

Insecticides and Their Uses in Minnesota - 1968

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The status of several pesticides registered with USDA on a "No Residue" basis or with a zero residue tolerance is uncertain for the 1968 season. Eventually (by the end of 1970) all of these will either be registered with a finite residue tolerance or else the registration will be cancelled.

Users should be sure to check the current status of these materials before applying them in 1968. Information concerning cancelled registrations will be made available to county agents and will also be disseminated from basic manufacturers, formulators, and distributors.

Insecticides continue to be an essential part of insect control programs. Effective, safe, and economic insect control depends upon proper identification of the pest, a knowledge of its habits and biology, and an intelligent selection of the best combination of practices and chemicals available.

It is extremely important to store and use all pesticides properly to avoid injury to:

1. The person applying the chemicals;
2. Children and others who may come into contact with improperly stored chemicals or application equipment;
3. Treated crops or animals through overtreatment, through selection of the wrong formulation, or because of illegal chemical residues;
4. Adjacent crops and livestock because of drift;
5. Fish, wildlife, and other nontarget organisms in the treated area.

General Precautions for Using Pesticides

1. Always read the label before using sprays or dusts. Note warnings and cautions each time before opening the container.
2. Keep sprays and dusts out of reach of children, pets, and irresponsible people. Sprays and dusts should be stored outside of the home, away from food and feed, and under lock and key.
3. Always store sprays and dusts in original containers and keep them tightly closed. Never keep them in anything but the original container.
4. Never smoke or eat while spraying or dusting.
5. Avoid inhaling sprays or dusts. When directed on the label, wear protective clothing and masks.
6. Do not spill sprays or dusts on the skin or clothing. If they are spilled, remove contaminated clothing immediately and wash thoroughly.
7. Wash hands and face and change to clean clothing after spraying or dusting. Also wash clothing each day before reuse.
8. Cover food and water containers when treating around livestock or pet areas. Do not contaminate fish ponds.

9. Use separate equipment for applying hormone-type herbicides in order to avoid accidental injury to susceptible plants.
10. Always dispose of empty containers so that they create no hazard to humans, animals, or valuable plants.
11. Observe label directions and cautions to keep residues on edible portions of plants within the limits permitted by law.
12. If symptoms of illness occur during or shortly after spraying or dusting, call a physician or get the patient to a hospital immediately.

Provide for Safe Disposal of Empty Containers

For all empty containers of all types: Do not reuse the container. Completely empty the contents and bury the unused chemical at least 18 inches deep in an isolated location away from water supplies. *The best place to take empty containers of all kinds is a properly operated sanitary landfill dump maintained by a city or community. If such a dump is not available, the following procedures should be followed:*

Glass containers: Break the container and bury the pieces at least 18 inches deep in an isolated location away from water supplies.

Fiber and paper containers: Burn the empty containers completely. Exercise extreme caution and stay well away from the smoke.

Always read and follow the directions and precautions on the label of a pesticide container. Handle empty containers as carefully as those that are full.

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Safety Precautions and First Aid

Precautions when using toxic phosphates

Use natural rubber gloves to prevent absorption through the skin. Remove and wash contaminated absorbent clothing.

Avoid breathing any wettable powder dust or contacting an emulsion. If this is unavoidable, use a respirator specifically made for phosphates. A list of respirators can be obtained by writing to the Department of Entomology, Fisheries, and Wildlife; University of Minnesota; Institute of Agriculture; St. Paul, Minnesota 55101.

Phosphate-poisoning symptoms and antidotes

Many organic phosphate insecticides (TEPP, parathion, methyl parathion, tetraethyl dithiopyrophosphate, EPN, demeton, azinphosmethyl, mevinphos, phorate, disulfoton, and schradan) are hazardous to man during mixing operations and application. Contact with recently treated plants or surfaces may also be hazardous. Certain organic phosphates have been found which are considerably less toxic; malathion, dicapthon, coumaphos, and ronnel are much less toxic and diazinon, trichlorfon, and dioxathion are of intermediate toxicity.

All of the organic phosphates discussed, including the least toxic, produce similar symptoms in human beings. All require the same antidote. The symptoms may be produced by absorption through the skin, inhalation, or swallowing. Signs of poisoning include blurred vision (pinpoint pupils), abdominal cramps, tightness of the chest, digestive upsets, sweating and excessive salivation, restlessness, giddiness, headache, and twitching of the facial and eye muscles. *If any of these symptoms occur:*

1. Call physician immediately.
2. Remove contaminated clothing and wash skin thoroughly with soap and water.
3. If chemical has been swallowed, induce vomiting.
4. Keep patient quiet and warm.
5. Physician may administer atropine and/or 2-PAM as an antidote.

If you have had these symptoms from organic phosphorous compounds, do not handle the compounds again until your physician determines by a blood analysis that your condition is satisfactory. Persons who often use these compounds should have analyses of the blood made at regular intervals.

Chlorinated-hydrocarbon first aid

For *chlorinated hydrocarbons* (such as aldrin, BHC, chlordane, dieldrin, DDT, endrin, heptachlor, lindane, methoxychlor, toxaphene, endosulfan):

1. If chemical has been swallowed, call physician immediately. If patient is conscious, induce

vomiting with warm, salty water. Continue until vomit fluid is clear.

2. If chemical has been spilled on the skin or clothing, remove clothing and wash skin thoroughly with soap and water. *Do not use kerosene, gasoline, or other solvents.*
3. Keep patient quiet and warm.
4. Physician may administer sedatives such as phenobarbital or other barbiturates to keep patient calm or to control convulsions.

Minnesota poison information centers

These centers have been established by the Minnesota Department of Health to provide physicians with information about pesticides and common household poisons, their antidotes, and treatments. Most of these centers operate on a 24-hour basis.

City	Address	Telephone
Bemidji	Bemidji Hospital	751-5430
Brainerd	St. Joseph's Hospital	2861
Crookston	Bethesda Hospital St. Francis Hospital	281-4682 281-2490
Duluth	St. Lukes Hospital 915 E. 1st Street	727-6636
Fergus Falls	Lake Region Hospital	736-5475 Night: 736-3255
Mankato	Immanuel Hospital	628-1605
Marshall	Lewis Weiner Memorial Hospital	532-2263
Minneapolis	Division of Special Health Services State Health Dept. Abbott Hospital 110 E. 18th Street Fairview Hospital 2312 S. 6th Street Hennepin County General Hospital 619 S. 5th Street North Memorial Hospital 3220 Lowry Ave. N. Northwestern Hospital 810 E. 27th Street	339-7751 Night: 339-1411 339-8414 Extension 226 332-0282 Extension 331 330-3930 588-9451 332-7266
Moorhead	St. Lukes Hospital (Fargo)	235-3161
Morris	Stevens County Memorial Hospital	1191
Rochester	St. Mary's Hospital	282-4425 Extension 591
St. Cloud	St. Cloud Hospital	251-2700

St. Paul	Ramsey County Hospital	222-0353	
	Bethesda Hospital	227-8611	
	559 Capitol Blvd.		
	St. John's Hospital	776-8595	
	403 Maria Avenue	Extension	531
	St. Joseph's Hospital	222-2861	
Virginia	69 W. Exchange		
	St. Luke's Hospital	222-6644	
	300 Pleasant Avenue		
	Children's Hospital	227-6521	
Willmar	311 Pleasant Avenue		
	Virginia Municipal Hospital	741-3340	
Worthington	Rice Memorial Hospital	235-4543	
	Worthington Memorial Municipal Hospital	376-4141	
		Night: 376-4142	

Regulations on Sale and Uses

The sale and uses of insecticides are regulated by two federal acts and by corresponding state laws. The federal regulations cover the interstate phases of insecticide labeling and sales and the interstate movement of treated foods or agricultural products. The state laws cover these areas within the state.

The federal acts are the Federal Insecticide, Fungicide, and Rodenticide Act, with amendments, and the Food, Drug, and Cosmetic Act as amended. The Insecticide, Fungicide, and Rodenticide Act is administered by the USDA. It provides that all pesticides sold in interstate commerce be approved and labeled according to the Act's provisions.

The Food, Drug, and Cosmetic Act, with amendments, is administered by the Food and Drug Administration. It provides for the establishment of tolerances for pesticides in or on agricultural commodities. This means that the applications of chemicals to crops and livestock must be done in such a way that their residues left in or on the commodities are within the established tolerances. This can be done by following *to the letter* suggestions as to dosage, time of application, crops or livestock to be treated, waiting periods between treatment and harvest, and other limitations stated in current recommendations and on current labels.

Forms of Insecticides

1. **Dusts** are dry powders ready for immediate use. They may contain $\frac{1}{2}$, 1, 2, 3, 4, 5, 10, or 20 percent of the actual chemical. The rest of the dust is a carrier, such as talc or pyrophyllite. Combination dusts with two or more insecticides or fungicides are available.

Dusts should not be used in sprayers because they do not mix properly with water or oil.

2. **Wettable powders** are dry powders which may be mixed with water to make sprays. Formulations containing 15, 25, 40, 50, 75, and 80 percent of the actual ingredient are available. These powders contain a carrier plus a wetting agent which permits them to form suspensions when mixed with water. This formulation is useful on vegetation because it does not injure foliage as readily as do emulsions or oil solutions. High-volume hydraulic sprayers with mechanical agitators are best suited for handling wettable powders.

3. **Soluble powders.** Only a few organic insecticides, made of newer materials, dissolve in water. Powders of these chemicals are called soluble powders. They may be mixed with water in the same way as wettable powders and used in the same type of sprayers that handle solutions or emulsions.

4. **Emulsifiable concentrates** are liquids which contain the insecticide dissolved in a suitable solvent and an emulsifier. This permits the concentrate to mix with water to form an emulsion. These concentrates may contain many different amounts of the active ingredient, but the label will give this information plus the weight of active chemical per gallon. For example: 25-percent DDT emulsifiable concentrate contains 2 pounds actual DDT per gallon; 18.5-percent dieldrin emulsifiable concentrate contains $1\frac{1}{2}$ pounds actual dieldrin per gallon; 57-percent malathion emulsifiable concentrate contains 5 pounds actual malathion per gallon, etc. Emulsions may be used in low-pressure low volume sprayers without mechanical agitation. Be sure the use on plants is specifically recommended or included on the label as emulsions damage some types of foliage. Some insecticides are available as "flowable" formulations; these may be handled in about the same way as emulsions.

5. **Oil solutions** are solutions, generally ready to use, of the insecticide in a suitable solvent and an oil carrier. Ready-to-use solutions usually contain from $\frac{1}{2}$ to 10 percent active ingredients. Some solution concentrates are available for further dilution with oil or to form oil sprays such as those used by aerial spray equipment, foggers, and mist blowers. Oil solutions should not be used on plants or animals except for special uses with special formulations, such as certain fly sprays on cattle.

6. **Granules** are ready-to-use preparations of the insecticide in or on particles of a carrier, such as attaclay or bentonite. The particles are usually from 25 to 60 mesh in size or from the consistency of granulated sugar to that of coffee grounds. Granules are particularly useful for controlling soil insects because they sift down through foliage and last longer than other formulations. The granules are also effective for corn borer control because they roll down into the whorl of the plant. They may be applied with

fertilizer spreaders, seeders, or special granule applicators, ground or aerial.

7. **Aerosol and spray bombs** contain one or more insecticides, an oil solvent, and a propellant gas. These bombs produce a very fine mist (an "aerosol") or a coarse spray, depending on the purpose of the bomb. The fine mist aerosols are for the control of flying insects, such as flies and mosquitoes, in a closed room. The coarser spray bombs are used to apply a residual deposit of insecticide. You may use some spray bombs on certain plants, but check the labels carefully beforehand. Large aerosol cylinders are available for use in greenhouses, warehouses, etc.

8. **Miscellaneous.** In addition to the main insecticides, there are a number of special types. Baits, insecticide-fertilizer mixtures, insecticide-herbicide mixtures, mothproofing agents, etc. should be used according to recommendations and label directions.

Calculating Dosage and Rates of Application

Most recommendations are given in terms of amount of actual insecticide per acre, percent active ingredient in the finished spray, or as recipes using a given formulation in 1, 5, 25, or 100 gallons of water. The following formulas and tables will help you calculate proper dosages. This is extremely important in order to avoid waste, excessive residues, or injury to treated plants or animals.

1. To figure amount of emulsifiable concentrate needed for a required amount of actual chemical to be mixed in a spray tank:

$$\frac{\text{Acres to be sprayed per tank} \times \text{pounds actual needed per acre}}{\text{Pounds actual per gallon in concentrate used}}$$

Example:

How many gallons of 25-percent DDT emulsifiable concentrate (2 pounds per gallon) are needed to give $\frac{3}{4}$ pound actual DDT per acre, using a sprayer with a 50-gallon tank applying 10 gallons per acre (5 acres per tank)?

$$\frac{5 \times 0.75}{2} = 1.87 \text{ gallons of 25-percent DDT in 50-gallon tank}$$

2. To figure amount of wettable powder needed for a certain amount of actual chemical per acre:

$$\frac{\text{Acres per tank} \times \text{pounds actual needed per acre}}{\text{Pounds actual chemical per pound of powder used}}$$

Example:

How many pounds of 50-percent DDT wettable powder are needed to apply $\frac{3}{4}$ pound actual DDT per acre, using a sprayer with a 50-gallon tank applying 10 gallons per acre (5 acres per tank)?

$$\frac{5 \times 0.75}{0.5} = 7.5 \text{ pounds of 50-percent DDT in 50 gallons of water}$$

3. To figure amount of wettable powder needed to mix a spray containing a given percent of actual toxicant:

$$\frac{\text{Gallons of spray wanted} \times \text{percent actual toxicant wanted} \times 8}{\text{Percent active ingredient in powder used}}$$

Example:

How many pounds of 25-percent malathion wettable powder are needed to make 100 gallons of a 1-percent malathion spray?

$$\frac{100 \times 1 \times 8}{25} = 32 \text{ pounds}$$

4. To figure the percent actual toxicant in a spray mixture:

$$\frac{\text{Pounds of insecticide used} \times \text{percent active ingredient}}{\text{Gallons of spray} \times 8}$$

Example:

What percent DDT is in a spray in which 8 pounds of 50-percent DDT powder were used in 100 gallons of water?

$$\frac{8 \times 50}{100 \times 8} = 0.5 \text{ percent}$$

5. To figure the gallons of emulsifiable concentrate needed to mix a spray containing a given percent of active ingredient:

$$\frac{\text{Gallons wanted} \times \text{percent active ingredient wanted} \times 8}{\text{Pounds active ingredient per gallon of insecticide} \times 100}$$

Example:

How much 25-percent DDT emulsion concentrate (2 pounds per gallon) is needed to make 50 gallons of an 0.25-percent DDT spray?

$$\frac{50 \times 0.25 \times 8}{2 \times 100} = 0.5 \text{ gallon}$$

6. For small jobs, it is often necessary to figure how much insecticide to use for 1 gallon of spray. If the recommendation is given in terms of 100 gallons, use the following formulas for 1 gallon.

With wettable powder:

1 level tablespoon per gallon of water = approximately 1 pound per 100 gallons of water.

With emulsion:

1 teaspoon per gallon of water = approximately 1 pint per 100 gallons of water.

Table of equivalents

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

1 gallon (United States) = 0.83 (approximately 4/5)
 gallon (British or Imperial)
 1 gallon (British or Imperial) = 1.2 gallons (United States)
 1 gallon water (United States) weighs 8.345 pounds

1 pound = 16 ounces or 453.59 grams
 1 gram = 0.0353 ounce
 1 ounce = 28.3 grams
 1 kilogram = 35.27 ounces or 2.2 pounds
 1 milligram per kilogram = 1 part per million

Dilution table—emulsifiable concentrates

Actual chemical per gallon of concentrate used	Desired pounds per acre of actual chemical						
	0.125 lb. (2 oz.)	0.25 lb. (4 oz.)	0.50 lb. (8 oz.)	0.75 lb. (12 oz.)	1 lb.	2 lb.	3 lb.
pounds	pints of emulsion concentrate to apply per acre						
1	1.0	2.0	4.0	6.0	8.0	16.0	24.0
1½	0.67	1.3	2.6	4.0	5.3	10.6	16.0
2	0.50	1.0	2.0	3.0	4.0	8.0	12.0
3	0.34	0.67	1.3	2.0	2.7	5.4	8.0
4	0.25	0.50	1.0	1.5	2.0	4.0	6.0
5	0.20	0.40	0.80	1.2	1.6	3.2	4.8
6	0.17	0.34	0.67	1.0	1.3	2.6	4.0
7	0.14	0.30	0.60	0.90	1.1	2.3	3.4
8	0.125	0.25	0.50	0.75	1.0	2.0	3.0

Dilution table—wettable powders (for sprays)

Percent wettable powder used	Desired pounds per acre of actual chemical							
	0.125 lb. (2 oz.)	0.25 lb. (4 oz.)	0.50 lb. (8 oz.)	0.75 lb. (12 oz.)	1 lb.	2 lb.	3 lb.	4 lb.
	amount of wettable powder to use per acre							
15	13 oz.	1¾ lb.	3 lb., 5 oz.	5 lb.	6½ lb.	13 lb.	20 lb.	26½ lb.
25	8 oz.	1 lb.	2 lb.	3 lb.	4 lb.	8 lb.	12 lb.	16 lb.
40	5 oz.	10 oz.	1¼ lb.	1¾ lb.	2½ lb.	5 lb.	7½ lb.	10 lb.
50	4 oz.	8 oz.	1 lb.	1½ lb.	2 lb.	4 lb.	6 lb.	8 lb.
75	3 oz.	6 oz.	12 oz.	1 lb.	1 lb., 5 oz.	2 lb., 11 oz.	4 lb.	5 lb., 3 oz.

Description of Insecticides

Chlorinated Hydrocarbons

Aldrin is available in emulsions, wettable powders, and granule formulations of from 2 to 20 percent. It is used to control soil-infesting insects. It has a shorter residual action than dieldrin, but a small percentage of the chemical converts to dieldrin on foliage and in soils containing numbers of micro-organisms. Aldrin is of moderate toxicity, and persistence in animal tissues is chiefly associated with the formation of dieldrin. Such persistence has led to recent problems with residues in certain crops.

Bandane, a new chlorinated hydrocarbon, is registered only for application to lawn or turf. It controls ants and white grubs when used at the same rate as recommended for crabgrass control. Chemically it

contains several related compounds (isomers) of polychlorodicyclopentadiene. It must not be used where it might contaminate streams, lakes, or ponds. Children and pets are to be kept off treated areas until bandane is washed into the soil.

Chlordane is available in all common formulations, including dust and granules. However, commercial fertilizer-insecticide mixes are not common.

Chlordane is effective against such field pests as grasshoppers, cutworms, ants, and many soil insects. Dosages used are higher than for aldrin, dieldrin, or heptachlor. Solutions of chlordane may be used for spot treatments against household pests, such as roaches, silverfish, carpet beetles, and clothes moths. Proper household applications of chlordane are limited to coarse sprays applied to baseboards, closets, and similar areas where there might be crawling insects.

Dilution table—to obtain a finished spray containing a desired concentration of actual chemical (approximate)

Formulation to use in 100 gallons of water	Desired concentration of finished spray, percent									
	0.01	0.03	0.06	0.1	0.25	0.5	1.0	2.5	5.0	
Wettable powders (percent)										
15	½ lb.	1½ lb.	3 lb.	5½ lb.	13½ lb.	27 lb.	54 lb.			
25	⅓ lb.	1 lb.	2 lb.	3 lb.	8 lb.	16 lb.	32 lb.			
40	1/5 lb.	¾ lb.	1½ lb.	2 lb.	5 lb.	10 lb.	20 lb.			
50	1/10 lb. (1½ oz.)	½ lb.	1 lb.	1½ lb.	4 lb.	8 lb.	16 lb.	40 lb.		
75	1/6 lb. (2½ oz.)	⅓ lb.	¾ lb.	1 lb.	2½ lb.	5 lb.	10 lb.	25 lb.	50 lb.	
Emulsifiable concentrate (pounds per gallon)										
1	1⅓ cup	1 qt.	2 qt.	3 qt.	2 gal.	4 gal.	8 gal.	20 gal.	40 gal.	
1½	¾ pt.	1½ pt.	3 pt.	½ gal.	1⅓ gal.	2⅔ gal.	5 gal.	13½ gal.	27 gal.	
2	¾ cup	1 pt.	2 pt.	3 pt.	1 gal.	2 gal.	4 gal.	10 gal.	20 gal.	
4	½ cup	½ pt.	1 pt.	1½ pt.	½ gal.	1 gal.	2 gal.	5 gal.	10 gal.	
5	2 fluid oz.	6 fluid oz.	¾ pt.	2⅔ cups	3 pt.	3 qt.	1¾ gal.	4 gal.	8 gal.	
6	1¾ fluid oz.	¾ cup	1½ cups	1 pt.	2⅔ pt.	5 pt.	1½ gal.	3¾ gal.	6¾ gal.	
8	1 fluid oz.	¼ pt.	½ pt.	¾ pt.	1 qt.	½ gal.	1 gal.	2½ gal.	5 gal.	

It is not recommended for indoor fogging. Chlordane is of moderate to low acute toxicity.

DDT is available in all of the previously mentioned forms except the fertilizer-insecticide mixture. It is sold as a dust, a 50- or 75-percent wettable powder, an emulsion concentrate, an oil solution, and in aerosol bomb form usually combined with pyrethrum or the synthetic counterpart, allethrin.

Although DDT is still widely used, it is not effective on grasshoppers, crickets, most plant- and animal-feeding mites, certain aphids (such as the cabbage aphid), most ants, the plum curculio, German and Oriental cockroaches, resistant houseflies, and Colorado potato beetles. Recommended concentrations of DDT wettable powders and dusts may be used safely on any plants except most cucurbits (certain varieties of squash, melons, and cucumbers). Here DDT may be used only with careful uniform dusting or with low concentrations of sprays or dusts. Tomatoes are also somewhat sensitive. Methoxychlor is safer on these crops.

With ordinary handling precautions, DDT is not hazardous during preparation and application. It is classed as a moderately toxic chemical based upon acute toxicity data.

DDT concentrates and accumulates in fatty animal tissues and in butterfat of milk. Therefore, it is inadvisable to apply DDT in any form on dairy cattle or in dairy barns. DDT can also get in milk if cows eat crops such as corn and alfalfa which have been sprayed with DDT. This chemical decomposes much more rapidly outdoors than indoors, but may last over

30 days outdoors under many environmental conditions.

Antiresistant DDT is a sulfonamide compound sometimes referred to as WARF Antiresistant DDT. The compound has no practical insecticidal properties of its own, but when combined with DDT provides effective control of DDT-resistant houseflies. A commonly used ratio is 1 part of Antiresistant DDT to 5 parts of DDT, although a 1:1 ratio has also been used effectively. Such a spray combination can be used only in situations where DDT is approved (this eliminates use in dairy barns).

Dieldrin differs chemically from aldrin in having an epoxy (oxygen-containing portion) group and in being more stable. It is available in all common forms, including oil solutions for household use, but is more costly than aldrin. It is effective against soil-infesting insects, grasshoppers, plum curculios, thrips, and other insect pests. Dieldrin is approved for control of many household insect pests but has been withdrawn for use on many crops because of residue problems.

Dieldrin is of moderately acute toxicity. Although more toxic than DDT, it persists in lipids somewhat similarly to DDT.

Endrin is a chemical isomer of dieldrin. It is primarily available in emulsion and granule forms. Although very effective against a wide range of insects, endrin is especially good against leaf-feeding caterpillars. It is also effective against some leafhoppers and plant bugs, and is better than most chlorinated hydrocarbons (except endosulfan) against aphids. Endrin has rather high acute toxicity and must be

handled carefully. Chemically it is somewhat less stable than dieldrin when used in certain environmental conditions.

Heptachlor is a close chemical relative of chlordane. It is available in emulsion, wettable powders, and granule formulations. Heptachlor controls most soil-infesting insects. Doses used are lower than chlordane and are comparable with aldrin. Heptachlor converts to a persistent form known as heptachlor epoxide. Because of persistent residues, restrictions must be followed.

Kepone is a persistent chlorinated hydrocarbon insecticide which has been effectively used in bait form for imported fire ants (southern states only) and for German roaches. It has shown effectiveness against some wireworms when used in a corn meal bait. It has intermediate mammalian toxicity.

Lindane and benzene hexachloride are more poisonous to warm-blooded animals in a single dose than DDT. Lindane, however, is in the moderately toxic class and does not accumulate and persist in body tissues for a long time. Nevertheless, small amounts of lindane will appear in milk from dairy cows fed on treated forage or animals sprayed directly.

For most purposes, lindane is preferable to benzene hexachloride. Lindane contains at least 99 percent of the *gamma* isomer of benzene hexachloride. This is the most toxic of the BHC isomers to insects and certain mites. In addition, lindane does not have the taste or odor problem characteristic of benzene hexachloride.

Methoxychlor is a good replacement for controlling many insects where the use of DDT would be hazardous to animals, humans, or susceptible plants. It is a compound of low toxicity. Although sprays are not recommended on milking cows because small quantities appear in the milk, wettable powders can be rubbed into cows' hair for fly control.

Methoxychlor is safer to use on cucurbits and tomatoes than DDT and many other insecticides. Except for the plum curculio, it is ineffective against Minnesota insects that are difficult to control with DDT, including DDT-resistant flies. Methoxychlor should replace DDT on the parts of vegetables that are to be eaten. Nevertheless, as with all insecticides, the day-interval indicated for each insect problem must be observed. Methoxychlor is available in all the common formulations.

Mirex is a chlorinated hydrocarbon very closely related to Kepone. The compound does not contain the ketone grouping of Kepone. It is of low mammalian and bird toxicity in the form in which it is used. At present its effective use appears to be in bait form for ant control with safety to game animals. No uses on crops have been approved.

Perthane is a compound of low toxicity, similar to methoxychlor. Emulsions and wettable powders are

used in agriculture, although approved uses are rather limited. It is sometimes used in combination with parathion for cabbageworm control. Oil solutions and preparations in aerosol bombs are useful to control the clothes moth, carpet beetle, and other household insects. The compound is one of the most recent DDT relatives to become commercially available.

TDE (or DDD) is low in acute toxicity to warm-blooded animals. Cumulative amounts occur similar to DDT. Emulsions and wettable powder are available. It is useful against the red-banded leaf roller in apple sprays and is effective against tomato hornworms and fruitworms on tomatoes. Other usages are rather limited. As with methoxychlor, TDE is not very effective on species which have developed resistance to DDT.

Telodrin is a chlorinated hydrocarbon of medium persistence. At present, although it is effective against a number of lepidopteran larvae and certain beetles, its use on crops is not permitted. It is included with highly toxic compounds. Mammalian toxicity is nearly that of endrin. Telodrin is ineffective against mites.

Endosulfan (Thiodan) is a sulfur-containing chlorinated hydrocarbon. Prepared formulations include a miscible formulation, a wettable powder, dusts, and granular dusts. It has approval for use on some potato insects, including aphids. It is also effective on plant bugs present on vegetables and forage crops, and on the sugar beet webworm. Effectiveness on cyclamen mites makes it a potential greenhouse pesticide. Close to DDT in acute toxicity, it is of moderate toxicity to warm-blooded animals.

Toxaphene is a mixture of chlorinated camphene products. It is most commonly used in the emulsion forms. Dusts and 6- and 8-pound per gallon concentrates are also available. Toxaphene is effective against grasshoppers, plant bugs, cutworms, armyworms, and other insects. It has a fairly long residual effect, so the day-interval period should be carefully checked.

Organic phosphates

Abate is an organophosphate that is highly effective against mosquito larvae. It has a very low mammalian toxicity and presents little hazard to fish and birds. Abate is available in several granular formulations and as an emulsifiable concentrate containing 4 pounds actual toxicant per gallon.

Azodrin is a systemic dimethyl phosphate that has been used effectively on cotton insects. It is highly toxic and is available as an emulsifiable concentrate containing 5 pounds actual toxicant per gallon.

Bomyl is a dimethyl vinyl phosphate that contains no chlorine. It is quick acting, producing a rapid knockdown and death of flies that may be resistant to other insecticides. It is recommended as a dry sugar bait in dairy barns and poultry houses. It will be effective for a relatively long time in dry, sheltered

areas where lime is not present. The nonformulated product is toxic to warm-blooded animals, but in bait form there is little hazard.

Butonate is an organophosphate which is low in toxicity to warm-blooded animals. The compound has not had extensive use but is promising for household pests such as flies, mosquitoes, roaches, and silverfish. Formulations have been prepared for use as liquid sprays or as aerosols. Some aerosol combinations have been prepared with synergized pyrethrins.

Ciodrin is a thiophosphate with low mammalian toxicity. The compound has been given approval for biting fly control on dairy cows. The compound is not considered to be a systemic insecticide. It persists as an effective material longer than other insecticides used for this purpose. It is slower in action than some phosphates, such as DDVP, but for certain purposes, such as face fly control, may be combined with DDVP.

Co-Ral is listed under animal systemics, page 12.

Compound 4072 is a chlorinated organophosphate (diethyl-1-(2, 4-dichlorophenyl)-2-chlorovinyl phosphate) that has shown a rather broad spectrum of activity. It is promising as a residual fly spray in barns.

Dichlorvos (DDVP or Vapona) is a highly active compound that gives rapid knockdown and kill of flies. It is principally available as a liquid bait formulation for housefly and specialized roach control. A lower concentration has been approved for face fly control on cattle. The compound is not very stable and is short lived in its effect. DDVP is moderately toxic to warm-blooded animals. It is frequently combined with Ciodrin for fly control.

Dioxathion (Delnav) is an organic dithiophosphate with good persistent properties. It is a mixture of two chemical isomers available chiefly as 30- and 47-percent emulsion concentrates. Delnav is of moderate toxicity to warm-blooded animals; the toxicity is in the same general range as for diazinon and lindane. It is effective against a number of insects and currently is recommended for sheep ked, lice, hornflies, and ticks on livestock. Delnav has been approved for use as a dip or spray for nonmilking cattle, sheep, goats, and hogs. The biological activity is primarily as a contact or stomach poison, with very little fumigant activity at moderate temperatures.

Demeton is listed under plant systemics, page 12.

Diazinon is one of the more persistent phosphates showing rather broad application possibilities. This organic thiophosphate is valuable against a number of fruit pests, including mites, useful against a number of vegetable and forage crop pests, and widely used in housefly and corn rootworm control. It is of moderate toxicity to warm-blooded animals. It is available in 4-pound-per-gallon emulsions, a 50-percent wettable powder, and 14-percent granules.

Fenthion (Baytex or Entex or Tiguvon) is a phenylated organic thiophosphate having a broad spectrum of activity and moderately high stability. It is highly toxic to mosquitoes, can be used as a residual spray for houseflies, and will be used on a number of fruit and vegetable insects. Emulsions containing 4 pounds of active ingredient per gallon and 25 percent wettable powders are available. Used as Entex, this insecticide is used by pest control operators at a 3-percent concentration in an oil base. It is effective against many household pests. The compound has moderately high toxicity to warm-blooded animals; its acute toxicity is somewhat less than that of DDT.

Naled (Dibrom) is a bromine, chlorine-containing organic phosphate with a rapid effect as a contact insecticide. It has slight vapor toxicity and a short residual life. The compound has low mammalian toxicity. Emulsion concentrates (4 and 8 pounds per gallon) and dusts are available. Recommendations for control of various vegetable insects include a short day interval between application and harvest. Dibrom baits and sprays are used for fly control in dairy barns and poultry houses.

Dicaphthon has appeared valuable for control of DDT-resistant houseflies and chlordane-resistant German roaches. It has been prepared in emulsion concentrates and wettable powders. It appears to have some potential use for household pests, but staining properties have delayed its advancement. Its uses on crop insects are still being studied. The compound has low acute toxicity.

Dimethoate (Cygon) is a moderately toxic phosphate which shows some systemic activity in both plants and animals. It is registered for housefly control where resistance to DDT, malathion, and diazinon exists. It is sold as a concentrate containing 2.67 pounds active ingredient per gallon and as a 25-percent wettable powder. The acute oral toxicity to rats is in the moderate range and dermal toxicity is lower. It is effective against aphids on ornamentals and certain food crops.

Trichlorfon (or Dipterex or Dylox or Neguvon) is a chlorinated water-soluble phosphate available under the name Dipterex for applications in barns for housefly control. The granular form is commonly available. This product is also effective on chlordane-resistant German roaches. The name Dylox is used for formulations, such as 50-percent soluble powder and 5-percent dusts, for some agricultural pests, particularly webworms and chinch bugs. This chemical is about one-half as toxic as DDT to warm-blooded animals, with no indication of accumulation or storage in tissues. Neguvon will be formulated in several ways for ectoparasites and endoparasites of cattle and small animals.

Dasanit (Bay 25141) is a promising new phosphate soil insecticide and nematocide. It performs well

against corn rootworms. It is formulated as 10 percent granules and as a spray concentrate.

Dursban is a new pyridyl phosphate that appears to be effective against a wide range of insects. It has been tested extensively against mosquitoes. Dursban is moderately toxic with an acute oral LD/50 of 135 mg/kg to rats, is somewhat irritating to the eyes, but is not readily absorbed through the skin.

Dyfonate (N2790) is an ethylphosphoro dithioate that has performed well against soil insects and is presently registered for corn rootworm control. The oral mammalian toxicity is quite high (LD-50 = 7.94 mg/kg to white rats). It is available as 5 and 10 percent granules and as a 4-pound-per-gallon emulsifiable concentrate.

Disulfoton (Di-Syston) is listed under plant systemics, page 13.

EPN is very effective in controlling most plant-feeding mites, except the clover mite. A wettable powder containing 25 percent EPN is available. It is approved for use on European corn borer, and is also used in place of parathion on some insects. Although EPN is effective on plum curculio, dieldrin is usually recommended for this pest. It is about one-eighth as toxic as parathion but still classed as highly toxic.

Ethion is the common name of an organic thiophosphate which appears particularly promising for control of several fruit pests. It has been used on rosy apple aphids, bud moths, several mites, onion maggots, and scale insects. Some effective uses have included combinations with dormant oils on fruit trees and woody ornamentals. Ethion is prepared as a 25-percent wettable powder and in two types of 4-pound per gallon emulsifiables (one for usual use and the other for combining with spray oils). A 4-percent dust and granules are also available. Ethion has a rather long residual effect for a phosphate without any marked systemic activity. The compound is moderately toxic to warm-blooded animals.

Azinphosmethyl (Guthion) is a dithiophosphate with a persistent insecticidal effect. It is sold as a 1½-pound per gallon emulsion, a 25-percent wettable powder, and as a 3-percent dust. It must be handled with considerable care during mixing and spraying as it is of high acute toxicity to warm-blooded animals. It has been approved for use on several fruit and vegetable pests. It is also used on cotton and potato pests, particularly where the cotton boll weevil is resistant to chlorinated hydrocarbons. A closely related compound, azinphosethyl, is available.

Gardona (Rabon) is a vinyl phosphate with a low mammalian toxicity that has shown promise for the control of houseflies and some lepidopterous larvae such as corn carworm. Gardona is not registered for commercial uses at this time.

Malathion is an organic thiophosphate chiefly available as a 4- or 5-pound per gallon emulsion concentrate, a 25-percent wettable powder, and a 4-percent dust. Granules are not common but can be obtained. It is very useful on most aphid, mite, and scale problems on plants. Previously parathion would have been used routinely for these pests except for the hazard involved. Malathion is useful for small gardeners and is valuable for use in ground sprayers and dusters where more hazardous materials could not be used. It is approved as a grain protectant. The advantages include fairly rapid deterioration on crops so that short waiting periods are possible.

Malathion shows a fast and effective kill on DDT-resistant strains of houseflies, although some areas in the United States report some resistance of houseflies to malathion. The lasting period of effectiveness varies from about 1 to 2 weeks, depending on the mixture used and the environmental influences on the insecticide after it has been sprayed. It is of very low mammalian toxicity. It may also be applied undiluted to crops by aircraft as an ultra low volume concentrate.

Phorate is listed under plant systemics, page 13.

Mevinphos (Phosdrin) is a very toxic phosphate containing two chemical isomers. It is a strong contact toxin, but is translocated in growing plants. It gives quick initial kill of sucking insects and several larvae, including cabbage loopers and red-banded leaf rollers. It is usually applied as a foliage spray. Comparatively short waiting periods are required between application and harvest because mevinphos deteriorates quickly. It must be handled with care because of its high toxicity.

Phosphamidon (Dimecron) is a chlorinated organophosphate that produces rapid kill to many insects by contact. However, it has plant systemic activity which provides some residual effect to sucking insects. The compound deteriorates rapidly. Phosphamidon has rather high toxicity to mammals. A 4-pound per gallon spray concentrate is miscible with water. Recommendations for use include aphids, mites, and scale insects on fruit; aphids on peas and sugar beets; several potato insects; and certain pests of ornamentals.

Rommel is listed under animal systemics, page 12.

Methyl Parathion is the methyl homologue of parathion and is less hazardous than parathion. It is sold chiefly as a 25-percent emulsion concentrate. It is approved for use against many aphids and other plant-feeding insects. It is also used for cotton boll weevils which may be resistant to chlorinated hydrocarbons. It is of high toxicity.

Parathion is an organic thiophosphate which is highly effective against insects and mites. It is available as a 2-pound (25-percent) or 8-pound per gallon emulsion concentrate, or as a 15- or 25-percent wettable powder. Dusts of 1 or 2 percent and 10-percent

granules may also be obtained. The lasting effect against insects is generally a matter of a few days, usually shorter than with most of the chlorinated hydrocarbon insecticides. It is very hazardous to human beings, particularly during mixing and spraying operations or when the chemical has recently been applied to a crop. To minimize the hazard, most applications should be made by qualified aerial spray operators.

The hazards in using parathion can scarcely be overemphasized. Read carefully what precautions to take to prevent phosphate poisoning and the symptoms which can result from it. Parathion should not be used by home gardeners!

Schradan is listed under plant systemics, page 13.

Tetraethyl pyrophosphate (TEPP) is sold for direct dilution in water. A wetting agent is necessary, but most products have this in the solution to be diluted. Most of the products contain 20 or 40 percent TEPP. Large aerosol bombs containing TEPP are also available for insect and mite control in greenhouses.

TEPP, although extremely toxic, decomposes rapidly in the presence of moisture or when mixed as a water spray. It must be used promptly after mixing because most of its effectiveness is lost in 4 to 6 hours. Thus, it becomes harmless on the plant after a day or two.

Tetraethyl dithiopyrophosphate is closely related to TEPP, but is more stable and a little safer on plants. Although slightly less hazardous, it requires the same precautions. It is prepared in bomb form for greenhouse use only.

Carbophenothion (Trithion) is a monochlorinated thiophosphate compound that has shown great effectiveness against aphids and most plant-feeding mites. Current recommendations are on fruit pests, onion maggot, and other soil insects.

Formulations include a 25-percent wettable powder, a 4-pound per gallon emulsifiable (flowable) concentrate, granules, and a 2- or 3-percent dust. A 4-pound per gallon formulation for use only in oil sprays especially for scale insects or aphids is also available. Trithion is not systemic in activity, but has a long residual for a phosphate compound. It is of moderate toxicity when ingested, but of low toxicity by skin absorption.

VC-13 is a chlorinated organic thiophosphate with insecticidal and nematocidal properties. One approved use is as a soil insecticide for control of onion maggots.

VC-13 is available as an emulsifiable product and as granules. The compound has moderately low acute toxicity, in about the same range as DDT. It is relatively stable, except under alkaline conditions.

Animal systemics

Coumaphos (Co-Ral) is an animal systemic which controls cattle grubs and lice. It is a thiophosphate

with a coumarin ring structure. Wettable-powder or emulsion formulations are sprayed directly on the animals or used as "pour-on" treatments. Approval for use on nonmilking cattle has been given, and hornfly and screwworm recommendations have been completed. Co-Ral dusts are also available for use on poultry mites and lice. Late fall applications are most effective for grub control.

Dimethoate is listed under organic phosphates, page 10.

Famophos is a thiophosphate compound which has shown systemic effectiveness in cattle against cattle grubs and screwworms. Its commercial use in cattle has not yet been approved.

Ronnel (Korlan, Trolene), a chlorinated organic thiophosphate, is sold as Korlan for control of houseflies, roaches, fleas, bedbugs, cattle lice, and other pests. Formulations include 12- and 24-percent emulsion concentrates, a 25-percent wettable powder, and a pressurized livestock bomb. A purified product is used as an animal systemic in which treated feeds are given to cattle, particularly for cattle grub control. Ronnel has low mammalian toxicity.

Ruelene has been developed as an important animal systemic of rather broad parasiticidal activity. Both external application of it to cattle and as a medicated feed treatment have largely accomplished the control of cattle grubs. A "pour on" method has been as effective as spraying with high pressure equipment. However, such an external treatment appears inadequate to control cattle roundworms. Drench treatments (oral) have been effective in cattle, goats, and sheep.

Emulsions for spraying, oil solutions for the "pour on" method, and liquid concentrates for drenching animals are available. Dosages used are approximately one-tenth that which might cause serious illness or death. Mammalian toxicity is low.

Plant systemics

Bidrin is a vinyl phosphate (formerly SD 3562) with contact and systemic properties. It is approved as a foliage spray on certain cotton insects and as an injection treatment for the control of elm bark beetles to prevent Dutch elm disease. The material is quite toxic and must be handled with care. Only qualified operators are permitted to apply it to elm trees.

Demeton (Systox) contains two thiophosphate isomers which are extremely active as contact, fumigant, and stomach poisons and have a pronounced systemic action within a plant. Most sucking insects can be controlled with demeton. It is a highly toxic phosphate and must be handled with great care. Demeton is chiefly sold as an emulsifiable concentrate. Most applications are made by foliage treatment. Pests of ornamentals and of certain vegetables and fruits are included in control recommendations.

Disulfoton (Di-Syston) is an organic thiophosphate insecticide, closely related to phorate. Principal recommendations include soil treatment, especially on potatoes, alfalfa, and on corn for resistant rootworms. Seedlings are protected from sucking insects and mites for several weeks. Disulfoton is supplied in 5- and 10-percent granular formulations. It is highly toxic.

Phorate (Thimet) is a fairly close chemical relative of demeton and is very similar to Di-Syston. It is used to greatest advantage as a seed treatment for cotton, alfalfa, and sugar beets. It may also be used in the soil for protection of potatoes and for rootworm control in corn. These treatments protect the plants against early season insect and mite attack. Formulations include emulsions, high concentrate powders (charcoal base), and granular preparations on sand or attapulgitic clay. The compound is highly toxic to mammals.

Phosdrin and Phosphamidon are listed under organic phosphates, page 11.

Schradan, sometimes referred to as **OMPA**, is another relatively toxic phosphate systemic in action. Unlike demeton, it has no effective fumigant action but must be converted into an active material within the plant and by the sucking insect. A similar conversion appears to occur in the liver of warm-blooded animals.

Schradan was one of the earliest plant systemics, but has not become widely used. It is best on aphids and is available in bomb form for greenhouse insect control.

Plant derivatives

Pyrethrum is prepared from the flowers of imported chrysanthemum plants. The active ingredients, pyrethrins, are nonpoisonous to humans but fast acting against insects. Pyrethrum is effective only for about a day when used outdoors. Its effectiveness is increased when used with one of the so-called synergists (an added chemical which increases the effectiveness of the main chemical).

A new synthetic chemical, *allethrin*, is very similar chemically. It is used in place of pyrethrum for a few control problems.

Rotenone, one of the oldest insecticides, is prepared from a tropical plant called cubé. A comparatively safe material, it is useful for controlling several vegetable insects. It lasts longer than pyrethrum but not as long as chlorinated hydrocarbon insecticides.

Ryania is produced from the stems of a South American plant. It is not prepared synthetically and only limited amounts are usually available. Ryania gives nearly the same control of the European corn borer as DDT. The advantage over DDT is that it

does not accumulate in body tissues of cattle and other livestock.

The 100-percent product can be used as a wettable powder in water. However, the resulting suspension is much poorer than with synthetic insecticides. A 50-percent wettable powder is now available which approaches the 100-percent product in toxicity. The 37- to 40-percent dust can be used directly on plants. Dusts of lower concentrations are also available.

Carbamate compounds

Baygon (Bayer 39007) is a methyl carbamate that has been used by professional pest control operators for the control of cockroaches, ants, and certain other household pests. It is quite fast-acting but also has a fairly long residual action, except on concrete.

Bux-Ten (0-5353) is a new carbamate developed for the control of hydrocarbon-resistant corn rootworms; it is presently available as a 10-percent granular formulation.

Carbaryl (Sevin) is chemically different from the organic phosphates and the chlorinated hydrocarbons. It is formulated as 50-percent, 80-percent, and 85-percent wettable powders, a 5-percent dust, and 5 and 20-percent granular material. A liquid concentrate flowable formulation is also available. Sevin has been approved for use on the major fruit insects, European corn borer, corn earworm, and poultry pests. It also looks promising against a number of vegetable and ornamental pests except aphids.

The insecticide has a comparatively low toxicity to warm-blooded animals, particularly low by skin absorption. It does not present any serious hazard under conditions of pest control use. Rather short day-intervals are permissible.

Dimetilan is a carbamate insecticide with a pyrazolyl structure used exclusively for commercial treatment of thin bands which can be hung in buildings for fly control. An attractant is used with the insecticide and the band is colored red. DDT-resistant (and some phosphate-resistant) houseflies are killed when they land on the bands and remain for a short time. At present the compound is not recommended in other forms.

Furadan (NIA 10242) is a very toxic methyl carbamate that acts as a systemic soil insecticide. It has shown promise for corn rootworm control and also as a potato systemic insecticide. Furadan has not yet been registered for any commercial uses.

Landrin (SD 8530) is a carbamate compound with a long residual activity and very low water solubility. It is an effective soil insecticide. The acute oral LD₅₀ to white rats is 178 mg/kg, which makes Landrin slightly less toxic than DDT.

Temik (UC 21149) is an aliphatic carbamoyloxime available as 10-percent granules. It has been used experimentally against soil insects and also shows

promise as a systemic insecticide and miticide when applied to the soil. It is a cholinesterase inhibitor and is highly toxic.

A related material, *Tranid*, is also under development.

Zectran is a new methylcarbamate compound shown to have effectiveness on certain ornamental insects and slugs. It has moderate toxicity but no tolerances have been set. The compound will not control mites. It is no longer generally available.

Carbonate-type miticide

Morestan is a dithiol cyclic carbonate that is effective on resistant mites and mite eggs. It is relatively ineffective against insects. Approvals have been made on certain fruits and ornamentals. Morestan is low in toxicity to warmblooded animals.

Chlorinated miticides

Certain chemicals are more effective on mites than on insects; some are effective on both. Most of those listed below have their greatest potential use as mite killers and are much less hazardous than phosphates.

Aramite (beta chloroethyl-beta-[p-tertiary butylphenoxy]alpha methylethyl sulfite) is effective on several plant-feeding mites. A 15-percent wettable powder may be used at the rate of 1½ pounds per 100 gallons of water. At the rate used, aramite has little effect on mite eggs. In some cases, however, it will persist and kill active mites for about a week. Its use on food crops is very limited.

Chlorbenside (Mitox) is a chemical relative of ovex, p-chlorobenzyl p-chlorophenyl sulfide. It is a slow-acting material that specifically affects mites but not insects. A 40-percent wettable powder has been used effectively at 1 pound per 100 gallons of water, especially for European red mites and two-spotted mites.

Chlorobenzilate, a 4, 4-dichlorobenzilic acid ethyl ester, is effective on many species of plant-feeding mites. It is a comparatively safe material, and is compatible with nearly all pesticides except those in which alkaline reactions may take place.

Chloropropylate (Acaralate) is very closely related to chlorobenzilate and is registered for mite control on fruit trees. It is available as an emulsifiable concentrate containing 2 pounds active ingredient per gallon.

Dicofol (Kelthane) is a chlorinated miticide that is very effective on a wide range of mites. It is available as an 18½-percent wettable powder or an 18½-percent emulsion concentrate. Dicofol is effective on cyclamen mites and other plant-feeding mites.

Fenson is a chlorinated hydrocarbon miticide (parachlorophenyl benzenesulfonate) closely related to ovex. The compound has low mammalian toxicity and has proved effective against the plant-feeding mites on apples and pears. It is not permitted on fruits, and therefore must be used prior to blossoming. It is ineffective on insects.

Genite 923 is a miticide made up of a 2, 4-dichlorophenyl ester of benzene sulfonic acid. A 50-percent emulsifiable form has been registered for certain mite control problems, particularly against the European red mite on apples. The rate of use is 1 pint per 100 gallons of water for light to moderate infestations and 1 quart per 100 gallons of water for severe infestations.

Ovex (Ovotran), or p-chlorophenyl p-chlorobenzene sulfonate, is a mite killer which is effective against the egg and active stages. Ovex remains effective for 2 weeks or longer under some outdoor conditions. The 50-percent wettable powder form may be used at rates of 1 to 2 pounds per 100 gallons of water. It has been tested in the greenhouse and on mites infesting fruit.

Pentac is a persistent chlorinated miticide not closely related to other miticides. It is particularly valuable against mites on roses and other greenhouse crops where mite resistance has become general to a number of other materials. It is available as a 50-percent wettable powder. It is ineffective on insects and partially effective on cyclamen mites. Pentac is rather slow acting but fairly long lasting.

Tetradifon (Tedion) is a miticide described as a chlorinated diphenyl sulfone. It is proving effective on orchard and greenhouse mites and is not harmful to beneficial insects. Tedion is sold as a 25-percent wettable powder for spraying or using as a slurry (suspension of the highly concentrated wettable powder in water) on steampipes in greenhouses. It is one of the safest materials as far as mammalian toxicity is concerned.

Binapacryl (Morocide) is a new nitrophenyl miticide which is promising for use on fruits and ornamentals.

Use of trade names in this publication is for information only and does not constitute endorsement of products named or criticism of those not mentioned by the University of Minnesota Agricultural Extension Service.

Field Crops Insects
Do Not Use After 1968

To help prevent illegal residues in livestock and livestock products, it is suggested that aldrin, dieldrin, DDT, or heptachlor *not* be used for any purpose on dairy farms and that aldrin or heptachlor be used as a soil treatment on corn grown for grain only. If it is absolutely necessary to harvest such treated corn for silage, it should be cut to leave a stubble of 12 inches or more if possible. Dairy cows, heifers, and meat animals being finished for slaughter should not be permitted to graze aldrin or heptachlor treated fields.

It is further suggested that if fields have been treated annually with aldrin or heptachlor for 5 or more years at least 1 year should elapse before planting soybeans or alfalfa.

Illegal residues may also occur in potatoes, sugar beets, or carrots grown in fields previously treated with these materials.

Insect	Crop	Insecticide	Dosage (actual toxicant per acre)	Limitations (days before harvest)
Aphids	small grain	malathion	1 lb.	7 days.
		methyl parathion	4 oz.	Not after heads form.
		parathion	4 oz.	15 days.
	corn	malathion	1 lb.	5 days.
		parathion	4 oz.	12 days.
		phorate (Thimet)	1 lb.	Direct granules into whorls of plants.
Armyworms	small grain	carbaryl (Sevin)	1 lb.	Do not apply after heads are visible.
		toxaphene	1½ to 2 lb.	Do not use straw for feed or bedding.
	corn	carbaryl	1 lb.	
		toxaphene	1½ to 2 lb.	Do not feed stalks, leaves, and husks.
Bean Leaf Beetle	soybeans	carbaryl	1 lb.	
		toxaphene	1 to 1½ lb.	21 days.
Beet Webworm	sugar beets	carbaryl	2 to 3 lb.	14 days (tops).
		endosulfon (Thiodan)	¾ to 1 lb.	Do not feed tops.
		toxaphene	2 to 3 lb.	60 days. Do not feed tops.
		trichlorfon (Dylox)	½ to 1 lb.	14 days. 28 days (tops).
Corn Earworm	sweet corn	diazinon	1 to 1½ lb.	
		carbaryl	1½ to 2 lb.	

Field Crop Insects (continued)

Insect	Crop	Insecticide	Dosage (actual toxicant per acre)	Limitations (days before harvest)	
Corn Rootworm	corn	Bux-Ten	¾ to 1 lb.	} Band application at planting or cultivation, except Bux-Ten, Dasanit and Dyfonate should be applied at planting time only. Rate given for 40-inch rows.	
		diazinon	1 lb.		
		Dyfonate	¾ to 1 lb.		
		phorate	1 lb.		
		Dasanit	¾ to 1 lb.		
<p>Carbaryl (Sevin 20G), disulfoton (DiSyston 10G), and stabilized parathion are also registered and available for corn rootworm control, but performance of these materials has been inconsistent in this area.</p>					
Corn Rootworm Adults ("silk beetles")	corn	carbaryl	1 lb.	5 days.	
		malathion	1 lb. or 0.6 lb. ULV by air		
Cutworms	corn	aldrin	2 lb.	} Preplant broadcast disked in.	
		heptachlor	2 lb.		
		chlordane	4 lb.		
		diazinon	2 to 4 lb.		Band treatment at planting time.
			trichlorfon	½ to 1 lb.	} Postemergence spray over the row.
			toxaphene	2 lb.	
		small grain	toxaphene	2 lb.	Do not use straw.
		soybeans	carbaryl	1 lb.	
			toxaphene	1 to 1½ lb.	21 days.
		sugar beets	carbaryl	1 lb.	14 days (tops).
		trichlorfon	½ to 1 lb.	14 days. 28 days (tops).	
European Corn Borer	corn	carbaryl	1½ lb.	Grain only.	
		DDT	1 to 1½ lb.	10 days.	
		diazinon	1 to 2 lb.	45 days.	
		EPN	½ lb.	14 days.	
		toxaphene	2 lb.	Grain only.	
				<i>Bacillus thuringiensis</i> (as labeled)	No limitations.
Grasshoppers	alfalfa, clover hay, and forage	carbaryl	1 to 1½ lb.	7 days.	
		diazinon	½ lb.		
		malathion	1 to 1½ lb. or 0.6 lb. ULV by air		
	corn	carbaryl	1 to 1½ lb.		

Field Crop Insects (continued)

Insect	Crop	Insecticide	Dosage (actual toxicant per acre)	Limitations (days before harvest)
		diazinon	½ to 1 lb.	
		malathion	1 to 1½ lb.	5 days.
		toxaphene	1 to 1½ lb.	Grain only.
	small grain	carbaryl	1 lb.	Not after heads are visible.
		malathion	1 to 1½ lb. or 0.6 lb. ULV by air	7 days.
		toxaphene	1 to 1½ lb.	Grain only.
	soybeans	carbaryl	1 to 1½ lb.	
		malathion	0.6 lb. ULV by air	
		toxaphene	1 to 1½ lb.	21 days. Beans only.
	grass (pasture, hay)	carbaryl	1 to 2 lb.	
		diazinon	½ lb.	No time limitations for grazing. 21 days for hay. Do not retreat within 30 days.
	grass (pasture, hay)	malathion	1 to 1½ lb. or 0.6 lb. ULV by air	
		naled (Dibrom)	½ to ¾ lb.	
Leafhoppers	alfalfa	diazinon	½ lb.	7 days for hay.
		methoxychlor	1½ lb.	7 days.
Pea Aphid	alfalfa, clover	demeton (Systox)	4 oz.	21 days.
		diazinon	½ lb.	7 days.
		malathion	1 lb.	
		parathion or methyl parathion	4 oz.	15 days.
Plant bugs	alfalfa, clover (seed crop only)	DDT	1½ to 2 lb.	} Do not graze or cut for feed.
		toxaphene	2 to 3 lb.	
Sugar Beet Root Maggot	sugar beets	carbophenothion (Trithion)	1½ lb. (Row)	} Apply as granules before or at planting time.
		diazinon	4 lb. (Broadcast)	
		disulfoton	1 lb. (Row)	
		phorate	1 lb. (Row)	
Sunflower Moth	sunflowers	endosulfan	1 lb.	Not more than 3 applications.

Field Crop Insects (continued)

Insect	Crop	Insecticide	Dosage (actual toxicant per acre)	Limitations (days before harvest)
Sweet Clover Weevil	sweet clover (plowdown)	toxaphene	2 to 3 lb.	Do not graze or cut for feed.
Thrips	barley	parathion or methyl parathion	4 to 6 oz.	15 days.
Wireworms	corn, beans, small grain	aldrin, dieldrin, heptachlor, or lindane	} 1 oz. per bushel	Seed treatment.
Wireworms and White Grubs	corn	aldrin or heptachlor chlordane		

Household Insects

Insect	Insecticide	Dosage*	Remarks
Ants (indoors). (See also under pests of trees, shrubs, turf.)	chlordane	2% to 5% solution or emulsion, 5% to 6% dust	} Apply to runways. Do not contaminate food or utensils.
	diazinon	0.5% solution or emulsion	
	dieldrin	0.5% solution or emulsion	
	lindane	0.5% solution, 1% dust	
	malathion	3% solution or emulsion	
	ronnel (Korlan)	1% emulsion	
Note: A treatment with chlordane or dieldrin on the outside walls and foundation, as described under boxelder bugs, may help keep ants from entering the house.			
Bedbugs	chlordane	2% to 3% solution or emulsion	} Apply to springs and frames of beds and to cracks and crevices around doors, window casings, baseboards, etc.
	DDT	5% solution	
	lindane	0.5% solution	
	ronnel	1% spray	
Boxelder bugs	carbaryl (Sevin)	1 lb. 50% W.P. per 50 gal. water	} Spray infested boxelder trees during late summer when bugs are small.
	chlordane	2 pt. 45% E. C. per 50 gal. water	
	dieldrin	3 pt. 15% E. C. per 50 gal. water	

Household Insects (continued)

Insect	Insecticide	Dosage	Remarks
	diazinon	1% emulsion	} Apply <i>outside</i> to foundations, walls, and tree trunks where bugs gather.
	dieldrin	2 pt. 15% E. C. per 8 gal. water	
	Note: Household insecticides are not effective against hibernating bugs in the home. The best treatment is a broom and dustpan. Thoroughly caulk cracks around windows and doors; see that doors and windows fit tightly. See Entomology Fact Sheet No. 10 for further details.		
Carpenter ants	chlordane	2% to 3% solution or emulsion	} Paint or spray infested wood and runways.
	dieldrin	0.5% solution or emulsion	
Carpet beetles	chlordane	2% to 3% solution	} Apply to backs of carpets, rugs, and pads. Spray or paint along baseboards. Pressurized spray cans may be used for treating clothing. Dust formulations may be applied to the floor before laying carpeting.
	dieldrin	0.5% solution	
	lindane	0.5% to 1% solution	
	diazinon	0.5% solution	
	malathion	3% solution	
Clothes moths	chlordane	2% to 3% solution	} Apply lightly to clothing.
	DDT	5% solution or in EQ-53 for washable woolens	
	dieldrin	0.5% solution	} Apply lightly to clothing (dryclean before using treated clothing).
	lindane	0.5% or 1% solution	
	malathion	3% solution	} Apply lightly to clothing.
	Perthane	5% solution	
	naphthalene or PDB flakes, crystals		
Clover mites	(For use <i>outside</i> the home to prevent mites from entering)		
	chlorobenzilate	2 tsp. 25% E. C. per gal. water	} Apply thoroughly to foundations, walls, and to the lawn for at least 20 feet out from and all around the house. Use a drenching spray.
	dicofol (Kelthane)	3 tbsp. 18½% W. P. per gal. water	
	malathion	3 tsp. 50% E.C. per gal. water	
Note: A mixture of malathion with either dicofol or chlorobenzilate at the above rates is reported to be more effective than either chemical used alone. An 18- to 24-inch sod-free band immediately next to the house will help reduce the clover mite problem. Wipe up mites inside the home with an oily dustcloth or a vacuum cleaner. Also see Entomology Fact Sheet No. 15.			
Cockroaches (roaches, "water bugs")	chlordane	2% or 3% solution or spray, 5% or 6% dust	} Apply with paintbrush or as "spot treatment" with sprayer or duster. Treat cracks, crevices, and other hiding places or runways. Do not contaminate food or utensils.
	diazinon	0.5% solution or spray	
	dieldrin	0.5% solution or spray	
	ronnel (Korlan)	1% to 2% spray	
	lindane	0.5% to 1% solution or spray	
	malathion	2% or 3% solution or spray	
	Kepone bait	as labeled	

Household Insects (continued)

Insect	Insecticide	Dosage	Remarks
Crickets	chlordane	2% to 3% spray or 5% to 6% dust	} Apply as "spot treatment" to corners, baseboards, under cabinets, in closets, etc.
	diazinon	0.5% spray	
	dieldrin	0.5% spray	
	malathion	2% to 3% spray	
			Note: A treatment with chlordane or dieldrin on the outside walls and foundation, as described under boxelder bugs, will help prevent crickets from entering the house.
Fleas Dogs	DDT or as for cats	5% to 10% dust or in washes or shampoos	
Fleas Cats	carbaryl	5% dust	
	malathion	4% dust	
	methoxychlor	1% dust	
	rotenone	1% dust	
Fleas Infested kennels, beds, or other areas	DDT	5% spray	<i>Do not use DDT on cats.</i>
	diazinon	0.5% spray	
	malathion	2% or 3% spray	
	methoxychlor plus pyrethrins	ready-to-use household sprays	
	ronnel (Korlan)	1% spray	
Houseflies (indoors)	pyrethrins plus synergist or dichlorvos	Space sprays or aerosol "bombs"	
	dichlorvos	slow-release resin strips	
Residual treatment of outbuildings or outside of the home	diazinon	1% spray or bait	} Apply to resting places of flies—around windows, doors, frames, under eaves, etc., or as a window screen paint.
	naled (Dibrom)	0.4% bait	
	dimethoate (Cygon)	1% spray	
	trichlorfon (Dipterex)	1% bait	
	dichlorvos (DDVP)	½% to 1% bait	
	malathion	1% spray or bait	
	ronnel (Korlan)	½% to 1% spray or 1% bait	
Compound 4072	0.5% spray		
			Note: Fly control depends on good sanitation. Keep garbage in tightly closed cans; dispose of garbage twice a week. Clean up decaying organic matter, haul out manure twice weekly, treat compost piles if flies are breeding in them. Use well-fitting screens on doors and windows.
Mosquitoes (indoors)	pyrethrins plus synergist, or dichlorvos (DDVP)	} Space sprays or in aerosol "bombs." Some aerosols may also contain DDT or methoxychlor.	
Mosquitoes (outdoors)	DDT	1 lb. 50% W. P. per 5 gal. water, or 5% emulsion spray plus 1% malathion spray	} Apply to mosquito resting places such as shrubbery, hedges, and under eaves. May also be painted on screens. <i>Do not apply to feed or food crops. Do not allow drift to contaminate such crops or pastures.</i>
	chlordane	0.5% spray	

Household Insects (continued)

Insect	Insecticide	Dosage	Remarks
	dichlorvos (DDVP), naled (Dibrom)	1% to 3% solution	Fogging for temporary adult control.
	dieldrin	1 pt. 15% E. C. per 5 gal. water	Apply to mosquito resting places such as shrubbery, hedges, and under eaves. May also be painted on screens. Do not apply dieldrin or Cygon to feed or food crops. Sensitive plants may be harmed from over-spraying or by large droplets.
	dimethoate (Cygon)	1% emulsion spray	
	malathion	1% emulsion or suspension spray	
<p>Note: Mosquito control in towns and cities should be an organized community program based on treatment of breeding areas and must be approved by the Minnesota Department of Agriculture.</p>			
Powder-post beetles	chlordane	2% oil solution	Paint, spray, or dip to saturate wood.
	DDT	5% oil solution	
	pentachlorophenol	4% to 5% solution	
Silverfish, firebrats	DDT	5% solution 5% to 10% dust	Apply to infested areas, corners in closets, behind radiators, around pipes.
	chlordane	2% to 3% solution, 5% to 6% dust	
	diazinon	1% spray	
	dieldrin	0.5% spray	
	lindane	0.5% spray, 1% dust	
	ronnel (Korlan)	1% spray	
Stored-food pests (flour beetles, meal moths, larder beetles, etc.)	chlordane	2% to 3% solution	Find and destroy or heat-treat infested foods. Paint or spray insecticides on shelves, cracks, corners. Do not contaminate food or utensils. Keep susceptible food stored in tight glass, metal, or plastic containers. Store at low temperatures. Clean storage area thoroughly. See Entomology Fact Sheet 13, "Pantry Pests."
	DDT	5% solution	
	lindane	0.5% solution	
Termites	chlordane dieldrin heptachlor	Termite infestations usually require the services of an experienced pest-control operator. Consult Entomology Fact Sheet 6, "Are They Really Termites?"	
Millipedes	carbaryl (Sevin)		1 lb. 50% W. P. per 10 gal. water as a barrier spray on outside foundation walls.
	Zectran		1 tbsp. 22% EC per gal. of water on outside walls.
Nuisance bees and wasps	dichlorvos (DDVP) carbaryl (Sevin)	spray or aerosol 5% dust	Treat nests in walls For ground-nesting species.

* Abbreviations: E. C.—emulsion concentrate; W. P.—wettable powder.

Livestock and Poultry Pests
Do Not Use This Table After 1968

Pest	Host	Insecticide	Rate	Limitations
Cattle Grubs	Dairy cattle	rotenone	7½ lb. 5% powder per 100 gal. 12 oz. 5% powder per 1 gal wash	
	Beef cattle or non-lactating dairy cows and heifers	coumaphos (CoRal)	0.5% spray, 4% pour-on	Not within 15 days of lactation for dairy cattle.
		ronnel (Trolene, Rid-Ezy, Steer-Kleer)	In feed or mineral	Not after Oct. 31. 60 days before slaughter or before lactation of dairy heifers. Do not treat mature dairy animals.
		Ruelene	0.5% spray 9.4% pour-on	Not after Oct. 31. 28 days before slaughter or before lactation for non-lactating dairy cattle.
		trichlorfon (Neguvon)	1% spray 8% pour-on	14 days before slaughter. Do not use on dairy animals.
Cattle Lice	Dairy cattle	Synergized pyrethrum	0.05 to 0.1%	
		rotenone	2 lb. 5% powder per 100 gal.	
		Ciodrin	0.25% emulsion spray	
	Beef cattle	carbaryl (Sevin)	0.5% spray	7 days.
		coumaphos	0.25% spray	
		Ciodrin	0.25% spray	
		dioxathion (Delnav)	0.15% dip or spray	Not more than every 2 weeks.
malathion		0.5% dip or spray	7 days.	
	methoxychlor	0.5% dip or spray		
	ronnel (Korlan)	0.25% spray or 1% in oil on backrubber	8 weeks. 14 days.	
	toxaphene	0.5% spray	28 days.	
	trichlorfon	0.25% spray	14 days.	
Face Flies	Dairy cattle	dichlorvos (Vapona)	½-1% baited spray	} Apply to face daily at not over 2 oz. per head per day.
		dichlorvos	1% oil solution	
		Ciodrin	1% oil solution	
	Beef cattle	Same as for Dairy or		} On back rubbers or face treating devices may give some control.
		toxaphene or Ciodrin	5% oil solution 2% oil solution	
Flies (horn, stable, horse) and mosquitoes	Dairy cattle	dichlorvos	1% oil spray	
		Ciodrin	1% oil spray	
		(or combinations of above)	2% dust	

Livestock and Poultry Pests (continued)

Pest	Host	Insecticide	Rate	Limitations
		coumaphos	1% on backrubbers	At least 5 hours before milking. Apply after milking not more than every 3 weeks.
		malathion	4 to 5% dust	
		methoxychlor	50% W.P. as dust	
		synergized pyrethrum (may also contain repellents)	0.05% to 0.1%	
		thiocyanates (Lethane, Thanite)	3.5%	
	Beef cattle	carbaryl (Sevin)	0.5% spray	7 days.
		coumaphos	0.25% spray 1% on backrubber	
		dioxathion	0.15% spray or dip 1.5% in oil on backrubber	Not more than every 2 weeks.
		lindane	0.03% spray 0.2% in oil on backrubber	30 days.
		malathion	0.5% spray 2% in oil on backrubber. 0.6 lb. tech. ULV by air	
		methoxychlor	0.5% spray 5% in oil on backrubber	
		ronnel	0.5% spray 1% in oil on backrubber	8 weeks. 14 days.
		toxaphene	0.5% spray 5% in oil on backrubber 50% WP as dust	} 28 days.
		trichlorfon	1% spray	
<p>Note: Aerial application of 0.6 lb. technical malathion ULV to beef cattle in pasture may give adequate control of horn-flies, faceflies, and mosquitoes.</p>				
Poultry mites, lice	chickens, turkeys	coumaphos	½% dust	
		malathion	0.25% spray	
		carbaryl	0.5% spray 4 to 5% dust 5% dust, 0.05 lb. actual per 100 birds as spray. 0.5% spray in building.	
Sheep Keds	Sheep	coumaphos	0.25% spray	15 days.

Livestock and Poultry Pests (continued)

Pest	Host	Insecticide	Rate	Limitations
		dioxathion (Delnav)	0.15% spray or dip	
		diazinon	0.03% to 0.06% spray or 2% dust	14 days.
		malathion	0.5% spray	
		methoxychlor	0.5% spray	
		ronnel	0.25% spray	84 days.
		toxaphene	0.5% spray	28 days.
House flies in barns and other buildings	Milkhouse or food processing buildings	pyrethrins	0.1% plus synergist	Space spray.
		dichlorvos	0.5% spray or 20% "slow release" strips.	Spot treat. Do not contaminate food products or utensils.
	Barns and animal housing areas	pyrethrins	0.1%	} Space spray with fogger, aerosol, or mist.
		dichlorvos	1.0%	
		naled	0.3%	
		diazinon	1.0% 0.2% bait	Not in poultry houses.
		Bomyl	0.5% bait	
		naled	0.5% bait	
		dichlorvos	0.5% bait	
		trichlorfon (Dipterex)	1.0% bait	
		dimethoate	1.0% residual spray	
		Dimetilan (Snip)	Fly bands	Hang securely so animals cannot con- tact bands.
	malathion	1% residual spray 1 to 2% bait		
	ronnel (Korlan)	0.5 to 1.0% residual spray		
Compound 4072	0.5% residual spray			
	Barns other than dairy or poultry	fenthion (Baytex)	1.0% residual spray	

Tree, Shrub, and Lawn Insects

Pest	Where found	Insecticide	Dosage	Remarks
Note: The all-purpose garden and fruit mixture of methoxychlor plus malathion will control most leaf-feeding and sap-sucking insects on trees and shrubs. DDT may be substituted for the methoxychlor. For special problems, follow recommendations given below.				
Ants	Lawn	chlordane	5% to 10% dust or granular	¼ lb. per 100 sq. ft.
			50% W. P., 3 tbsp. per gal. water	Apply as spray to 100 sq. ft.
			45% E. C., 5 tsp. per gal. water	Apply as spray to 100 sq. ft.
		diazinon	4 fl. oz. 4 lb. E. C. per 3 gal. water	Spot treat nests.
		dieltrin	5% dust or granular	½ lb. per 100 sq. ft.
heptachlor	2½% dust or granular	¼ lb. per 100 sq. ft.		
			25% E. C.	3 tsp. per gal. on 100 sq. ft.
Note: Liquid sprays may be used as a drench on individual ant nests. Water broadcast treatments thoroughly. Keep children and pets off until dry.				
Aphids	Trees, shrubs	malathion	2 pt. 50% E. C. per 100 gal., or 2 tsp. per gal. water	Apply thoroughly to all foliage
Aphids		dimethoate (Cygon)	1½ pt. 2.67 lb. E. C. per 100 gal.	May be toxic to some plants; check restrictions on label.
Note: Some aphids, such as elm cockscomb gall, elm leaf, woolly apple, woolly elm, and woolly elm bark, may be controlled with dormant sprays described under scale insects.				
Borers	<p>Borers usually attack trees which are low in vigor, damaged, or suffering from drought, lack of nutrients, or winter injury. To prevent borer attack, trees should be well watered and fertilized, if needed; prune out dead or dying branches and properly dress all wounds.</p> <p>Active borer tunnels or burrows may be treated by injecting carbon disulfide into them with an oil can. After treating, plug the burrows with clay or putty. Carbon disulfide is extremely explosive so avoid smoking or any flame when using it.</p> <p>A strong DDT-emulsion spray or wash containing 2½% DDT applied to the trunks and lower branches will control some borers. Avoid treating the foliage with the concentrated spray.</p> <p>The proper time to apply DDT is about the time the adult borers are laying eggs. This usually occurs at the following times of the year:</p>			
Bronze-birch borers	Late June, early July			
Poplar borers	August			
Apple-tree borers	Late May, early June			
Lilac borers	Late May, early June			
Locust borers	August			

Tree, Shrub, and Lawn Insects (continued)

Pest	Where found	Insecticide	Dosage	Remarks
Cankerworms, spring and fall	Elm, apple, oak, maples, boxelder, and other trees	DDT methoxychlor carbaryl (Sevin)	} 50% W. P. 2 lb. per 100 gal. or 2 tbsp. per gal.	Apply at first sign of injury, usually early in May.
Caterpillars and sawflies	Various trees and shrubs	Most leaf-chewing caterpillars and sawfly larvae may be controlled by spraying the foliage with 2 lb. 50% DDT or methoxychlor per 100 gal. of water (2 tbsp. per gal.), or with carbaryl as directed on the label. The time when these different worms appear varies. Some of the common defoliators are listed along with the time they are usually present on the trees.		
		Time to control		
Eastern tent caterpillars	Wild cherry, apple, mountain ash, other	Early to mid-May, when tents are noticed		
White-marked tussock moths	Elm, basswood, poplars, apple	Middle to late May; occasionally again in August		
Fall webworms	Most deciduous trees	July and early August		
Spiny elm caterpillars	Elm	Late May, early June		
Brown-headed ash sawflies	Ash	Late May, early June		
Red-headed pine sawflies	Jack pine	Late June, early July		
Jack-pine sawflies	Jack pine	Late May, early June		
Introduced pine sawflies	White pine	Early feeding in June, again in August		
Spruce budworms	Fir, spruce	As buds break and again 10 days later		
Galls	Most deciduous trees, especially oak, hackberry, maple, linden, elm	Chemical control of the insects or mites that cause galls usually is not satisfactory. Most galls do not seem to cause much injury. Pruning out and burning infested twigs or leaves sometimes reduce the problem.		
Elm bark beetles	Elm	DDT or methoxychlor	25% E. C.; 8 gal. per 100 gal. total spray (hydraulic sprayers); 50 gal. per 100 gal. total spray (mist blowers)	See Ext. Folder 211, "The Dutch Elm Disease." Cover all bark surfaces thoroughly as spring dormant spray. DDT may be used in fall dormant period. Methoxychlor used as spring dormant will minimize danger of harming birds.
Leaf beetles	Many deciduous trees, especially willow, elm, cottonwood, aspen	DDT, methoxychlor, or carbaryl (Sevin)	2 lb. 50% W. P. per 100 gal. or 2 tbsp. per gal. water	Apply when adult beetles appear; repeat when larvae appear.
Leafhoppers	Many trees and shrubs, especially caragana	DDT, methoxychlor	2 to 4 lb. 50% W. P. per 100 gal. or 2 to 4 tbsp. per gal. water	

Tree, Shrub, and Lawn Insects (continued)

Pest	Where found	Insecticide	Dosage	Remarks
Mites ("red spider," spider mites)	Many trees and shrubs, especially evergreens and ornamentals	aramite	2 lb. 15% W. P. per 100 gal. or 2 tbsp. per gal. water	
		chlorobenzilate	1 qt. 25% E. C. per 100 gal. or 2 tsp. per gal. water	
		dicofol (Kelthane)	2 lb. 18½% W. P. per 100 gal. or 2 tbsp. per gal. water	
		ovex	1½ lb. 50% W. P. per 100 gal. or 2 tbsp. per gal. water	
		tetradifon (Tedion)	1½ lb. 25% W. P. per 100 gal.	
		malathion	2 pt. 50% E. C. per 100 gal. or 2 tsp. per gal. water	Usually requires two or three treat- ments at 7- to 10-day intervals.
Night crawlers, earthworms	Lawn, turf	chlordane	Will help reduce numbers of night crawlers when used as recommended for white grubs.	
Scale insects		Dormant sprays		
Oyster-shell European elm Scurfy Cottony maple European fruit lecanium		DN-289	1 gal. per 100 gal. water	Apply in fall after all growth has stopped or in spring before buds open but when temperature is above freezing.
		Elgeton 318	1 gal. per 100 gal. water	
		dormant oils or dormant oil plus ethion or diazinon	2 to 3 gal. per 100 gal. water as labelled	
Pine-needle		liquid lime sulfur	1 part to 9 parts water	Apply in spring before buds open but when temperature is above freezing.
		Crawler sprays:		
		2 pt 50% emulsion concentrate of malathion per 100 gal. water, or 2 lb. 50% W.P. of carbaryl.		
		When to apply:		
European fruit Lecanium	Elm, fruit trees	Late June, early July (about when catalpas bloom)		Thorough coverage of foliage, twigs, and branches.
Oystershell	Many shade, fruit, ornamental trees, shrubs	When apple petals have fallen (early June)		
Cottony maple		Late June, July		
Scurfy	Elm, maple, hackberry	June and July		

Tree, Shrub, and Lawn Insects (continued)

Pest	Where found	Insecticide	Dosage	Remarks
Pine-needle	Pines, spruce		Late May (when lilacs bloom)	Repeat in 10 to 15 days.
White grubs,	Lawn, turf	aldrin	4 lb. actual per acre 1½ lb. 5% dust or granular per 1,000 sq. ft. 5 fl. oz. of 2 lb. E. C. concentrate per 1,000 sq. ft.	Note: Apply to seedbed before seeding or sodding or apply to the surface of established turf and soak thoroughly. May be combined with lawn fertilizer. Following soaking, keep children and pets off treated area until dry.
		chlordane	2½ lb. 10% dust or granular per 1,000 sq. ft. 8 fl. oz. of 45% E. C. per 1,000 sq. ft.	
		dieldrin	4 lb. 2½% dust or granular per 1,000 sq. ft. 6 fl. oz. of 15% E. C. per 1,000 sq. ft.	
		heptachlor	¼ lb. 20% granular per 1,000 sq. ft. 4 fl. oz. 2 lb. E. C. per 1,000 sq. ft.	
Sod webworms	Lawn, turf	carbaryl (Sevin)	2 cups 50% W. P. per 1,000 sq. ft. in 20 to 25 gal. water.	
		chlordane	1 to 2 lb. 10% granules or 8 fluid oz. 45% E. C. per 1,000 sq. ft.	
		diazinon	1 lb. 14% granules or ½ pt 25% E. C. per 1,000 sq. ft.	

Stored Grain Insects

Note: Market or food grains should not be stored in barns, in buildings where livestock feed is stored, or in other situations where they are near to sources of infestation. Excessive moisture content, dirty or damaged grain, and dirty bins all encourage insect infestation.

Bin sprays	Thoroughly clean bins as soon as they are emptied; spray walls, ceilings, and floors of the empty bin with one of the following:	
	malathion	1 gal. 57% <i>premium-grade</i> E. C. in 25 gal. water (1 pt. in 2 to 5 gal. water); apply to runoff.
	methoxychlor	2 gal. 25% E. C. for 25 gal. of spray or ready-to-use methoxychlor bin spray.
	synergized pyrethrins	Ready-to-use bin spray.
Grain protectants applied directly to grain as it comes from combine or as it is binned:	malathion	1 pt. <i>premium-grade</i> E. C. per 2 to 5 gal. water per 1,000 bu.
	malathion	1% <i>premium-grade</i> wheat flour dust, 60 lb. per 1,000 bu.
	synergized pyrethrins	Ready-to-use protectant sprays or dusts, as labeled.
Surface treatments applied to surface of grain after it is in the bin:	malathion	½ to 1 pint <i>premium-grade</i> E. C. in 2 gal. water per 1,000 sq. ft. of grain surface area.
	malathion	1% <i>premium-grade</i> wheat flour dust, 30 lb. per 1,000 sq. ft.
	synergized pyrethrins	Ready-to-use, 1 gal. per 1,000 sq. ft.

Fumigation (Applied to binned grain to stop insect infestation. Does not give a residual preventive treatment.)

Many commercial fumigants are available; some of the common ones are listed below. Grain to be fumigated should be in a tight bin and leveled to a height no more than within 6 to 8 inches from the top of the side walls of the bin. Fumigate on a calm day when the *grain* temperature is at least 60° F. Persons applying or handling the fumigant should protect themselves from vapors by using suitable gas masks and protective clothes. More than one person should be present at the job in case of accident. Read and follow all precautions listed on the labels for each different fumigant. Information about other fumigants is available from the Department of Entomology, Fisheries, and Wildlife, University of Minnesota, St. Paul, Minnesota 55101.

Fumigant	Dosage (gal. per 1,000 bu.)			
	Small grain		Shelled corn	
	Wooden bins	Metal bins	Wooden bins	Metal bins
Carbon tetrachloride-carbon disulfide, 80-20	4	2	6	5
Carbon tetrachloride-ethylene dibromide, 95-5	4	2	6	5
Carbon tetrachloride-ethylene dichloride, 3-1	6	3	8	6
Carbon tetrachloride-ethylene dichloride-ethylene dibromide, 60-35-5	4	2	6	5
Use other liquid fumigant mixtures as labeled.				

Aluminum phosphide (Phostoxin). Tablets may be added to grain as it is binned, or probed into binned grain.

Type of storage	Grain temperature	Dosage (tablets per 1,000 bu.)
Concrete or steel elevator tanks	54-59° F.	150
	60-68° F.	90
	over 68° F.	60
Round steel bins ("Butler" type)	54-59° F.	180
	60-68° F.	120
	over 68° F.	90

For average wooden farm bins use 180 tablets per 1,000 bu.

Greenhouse and Floricultural Pests

1968

The major crops and their major pests are as follows:

African violets	Cyclamen mites, also spider mites, Pritchard mealybug, occasionally aphids
Azaleas	Spider mites, cyclamen mites, whiteflies, greenhouse thrips, leaf miner, leaf roller
Begonias	Cyclamen mite probably most serious, thrips
Cacti (succulent plants)	Mealybugs
Camellias	Aphids, thrips, leaf miners, spider mites
Chrysanthemums	Aphids, leaf miners (<i>Phytomyza atricornis</i>)
Cyclamens	Cyclamen mite, spider mites, aphids
Ferns	Root aphids, foliar aphids, scale insects, mealybugs
Geraniums	Aphid, spider mites, plume moth (<i>Platyptilia pica</i>)
Lillies	Aphids
Orchids	Orchid fly, <i>Eurytoma orchidearum</i> , slugs
Poinsettias	Mealybug, whitefly, spider mites, scale insects, root aphids
Roses	Spider mites, thrips, aphids, midge, leaf roller
Snapdragons	Spider mites, aphids, cyclamen mite, whiteflies

Greenhouse and Floricultural Pest Control

Pest	Insecticide, miticide	Dosage per 100 gal. spray unless otherwise stated	Remarks
Ants	<p style="text-align: center;">SPRAYS OR DUSTS</p> <p>chlordane</p> <p>diazinon</p> <p>dieldrin</p>	<p>5% dust or 2½ lb. of 40% W.P.</p> <p>1 to 2 lb. 50% W.P.</p> <p>2% dust, 1 lb. of 50% W.P. or 1½ qt. of 18.6% E.C.</p>	} Apply 1 lb. of dust or 1 gal. spray per 1,000 sq. ft. soil along walks. Do not apply to foliage.
Aphids	<p style="text-align: center;">AEROSOLS and VAPORS</p> <p>dichlorvos (DDVP)</p> <p>naled (Dibrom)</p> <p>parathion</p> <p>sulfotepp (Dithio)</p> <p style="text-align: center;">SPRAYS</p> <p>diazinon</p> <p>dimethoate (Cygon)</p> <p>endosulfan (Thiodan)</p> <p>lindane</p>	<p>6 oz. smoke generator for 10,000 cu. ft.; 1 oz of 81% E.C. per 10,000 cu. ft. on steam pipes.</p> <p>2 fl. oz. of 4 lb. E.C. per 10,000 cu. ft.</p> <p>10% aerosol using 1 lb. per 50,000 cu. ft.</p> <p>Smoke or 5% aerosol bomb using 1 lb. per 50,000 cu. ft.</p> <p>1 lb. 50% W.P. or 1 qt. 25% E.C.</p> <p>1 to 1½ pt. of 2.67 lb. E.C. For soil drench use 6 fl. oz. per 1,000 sq. ft. bench</p> <p>1 lb. 50% W.P. or 1 qt. 24% E.C.</p> <p>1 lb. 25% W.P.</p>	<p>Apply as steam pipe fumigant.</p> <p>Causes leathery leaves on gardenias; not recommended on asters and white cyclamen.</p> <p>Never use on <i>Chrysanthemums</i>; certain varieties of <i>Azalea</i>, fern, Easter lily, gloxinia, hydrangea, <i>Schleffera</i> and <i>Saintpaulia</i> have been damaged.</p> <p>3% dusts may also be used.</p>

Greenhouse and Floricultural Pest Control (continued)

Pest	Insecticide, miticide	Dosage per 100 gal. spray unless otherwise stated	Remarks
Caterpillars (various species)	malathion	2 lb. 25% W.P. or 1½ pt. 50% E.C.	Dosage doubled for scale insects. Injury occurs to some crassulas, cucurbits, ferns, petunias, orchids, sweet peas. Phytotoxicity greatest with E. C. Dusts may also be applied.
	oxydemetonmethyl (Meta-Systox R)	1½ pt. of 2 lb. E.C. For soil drench use 1 tablespoon in 3 gal.; 3 gal. treats 100 6-inch pots.	Causes leaf scorch on Easter Lily; injury noted on mum varieties: Hurricane, Iceberg, Whitecap, and Pennant.
	carbaryl (Sevin)	2 lb. of 50% W.P. or 1 qt. of 80% sprayable	Except for older stages of cabbage looper.
	methoxychlor	2 lb. of 50% W.P.	Preferred for sensitive foliage.
Centipedes, symphylids	trichlorfon (Dylox)	2 to 3 lb. of 50% soluble powder	Some injury to certain varieties of carnation and zinnia.
	lindane	10 oz. of 25% W.P. per 1,000 sq. ft.	Work into soil. Steam sterilization is also advised.
Cutworms	carbaryl	2 lb. of 50% W.P. or 1 qt. 80% sprayable	} Soil treatment.
	chlordane	5% to 10% dust, 2 lb. 50% W.P. or 2 pints 45% E.C.	
	DDT	10% dust or 2 lb. of 50% W.P.	
	dieldrin	2% dust, 1 lb. of 50% W.P. or 1 qt. of 19.5% E.C.	
Cyclamen mites	dicofol (Kelthane)	1 lb. of 35% W.P. 1 pt. of 18.5% E.C.	} Make 2 or 3 applications at 2-week intervals. Use sanitation and isolation during clean-up period.
	endrin	1 qt. of 18.5% E.C.	
	endosulfan	2 lb. of 25% W.P. or 1 qt. of 24% E.C.	
Fungus gnats	chlordane	1 qt. of 75% E.C.	} Treat soil weekly until infestation is controlled.
	dieldrin	1 lb. of 50% W.P. or 1 pt. of 19.5% E.C.	
	malathion	4% dust or 1½ to 2 pts. of 57% E.C.	
Grasshoppers	aldrin	1 lb. of 25% W.P.	
	chlordane	1 lb. of 50% W.P.	
	dieldrin	½ lb. of 50% W.P.	
	heptachlor	1 lb. of 25% W.P.	
Leafhoppers	carbaryl	2 lb. of 50% W.P.	
	DDT	2 lb. of 50% W.P.	
	diazinon	½ lb. of 50% W.P.	

Greenhouse and Floricultural Pest Control (continued)

Pest	Insecticide, miticide	Dosage per 100 gal. spray unless otherwise stated	Remarks	
Leaf miners and foliar nematodes	diazinon	2 lb. 50% W.P.		
	dimethoate	directions under aphids		
	malathion	1½ pt. 50% E.C. 2 lb. 25% W.P.		
	oxydemetonmethyl	1½ pt. of 2 lb. E.C. Soil drench may be used as given under aphids		
	parathion	1 lb. of 25% W.P. 1 pt. 25% E.C.	Avoid excessive treatment of asters, gardenias, and white cyclamen.	
Leaf rollers	carbaryl (Sevin)	2 lb. of 50% W.P. or 1 qt. of 80% sprayable		
	DDD (TDE)	2 lb. of 50% W.P. ¾ lb. of 25% W.P.	Dusts and sprays more effective than aerosols.	
	trichlorfon	2 to 3 lb. of 50% soluble powder	Some injury to certain varieties of carnation and zinnia.	
Mealybugs	SPRAYS			
	diazinon	2 lbs. of 50% W.P. or 1 qt. of 25% E.C.		
	dimethoate	1½ pt. of 2.67 lb. E.C.	Avoid chrysanthemums and other varieties listed under aphid recommendations.	
	lindane	½ lb. of 25% W.P. or 8 oz. of 20% E.C.		
	malathion	3 lb. of 25% W.P. or 1½ pt. of 57% E.C.		
	parathion	1 lb. of 25% W.P.	Repeat in 3 to 4 weeks.	
	VAPORS, AEROSOLS			
	dichlorvos	6 oz. smoke generator for 10,000 cu. ft. 1 oz. of 81% E.C. per 10,000 cu. ft. on steam pipes		
	malathion	15% bomb using 1 lb. per 50,000 cu. ft. 1 10% bomb at 1 lb. per 50,000 cu. ft.		
	naled	2 fl. oz. of 4 lb. E.C. per 10,000 cu. ft. on steam pipes		
sulfotepp	15% bomb using 1 lb. per 50,000 cu. ft.			
Roaches	chlordan diazinon dieltrin	} same as for ants		
Scale insects	diazinon dichlorvos dimethoate malathion parathion sulfotepp	} same as for mealybugs	} 3 or 4 applications, but repeat as necessary. Best control when crawlers are present.	

Greenhouse and Floricultural Pest Control (continued)

Pest	Insecticide, miticide	Dosage per 100 gal. spray unless otherwise stated	Remarks
Slugs, snails	metaldehyde, or proprietary baits containing metaldehyde	2 oz. of 15% dust per 100 sq. ft. or 1 oz. of 20% E.C. to cover 100 sq. ft.	Apply once every 2 weeks to soil, using fresh material.
Sowbugs (pillbugs)	chlordane	5% to 10% dust	
	diazinon	1 lb. of 50% W.P. or 1 qt. of 25% E.C.	
Spider mites	lindane	1 lb. of 25% W.P.	
	SPRAYS		
	Aramite	1½ lb. 15% W.P.	Avoid higher temperatures because of discoloring rose petals and burning of hydrangeas.
	carbophenothion	1 pt. of 4 lb. flowable or 2 lb. of 25% W.P.	Do not treat Crassula and maiden hair fern.
	chlorobenzilate	1 lb. of 25% W.P. or 1 pt. of 25% E.C.	Not as effective when sulfur is used.
	dicofol	1 lb. of 35% W.P. or 1 pt. of 18.5% E.C.	Incompatible with sulfur.
	dimethoate	1 to 1½ pt. of 2.67 lb. E.C.	
	malathion	1½ pt. of 50% E.C.	
	Morestan	½ lb. of 25% W.P.	Certain rose varieties damaged.
	oxydemetonmethyl	1½ pt. of 25% E.C.	
	Pentac	½ lb. of 50% W.P.	Certain varieties of mums may be damaged.
	tetradifon (Tedion)	½ lb. of 50% W.P. 1 qt. of 12.3% E.C.	Avoid treatment of White Butterfly and Cinderella roses.
	AEROSOLS		
	Aramite	10% bomb for 50,000 cu. ft.	
	chlorobenzilate		
	dichlorvos	6 oz. for 10,000 cu. ft.	
	malathion	15% bomb using 1 lb. for 50,000 cu. ft.	
	parathion	10% bomb for 200,000 cu. ft.	
	sulfotepp	15% bomb to 200,000 cu. ft.	
	VAPORS OR SMOKES		
	Aramite	Paint 8 oz. tech. material per 100,000 cu. ft. on steam pipes	
	naled	Paint 1 fl. oz. of 58% E.C. per 10,000 cu. ft. on steam pipes	Corrosive to metals.
	sulfotepp	15% sulfotepp, using 1¾ oz. to 5,000 cu. ft.	
	tetradifon	Paint 10 oz. of 50% W.P. as slurry to steam pipes for 200,000 cu. ft.	
	tetradifon 15% + sulfotepp, 12.5%	Smoke generator 6 oz. for 10,000 cu. ft.	

Greenhouse and Floricultural Pest Control (continued)

Pest	Insecticide, miticide	Dosage per 100 gal. spray unless otherwise stated	Remarks	
Spittle bugs	dieldrin	1 lb. of 50% W.P. or 1 qt. of 18.5% E.C.		
	endosulfan	1 lb. of 50% W.P. or 1 qt. of 24% E.C. or 3% dust		
	lindane	½ lb. of 25% W.P. or 8 oz. of 20% E.C.		
Springtails	SOIL TREATMENT			
	chlordane	1 lb. of 40% W.P. ½ pt. of 75% E.C.		
	diazinon	1 lb. of 50% W.P. 1 qt. of 25% E.C. 2% dust watered in		
Symphylids (see Centipedes) Tarnished plant bugs and other plant bugs	carbaryl	1 qt. of 80% sprayable 1 lb. of 4 lb. flowable		
	DDT	1 lb. of 50% W.P. or 1 qt. of 25% E.C.		
Thrips	DDT	2 lb. of 50% W.P. or 1 qt. of 25% E.C. or 5% dust		
	diazinon	1 lb. of 50% W.P. 1 qt. of 25% E.C., 2% dust		
	dieldrin	½ lb. of 50% W.P. or 1 pt. of 19.5% E.C.	For evaporative cooling pads add 2 pt. of 19.5% E.C. dieldrin per 100 gal. circulating water.	
	dimethoate	1½ pt. of 2.67 E.C.	See remarks under aphids for restrictions.	
	heptachlor	1 lb. of 25% W.P. or 1 pt. of 25% E.C.		
	lindane	½% to 1% through evaporative pads		
White flies	SPRAYS			
	DDT	2 lb. of 50% W.P.		
	diazinon	2 lb. of 50% W.P.		
	dimethoate	1½ pt. of 2.67 E.C.	See remarks under aphids for restrictions.	
	endosulfan or endosulfan plus malathion or parathion	Same as for aphids 1 lb. of 50% W.P. plus 3 lb. of 25% W.P. or 1 lb. of 25% W.P.	See remarks under aphids.	
	VAPORS, AEROSOLS			
	dichlorvos	6 oz. for 10,000 cu. ft. or paint 1 fl. oz. of 81% E.C. per 10,000 cu. ft.		
	endosulfan	1 lb. 10% aerosol per 50,000 cu. ft.		
sulfotepp	1 bomb per 200,000 cu. ft.			

Resistance of Certain Aphids (particularly Green Peach Aphid) and Red Spider Mites

There appears to be no easy way of minimizing the development of resistance except to minimize or avoid using certain chemicals. On the other hand there are a few guidelines which may be helpful, such as:

- (1) Prevent introduction of new strains from other sources by careful inspection of the plants upon receipt; preferably isolate for a time before a treatment; if an infestation is present give a thorough treatment before permitting the plants to be mixed with the others.
- (2) Keep conditions as cool and unfavorable for the aphids and mites as possible without interfering with the growing conditions of the plants.
- (3) Make each treatment thorough.
- (4) Alternate effective insecticides; change from one type of chemical grouping to another. In the case of aphids, there are only two major insecticide groups. With spider mites, there are more possibilities. Materials used along with their classifications are given below:

Aphids: (1) *Chlorinated hydrocarbons*—endosulfan (Thiodan), lindane. (2) *Organophosphates*—carbophenothion (Trithion), demeton (Systox), dichlorvos (DDVP), diazinon, dimethoate (Cygon), malathion, naled (Dibrom) oxydemetonmethyl (Meta Systox R), parathion, phorate (Thimet), Sulfotepp (Dithio).

Red Spider Mites: (1) *Chlorinated hydrocarbons*—chlorobenzilate, dicofol (Kelthane), Pentac; (2) *Organophosphates*—carbophenothion (Trithion), demeton, dichlorvos, dimethoate, naled oxydemetonmethyl, parathion, phorate, schradan, sulfotepp. (3) *An organic carbonate*—Morestan; (4) *Sulfur compounds* (not phosphates)—Aramite, tetradifon (Tedion).

Toxicity and Hazard

The hazard from insecticides is not only dependent upon the toxicity of the chemical but how it is used and what form of the insecticide might be contacted.

The following table illustrates relative hazard differences due to the physical state (++++ = very hazardous, + least hazardous.)

Physical State	Lungs	Hazard through skin	By Mouth
Droplets of:			
Emulsions	++	++++	+
Wettables or Flowables	++	++	+
Solutions	++	++++	+
Smokes	+++	+	+
Vapors (aerosols)	++++	+	+
Dusts	+++	++	+
Granules	+	++	++

The extremely and highly toxic (less than 5 gram or 1/6 oz. active ingredients for a man):

phorate (Thimet)	mevinphos (Phosdrin)
demeton (Systox)	carbophenothion (Trithion)
endrin	
parathion	

The moderately toxic: (1/6 oz. to 2 oz. for a man)

aldrin	heptachlor	dichlorvos
chlordane	lindane	diazinon (oral)
DDT	endosulfan	naled (Dibrom)
dieldrin	toxaphene	oxydemetonmethyl (oral) (Meta Systox R)

The slightly toxic: (2 oz. to 10 oz. for a man)

carbaryl (Sevin) (oral)	TDE
chlorobenzilate	
DDT (dermal)	Ovotran
trichlorfon (Dipterex or Dylox)	
dicofol (Kelthane)	
ronnel (Korlan)	
malathion (oral)	

Practically non-toxic: (10 oz. to 26 oz. for a man)

Aramite
carbaryl (oral)
malathion (dermal)
methoxychlor
