrytis blight or gray-mold	chlorothalonil	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.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	benomyl, 50% WP	1/2 lb	2 t	
	Topsin M, 70% WP	See label.		
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Ornalin, 50% WP	1/2-1 lb	--	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Black leaf spot	fixed copper, 50-56% Cu	See label.		Drench soil at base of plants in fall. Spray young shoots in spring with fixed copper at 2T per gal of water.
DIEFFENBACHIA				
Bacterial soft rot or stem rot	streptomycin formulations	Apply at 200 parts per million.		Dip cane cuttings. Carefully follow the manufacturer's directions on the label.
Fungal root and stem rots Damping-off	Banrot	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.
	Ornalin, 50% WP	1/2-1 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Bacterial leaf spot	streptomycin formulations	Apply at 200 parts per million.		Spray the foliage and canes during damp weather, starting when disease appears. Follow label directions.
Nematodes	Vydate L	--	--	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.
	Ornalin, 50% WP	1/2-1 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Fungal cutting or stem rots	Banrot	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, or Subdue + PCNB (Terraclor), 75% WP	See labels. 1/4 lb	1 t	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
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.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	Kocide 101, 77% WP	See label.		
	chlorothalonil	See label.		
Root rots	Banrot	See label.		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.		
FREESIA				
Bacterial scab	thiram, 50-75% 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	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray foliage and flowers at 7- to 10-day intervals in cool, damp, overcast weather. Follow label directions.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	--	
FUCHSIA				
Botrytis blight or gray-mold	chlorothalonil	See label.		Spray at 7- to 10-day intervals in cool, damp, overcast weather. In greenhouses, may use Exotherm Termil or Ornalin Fumigator.
	benomyl, 50% WP	1/2 lb	2 t	
	Ornalin, 50% WP	1/2-1 lb	--	
Rust	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray weekly starting when rust first appears.
GARDENIA				
Canker	ferbam, 76% WP	--	--	Mix 1/2 lb ferbam with 100 lb of sand for cutting bed or spray rooted plants with ferbam at 1-1/2 lb per 100 gal or 2T per gal. Spray at 10-day intervals to keep plants protected.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Fungal leaf spots	ferbam, 76% WP	1-1/2 lb	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.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	chlorothalonil	See label.		
Crown and root rots	Banrot	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 Chrysanthemum.
	Mocap EC	1/2 pint		Apply 1 gal per sq yd. Wash from foliage. After treatment, wet soil to 6 to 12 inches.
	Field nursery stock			
	Bed and bench	1/2-1 pint		Mix with enough water to cover 1000 sq. ft. Wet soil to 4 to 6 inches.
	Pot drench	1/2 pint		Drench with 1/2 pint per 6-inch pot and 1 pint per 8 inches.
	Root dip	1 pint		Allow only roots to soak for 30 minutes.
	Nemacur, 10G			See Ajuga.
	Temik 15G			See African Violet.
	Vydate L			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 or Ornalin Fumigator. Keep old flowers and leaves picked off and keep water off the foliage. Check label registrations.
	zineb, 75% WP	1 lb	1 T	
	Ornalin, 50% WP	1/2-1 lb	--	
	chlorothalonil	See label.		
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Topsin M, 70% WP	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]
Fungal leaf spots	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray or dust at 7- to 14-day intervals. Start when disease first appears. Keep the foliage protected during damp, overcast weather when infections occur. Sanitation is important.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	chlorothalonil	See label.		
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	Topsin M, 70% WP	See label.		
	benomyl, 50% WP	1/2 lb	2 t	
Rust	Plantvax, 75% WP	1 to 1-1/2 lb	1 T	Apply Plantvax or Bayleton at 2- to 4-week intervals when rust is present. Spray or dust maneb, zineb, mancozeb, and chlorothalonil at 7- to 10-day intervals, starting when rust is first evident.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Bayleton, 25% WP	2-4 oz	--	
	chlorothalonil	See label.		
Rhizoctonia root and stem rot Damping-off	PCNB (Terraclor), 75% WP	1/2 lb	2 t	Drench established plants with Terraclor or Banrot once, using 1 pint to 1 qt 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.
	benomyl, 50% WP	1/2 lb	2 t	
	Banrot	See label.		
	Chipco 26019, 50% WP	6-1/2 oz	--	
Blackleg (*Pythium*)	captan, 50% WP	2 lb	1-1/2 T	Spray cuttings in the cutting bench. Several spray applications may be needed, spaced 1 to 3 weeks apart.
	Subdue, Truban, Banol, or Terrazole	See labels.		
Foliar nematodes	Temik 15G	--	--	See African Violet.
Other root rots	Subdue, Terrazole or Truban + benomyl, 50% WP	See labels. 1/2 lb	2 t	Drench established, well-rooted plants once. Use 1 qt of fungicide mix per sq ft or 1/2 pint per 6-inch pot.
	Banrot	See label.		
GERBERA, TRANSVAAL DAISY				
Phytophthora root rot	Truban or Terrazole	See labels.		Apply as a soil drench or mix thoroughly into the soil just before planting. Follow the manufacturer's directions.
	captan, 50% WP	2 lb	2 T	
	Banrot	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]
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	
Botrytis blight Damping-off Sclerotinia blight	Ornalin, 50% WP	1/2-1 lb	--	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 African Violet.
GLADIOLUS				
Fusarium yellows and corm rot	benomyl, 50% WP	1-2/3 lb	2 T	Within 24 hours after digging, soak gladiolus corms in a basket or loosely woven sack for 15 minutes at a water temperature of 80° to 85°F. Or dust corms as for bacterial scab. Dry and store properly.
Penicillium corm rot	Mertect 160-F, 60% WP	1-1/2 lb	2 T	
	Ornalin, 50% WP	1-1/2 to 2 lb	--	
	Topsin M, 70% WP	See label.		
Stromatinia corm rot	Botran, 75% WP	8 lb	20 T	Before planting, dip corms following label directions. Or apply Botran in the furrow at 1-1/3 lb per 1000 ft of row at planting.
	Ornalin, 50% WP	1-1/2 to 2 lb	--	
Bacterial scab	thiram, 50 or 75% WP			Dust disease-free corms with thiram or thiram-insecticide combination before planting and just before storage.
Nematodes	Dasanit, 15G	--	--	See Chrysanthemum.
	Vydate L	--	--	See African Violet.
Botrytis leaf and flower spot and corm rot	Topsin M, 70% WP	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	
	zineb, 75% WP	1-1/2 lb	2 T	
	captan, 50% WP	2 lb	2 T	
	chlorothalonil	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 footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Other fungal leaf spots	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray weekly during rainy periods, starting when the leaf spots appear. Add a commercial spreader-sticker (surfactant) to the spray.
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	Dyrene, 65% WP	2 lb	2 T	
	chlorothalonil	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.
	zineb, 75% WP	1-1/2 lb	1 T	
	chlorothalonil	See label.		
	Topsin M, 70% WP	See label.		
	Ornalin, 50% WP	1/2-1 lb	--	
Crown rot Leaf and tuber rot	Banrot	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.		
HOLLYHOCK				
Rust Leaf spots Anthracnose	chlorothalonil	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	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	ferbam, 76% WP	2 lb	2 T	
	sulfur, 90-95% WP	See label.		
	Bayleton, 25% WP	2-4 oz	--	
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, 50-75% WP	1 lb	1 T	
	Ornalin, 50% WP	1/2-1 lb	--	
Fungal bulb rots	Truban or Terrazole + benomyl, 50% WP, or Mertect 160-F, 60% WP thiram, 50-75% WP	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 minutes in Ornalin suspension.
		1/2 lb	2 t	
		See label.		
	Ornalin, 50% WP	1-1/2 to 2 lb	--	

HYDRANGEA--See *Disease Control Programs for Woody Ornamentals*, Circular 1260.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
IRIS				
Leaf spot	chlorothalonil	See label.		Spray 4 to 6 times, 7 to
Rust	zineb, 75% WP	1-1/2 lb	1-1/2 T	10 days apart. Start when
	maneb, 80% WP	1-1/2 lb	1-1/2 T	new leaves are several
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	inches tall. Add a
	folpet (Phaltan), 50-75% WP	1 to 1-1/2 lb	1-1/2 T	spreader-sticker to the spray to ensure better
	benomyl, 50% WP	1 lb	1 T	wetting and coverage. If
	Bayleton, 25% WP	1 lb	--	rust is a problem, spray
	Chipco 26019, 50% WP	1-2 lb	1-2 T	with zineb, mancozeb, maneb, Bayleton, or chlorothalonil.
	Topsin M, 70% WP	See label.		
Fungal crown, rhizome, and bulb rots	PCNB (Terraclor), 75% WP	1/2 lb	1 T	Apply as a soil drench at 1 pint to 1 qt per sq ft at or
	Botran, 50-75% WP	1-1/2 lb	1-1/2 T	before planting and again
	Mertect 160-F, 60% WP	See label.		when new growth appears in spring. Apply Mertect, Ornalin,
	Topsin M, 70% WP	See label.		and Topsin M as bulb dips only.
	Ornalin, 50% WP	See label.		
Bacterial soft rot and rhizome rot	Apply recommended insecticides starting when fan leaves are several inches tall.			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 African Violet.
	Dasanit, 15G	See label.	--	See Chrysanthemum.
IVY, ENGLISH				
Fungus leaf spots and blight	benomyl, 50% WP	1/2 lb	2 t	Spray or dust several times
	zineb, 75% WP	1-1/2 lb	1-1/2 T	at 7- to 10-day intervals.
Stem spot	fixed copper,			Keep the foliage protected
Twig blight	50-56% Cu	See label.		during rainy spring and
	Duosan, 75% WP	1-1/2 lb	--	early summer weather. Start
	Zyban, 75% WP	1-1/2 lb	--	when the disease first
	ferbam, 76%	1-1/2 lb.	1-1/2 T	appears.
Root rot	Banrot	See label.		Keep soil mix on the dry
Crown rot	Chipco 26019, 50% WP	6-1/2 oz	--	side. Apply Banrot as a soil drench or blend granules into soil before planting. Follow label directions. Apply Chipco 26019 at transplant time.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
Nematodes	Nemacur, 10G	--	--	See Ajuga.
	Vydate L	--	--	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.
	Ornalin, 50% WP	1/2-1 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
KALANCHOE				
Crown or stem rot Wilt Root rot	Banrot	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 milew	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	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Milban, 39% EC	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. Sanitation is important. Keep water off the foliage.
	Ornalin, 50% WP	1/2-1 lb	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	--	Same as for Botrytis blight above. Keep water off the foliage.
	Zyban, 75% WP	1-1/2 lb	--	
Nematodes	Vydate L	--	--	See African Violet.
LARKSPUR--See Delphinium.				
LILY				
Root rot complex	Subdue, Terrazole, or Truban + benomyl, 50% WP	See labels. 1 lb	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 Truban or Terrazole or Banrot granules into potting mix. Banrot can be applied at 4- to 12-week intervals.
	Banrot	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]
	Banol, Subdue, Terrazole, or Truban + benomyl, 50% WP or Mertect, 160-F, 60% WP	See labels. 2.7 oz See label.	--	Dip bulbs 10 to 15 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.		
	Topsin M, 70% WP	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 or Ornalin Fumigator. Sanitation is important.
	chlorothalonil	See label.		
	Ornalin, 50% WP	1/2-1 lb	--	
	Topsin M, 70% WP	See label.		
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Bulb rots (*Rhizopus and Penicillium*)	thiram, 50-75% WP or thiram + benomyl, 50% WP			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 + benomyl, 50% WP or Mertect 160-F, 60% WP	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 15 minutes as given under root rots.
	Banrot	See label.		
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 Ajuga.
	Temik 15G	See label.	--	
	Dasanit, 15G	See label.	--	See Chrysanthemum.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
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. Sanitation is important.
	benomyl, 50% WP	1/2 lb	2 t	
	chlorothalonil	See label.		
	Ornalin, 50% WP	1/2-1 lb	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	-	
Phytophthora stem rot and wilt	Banol, Terrazole, Truban, or			Thoroughly mix the fungicide into the soil just before planting or apply as a soil drench after planting.
	Subdue	See labels.		
	Banrot	See label.		
Nematodes	Vydate L	--	--	See African Violet.
NARCISSUS, DAFFODIL				
Fungal bulb rots	PCNB (Terraclor), 75% WP	50 lb	1/2 lb	Dip cleaned bulbs for 5 minutes in a suspension of Terraclor, Mertect, Topsin M, or benomyl for 15 to 30 minutes 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 160-F, 60% WP	See label.		
	benomyl, 50% WP	1-2/3 lb	2 T	
	Ornalin, 50% WP	1-1/2-2 lb	--	
	thiram, 50-75% WP	See label.		
	Topsin M, 70% WP	See label.		
Foliar nematodes		--	--	See Chrysanthemum.
ORCHIDS				
Black rot Root rot Damping-off	8-hydroxyquinoline sulfate, 5% WP	See label.		Dip infected plants, pot and all, for an hour. Repeat a week later if disease persists. Or drench plants with Truban or Terrazole following label directions.
	Truban or Terrazole	See labels.		
Botrytis flower spot or blight or gray-mold	chlorothalonil	See label.		In closed greenhouses, you may use Exotherm Termil or Ornalin Fumigator as directed by the manufacturer. Test trial varieties for possible injury.
	Ornalin, 50% WP	1/2-1 lb	--	
Nematodes	Vydate L	--	--	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]
Foliar nematodes	Temik 10G	--	--	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	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
Nematodes	Vydate L	--	--	See African Violet.
	Nemacur, 10G	--	--	See Ajuga.
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	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	benomyl, 50% WP	1/2 lb	2 t	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
Rust Powdery mildew	Bayleton, 25% WP	2-4 oz	--	Spray when disease appears. Follow label directions.
Seed rot Seedling blights Damping-off	captan, 50-75% WP	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 granules into soil before planting. Follow label directions.
	Banrot			
Nematodes	Vydate L	--	--	See African Violet.
PELARGONIUM--See Geranium.				

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]
PEONY				
Botrytis blight, leaf blotch, bud blast, and shoot blight	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 in the spring and continue until flowers begin to open. Add a commercial spreader-sticker to the spray.
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
	benomyl, 50% WP	1 lb	1 T	
	Topsin M, 70% WP	See label.		
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	
	zineb, 75% WP	1-1/2 lb	1-1/2 T	
Foliar nematodes	Temik 10G	--	--	See African Violet.
Nematodes	Vydate L	--	--	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 Ajuga.
	Vydate L	--	--	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 or Ornalin Fumigator according to label directions.
	Ornalin, 50% WP	1/2-1 lb	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb	--	
	chlorothalonil	See label.		
Nematodes	Vydate L	--	--	See African Violet.
Fungal root and crown or foot rots (*Pythium* and *Rhizoctonia*)	Banrot	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 4- to 12-week intervals. Or blend 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]
PHILODENDRON				
Bacterial leaf spot	streptomycin formulations	Apply at 200 parts per million.		Remove spotted and dead leaves and spray foliage during damp weather at 4 to 5 day intervals starting when the disease first appears. Follow label directions.
	Kocide 101, 77% WP	See label.		
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	--	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	--	
	chlorothalonil	See label.		
	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	
Damping-off Root and stem rots	Banrot	See label.		Drench plants following the manufacturer's directions or blend granules into soil mix before planting.
Nematodes	Mocap EC	--	--	See Gardenia.
	Vydate L	--	--	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	--	
	Karathane, 19.5% WP	1/4 lb	1 t	
	folpet (Phaltan), 50-75% WP	1-1/2 to 2 lb	2 T	
	Funginex, 6.5% L or 18.2% EC	See label.		
	sulfur, 90-95% WP	3-1/2 lb	2-1/2 T	
	Rubigan, 12.5% EC	3-5 fl oz	--	
Fungal leaf spots Rust	zineb, 75% WP	1-1/2 lb	1-1/2 T	Spray several times, 7 to 10 days apart. Start when disease first appears on the leaves. For rust use zineb, ferbam, or Bayleton.
	benomyl, 50% WP	1/2 lb	2 t	
	ferbam, 76% WP	2 lb	2 T	
	Bayleton, 25% WP	2-4 oz	--	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb		
Root rots	Banrot	See label.		Drench plants following 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]
POINSETTIA				
Botrytis blight	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 7- to
or gray-mold	Ornalin, 50% WP	1/2-1 lb	--	14-day intervals during
Stem canker and	Duosan, 75% WP	1-1/2 lb	--	cool, damp, overcast
leaf spot	Zyban, 75% WP	1-1/2 lb	--	weather. Do not spray
Scab	Chipco 26019,			Ornalin when plants are in
	50% WP	1-2 lb	1-2 T	color; some poinsettia cultivars may be sensitive to leaf spotting.
Root and stem	Banrot	See label.		If disease appears after
rot complex	Truban,			potting, drench established
(*Rhizoctonia*,	Terrazole,			plants once. Apply 1/2
Thielaviopsis,	Subdue, or			pint per 6-inch pot and water
Pythium, etc.)	Banol +	See labels.		the chemical into the soil
	PCNB (Terraclor),			immediately. If the
	75% WP or	1/4 lb	1 t	disease appears later,
	benomyl, 50% WP	1/2-1 lb	3 t	apply Subdue, Banol,
	Chipco 26019,			Truban, or Terrazole, plus
	50% WP	6-1/2 oz	--	benomyl at 1/4 lb per 100 gal using 1/2 pint per 6-inch pot at 20-day intervals. Or apply Banrot alone according to label directions. Apply Chipco 26019 at transplant time to control *Rhizoctonia*.
ROSE -- See *Disease Control Programs for Woody Ornamentals*, Circular 1260.				
SNAPDRAGON				
Anthracnose	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray or dust at 7- to 10-
Fungal leaf spots	zineb, 75% WP	1-1/2 lb	1-1/2 T	day intervals during rainy
	chlorothalonil	See label.		periods. Start when
	benomyl, 50% WP	1/2 lb	2 t	disease first appears.
	captan, 50% WP	2 lb	2 T	Adding a spreader-sticker
	Duosan, 75% WP	1-1/2 lb	--	ensures better wetting. In
	Zyban, 75% WP	1-1/2 lb	--	closed greenhouses, may use
	folpet, 50-75% WP	1-1/2 lb	1-1/2 T	Exotherm Termil or Ornalin
	Topsin M, 70% WP	See label.		Fumigator. Sanitation is important.
Botrytis blight	benomyl, 50% WP	1/2 lb	2 t	Spray at weekly intervals
or gray-mold	zineb, 75% WP	1-1/2 lb	1-1/2 T	during cool, damp, overcast
Phyllosticta leaf	chlorothalonil	See label.		weather. In closed
and stem blight	Duosan, 75% WP	1-1/2 lb	--	greenhouses, may use
	Zyban, 75% WP	1-1/2 lb	--	Exerotherm Termil or Ornalin
	Chipco 26019,			Fumigator. When plants are
	50% WP	1-2 lb	1-2 T	in bloom, use only benomyl and at half strength: 1/4 lb per 100 gal or 1t per gal.

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]
Rust	mancozeb, 80% WP	1-1/2 lb	1-1/2 T	Spray at 5- to 10-day
Downy mildew	maneb, 80% WP	1-1/2 lb	1-1/2 T	intervals in damp or rainy
Other fungal	zineb, 75% WP	1-1/2 lb	1-1/2 T	weather. Start when disease
leaf spots	Zyban, 75% WP	1-1/2 lb	--	first appears. Use
and blights	Duosan, 75% WP	1-1/2 lb	--	mancozeb, zineb, maneb,
	Bayleton, 25% WP	2-4 oz	--	Funginex, or Bayleton to control
	Funginex, 6.5% L or 18.2% EC	See label.		rusts. Bayleton will not control any of the other diseases.
Powdery mildew	benomyl, 50% WP	1/2 lb	2 t	Spray at 7- to 10-day
	Karathane, 19.5% WP	1/4 lb	1 t	intervals. Add a commercial spreader-sticker to the
	Bayleton, 25% WP	2-4 oz	--	spray. Use benomyl at 1t
	Funginex, 6.5% L or 18.2% EC	See label.		per gal on seedlings.
Rhizoctonia stem	PCNB (Terraclor),			Apply as a soil drench once
and root rot	75% WP	1/2 lb	1 T	to established plants when
or wirestem	Banrot	See label.		disease is expected.
Damping-off	Chipco 26019,			Follow all label directions.
	50% WP	6-1/2 oz	--	Apply Chipco 26019 at seeding and transplanting time.
Nematodes	Vydate L	--	--	See African Violet.
Pythium and	Banol, Subdue,			Drench established plants
Phytophthora	Truban, or			using 1 pint to 1 qt per sq
crown and root	Terrazole	See labels.		ft. Repeat in 4 to 8 weeks
rots	Banrot	See label.		if needed.
STOCK				
Botrytis blight	benomyl, 50% WP	1/2 lb	2 t	Spray several times at 7-
or gray-mold	zineb, 75% WP	1-1/2 lb	1-1/2 T	to 10-day intervals during
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	--	cool, damp, overcast
	Zyban, 75% WP	1-1/2 lb	--	weather. Sanitation is important.
Root and	PCNB (Terraclor),			Drench plants using 1 pint
stem rots	75% WP	1/2 lb	2 t	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-
	benomyl, 50% WP	1/2 lb	2 t	to 10-day intervals. Start
	sulfur, 90-95% WP	3-1/2 lb	2-1/2 T	when mildew first appears on the leaves.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
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.
Root and stem rots	PCNB (Terraclor), 75% WP + benomyl, 50% WP	1 lb See label.	1 T	Thoroughly mix Terraclor and benomyl as a dust into the top 2 inches of soil before planting. Or apply Terraclor or benomyl as a soil drench once at 1 pint to 1 qt per sq ft after planting.
TRANSVAAL DAISY--See Gerbera.				
TULIP				
Fire or Botrytis blight or gray-mold	Botran, 50-75% WP chlorothalonil benomyl, 50% WP mancozeb, 80% WP Ornalin, 50% WP Chipco 26019, 50% WP Topsin M, 70% WP	1 lb See label. 1/2 lb 1-1/2 lb 1/2-1 lb 1-2 lb See label.	1 T 2 t 1-1/2 T -- 1-2 T	Spray several times at 5- to 10-day intervals. Start when the leaves emerge from the soil and continue to early bloom. Add a spreader-sticker to the spray to ensure wetting the foliage and getting good coverage. Treat the soil at planting time and drench the soil before emergence using Botran or benomyl at 1T per gal. Ornalin may also be used as a bulb dip (1-1/2 to 2 lb per 100 gal.)
Bulb rots	PCNB (Terraclor), 75% WP or thiram, 50-75% WP, or Truban, or Terrazole + benomyl, 50% WP, or Mertect 160-F, 60% WP Ornalin, 50% WP Topsin M, 70% WP	50 lb See labels. 1/2 lb See label. 1-1/2 to 2 lb See label.	1/2 lb 2 t -- 	Before planting, dip bulbs for 5 minutes in a Terraclor, Mertect, Topsin M, or Ornalin suspension or dust bulbs thoroughly with thiram. See remarks on root rot complex of lily.

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
VERBENA				
Rhizoctonia stem and root rot	PCNB (Terraclor), 75% WP	1 lb	1 T	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 of bed.
	benomyl, 50% WP	See label.		
	Banrot	See label.		
Fungal leaf spots	Duosan, 75% WP	1-1/2 lb	--	Spray foliage several times at 10-day intervals during wet periods. Start when disease first appears.
	Zyban, 75% WP	1-1/2 lb	--	
Nematodes	Vydate L	--	--	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 the 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 or Orthocide, 50 or 75% WP. Sanitation is important.
	maneb, 80% WP	1-1/2 lb	1-1/2 T	
	zineb,75% WP	1-1/2 lb	1-1/2 T	
	folpet (Phaltan), 50-75% WP	2 lb	2 T	
	Duosan, 75% WP	1-1/2 lb		
	Zyban, 75% WP	1-1/2 lb	--	
	Chipco 26019, 50% WP	1-2 lb	-- 1-2 T	
	Bayleton, 25% WP	2-4 oz	--	
Powdery mildew	Funginex, 6.5% L or 18.2% EC	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	--	
	Zyban, 75% WP	1-1/2 lb	--	
	benomyl, 50% WP	1/2 lb	2 t	
	Karathane, 19.5% WP	1/4 lb	1 t	
	Acti-dione PM, 0.027% WP	See label.		
	chlorothalonil	See label.		
	Bayleton, 25% WP	2-4 oz	--	
	Milban, 39% EC	See label.		
	Rubigan, 12.5% EC	3-5 fl oz	--	

See footnotes at the beginning of Table 3.

Flower and disease	Chemicals for control[a]	Rate[b] 100 gallons	1 gallon	Remarks[c]
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.
	Ornalin, 50% WP	1/2-1 lb	--	
	Chipco 26019, 50% WP	1-2 lb	1-2 T	
	Duosan, 75% WP	1-1/2 lb	--	
	Zyban, 75% WP	1-1/2 lb		
Root and stem rot complex	Banrot	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.		
		1/2 lb	2 t	
	Chipco 26019, 50% WP	6-1/2 oz	--	

See footnotes at the beginning of Table 3.

NOTES

Date	Chemical	Plant(s) treated	Dosage	Remarks

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1987 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). 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. — Chemical Control of Broadleaf Weeds in Turf

	2,4-D[a]	MCPP[b]	Dicamba[c]	Combination of the three[d]
(S = susceptible; I = intermediate control; R = resistant)				
Black medic	R	I	S	S
Carpetweed	S	I	S	S
Chickweed, common	R	S-I	S	S
Chickweed, mouse-ear	R	S-I	S	S
Chicory	S	S	S	S
Daisy, oxeye	I	I	I	I
Dandelion	S	S-I	S	S
Dock, curly	I	I-R	S	S
Ground ivy	I-R	I	S-I	S
Hawkweed	S-I	R	S-I	S
Henbit	I	I	S	S
Knotweed	R	I	S	S
Lambsquarters	S	S	S	S
Mallow, roundleaf	I-R	I	S-I	S
Plantain, broadleaf	S	I-R	R	S
Plantain, buckhorn	S	I-R	R	S
Purslane	I	R	S	S
Red sorrel	R	R	S	S
Speedwell, creeping	R	R	R	I
Speedwell, purslane	I	I	I	S
Spurge, prostrate	I-R	I	S-I	S
Thistles	S-I	I	S	I
Violet[e]	R	R	R	R
White clover	I	S	S	S
Wild carrot	S	S-I	S	S
Wild onion	I	R	S-I	S
Woodsorrel, yellow	I	I	I	S
Yarrow	I	I-R	S	S

Note: Bromoxynil may be used at ⅜ lb./A. for broadleaf control in seedling or newly-established turf.

[a] A basic herbicide for use in combination with one or more of the others for broad-spectrum postemergence control of broadleaf weeds. Standard rate of application is 1 lb./A. Not recommended for use on bentgrass putting greens.

[b] Safe for use on bentgrass putting greens at ½ to 1 lb./A. during cool weather periods. Can apply to general turf at 1 lb./A. with 2,4-D.

[c] A very effective herbicide for broadleaf weed control when combined with 2,4-D or as a 3-way combination. Use at ¼ lb./A. with 2,4-D; use at ⅛ lb./A. with 2,4-D + mecoprop. Do not apply above roots of trees and shrubs.

[d] Premixed combinations of 2,4-D, MCPP, and Dicamba are commercially available. Premixed combinations of 2,4-D and dichloroprop (2,4-DP) are also commercially available and control a similar spectrum of weeds.

[e] A combintion of 2,4-D and triclopyr (Turflon D) can provide effective control of wild violets and other hard-to-control weeds.

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

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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. 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.

Table 2. — Chemical Control of Weed Grasses in Turf

Weeds	Life length	Herbicide	Rate (lb. a.i. per acre)	Remarks
Annual bluegrass	annual or perennial	benefin (Balan)	3	Apply in late summer. Do not use on bentgrass putting greens.
		benefin and trifluralin (Team)	2	Apply in late summer. Do not use on bentgrass putting greens.
		bensulide (Betasan)	10	Apply in late summer before the return of cool weather to prevent development of new plants. Fairly safe for use on bentgrass putting greens.
		DCPA (Dacthal)	12	Apply in late summer. Do not use on Cohansey or Toronto bentgrass putting greens.
		ethofumesate (Prograss)	1.5	Use on perennial ryegrass or bermudagrass turf only. Has both preemergence and early postemergence activity. Apply in early spring and late summer.
		pendimethalin (Scotts turf-weedgrass control, Lesco PRE-M)	1.5-3	Apply in late summer. Do not use on bentgrass turf.
Crabgrass Foxtails Barnyardgrass	annual	benefin (Balan)	2	Apply before emergence of crabgrass in early spring. Not recommended for use on bentgrass turf.
		benefin and trifluralin (Team)	1½-2	Apply before emergence of crabgrass in early spring. Not recommended for use on bentgrass putting greens.
		bensulide (Betasan)	7.5	Apply before emergence of crabgrass in early spring. Higher rates may be necessary for control of foxtails.
		DCPA (Dacthal)	10	Apply before emergence of crabgrass in early spring. May injure bentgrasses and fine-leaf fescues.
		siduron (Tupersan)	12	Apply before emergence of crabgrass in early spring. Use at half the recommended rate in conjunction with seeding Kentucky bluegrass May injure some bentgrasses and fine-leaf fescues. Do not use on bermudagrass.
		pendimethalin (Scotts turf-weedgrass control, Lesco PRE-M)	1.5-3	Apply before emergence of crabgrass in early spring. Do not use on bentgrass turf or *Poa annua* turf.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence of crabgrass. Three applications at 7- to 10-day intervals are usually required. May cause some discoloration of the turf.
Goosegrass	annual	DCPA (Dacthal)	15	Goosegrass is harder to control than crabgrass; 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.
		oxadiazon (Ronstar)	3	Apply before emergence of crabgrass in early spring. Do not use on red fescue or bentgrass. Do not apply to wet turf.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence. Three or more applications at 7- to 10-day intervals may be required for control. May cause some discoloration of the turf.
Bentgrass Nimblewill Tall fescue Quackgrass Bermudagrass	perennial	amitrole dalapon glyphosate	4 10 2	These give nonselective control. Amitrole and dalapon may persist in the soil for up to 4 and 6 weeks, respectively. Over-seeding should be delayed until chemical residues have dissipated. Glyphosate has no residual activity in the soil; repeated treatments may be necessary for complete control.
Nutsedge	perennial	bentazon	1	Treat soon after emergence before new nutlets form. Repeat application as necessary for control, up to a total of 3 lb. a.i. per acre per season.

INSECT CONTROL

Insecticides are pesticides that reduce insect populations below levels that are injurious to turf. Although insecticide chemistry is quite varied, most of the commonly used materials act as contact poisons. Effective control is dependent upon ensuring contact between the insect and the insecticide. Control of soil-inhibiting insects (such as grubs) is best achieved by drenching the insecticide into the soil, whereas foliar-feeding insects (for example, sod webworms) should be controlled by a foliar spray with no irrigation or rainfall for at least 24 hours afterwards.

Most insecticide applications are for control — the insect is controlled after the early signs of injury have been observed. No single insecticide will control all insect pests found in turf. Identify the specific insect before attempting control with an insecticide. Learn to recognize early signs of insect injury to avoid wide-scale loss of turf.

DISEASE CONTROL

Fungicides are pesticides that kill or inhibit the growth of disease-causing fungi. Depending upon the manner in which they protect plants against infection, 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 plants. This kind of fungicide must be applied fairly frequently to turf (7- to 21-day intervals) since mowing and irrigation remove much of the surface chemical soon after application. Relatively high spray volumes (3 to 5 gal. water per 1,000 sq. ft.) are required to supply uniform and continuous coverage of the foliage by the fungicide. Adding a spreader-sticker (surfactant) to the spray mixture facilitates good foliar coverage. Many of the available fungicides for turf are the protective-contact type.

Systemic fungicides, or chemotherapeutants, are absorbed and distributed within the plant destroying established infections and controlling certain diseases for several weeks or months. These fungicides are absorbed principally by the roots and hence should be drenched or watered in for best results. Examples of systemic fungicides are benomyl (Tersan 1991), chloroneb (Terraneb SP), etridiazole (Koban), and triadimefon (Bayleton).

Table 3. — Chemical Control of Insects

Insect	Insecticide[a]	Formulation[b]	Suggestions
Annual white grubs Ataenius grubs	diazinon trichlorfon (Dylox, Proxol) isofenphos (Oftanol) bendiocarb (Turcam) ethoprop (Mocap)	EC or G SP or G G or EC WP G	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.
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	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.
Armyworms Cutworms	carbaryl (Sevin) chlorpyrifos (Dursban) trichlorfon (Dylox, Proxol)	WP or G EC or G SP or G	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
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.

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 (*Drechlera poae*)	Kentucky bluegrass	March-June; Sept.-Nov. 7 to 21 days	Acti-dione RZ (1.2 oz.) Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (2 oz.) Bromosan (see label) Chipco 26019 WP 50% (2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (4 to 6 oz.) Dyrene or Dymec WP 50% (4 to 8 oz.) Fore or Formec 80 WP 80% (4 to 6 oz.) Kromad WP (3 to 6 oz.) PCNB (Terraclor) WP 75% (see label) Vorlan WP 50% (2 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 (see label) *or* Rubigan WP 50% (2 to 4 oz.) *plus* Bayleton WP 25% (4 to 8 oz.), Chipco 26019 WP 50% (4 oz.), Cleary's 3336 (6 to 8 oz.), Fungo WP 50% (4 to 8 oz.), Tersan 1991 WP 50% (5 to 8 oz.)
Comments: Apply when disease is expected or first appears. Repeat in 14 to 21 days if necessary. Drench fungicide into root zone using ½ inch (300 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 21 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Banner (see label) Bayleton WP 25% (1 to 2 oz.) Bromosan (see label) cadmium compounds (see label) Chipco 26019 WP 50% (2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (3 to 6 oz.) Dyrene or Dymec WP 50% (3 to 8 oz.) Kromad WP (3 to 6 oz.) Rubigan WP 50% (0.2 to 0.4 oz.) thiram WP 75% (4 oz.) Vorlan WP 50% (2 oz.)
Red thread or pink patch (*Laetisaria fuciformis* and *Limonomyces roseipellis*)	All turfgrasses	April-June; August-Nov. 7 to 21 days	
Comments: Resistance to cadmium compounds, 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 (*R. solani*)	All turfgrasses	May-Oct. 5 to 14 days	Chipco 26019 WP 50% (2 oz.) Daconil 2787 WP 75% or 500 (3 to 11 oz.) Duosan WP (4 to 6 oz.) Dyrene or Dymec WP 50% (4 to 8 oz.) Fungo WP 50% (2 to 3 oz.) Kromad WP (3 to 6 oz.) Rubigan WP 50% (0.4 to 0.8 oz.) Tersan 1991 WP 50% (2 to 3 oz.) Vorlan WP 50% (2 oz.) + Fungo WP 50% (2 oz.)
Rusts: leaf and stem (*Puccinia* spp.)	All turfgrasses, espepcially certain cultivars of Kentucky bluegrass, Perennial ryegrass, Zoysiagrass, and Bermudagrass	June-Oct. 7 to 14 days	Acti-dione RZ (1.2 oz.) Acti-dione TGF (2 oz.) Bayleton WP 25% (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (4 to 6 oz.) Dyrene or Dymec WP 50% (4 to 8 oz.) Fore or Formec 80 WP 80% (2 to 4 oz.) zineb WP 75% (2 to 4 oz.)

[a] Causal fungus listed in parentheses.

[b] Denotes either fungicide, coined name of that material, 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 21 days	Bayleton WP 25% (5 to 8 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (3 to 6 oz.) Fungo WP 50% (2 oz.) + Vorlan WP 50% (2 oz.) Rubigan WP 50% (2 to 4 oz.) 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.	Bayleton WP 25% (6 to 8 oz.) *or* Fungo WP 50% (6 to 8 oz.) *or* Rubigan WP 50% (4 oz.) *or* Tersan 1991 WP 50% (6 to 8 oz.) *plus* PCNB (Terraclor) WP 75% (see label)
Comments: Make 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 14 days	Acti-dione RZ (1.2 oz.) Acti-dione TGF (1 to 2 oz.) Bayleton WP 25% (5 to 8 oz.)
Snow molds Typhula blight (*T.* species) Fursarium patch (*F. nivale*)	All turfgrasses	Nov.-March see label for interval	Bayleton WP 25% (5 to 8 oz.) Chipco 26019 WP 50% (2 to 4 oz.) Calo-clor, Calo-Gran (see label)[c] Daconil 2787 WP 75% or 500 (8 to 11 oz.) Rubigan WP 50% (2 to 4 oz.), *or* Teremec SP or Terraneb SP WP 65% (6-9 oz.) *plus* PCNB (Terraclor) WP 75% (see label)
Pythium blight, grease spot, spot blight (many *P.* species)	All turfgrasses	April-Nov. 5 to 10 days	Banol WP 65.5% (1⅓ to 4 oz.) Koban (see label) Subdue 2E WP 25% (1 to 2 oz.) Terrazole WP 35% (4 to 8 oz.) Teremec SP or Terraneb SP WP 65% (4-6 oz.) Chipco Aliette (see label)
Fairy rings (*Marasmius oreades, Agaricus* or *Psalliota campestris, Chorophyllum* [*Lepiota*] species)	All turfgrasses		methyl bromide chloropicrin Vapam Soil Fumigant Vorlex formaldehyde
Comments: Soil temperature should be above 60° F for fumigation. Cover area with gas-proof cover for several days, *or* instead of treating with fungicide, 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, Helminthosporium* sp., *Colletotrichum graminicola*)	All turfgrasses	Treat seed before planting.	captan *or* thiram 50% to 75%, *plus* Koban WP 35% *or* Apron (see label)
		Spray just after seeding, at early seedling emergence, and 7 to 10 days later (see labels.	Koban WP 35% *or* Subdue 2E WP 25% *plus one of these:* captan W 50% Chipco 26019 WP 50% Dyrene *or* Dymec WP 50% zineb WP 75%
Nematodes (many genera and species)	All turfgrasses	fenamiphos (Nemacur), ethoprop (Mocap Nematicide-Insecticide, Proturf Nematicide-Insecticide), or fensulfothion (Dasanit): granules.	
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. Aerifying turf before application improves results. *Do not apply to newly seeded areas.* For use only by certified pesticide applicators.			
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.)

[c] Cleared for use *only* on golf course greens, aprons, and tees by certified golf course superintendents.

Fungicides, Disinfectants, Grain Preservatives, Surfactants and Soil-Disinfesting Chemicals

M. Shurtleff, B. Jacobsen, T.Melton, and W.Kirby

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 anthracnoses, *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.

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" Benomyl Fungicide; Tersan 1991 Turf Fungicide; Benlate PNW; Bonide Benomyl (DuPont New Systemic Fungicide); Science Benomyl Systemic Fungicide; Rockland Benomyl Fungicide; Benomyl Turf Fungicide Granules; 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.

BOTRAN (DCNA) [2,6-dichloro-4-nitroaniline]

A foliar, seed, soil, pre- and post-harvest 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 50% WP; 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, whereas Orthocide Botran 35-35 Seed Protectant contains 35% each of Botran and captan. Ortho Difolatan Botran 20-60 Seed Protectant contains 20% Botran and 60% captafol. The 35-35 Seed Protectant contains 35% each of Botran and captafol.

CAPTAFOL [N-[(1,1,2,2-tetrachloroethyl)thio]-4-cyclohexene-1,2-dicarboximide]

A very long-lasting, protective contact-eradicant foliar, fruit, seed, and soil fungicide related to captan and folpet. Controls downy mildews, numerous fungal leaf spots and blights, blossom blights, fruit spots and rots, scabs, anthracnoses, seed rots, damping-off, and gray molds (*Botrytis*) of certain tree and bush fruits, vegetables, and ornamentals. Some persons are allergic or become sensitized to captafol. Avoid contact with eyes, skin, or clothing.

Trade names. Ortho Difolatan 4 Flowable; Ortho Difolatan 80 Sprills. Difolatan-Botran contains a 60-20 mix of these two fungicides.

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, 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. Stauffer Captan 50-WP and 80-WP, Captan-Moly-Planterbox Treater, Captan-Thiram 43-43 WP & Dust; Captan 25, 75, and 80 Seed Protectant; Captan Garden Spray; Evershield Captan Seed Protectant; Gallotox Captan FP-700R; Captan 80 Spray-Dip; Orthocide 50 and 80 Wettable; Orthocide Fruit and Vegetable Wash; Agway Captan 5D and 7.5D; Orthocide 65 and 75 Seed Protectant; Miller's Captan 50W; 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; Captan 25 Planterbox Treater; 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; Vancide 89; Captan 10 Potato Seed Protectant; Soybean MO(2X) Seed Protectant, Nu-Gro Captan 65 Sprills Seed Protectant.

Orthocide Vitavax 20-20 is a mixture of captan and carboxin. Agrosol-S, Granox, and Orthocide Maneb 30-30 Seed Protectant are 30:30 mixtures 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.

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, rice, 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, and Captan Vitavax 20-20 Seed Protectant contain 20% each of carboxin and captan. They are registered for wheat, oats, and barley as a drill-box treatment.

CHLORONEB [1,4-dichloro-2,5-dimethoxybenzene]

A protective, locally systemic soil fungicide that controls pre- and postemergence 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.

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 soilborne fungi because of rapid breakdown. Use cautiously; cases of dermatitis have been reported with all formulations.

Trade names. Daconil 2787; Daconil 2787 Flowable Fungicide; Bravo W-75; Bravo 6F; Ornathol; Turf Disease Control; Exotherm Termil; Diamond 75% Chlorothalonil; Scotts ProTurf 101V Broad Spectrum Fungicide and ProTurf Fertilizer plus 101 Broad Spectrum Fungicide; Lebanon Fungicide Type D; Green Gold Turf Fungicide; Thal-O-Nil; 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. 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 treats 1,000 square feet of greenhouse area.

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 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, Basi-Cop, Copper Pride, 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. Cop-O-Zinc contains copper sulfate plus zinc salt.

2. *Chlorides*--Coprantol, Aceto Copper Chloride, Copper Oxychloride Sulfate, C-O-C-S, Kauritil.

3. *Oxides*--Kuprite; Cuprocide; Kocide 101 Wettable Powder, 606, 404 Flowable, 3% and 5% Dust, and SD Seed Dressing; Copper Oxide; Cuprous Oxide; 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.

4. *Liquids*, i.e., emulsifiable--Oxy-Cop 8L, Copoloid, Cop-O-Cide, Citcop 4E, 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 and -N are liquid fungicides containing 8% ammonical copper and 5% sulfur.

CYCLOHEXIMIDE [3-[2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl]-glutarimide]

A short residual, eradicant, highly toxic, antifungal antibiotic that is absorbed through plant surfaces and is distributed locally within a plant. Effective against powdery mildews, certain rusts, a number of turfgrass diseases, cherry leaf spot, and azalea petal blight. Plants are very sensitive to overdose with this chemical. Do *not* apply at temperatures above 85°F.

Trade names. Acti-dione PM and TGF. Acti-dione TGF is now registered for tank mixing with triadimefon (Bayleton) and chlorothalonil (Daconil 2787) to control a number of turfgrass diseases.

Cycloheximide-PCNB is sold as Acti-dione RZ. *Cycloheximide-thiram* is sold as Acti-dione Thiram.

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]

A low toxicity, moderately residual soil, turf, and seed fungicide specific for controlling soilborne water molds (*Aphanomyces, Phytophthora, Pythium*).

Trade names. Terrazole (35% Wettable Powder, 25% EC 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.

FERBAM [Ferric dimethyldithiocarbamate]

A general-purpose, very low toxicity, long-lasting fungicide that controls a wide range of foliar diseases of flowers, trees, shrubs, and fruit, including fungus leaf spots and blotches, scabs, rusts, and damping off. Does NOT control powdery mildews.

Trade names. Karbam Black; Carbamate; Agway Ferbam 76W and 7.6D; E-Z-Flo Ferbam 76; Allied Ferbam; Aceto Ferbam 76% and 93%; Kerr-McGee Ferbam; Thompson-Hayward Ferbam; Grace Ferbam; Chemform Ferbam (Wettable Powder); Ferbam 76W; Ferbam 95W; Miller's Ferbam; Naco Hi-Test Ferbam Wettable Powder; Champion 15% Fermate Dust; Crown 15% Fermate Dust; Gold Kist Fermate Dust; Green Cross 7% Karbam Black Dust Fungicide and 76% Karbam Black Fungicide; Naco Fermate 15 Dust; Bartlett Ferbam 76W; Farmrite Ferbam 76%; Chempar Ferbam 76 Wettable Powder; Patterson's Ferbam; Security Ferbam Fungicide; Shepard Chemical Ferbam.

FOLPET [N-(trichloromethylthio)phthalimide]

Used to control many diseases--on bush and tree fruits, flowers, vegetables, trees, and shrubs. A protectant-contact-eradicant fungicide that gives fair control of many powdery mildews but not of rusts. Used in plant beds to control damping-off and seedling blights.

Trade names. Ortho Phaltan Rose & Garden Fungicide; Ortho Phaltan 50 Wettable; Niagara Phaltan 50 Wettable; Stauffer Folpet 50-WP; Agway Folpet 50-W; Naco Phaltan Folpet 50 Wettable Fungicide; Acme Phaltan Fungicide; Science Rose and Garden Fungicide; Aceto Folpet; Patterson's Phaltan Wettable Powder.

MANCOZEB (or MANEB AND ZINC ION) [Includes products containing zinc and maneb]

Excellent, very low toxicity, broad-spectrum, largely protective contact seed and foliar fungicide for cereals, nuts, fruits, turfgrasses, vegetables, trees, flowers, and shrubs. Does NOT control powdery mildews.

Trade names. Manzate 200 Fungicide and Manzate 200 Flowable Fungicide; Manzate Flowable with Zinc; Tersan LSR Turf Fungicide; Dithane M-45; Maneb 80; Penncozeb; Fore; Acme Fore; Vancide Maneb Flowable; 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]

Excellent, general, broad-spectrum, very low toxicity 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; Dithane M-22, FZ, and 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; Vancide Maneb 80. Granox Plus contains 50% maneb and 2% thiabendazole.

PCNB or Quintozene [Pentachloronitrobenzene]

A very long-lasting soil, turf, seed, bulb, and corm fungicide that controls various soilborne diseases of many plants.

Trade names. Terraclor; 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 Granules; Lesco PCNB 10% Granular Fungicide; Turfcide 10% Granular and Emulsifiable; Lawn Fungicide Spray.

Captan-PCNB mixtures are sold as Orthocide Soil Treater "X" and "3X"; Orthocide PCNB 10-20 Dust; Orthocide PCNB-Nutrient Spray; Stauffer Captan-Terraclor 10-10 Seed Treatment and 30-30 Seed Protectant; 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]

A very low toxicity, broad-spectrum, largely protectant fungicide for application on foliage, fruit, seed, and soil. Polyram's range of activity is very similar to mancozeb, maneb, and zineb.

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; Phytomycin; Streptomycin Antibiotic Spray Powder; Streptomycin Wettable Powder; Agri-Strep 500; Security Fire Blight Spray.

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; Kolodust; Kolospray; Bonsul Spray-Dust Sulphur; Naco Micronized Wettable Sulfur; Pratt Wettable Sulfur; Sperlox-S; Nutonex Sulphur Wettable.

Kolofog contains 30% fused bentonite sulfur. Fungi-Sperse, Liquid Sulfur, 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 is a combination fungicide-insecticide (scalecide), miticide more phytotoxic than other sulfurs. It is caustic and is disagreeable to apply, and it 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]

A very low toxicity, 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 LSF, 160-F, and 340-F; Tecto; Potato Seed Dust T; Thiabendazole; TBZ. Arbotect 20-S, the phosphate 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, and flowables.

Trade names. Topsin M 70WP, ULV 4.5F, and E; Fungo 50; Cleary's 3366; Tops; 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; ProTurf Fluid Fungicide is a combination of thiophanate-methyl plus iprodione.

THIRAM [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. Gustafson 42S; 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; 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; Vancide TM-95 and TM Flowable; Chemform 75% Thiram WP; Kerr-McGee Thiram; Science Gladiolus and Bulb Dust; Lebanon Fungicide Type T; Lesco Thiram 75WP.

Stauffer Captan-Thiram 43-43 Seed Protectant contains 43% each of captan and thiram. Lesco Snow Mold Turf Fungicide is a granular containing 2.5% thiram and 0.38% cadmium chloride.

ZINEB [Zinc ethylenebisdithiocarbamate]

Excellent, very low toxicity, general, broad-spectrum foliar, seed and soil fungicide for field crops, tree and bush fruits, vegetables, flowers, trees, shrubs, and nuts. Will NOT control powdery mildews. Only protective in activity.

Trade names. Security Zineb Spray; Science Zineb Fungicide; Black Leaf Sheen; Aceto Zineb-75 and 85%; Acme Zineb 75W Fungicide; Niagara Zineb 75 Wettable; Vancide Zineb 85% WP; Sherwin-Williams Zineb; E-Z-Flo Zineb 75; Pennwalt Zineb W-75; Miller's Zineb 6D; Chipman Zineb; Patterson's Zineb Wettable Powder; Chemform 65% Zineb; Chempar Zineb 75 WP; Zineb Garden Fungicide; Shepard Chemical Zineb; Argisect Brand Zineb 75% Wettable Powder; Hopkins 15% Zineb Dust and 6% Dithane Z-78 Dust; Naco Dithane 6 and 10 Dust; D.H. 10% Dithane Dust; Gold Kist Zineb Dust No. 10; Green Cross Thiogreen Dust Fungicide; New Dragon Tomato Dust; Miller Zineb 75%; Staples Dithane Seed Treating Dust; Vancide Zineb 85; BASF Zineb 80WP; E-Z-Flo Special Mushroom Dust; Superior's Zineb 75% Wettable; Polyram Z.

ZIRAM [Zinc dimethyldithiocarbamate]

General, very low toxicity 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; Vancide MZ-96 and MZ Flowable; Shepard Chemical Ziram; Samincorp Ziram.

Fungicides of Less General Use (see RPD 1002 for a complete listing as well as Illinois Extension Circulars 1184, 1231, 1259, and 1260).

These chemicals include a large number of products with limited use. 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 root and stem rots of ornamentals. The 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 eradicant fungicide that is highly effective against many different fungi infecting ornamentals, turfgrasses, and fruits. Available as a 12% EC, and as a 50% WP. Its use is still under experimentation in the United States. Contains a-(2-chlorophenyl)-a-(4-chorophenyl)-5-pyrimidime methanol as the active ingredient.

Iprodione (Chipco 26019, Rovral)--A broad-spectrum contact seed, soil, and foliar fungicide for fruits, ornamentals, and vegetables, with excellent activity against *Botrytis, Corticium, Monilinia, Sclerotinia, Penicillium, Rhizopus, Ascochyta, Phoma, Alternaria, Fusarium, Helminthosporium (Drechslera),* and *Rhizoctonia*. Scotts ProTurf Fungicide VI is a granular turfgrass fungicide containing 1.3% iprodione. Iprodione contains 3-(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 for use on turf and woody and nonwoody ornamentals to control *Pythium* and *Phytophthora* species. It contains 80% aluminum tris-O-ethyl phosphonate as the active ingredient.

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.

Metalaxyl (Subdue 2E and 5G; Apron 25W; Ridomil 2E and MZ58) -- 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 (nonbearing), ornamentals, turf, 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.

Triadimefon (Bayleton, Scotts ProTurf Fungicide 7)--A wettable powder, protective fungicide with systemic and eradicant properties. Has excellent activity against rusts, powdery mildews, and other fungi on fruits, 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, 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, Ortho Triforine 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 18.2% N,N'[1,4,piperazinediylbis(2,2,2-trichloroethylidene)-bis-[formamide]] by weight as the active ingredient.

Vinclozolin (Ornalin, Ronilan, Vorlan) A long-lasting protective-contact fungicide used as a seed treatment, foliar spray, and post-harvest dip for turf, ornamentals, vegetables, and small fruits to control *Botrytis, Monilinia, Sclerotinia, Ovulinia, Stromatinia, Ciborinia, Fusarium,* and *Rhizoctonia.* It is sold as a 50% wettable powder. Contains 3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedione as the active ingredient.

Propiconazole (Banner, Tilt) A turf and grass (grown for seed) protective, curative, and systemic fungicide that controls rusts, powdery mildew, dollar spot, red thread, leaf smuts, summer patch, and necrotic ring spot. It is still largely experimental in the United States. Contains 1-[2-(2,4-dichlorophenyl)-4-propyl-1-3-dioxolan-2-ylmethyl)-1H-1,2,4-triazole 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--Used for treating storage areas, tools, and equipment. It contains 50% didecyl dimethyl ammonium chloride and 20% isopropanol.

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 materials (e.g., Hyamine 1622, 2389, and 3500) 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, 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 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

post-harvest spoilage from storage molds (primarily species of *Aspergillus* and *Penicillium*). Sold under such trade names as Aceto Propcorn, ChemStor and ChemStor III, Grain Storer P, Tenox Grain Preservatives, Ortho-Guard G.P., Grain Treet, Grain Treat, and Sentry Grain Preserver. 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); Kromad; iprodione (Chipco 26019); Fore; triadimefon (Bayleton); propiconazole (Banner); fenarimol (Rubigan); Tersan 1991 Turf Fungicide; Bromosan; Duosan; Vorlan; thiophanate materials (Fungo 50, Cleary's 3336, Scotts ProTurf Systemic Fungicide); Acti-dione Thiram, RZ, and Acti-dione TGF; Scotts ProTurf and Lawn Disease Preventer fungicides. Turf fungicides that control one to several diseases contain cadmium (Caddy, Cad-Trete, Cadminate), zineb, 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, 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, AIM Spreader-Activator, Ag-Chem Activator, 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, 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

Aldicarb (Temik). 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, and most ornamentals. Effective for soybean cyst nematode control. The active ingredient is 2-methyl-2(methylthio) propionaldehyde-o-(methylcarbamyl)oxime. Oral LD_{50} (rat) = 0.9 mg/kg. Water solubility = 6000 ppm. Formulated as 10G and 15G.

Carbofuran (Furadan). A broad-spectrum nematicide-insecticide-miticide that may be soil applied at planting for control of nematodes on corn, soybeans, sorghum, 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. Formulated as 10G and 15G.

Diazinon (D-264, Diazol, DZN, DZN AG 500, Knox Out, Sarolex Spectracide, and others). A broad-spectrum nematicide-insecticide for application to turf. Fairly effective against nematodes in sandy soils. The active ingredient is 0,0-diethyl 0-2(isopropyl-4-methyl-6-pyrimidinyl)phosphorothiote. Oral LD_{50}(rat) = 542 mg/kg. Water solubility = 40 ppm. Formulated as granules, liquids, wettable powders, and ULV.

Ethoprop (Mocap, Mocap Plus). A long-lasting, broad-spectrum, contact nematicide-insecticide that is applied as a nematicide at planting on corn, soybeans, 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, distribute evenly over established turf and drench in immediately with at least .5 inch of water. The active ingredient is 4-benzothienyl-N-methyl-carbamate. Oral LD_{50}(rat) = 61.5 mg/kg. Water solubility = 750 ppm. Formulated as 6EC, 10G, 15G, and 10% combined with 5% disulfoton.

Fenamiphos (Nemacur). 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 (Bay 25141, Dasanit, S767, Terracur P). A broad-spectrum contact nematicide-insecticide for use on commercial turf, tomatoes, sweet potatoes, many ornamental flowers, shrubs, and foliage plants. Used as a plant dip and soil drench. See ethoprop for turf application. The active ingredient is 0,0-diethyl 0-[4-(methylsulfinyl)phenyl]phosphorothioate. Oral LD_{50}(rat) = 1-10 mg/kg. Water solubility = 1600 ppm. Formulated as 15G, 6EC, and in combination with fenamiphos or fensulfothion.

Oxamyl (Vydate L). A nematicide-insecticide for use on carrots, some cucurbits, peppers, potatoes, soybeans, 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. Formulated as 2L.

Terbufos (Counter). A systemic nematicide-insecticide applied at planting for the control of nematodes on corn. The active ingredient is S-[(1,1-dimethylethyl) methyl]0,0-diethyl phosphorodithioate. Water solubility = 15 ppm. Formulated as 15G.

NEMATICIDES

Fumigants (see Table 1 for applications)

All nematicides, except Diazinon, are restricted use and only are to be purchased and applied 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, D-D, Nemafume, Terr-O-cide). Often mixed with chloropicrin.

Chloropicrin (Acquinite, Chlor-O-Pic, Dojyopicrin, Dolochlor, Larvacide, 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, Mylone, N-521, Prezervit).

Metam-sodium or SMDC (A7 Vapam, Busan 1020, Karbation, Maposl, Metam-Fluid BASF, Solasan 500, Sometan, Trimaton, Vapam, VPM).

Methyl Bromide (Brom-O-Gas, Brom-O-gaz, Brom-O-Sol, Celfume, Kayafume, MeBr, Meth-O-Gas, Terr-O-Gas 100). Many combination formulations are available; most also contain chloropicrin.

Methylthioisocyanate or MIT (Vorlex). Vorlex is 20% MIT, 80% 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 min., 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).

Table 1. Continued

MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
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. (Tear gas or trichloro-nitromethane.) For combinations with methyl bromide see above; combinations with D-D include Terr-O-Cide 15-D, 30-D, and 57/43/T.	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 gasproof cover or sufficient water to soak upper inch of 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 Nemacide; 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.

Table 1. Continued

MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
Fensulfothion (Dasanit, Mobay Dasanit Insecticide-Nematicide, Terracur P, and Dasanit Ornamental and Turf Nematicide). (0,0-diethyl 0[4-(methylsulfinyl) phenyl] phosphorothioate)	A highly toxic, long-lasting, primarily contact nematicide-insecticide for commercially grown turfgrasses, tomatoes, sweet potatoes, flowers, ornamental shrubs, and foliage plants. Also used as a plant dip.	Apply the same as for ethoprop (above); 1 to 3.3 gal/A of liquid concentrate or 20 to 184 lb/A of the granular product.
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 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, Korbation, Maposl, Sometan, Trimaton; Vapam; VPM; 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.

Table 1. Continued

MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
Methyl Bromide Terr-O-Gas 100, Bromoaz, Brom-O-Gas, Brom-O-Sol, Celfume, Meth-O-Gas, Nemaster. (Methyl bromide, usually with chloropicrin added.) There are too many 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 ft; for other pests, 1 to 2 lbs. Do NOT use before planting onions, garlic, celery, carnations, salvia, 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 gass proof 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.

Table 1. Continued

MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
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.
Chemicals Primarily for Nematode Control		
1,3-D: D-D Soil Fumigant, Telone II, Nemafume (mixed dichloropropenes). Terr-O-Cide 15D is a mixture of 85% D-D and 15% chloropicrin. Terr-O-Cide 30D contains 70% D-D and 30% chloropicrin. 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 8-120 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, etridiazole, thiram, Polyram, Banrot, metalaxyl, zineb, ferbam, 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 incehs of soil. Seed can be planted immediately after treatment. May also be applied as a postplant 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.

Table 1. Continued

MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
PCNB or quintonzene Terraclor; Tri-PCNB; Fungiclor. (Pentachloronitro-benezene)	PCNB controls certain disease-causing fungi, e.g., *Rhizoctonia, Botrytis, Sclerotinia, Sclerotium.* (etridi-azole, fosetyl-Al, metalaxyl, and promo-carb 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), promocarb (Banol), captan, ferbam, captafol, benomyl, or chloroneb. Thorough mixing with soil is essential. Follow manufacturer's directions regarding rates and methods of application.

Application Equipment and Calibration References

L. Bode and S. Pearson

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

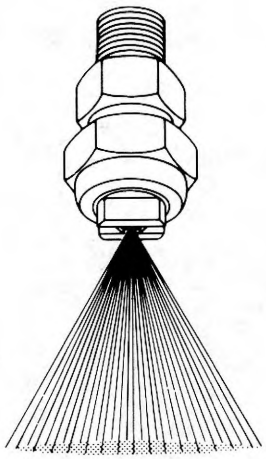
Install the selected nozzle tips in the sprayer. Determine the required flow rate for each nozzle in ounces per minute (OPM) from the following equation:

$$OPM = GPM \times 128$$
(1 gallon = 128 ounces)

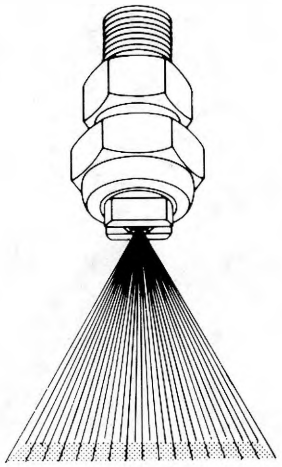
Collect the output from a nozzle using a container marked in ounces. Adjust the pressure until the required OPM is collected. Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear. Replace the nozzle tips and recalibrate 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.

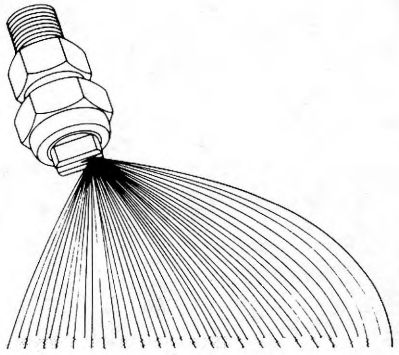
TYPES OF SPRAY NOZZLES



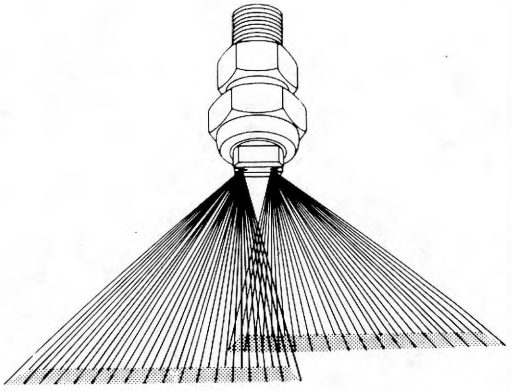
Flat Fan



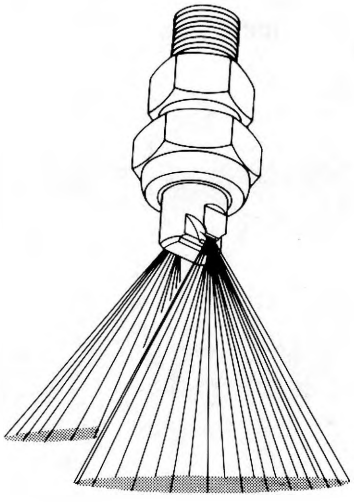
Even Fan



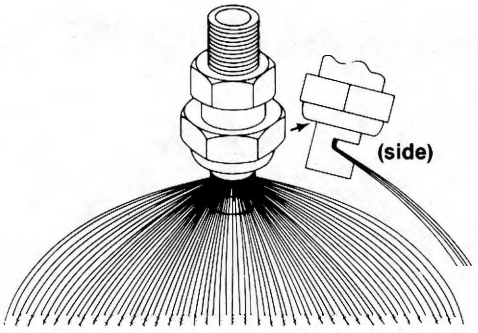
Off Center Fan



Twin Orifice (Off – Center)

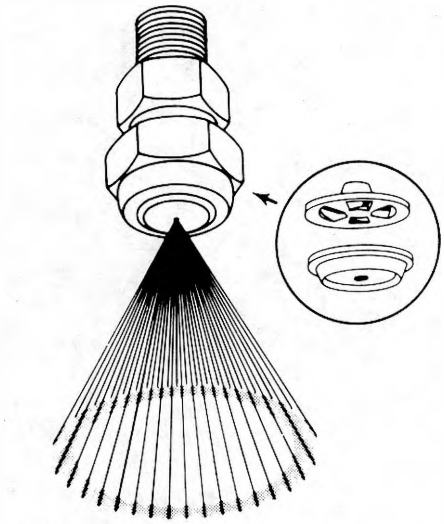


Twin Orifice (Flat Fan)

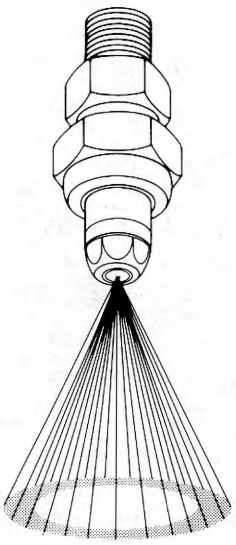


Flooding (front)

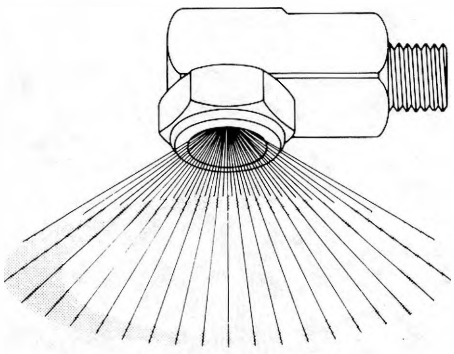
TYPES OF SPRAY NOZZLES



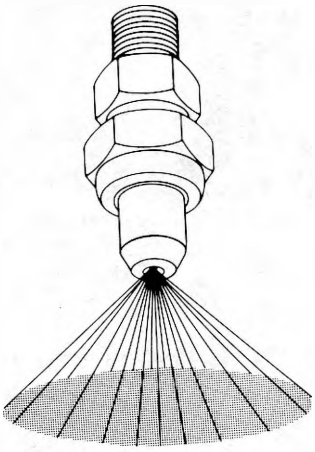
Hollow Cone (Disc – Core)



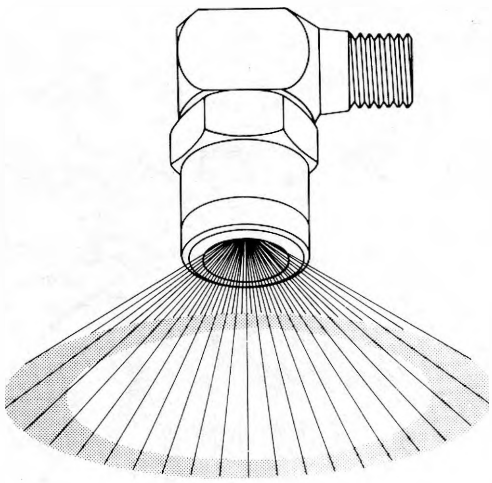
Hollow Cone (1 piece)



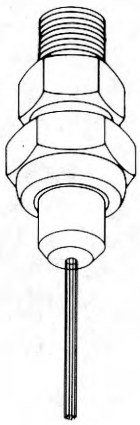
Swirl Chamber



Wide Angle Full Cone



RA – Raindrop



Straight Stream

FLAT-FAN NOZZLES

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan LF.67 Spraying Systems 80067 (100 mesh)	20	.05	6.4
	25	.055	7.0
	30	.06	7.7
	40	.067	8.6
	50	.07	9.0
Delavan LF1 Spraying Systems 8001 Lurmark 01-F80 (100 mesh)	20	.07	9.0
	25	.08	10.2
	30	.09	11.5
	40	.10	12.8
	50	.11	14.1
Delavan LF1.5 Spraying Systems 80015 Lurmark 015-F80 (100 mesh)	20	.11	14.1
	25	.12	15.4
	30	.13	16.6
	40	.15	19.2
	50	.17	21.8
Delavan LF2 Spraying Systems 8002 Lurmark 02-F80 (50 mesh)	20	.14	17.9
	25	.16	20.5
	30	.17	21.8
	40	.20	25.6
	50	.23	29.4
Delavan LF3 Spraying Systems 8003 Lurmark 03-F80 (50 mesh)	20	.21	26.9
	25	.24	30.7
	30	.26	33.3
	40	.30	38.4
	50	.34	43.5
Delavan LF4 Spraying Systems 8004 Lurmark 04-F80 (50 mesh)	20	.28	35.8
	25	.32	41.0
	30	.35	44.8
	40	.40	51.2
	50	.45	57.6
Delavan LF5 Spraying Systems 8005 Lurmark 05-F80 (50 mesh)	20	.35	44.8
	25	.40	51.2
	30	.43	55.0
	40	.50	64.0
	50	.56	71.7
Delavan LF6 Spraying Systems 8006 Lurmark 06-F80 (50 mesh)	20	.42	53.7
	25	.47	60.2
	30	.52	66.6
	40	.60	76.8
	50	.67	85.8
Delavan LF8 Spraying Systems 8008 Lurmark 08-F80 (50 mesh)	20	.57	73.0
	25	.63	80.6
	30	.69	88.3
	40	.80	102.0
	50	.89	114.0

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

FLAT-FAN NOZZLES, continued

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan LF10 Spraying Systems 8010 Lurmark 10-F80	20	.71	91
	25	.79	101
	30	.87	111
	40	1.00	128
	50	1.12	143
Delavan LF15 Spraying Systems 8015 Lurmark 15-F80	20	1.06	136
	25	1.19	152
	30	1.30	166
	40	1.50	192
	50	1.68	215
Delavan FL20 Spraying Systems 8020 Lurmark 20-F80	20	1.41	180
	25	1.58	202
	30	1.73	221
	40	2.00	256
	50	2.23	285

*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
	30	.09	11.5
(100 mesh)	40	.10	12.8
Delavan LE-15	20	.11	14.1
Spraying Systems 80015E	25	.12	15.4
	30	.13	16.6
(100 mesh)	40	.15	19.2
Delavan LE-2	20	.14	17.9
Spraying Systems 8002E	25	.16	20.5
	30	.17	21.8
(50 mesh)	40	.20	25.6
Delavan LE-3	20	.21	26.9
Spraying Systems 8003E	25	.24	30.7
	30	.26	33.3
(50 mesh)	40	.30	38.4
Delavan LE-4	20	.28	35.8
Spraying Systems 8004E	25	.32	41.0
	30	.35	44.8
(50 mesh)	40	.40	51.2
Delavan LE-5	20	.35	44.8
Spraying Systems 8005E	25	.40	51.2
	30	.43	55.0
(50 mesh)	40	.50	64.0
Delavan LE-6	20	.42	53.7
Spraying Systems 8006E	25	.47	60.2
	30	.52	66.6
(50 mesh)	40	.60	76.8
Delavan LE-8	20	.57	73.0
Spraying Systems 8008E	25	.63	80.6
	30	.69	88.3
(50 mesh)	40	.80	102.0
Delavan LE-10	20	.71	91.0
Spraying Systems 8010E	25	.79	101.0
	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
	30	1.30	166.0
	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

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity	
		gal/min (GPM)	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.

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

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

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
	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
	40	.30	38.4
(50 mesh)	60	.37	47.4
Delavan LX-4	20	.28	35.8
Spraying Systems OC-04	30	.35	44.8
	40	.40	51.2
(50 mesh)	60	.49	62.7
Delavan LX-6	20	.42	53.8
Spraying Systems OC-06	30	.52	66.6
	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
	40	.80	102.4
(50 mesh)	60	.98	125.4
Delavan LX-12	20	.85	108.8
Spraying Systems OC-12	30	1.0	128.0
	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
	40	1.6	204.8
	60	2.0	256.0

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

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 D25 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

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

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 (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
Delavan 1/4WRW4 Delavan RA-4 (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 (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 (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	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

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

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	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	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)	Capacity oz/min (OPM)
Delavan HB-1 (HC-1) Spraying Systems TX1 (100 mesh)	30	.0145	1.8
	40	.1067	2.1
	60	.0200	2.6
	75	.0233	3.0
	90	.0250	3.2
Delavan HB-2 (HC-2) Spraying Systems TX2 (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 (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 (50 mesh)	30	.0583	7.5
	40	.0667	8.5
	60	.0817	10.5
	75	.0917	11.7
	90	.0100	12.8
Delavan HB-6 (HC-6) Spraying Systems TX6 (50 mesh)	30	.0867	11.1
	40	.0100	12.8
	60	.1217	15.6
	75	.1367	17.5
	90	.1500	19.2
Delavan HB-8 (HC-8) Spraying Systems TX8 (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 (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 (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 (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 (50 mesh)	30	.3750	48.0
	40	.4333	55.5
	60	.5300	67.8
	75	.5933	75.9
	90	.6500	83.2

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

HOLLOW-CONE NOZZLES (DISC AND CORE TYPE)

Manufacturer tip no.*, (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)	Capacity oz/min (OPM)
Delavan DC2-13 Spraying Systems D2-13 (50 mesh)	40	.08	10.2
	60	.10	12.8
	80	.11	14.1
	100	.12	15.4
	150	.14	17.9
Delavan DC2-23 Spraying Systems D2-23 (50 mesh)	40	.10	12.8
	60	.13	16.6
	80	.14	17.9
	100	.16	20.5
	150	.19	24.3
Delavan DC3-23 Spraying Systems D3-23 (25 mesh)	40	.12	15.4
	60	.14	17.9
	80	.16	20.5
	100	.18	23.0
	150	.21	26.9
Delavan DC2-25 Spraying Systems D2-25 (25 mesh)	40	.16	20.5
	60	.19	24.3
	80	.22	28.2
	100	.25	32.0
	150	.29	37.1
Delavan DC3-25 Spraying Systems D3-25 (25 mesh)	40	.19	24.3
	60	.23	29.4
	80	.26	33.3
	100	.29	37.1
	150	.35	44.8
Delavan DC3-45 Spraying Systems D3-45 (25 mesh)	40	.23	29.4
	60	.28	35.8
	80	.33	42.2
	100	.36	46.1
	150	.44	56.3
Delavan DC4-25 Spraying Systems D4-25 (25 mesh)	40	.29	37.1
	60	.35	44.8
	80	.40	51.2
	100	.45	57.6
	150	.54	69.1
Delavan DC5-25 Spraying Systems D5-25 (25 mesh)	40	.35	44.8
	60	.42	53.8
	80	.48	61.4
	100	.54	69.1
	150	.65	83.2
Delavan DC4-45 Spraying System D4-45 (25 mesh)	40	.36	46.1
	60	.43	55.0
	80	.50	64.0
	100	.56	71.7
	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
	80	.64	81.9
(25 mesh)	100	.71	90.9
	150	.86	110.1
Delavan DC7-25	40	.52	66.6
Spraying System D7-25	60	.63	80.6
	80	.73	93.4
(16 mesh)	100	.81	103.7
	150	.98	125.4
Delavan DC6-45	40	.58	74.24
Spraying System D6-45	60	.72	92.2
	80	.83	106.2
(16 mesh)	100	.93	119.0
	150	1.15	147.2
Delavan DC7-45	40	.68	87.0
Spraying System D7-45	60	.84	107.5
	80	.97	124.2
(16 mesh)	100	1.11	142.1
	150	1.35	172.8
Delavan DC8-45	40	.84	107.5
	60	1.04	133.1
	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
	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
	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

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

FLOODING & RAINDROP 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	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	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	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	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	10	6.0
	20	8.5
	30	10.4
	40	12.0
	50	13.4
Delavan F80 Spraying Systems 1/2K-80	10	8.0
	20	11.3
	30	13.9
	40	16.0
	50	17.9
Delavan F100 Spraying Systems 3/4K-100 Delavan RA200	10	10.0
	20	14.1
	30	17.3
	40	20.0
	50	22.3
Delavan F120 Spraying Systems 3/4K-20 Delavan RA-240	10	12.0
	20	17.0
	30	20.8
	40	24.0
	50	26.8

FLOODING & RAINDROP NOZZLES (HIGH-CAPACITY), continued

Manufacturer tip no.* (Nozzle screen size)	Liquid pressure (psi)	Capacity gal/min (GPM)
Delavan F150 Delavan RA-300	10	15.0
	20	21.2
	30	26.0
	40	30.0
	50	33.5
Delavan F210 Spraying Systems 3/4K-210	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

*Some nozzles may not interchange exactly among manufacturers. However, tolerances are such that in most cases flow rates are practically identical.

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 and 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:

$$\text{Travel speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Travel Speeds

Speed in MPH (miles per hour)	Time Required in SECONDS to Travel a Distance of: 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. Therefore conversion factors for flow rates of solutions of any known density can be calculated:

$$\text{Conversion Factor} = \sqrt{1 / SG}$$

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. Since nozzle tables are based on spraying water, the conversion factors from the table can be multiplied by the GPM in the catalog tables to determine the flow rate for the solution being sprayed.

To select the proper nozzle size from the nozzle tables divide the desired flow rate by the conversion factor. This gives the equivalent flow rate for water, on which the tables are based.

Effect of Solution Density on Nozzle Flow

Weight of solution (lb/gal)	Specific gravity	Conversion factor
7.0	.84	1.09
7.5	.90	1.05
8.0	.96	1.02
8.34*	1.00	1.00
8.5	1.02	.99
9.0	1.08	.96
9.5	1.14	.94
10.0	1.20	.91
10.5	1.26	.89
11.0	1.32	.87
11.5	1.38	.85
12.0	1.44	.83
14.0	1.68	.77
16.0	1.92	.72
18.0	2.16	.68
20.0	2.40	.65

*Water

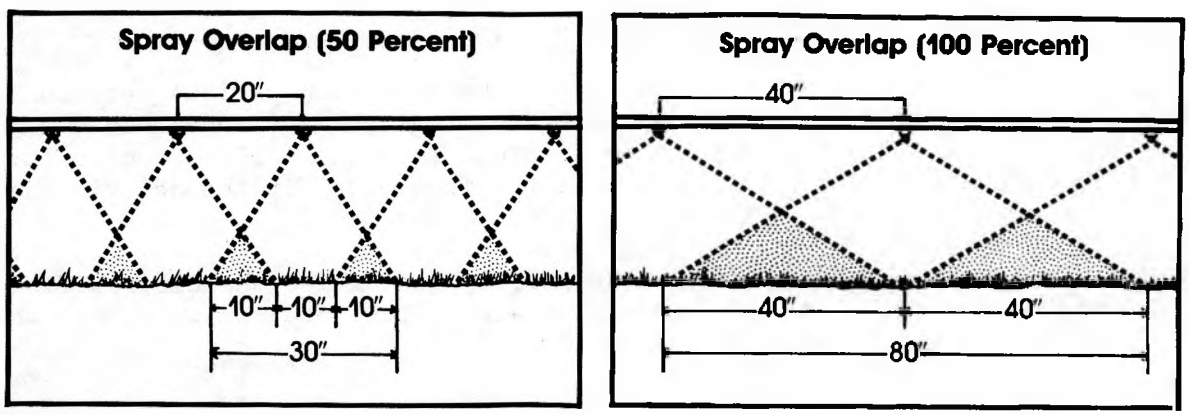
NOTE: This table is based on theoretical solution densities only and may vary in actual practice because of differing solution characteristics. Applies to flood nozzles but not Raindrop nozzles.

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:

$$\text{Percent overlap} = \frac{\text{Spray Coverage - Nozzle Spacing}}{\text{Nozzle Spacing}}$$

$$\text{Spray Coverage} = (\text{Nozzle Spacing} \times \text{percent overlap}) + \text{Nozzle Spacing}$$

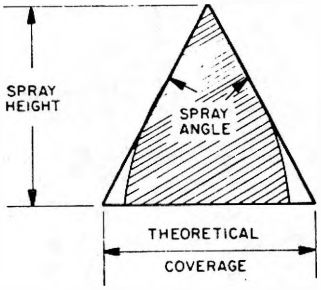


Spray Coverage Required to Obtain Proper Overlap

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

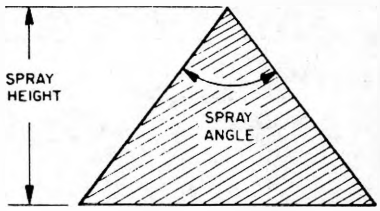
Spray angle (degrees)	Width of spray pattern at various distances from nozzle orifice													
	2"	4"	6"	8"	10"	12"	15"	18"	24"	30"	36"	42"	48"	60"
15	.5	1.1	1.6	2.1	2.6	3.2	3.9	4.7	6.3	7.9	9.5	11.1	12.6	15.8
25	.9	1.7	2.7	3.5	4.4	5.3	6.6	8.0	10.6	13.3	15.9	18.6	21.2	26.6
30	1.1	2.1	3.2	4.3	5.4	6.4	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" Spacing	30" 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 (in 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 ft. 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 thru 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

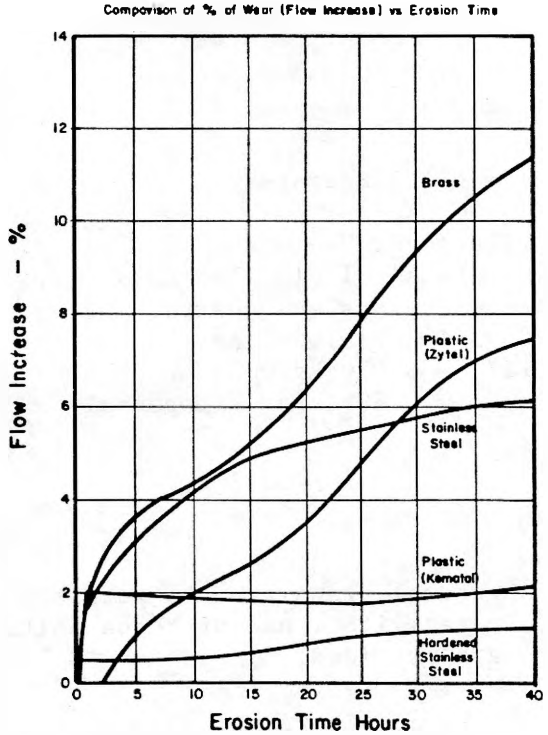
Nozzle tips are available in a variety of materials, including hardened stainless steel, stainless steel, thermoplastics, and brass. Hardened stainless steel is the most wear-resistant material, but it is also the most expensive. Stainless steel tips have excellent wear resistance with either corrosive 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.

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 (m2)
	acres	0.4047	hectares (ha)
VOLUME	gallons	3.785	cubic decimeters (dm3)
	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)

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

$$\text{GPM (Per Nozzle)} = \frac{\text{GPA X MPH X W*}}{5940}$$

$$\text{GPA} = \frac{\text{5940 X GPM (Per Nozzle)}}{\text{MPH x W*}}$$

*W = Nozzle spacing (in boom spraying) or spray swath (in boomless spraying)...in inches.

Volume and Liquid Measures

8 fluid ounces = 16 tablespons = 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/cm2
= 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.

Restricted-Use Pesticides

F. Miller

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 regulation are listed in Table 1.

Table 1. Restricted-Use Pesticides (January 1987)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
aldicarb	Temik	insecticide	all formulations	accident history
aluminum phosphide	Phostoxin, Detia, many others	fumigant	all formulations	human inhalation hazard
amitraz	Tuco BAAM, Mitac E.C.	insecticide-acaricide	all formulations	possible oncogenicity
arsenic pentoxide	many	wood preservative	all formulations	oncogenic, mutagenic, reproductive, fetotoxic effects
avitrol	several	avicide	all formulations	hazard to fish and nontarget birds
azinphosmethyl	Guthion, many others	insecticide	all liquids with concentrations above 13.5%	human inhalation toxicity
brodifacoum	Talon G, Rodenticide Pellets, Rodenticide Bait Pack	rodenticide	pellets	hazard to nontarget organisms
bromadiolone	Maki Urban Rat and Mouse Meal Bait	rodenticide	only product	fish and wildlife hazard
calcium cyanide	Degesch, calcium cyanide, G-fumigant	fumigant	all formulations	human inhalation hazard
captafol	many	fungicide	all formulations	exposure risk for farm workers
carbofuran	Furadan	insecticide-nematicide	concentrate suspensions and wettable powders; all granular formulations	acute inhalation toxicity
carbophenothion	Hopkins-Trithion	insecticide	all formulations	potential adverse effects to aquatic, avian, and terrestrial species

Table 1. (continued)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
chlordimeform	Galecron	insecticide	all formulations	causes cancer in laboratory animals
chlorfenvinphos	several	insecticide	all formulations	acute dermal toxicity
chlorobenzilate	Acaraben	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
creosote	many	wood preservative	all formulations	possible oncogenic and mutagenic effects
curacron	Polycron, Selecron	insecticide/ acaricide	emulsifiable concentrates	corrosive to eyes
cyanazine	Bladex	herbicide	all formulations	groundwater contamination, teratogenicity, fetotoxicity
cycloheximide	Acti-Aid	fungicide	all formulations greater than 4%	acute dermal toxicity
cypermethrin	Cymbush, Ammo	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
dicrotophos	Bidrin, others	insecticide	all liquid formulations	acute dermal toxicity, residue effects on birds

Table 1. (continued)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
diflubenzuron	Dimilin	insecticide	all formulations	lack of environmental hazard data
dioxathion	Delnav, Deltic	insecticide	all formulations	acute dermal toxicity
disulfoton	Di-Syston	insecticide	all granular formulations greater than 2%; all solutions	acute dermal and inhalation toxicity
endrin	Endrin, many others	insecticide	all formulations	acute dermal toxicity, hazard to nontarget organisms
EPN	EPN, many others	insecticide	all liquid and dry formulations	acute dermal and inhalation toxicity, residue effects on birds
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
fensulfothion	Dasanit	insecticide	emulsifiable concentrates and solutions, all granular formulations	acute dermal and inhalation toxicity
fenvalerate	Pydrin	insecticide	emulsifiable concentrates, (ear-tags not included)	high fish toxicity
flucythrinate	Pay-Off	insecticide	all formulations	possible adverse effects on aquatic organisms
fluoroacetamide	1081, others	rodenticide	all formulations	acute oral toxicity
fonofos	Dyfonate	insecticide	all liquid formulations; granular formulations greater than or equal to 20%	acute dermal toxicity

Table 1. (continued)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
hydrocyanic acid	several	fumigant	all formulations	human inhalation hazard
lindane	many	insecticide	all liquid formulations	RPAR decision, possible oncogenicity
magnesium phosphide	Degesch Fumi-Gel, Degesch Fumi-Strip	fumigant	all formulations	acute inhalation toxicity
mesurol	Bay 37344, Draza	bird repellent	dusts	possible hazard to nontarget organisms
methamidophos	Monitor	insecticide	all 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
methomyl	Lannate, Nudrin	insecticide	all concentrated solution formulations	residue effects on mammals, accident history
methyl bromide	many	fumigant	all formulations in containers heavier than 1.5 pounds	accident history, acute inhalation toxicity
methyl parathion	many	insecticide	all formulations	acute dermal toxicity, residue effects on birds, bees, and mammals
mevinphos	Phosdrin, many others	insecticide	all formulations	acute dermal toxicity, residue effects on birds and mammals
milban	Milban	fungicide	all formulations	corrosive to eye tissue
monocrotophos	Azodrin, many others	insecticide	liquid formulations	residue effects on birds and mammals

Table 1. (continued)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
nicotine (alkaloid)	Blackleaf 40	insecticide	all formulations	acute inhalation toxicity, effects on aquatics
paraquat dichloride	Gramoxone	herbicide	all formulations	use and accident history
pentachlorophenol	Agway Penta Wood preservative	wood preservative	all formulations	voluntary restriction, reproductive effects
permethrin	Ambush, Pounce	insecticide	all formulations (except ear-tags)	high fish toxicity
phorate	Thimet	insecticide	all formulations, liquid and granular formulations greater than 5%	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	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
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	many	fumigant	all formulations	acute inhalation toxicity

Table 1. (continued)

Active ingredient	Trade name	Type	Formulation	Criteria for restricted use
sodium fluoro-acetate	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
sulfotepp	Bladafum	fumigant	all formulations	acute inhalation toxicity
sulfuryl fluoride	Vikane	fumigant	all formulations	acute inhalation hazard
sulprofos	Bolstar	insecticide	all formulations	wildlife hazard
TEPP	Tetron, Vapotone	insecticide	all formulations	acute dermal and inhalation toxicity, residue effects on birds and mammals
terbufos	Counter	insecticide	all formulations	effects on nontarget organisms
toxaphene	many	insecticide	all formulations	oncogenicity, hazard to nontarget organisms
tralomethrin	Scout	insecticide	E.C. formulations	toxicity to aquatic organisms
triphenyltinhydroxide (TPTH)	many	fungicide	all formulations	possible mutagenic effects
zinc phosphide (all products suspended)	Phosvin, Blue-Ox	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, and E. Killion

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 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 produce 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 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 refesr to all wild vertebrates most of the remarks and examples will 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 poorest bird populations, essentially the same as plowed bare ground; wheat fields are only slightly better, and oat fields have conspicuously higher bird populations. Grasslands and hayfields are very rich bird habitats, with forty to seventy native species in 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 wheat field do not stop at the borders of that wheat field. Animals, especially birds, from adjacent fields may pass through the poisoned wheat field or even forage at its boundaries. A 1964 study in Illinois indicated that in a single breeding season two successive populations of birds in a hay field were killed from the effects of one application of 1/4 pound of dieldrin on a nearby wheat field. The hay field had not been sprayed, but the birds there were dead. A third population of birds that moved into the hay field 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 heights. Over 200 species are present in the state, and the numbers are many times the normal breeding populations. Many of these species are highly 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 on bare fields and grass-lands 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 containing insecticides, herbicides, and fertilizers; improper application of aquatic herbicides and pesticides; and a number of other factors not related to pesticide use. Pesticides, including insecticides and herbicides, can be very toxic to fish if allowed to enter water systems (see Table 1). Thus, pesticides should be applied carefully in areas near ponds, lakes, or streams. Precautions should be taken to prevent pesticide drift from the nontarget area, including drift in the form of runoff.

Even chemicals registered for use in aquatic systems can cause fish kills when applied improperly or carelessly. When applying chemicals registered (by the federal EPA) 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 will help answer questions about insecticides and their potential to cause fish kills. The decision to use a chemical should be based not only on the exact toxicity but also on stability of the compound, its tendency to store in fatty tissue, the method and rate of use, and its affinity for soil particles and solubility. Chemical toxicity is often expressed in LC50 units, the amount of pesticide in parts per billion needed to kill 50 percent of the test fish in a 24-hour period in an aquarium. This number includes those fish killed immediately after exposure, not delayed mortality caused by compounds in fish fat reserves. In the table, LC50 values and rates of toxicant per acre-foot of water are based on laboratory tests using 2-inch bluegills exposed for 24 hours. (Bluegills are used rather than trout because they are a popular Illinois sport fish.)

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. Growers 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 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 spray drift will reduce bee losses and may mean the difference between a satisfied producer and one faced with a lawsuit.

The toxicity to bees of insecticide applications can be drastically modified by abnormal weather conditions. Unusually low temperatures after an application can cause residues on crops to remain toxic to bees up to 20 times longer than these residues would be toxic during reasonably warm weather. The same holds true if abnormally high temperatures occur during late evening or early morning, bees may actively forage on treated crops during these times.

Relative Toxicity of Pesticides to Honey Bees

Pesticides differ greatly in their effects on honey bees. The formulation of the material 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. These materials and the insecticides can be placed in three groups in relation to their effects on bees: highly toxic, moderately toxic, and relatively nontoxic.

Highly Toxic Materials

This groupd 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)
arsenicals
Azodrin, monocrotophos
Baygon, propoxur
Baytex, fenthion
Cygon, dimethoate
Cythion, malathion
Dasanit, fensulfothion
DDVP, dichlorvos
Dibrom, naled*
De-Fend, dimethoate
diazinon, Spectracide
Dimecron, phosphamidon
Dursban, chlorpyrifos
EPN
Furadan, carbofuran
Gardona, tetrachlorvinphos
Guthion, azinphos-methyl
heptachlor
Imidan, phosmet
Lannate, methomyl
Lorsban, chlorpyrifos
malathion
Mesurol, methiocarb
methyl parathion
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
Agritox, trichloronate
Carzol, formetanate hydrochloride
Ciodrin, crotoxyphos
Counter, terbufos
Di-Syston, disulfoton (honey bee repellent)
Dyfonate, fonofos
Larvin, thiodicarb
Lorsban, 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
Bactur
Birlane, chlorfenvinphos
Delnav, dioxathion
Dessin, dinobuton
Dimilin, diflubenzuron (insect growth regulator)
Dipel, Thuricide, Tribactur, SOK-Bt
Dylox, trichlorfon
Fundal, chlordimeform
Galecron, chlordimeform
Heliothis polyhedrosis virus
Kelthane, dicofol
Marlate, methoxychlor
Morestan, oxythioquinox
Morocide, binapacryl
Murvesco, fenson
Omite, propargite
Pentac, dienochlor
Plictran, cyphexatin
pyrethrum (natural
rotenone
Sevin XLR, 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
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

Herbicides, Defoliants,and Desiccants continued

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, nitrofen
Tolban, profluralin
Tordon, picloram
Treflan, trifluralin
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 spraying 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. DST and before dawn, 3 a.m.) 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 severe 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 before pesticide treatment 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 trees are not in bloom but when there is attractive clover beneath them, and to alfalfa when weeds, such as yellow rocket and mustard, are in bloom.

Table 1. Insecticides, Common Agricultural Rates, Extent of Use, LD_{50} to White Rats, Birds, and Fish, 24-Hour LC_{50} to Bluegills, and the Calculated 24-Hour LC_{50} in Pounds of Toxicant per Water Acre 3 Feet Deep

Insecticide	Common agr. rate, (lb/A)	Use in Illinois	White rats Approximate LD_{50}, mg/kg Oral	White rats Approximate LD_{50}, mg/kg Dermal	Birds[a] LD_{50} mg/kg	Fish LD_{50}, ppb	Lb. toxicant per ft.-acre for bluegill LC_{50}	Comments apply only to fish kill
toxaphene[b]	1.5	Moderate	85	925	31	7	.02	Extremely toxic to fish. Do not use in
DDT[b]	...	None	115	2,510	595	7[c]	.02	the vicinity of streams or ponds.
azinphosmethyl (Guthion)[d]	.5	Moderate	12	220	75	8?	.02+	
aldrin[b]	1.0 to 1.5	Heavy[e]	49	98	6	10	.03	
phorate (Thimet)[d]	1.0	Heavy	1	3	<1	10	.03	
rotenone	...	None	75	940+	>1,414	24	.06	
methoxychlor[b]	1.5	Light	5,000	6,000+	>2,000	31	.08	
heptachlor[b]	1.0 to 1.5	Moderate	131	230	>2,000	35	.09	
diazinon[d]	1.0	Moderate	92	680	4	54	.15	Highly toxic to fish. Use great caution
parathion	.25 to .5	Light	12	14	2	56	.15	if applied in the immediate vicinity of
lindane[b]	...	None	89	950	900	61	.16	streams and ponds.
malathion[d]	1.0	Moderate	1,200	4,000+	167	120	.32	Moderately toxic to fish. Use cautiously
demeton (Systox)[d]	...	None	5	11	7	195	.53	around streams and ponds. Avoid direct
naled (Dibrom)[d]	.75	Light	250	800	52	220	.59	application of agricultural sprays to
carbofuran (Furadan)	.75-1.0	Heavy	5	885	<1	240[f]	.60	water with fish.
carbaryl (Sevin)[g]	1.0 to 2.0	Heavy	675	4,000+	265	3,400	9.2	Least toxic to fish. Reasonably safe for
trichlorfon (Dylox)	1.0	Light	595	2,000+	37	5,600	15.1	use around ponds or streams with fish.
methyl parathion[d]	.25-.5	Light	19	67	8	8,500	23.0	
dimethoate (Cygon)[d]	.5	Light	215	505	9	28,000	75.6	

[a]Test bird: Mallard duck, ring-necked pheasant, bobwhite, or California quail. Toxicant administered as a single oral dose. Data from Denver Wildlife Research Center, Bureau of Sport Fisheries and Wildlife.

[b]Chlorinated hydrocarbons, aldrin (as dieldrin), DDT, dieldrin, and heptachlor (heptachlor epoxide) are stored in fat and persist as residues. Metoxychlor is less readily stored, and its toxicity is lower than many others. Toxaphene does not tend to store and is rapidly excreted.

[c]Lower than some studies show.

[d]Organic phosphates are usually not readily stored and break down in water. Some are highly toxic to warm-blooded animals.

[e]Used as soil treatments; adheres readily to soil particles.

[f]Four-day exposure for LC_{50}.

[g]This carbamate is more residual than many phosphates but is relatively nontoxic fish and wildlife.

Reducing Bird Damage in Illinois

R. Ogden

Estimates of the economic impact of birds on agricultural crops in the United States are as high as $100 million annually. Bird damage in Illinois occurs where human use of land is intensive, agricultural foods are available, and when certain species of birds congregate after the breeding season, during migration, and in the winter. Agricultural crops near roosts provide attractive and often preferred feed for crop-consuming birds such as blackbirds and starlings. Problems result when the birds radiate out from their roosts into fields of unharvested crops or to livestock feedlots.

The best solution to a bird problem will usually involve an integrated approach that includes several control techniques. Control programs that rely exclusively on the use of one method are usually doomed to failure. It is important that a program be planned with a thorough understanding of both the biology of the birds and the advantages and limitations of the various control technologies. This report is intended to provide the reader with a basic understanding of the biology of those birds usually associated with damage, the type of damage control techniques available, and suggestions for dealing with bird damage situations in Illinois.

Problem Birds in Illinois

European starling	*Sturnus vulgaris*
Red-winged blackbird	*Agelaius phoeniceus*
Brewer's blackbird	*Euphagus cyanocephalus*
Rusty blackbird	*Euphagus carolinus*
Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
House sparrow	*Passer domesticus*
Pigeon	*Columba livia*
Crow	*Corvus brachyrhynchos*

The identification characteristics, biologies, and habits of these problem birds are discussed in an article titled "Reducing Bird Damage in Illinois" by R.D. Ogden reprinted entirely in 1983, 1984, 1985, and 1986 editions of the *Illinois Custom Spray Operators Training School Manual*.

Techniques for Controlling Bird Damage

Methods for alleviating bird damage generally fall into three broad categories: biological, mechanical, and chemical.

Biological Controls

Decoy crops and cultural practices. Sometimes it is economical to divert the birds by planting a less valuable crop, one that is more attractive to depredating birds, adjacent to valuable crops. Often techniques such as planting or harvesting early or late, changing crop types, leaving stubble fields standing, and planting all grain in an area at the same time can reduce serious bird damage to field crops.

Habitat manipulation. Most commonly used for roosting problems, this technique consists of thinning or removing roosting cover or eliminating access to roosting or nesting sites in or around buildings and other structures.

Bird-resistant varieties. Some progress has been made in developing bird-resistant crop varieties. The use of these varieties, especially grain sorghum, may be a means of reducing losses to birds in the future.

In general, because most biological methods are costly or impractical, they have not been widely accepted by agriculturalists. When these methods are applicable, however, they have effectively reduced bird damage.

Mechanical Controls

Mechanical control methods, which consist primarily of scaring devices, are widely used and are often effective in the control of birds in grain fields and in urban areas. Frightening devices include propane or acetylene exploders, shellcrackers, fireworks, windmills, scarecrows, and hawk or owl models. Recorded alarm or distress calls of birds broadcast through mobile or stationary units or played on record players are also effective. Other types of mechanical controls include netting, "porcupine wires," and sticky compounds used to discourage birds from roosting in or on buildings. Frightening devices are discussed in greater detail below. Decoy traps have been used effectively in Illinois and elsewhere to remove small populations of birds, especially in feedlots, orchards, and berry plantings.

Chemical Controls

Chemicals applied for control of birds must be species selective, effective, economically practical, and environmentally safe. Types of chemicals for managing bird problems include repellents, stressing agents, toxicants, chemosterilants, and frightening agents. The use of poisons (toxicants) for bird control in Illinois is restricted to nonprotected species or to use by trained government agents. Refer questions about the legality of a planned bird control program to the Illinois Department of Conservation or to the U.S.D.A. - APHIS - Animal Damage Control, both located in Springfield, Illinois.

Repellents. The most promising repellent compound found to date is methiocarb, which is effective in protecting newly planted corn from blackbirds, crows, and pheasants. Methiocarb is registered for use in Illinois as a seed treatment and for controlling bird damage to fruit. It is hoped that after additional testing this product will become more widely available for use in controlling bird damage to crops.

Frightening agents. One of the most useful chemicals for reducing bird damage to agricultural crops is the chemical frightening agent Avitrol. This chemical is considered a frightening agent because most birds that ingest treated bait react by flying erratically and emitting distress cries. This behavior frightens other members of the flock from the area. Avitrol is relatively effective at low use levels and is relatively safe, killing less than 1 percent of the flock. It is effective in reducing bird damage to field corn and sweet corn. Avitrol can be mixed on many types of grain baits and has been shown to be an effective control in feedlots and other areas, in addition to grain fields.

Stressing agents. Stressing agents are essentially detergents or wetting agents that lower the surface tension of water and enhance the wetting of a bird's feathers. The bird-stressing agent PA-14 is registered for use by qualified government animal control personnel or by those under their direct supervision. This chemical is poisonous to fish and, to some degree, plants. Spraying tree roosts should be confined to the period when trees are dormant. Use of this chemical is recommended only in cases of extremely large and serious bird problems where other techniques will not work.

Toxicants. The development of toxic agents or poisons has been directed primarily at starlings. Starlicide is a pelleted toxic bait registered for use in cattle feedlots and poultry-raising operations. The treated pellets, diluted with untreated pellets at a 1:10 ratio, are scattered thinly in empty pens and alleyways or in troughs placed above feeding bunks. Available only in the pelleted forms, Starlicide may not be effective unless mixed with materials on which the starlings are feeding. Starlicide is a slow-acting poison highly toxic to starlings and blackbirds but generally less toxic to most other birds. The safety of the compound can be increased by careful consideration of bait material and placement, dilution rates, and timing. Its effectiveness is probably related to its slow action; it takes up to 48 hours for birds to die after they ingest a lethal dose, and they do not show bait aversion.

Poison perches. Poison perches are useful for killing birds inside or on buildings when it is impossible to exclude them by other means. Poison perches consist of a small metal tube with an exposed wick and vary from a few inches to several feet in length, with different sizes to fit the feet of the target birds. The cloth wick inside this tube is soaked with a contact poison; birds perching on the tube absorb the poison through their feet and are killed. Because of its low toxicity to other animals, fenthion is most desirable for use in these perches. Endrin can also be used, but it is highly toxic to other animals. **Exercise extreme care in the use of contact poisons.** These chemicals should be used only by a licensed pest control operator. Do not install perches near feeding operations or food storage areas.

Chemosterilants. The only registered chemosterilant for birds is Ornitrol, which is used on wild pigeons. Although this form of "birth control" for pigeons works, it has several disadvantages: (1) The treated bait must be eaten in a sufficent quantity for several days before it is effective. (2) This chemical is capable of inhibiting reproduction only for up to six months and must be used once or twice each year to ensure population suppression. Research is being conducted in an attempt to develop a chemosterilant for reducing damage by blackbirds.

BIRD PROBLEMS AND SOLUTIONS

Protecting Grain Fields

Damage to ripening grain can be avoided or reduced by modifying the crop culture, frightening birds from fields, or both.

Cultural methods. The number of birds in many grain-producing areas increases as the season progresses; thus, late grain may be subject to the heaviest attack, whereas early grain is less damaged. Bird damage is usually greatest in fields or parts of fields close to a body of water, marshland, desirable resting cover, or a regularly used flightline. In this type of situtation a decision to grow a crop not usually subject to severe bird attack may be in order. Sometimes grain damage can be reduced by removing loafing or roosting cover adjacent to grain fields. Stubble fields left standing until the bird danger is past will provide the birds with alternate feeding sites and thus decrease damage to unharvested crops.

Certain varieties of grain show some resistance to blackbird attack. Even when an attack is heavy, sorghum growers can usually obtain appreciable relief from crop damage if they use protection methods properly.

Frightening devices. Gas exploders, .22-caliber rifles, rope firecrackers, shellcrackers, airplanes, shotguns, and recorded blackbird alarm cries are used to scare blackbirds from grain fields. Frightening blackbirds from a field will not necessarily correct the problem. If other acceptable seed foods are available nearby, blackbirds will feed on them. For best results from frightening devices, the following procedures are recommended:

(1) Begin bird scaring when grain is first susceptible to damage or at least at the earliest indication that blackbirds are feeding on grain.

(2) During the damage season, use corn-protection measures throughout the day, particularly in the early morning when blackbirds first appear, and again during the late-afternoon feeding period. Extra protection is also required during rainy or foggy weather.

(3) A combination of bird-scaring techniques should be used whenever possible, particularly at times when bird pressure is high, such as in early morning, in late afternoon, and during bad weather.

(4) For maximum benefit, the scaring devices, especially the stationary ones such as gas exploders and rope firecrackers, should be moved at least twice daily in a grain field.

The automatic gas exploder, probably the principal bird-frightening device, usually reduces grain damage. Gas exploders produce loud explosions at automatically timed intervals when a spark or pilot flame ignites the propane, butane, or acetylene gas. Some exploder models have unique modifications, such as automatic starting and stopping switches controlled by timing or light-sensing mechanisms, an apparatus for partly rotating the exploder after each firing so that the sound carries in a different direction, and a means of mounting the exploder on a vehicle with a detonating switch in the cab. Exploders mounted on platforms and operated above the height of the corn give the best results. Some

farmers have excellent results by mounting an exploder on the roof of a pick-up truck in addition to using stationary units in the field. A woods margin or buildings may help direct or intensify the sound. The effective range of an exploder varies. Tests show that grain damage can be cut in half within 600 feet of an exploder (which is equivalent to 26 acres of protection), but as a general rule, with moderate bird pressure, one exploder should be used for every 10 acres of grain.

The .22-caliber rifle is an effective bird-scaring device, but it should be used only where it is legal and safe. One rifleman from a high position such as a rooftop, silo, or tall platform can protect as much as 100 acres. As birds settle into a field, a bullet is fired earthward into their midst.

Flash-salute-type fireworks, popularly known as bulldogs, cannon crackers, cherry bombs, or salutes, are used in rope firecrackers. Firecracker fuses are inserted at intervals between strands of a loosely twisted, cotton rope, one end of which is tied to the apex of a tripod of wooden stakes. The free end of the rope is ignited and as it burns, the ignited firecrackers drop from the rope and explode. Approximately 10 acres of standing grain can be protected with one rope firecracker assembly. A 55-gallon barrel with the rope suspended inside amplifies the sound and reduces the fire hazard. Fireworks are prohibited in many areas. Consult local laws before using fireworks in bird control.

A shotgun firing either regular ammunition or shellcrackers is an effective bird-scaring tool. Shellcrackers are special shotgun shells that discharge a projectile that explodes after traveling about 100 yards. Shotgun shells and shellcrackers can be used to supplement automatic devices or can be used alone, especially in early morning and late afternoon. Shellcrackers should not be fired over or into dry vegetation or other potentially flammable materials. The occasional killing of a bird with regular shotgun shells can increase the effectiveness of shellcrackers and other scare devices.

Light airplanes, sometimes equipped with sirens or horns and flown slightly above tassel height, are used in some areas to frighten birds. Pilots often try to cover a grain field systematically, because the birds frequently drop farther down into the grain rather than flushing when the plane approaches. Airplane operations are restricted to times when flying conditions are favorable; they are expensive, and the results inconsistent. Federal law prohibits shooting or harassing any wildlife from aircraft without an appropriate state permit.

Chemical frightening agents. The use of Avitrol has been demonstrated to be of value in protecting field corn, sunflowers, and sweet corn from damage by blackbirds. When treating fields, do not place the bait nearer than 40 to 50 feet from the edge of the field because nontarget birds use the outer perimeter heavily. Avitrol is registered for use in protecting corn but not for protecting grain sorghum. Cowbirds do not respond as well to the Avitrol baits as do some blackbirds. Use of Avitrol is restricted to pest control operators or government personnel trained in bird damage control. Several aerial applicators have been certified in Illinois to apply Avitrol to cornfields.

Other methods. In areas where other control techniques are not legal or practical, visual deterrents can offer some protection. These methods include twirlers, windmills, scarecrows, twine strung over the grain, and reflecting

plates. Small plots can be protected by covering the grain with netting or by putting paper cups or bags on individual ears after pollination.

Population reduction. Blackbirds are protected by Illinois state law. They can be killed when committing or about to commit serious damage to agricultural crops only after a permit has been received from the Illinois Department of Conservation. Such operations must be conducted in conformity with state law, so check with the Illinois Department of Conservation before initiating lethal bird control activities. There is no feasible method at present for appreciably reducing most populations of grain-depredating birds during the damage period in late summer and early fall. Shooting is widely practiced, but it is more effective as a scaring technique. The large decoy trap, which has been moderately successful in certain fruit-growing areas, has not been successful as a means of alleviating grain damage because so many traps are needed. No completely satisfactory chemicals have been developed either as repellents, lethal baits, or contact poisons for use in ripening grain fields or roosting areas. These problems are compounded by the fact that most of the problem species are migratory and have a high reproductive capacity.

Roosts in and on buildings. House sparrows, pigeons, and starlings are the most common birds creating roosting problems in buildings. They may get into machine sheds, barns, garages, and other buildings either to nest or to roost. The best and most permanent solution to this type of problem is, of course, to deny the birds access to the building or to roosting or nesting sites within the building. Doors should be tight-fitting and should be kept closed; windows should be closed or covered with .25-inch or smaller wire mesh.

If it is impossible to exclude birds from the interior of the building, it is sometimes possible to screen off rafters and other preferred nesting and roosting areas with .25-inch hardware cloth. Sticky or irritating compounds can be applied to roosts and will sometimes discourage the birds from using them. Perches poisoned with fenthion or endrin can be used, but ways to keep birds from getting in should also be used. Revolving lights and ultrasonic sounds have had varying results in repelling birds from buildings and warehouses. Homeowners can usually control individual starlings by live-trapping them with a nest-box trap or other type of live trap. Sparrows and pigeons can be discouraged from nesting in buildings by destroying their nests and eggs at two-week intervals during the spring and summer months. Use a hook fastened to the end of a long pole to tear down nests in rafters or under eaves. If at all possible, block off nesting sites after the nests have been destroyed. Several types of commercial traps are also available and are sometimes effective in reducing numbers of sparrows and pigeons. Poison baits may also be used if other techniques do not work.

Birds and Feedlots

Cattle feedlots are prime locations for bird concentrations, especially from about October through mid-March. Starlings, and to a lesser extent grackles, blackbirds, cowbirds, sparrows, and pigeons, are the primary species associated with feedlot damage. Feedlots have an abundant food supply and sometimes provide warmth and shelter. Best estimates indicate that about $175 per 1,000 starlings is lost for the six-month wintering period.

One of the keys to successful bird control in feedlots is knowing the seasonal cycle of the birds and also anticipating the problem. Controls implemented as

soon as the birds begin to congregate are much more effective than those applied after they have already become established. Many problem birds are migratory or at least seasonal in their activities. Most blackbirds, cowbirds, and grackles are a problem only during spring and fall, when migrating in large flocks. In southern Illinois, however, they establish winter roosts. Although they are not totally migratory, starlings also gather into flocks from late summer until early spring. During the nesting season in late spring and early summer they are well scattered and present little trouble to the feedlot operator. Sparrows, of course, are year-round residents and can be a nuisance during any season.

Several techniques are available for controlling birds in feedlots. One of the most important considerations in using chemicals to control birds at feedlots is to determine where to place the bait. In warm weather, large fly populations at feedlots may sometimes attract and hold large number of birds; therefore, an effective fly control program may also reduce a bird problem.

In many feedlot damage situations it will probably be necessary to use an integrated approach. Most toxicants used in conjunction with scare devices are not effective unless the scare devices are used to concentrate birds into one area. Live traps may also supplement the other techniques. Wherever possible, roosting or nesting sites should be eliminated, and care should be taken to avoid feed spillage. Every situation is unique. It is important to consult experts in bird control before designing or implementing a major bird-control program. Some bird problems at feedlots are among the most difficult wildlife damage problems to solve.

Fruit Protection

Frightening devices are usually effective for protecting vine and cane fruits, especially in small- to moderate-sized areas. Tree fruits can also be protected by noise devices, but more time, equipment, and persistence are required. Propane or acetylene exploders have been effective in orchards and vineyards against starlings, grackles, and blackbirds, but they are not as effective against robins, cedar waxwings, warblers, juncoes, orioles, and other birds. Rope firecrackers have about the same effect as exploders, but they cover a smaller area. In using either device, it is important to place it well above the tops of the trees or vines if at all possible. Shellcrackers or ordinary shotgun shells are useful as a supplement to automatic noise devices because they will move large flocks of birds more effectively.

Relatively inexpensive cloth or plastic netting is often best for fruit or vegetable crops. Plastic twirlers, cloth strips, suspended pie tins, and other moving objects help to reduce damage, especially in small areas. Shredded newspapers wrapped around posts may reduce damage in small fruit patches or vineyards. Lethal measures are not very effective in reducing fruit damage. They are also hazardous and may endanger protected species. Use of decoy traps can provide relief in many situations. Traps should be kept well supplied with food and water, and protected species should be released. Methiocarb, now registered as a repellent for control of bird damage to cherries and blueberries, is being studied as a repellent on milo and sunflowers.

Agency Responsibility

The primary objectives of bird damage control in Illinois must be to prevent or minimize losses, diseases, and nuisance problems caused by birds. The Federal Migratory Bird Act places responsibility for managing migratory birds with the U.S. Department of Interior through the Fish and Wildlife Service. Illinois law places responsiblity for managing nonmigratory birds with the Illinois Department of Conservation Wildlife Resources. All birds except starlings, house sparrows, and ferrel pigeons are protected by Illinois law, and a permit must be obtained before any lethal control can be used. Permits can be obtained through the Division of Wildlife Resource in Springfield or through the local conservation police officer. Plans for decoy traps and leaflets on other controls can be obtained from the U.S.D.A. - APHIS - Animal Damage Control, Room 105, 600 East Monroe, Springfield, IL 62701 (217/492-4308).

Control of Rats and Mice

R.Ogden

RATS

Once you have determined where rats are living, feeding, and traveling, the first step in controlling them is to eliminate their shelter, food, and water. Sanitation is the backbone of any successful rat-control program. Do not overlook or neglect obscure corners and shelves. Look under and in such areas as cabinets, worktables, lockers, and equipment when cleaning out potential rat harborage areas.

Outside harborage areas should also be given careful attention. Grass, weeds, and other vegetation near buildings should be kept closely cut. Eliminate debris such as lumber, rock piles, rubbish, old equipment, and construction materials, and store items that must be kept at least 18 inches above the ground and 12 inches away from walls or fences. Block off spaces under loading docks and outside storage buildings or sheds so that rats cannot gain entry. Fill in old rat burrows and holes with earth.

Identification characteristics, biologies, and habits of problem rats and mice are discussed more extensively in "Control of Rats and Mice" by R. D. Ogden in the 1986 *Illinois Pest Control Handbook*.

Ratproofing

One of the principal entry places for rats is the space under exterior doors. The bottoms and edges of these doors can be built up with wood so that no opening is greater than 0.5 inch and the doors can then be covered with a metal cuff. Wood doorjambs that are susceptible to gnawing by rats can be covered with sheet metal (24 gauge or heavier).

Openings such as windows, coal chutes, ventilating fans, and foundation vents can be ratproofed by tightly covering the opening with 19-gauge hardware cloth that has openings no larger than 0.5 inch. Cover holes through wooden walls with hardware cloth or sheet metal, and cement shut holes through masonry walls. Protect pipes and wires running up outside walls with metal guards, and protect grain bins and corn cribs with sheet metal around the bottom.

Use of Poisons

After you have tried to control rats as much as possible through sanitation and ratproofing, the next step is the use of poison baits or traps. Perimeter control is very important because it intercepts rats before they invade buildings, bins, or sheds. Burrows must be gassed and sealed. Weatherproof, permanent bait stations plus weatherproof poison baits should be strategically placed along predetermined invasion routes. Bait stations should also be placed along all potential avenues of entry, such as doorways and basement windows, and along building walls or shipping docks.

Because rats tend to feed on things that are familiar to them, using the proper bait will often have more bearing on the results than the choice of rodenticide or placement of bait. As a general rule, Norway rats (the species commonly found in the Midwest) prefer meat and fish. Even if their favorite food is used, "prebaiting" with unpoisoned bait for several nights may be necessary in order to gain the rats' acceptance of the bait. The bait material, of course, must be the same during both periods. Although prebaiting is useful for controlling "difficult" rats with quick-acting rodenticides, it is too costly for routine or large-scale use and is unnecessary when you use anticoagulants. Test baiting is also a useful technique to determine which baits rats prefer, the number of baits needed, and where they should be placed.

Most poisons must either be mixed in a water solution (where possible) or added as solids to bait materials that are attractive to rats. All bait materials should be fresh and must not taste or smell of chemicals. Anticoagulant poisons are commonly mixed with cereal baits such as corn meal, rolled oats, or cracked corn, together with corn oil, peanut oil, sugar, molasses, or similar substances that may add to their attractiveness. Mix bait well so that the toxicant is distributed evenly throughout. Meat, fish, canned cat or dog food, cereals, fruits, vegetables, nuts, and many other baits are also used. Baits may be ground, sliced, or cut into cubes, although crumb-sized or sloppy-paste baits are preferable because they reduce the possibility that rodents will carry baits to other areas. All recognizable foods (such as peanut butter) should be prepared in such a way that they are made unrecognizable (e.g., by dyeing them green or red).

If you mix your own baits, follow the directions on the registered label. Do not use more than the recommended amount of any poison because to do so would increase the danger of the bait to man and domestic animals and might decrease the bait's acceptability to the rats. Too low a concentration, on the other hand, will lead to incomplete control.

Place bait in rat runways wherever possible, and put solid bait in small cups or dishes so that it can be easily picked up when it is no longer needed. Place all bait close to walls and near doorways wherever possible. When practical, baiting should be done in the late afternoon so that the bait will be fresh at dusk, when the rats become active.

Because rats often feed in one place, a small number of bait stations will be sufficient. The amount of bait needed can usually be determined after one night of baiting and depends upon the number of rats present and the toxicant being used. Use enough bait to feed all the rats present. Do not put out more bait than the rats are likely to consume because extra bait will create a hazard to pets and children.

Because bait must be placed so that it is not readily accessible to children, pets, and domestic animals, bait boxes will be needed in some areas. Three types of containers are used for rodent bait. (1) Open bait trays are used for dry, wet, or liquid baits. These trays have no cover, offer little or no protection to the bait, and do not prevent pets or children from reaching the poison. (2) Covered bait stations are designed to confine the bait, to protect it from the elements, and to avoid environmental contamination, but not to provide safety protection to pets or children. (3) Safety bait stations are constructed of materials that will protect the bait and are designed to prevent pets and humans from having ready access to it. Safety bait stations can be locked to discourage tampering.

Several kinds of rodenticides are available; these are commonly categorized as (1) anticoagulants, and (2) single-dose or quick-acting rodenticides.

ANTICOAGULANT POISONS. Although most anticoagulant formulations are available only for use by specialists, some are available to the general public as a ready-to-use bait, concentrates to be mixed with baits or water, weatherproof pellets, paraffin blocks or cakes, and tracking powders. Whether the poisons are to be used inside or outside, you should determine the moisture conditions and use the appropriate formulations.

The anticoagulant rodenticides, which include the hydroxycoumarin compounds (Warfarin and Fumarin) and the indandione compounds (Pival, diphacinone, chlorophacinone, and PMP), act by disrupting the normal blood-clotting mechanisms, causing the rats to die of internal hemorrhaging. These rodenticides are mostly slow acting and require several days of continous feeding before a rat dies, so a single dose is seldom lethal. Baits must therefore be made available continuously for 5 to 12 days, and reasonable control of a rat population may not occur for two weeks. (Single-feeding anticoagulants are now being marketed and if successful will be very useful in rodent control projects.)

One advantage of anticoagulant baiting is that bait shyness does not develop, primarily because there is no violent reaction to feeding. The action of the poison is apparently painless, and rats do not suspect any danger. Unfortunately, anticoagulant baits do not cause rats to go outside before dying, and odor problems will develop if the rats die indoors.

One advantage of anticoagulant baiting is that the necessity for repeated doses provides a built-in safety feature for most animals. Pigs, cats, and dogs are especially susceptible, however, and have succumbed to a single dose of anticoagulant. A useful antidote, vitamin K, is available to veterinarians for treating anticoagulant poisoning.

Thus, although anticoagulants are considered relatively safe, care must be used to protect the public and domestic animals. Follow closely the recommendations of the manufacturer and the label directions for mixing and safe handling. The concentrations recommended on registered labels should be adhered to for maximum effectiveness and to prevent increasing the hazard or reducing rodent acceptance. Present the bait in a safe manner to avoid contamination of food or food stuffs. Exposure inside a building should be at floor level. Open bait trays can be used indoors only if placed in areas that are not readily accessible to the public or domestic animals.

When baiting outdoors, place all bait in burrows, tunnels, or covered rodent bait stations. All dry bait should be inspected at least once a week and, if it is infested with insects, moldy, or otherwise unattractive to rats, it should be replaced with fresh bait. Daily baiting is necessary when using perishable baits such as fruits and vegetables. Bait supplies should be available to the rats at all times.

Place mixed-cereal or solid bait in waterproof containers in a cool, dry place if they are stored for a considerable length of time. Upon completion of the control program, pick up and dispose of all bait containers that are accessible to the public.

SINGLE-DOSE POISONS. The single-dose or acute rodenticides form a second group of poisons and include the more toxic baits: zinc phosphide, strychnine, norbormide, and red squill. Each poison has special characteristics, uses, and hazards, and all of these should be well understood before the poison is used. These poisons not only kill rodents but are dangerous to man, pets, and domestic animals.

Zinc phosphide is an effective rat and mouse poison that has been used successfully for many years. It is a black powder with a distinctive odor that makes it unattractive to people and to pets. Some zinc-phosphide rat poison comes with an emetic that gives additional protection from most nontarget animals. Although its safety record is very good, zinc phosphide still requires special handling and must be mixed in a well-ventilated area. Although zinc-phosphide bait remains toxic for long periods of time, its quick action, effectiveness, and low hazard make it one of the most useful rodenticides.

Strychnine sulfate and strychnine alkaloid are sometimes used as rodenticides, particularly on poisoned seeds for mouse control. The sulfate is preferred for treating grains because it will soak into the kernels, whereas the alkaloid must be coated on the outside with starch and other adhesives. These poisons do not normally give good results in rat control because they have an extremely bitter taste and are fast acting. Because strychnine is so fast acting (death can occur as soon as 12 mintues after eating) and is toxic to all forms of life, it is a very hazardous material and must be used only in special situations and with great care. Because the use of strychnine creates secondary hazards, pick up all dead animals and dispose of them either by burning or deep burial.

Norbormide, better known by the finished-bait trademark Raticate or the chemical trademark Showoin, is a quick-acting poison for Norway rats. Although norbormide has shown great promise because of its quick action and safety, it is not widely used because bait acceptance is poor and tolerance develops after sublethal doses. It is useful, however, for quick reduction of a Norway rat population where safety is of utmost importance.

Red squill is a quick-acting rodenticide with a natural emetic action that causes prompt vomiting except in rats, which cannot vomit. It also has a bitter taste that is objectionable to man and many domestic animals. Because of its strong taste, red squill is effective against the Norway rat only, and even with this pest a sublethal dose will cause severe bait shyness. As a result, its most effective use is for the quick reduction of a rat population over a short period of time. Red squill absorbs water from the air and becomes caked and hard, so it should be stored in tightly sealed containers. Care should be taken not to get it on the skin because it is extremely irritating.

Tracking powders. Both anticoagulant and single-dose poison tracking powders can be used in enclosed areas where food materials will not be contaminated.

Poison gases. Certain gases can be used to supplement the anticoagulant and single-dose poisons. Calcium cyanide (Cyanogas or "A" Dust), chloropicrin aluminum phosphide, and methyl bromide are used for quick kill of rodents and their ectoparasites in burrows outdoors. These gases can be quite dangerous and should be used very carefully and only by certified applicators.

Calcium cyanide is available as a dust that can easily and safely be put into burrows with foot pumps made available specifically for this purpose. The dust reacts with water vapor in the air and gives off hydrogen cyanide gas (HCN), an

extremely toxic fumigant. The HCN gas can be absorbed through the skin, especially if the skin is damp with perspiration. Calcium cyanide is used primarily in control of rats, but also for control of chipmunks, ground squirrels, and other burrowing rodents. The dust is most effective when it is forced into the rat burrow with a pump and then contained by closing the burrow. This process also makes it easier to determine whether or not a burrow has been reopened and rat activity still persists. You can usually close burrows simply by stomping dirt into the hole with the heel of your shoe. Dusting should be done on a still day so that air currents will not carry the gas away or to the operator. Do not treat burrows that lead under occupied buildings with calcium cyanide.

Chloropicrin, methyl bromide, and aluminium phosphide are used in much the same manner as calcium cyanide to control rodents in burrows. It is very important to adhere closely to label directions in all control operations. Aluminum phosphide comes in tablet or pellet form.

Use of Traps

In certain situations, particularly where there is danger of contaminating food products or of harming pets or children, it may be necessary to trap for rats. Many types are used: common wood-base snap traps, steel traps, live traps, and multiple-catch box traps such as the Ketch-All.

The trap most commonly used in rat control is the wood-base snap trap. It may be baited, or the trigger device may be expanded and the trap used without bait. Steel traps like those used to catch small fur-bearing animals are less suitable for trapping rats because they usually catch the rat by snapping shut on one leg, and the rat will often chew the leg off and escape.

To bait snap traps, use suitable food baits not larger than the end of the index finger. Tie the bait to the trigger of the trap, and set it in a runway. To expand the trigger device, attach a piece of screen wire or light cardboard (the same width as the trap) securely to the trigger, and set the trap in a runway so that a rat crossing the trap will step on the enlarged trigger and be captured.

Always set the traps in rat runways. Where necessary, boxes or other obstructions (rats may avoid new materials or objects for a day or so) may be placed along a wall to create a runway so that rats will have to cross your traps. It is necessary to move the traps about once a week and to change baits frequently because rats easily become trap shy and will avoid traps baited with the same food or left in one location too long.

Although the traps with enlarged trigger devices do not need bait, bait is certainly an additional attraction. Many baits are effective, from peanut butter and cake crumbs to bacon and gumdrops. Because they tend to spoil easily, however, fresh baits should be used only where the extra attraction is needed.

A number of traps should be used, and they should be spaced within 20 feet of each other. Traps should be checked frequently, and trapped rodents should be removed.

Other Control Methods

Ultrasonic devices are another method of control, but limitations at this time make them impractical. Most units are quite expensive and use a great amount of

energy. Only under unusual conditions would it be possible to set up sound barriers that rats and mice will not pass, and this method would remain effective only as long as the equipment was in proper operating condition.

Chemosterilants have been tested in attempts to develop materials to sterilize female, young, or male rats, but most of these products are effective only if fed to rats repetitively. Bait shyness has been a major problem with the compounds developed to date, and a permanent, effective sterility compound has yet to be developed. Alpha-chlorohydrin (Epibloc) is the most promising new development. This material acts as an acute poison but sterilizes male rats if the dosage eaten is not fatal.

MICE

The first step in mouse control is to look for signs of mouse infestation, so that you will know the extent of the problem before you begin control measures. Fresh droppings are a sure sign of mice. Care must be taken, however, to distinguish mouse droppings from those of the larger roaches that are frequently found in the same areas. The droppings of both are 0.25 inch long, but mouse droppings are pointed on the ends whereas cockroach droppings are blunt ended and ridged down the sides. Mouse nests are frequently found in and near their food supply. The nest is made from almost any soft material chewed into small bits to make a soft bed. Holes are another sign of infestation; holes gnawed by mice are usually small and clean-cut rather than large and torn, like rat holes.

Mouseproofing

Buildings can be mouseproofed by closing the openings around pipes, doors, and windows; holes in walls; and other places similar to those closed for ratproofing. Because mice can often enter any opening larger than 0.25 inch, it is frequently difficult to find all openings.

Use of Poisons

The same poisons used for rat control (with the exception of red squill) will give effective mouse control. To bait for mice, place many smaller baits rather than a few large baits because mice do not usually travel very far in search of food. Make it easy for a mouse to find your bait. Place cups of bait actually touching walls and the sides of other runways because bait placed several inches from a wall may be bypassed consistently. Be very careful to place bait near all openings where mice may enter the building and also next to all inside doorways that remain open. Be very careful to replace baits frequently because mice are not attracted to old, dirty bait. Tracking powder can be used in confined spaces where food material will not be contaminated.

Use of Traps

Trapping of all kinds, particularly with the automatic trap, is very desirable where baiting with poisons is hazardous. Traps should be placed within 10 feet of each other.

Bait for mouse traps must be carefully selected. Although it is frequently the choice of the housewife, cheese has no place in large mouse-control projects. Bacon, nuts, hard sugar candy, gumdrops, peanut butter, and small sardines are

usually the best baits. Solid baits should be tied firmly on the trigger. If mice are removed from traps as they are caught, it is quite possible to catch a dozen or more with the same trap without changing the bait.

Odor Control

It is desirable to remove dead mice for the same reasons given in the rat-control section. Frequently, however, carcasses are located in wall voids or other inaccessible places in buildings. If the dead rodents cannot be retrieved, the area should be ventilated as well as possible, and a masking agent should be applied. If a carcass is located in a wall void, a pint of water mixed with a masking agent can be poured or forced into the area, and the odor usually will be eliminated immediately. If the rodent cannot be precisely located, a masking-agent solution can be applied more generally to the affected area. In severe cases, it may be necessary to use a mist or ULV machine in the area. Repeated application may be necessary until the carcasses dry up. Several masking agents are available, including Neutroleum Alpha, isobornyl acetate, and Styamine 1622. Label directions should be followed closely.

FIELD MICE

To find food and shelter, field mice often invade homes, yards, and gardens in the winter. They can create a nuisance and damage ornamental trees and shrubs by root pruning and trunk or root girdling. Extensive damage may occur to orchards during periods of heavy snow cover. Because field mice move in from adjacent fields and brushy areas, they can usually be eliminated by mowing those areas closely. Mowing orchards or maintaining bare areas near the base of the trees helps to suppress populations. Field mice can also be controlled by wrapping tree trunks, by the proper use of wood-base snap traps and toxic baits labeled for such use, and by making structural modifications to exclude mice from buildings.

Field mice are especially damaging to no-till plantings of corn and other crops because they will follow the seed furrow and eat the seeds. The seeds can be treated with Mesurol, which will deter the mice for a few days. Mesurol detoxifies too quickly to be totally effective. The best control can be achieved by using a field-mouse bait (zinc phosphide) before planting. Only those areas showing high populations of mice, evidenced by their trails in the sod, need to be treated. Often only border areas of a field will be infested unless the seeding is into heavy sod. Bait from one to two weeks before planting. Baiting after planting is presently illegal, but efforts are being made to register zinc phosphide for placement in the seed furrow.